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# PROBLEMY EKOROZWOJU

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## **PROBLEMS OF SUSTAINABLE DEVELOPMENT**

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## Sustainable Development and Sustainable Science. Where We Came From, Where We Are Now and Where We Are Heading? Part I: The History of the Concept

## Zrównoważony rozwój i nauka o zrównoważoności. Skąd pochodzimy, gdzie jesteśmy teraz i dokąd zmierzamy? Część I: Historia koncepcji

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#### Abstract

This work focuses on the origin, the history and milestones that led to the conceptualization of sustainable development (SD). Not only is the concept of SD broad, but it is often used interchangeably with the more general (but sometimes also more specific) concept of sustainability. The concept of SD is analysed based on its development and relationships with sustainability and related scientific (theoretical) and practical concepts. The rationale behind this work lies in clarifying the meaning of SD, including the concept of sustainability, and, on the basis of this, identifying the main ways of moving closer towards the aims of SD, including quality of life and wellbeing. The limitations of the concept are identified and summarized, as are the alternatives to SD and sustainability. The rationale behind this work lies not only in the clarifying of the SD concept, but also in the normative evaluation of this concept in relation to the wellbeing and quality of life of the Earth's population for an infinite time period, while maintaining the supply of ecosystem services which the planet provides, taking into account that these resources are not only a source of people's wellbeing, but are essential for people's survival in general. Hence this work includes an in-depth sophisticated consideration of the SD concept based on its historical development, with a focus on the most crucial milestones, as well as normative assessments of the concept resulting from this knowledge.

Key words: development, history, progress, quality of life, sustainable development, sustainability, wellbeing JEL Classification: 110, 113, 115, 118, Q01

Słowa kluczowe: rozwój, historia, postęp, jakość życia, zrównoważony rozwój, zrównoważoność, dobrostan

#### 1. Introduction

Sustainability is a nebulous but attractive concept which poses an essential question for every activity – whether it can continue. Not only is the concept of sustainability broad, but it is also often used interchangeably with the concept of sustainable development (SD), with which it is significantly interconnected. However, they are not the same. If an activity is sustainable, in practice it can continue forever, which is in compliance with a general definition of sustainability in relation to the SD concept.

The human species is fundamentally dependent on the flow of ecosystem services which are used in production and consumption in order to increase their wellbeing and quality of life. Hence it is necessary to identify these services in order to determine the relationships between the three distinct pillars of SD, wellbeing and quality of life. Different definitions of ecosystem services according to different scholars have been introduced. La Notte et al. (2017) addressed the challenges identified in ecosystem services research, and a survey and detailed analysis of definitions is provided in their work. For the purpose of this paper, only a few of them are provided to clarify and emphasise the essence, importance and relationships of these services to the concept of SD/sustainability and the survival of humanity in its current form. Some definitions are very similar, such as those claiming that ecosystem services are defined as the direct and indirect contributions of ecosystem structures and functions (Müller and Burkhard, 2012); the direct and indirect contributions of ecosystems to human wellbeing (Maes et al., 2016; TEEB, 2009); the benefits that people obtain from ecosystems (the outcomes sought through ecosystem management) (Wallace, 2007); the flow of services (outcome of structure and processes) provided by ecological assets in a certain assessment period (Bateman et al., 2011); the use of ecological assets over a certain time period (Boyd and Banzhaf, 2007). The Millennium Ecosystem Assessment (MA, carried out in 2001-2005; MA, 2005) assessed the consequences of ecosystem change for human wellbeing and established the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human wellbeing. It focuses on the linkages between ecosystems and human wellbeing and, in particular, on *ecosystem services*.

Ecosystem services are the benefits people obtain from ecosystems (this is in compliance with several definitions used above, especially that of Wallace, 2007). These include *provisioning services*, including food, (fresh) water, timber and fuel; *regulating services*, including climate regulation, flood regulation, disease regulation and water purification; cultural services, which provide educational, recreational, aesthetic and spiritual benefits; and *supporting services*, including primary production, soil formation, photosynthesis and nutrient cycling. In this work, the term ecosystem services is generally used to refer to some kinds of natural re/sources or sinks. What is usually meant when speaking about sources and sinks, or more generally about resources (unless explained otherwise), is provisioning, regulating and supporting services, or a combination of these.

To start broadly, in any situation of scarcity of resources generally representing environmental services, including (among others) means of production and sinks, choices are to be made. Either decrease in demand or increase in supply needs to be pursued. As regards supply increases, they can be achieved by military or by economic means, and by international free trade, or by increasing efficiency and substitution processes in the domestic market. The choices result in four strategies that are theoretically feasible and have been pursued in practice throughout history and different places, in isolation or, more frequently, in combination (Spangenberg, 2008). Based on an analysis of the history of the concepts of SD and sustainability, these approaches are further analysed in subsection 3.3. The crisis, which has several dimensions, namely social, economic, environmental and political, along with its associated cultural, spiritual and intellectual aspects, has its institutional origins in the emergence of the capitalist economy from the Scientific and Industrial Revolutions in England (see e.g. Merchant, 1980; Capra, 1983). The shift in attitudes towards nature shaped by the ideology of the Enlightenment was key in changing the view of the world, leading to a disillusionment about nature and a reduction of its power over physical and spiritual aspects of human life. (Eckersley, 1992; Merchant, 1980).

The SD paradigm emerged to provide a framework by which economic growth, social welfare, and environmental protection can be harmonized (Asara et al., 2015). Although such harmonization has proved elusive until very recently, it has been accepted in different areas of human activity. The concept of SD has experienced various developmental phases and the participation of a variety of institutions since its introduction, and has undergone different interpretations and critiques over time. In its development, the concept has been adapting to the requirements of a complex global environment, but the underlying principles and goals, as well as the problems of their implementation, remained almost unchanged (Klarin, 2018). However, policy goals have been updated, having responded to actual challenges. Generally, sustainability, a nebulous but attractive concept, poses an essential question for all human activities – i.e., that of whether they can continue. This means that activities such as production, consumption, and related uses of natural, physical, human or other forms of capital which can be carried out indefinitely can be regarded as sustainable. Hence, this concept is broader and more general than the concept of SD. An important challenge related to both concepts is to maintain the sources of people's wellbeing, but it's even more important to find ways of ensuring that this is compatible with environmental limits, while ensuring that a high level of social welfare and inclusion is achieved, and social imbalances are minimized.

This work focused on the origin, the history and milestones that led to the conceptualization of SD. It is crucial to study the notions of progress, growth and their mutual interrelations in order to discover a deeper meaning in this concept. The main aim of the work is to clarify the essence and deeper significance of SD based on an analysis of the history of the concept, key scientific works and practical policies, strategies, and actions. Putting the concept into operation is crucial – it should be aimed at sustaining or increasing wellbeing and quality of life within ecological limits. Analysis and synthesis of the relevant knowledge are used as the basic methods, and a normative approach and critical evaluation are applied to derive conclusions and recommendations. Concrete strategies, concepts and instruments are also analysed from the normative perspective when relevant to the aim of the paper.

In the introduction, the most famous and most quoted definition must be outlined to be able to analyse the meaning of the SD concept in detail. According to WCED (1987), sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: (1) the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and (2) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. Behind this general description many aspects are hidden and they will be detected, analysed and critically evaluated in the following sections. In this

place is necessary to emphasise that in compliance with this definition the notion of SD is composed of two crucial elements, i.e. meeting human needs and respecting the limits imposed by the environment (WCED, 1987). SD as originally conceived in this definition is still is a convincing concept.

Primarily, the rationale behind this study lies in a consideration of the concept of SD (and related concepts) and its adoption as a basic philosophy. Mainstream neoclassical environmental (EN) economics is considered as the basic scientific (theoretical) approach for dealing with environmental issues in economics. Other crucial approaches in economics, including alternative approaches, are also considered. These are understood to be the theoretical foundations for practical applications or for more practical concepts. Fourteen economic systems were studied by Beeks (2016). They include environmental (EN), circular (CR), green, resilience (RE), ecological (EC), complexity (CY), feminist (FE), compassionate (CT), caring (CG), degrowth (DH), steady-state (SE), no-growth (NH), ecosocialism (EM), and anarcho-ecosocialism systems (AEM). The formation of these systems by the author is related to the misunderstanding that a sustainable society can be based on an economy with economic growth which also has significant effects on ecosystem services. Nevertheless, the approach in this work is different to some extent. Not all of these concepts can be understood as alternatives to sustainability and SD (especially the first four: EN, CR, GN, and RE), although they can be understood as alternatives to capitalism from several perspectives. Additionally, the EN and EC economics can be understood more as the theoretical foundations to the practical concepts that focus on the relationships and balance between the economic, social, and environmental dimensions of economies. EC economics also provides an alternative to the neoclassical EN economics. Based on this approach, the concepts of sustainability and SD are considered as basic concepts, the concepts of green economy (GE) and green growth (GG) are regarded as more practical concepts, which also operationalize the concepts of sustainability and SD. As regards alternative approaches, the concepts of NH, SE, and DH economies, and a number of even more practical alternatives to the concept of degrowth, reflecting the cultural features of smaller communities, are considered in this work. The remaining concepts in the list (CY, FE, CE, CG, EM, and AEM) can be understood as more comprehensive concepts, which significantly support quality of life and wellbeing. Moreover, some of these concepts are significantly interrelated.

This paper has been divided into the following parts: Introduction (section 1); Analysis of the history concept of sustainable development and related concepts (section 2); Conclusions (section 3).

#### 2. Analysis of the history concept of sustainable development and related concepts

The important works dealing with the history of the SD concept include Spangenberg (2008), Grober and Cunningham (2012) or Du Pisani (2006). To understand the concept of SD, it is necessary to study the historic aspects of progress, growth, and development (more in Drastichová, 2018), as well as the milestones of the development of the SD concept, the more general concept of sustainability, and both their scientific basis as well as their integration into policies and strategies. Subsequently, it is necessary to study the more practical counterparts of these concepts as well as the alternative concepts which have developed not only as a criticism of the concept of SD and sustainability, but also of the whole prevailing socio-economic models and systems, especially that of capitalist. For a deeper understanding of the content of the concept of SD, the differences between SD and sustainability need to be analysed in more detail, specifying their supplementary concepts, including the human development approach (UNDP, 2022). The related theoretical and practical concepts and alternative concepts, particularly that of degrowth, need to be analysed as well (see more in Beeks, 2016).

In this section several crucial milestones, including their evaluation, are presented. The terms sustainability and sustainable appeared for the first time in the Oxford English Dictionary in the second half of the 20th century, but the equivalent terms in French (durabilité and durable), German (Nachhaltigkeit, literally meaning lastingness, and nachhaltig) and Dutch (duurzaamheid and duurzaam) have been used for centuries (Van Zon, 2002). The concepts of sustainability and SD have had a very long history in science as well as in policies. However, neither of them has been limited by one specific discipline (Spangenberg, 2008). Economic scarcities, social tensions and overexploitation of ecosystem services, i.e. sources and sinks, have accompanied human civilisations since the Stone Age. Scarcity of resource supply first became obvious in the most developed countries during the late 17th century, when pre-modern industrial production caused a shortage and a continuous price increase of wood. As early as 1713 Hans Carl von Carlowitz (head of the Royal Mining Office in the Kingdom of Saxony) referred to sustainable vield in the context of sustainable forestry management. He formulated ideas for the sustainable use of forest, and he is considered one of the founders of the concept of sustainability (von Carlowitz, 1713; Grober, 2007). Although the origin of the concept of sustainability can be traced back to even earlier times, there had never been more rapid growth in production, consumption and wealth in the world's history than after the Industrial Revolution. Particularly, the population and consumption growth after the Industrial Revolution, and the threat of the crucial resources depletion, such as wood, coal and oil, encouraged the awareness that the sustainable resource use is inevitable (Du Pisani, 2006). Van Zon (2002) indicated that the demand for raw materials and its impact on the environment have been a constant issue throughout human history (see more in Drastichová, 2018).

#### 2.1 The earlier development of the SD concept

Starting with a historical overview, it should be emphasised that it was the process of domination of the Northern developed countries, carried out through colonisation in pursuit of ecosystem services (resources, including land) and markets, and subsequently continuing with the globalisation of trade, technological knowledge, the money market and communications (The Ecologist, 1993), which eventually resulted in global impacts on natural and human systems. Vitousek (1994) argued that any clear difference between original ecosystems and human-altered areas that may have existed in the past had vanished. Currently, the Earth has crossed the boundary regarding environmental problems and their associated social impacts. Moreover, the sharing of the impacts is not equitable; the poor disproportionately bear the consequences of environmental degradation (e.g. Agyeman et al. 2003; Martinez-Alier, 2003). These environmental and social impacts and the effort to tackle them led to the forming of the concept of SD on the international agenda in the 1970s (Carley and Christie, 1992).

During the period of industrial and commercial expansion after World War II, there was also the rising public awareness of the rapid population growth, resource depletion and pollution, threatening the survival of humans. Environmental concern became more radical because of the fear that economic growth might endanger the survival of the humankind and the planet. During the 1960s, it had been optimistically assumed that the development problems of the less developed part of the world would be solved quickly as a result of world-wide economic growth. Since the late 1960s, there has been a large amount of scientific literature on the issues related to sustainability and SD, including alarming scientific information about the damage caused to the natural environment by human activities has been published in a number of books and articles. The crucial representative books in relation to the evolution of the SD concept included those of Carson (1962), Ehrlich (1968), (Meadows et al., 1972), Goldsmith (1972), Schumacher (1973) and crucial research articles included those Hardin (1968), or Molina and Rowland (1974) (among others).

The fight against the power of globalisation and market capitalism was initiated with Rachel Carson's work revealing practices in chemicals industry while shattering the assumption that the environment had an infinite capacity to absorb pollutants (Carson, 1962). Ehrlich (1968) predicted a demographic disaster in response to eventual food shortages and disease since the rate of population growth was surpassing agricultural growth and the capacity for renewal of Earth's resources. A crucial publication related to the development of the SD concept, commissioned by the Club of Rome, was prepared by a group of renowned economists and scientists and entitled The Limits to Growth (Meadows et al., 1972). Five basic factors were identified and investigated in the original model as factors determining and limiting growth. It was assumed that exponential growth accurately described their patterns of increase. These variables included: world population, agricultural/food production, natural resources (resource depletion), industrial production (industrialization), and pollution. The key message of the book is that unchecked consumption and economic growth on the finite planet leads the Earth towards *overshoot* of its carrying capacity, followed by disaster. The most crucial conclusions were that if the growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the following one hundred years. It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The Club also hoped to shock people, to provide warnings of potential world crisis if current trends are allowed to continue, and thus provide an opportunity to make changes in political, economic and social systems (Meadows et al., 1972). One of the motives behind the Club's project was the belief that scientists and politicians had become willing to believe that the solution can be found when things go too far. The Club also hoped to shock people, to provide warnings of potential world crisis if current trends are allowed to continue, and thus provide an opportunity to make changes in political, economic and social systems (Meadows et al., 1972). The purpose of publishing the book was to open the debate on accelerating global trends to a wider community. The intention of the research was not to make specific predictions, but to explore how exponential growth interacts with almost finite resources. This report forms the basis for the concept of sustainable production and consumption (SCP) (and also for both of these concepts if analysed separately) and for the concept of degrowth.

The publication of Goldsmith (1972) named A Blueprint for Survival was influenced by The Limits to Growth (Meadows et al., 1972) and emphasised the need to conserve and preserve environmental resources. It indicated that if current trends are allowed to persist, the breakdown of society and the irreversible disruption of the life-support systems on the planet, possibly by the end of the century, are inevitable. It required a stable society that could be sustained indefinitely while providing optimum satisfaction to its members Schumacher (1973) examined the modern economic system, its use of resources and how it affects people's lives and whether the system reflects what society cares about. He also dealt with the theme of non-growth, criticised the waste and overexploitation of resources and the over-reliance on capital and energy intensive technology. He argues that it is necessary to give up the belief that technology can solve all of people's problems. Hardin (1968) presented that a finite world can support only a finite population. An important conclusion also was that that free access and unrestricted demand for a finite resource ultimately reduces the resource through over-exploitation. Molina and Rowland (1974) showed that chlorofluorocarbons (CFCs) could destroy ozone. The depletion of the ozone layer subsequently be-

came one of the global environmental problems also indicating a deepening of unsustainable trends and unsustainable development. Among the authors mentioned above there were biologists (R. Carson, P. Ehrlich, G. Hardin), chemists (M. Molina, F. S. Rowland), economists (E. R. D. Goldsmith (also environmentalist and philosopher), E. F. Schumacher), Accordingly, the multidimensionality and multidisciplinarity of this research area could have been predicted.

By the 1970s, the existing notions of progress, growth and development were being challenged and in the 1970s, this optimism weakened. Economic growth did not prove to be the desired solution to global problems and inequalities. This realization required a paradigm shift to a notion of development. Formerly, development and conservation had been regarded as conflicting ideas, i.e. conservation as the protection of resources, and development as the exploitation of resources (Paxton, 1993). Then the concept of SD appeared as a compromise between the concepts of development and conservation, which became understood as interdependent issues. The term sustainability used in ecology to refer to a state or condition that can be maintained over an indefinite period, was introduced on a more regular basis into development discourses (Du Pisani, 2006). The first oil crisis (1973) had demonstrated the potential consequences of resource shortages. As a result of that the expectations of unlimited economic growth weakened when a worldwide recession occurred in the mid-seventies (1974-1976). Following the considerations about the causes of the recession, an awareness of the limits to economic growth arose (also following the publication of Meadows et al. (1972) mentioned above).

It can be summarized that during the 1960s and 1970s a global understanding of sustainability challenges developed with the emerging environmental movement that highlighted several environmental problems. The conceptual basis for the current use of the term *sustainable development* were consolidated in the early 1970s. At the beginning of the 1970s, this term was probably conceived by the founder of the International Institute for Environment and Development (IIED), Barbara Ward (Lady Jackson) (Ward and Dubos, 1973). Coomer (1979) pointed out that the sustainable society was one that lived within the self-perpetuating limits of its environment, but that it was not a no-growth society. Rather, it was a society that recognized the limits to growth and sought for alternative ways of growth.

The 1972 United Nations Conference on the Human Environment (UNCHE) was a first taking stock of the global human impact on the environment, an attempt at forging a basic common outlook on how to address the challenge of preserving and enhancing the human environment (Handl, 2012) and the conflicts between environment and development were first acknowledged (Kates et al., 2005). Since the 1980's, sustainability has emerged as a principle in opposition to unlimited growth (Gowdy, 1994). In the 1980s, environmental degradation and unsustainable use of natural resources was widely recognized internationally among political leaders. This resulted in new international policies and action plans regarding the sustainable use of forests, water, and seas, and the addition of development to the sustainability concept. As a consequence, the focus shifted from the state of ecosystems to the steering of society (Baker, 2006). In the 1980s, the new paradigm of SD became popular and more widely used. Allen (1980) defined SD as a development that is likely to achieve lasting satisfaction of human needs and improvement of the quality of human life. The term was also used in the International Union for the Conservation of Nature's (IUCN) World Conservation Strategy (IUCN, 1980), which argued that for development to be sustainable, it should support conservation rather than hinder it. Among the prerequisites for SD is the conservation of living resources, which are essential for human survival and SD, while they are increasingly being destroyed or depleted. The aim of this strategy was to help advance the achievement of SD through the conservation of living resources. This strategy among others explains the contribution of living resource conservation to human survival and to SD. It presents that conservation improves the prospects of SD and proposes ways of integrating conservation into the development process.

#### 2.2 The development of the SD concept (crucial milestones) in 1980s and 1990s

It can be seen that at the beginning of 1980s great importance in relation to SD was placed on ecosystem services and the conservation of living species, especially in the conception of the IUCN (IUCN, 1980). Its World Conservation Strategy of 1980 is the first international document on living resource conservation produced with inputs from governments, non-governmental organizations, and other experts. Some critique must be mentioned in relation to this report and its definition. Its declaration of domination over nature, and, by implication, humankind, was unpopular, as was the stance on *scarcity* as opposed to *redistribution* (Redclift, 1992; Achterhuis, 1993). The strategy was still environment-dominated with prevalent Malthusian connotation, and it failed to examine the so-cial and political changes which would be necessary to meet its conservation goals (Redclift, 1994).

Although these aspects have gained importance and are now even more crucial, the definition of SD and the SD concept in general have shifted into a more universal meaning. The General Assembly of the United Nations (UN), in its resolution 38/161 of 19 December 1983 welcomed the establishment of the World Commission on Environment and Development (WCED). When the WCED sought to define SD, it drew from Barbara Ward's landmark book (Ward and Dubos, 1973). The WCED submitted a report entitled *Our Common Future*, informally known as the Brundtland Report, to the UN in 1987 (WCED, 1987). In Chapter 2 of the WCED report, SD is defined as follows: *Sustainable development is development that meets the needs of the present without compromising the* 

*ability of future generations to meet their own needs.* This report represents a blueprint for the worldwide attention being paid to the concept of SD. Sustainability was agreed on as an aim for the use of natural capital, and SD as the principle for further development (WCED 1987; United Nations, 1992).

Another milestone in 1980's was an adoption of crucial international agreements to combat the depletion of the ozone layer. The IUCN subsequently defined it again in its following report (IUCN et al., 1991) as the capacity to maintain a certain process or state for improving the quality of human life, while living within the carrying capacity of supporting ecosystems. In this report important aspects related to are analysed. Caring for the Earth uses the word *sustainable* in several combinations, including *sustainable development, sustainable economy, sustainable society*, and *sustainable use*.

The more general WCED report (WCED, 1987) had crucial importance for the development of SD strategies and policies at the UN, or more generally at the international level, and subsequently national and lower levels, and up to the individual level. After taking the 1987 WCED report into consideration, the General Assembly of the UN called for the UN Conference on Environment and Development (UNCED) (also known as the Earth Summit, which took place in Rio de Janeiro, 3-14 June 1992). The primary goals of this summit were to come to an understanding of development that would support socio-economic development and prevent the continued deterioration of the environment, and to lay a foundation for a global partnership between developing- and more industrialized countries (United Nations, 1997). The central focus was how to relieve the global environmental system through the introduction of the SD paradigm. One of the major results of the UNCED was Agenda 21, a comprehensive plan of action calling for new strategies to invest in the future to achieve overall SD in the 21<sup>st</sup> century. The UN Framework Convention on Climate Change (UNFCCC) and the UN Convention on Biological Diversity (UNCBD) represent other crucial milestones related to the SD policies. However, in 1998, it was noted by the former Secretary-General of the Rio Summit (Maurice Strong) that despite recognition of and commitment to the principles of SD, action has not moved beyond the margins and has not led to the core changes needed to support a transition to SD (Drexhage and Murphy, 2010).

#### 2.3 The development of the SD concept (crucial milestones) in 2000s

In the 2000's there were several core milestones related to SD, which should be mentioned. The Millennium Declaration, the document unanimously adopted by the United Nations General Assembly (at the UN Millennium Summit in September 2000), contained a statement of the values, principles and objectives of the international agenda for the 21st century. The world leaders, who gathered at the Summit, committed their nations to a new global partnership to reduce extreme poverty in its many dimensions, and set out a series of time-bound targets, with a deadline of 2015 that have become known, since the Millennium Summit, as the Millennium Development Goals (MDGs). In the field of environmental protection, the Millennium Declaration stated that no efforts must be spared to set back the threat to the planet being irreversibly affected by human activities. Therefore, it was decided to adopt a new ethic of conservation and stewardship (United Nations, 2022).

The most recent summits convened by the UN must be mentioned due to their great importance in relation to SD. The World Summit on Sustainable Development (WSSD, held in Johannesburg, South Africa, 26 August – 4 September 2002) and brought together tens of thousands of participants and the impulse for this Summit was also a sense of disappointment over the failure of governments to implement the resolutions of the 1992 UNCED and take appropriate action to deal with environmental problems. Five themes of particular attention at the Summit were identified by the Secretary-General Kofi Annan. They included water, energy, health, agriculture and biodiversity. These issues, together with population and poverty, and the relationships among them, were assessed in the Report published before the Summit (United Nations, 2002a). The outcome documents more explicitly acknowledged the links between poverty alleviation and environmental protection than the outcome documents of the 1992 UNCED (Azmanova and Pallemaerts, 2006). This Summit was referred to as a significant failure. Governments awarded transnational corporations a central role in the implementation of SD. The negotiated final documents (Type I Outcomes) (United Nations, 2002b) have been criticized as being too vague and for setting weaker goals than those agreed upon in previous summits. Thus, new voluntary partnership initiatives (Type II Outcomes), by and between governments, NGOs and businesses, were intended to promote the implementation of the government-negotiated final documents. Critics also argued that the Summit has put poverty eradication in the forefront while advancing economic growth as the main strategy for poverty eradication. This would result in the usual recipes for economic growth (such as market liberalisation, direct foreign investment as a major funding mechanism, public-private partnerships, or good national governance to safeguard property rights) being redefined as SD strategies, but with few - if any - counterbalancing environmental and social rules and regulations, or redistributive mechanisms.

The UN Conference on Sustainable Development in 2012 (UNCSD, Rio+20, Rio de Janeiro, Brazil, 20 - 22 June 2012) aimed at securing renewed political commitment for SD (Stoddart et al., 201; United Nations, 2022a). The official discussions of UNCSD focused on two main themes, i.e. how to build a GE to achieve SD and lift people out of poverty; and how to improve international coordination for SD. The identification of the GE as one of the key themes for the Rio+20 represents an opportunity to define a new global economic paradigm (however, the

term greening the economy has been a re-emerging issue of the policy debates since the early 1970s.). Nevertheless, there was also a risk that previously hard-won global agreements on SD might be lost in the pursuit of the new agenda. Innovative guidelines on GE policies were also adopted. Concerning the institutional aspects, governments agreed to strengthen the United Nations Environment Programme (UNEP) in several areas. They also agreed to establish a high-level political forum for SD. It was also decided to establish an intergovernmental process under the General Assembly to prepare options on a strategy for SD financing. Forward-looking decisions were also adopted on a number of thematic areas, including decent jobs, energy, sustainable cities, food security and sustainable agriculture, water, oceans and disaster readiness (The International Institute for Sustainable Development IISD, 2022).

Governments also adopted the ten-year framework of programmes on sustainable consumption and production patterns (contained in document A/CONF.216/5: United Nations, 2012). In the area of the methodology and measurement of SD, governments also requested that the United Nations Statistical Commission initiate a work programme in the area of measures of progress to complement GDP indicators in order to better inform policy decisions. As part of the post 2015 development agenda, member states also decided to start the process of developing a set of Sustainable Development Goals (SDGs), based on the Millennium Development Goals (MDGs). This represents a crucial step towards a more integrated global SD agenda (UN General Assembly, 2012)

The adopted final political outcome document of UNCSD, named The future we want (United Nations, 2012; UN General Assembly, 2012), contained practical measures for implementing SD. It emphasized that poverty eradication, changing unsustainable and promoting sustainable patterns of consumption and production and protecting and managing the natural resource base of economic and social development are the overarching objectives of and essential requirements for SD. The need was reaffirmed to achieve SD by promoting sustained, inclusive and equitable economic growth, creating greater opportunities for all, reducing inequalities, raising basic standards of living, fostering equitable social development and inclusion, and promoting the integrated and sustainable management of natural resources and ecosystems that supports, inter alia, economic, social and human development, while facilitating ecosystem conservation, regeneration and restoration, and resilience in the face of new and emerging challenges (UN General Assembly, 2012). It must also be emphasised that in this outcome document of UNCSD, named The future we want (UN, 2012), economic growth is advocated in more than 20 articles. Article 4 is important for this philosophy, since it states that the need to achieve SD by promoting sustained, inclusive and equitable economic growth..., is reaffirmed. This approach is based on neoclassical environmental economics, supporting the concept of decoupling economic growth from environmental harm through dematerialization and depollution. This leads to improvements in eco-efficiency. In this conceptual framework, market prices can serve as the appropriate means for tackling environmental issues, internalizing externalities. Exogenous technological progress can counterbalance the effects of resource depletion. Similar aspects were already outlined in WCED (1987), presented and put into operation at UNCED (1992). The WSSD went even further, advancing economic growth as the main strategy for poverty eradication. All these milestones reflect the concept of weak sustainability (analysed in subsection 3.2) and other weak versions of several related concepts. This does not seem to provide adequate strategies, with the WSSD, in particular, regarded as a significant failure. One of the crucial results of the UNCED (1992) was the requirement to change consumption and production patterns, which the developed countries should have pioneered. In contrast, at the 2012 UNCSD, the GE was the theme pursued by the OECD, the EU and some other countries. This development could be understood as an attempt to put SD into practice in the form of the GE in order to meet the goals of the 1992 UNCED. On the other hand, it could also be understood as a diversion from what should have been achieved (see also Lorek and Spangenberg, 2014).

More particularly, in relation to the financial crisis of 2008 and the associated economic crisis, there has been a revival of interest in the application of the concepts of the GE and GG (first appearing in 1989) by inter/national authorities, and both concepts have started being widely applied (explained in subsection 3.1).

The most recent and the most comprehensive global political effort towards achieving SD is the post-2015 development agenda – the UN Agenda 2030, including the set of Sustainable Development Goals (SDGs), formulated by the UN in 2015 as a comprehensive global policy framework for addressing the most crucial economic, social and environmental challenges for humanity (UN General Assembly, 2015). The SDGs represent a comprehensive framework to promote synergies and manage trade-offs across sectoral policies in an integrated manner, to engage all actors in the policymaking process (OECD, 2020). The SDGs are *context specific*. To achieve the goals, it is necessary to consider the social, political and environmental circumstances of particular locations (Oliveira et al., 2019; Weitz et al., 2018). The agenda and the SDGs reflect the previous experience with the MDGs (applied during 2000-2015). While the MDGs focused on improving wellbeing in the developing world, the 17 SDGs address all countries and aim at reconciling economic and social with environmental goals (Eisenmenger et al., 2020). Achieving this agenda, including all the SDGs, would require a comprehensive, holistic and transformative approach, combining different means of implementation and integrating the economic, social and environmental dimensions of SD. The UN Agenda 2030 should have been designed in such a way so as not to repeat the insufficiencies of the previous programmes, such as lack of action and practical orientation, not creating a win-win strategy, etc. It is still not obvious to what extent these aims have been or will be met. To summarize the relationships between the SDGs and the MDGs, the first set is built on the second. The SDGs can be broadly divided into three categories. First group is an extension of MDGs and it includes the first seven SDGs. The second group can be referred to as inclusiveness. It includes jobs, infrastructure, industrialization, and distribution. Goals 8, 9, and 10 are involved in this group. The third group covers the last seven goals: sustainable cities and communities, responsible consumption and production, life on land and below water, climate action, peace and justice and the means of implementation, and global partnership for it (Kumar et al., 2016)

The MDGs included specific targets and milestones in eliminating extreme poverty and therefore were narrower in scope and more specific, especially focusing on the social pillar of SD. In the group of the eight goals only MDG 7: ensure environmental sustainability includes the crucial targets in the environmental pillar of SD, including those of other key political strategies at the international level, while the target of halving the proportion of people without sustainable access to safe drinking water and basic sanitation is also included in this goal. It can be concluded that the key environmental pillar is quite compressed in one (the seventh) goal. The same, and to an even greater extent, applies to the economic pillar of SD. In this goal the aspects of the economic pillar of SD are compressed, but the targets are even limited to those which can reduce some burdens and obstacles which are faced by the developing countries, including the least developed countries. The SDGs expanded its scope to 17 goals from the eight (8) goals in the MDGs, which covers universal goals on fighting inequalities, increasing economic growth, providing decent jobs, sustainable cities and human settlements, industrialization, tackling ecosystems, oceans, climate change, sustainable consumption and production as well as building peace and strengthening justice and institutions. Unlike the MDGs, which only targets the developing countries, the SDGs apply to all countries, both the developed and developing ones. The SDGs are also nationally-owned and country-led, wherein each country is given the freedom to establish a national framework in achieving the SDGs (see e.g. PSA (2022)). Both the MDGs and the SDGs are summarized in Table 1.

MDGs	SDGs	GOAL 9: Industry, Innovation and Infra-
		structure
GOAL 1: Eradicate extreme poverty and	GOAL 1: No Poverty	GOAL 10: Reduced Inequality
hunger		
GOAL 2: Achieve universal primary ed-	GOAL 2: Zero Hunger	GOAL 11: Sustainable Cities and Commu-
ucation		nities
GOAL 3: Promote gender equality and	GOAL 3: Good Health and	GOAL 12: Responsible Consumption and
empower women	Well-being	Production
GOAL 4: Reduce child mortality	GOAL 4: Quality Education	GOAL 13: Climate Action
GOAL 5: Improve maternal health	GOAL 5: Gender Equality	GOAL 14: Life Below Water
GOAL 6: Combating HIV/AIDs, ma-	GOAL 6: Clean Water and	GOAL 15: Life on Land
laria, and other diseases	Sanitation	
GOAL 7: Ensure environmental sustain-	GOAL 7: Affordable and	GOAL 16: Peace and Justice Strong Institu-
ability	Clean Energy	tions
GOAL 8: Develop a global partnership	GOAL 8: Decent Work and	GOAL 17: Partnerships to achieve the Goal
for development	Economic Growth	

Table 1 Comparison of the MDGs and the SDGs set, source: Kumar et al. (2016)

Important aspects which need to be emphasized in relation to the Agenda 2030 include the need for significant changes in consumption and production. They are reflected in, both in the form of a commitment to make *funda-mental changes in the way that our societies produce and consume goods and services*, and through one of its 17 SDGs dedicated to ensuring SCP (SDG 12) (Akenji and Bengtsson, 2014). Elements of SCP, including improvements in energy-efficiency, are also included in the other SDGs (Bengtsson et al., 2018). Health aspects included in both sets must be emphasized since health represents a fundamental factor and component of wellbeing. SDG 3 is wider-ranging compared to the health goals in MDGs that were limited to child and maternal mortality and communicable diseases. However, the social determinants of health are also addressed through the majority of the remaining Goals 1-13 and 16.

To sum up, a number of differences between the MDGs and the SDGs can be identified. MDGs focused on developing countries with funding from developed countries. All countries are concerned in the SDGs. While the MDGs include 8 goals, 21 targets and 63 indicators, the SDGs include 17 goals and 169 targets. MDGs were created by a group of experts in the *basement of UN headquarters* while the SDGs have evolved after a long and extensive consultative process, including the participation of general public (see more in Kumar et al. (2016). The pillars of human development, human rights and equity are deeply rooted in SDGs and several targets seven explicitly refer to people with disabilities, six to people in vulnerable situations, and two to non-discrimination. These were not mentioned in the MDGs. While the MDGs had 3 direct health goals, 4 targets and 15 indicators with emphasis on child, maternal mortality and communicable diseases. SDGs have one comprehensive goal emphasizing wellbeing and healthy living (a crucial goal emphasized above). The MDGs had a time period of 25 years though adopted in 2002 baseline data for the year 1990 was used and some of the baselines were revised subsequently which shifted 'the goal post'. For the SDGs, the baseline is from 2015 estimates. It may be revised as more recent data becomes available. The SDGs include a vision of building systematic partnerships with private sector to achieve SD. MDGs had no concrete role for the Civil Society Organizations (CSOs), whereas SDGs have paid attention to this right from the framing stage itself with significant engagement of civil society actors (Kumar et al., 2016)

In relation to the crucial recent unsustainable trend and global problem which is climate change, the Paris Agreement was accepted within the United Nations Framework Convention on Climate Change (UNFCCC) at its 21<sup>st</sup> Conference of the Parties (COP 21) in 2015. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius compared to pre-industrial levels. The most recent milestone in this area is the COP 26 (31 Oct – 13 Nov 2021). The importance of international cooperation in addressing climate change and its impact in the context of SD and efforts to eradicate poverty was emphasised. The destructive impact of the coronavirus 2019 pandemic was also recognized. The importance of ensuring a sustainable, resilient and inclusive global recovery was emphasised. This is as crucial an aspect for the social dimension as for the whole of SD. The final decisions have just been formulated and it will be seen after some time how successful this Climate Change Conference was. Next, the conclusions resulting from the analysis of history and crucial scientific works dealing with SD are summarized.

#### 3. Conclusions

The crucial milestones in the development of the SD concept, including the crucial publications, *The Limits to Growth* (Meadows et al., 1972) and *Our Common Future* (WCED, 1987), which determined the foundation of this concept, were introduced. The crucial conferences and strategies were also identified, and the current global Agenda for SD introduced. A growing number of publications on sustainability/SD has led to the perception of sustainability science as a distinct field of science. Within sustainability science as well as in the practical application of sustainability/SD strategies, the challenges for the future include addressing crucial sustainability problems and advancing research, methodological aspects and the institutional background for putting the sustainability/SD concepts into operation, and on the basis of this thoughtfully responding to public sustainability concerns As regards the most recent milestones in the field of SD, at the UN Millennium Summit in September 2000, a

commitment to a new global partnership to reduce extreme poverty in its many dimensions was adopted, and a series of time-bound targets, Millennium Development Goals (MDGs), were set out. In the field of environmental protection, the Millennium Declaration stated that no efforts must be spared to avert the threat of the planet being irreversibly affected by human activities. The following and the current glob-al Agenda for SD is the UN Agenda 2030, including the set of Sustainable Development Goals (SDGs) formulated by the UN in 2015. It would be desirable that the UN Agenda 2030 not repeat the insufficiencies of previous programmes, such as lack of action and practical orientation or failure to create win-win strategies. However, this cannot be evaluated until a longer period after its implementation.

The relationships between the MDGs and SDGs, as the crucial most recent global agendas for achieving SD, can be summarized as follows. The first set is built on the second. The SDGs can be divided into three categories. The first group is an extension of MDGs and it includes the first seven SDGs. The second group, including jobs, infrastructure, industrialization, and distribution, can be referred to as inclusiveness. The third group involves the last seven goals focusing on sustainable cities and communities, responsible consumption and production, life on land and below water, climate action, peace and justice and the means of implementation, and global partnership to achieve it. All these topics are crucial for achieving global SD in general, while particular countries (and lower units within them) can flexibly prepare strategies on the basis of their situations and developments in particular areas and the relationships between them.

For a deeper understanding of the content of the SD concept, the differences between concepts of SD and sustainability need to be analysed in more detail. The related basic and more practical concepts, and alternative scientific concepts need to be analysed and correctly understood. This will be discussed in the second part of this paper.

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## The Real Tragedy of the Commons – Garrett Hardin (1968) Revised

## Tragedia wspólnego pastwiska – Garret Hardin (1968) zaktualizowany

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#### Abstract

Garrett Hardin's seminal 1968 paper describes the tragedy of the commons in terms of common goods being neglected or overused. His theory has been widely adopted. However, it refers only to a special case, when inadequate public goods have to compete with the maximisation of private yield. The real tragedy of the commons is not that it is overused or neglected, nor is it any free-rider and spillover effects it gives rise to, but rather the underlying financial incentives and disincentives that prevent an adequate supply. Consequently, the misalignment between our current monetary system and the global commons has led to the latter's erosion and partial destruction. Introducing a new monetary and fiscal policy of strategic triangulation can provide an adequate tool to finance our commons. With their ongoing central bank digital currency (CBDC) initiatives, regulators and central banks can offer a direct monetary mechanism to overcome this tragedy of the commons.

Key words: financing the commons, new financial engineering, fiscal and monetary policy, CBDC, strategic triangulation

**Słowa kluczowe:** finansowanie wspólnego pastwiska, nowa inżynieria finansowa, polityka fiskalna i monetarna, CBDC, triangulacja strategiczna

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#### Introduction

In 1968, Garrett Hardin published a seminal paper on the tragedy of the commons, which is one of the most cited scholarly articles of the twentieth century. Hardin defined common goods as ones that 1 cannot be sufficiently excluded from private use, and argued that these goods will eventually be either neglected or overused. This triggered several decades of debate, culminating in the Nobel Prize in Economics being awarded to Elinor Ostrom (1990). Today, the 2 discussion is far from over. The current UN SDGs (UN, 2015) and recurrent 3 external shocks (like pandemics) are raising the issue again, since most, if not all, of these challenges affect our commons in one way or another. Two fundamental questions arise. What makes a common good a common good? And if a right, a good or a service causes free-rider effects, what kind of economy or financial mechanism would we need to ensure a maximum of wealth, both for the private and public sectors and for society as a whole (Coase, 1960; Buchanan & Musgrave, 2001)?

#### Empty and full worlds - the Anthropocene era

Historically, we used to live in a large, slow, empty world with a low population and low levels of energy and resource consumption (Rockström & Klum, 2016). Now we are living in a fast, full, complex world with a high population density and high levels of energy and resource consumption. The relation between private and common goods in these two worlds is different. In the former, *empty* world, private equity and wealth played a subordinate role and the commons dominated. In the *full* world, private goods dominate and the commons comes second (Club of Rome, 2019). And we have to admit that without the options opened up by private capital accumulation, the world would have been poorer in all respects. However, in a full world where everything is interdependent and interconnected and where we risk overshooting planetary boundaries, private wealth depends on healthy, functional commons. A full and interconnected world, where there are no social or ecological externalities, without functioning commons would be a poorer world in all respects, too. So rather than further privatising the world (Credit Suisse wealth report, 2021) by exploiting common goods, shouldn't we instead come up with a sensible interplay between the private and the public sector? In order to better understand this intersection, the monetary and financial sector is key. The relation between privates and commons is like an asymmetric iceberg paradox. Although the commons only makes up 10% of all aggregated assets, it represents the basis of all private wealth accumulation. Can we patent the sun, fresh water, access to preschooling or collective healthcare? Yes, we can, but we shouldn't!



Figure 1. Privates and commons - an asymmetric iceberg effect

#### A revised definition of our commons

Traditionally, we define our commons as goods which are not excludable, which are easily overused or neglected and which cause free-rider effects. But this is incomplete and partly misleading. A common good is not a thing, but a convention, like a marriage contract, the rules of a club or a legal code governing our use of or access to a good or service. We as a society determine whether a good or a service becomes common or private, depending on the nature of the good or service in question, with this determination being regulated by our peers. This is equally true for fresh air, species conservation or access to healthcare, preschooling or personal information on digital platforms.

We define a (social or natural) common in terms of sustainable, universal use of or access to a good, service or right, regulated by the peers involved. This could be local, regional, national or global in scale, depending on the nature of the common.

Commons differ from private assets, which have an unlimited capacity to grow (Schneider, 2007). For example, once the protection of biodiversity has been achieved, global warming has been stemmed or access to healthcare for everybody has been organised, these commons are complete. Once achieved, commons meet a ceiling, where maintaining the status quo is key. The very nature of commons requires mechanisms to repair, recycle, maintain, refurbish, replace and reuse them over and over again, once everybody has access to them. Meanwhile, private goods by their very nature can be stored, replaced and collected in an unlimited fashion. In other words: we could collect dozens of SUVs, pools, paintings and jewels privately, but once we have provided access to nurseries or collective healthcare, higher education, security and shelter, the job is done. In this sense, common goods are circular and regenerative by their very nature; they are a means to an end and do not force communities to grow in order to maintain their status. In contrast, private goods are a continuous, accumulative process of linear, exponential and unlimited growth, yields and insatiable desires. Commons are not. In short, fresh and clean air will always remain fresh and clean air; attending a nursery will always be simply attending a nursery. Once we all have fresh and clean air and all children have access to preschooling, these commons have been attained. The same is true for entitlement to a universal basic income, access to clean water and energy, and all basic human rights. The table 1 contrasts some features of private and common goods.

Empirically, commons have an extremely impressive return on investment. The commons included in the UN SDGs have an arithmetical average return of 1:15 per annum, which is up to 100 times greater than the figure for S&P stocks (10% annual return) or returns on treasury bills (3–5% annual return) (Copenhagen Consensus, 2019b; Damodaran, 2019). This means that investing 100 billion USD in commons generates 1.5 trillion USD equivalent

of social and ecological goods, a benefit at least 10 to 15 times greater than the initial invested dollars – for all of us. This is when we start waking a sleeping giant (Copenhagen Consensus, 2019a, 2019b).

Table 1.1 Catures of ph	vate and common goods
Private goods	Common goods
Private property claim with limited private liability	Public property claim with collective liability
Free-rider effect causing negative externalities, paid for by	Free-rider effect causing additional costs for the public sec-
someone else	tor
Ongoing and unlimited yield maximisation	More circular and regenerative, need to be maintained
Tradable	Not (necessarily) tradable
Excludable or club goods restricted to a defined membership	Non-excludable, non-rival
Positional, luxury goods compared in terms of their relative	Collective entitlement for all of us, means to an end
value by someone else	
Unlimited growth (rate), unsaturable	Ceiling effect: once the commons are achieved, mission is
	accomplished

Table 1.	Features	of	private	and	common	goods
ruore r.	i cutures	<b>U</b> 1	private	unu	common	50000

#### The traditional way to do it: end-of-pipe financing

Three options have traditionally dominated the economic discussion on how to best manage our commons. The first is privatising all commons, and thus removing any public liabilities associated with them by turning them into private goods. The second is managing common goods by restricting access to them to defined communities. They are thus turned into club or cooperative goods. This form of limited membership resolves one of the biases that commons are subject to, namely overuse. The third option is allowing public or state authorities to regulate the usage of commons through laws and entitlements, with the commons being financed by taxes, fees, charity or philanthropy. Below, we describe a fourth option, which uses new and different monetary channels to finance common goods.

The most commonly advocated way of financing our commons is what is known as co-financing, which constitutes the core argument in most, if not all, economic theories on financing social and ecological commons. Co-financing is based on the principle that goods and services freely traded on the market are taxed and this revenue becomes the main source of finance for common goods. On this widely accepted view, commons are secondary and subordinate to the activities of the free market. Only when the market generates sufficient yields and liquidity and the political will is strong enough can common goods be financed. For example: if a pig farmer wanted to set up a business with 1,000 pigs in a rural area, providing jobs for 30 workers and supplying pork to the region, the local authorities and the media would see this as an innovative investment that deserves to benefit from tax breaks and other state support. But if a non-profit organisation wanted to establish a care home for 100 children suffering from parental neglect and educational deficits, which would employ 80 people and benefit dozens of other small and medium-sized firms and hundreds of additional families, and would require exactly the same amount of investment as the pig farm, the project would instead be considered a cost to and burden on society. This is surprising, given that we know that investing in early childhood has a return on investment (ROI) of 1:10 to 1:15 for society as a whole. The pig farm business model will never achieve this ROI and has several negative externalities besides, such as increased water consumption and a negative impact on human health.

This co-financing strategy is a form of end-of-pipe technology, well known in engineering science: we first implement a technology, lifestyle or economic activity that is damaging our environment (polluting fresh air, for example), then add a filter at the end of the process in order to avoid too much damage. The co-financing strategy follows the same logic. The economy grows, we take a certain amount of money (through tax or fees) from the added value chain and finally we distribute it to social and ecological projects.

The real tragedy of the commons is not that it is overused or neglected, nor is it any free-rider and spillover effects it gives rise to, but rather the underlying financial incentives and disincentives that prevent an adequate supply.

Could it be that we are using the wrong mechanism for real problems? Could it be that the mechanisms for distributing money only work well in stable environments with a high growth rate, strong governance, low externalities and minimal interconnectedness? But we are now living in a new era, where zero interest rates, high public debts and private hyper-liquidity are the norm, where the wealth gap is rising, a new power – Chinese state-funded capitalism – is destroying free market competition and a series of ecological shocks (pandemics, global warming and species loss) are challenging societies. Taken together, these factors are fundamentally changing the landscape of how to finance, fund, hedge and secure our (global) commons (Dario, 2021).

#### The indispensable triad - free market, enabling state and regulators

Traditionally, we think of the free market and state interventions as opposites, where the smallest common denominator would provide the best possible solutions. But we end up with over-regulated markets and over-indebted public agencies, finally leading to a pareto-inferior equilibrium for all of us. As an alternative to approaches focusing on causal relations, nudging, voluntary commitments, linear processing, simple stimulus responses, pushbacks or silo solutions, a *strategic triangulation* can offer an additional tool to avoid the smallest common denominator and suboptimal results. It involves introducing a third party that can overcome the polarity and instead unlock the full potential for both parties. Strategic triangulation can lead to a more systematic approach to problem-solving and allow us to overcome silo thinking.

Let's consider a specific example. A society decides to spend 40% of its GDP on public goods (hospitals, nurseries, universities, motorways, digital infrastructure, basic needs). If the society has sovereignty over its money creation process (i.e. if it can print money), does not have to rely on external debts nominated in a foreign currency and has the necessary human and natural resources, then it can eventually generate the amount of money needed by itself. Consequently, the subsidies and taxation schemes for the private sector initially brought in to finance these commons will be phased out over time. We would then end up with a free and competitive market system, which makes it possible to allocate goods and services optimally while *at the same time* having a high-functioning public sector, where the state authorities enable our commons.

We can take this argument one step further. The private purse is not the public purse (Randall, 2015; Kelton, 2020): private households and corporates have to budget carefully so they don't go bankrupt. Private households and corporates cannot spend more than they earn in the first place. The public purse, however, is different. In a situation where there is a sovereign nation state with the ability to issue money, the financing of its public budget follows a fundamentally different logic to the private sector. We simultaneously require a stronger enabling state and a stronger competitive fair market system in order to benefit from both institutions. But both require a third party to be involved to overcome the constraints of any end-of-pipe financing. Central banks and regulators, operating in a proactive, preventive and restorative manner, can serve this role. This means that monetary policy will trump fiscal policy when it comes to financing our commons. The figure below illustrates this indispensable triad:





#### **Creative Polarities:**

Traditionally Central Banks remain rather passive, neutral, restorative and indirect. Free market and state interventions search for a smallest common denominator. Linear, Silo and causal Thinking is prevailing. The welfare remains pareto-interior.

#### **Overcoming Polarities:**

Central Banks in the Anthropocene Era are becoming proactive, preventive and try to facilitate stable and free markets and strong states at the same time. System thinking in complex world is prevailing. The welfare becomes pareto-superior.

Figure 2. The indispensable triad – overcoming polarities

The misalignment between our global commons and the current monetary system that underlies it has prevented their full economic potential from being achieved for the benefit of us all, and has led to the commons being eroded. Our challenge is not to privatise the commons, but rather to adapt our financial system to the nature of the commons (Gaffney et al., 2018). In short, we need more and better finance. And in fact, this is happening already in a fledgling, experimental form. Monetary regulators and central banks are currently testing what are known as central bank digital currencies (CBDCs) (Gross & Schiller, 2020; Chaum et al., 2021) in order to provide additional, targeted liquidity, thereby enhancing their steering capacity, bolstering price stability and generating thousands of new green jobs and public revenues as well as operating in an anti-cyclical manner. If done in the right way, we would have the monetary mechanism in place to finance the UN SDGs and the associated commons. Eventually, we would have the tools available for new, almost unlimited forms of financial engineering to fund and hedge the associated risks. In short, we can wake this sleeping giant (Brunnhuber, 2021; Brunnhuber et al., 2021).

#### Conclusion - the curse of the moral hazard

At first glance it looks like any common will cause neglect or overuse, something that has been characterised as the moral-hazard or free-rider effect of goods and services which are accessible by everybody. But this view, to which Hardin (1968) subscribes, is misleading. It only applies for a special singular case, where private positional

goods or services are competing with commons. In this case, commons are either neglected or overused. For example, the overuse of common land by privately operating farmers. In this special case, a common good (specifically, common land) is neglected due to a lack of regulation. However, the nature of most commons is different. In other words, the moral-hazard or free-rider effect only occurs in the world of the commons if there is an inadequate supply. Unlike privates or positional goods and services, commons have what is known as a ceiling effect. Once everybody is provided with a common, the market for it is saturated. For example: if there is a need for 1,000 places for 1,000 children to attend a nursery, we have to provide and finance 1,000 places for those children. The same is true for fresh air, basic needs, public parks, access to healthcare and so on. We know how to treat malaria, how to educate preschool children, how to set up a sewage system to prevent water-borne infectious diseases, how to build hospitals and schools and how to train teachers and doctors. Awakening this sleeping giant requires not so much technical skills as it does sufficient liquidity and purchasing power. On this understanding, public goods do not represent a market failure, but rather preconditions for functional competitive markets. They are like a visible hand to complement the invisible one. This view changes our perspective entirely. And it would require a shift from austerity to an augmented and adjusted monetary policy.

In fact, the tragedy of the commons as described by Hardin (1968) is a special case, which applies only when the maximisation of private yield meets collective property. This special case has generally been referred to as the tragedy of the commons. However, in almost all cases the commons, where there is adequate financing and provision, follows a different logic. The misalignment between our current monetary system and the global commons has prevented either's full economic potential from being achieved for the good of humankind. Our task is to adapt the economy to conform to the nature of the commons, in the interest of sustainability. And this is why we need to revise Hardin's theory of the tragedy of the commons.

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## Towards Co-existence. Responsibility in the Anthropocene Debate

## W stronę koegzystencji. Odpowiedzialność w dyskusji o Antropocenie

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#### Abstract

P. Crutzen and E. Stoermer's concept that humanity has entered a new geological epoch – the Anthropocene, in which the human species has become the leading geological force, is the subject of multidisciplinary scientific research. The debate on the Age of Man reconnects the sphere of facts and the normative sphere, while still continuing the eco-developmental concept oriented towards the search for new socio-economic solutions. One of the assumptions of the naturalistic narrative of the Anthropocene is the conviction that human action has the greatest impact on the environment and we are responsible for its condition. Often compared in literature to other great revolutions in science – Copernicus' and Darwin's theory – the paradigm shift in thinking in the Anthropocene forces us to rethink the key concepts of classical philosophy: human, nature, responsibility. The article presents an outline of the ethical debate on responsibility in the Anthropocene, considering its collective and individual aspects, and introduces a new concept of co-existence, which integrates ecosystems with the technosphere.

Key words: Antrophocene, human, nature, responsibility, ethics, technosphere Slowa kluczowe: Antropocen, ludzie, przyroda, odpowiedzialność, etyka, technosfera

#### The Anthropocene

In the year 2000 the Nobel Prize winner – an atmospheric chemist – P. Crutzen and a biologist – E. Stoermer put forward a revolutionary theory that humanity has entered a new geological epoch – the Anthropocene. E. Stoermer introduced the term – the Anthropocene into literature as early as the 1990's but it was not until his collaboration with P. Crutzen that allowed to popularize the theory that humanity had become a geological force. The Anthropocene is an epoch, in which we observe an active human interference in the processes governing the geological evolution of the planet (Bińczyk, 2018). According to B. Latour *What makes the Anthropocene an excellent marker, a 'golden spike' clearly detectable beyond the frontier of stratigraphy, is that the name of this geohistorical period may become the most pertinentphilosophical, religious, anthropological, and – as we shall soon see – political concept for beginning to turn away for good from the notions of 'Modern' and 'modernity' (Latour, 2017).* B. Stiegler comments the Anthropocene: The question that arises here is exceptional and extraordinary in every respect – and this extra-ordinariness is overwhelming: how can we live under the weight of a common protention that is potentially but massively negative on a worldwide scale?

However E. Bińczyk notes that the Age of Man is devoid of the tone of victory over nature.

t the end of the 19<sup>th</sup> century, the Swedish chemist and Nobel Laurate – S. Arhenius put forward the hypothesis that industrialization could affect climate change within a few thousand years. In 1908, he corrected his calculations by predicting anthropogenic climate change within a few hundred years. After the Second World War, in W. Vogt's *Road to Survival* and H. Fairfield's *Our Plundered Planet*, human activity is presented as a threat to the environment, and the anthropos itself as the driving force of nature. In the second half of the 20<sup>th</sup> century, Ecophilosophy and humanistic ecology addressed the issue of responsibility for the environment and living conditions,

and along with technological progress enabling new ways of collecting data on ecosystems, these concepts became increasingly important within the concept of sustainable development. The dynamic development of earth sciences has in particular, allowed a new holistic view of the world and more precise monitoring of human activities. In 2015, the Intergovernmental Panel on Climate Change released a report which indicated a 95-100% probability that climate change was caused by human beings. The term the Anthropocene has gained four meanings on the ground of humanistic discourse:

- A proposal for a new geological epoch, which is currently being studied by the International Commission on Stratigraphy (ICS) and the International Union of Geological Sciences (IUGS). A special Anthropocene Working Group (AWG) of the ICS was formed in 2009 to address this issue (Ptaszyńska, 2017).
- 2) From a second perspective, the Anthropocene represents an emerging new scientific paradigm. The dynamic development of the earth sciences since the 1970's has provided a new perspective on the earth as a whole system of processes in the earth system. By observing carbon dioxide and greenhouse gases emissions, climatologists have shown that the temperature of the earth has been steadily rising since measurements began in the 19th century. In terms of earth sciences, man started to be treated as the driving force of nature, and the boundary between nature and civilization began to blur. Thus, the human being is no longer an *inhabitant* and nature is not an *environmental space*. We are gradually forced to redistribute entirely what had formerly been called natural and what had been called social or symbolic. (Latour, 2017). The Anthropocene discourse has its roots in natural sciences. The humanists of the turn of the 19th/20th century discussed the inevitable need for a post-anthropocentric turn, emphasizing the value of multispecies eco-justice within such disciplines as ecolinguistics, anthropology, animal studies, biohistory, environmental ethics, or science and technology studies (Bińczyk, 2017). The interdisciplinary science of the Anthropocene blurs the boundaries between the factual and the normative realms. Similarly to ancient thought, ethics arises from the observation and understanding of the natural world. J. Fressoz and C. Bonneuil note that the revolution which the new vision of man brings, may be met with resistance similar to the adoption of the theory of evolution. The view of the world and man which emerges in the Anthropocene forces us to confront difficult truths and calls for radical changes in behavior.
- 3) In the third, broadest sense, the Anthropocene is a general term describing human impact on the environment and landscape. wider conversation around humanity's place in the web of life a conversation unfolding in the popular press, in activist circles, and across the Two Cultures of the human and natural science (Moore, 2017). In his *End of Nature*, B. McKibben argues that there is no area left on earth untouched by human activity. The first Nature that is the nature before man has been completely absorbed by the Second Nature produced by man. In this meaning of the word, the Anthropocene is a term connected with the notion of environmental crisis and the Sixth Great Extinction as human-induced civilizational threats.
- 4) In the fourth sense, the Anthropcen is a feeling, a state of mind which we experience while living under the influence of negative protention on a global scale. Eco-philosophy, which has introduced terms such as eco-anxiety, eco-grief or eco-guilt deals with the impact of environmental crisis. Rising temperatures, heat waves, floods, tornadoes, hurricanes, droughts, fires, loss of forest, and glaciers, along with disappearance of rivers and desertification, can directly and indirectly cause human pathologies that are physical and mental (Cianconi, 2020). The World Health Organization (WHO) estimates an increase of 250,000 excess deaths per year between 2030 and 2050 due to the *well understood impacts of climate change*. The expanding research literature on climate change and Mental health includes increasing evidence that extreme weather events which are more frequent, intense, and complex under a changing climate can trigger post-traumatic stress disorder (PTSD), major depressive disorder (MDD), anxiety, depression, complicated grief, survivor guilt, vicarious trauma, recovery fatigue, substance abuse, and suicidal ideation (Hayes, 2018).

The discussion around the Anthropocene has numerous references to the concept of sustainable development. Since the 1970's, scientists have been discussing the need to seek long-term solutions on a global scale that will maintain a balance of nature. As W. Tyburski rightly notes the progressive destruction of the world of nature, the impending and locally experienced ecological crisis forces us to intensify and integrate the organizational efforts of entire societies, to undertake systematic actions and to search for various ways to stop the adverse processes and repair what has been contaminated and devastated (Tyburski,2006). The discussion is a continuation of consideration on the basis of eco-philosophy. It is characterized by an interdisciplinary character of research and a sense of mission in the face of civilization's environmental challenges. Significant new issues in the discussion include philosophical, social and ethical consequences of the formal proposal of a new geological epoch causing theoretical changes in philosophy and science related to the new way of understanding man and nature in the Anthropocene era.

#### **Environmental crisis**

In the naturalistic view (Crutzen P., McNeill J., Zalasiewicz J., Chakrabarty D., Steffen W), the Anthropocene is an epoch in which humans became the dominant force of nature. The official grand narrative of the Anthropocene presents not only a unique view of Earth, of which we should all have the same representation, *from nowhere*, but

also a humanity seen as biological entity and geological agent. The grand narrative of the Anthropocene becomes that of the evolution of humans ... from hunter-gatherers to a global geophysical force (Bonneuil, Fressoz, 2017). The most important assumption of the Anthropocene is: as a species man has achieved an influence similar to other natural forces that determine the functioning of the earth system (Bonneuil, 2017). In natural sciences the destabilization and the Sixth Great Extinction are treated as the consequences of land exploitation. W. Steffen and J. Rockstrom emphasize the destructive nature of the impact of human activity on the environment, which now threatens millions of animal and plant species. Researchers stress that continued growth of global economy must eventually reach an end. We live on a planet with limited natural resources, thus it is necessary to consider further development from the perspective of planetary boundaries - nine parameters on which environmental stability depends. Humanity has already exceeded four of them: climate change, biodiversity loss, biogeochemical disturbance, and chemical pollution. In 1922, over 1 700 independent scientists, including Nobel Prize laureates signed a letter entitled Scientists of the World Warn Humanity. They expressed their concern about the rapidly advancing changes on earth in terms of deforestation, dwindling drinking water supplies, changes in ocean life, loss of biodiversity, climate change and population growth. Twenty five years later, in 2017, in another letter, these scientists emphasized that the situation deteriorated significantly since 1992. We are jeopardizing our future by not reining in our intense but geographically and demographically uneven material consumption and by not perceiving continued rapid population growth as a primary driver behind many ecological and even societal threats (Ripple, 2017). The latest UN GEO-6 report predicts that humanity will exceed the 10 billion mark in less than 50 years. The forecasted population growth along with deteriorating living conditions will accelerate the ongoing migration crisis. In the report entitled Future of the Human Climate Niche, the authors stress that global warming may cause apparent temperature to increase to 7.5 °C by 2070, which means that living conditions on 19% of the earth will be unfavorable for nearly 3.5 billion people. The latest IPCC report already informs about nearly 30 million climate refugees. With varying, but high probability, the UN report warns that further climate destabilization may cause droughts, loss of access to drinking water in many parts of the world, deterioration of living conditions, as well as further extinction of species and animals, the rate of which can only be compared to the mass extinction 66 million years ago, when 3/4 of plant and animal species disappeared from the earth.

#### Towards a new ethics of the Anthropocene

In modern science, the environmental crisis is the key challenge for humanity. As C. Hamilton notes, the return to the conditions of the Holocene has become impossible, currently we can only manage the crisis. E. Bińczyk draws attention to the fact that the effects of human activity in the Anthropocene force us to once again ask ourselves questions concerning reasons, responsibility and freedom. The possibility that Earth might be thrown out of the stable equilibrium of the Holocene questions the existing order of concepts, including the modernist axiological order (based on values such as linear progress, emancipation from the fatalism of nature, the assumption of the autonomy of nature, the Enlightenment hopes in science and technology, and the value of trust in the rational evaluation of gains and compensations of losses). We can even risk the thesis that the moral codes we have known to date, may not be adapted to the challenges of the crisis on a planetary scale, which is being discussed in the Anthropocene debate (Bińczyk, 2018).

In the humanist reception of the naturalistic concept of the Anthropocene, the beginning of the new geological era which naturalists have come to understand as the industrial revolution is arguable. The turn of the  $18^{th}$  and  $19^{th}$ century sees a rapid surge of environmental changes. Elements stored underground for millions of years are released into the atmosphere within two hundred years. A dynamic development of industry based on fossil fuels causes a significant increase in the emission of greenhouse gases, in particular carbon dioxide and methane. P. Crutzen accepts the invention of the steam engine as a symbolic turning point. J. Fressoz and C. Bonneuil point to the fact that the rapid emission we have to deal with, did not occur until after the Second World War. The authors of the Shock of the Anthropocene point out to the rise in social awareness of the negative impact of the human being on the environment. J. Moore insists that the period of the Euro-European conquest of South America and the beginning of expansive wasteful exploitation of resources, was the beginning of the Anthropocene. T. Morton notes that agrologistics - cultivation aimed at exploitation was present from the very beginning of agriculture and suggests the theory of early Anthropocene. The problem with the early Anthropocene concept, as with the Columbian exchange theory, is that there is no sufficient data proving significant human influence on climate in the period before the 19th century. Furthermore, as C. Hamilton rightly notes the adoption of an *early* beginning of the Anthropocene could justify the current situation – the environmental crisis as a *natural* consequence of the development of civilization and push back the sense of responsibility for the Sixth Great Extinction.

The very interdisciplinary dispute over the beginning of the Anthropocene reveals the key questions in the field of ethics on the basis of a new scientific paradigm. First of all, are we actually really responsible for the environmental crisis? Secondly, if we accept responsibility should we treat it as species-based or should we basing on analytical methods, pursue justice by identifying and obliging the guilty to act? Finally, through what course of action should we find a solution to the present situation? In *The Anthropocene Project: Virtue in the Age of Climate* 

*Change* B. Williston notes that considerations proceed towards collective and individual responsibility. The potential for discussion is much broader, with humanists drawing attention to the need to discuss human rights, legal protection of living and inanimate entities, new economic and educational solutions and critical analysis of technology and production. In the remainder part of this article I will only elaborate on the issue of responsibility as the focal point of discussion and the transition from biocentrism to co-existence.

#### **Responsibility in the discussion on the Anthropocene**

Historians C. Bonneuil and J. Fressoz stress that scientists have been warning humanity about the dangers of unsustainable human activity ever since World War II. Literature even points to W. Blake as a precursor in critical thinking about industrialization and progress. As A. Kiepas rightly observes, the changed nature of human activity is also manifested in the fact that many effects of these actions are of a cumulative nature today. They are the effect of the coupling of many activities and their consequences, and therefore it is not only the immediate effects that are most important, but often it is the secondary and long-term effects that are more important and have more significance. The shortsightedness of traditional ethics and its focus only on immediate consequences consequently led to losing sight of what today seems to be necessary and indispensable for the moral evaluation of these actions although at the same time difficult to do (Kiepas, 2000). The naturalistic trend in the discussion on the Anthropocene is based on the shift in perspective from an anthropocentric to a biocentric one, which is already adopted in ecological humanities, the acceptance of the value of life, perceived very broadly, also as living conditions (which enforces the protection of the stability of ecosystems), and interspecies and intergenerational justice. As early as in the 1970's H. Jonas outlined the concept of human responsibility for the environment. According to the author of the principle of responsibility, man has the driving force that allows him to make far-reaching, irreversible interference in the environment, threatening the future of the entire species. The preventive and biocentric ethics of H. Jonas is an example of the concept of responsibility developed in ecophilosophy. As H. Ciażela notes, the fundamental feature of the new ethics of Hans Jonas' approach is its negative character. Responsibility as a principle for a technical civilization is understood here as a principle leading to an absolute avoidance of risks that would expose the human being to the danger of undertaking actions that could result in irreversible changes that would shatter the achievements of evolution to date, which resulted in the creation of man both in the form of his extinction and the appearance of irreversible changes in human biology perceived as a premise for the development of a specifically human spirituality (Ciążela, 2006). Jonas' concept has shown the dangers of developing a civilization based on technology that is not subject to evaluation. Contemporary philosophy of technology and ecophilosophy emphasizes the need for a critical approach to the consequences and effects of technological development. In the discussion on the Anthropocene posthumanists and eco-modernists stand up for the technological possibilities of saving the environment. Eco-modernism, which postulates the possibility of technological correction of the climate, is politically attractive because it promises no changes in the world economy focused on further growth, but it has no support against the backdrop of the discussion on the Anthropocene, in which the problem is the depletion of natural resources and a simultanous population growth while continuing a *business as usual* policy. C. Hamilton points to the fact that we should seek local solutions. C. Bonneuil, in turn, suggests eco-socialist solutions based on the idea of sharing and reducing consumption, a concept that has been in use for many years. The discussion on responsibility is closely linked to the reevaluation of the concept of freedom in the Anthropocene. Eco-catastrophic, naturalist, eco-feminist, humanist-teleological and eco-Marxist currents are against technological interference with the climate - geoengineering.

In the discussion on the Anthropocene humanists are increasingly turning to the data of the natural, social, and economic sciences in order to draw ethical implications on the basis of that data. Thinking about the Anthropocene means taking into account the data and models of the Earth system science that tells us with increasing precision about perturbations in the geological time scale which will radically change the conditions of human existence. It means taking the measure of the telluric force of industrialization and commodification, which has derailed the Earth beyond the stable parameters of the Holocene, and of the need to give our freedom different material foundation. (Bonneuil, Fressoz 2017). The responsibility of humanity in the Anthropocene is being fostered in two directions: collective and in-individual. The collective perspective primarily considers international legal solutions that oblige signatories to move towards a low-carbon economy and solutions that reduce carbon footprints. The individual perspective draws attention to how a person treats the world around them. The starting point for the discussion on the Anthropocene is the belief that the environmental crisis is linked to negative socio-economic consequences. Further overexploitation of the earth by human beings will lead to exceeding planetary boundaries and, as a result, weather anomalies will be inevitable, leading to catastrophic deterioration of living conditions for billions of people. Already now, according to the UN Geo-6 report, living conditions on 29% of land surface is described as dramatic for 3.2 billion people.

C. Hamilton notes that without a discussion on responsibility in the Anthropocene, an effective management of the environmental crisis will not be possible. In the postnaturalist view (Latour B., Morton T., Stenger I.), escape from responsibility is impossible insofar as we ourselves have become the leading force of nature and we can no longer refer to the space we live in, as nature. We live in a post naturalist environment where the mass of plastic

is greater than the biomass of animals, and the mass of buildings and infrastructure is greater than the biomass of trees and shrubs. Nature is shaped by economic strategies, political and legal decisions, as well as technology. As T. Morton notes every time we start our engine we contribute to the Sixth Great Extinction of animals and plants. Statistically, our actions may seem insignificant, but on a global scale we are talking about hundreds of billions of tons of carbon dioxide released into the atmosphere. In The Age of Man – E. Bińczyk puts forward a thesis that we have found ourselves in a situation of environmental stagnation. On one hand, we are well informed about the risks of contemporary science and on the other hand, in order to achieve the goals of the Paris Agreement we should stop extracting coal and oil straight away. C. Hamilton believes that we should not wait for international legal solutions, but undertake action immediately to support local communities, moving away from the global economy. As early as in the 1990's D. Jamieson suggested the most radical criticism, putting forwards a theory that the environmental crisis is as a matter of a fact a crisis of values as lack of moderation and greed are the direct cause of the environmental crisis. In turn, J. Moore emphasizes that the responsibility should be borne by countries and corporations with the largest carbon footprint, pointing to the direct connection between environmental damage and immoderate capitalistic consumption. Instead of the Anthropocene, he proposes the term - the Capitalocene. According to eco-Marxists, the environmental crisis will only further deepen social inequality. H. Kempf in *How the Rich Are Destroying the Earth* points to the fact that just 1% of the richest people own 48% of the world's wealth while half of humanity owns a total of 1%. As A. Hornborg notes as of 2008, less than 20% of humanity has emitted more than 70% of the carbon dioxide since 1850. The average citizen of the United States produces 500 times more carbon dioxide than the citizens of some African or Asian countries. According to B. McKibben, the management of oil industry companies and the politicians who support their further development are to blame. In turn, S. Gardiner points out that the discussion on responsibility has so far been dominated by the conviction that the developed countries should take responsibility, while the developing countries should be exempt from restrictions. However, such solutions have proved ineffective when trying to implement international agreements. Gardiner considers individual-level solutions to be more important. H. Shue proposes to strive to reduce global emissions while legislating the right to minimum necessary emissions. This concept reflects the existing solutions suggested within the framework of sustainable development. J. Rockstrom notes that any collective change will limit freedom and will entail a socio-economic revolution that will not happen as long as the major emitters have an economic interest in further exploitation of fossil fuels.

Accountability is also considered on the individual level. As E. Bińczyk notes after B. Latour every day we deny the reality of climate destabilization processes by not taking countermeasures. Climate change denial has a diverse background. K. Norgard believes that it is the scale of the global problem that man has to face that deprives him of the ability to act. The perspective of a catastrophe and helplessness leads to apathy and denial of the problem. N. Oreskes in the Merchants of Doubt puts forward the thesis that much more could be done to protect the climate if the scientific consensus on the anthropogenic origin of climate change was not undermined for ideological reasons. B. Latour stresses that the theory of climate change is one of the best documented phenomenon in the history of science. In *Facing Gaia*, he argues that the problem is the very notion of nature itself. In the philosopher's opinion the stagnation humanity finds itself in, is caused by the fact that we mistakenly imagine nature conservation as an opportunity to return to *wilderness*. We use the mythical-religious concept of pure and primordial nature, untouched by man, which we have lost through the development of civilization. Thus, civilization is perceived negatively, as the direct cause of the crisis and we are forced to function in it, but are unable to return to the preindustrialization era. According to S. Vogel, so far the subject of interest of ecologists and environmental ethicists has been everything which is natural and alive. Eco-philosophy has made a turn from anthropocentrism to biocentrism, but in the opinion of the author of *Thinking like a Mall* we live in a world where the boundary between technology and nature has been blurred and we should also include artifacts, as well as elements of the technosphere in environmental considerations. This way of thinking is often called a flat ontology, because on its basis both humans and other beings (animals, things, minerals, plants, etc.) exist in the same way, they have an equal ontological status (Marzec, 2019). Our perception of objects was constituted by the tradition of thought adopted from Aristotle, who considered artifacts to be intentional works of man, inferior in their nature to natural entities. Environmental philosophy continues Aristotle's divisions, however many currents of the philosophy of technology, numerous researchers using the actor-network theory (ANT) and supporters of the Object-Oriented-Onthology do not value entities/beings on the basis of their naturalness. According to B. Latour objects construct what is social. The world surrounding us is full of hybrid connections. Instead of talking about society, we should be talking about a community which is made up of non-humans in addition to humans. As E. Bińczyk aptly comments - thanks to the coupling of the spectacular practical success of laboratories, industry, globalization processes and market conditions, we have created a new form of risk. In 1986, Ulrich Beck 1986 called it a modern systemic risk: invisible, supranational, and threatening to destabilize the world as we know it (ecologically, financially, and politically). Thus, as Latour emphasizes, it is not human society itself that should be saved from risk but the collective – the area of people and non-human factors (Bińczyk, 2013). The reductionist thinking to date has marginalized the dependence of man on the objects he creates, whereas the discussion on the Anthropocene draws attention to the coexistence with non-humans. In Dark Ecology T. Morton argues that the human being has always been associated with non-humans – objects on which our daily lives depend. Only an Anthropocentric perspective of the world, allows us to regard objects as incomplete, inferior, or subordinable. Only an Anthropocentric perspective of the world allows us to perceive an object as incomplete, inferior, or subordinable. Being human, based on community, kindness, solidarity, friendship, and symbiosis, is possible only by connecting with what is nonhuman (Marzec, 2018). In the view of environmental philosophy, objects have so far been marginalized, sometimes even regarded as a manifestation of the harmful activity of human-beings. Meanwhile, we have no way to dispose of man-made objects; we are forced to function in a world full of waste and toxic substances. What is more, opening up to a world of non-humans allows us to move beyond a simple profit and loss account. Ecological awareness that abandons the notion of Nature assumes that man is no longer the measure of all things, but also of all the most important earthly events. From the perspective of flat ontology, the existence of a paper cup is as meaningful and mysterious as human existence. In this context, our view of a given thing is not as flawless – what it actually is and how it presents itself to us (Marzec, 2019). We need a new ecological awareness that allows us to connect current decisions, especially those concerning consumption, with distant consequences in time and space, to combine thinking about the technosphere and the biosphere, taking care of the entire post-natural environment. Responsibility should be based on linking the current carbon footprint to the burning out forests for crops, rising sea and ocean levels or desertification. According to B. Williston, the new environmental awareness which guides us in our daily choices should be based on emotional conditioning of desired attitudes through social shaming of self-centered people who do not respect the environment as a common good. Furthermore, we can achieve a sense of solidarity by strengthening *environmental honor*, because taking care of the environment now comes down to following unwritten social rules.

C. Hamilton is critical of the departure from the Anthropocentric view of the world proposed by postnaturalists. According to the author of the *Defiant Earth*, our specific place in the structure of the world lies in the fact that we are a telluric force which is aware of its actions and the consequences of our actions. A drift from anthropocentrism could be an escape from responsibility. In eco-catastrophic terms, the environmental catastrophe has already occurred and it is necessary to manage the crisis effectively. Similarly, to the naturalist movement, which emphasizes the duty of science to take a leading role in finding effective solutions and informing the public of the danger we have found ourselves in. C. Hamilton believes that the most important thing is to criticize the neoliberal concept of freedom, because further excessive consumption in the face of depleting natural resources, on which the world economy is currently based, must eventually lead to an escalation of the environmental and socio-economic crisis.

#### Conclusions

With the advent of environmental philosophy, there is a shift from anthropocentric to biocentric thinking. Due to the growing human impact on the environment, the need to change was postulated on the basis of philosophy of sustainable development. Researchers emphasized the value of life and the conditions for life, pointing out the consequences of disturbing the stability of ecosystems. In the Anthropocene epoch there is a further shift towards co-existence of both animate and manufactured elements of the environment. As the boundary between civilization and nature is blurred, the technosphere has become the subject of interest of researchers engaged in the ethical-environmental aspects of the Anthropocene. Co-existance is based on a new broad ecological awareness, in which responsibility examined on a collective and individual level is also linked to man-made objects.

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## **Post-COVID-19 Revitalisation and Prospects** for Climate Neutral Energy Security Technologies

## Rewitalizacja po COVID-19 i perspektywy wykorzystania neutralnych dla klimatu technologii bezpieczeństwa energetycznego

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#### Abstract

Dealing with the effects of COVID-19 is on the energy security agenda. Consolidation of efforts at the regional, national and international levels to exchange experience in the implementation of successful practices and the formation of institutional support of the sustainable energy development contributes to the post-COVID-19 revitalisation. With this in mind, the article is devoted to studying the peculiarities and experience of the post-COVID-19 revitalisation of the energy sector in different countries and determining the development prospects of climateneutral technologies in the energy security sphere. A change in the behaviour of energy consumers by the secondary energy source in the context of increased quarantine restrictions has been established. In particular, a downward trend in the volume of energy consumption from traditional sources (oil, coal, etc.) has been traced. At the same time, the demand for energy consumption from renewable sources (solar energy, wind energy, etc.) has grown, which made it possible to diagnose the reduction in CO<sub>2</sub> emissions. Based on the analysis of measures to reduce the negative impact of the COVID-19 on energy security in different countries, the integration of the foundations of climate neutrality through the development of new critical technologies in the field of renewable energy sources has been established. As a result of a survey of green energy stakeholders using PEST analysis, it was proved that the complexity of integrating the principles of climate neutrality into the energy sector is that the result is not an economic effect but primarily an environmental effect (energy decarbonization). As a result, a methodology for determining the sustainability indicators for developing climate-neutral technologies in energy security using fuzzy set methods is proposed. The prospect of developing climate-neutral technologies in energy security lies in the transition to cross-sectoral interaction based on a closed cycle of energy consumption from renewable sources and the use of Industry 4.0 technologies. The proposed methodology will be a tool for further research on the developing organizational and innovative support and justifying the economic feasibility of introducing climate-neutral technologies based on the clustering of industries and a circular economy in the energy security sphere.

**Key words:** energy decarbonization, climate-neutral innovations, renewable energy, critical infrastructure, COVID-19, sustainable development, circular economy

**Słowa kluczowe:** dekarbonizacja energii, innowacje neutralne dla klimatu, energia odnawialna, infrastruktura krytyczna, COVID-19, zrównoważony rozwój, gospodarka o obiegu zamkniętym

#### Introduction

Energy resources are needed to ensure the full functioning of any socio-economic system. At the same time, a significant risk factor for the disruption of this process is the limited, inaccessible, inconsistent, non-preserved or depleted resources. Considering this, the issues of obtaining access, ensuring, and efficient use of energy resources in the conditions of COVID-19 are in the interests of both national security and global (transnational) interaction. Energy security is considered a component of national security, and the energy sector is included in the critical infrastructure of strategic importance for the sustainable energy development.

In general, "the COVID-19 pandemic has changed the electricity consumption profile by the specifics of human activity. Global household electricity consumption has risen by 40% as citizens have been forced to work from home to stop the spread of the virus. At the same time, during the aggravation of the pandemic, electricity consumption in non-residential sectors decreased" (Soava, 2021). Analytical agency Renewables Now notes "the growth dynamics of renewable energy in 2020-2021 under the influence of coronavirus by 10%" (Renewables now, 2021).

Changes in behaviour and energy consumption during the pandemic have been directly reflected in global levels of  $CO_2$  emissions. In particular, "in 2020, an overall reduction of 2.58 Gt of energy-related  $CO_2$  emissions was recorded in 2020 of 2.58 Gt. Overall,  $CO_2$  emissions decreased by an average of 26% (at peaks) during the broad lockdown in selected countries" (Peng, 2021).

The energy sector is one of the industries whose activities lead to a negative impact on the climate. In this context, the results of a study by the International Energy Agency in the annual World Energy Outlook report on the world's response to COVID-19 are of interest. In particular, "demand for coal is predicted not to return to pre-COVID levels and that it will account for less than 20% of energy consumption by 2040. Oil is also experiencing fluctuations in consumption levels, and after 2030, demand for it will begin to decline. At the same time, it is predicted that renewable energy sources with zero carbon impact on climate change can meet 80% of electricity demand growth over the next ten years" (COVID-19 can change the future of energy for many years to come – IEA forecast, 2020). By 2025, renewable energy sources will replace coal as the primary means of generating electricity. Such trends in the development of the energy industry indicate the relevance of transforming the managerial, marketing and technological approaches to the formation of the energy supply chain in the post-COVID-19 period through the transition to climate-neutral energy security.

#### Literature review

The study results (Soava, 2021; Kuzemko, 2020; Brych, 2021; Dluhopolskyi, 2021) show that domestic or imported electricity consumption affects economic growth, while economic growth affects the level of electricity consumption in individual households. Within COVID-19, proportions observance between the types of primary energy carriers and avoiding the dominance of one or another non-renewable energy resource is among the ways to maintain the energy balance (Pysmenna, 2020). In (Peng, 2021) structural changes in energy demand and consumption are considered in a comprehensive manner, which covers the following aspects: changing patterns of energy consumption in time, space, sector and size of use; additional energy needs; energy development stabilization; restoration of the energy consumption level.

Within post- COVID-19 strengthening of energy security, the development of renewable energy is seen to ensure economic growth, improve social standards and well-being, and an environment for the implementation of climateneutral innovations. As a result, the focus on innovative post- COVID-19 solutions in the energy sector as part of critical infrastructure is particularly significant. Along with this, scholars confirm "the vulnerability of the renewable energy sector by a bidirectional causal relationship between the energy consumption volume from renewable energy sources and economic growth in the long term" (Marinas, 2018). Among the factors of disproportion in the energy balance in renewable energy, there is "a decrease in business activity (a decrease in average daily energy consumption, which led to changes in the proportions of the electricity balance between types of energy generation); an increase in the volume and number of restrictions on generation from renewable energy sources due to a general drop in energy consumption; a decrease in the solvency of consumers and an increase in debt in the energy market; reconfiguration of the daily load schedule of the interconnected energy systems" (Pysmenna, 2020). Because of this, the search for new approaches to effective pandemic management to ensure sustainable development is particularly essential (Elavarasan, 2021; Halysh, 2021; Brych 2022).

The complexity of climate policy development in the energy market in the coronavirus context lies in need to make quick management decisions that will make it possible to prevent stagnation in the economy as soon as possible. Because of this, environmental issues (including the development of measures to adapt to climate change) are measures that "determine the unproductive costs of the economy and diversification of supplies and development of its resource base cause an increase in risks in the economy. In contrast, measures on energy efficiency, increasing the share of renewable energy sources are referred to as the measures aimed at ensuring economic growth decoupling. They have a positive impact on productivity and economic growth" (Pysmenna, 2020). In this context, it is advisable to note that energy is a critical infrastructure component that ensures the country's life. As a result, such a dualistic approach to adaptation to climate change in the energy sector necessitates deepening research on

adopting innovative solutions to ensure energy security within post-COVID-19 revitalisation in the context of the development of climate-neutral technologies.

The purpose of the article is to study the peculiarities and experience of post-COVID revitalisation of the energy sector in different countries, assess the conditions for integrating climate-neutral innovations in the energy sector and develop a methodology for determining sustainability indicators for the development of climate-neutral technologies in the energy security sphere.

#### **Research methodology**

In the context of the COVID-19, the preference of energy consumers to ensure uninterrupted energy supply to diversified channels for obtaining secondary energy (in particular, from renewable energy sources) led to the expansion of the green energy segment in the energy market and, as a result, an increase in the need for energy services. Previous studies (Brych, 2021) propose determining the positioning of *green* energy services in terms of the energy consumption level by applying difference equations. At the same time, when determining the methodology of this study, we took into account the fact that measures to decarbonize the energy sector in order to prevent climate change are considered as unproductive expenses of the economy, which indicates the need to justify the need to change such a vision. This justification was our study of evaluating the effectiveness of promoting *green* energy services (Borysiak, 2021), in which we used optimization methods.

As a result, this allowed us "to identify the indicator of maximizing the ecological (green) effect (decarbonizing the environment) and the indicator of minimizing energy consumption costs:

$$f(G) = \sum_{i=1}^{n} g_i s_i \to max$$
(1)  
$$f(C) = \sum_{i=1}^{m} c_i e_i \to min$$
(2)

f(G) i f(C) – the functions maximizing the ecological (green) impact of the green energy services provision s\_i and minimizing energy costs e\_j; g\_i – indicator of the level of decarbonization from the use of green energy services s\_i; c\_j – the cost of consuming the relevant type of energy e\_j; n – number of types of green energy services (i=1...n); m – number of types of energy (j=1...m)" (Borysiak, 2021).

Because of this, the methodological basis of our current study, in particular the study of post-COVID-19 revitalization aspects and the prospects for the development of climate-neutral technologies in the energy security sphere, is based on the use of fuzzy set methods, which will determine the sustainability indicators for the development of climate-neutral technologies in the energy security sector in the absence of clear parameters of the objects under study (influence factors). A PEST analysis of the factors influencing the integration of climate neutrality into green energy was carried out by polling green energy stakeholders. The equation for calculating the elements of the combined decision matrix Xij is taken as a basis to determine the stability indicators (Elavarasan, 2021):

$$\begin{aligned} x_{ij} &= (A_{ij}, B_{ij}, C_{ij}) \\ A_{ij} &= \min \{ ak_{ij} \}, B_{ij} = 1K \sum k_n, C_{ij} = \max \{ ck_{ij} \} \end{aligned}$$

where a,b,c are the fuzzy numbers components associated with the decision matrix of each stakeholder, A,B,C are the fuzzy number components corresponding to the combined decision matrix, i represent the prospects (recoverability and sustainability) of the ratings, j represents the PEST coefficients and k is the number of decision makers or decision matrix.

In turn, we believe that the sustainability of the energy system functioning depends on technological modernization and the adoption of energy-efficient solutions. First of all, this concerns the creation of favourable conditions for the uninterrupted supply of secondary energy (*green* energy) to consumers and the specifics of the interaction of primary energy suppliers from renewable energy sources with producers of *green* energy. Therefore, in order to form a list of factor signs of obtaining an environmental, economic and social effect, the PEST analysis takes into account the key factors influencing the prospects for the development of climate-neutral technologies in the energy security sphere, such as the innovative potential of green energy enterprises, the diversification level of secondary energy supply sources, the digitalization level of energy supply management systems, the well-being level of the population, the environmental education level of population.

#### **Research results**

Like other business entities, the energy sector, regardless of the primary energy source (traditional and renewable energy sources), has been affected by COVID-19. "In the first quarter of 2020, global energy demand decreased by 3.8%, with most of the impact occurring in March when Europe, North America and other countries applied containment measures due to the spread of COVID-19" (Global Energy Review, 2020).

"The global demand for coal suffered the most, falling by almost 8% compared to the first quarter of 2019. Oil demand decreased by almost 5%, demand for gas decreased by about 2%. At the same time, there was a drop in demand for electricity by 20%, primarily for electricity produced from traditional energy sources (oil, gas, coal, nuclear energy). On the other hand, there is a positive trend in the growth of demand for electricity from renewable sources and directly for renewable energy sources (solar energy, wind energy, hydropower, geothermal energy), and bioenergy (biofuel) and energy production from waste. A decline in economic activity starting in the first

quarter of 2020 and continuing into the second quarter of 2020 was identified in most European countries. Activity in industry and services declined mainly in the second quarter of 2020 in Germany, Spain, France, Italy. As a consequence, a reduction in energy consumption was found. In particular, electricity consumption in Europe decreased by 11% in the second quarter of 2020 compared to the same period in 2019" (Marinas, 2018; Soava, 2021). At the same time, economic activity in European countries did not decrease evenly on the entire continent, and different isolation measures taken by countries had different effects on energy consumption. The most significant decline in energy consumption was observed in member countries with the most substantial decline in gross domestic product. "Initially, Germany saw a smaller decline in consumption due to less restrictive conditions than its neighbours and a stable industrial sector with a relatively high share of GDP. Instead, in the countries of Southern Europe (Italy, Spain and France), there was a significant reduction in energy consumption due to measures that seriously affected the tourism sector. Thus, in Italy, energy consumption decreased by almost a third compared to the same period in 2019. Energy consumption during the lockdown fell by at least 15% in France, Spain, while in Italy, at the height of the outbreak, electricity demand sometimes dropped, falling by up to 75%" (Marinas, 2018; Soava, 2021).

As a member state of the EU, Romania also experienced a drop in energy consumption. However, "in 2020, a recovery was being monitored due to implementing the terms of the EU End-Use Energy Reduction Strategy to reduce energy consumption and increase energy efficiency and resumption of economic activity" (Soava, 2021). "If in January 2020 the cost of consumption was the same as in 2019, starting from February 2020, there was a significant increase in household electricity consumption compared to the same period of the previous year, reaching the highest increase in 2020, 8.33% compared with the same month of 2019" (Soava, 2021).

In Ukraine, as in other countries, starting from 2020, a trend has been observed to revive economic activity and increase energy consumption. In particular, according to the Ministry of Energy of Ukraine, "in August 2020, the share of renewable energy reached 16.6%" (Record of Ukrainian energy, 2021). The renewable energy sector of Ukraine, as in other countries of the world during the corona-virus crisis, did not suffer a fall compared to the traditional energy sector.

The use of timely preventive measures to reduce the risks (Table 1) from the impact of COVID-19 in different countries made it possible to stabilize the situation in terms of energy security.

No	Country Characteristics of anti-COVID activities							
1		Traditional energy (coal-fired power)						
	European Union	Launch of the Platform Coal Regions Transformation and the Environmental Reconstruction						
		and Repurposing Toolkit: EU Guidance for Managing Environmental Restoration and Asset						
		Repurposing in Coal Regions in the Transformation Process.						
	Germany	Siemens project Introduction of ETES Thermal Battery in Coal-fired Power Plants in Hamburg						
		Harbor 2019 (Electrical Thermal Storage/ETES technology uses fans from surplus electricity						
		generation at wind farms to heat 1,000 tons of the power plant's volcanic stone to temperatures						
		of 750-800 degrees Celsius, the resulting heat can be used for the reverse production of electric-						
		ity using steam or by distributing thermal energy to end consumers).						
	Hungary	Project to grow energy plants and install solar panels on the territory of a closed lignite mine						
		owned by the Marta Power Plant coal-fired power plant (replacement of coal consumption with						
		electricity from renewable energy sources and the creation of an industrial park based on the						
		mine; excess heat and electricity from the power plant in the cluster industrial park, and the by-						
		products of these enterprises (biomass) are supplied to the power plant for electricity generation).						
	Great Britain	Developed by the International Council on Mining & Metals Best Practice Guide for Compre-						
		hensive Mine Closure.						
	Ukraine	Development of Ukraine of the concept of reforming the coal industry On the development of a						
		national program for the transformation of the coal regions of Ukraine until 2027 (Octobe						
		2020). Decree of the Cabinet of Ministers of Ukraine dated September 22, 2021 No. 1024 On						
		approval of the Concept of the State Target Program for the Fair Transformation of the Coal						
		Regions of Ukraine for the period up to 2030.						
	China	Project for the introduction of high-efficiency natural gas generation at coal-fired power plants						
		(transformation of a coal-burning power plant into a natural gas combined cycle power plant						
		producing electricity and heat and reducing the negative impact on the environment).						
2		Renewable energy and green energy services						
	the EU	The European Commission has developed a comprehensive action plan to implement the prin-						
	ciples of the European Green Deal, the main element of which is the Sustainable Europe Inv							
		ment Plan, which covers investments in various sectors for their decarbonization. A Just Tran-						
		sition Mechanism has been created, financed from the EU budget.						
	Germany	The Green Stimulus Package (June 2020) includes at least €50 billion in climate change, solar						
		and wind energy spending.						
I								

Table 1. Measures to prevent the negative impact of COVID-19 on energy security in different countries (Quarterly report 1, DiXi Group, 2021)

2	Renewable energy	and green energy services – continuation
	Ukraine	Establishment of a <i>green</i> tariff for electricity from renewable energy sources (in accordance with the Law of Ukraine <i>On the electricity market</i> ) and an incentive tariff for thermal energy from renewable energy sources (the Law of Ukraine <i>On Amendments to the Law of Ukraine 'On Heat Supply' to stimulate the production of heat energy from alternative energy sources</i> ).
	Canada	A C\$ 1.7 billion investment program has been initiated to clean up old and abandoned oil and gas wells to reduce pollution levels. A C\$750 million Emission Reduction Fund has been created to help oil and gas companies operating onshore and offshore receive funding for environmental initiatives to reduce pollution and save jobs. A program for the availability of loans has been developed, in particular for entities of the energy sector.
	South Korea	On July 14, 2020, the country's government announced the Green New Deal initiative. The ac- tion plan is focused on stimulating the development of the renewable energy sector, gradual withdrawal of financing from the coal industry. In December 2020, the 2050 Carbon Neutral Strategy of the Republic of Korea: Towards a Sustainable and Green Society was published, which set clear targets for reducing the carbon footprint of industries.
3		Tariff policy
	the EU	The updated Electricity Market Directive, adopted in 2019 as part of the Clean Energy for All Europeans package, seeks to reduce supplier switching procedures to 24 hours, ensure the right of consumers to demand the installation of smart meters that can measure consumption in real time and remotely, as well as provide the ability to create reliable tools (sites) for comparing commercial offers from suppliers. The European Commission has published guidance on energy poverty and provides support through the European Energy Poverty Observatory. In October 2020, the European Commission provided guidance on energy poverty due to the effects of the COVID-19 pandemic.
	Great Britain	There is an independent energy market regulator, a dedicated agency called Ofgem, which is implementing a dedicated strategy focusing on supporting vulnerable customers, and working with governments, industry, and consumer groups to ensure a clean economy and the lowest cost for consumers, especially vulnerable ones. In March 2020, the country also launched a <i>Supervisory Service Package</i> along with energy suppliants to suppress the camp of companions during the COVID-19 pandemic. Guidelines have been developed for energy suppliers and other market participants that draw attention to certain risks and provide examples of best practices to support consumers affected by the effects of the COVID-19 pandemic.
	Ukraine	In February 2021, a Memorandum was signed between local authorities, the Ministry of Energy, the Ministry of Regional Development, National Commission for State Regulation in the Sphere of Energy and Utilities, and Naftogaz on the unchanged tariffs for heating and hot water until May 2021. The Anti-Crisis Energy Headquarters, chaired by the Prime Minister, approved the action plan for the implementation of this Memorandum.

In turn, effective post-COVID-19 measures in the energy sector include (Peng, 2021; Kuzemko, 2020) the following measures: digitalization of the energy sector (increased digitalization and the Internet of Things, IoT); taking into account the new way of life in cities with less energy consumption; building resilience through the circular economy; opportunities for renewable sources, energy storage and energy savings. In addition (Jiang, 2021), proposed a new concept of the relationship between health, energy and the environment under the constraints associated with climate change.

Given the fact that energy security is an integral part of national security, and energy is included in critical infrastructure facilities, an important decision to ensure energy security in the post-COVID-19 period is to create conditions for the development and implementation of critical technologies. The digitalization of energy networks is essential for the transition to Industry 4.0 technologies. After all, understanding the role of technology in supporting humanity opens up new perspectives for effective pandemic management. This role of technology is expressed in terms of uninterrupted connectivity, fast communication, mobility, technological impact in healthcare, the impact of digitalization, surveillance and security, artificial intelligence (AI) and the Internet of Things (IoT) (Elavarasan, 2021; Liakhovych, 2021).

"National Report – 2017 Sustainable Development Goals: Ukraine to achieve the goal Affordable and clean energy, four tasks are defined (Expanding and modernizing the energy infrastructure for sustainable energy supply based on innovative technologies; Diversifying the supply of primary energy resources; increasing the share of renewable energy sources) and seven indicators of sustainable development in the energy sector (electricity generation; technological costs of electricity in distribution networks; heat losses in heating networks, the maximum share of imports of primary energy resources (except nuclear fuel) from one source in the total supply; the share of one supplier in the nuclear fuel market, the share of energy from RES in total final consumption; primary energy intensity of GDP), as well as the target values of these indicators by 2030" (Pysmenna, 2020).

At the same time, the increased awareness of the climate change consequences in the last decade leads to considering the issues of assessing the level and factors of negative impact on the climate of various industries (including energy), as well as determining the level of their vulnerability to climate change and introducing climate-neutral innovations. In particular, in the context of the information analysis in Table 1, it should be noted that in preventing stagnation in the economy within the coronavirus, the issue of developing measures to adapt to climate change was also on the agenda. In particular, on February 24, 2021, the European Commission adopted the EU Strategy for Adaptation to EU Climate Change. On October 20, 2021, Ukraine adopted the Strategy for Environmental Security and Adaptation to Climate Change until 2030. In November 2021, participants in the COP26 Conference in Glasgow also focused on climate change.

It should be noted that the diagnosis of the prospects for the development of renewable energy to growth as a result of the transition to energy consumption from renewable sources in the context of the coronavirus, which led to a decrease in  $CO_2$  emissions (by reducing the use of energy from traditional sources), indicates the importance of expanding climate-neutral activities to strengthen energy security in the post-COVID-19 period. In this context, it is of strategic importance for the industry to obtain the effect of energy security decarbonization and a positive economic effect (value-added) due to the development and implementation of critical climate-neutral innovations at all stages of the energy supply chain.

We agree with the statement that in order to establish a bidirectional relationship between the volume of energy consumption from renewable energy sources and economic growth in the long term, it is advisable in (Marinas, 2018; Brych, 2021; Pysmenna, 2020) to adjust their energy, industrial and innovation policies in order to use their own technological base, their own financial and human capital, own material resources, as well as public-private partnership mechanisms and innovative programs at the state level for the development of energy technologies from renewable energy sources to maximize the impact on the sustainability of economic growth.

The prospect of developing climate-neutral technologies for energy security lies in the transition to cross-sectoral interaction based on a closed cycle of energy consumption from renewable sources and the transition to Industry 4.0 technologies. On this path, it is vital to develop the interaction of agricultural enterprises (biomass producers) and enterprises producing *green* energy as a result of factorial modeling of biomass supply chain optimization (Brych, 2021). The next step should be the organizational and economic support for developing and implementing critical technologies in the energy security sphere based on climate-neutral clustering and optimization of the environmental and energy management of the national economy.

PEST analysis was carried out to determine the factors influencing the integration of the climate neutrality foundations in the energy efficiency sphere (Table 2). For this aim, six stakeholders were interviewed (online survey), namely, one representative from such stakeholder groups: non-governmental organizations, the media, local governments, scientific institutions, educational centres, innovation hubs). The content of the survey was the assessment of indicators for obtaining environmental, social and economic effects from the development of *green* energy (from 1 to 5 points, where 1 - the minimum level of effect, 5 - the maximum level of effect). The results of the assessments are averaged and multiplied with a significant factor.

Indicator Expert assessment						Average rating	Factor ignificance	Impact assessment	
	1	2	3	4	5	6		s	.,
		Ecolog	gical effec	t					
Biodiversity conservation	3	3	2	3	2	3	2,7	0,5	1,6
Rational nature management	3	2	2	2	4	2	2,5	0,5	1,3
Decarbonization of settlements	3	3	3	4	3	3	3,1	0,6	1,9
Group average :							2,8	0,5	1,6
Economic effect									
Entrepreneurship development	5	4	4	4	5	4	4,3	0,9	3,9
Implementation of energy efficient technologies in production processes	4	4	4	5	5	4	4,3	0,9	3,9
Flexibility of energy tariff policy	3	3	3	3	3	3	3,0	0,6	1,8
					Group a	werage :	3,9	0,8	3,2
		Soc	ial effect						
Building a culture of energy management	3	4	3	3	3	4	3,3	0,7	2,3
Improving the welfare of the population	5	4	4	4	4	5	4,3	0,9	3,9
Public health promotion	3	3	3	4	3	3	3,1	0,6	1,9
					Group a	werage :	3,6	0,7	2,7

Table 2. PEST-analysis of factors influencing the integration of the climate neutrality foundations in the energy eff	iciency
sphere (formed on the basis of the results of the questionnaire survey)	

Since the introduction of climate-neutral technologies is aimed primarily at achieving the effect of decarbonization in *green* energy and the units of measurement are not economic, but of an environmental one, but fuzzy set methods
were used to develop a methodology for determining the sustainability of climate-neutral technologies including methods of fuzzy cluster analysis. Appropriate characteristics are set to build a fuzzy clustering model.

The criteria according to which the PEST analysis factors are evaluated, we propose to interpret as sustainability indicators (maximum score 5) and vulnerability indicators (minimum score 1) can be characterized as sustainability criteria and vulnerability criteria.

Let a set of objects be given:

$$X = \{X_i = (x_{i1}, x_{i2}, \dots, x_{iM}), i = 1, N\}$$
(3)

characterized by many features:

$$K = \{K_1, K_2, \dots, K_M\},\$$

i.e., x\_ij is the value of the j-th feature (influence factor) for the i-th object (stakeholder). It is necessary to divide this set into G fuzzy clusters according to a given criterion, i.e. to construct an algorithm  $\Theta$ , the execution of which would allow determining the degree of belonging of an object to each of the clusters, i.e.

 $X_i \to (\mu_1(X_i), \mu_2(X_i), \dots, \mu_G(X_i))$  where  $??_g(X_i)$  is the belonging degree of the object  $X_i$  of the cluster numbered g,  $g = \overline{1, G}$ , and  $X_i \sum_{g=1}^{G} \mu_g(X_i) = 1$  (Mulesa, 2015).

The rationale for using fuzzy cluster analysis of factors influencing the resilience of critical climate-neutral technologies is that there is no clear description of the criteria list for determining the economic, social and environmental effects into which PEST analysis is broken down. "The method of fuzzy c-means (FCM method: fuzzy cmeans) is used to solve the formulated problem, which, for solving the problem of fuzzy clustering, has an iterative character of sequential improvement of a certain initial fuzzy partition  $R(A) = \{A_v | A_v I A\}$ , which is set by the user or generated automatically according to a certain heuristic rule. At each of the iterations, the values of the belonging functions of fuzzy clusters and typical representatives are recursively enumerated. The FCM method will terminate when a certain finite number of iterations specified a priori is executed or when the absolute minimum difference between the values of the belonging functions at two successive iterations does not become less than some a priori specified value" (Fuzzy logic information site, 2021).

The main difficulty in applying this method, in this case, is that, as a rule, "a significant part of the coordinates of the *Xi* vectors takes non-numeric values, which leads to the need to introduce special functions of the distance between objects. Also, when dividing objects into clusters, it is necessary to consider the clusters' features" (Mulesa, 2015).

In order to determine the number of clusters (we have three of them: environmental, economic and social effects), the factors influencing the development sustainability of critical climate-neutral technologies for energy security are divided into compact and separate (different in quality) groups (clusters) from one another. In this situation, it is recommended to use the Xie-Beni index for the FCM method (Fuzzy logic information site, 2021).

According to the results of the PEST analysis, it was found that the factors of influence (sustainability indicators) in the cluster of economic effect (3,9 points) have priority in determining the sustainability of critical climateneutral technologies. The introduction of energy-efficient technologies in production processes is an opportunity to obtain added value. The next most crucial factor is influence factors in the social effect cluster (3,6 points). The least significant in determining the development sustainability of critical climate-neutral technologies are the impact factors (indicators of vulnerability) in the cluster of environmental effects (2,8 points). This trend is due to the opinion formed among the public that *green* energy technologies are, first of all, energy efficient technologies aimed at obtaining such an innovative effect as the rational use of energy resources.

## Conclusions

The challenge of the post-COVID-19 revitalization for the energy industry is to ensure rapid economic growth, energy security and the transition to climate-neutral development. In this context, there is a shift in priorities regarding primary energy sources towards the transition to energy from renewable sources, contributing to low-carbon development. Given this, among the post-COVID-19 measures to restore the energy sector is the development of climate-neutral technologies in the energy security sphere. At the same time, the prospects for developing such technologies depend on the possibility of obtaining both environmental and economic benefits.

It requires organizational and innovative support for developing critical technologies in the national security sphere within the energy sector transition to climate-neutral development. Calculating the multiplier effect of the climate-neutral technologies' impact on the economy and climate change in energy efficiency is essential. The prospect of developing climate-neutral technologies in energy security lies in the transition to cross-sectoral interaction based on a closed cycle of energy consumption from renewable sources and the use of Industry 4.0 technologies. The suggested methodology for determining sustainability indicators for the development of climate-neutral technologies for energy security through the use of fuzzy set methods will be a tool for further research on the development of organizational and innovative support and substantiation of the economic feasibility of introducing climate-neutral technologies based on clustering of industries and a circular economy.

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# COVID-19: Vaccine Hesitancy in Africa and the way Forward

# COVID-19: konsekwencje powstrzymywania się przed szczepieniami w Afryce

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# Abstract

COVID-19 pandemic took the world by storm in late 2019, scientists and health authorities across the globe struggle to contain the deadly virus. Socio-economic activities across the globe were partly halted as countries around the world introduce various forms of restrictions to contain the spread of the COVID-19 virus. Most developing countries' economies, especially in Africa, slid into recession, unemployment among Africa countries skyrocketed to an all-time high, and famine and starvation were beginning to knock harder on poorer nations around the world. The race to develop a vaccine was pressing harder; developed countries continue to pump more money to help develop a vaccine within the shortest period of time, as that seems the only viable solution to the economic downturn of the global world.

Finally, vaccines were developed and proved to have high efficacy. This has helped reverse the negative trend of the global economy caused by the COVID-19 pandemic. This vaccine faced a lot of global scrutinies; people have refused to get vaccinated and have also rejected the idea of making COVID-19 vaccination compulsory for citizens worldwide. This study analyzes the challenges posed by this ugly trend of COVID-19 vaccine hesitancy in African countries, its socio-economic consequences and the way forward.

**Key words:** hesitancy, economy, COVID-19, Africa, vaccines **Slowa kluczowe:** wahanie, ekonomia, COVID-19, szczepionki

#### Introduction

The world health organization (WHO) was first informed of pneumonia cases in Wuhan city by the Chinese government on December 31 2019. The causes were unknown when it was first reported (Africa-CDC, 2020). This unknown virus was later identified as a novel coronavirus by the Chinese health authorities on January 7 2021, and it was tagged 2019-nCoV, before it was fully named COVID-19 virus (Nordling L, 2020). Since the discovery of the new COVID-19 virus in Wuhan, China, there has been a rapid and widespread of the COVID-19 virus across the globe, calling into question if the Chinese authorities reported the discovery of the virus at the right time (WHO, 2020). The widespread of the COVID-19 virus lead to several countries putting up stiff measures to help curb and mitigate the effect of the novel coronavirus on their economy.

In European countries, especially Italy, Spain and Greece, there was a total lockdown of the economy, and the movement of people was restricted (Oppenheim et al., 2019). Schools and Universities were not left out as the world struggled to contain the rampaging spread of the COVID-19 virus. During the first wave of the COVID-19 virus in Europe, Italy alone experience over hundred and thirty thousand dead, with millions of people testing positive to the COVID-19 virus, making Italy the second Country in the world aside from China with the highest COVID-19 tatality rate (Nkengasong & Mankoula, 2020) The U.S. wasn't left out of the raging spread of the deadly COVID-19 virus, hospitals were filled up, and the emergency unit could no longer cope with the large number of people requiring to be admitted into the intensive care unit (ICU) (Daou M, 2020). Several makeshift centres were set up to handle people requiring hospital admission. Health personnel were stretched beyond their normal capacity, and the battle with the COVID-19 virus was becoming freighting, without a cure or vaccine readily available.

In Africa, the COVID-19 virus was first discovered in Egypt (Gilbert et al., 2020) before it hit several other African countries. This led government in the region to introduce several measures to help contain the spread of the deadly virus in the region. These measures were a bit successfully but had an adverse effect on the socio-economy wellbeing of the continent. The economy of South Africa, Nigeria, Ghana and Tanzania begins to contrast in the second quarter of 2020 due to the adverse effect of the measures introduced to help minimize the spread of the COVID-19 virus (Cheema, 2020). African countries were forced to relax the initial measures introduced to help reduce the transmission of the deadly virus, as its effect was biting harder than their economy could handle (Riotta C, 2020). This led to more positive cases during the third quarter of 2020 (Omeiza, 2020). Africa as a whole is prone to so many setbacks from COVID-19; this is partly due to the fact that most African countries are mono-economy, which lacks true economic diversification. The region was the last to be hit by the COVID-19 virus, probably due to its poor healthcare system and its inability to detect the virus on time. The region was already suffering from the impact of COVID-19 due to its trade links with Europe, Asia, and America being partly shut as a result of the restriction introduced in those regions. This paper analyses COVID-19 vaccine hesitancy in Africa, its effect on the economic wellbeing of the region and proffer solutions.

## 1. The Fear of COVID-19 Vaccination in Africa

The development of vaccines against the COVID-19 virus was a huge relief to the world, as the pandemic has almost crippled the world economy. Its arrival rejuvenates the world and gives hope to poorer nations, especially those countries whose internally generated revenue depends entirely on foreign tourists. Due to travel restrictions by European countries, Kenya alone lost about eight billion of its annual income from tourism (Hairsine K, 2020). The AstraZeneca/Oxford vaccine developments are more than welcome in most African countries, but there became the COVID-19 hesitancy in Africa (Daou M, 20 C.E.). Why are people scared of getting vaccinated, even after most of the vaccine developed has gotten WHO greenlight? Can we afford to live comfortably with the deadly COVID-19 virus? The answer is a capital no; Africa can't afford a huge number of its population not taking the COVID-19 vaccine. That will spell doom for the economy of the region, and Africa will become a breeding ground for health catastrophe (Lukman Ahmed Omeiza & Salawudeen Ahmed Tijani, 2019).

Most of the problems associated with COVID-19 hesitancy in Africa and, by extension, the world at large can be traced to China. During the early stage of the virus in Wuhan, the Chinese health authorities believed that not much was done to contain the deadly virus (Glassman A, 2020). The time the virus was reported to the world health authorities was questionable, and there was this general belief that the virus was reported late to the world health organization (WHO) (Rage S, 2020). At the time the virus was reported to WHO, it had already gone out of control, forcing the world health organization to declare a global health emergency. This lack of transparency in reporting the virus at the early stage by the Chinese health authorities created a sort of vacuum, and people began to doubt if the virus truly existed. Couple with the speed at which the virus was spreading to other nations, this further heightened the nation of many people around the world that the COVID-19 virus could be a mere hoax (Holmes C et al., 2020a)

Careless political statement by the political elite in the region doesn't help matters. A former U.S. president was quoted to have said that the COVID-19 virus was a China problem and doubted if it truly ever existed until America got hit by the deadly virus (Holmes C et al., 2020b). An African leader was said to have compared the deadly virus to mere flue and Malaria that has been around the region for a longer period of time and that there isn't anything

to worry about the COVID-19 pandemic (Abia A, 2020). African political classes tend to be more concerned about their political survival rather than putting an end to the deadly virus, thereby making several unguided statements. There were also a lot of concerns over vaccine development and its safety (MOE, 2018). A larger number of people question the speed at which several vaccines were developed and why there have been no vaccines for other equally deadly diseases, like Malaria and HIV/AIDS, which have been in our midst for decades. The deadly Ebola virus and laser fever all have no vaccines or cure, but the world was able to rally together and develop a vaccine for the COVID-19 virus within a period of one year. All this has caused a lot of misinformation within the populace, and getting people to take the vaccine willingly has become a challenge for health authorities in the region. The safety of vaccines developed is also a sort of concern, as there has been a well-documented report of blood clotting from the AZTRA COVID-19 vaccine. The emergency approval given by some countries for the use of the COVID-19 vaccines, despite vaccines not going through the three stages of the clinical trial, has also compounded the misery. In Russia, people were strongly against taking the SputnikV (COVID-19) vaccine because it was still in the last stage of a clinical trial when it was approved for emergency use by the Russian government (Hansrod Z, 2020).

# 2. Africa's Economy without the COVID-19 Vaccines

Over the years, the pandemic has had a disastrous and negative effect on the world economy, and their effects tend to outlive the virus itself (Beth P. Bellz et al., 2016). Five decades after the Bubonic Plague of 1348 to1350, the Europe population was much lower than before the pandemic outbreak(Bloom et al., 2013). The effects were devastating for the Europe economy, which resulted in manpower (labour) shortage across European countries and an increase in wage bills; there was also an astronomical increase in the middle class. The flu pandemic of 1918 affected thirty per cent of the world population, killing over six per cent worldwide (San et al., 2020). The United States (U.S.) was the worst culprit of the 1918 flue pandemic (IMF, 2020). Children born during this period were found to attain lower education standards, and there was a high rate of physical disability when compared to children born before this period.

Africa's economy was already in tatters, even though it had not been severely hit by the COVID-19 virus when compared to countries in Asia, America and Europe (Chirisa et al., 2021). The restrictions imposed by countries in that region were already biting hard on the African economy. Cape Verde is the most affected in Africa on a per capita basis; they derive eighteen per cent of its Gross Domestic Product (GDP) from tourism, a sector that has been severely affected by the COVID-19 pandemic. In Kenya, shipments of fresh flowers declined by eighty per cent as the demand from European countries vanished due to Europe COVID-19 related restrictions (Dan-Nwafor et al., 2020). At the beginning of the year 2020, the World Bank projected that the global economy would grow by 2.5 per cent. By June of 2020, that projection has changed to -5.2 per cent (Desson et al., 2021). The tourist-focused economy in Africa was projected to be particularly hard hit, including that of Seychelles, which was originally projected to grow at 3.3 per cent and is now projected to decline by 14.4 per cent (Ullah et al., 2021a). African countries whose economy relies heavily on oil also suffered similar faith. As oil price dropped from USD67 per barrel to USD30 a barrel between December 2019 and March 2020. South Sudan, Nigeria, Libya, Algeria, Mauritania and Gabon's economies went into recession between January 2019 and May 2020 as a result of the plummeting price of crude oil (Ullah et al., 2021b).

An increase in COVID-19 related deficits and debts are attributed to a combination of factors, including reduced internal revenues received by tax authorities and increased spending on fiscal and monetary policies designed to cushion the economic impact of the COVID-19 pandemic. Most African countries already faced a high debt to GDP ratio going into the pandemic, including Eritrea (189 per cent), Cape Verde (124 per cent) and Mozambique (104 per cent). Estimates are that the COVID-19 pandemic will cause the loss of an additional USD500 billion in Africa as a result the pandemic, leading to further borrowing and additional debt (Akpoji et al., 2022a).

The education sector has been heavily retard in most African countries. Schools in the region, unlike in advanced countries in Europe, don't have the facility and capabilities to carry out the kind of learning approach deployed by Western countries (Akpoji et al., 2022b). The study from home, which requires an online platform and a lot of technicalities, is not readily available in African Schools. Thereby leading to a total shutdown of Schools for the better part of the year 2020. Studying from home wasn't just possible in African countries starting from the lack of constant electric supply to decaying infrastructure; even in European countries that adopted the virtual learning platform, a lot of challenges were faced with courses that required field trips and practical classes (Akpoji et al., 2022). Most of these courses were pushed forward to the next semester, yet there were a lot of technical difficulties on the part of both the technicians and students, as the number of students will have to double for most of these technical classes in the next semester. Schools in South Africa, Ghana, Tanzania, Gabon and Nigeria were completely closed down for a period of six months. The situation was deicer in Nigeria as the entire first semester of the 2019/2020 academic cycle was cancelled. This creates an academic gap in the student's educational progression, which cannot be filled, leading to one more semester for all the students involved (Akpoji et al., 2022).

The health sector also suffered severe consequences, as more attention was given to COVID-19 patients, to the detriment of other deadly diseases. This causes another health challenge for the healthcare providers, as people continue to die from other ailments due to a lack of adequate attention by medical personnel (MacFarlane et al.,

2022). Hospitals in the region were also overwhelmed by COVID-19 patients. Medical researchers also switched attention to COVID-19 research, literally making the gains achieved in other equally deadly ailments suffer a huge setback (Petersen et al., 2021).

There is no gain saying the economy of Africa as a whole would have been in a state of comatose without the COVID-19 vaccine. The discovery of the COVID-19 vaccines was a huge relief to African leaders and economic experts in the region. What was more pressing at that time was getting the required funds to purchase the vaccines and get a huge number of its population vaccinated so that the economy could begin its recovery process. Suddenly, appeared the COVID-19 hesitancy in the region. According to a report in Kenya, fifty-five per cent of Oxford/Astra vaccines got expired because health professionals could not administer them to the populace, as people were not willing to get vaccinated (Bair, 2022). Even with the vaccines being free, people were not just ready to get vaccinated; with the already dangerous delta variant of COVID-19 in the region, Africa can't afford a second lockdown of its economy. The only option left is getting people within the region to be vaccinated, as time isn't on the side of policymakers in the region. The Delta variant of the COVID-19 has killed more people in South Africa in the second wave and seems to be more contagious than the first wave of COVID-19.

Since the beginning of the second wave of COVID-19 in Africa, largely caused by the more deadly delta variant, the African Union (A.U.) has increased its campaign to get more people vaccinated, as the region can't afford a second lockdown, outlining the dire economic consequences on the sustainable development goals of the region. This has yielded little or no effect, as people are not just willing to take the vaccines out the fear of the unknown; despite the limited availability of the vaccines in comparison to the population ratio, many got expired and has to be destroyed(Dudhill & Pillai, 2022). This is basically due to a larger population refusing to get vaccinated.

#### 3. Way Forward

Concerned by COVID-19 hesitancy in the region, a detailed survey was conducted by the Department of Biochemistry, Kogi State University Anyigba, in conjunction with the Science Lab Technology Department, Federal Polytechnic Bida, to help understand the intrigues behind the COVID-19 hesitancy in the region and proffer possible solutions that could be employed by political leaders in Africa to help get a larger number of its population vaccinated. The online survey was conducted in June 2021, with a total number of eight thousand eight hundred and four people taking part the survey. Patent questions were asked based on people's perspectives on COVID-19 vaccines. These questions range from safety concerns of the vaccines, doubts on virus existence, vaccines not of African origins, religious beliefs and lack of clarity on the origin of the virus. The online survey was divided into two sections; the first part tries to understand the reasons behind people's scepticism towards COVID-19 vaccines, their fears, worries and concerns. The second part of the survey allowed the people to proffer answers to their skepticisms. This allows the study to develop a solution that will be people-driven and have maximum effect on the future roadmap to get millions of people vaccinated in Africa. The table.1 below shows the names of institutions and the number of people that took part in the online survey from each institution across the region.

S/N	Institutions	Country	Number of Participants
1	Kogi State University Anyigba	Nigeria	3784
2	Federal Polytechnic Bida	Nigeria	1579
3	Atebubu College of Education	Accra	1255
4	University of Khartorum	Sudan	812
5	University of Fort Hare	South Africa	524
6	University of Pretoria	South Africa	519
7	ESCAE University	Benin Republic	411
8	Catholic University of Bukavu	Congo	404
9	Total		8884

Table 1. Total number of staff and students that participated in the survey

Figure 1 shows the data distribution of people from each institution that took part in the survey. A demographic survey was employed to help understand the opinion of people on the various concerns and to help answer patent questions on COVID-19 hesitancy in Africa.

Figure 2 gives a holistic view of people's perspectives on why they will not take the COVID-19 vaccines.

It's crystal clear that COVID-19 hesitancy in Africa is a real and urgent solution that needs to be put forward by policymakers to help allay the fears and concerns of the people. Vaccines safety is of utmost concern to the people in the region. There are well-documented cases of blood clotting and other side effects associated with the Astra-Zeneca/Oxford vaccine; health officials in the religion have failed woefully to provide answers to this puzzle [38]. Again, the emergency approval given to some of these vaccines during the clinical trial has also made people believe that these vaccines were not properly developed. Hence they are not safe. Health provider in Africa needs to work with the government information department to create awareness of vaccines' efficacy and safety in order for the vaccines to get the trust of the people. People should be made to understand that no vaccine in the world has a hundred per cent efficacy, and none of the COVID-19 vaccines has less than eighty per cent efficacy (Ullah



Figure 1. Chart showing numbers of participants in the online survey



Figure 2. The possible reason for COVID-19 vaccines hesitancy in Africa

et al., 2021c). The WHO has satisfied all these vaccines and approved them to be safe, just like every other vaccine approved by it. This mistrust of CVID-19 vaccines is a result of a lack of adequate information on their safety, thereby forcing people to hold on to whatever misinformation they have gotten on the vaccines. Since information is key, healthcare providers need to educate our students, farmers, traditional leaders, religious leaders, government agencies and market women on the safety of these vaccines. In the remark section of the survey, people also complained about the government not being ready to address their fears and complaints; rather than address all the complaints raised, the government is bent on forcing the vaccine on everybody. This has negatively impacted the notion of the people, as they now believe there are other motives from the government rather than the health benefits of the vaccines (Petersen et al., 2021). Africa is now dominated by fake COVID-19 certificates because the government of each country in the religion, in partnership with Africa Union (A.U.), will need to put resources together to effectively enlighten the people across the religion on the safety and efficacy of the COVID-19 vaccines.

It's quite unfortunate that people still doubt the existence of a virus that has killed more than two million people across the globe. This doubt can be traced back to the early stages of the virus in Wuhan, China. The Chinese authority was a bit late in informing the World Health Organization (WHO) about the novel coronavirus (Akpoji et al., 2022). As at the time it was declared a world health emergency, the virus had already spread to other countries, the speed at which the virus was spreading became a source of concern, and people began to doubt its existence. Several studies have also provided insight into this belief; from the findings of these studies, it was agreed that the virus must have been in existence several months back before the Chinese authorities decided to inform the world. This can only be addressed through a proper government sensitization program on the COVID-19 virus; information is key to unlocking the COVID-19 hesitancy in Africa. A logical and well development program is desperately needed on the side of our policymakers to help get a huge number of the population vaccinated.

Since these vaccines are not manufactured in Africa, there are also considerable fears based on the survey results that this vaccine might not serve the interest of the region. Governments across the religion need to educate Africans that COVID-19 is a global pandemic that requires a united effort across the world. COVID-19 is not confined to any region, and its vaccine origin should not bring any sort of controversy. Moving forward, the African Union (A.U.) needs to develop a roadmap that will ensure that most of the COVID-19 vaccine manufacturing companies

are situated in the region. This will go a long way in changing people's perspectives about the vaccines and also help with easy distribution logistics across the continent.

The Gantt chart summarizes people's responses to taking the vaccines across the region if their concerns are adequately addressed.

S/N	Description	Get vaccinted (20%)	Get vaccinated (40%)	Get Vaccinated (60%)	Get Vaccinated (80%)	Get vaccinated (100%)
1	Religious believe			<b>T</b> 7	1 1 1	
2	Virus does not exist			Und	lecided	
3	Vaccines not Manufactured in Africa					77 1 1 1 1
4	Vaccines safety					Undecided
5	Origin of Virus not known				Undecided	

Figure 3. Gantt chart showing the percentage number of people that will take the COVID-19 vaccines if their concerns are addressed

Figure 4 gave a simple process flow that, if adhered to, will go a long way in solving the problem of COVID-19 hesitancy in Africa. The government in the region will need to develop a timeframe for their COVID-19 vaccination program. A team on COVID-19 sensitization will need to be formed to address people's fears and sensitize them on the benefits of being vaccinated. A holistic report on the effects of the vaccines will also need to be made ready so that the government team will be able to address the problem of vaccines' safety with more clarity. This will gain the people's trust, and the government's coarse attitude toward COVID-19 vaccination will also need to stop in order not to give the wrong impression.



Figure 4. Vaccination flow process

# 4. Discussion

The study was carried out to help understand the reasons behind the rise in COVID-19 vaccine hesitancy in Africa and fashion ways through which an effective COVID-19 vaccination can be achieved in the region. It's no doubt that the African economy and its sustainable development goals have suffered a lot from the impact of COVID-19. The urgent need to find a way around this ugly development of vaccine hesitancy can't be overemphasized; the region can't afford to be isolated if its people refuse to be vaccinated.

With the help of the online demographic survey, we were able to understand some of the patent questions posed by COVID-19 vaccine hesitancy in Africa and solutions were offered. This will help reduce all the challenges associated with the setback that the vaccines have recently suffered in the region. Why vaccine hesitancy is not going to vanish within seconds, there is a need to tackle them right away in Africa. As the catastrophic effect on the economy will be damaging to the socio-economic development of the region.

#### 5. Conclusion

Based on the result of the study, it's crystal clear that the major reason for COVID-19 vaccine hesitancy in Africa is inadequate information on vaccine safety and the virus itself. Eighty per cent of the people that participated in the survey said they would take the vaccines if their concerns on COVID-19 vaccines were addressed and if vaccine manufacturing plants were situated in the region.

The study recommends a step by step approach to COVID-19 vaccination in Africa, as illustrated in figure four. The African Union (A.U.), in collaboration with the member state, are expected to form a committee on COVID-19 sensitization in the region. This will help address all the concerns raised by the people, and a smooth road to vaccination will be paved. This study also discourages forceful vaccination, as this tends to create a different notion among the populace. If Africa's economy is to sustain its current economic gains amidst the COVID-19 pandemic, getting a larger number of its population vaccinated will be key to future economic survival.

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# Impact of Entrepreneurship on Sustainable Development in Emerging Markets under the Conditions of COVID-19

# Wpływ przedsiębiorczości na zrównoważony rozwój na rynkach wschodzących podczas pandemii COVID-19

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# Abstract

This paper investigates the contribution of entrepreneurship to sustainable development and economic growth in emerging markets in the period before and during the COVID-19 pandemic. Additionally, the importance of various measures implemented by entrepreneurs and governments as responses to the changing environment in the COVID-19 pandemic is examined. By employing the data for 20 emerging markets, the findings revealed that only high-growth-expectation entrepreneurship (HEA) had a significant contribution to economic growth before the pandemic, but this relationship became negative during the COVID-19 crisis. Furthermore, this research pointed out that sufficient responses to the COVID-19 pandemic could be a useful instrument to encourage the development of entrepreneurship and revive the economy in the post-COVID period in emerging markets.

Key words: COVID-19, sustainable development, economic growth, entrepreneurship, emerging markets Słowa kluczowe: COVID-19, zrównoważony rozwój, wzrost ekonomiczny, przedsiębiorczość, rynki wschodzące

# 1. Introduction

Over the previous two years, the world has worked to contain the unprecedented health and economic crises brought by the COVID-19 pandemic. At the time of this paper release, the outlook for the pandemic and the path to economic recovery remains highly uncertain. In this context, the ongoing health of the economy remains a primary concern for economic policymakers. Previous research shows that entrepreneurship is one of the key drivers of economic growth and sustainable development. But bearing in mind the fact, that the COVID-19 pandemic presents a great challenge for all aspects of society, as well as for entrepreneurship, its role in sustainable development is also unclear.

We assume that the negative trends in the field of entrepreneurship have reduced its contribution to economic growth under the conditions of COVID-19. Many small businesses were closed by December 2021, especially firms in hospitality, retail, personal services, entertainment, and the arts industry, and in addition all SMEs were affected with an average 20% decrease in sales and a 16% decrease in customer base (Digitally Driven, 2021). Also, there was an increase in gender inequality in the field of entrepreneurship in the context of the COVID-19 pandemic, due to female owners of small businesses facing 35% higher losses than their male counterparts, largely explained by the fact that women disproportionately work in industries that are more severely affected by the

COVID-19 pandemic (Graeber et al., 2021). It caused a negative impact of entrepreneurship on sustainable development.

On the other hand, the emergence of digital technologies has significantly reduced the costs of entrepreneurs and offered opportunities for new business during the COVID-19 pandemic, due to the changes in people's lifestyles (Liguori & Winkler, 2020). Entrepreneurs able to create a platform-based ecosystem, have become a force of creative destruction (Acs et al., 2021). Also, rapidly evolving medical technologies and new ways of handling the COVID-19 crisis offered opportunities for entrepreneurs to start new businesses (Kuckertz et al., 2020). This led to an increase in the number of entrepreneurs. For all of these reasons, there is a general gap in the understanding of the effects of entrepreneurship on sustainable development under the conditions of COVID-19. The subject of this paper is to examine the influence of the COVID-19 pandemic on the relationship between entrepreneurship and sustainable development in emerging markets.

We choose emerging markets since there is no strong empirical evidence that the link between entrepreneurship and sustainable development is strong and statistically significant, and further empirical research is desirable. Furthermore, this group of markets is becoming a very strong competitor in the global market, thanks to their rapid development (Aizpun et al., 2019), and a global economy needs to understand drivers of their sustainable development which can revive the economy in the post-COVID-19 period. This paper supports these considerations with a statistical analysis, based on regression models on the panel data for the period 2011-2021, as well as cross sectional analysis for 2020 and 2021 in the sample of 20 emerging markets. The aim of the paper is to identify factors which can force sustainable development through entrepreneurship development under the conditions of COVID-19 in emerging markets and propose measures that macroeconomic policymakers could implement in order to revive global economy in the post-COVID-19 period.

The paper first gives an overview of literature that links entrepreneurship with sustainable development in emerging markets under the conditions of COVID-19. The next part of the paper presents methodology, the obtained results and the discussion of results and recommendations to macroeconomic policymakers. The final part of the paper presents concluding remarks.

# 2. Literature review and the hypotheses development

The novel coronavirus appeared at the end of 2019 in China. The virus caused the disease COVID-19 which has threatened millions of people's lives all over the world (Worldometers, 2021) and has significantly changed global society (Parnell et al., 2020). Due to the effects of the virus, many healthcare systems collapsed and the World Health Organization declared a worldwide pandemic on the 11th of March 2020. The pandemic had flow-on effects on other sectors as well. Under the conditions of COVID-19, people's lifestyles changed significantly, as well as living and working conditions (social distancing, hand washing, personal hygiene, digital forms of communication, working from home, etc. were promoted). It has had a great negative influence on the economy, particularly the tourism and hospitality industries, which are reliant on close contact between individuals as part of their business models (Belitski et al., 2021). In order to get life back on track, appropriate measures are needed to revive the economy in addition to an adequate cure for the virus. That is why economic policymakers are persistently looking for appropriate economic solutions that will enable them to get out of the crisis and encourage sustainable development.

Previous research has indicated that entrepreneurship is the key driver of sustainable development in developed countries (Valliere & Peterson, 2009; Carree & Thurik; 2010; Van Stel et al., 2018). Entrepreneurs may introduce important innovations, by entering markets with new products or production processes; enhancing knowledge of what is technically viable and what consumers prefer; introducing variations of existing products and services in the market (Van Stel et al., 2005; Williams et al., 2017). Under the conditions of COVID-19, entrepreneurs can use the possibilities offered by digital technology and adapt their businesses more easily than any other business entity to new consumer demands related to the changed lifestyle (Acs et al., 2021). The business creativity and innovations involved in agile and resilient new businesses can help entrepreneurs to find opportunities in the turmoil that the pandemic has caused globally (Zahra, 2021). Also, resulting learning process can speed up the discovery of the dominant design for product-market combinations enabling knowledge spillovers, stimulating economic growth and revitalization of the economy in the post-COVID-19 period. Bearing in mind the fact that several previous empirical studies have proven that entrepreneurship is an engine of economic growth and sustainable development, in developed countries, many of their economic policymakers have implemented measures to support the development of entrepreneurship under the condition of COVID-19.

However, the situation is much different in emerging markets. There is no strong empirical evidence that the link between entrepreneurship and sustainable development in emerging markets is strong and statistically significant (Ivanovic-Djukic et al., 2022). Most theoretical studies explain that entrepreneurship has a significant role in economic growth, but the results of empirical research are diverse. For example, studies conducted by Tang & Koveos (2004), as well as Zaki & Rashib (2016), showed a negative correlation between entrepreneurship and economic

growth in emerging markets, while research conducted by Valliere and Peterson (2009) showed that this relationship is positive, but insignificant. For that reason, there is no clear picture of the role and importance of entrepreneurship in economic growth and sustainable development in emerging markets. Bearing in mind the fact that emerging markets are becoming very serious players in the global market (especially Russia, China, India, Brazil), it is very important to analyze the drivers of their sustainable development, and predict whether entrepreneurship can be one of the instruments for economic recovery in the post-COVID-19 period.

We believe that the situation in emerging markets, as well as relationship between entrepreneurship and economic growth has changed significantly in recent years, due to the fact that income per capita in most of emerging markets has increased (the relationship between entrepreneurship and economic growth is caused by income per capita and stage of economic development, and it appears to be U-shaped) (Valliere & Peterson, 2009). Hence, the first hypothesis is:

**H1.** Entrepreneurship has a significantly positive impact on sustainable development in emerging markets and it can contribute to the economic recovery in the post-COVID-19 period.

The COVID-19 pandemic has become a challenge for all economic entities, including entrepreneurs. Many economies were in lockdown, with international travel restricted or banned, and many shops, restaurants, and hotels closed. It has created a huge number of problems for entrepreneurs in these areas. In addition, people were increasingly encouraged to work from home. For these reasons, many established businesses were hit hard, as orders drained away, and many new businesses were inevitably stillborn as markets evaporated (Ratten, 2020).

On the other hand, home deliveries boomed, both from online shopping and from a sharp rise in takeaway food deliveries. At the same time, new opportunities emerged with an initial and ongoing massive consumer demand for sanitizing products and protective personal equipment, followed rapidly by demand for online education and entertainment, then for online sales. According to GEM data, TEA was significantly lower in 2020 compared to 2019 in some emerging markets, such as Poland, Chile, Israel, but in some of them, such as Colombia, Panama, Egypt, TEA in 2020 was higher compared to 2019 (Bosma et al., 2020). This can be seen in Figure 1.



Figure 1. Levels of total early-stage entrepreneurial activity in 2019 compared to 2020 (Bosma et al., 2020, p. 42)

In 21 economies, out of the 35 examined economies, there was a fall in TEA between 2019 and 2020. While many of these falls were modest, others were much more dramatic. However, over the same period, in 14 economies there was an increase in TEA, including four economies in which TEA increased by more than a quarter. Three of them were emerging markets (Egypt, Panama, and Colombia) (Bosma et al., 2020).

At the first glance, it is uncertain what impact the COVID-19 pandemic had on entrepreneurship and how it affected the relationship between entrepreneurship and sustainable development. However, when you bear in mind the fact that many established businesses ceased to work, the situation is clearer. Also, the negative impact of the COVID-19 pandemic is confirmed by a large number of exits. There were six economies, such as: Panama, Saudi Arabia, India, Kuwait, Chile, and Poland, in which the pandemic is cited as the most important reason for exiting. The impact of COVID-19 pandemic on the establishment and stopping new business is shown in Figure 2.



Figure 2. Attitudes and perceptions in an age of COVID-19 (Bosma et al., 2020, p. 186-189)

It is obvious that there were more entrepreneurs who stopped a business due to the pandemic than those who started a new business in most emerging markets. At the same time, there were many entrepreneurs pursuing new opportunities due to pandemic. As a result, the level of established businesses increased rapidly in some emerging markets. For example, in Qatar, it was more than doubled and, in Egypt, more than tripled. This fact blurs the picture of the impact of the pandemic on entrepreneurship. But, when we take into account TEA in 2021, it is noticeable that its level has decreased in most emerging markets compared to 2019, especially in countries with higher levels of income per capita. For that reason, our second hypothesis is:

**H2.** The contribution of entrepreneurship to sustainable development and economic growth is lower under the conditions of the COVID-19 than in the previous period.

Many entrepreneurs and governments worldwide responded to the changed environment in the pandemic (Bosma et al., 2020). Entrepreneurs have implemented various organizational changes in response to the COVID-19 pandemic (Hill et al., 2021). For example, most of them adopted digital technologies and developed strategic, managerial, and digital skills to increase their efficiency (Audretsch & Belitski, 2021). A very dynamic response was the transformation of business models introducing business model innovation, based on digital platforms for ordering, selling, and charging products and services (Clauss et al., 2019). Also, digital communication, as well as online communities, had a very important role in the entrepreneurial response to the COVID-19 pandemic, offering support in: resolving problems, reframing problems, reflecting on situations, refocusing thinking and efforts (Meurer et al., 2021). Many entrepreneurs have improved financial performance in the COVID-19 crisis, by focusing on working from home as an opportunity rather than an activity that leads to frustration, loneliness, and worries about the future (Banerjee & Rai, 2020; Zhang et al., 2022). Also, partnerships between small and large firms, open innovation and knowledge spillovers, measures that entrepreneurial ventures undertake to preserve liquidity seems to be very useful forms of the entrepreneurial response to the COVID-19 pandemic (Block et al., 2021).

At the same time, various support policies were developed and provided by governments in response to address the needs of entrepreneurs. The 2020 GEM report mentions that 54 national governments made emergency policy decisions and actions in order to support entrepreneurs in response to the COVID-19 pandemic (Bosma et al., 2020). For example, in the United States, the largest Paycheck Protection Program (PPP) included the provision of funds to small businesses with a volume of \$650 billion during the early stages of the pandemic (Bhutta et al., 2020). In the UK, the government implemented the Coronavirus Job Retention Scheme for waged workers, which covers 80% of employee salaries up to a maximum of £2,500 per month (Yue & Cowling, 2021). German government intent to protect new businesses and start-ups included taxation support, and state-supported short-time work compensation schemes (PWC, 2020; Block et al., 2020). In lot of developed countries there have been programs providing loans to small businesses through banks, credit unions, and other financial institutions to keep small businesses open and retain employees on the payroll (Fairlie & Fossen, 2021).

Situation in emerging markets were similar as in developed countries. In China, measures were implemented in February 2020 when Chinese Central Bank unblocked extensions or renewals of loans to companies and announced a reduction in the banks' mandatory reserve ratio. The government presented a package to support the digitalization of SMEs in the context of the crisis. A wide range of policy measures was announced for SMEs at

the regional level in China, including deferred tax payments for SMEs, reduced rent costs, waived administrative fees, subsidized R&D costs for SMEs, social insurance subsidies, subsidies for training and purchasing teleworking services, and additional funding to spur SME loans (KPMG, 2020). Financial support in Russia was similar to the Chinese. State-owned banks supported small businesses by approving credit lines. These policy instruments can be broadly categorized into loan guarantees, direct lending to small businesses, grants and subsidies, and equity instruments (Liu et al., 2021). Brazilian and Indian governments provided little support to small business.

Many empirical studies, conducted in developed countries, proved that the governmental response has had positive effects on TEA. For example, a study conducted in the US found a positive relationship between loan receipt per business and number of businesses (Fairlie & Fossen, 2021). A study examining the effects of governmental policies on 42,401entrepreneurs and SMEs in UK demonstrated that government financial support may reduce the number of small businesses with negative earnings and allow extending the residual life of small businesses with negative earnings up to 194 days (Belghitar et al., 2021). The similar effects were found in Germany (Block et al., 2020).

According to GEM data, the entrepreneurial response, as well as the governmental response, was different in some emerging markets. But research examining the governmental and entrepreneurial response to the COVID-19 pandemic in emerging markets is very limited. We believe that situation in emerging markets is similar to the situation in developed countries, Also, we believe that contribution of entrepreneurship to sustainable development, as well as the success of TEA, was bigger in emerging markets whose entrepreneurs and governments responded more seriously to the COVID-19 pandemic. Therefore, the third hypothesis is:

**H3.** Appropriate entrepreneurial and governmental responses to the COVID-19 pandemic have a positive and significant impact on TEA and sustainable development.

According to GEM data, the entrepreneurial response to the new condition under COVID-19 was more appropriate compared to the governmental response in emerging markets. For that reason, we believe that organizational changes implemented by entrepreneurs in response to the COVID-19 pandemic had a bigger influence on TEA compared to the measures implemented by governments. Hence, the fourth hypothesis is:

**H4.** The contribution of the entrepreneurial response to the TEA, as well as sustainable development, was bigger compared to the contribution of the governmental response in emerging markets during the COVID-19 pandemic.

## 3. Data and methodology

# 3.1. Research context

Emerging markets can be defined as *economies transitioning from a dictatorship to a free-market-oriented-countries with increasing economic freedom, gradual integration, global marketplace, expanding middle class, improving standards of living, social stability and tolerance, as well as, increasing cooperation with multilateral institutions* (Kvint, 2009, p. 27). They include very diverse countries in different geographic areas, such as East Asia, Eastern Europe, and Latin America (Bruton et al., 2008), which have common characteristics, such as the following: low-income, rapid-growth, economic liberalization, high level of volatility, underdeveloped institutional infrastructures etc. (Peng, 2001; Aulakh & Kotabe, 2008; Yamakawa et al., 2008; Bruton et al., 2013).

These common macroeconomic characteristics have a great influence on entrepreneurship, as well as relationship between entrepreneurship and sustainable development (Bruton et al., 2008). For example, high level of volatility (pace at which prices move higher or lower), leads to an increase in economic instability that distorts the development of entrepreneurship. Also, insufficiently developed capital market and financial institutions make serious problems to entrepreneurs in acquiring capital to start and develop their business (Szirmai et al., 2011; Guegan et al., 2014). Additionally, emerging markets yet have had a problem with underdeveloped institutional infrastructures, such as legal systems and trade policies, presence of grey economy, corruption, unfair competition, non-incentive tax system, discriminatory legislation, unstable legal and political system, underdeveloped market economy mechanisms, etc. (Cuckovic & Bartlett, 2007; Bruton et al., 2008; Tracey & Phillips, 2011). Such institutional gaps and lack of resources have stimulated development of informal entrepreneurship (Yamakawa et al., 2008; Tracey & Phillips, 2011).

Thanks to a number of measures implemented, in recent years there has been an improvement in the macroeconomic environment, increase in income per capita and the development of entrepreneurship in emerging markets. They are becoming a very serious player on the global market (Lu et al., 2010). In 2021, the GDP of the emerging markets amounted to around 38.85 billion US dollars, which is approximately 41% of the total global GDP (Statista, 2022). Also, emerging markets account for 34% of global nominal GDP and 46% in PPP terms (Duttagupta & Pazarbasioglu, 2021). The World Bank predicts that emerging markets will account for half of the world's economic growth by 2025 (Lin, 2011). Given the growing importance of emerging markets, the analysis of the drivers of their economic growth and possible revitalization measures under the COVID-19 condition has become a very serious task of the researchers (Lu et al., 2010).

#### 3.2. Sample characteristics

There is no universal consensus on exactly which countries qualify as emerging markets. For example, Morgan Stanley Capital International Emerging Market Index qualifies 25 developing countries as emerging markets including Brazil, Chile, China, Colombia, Czech Republic, Egypt, Greece, Hungary, India, Indonesia, Korea, Kuwait, Malaysia, Mexico, Peru, Philippines, Poland, Qatar, Russia, Saudi Arabia, South Africa, Taiwan, Thailand, Turkey and United Arab Emirates (MSCI, 2021). The International Monetary Fund (IMF) classifies 20 countries as emerging markets, Standard and Poor's (S&P) classifies 25, and Russell classifies 24 countries as emerging markets, while Dow Jones classifies 25 countries as emerging markets.

We have selected 20 countries that are common to these lists. An additional reason for the inclusion of these countries in the research is the availability of data. The list of selected countries is presented in Table 1.

	GNI per capita, Atlas method (current US\$)		
Country	2019	2021	
Argentina	11,250	9,070	
Brazil	9,270	7,850	
Chile	14,990	13,470	
China	10,310	10,550	
Colombia	6,570	5,790	
Estonia	23,250	23,170	
Greece	19,650	17,930	
Hungary	16,520	15,890	
India	2,120	1,920	
Indonesia	4,050	3,870	
Latvia	17,790	17,880	
Malaysia	11,260	10,570	
Mexico	9,470	8,480	
Peru	6,790	6,030	
Poland	15,360	15,240	
Russia	11,250	10,690	
Slovak Republic	19,230	18,920	
South Africa	6,670	6,010	
Thailand	7,260	7,040	
Uruguay	17,760	15,790	

Table 1. Countries included in the study and GNI per capita in 2019 and 2021 (World Bank, 2022)

## 3.3. Research model and variables

In order to verify defined hypotheses, several regression models are applied. The first model examines the impact of total entrepreneurial activity (TEA) on sustainable development index (SDI), respectively. Other two models examine the impact of TEA and high-growth expectation entrepreneurship (HEA) on GDP growth before and during the COVID-19 crisis, respectively. All models include control variables for capital and labor (unemployment). The last three models examine the impact of entrepreneurial and governmental response on TEA under the COVID-19 condition in all emerging markets, as well as by clusters of emerging markets depending on the intensity of the response to the COVID-19 pandemic. Also, all models include control variable – National Entrepreneurship Context Index (NECI). The variables employed in the regression models are presented in Table 2.

Table 2. Varia	ables employe	ed in the reg	gression mode	ls (authors'	presentation)
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Variable	Variable Type	Model
Sustainable development index (SDI)	Dependent	M1
GDP growth rate (r)	Dependent	M2, M3
GDP per capita (GDPpc)	Control	M1, M2, M3
Inbound FDI per capita (FDIpc)	Control	M1, M2, M3
Gross capital formation per capita (GCFpc)	Control	M1, M2, M3
Unemployment (UNE)	Control	M1, M2, M3
National Entrepreneurship Context Index (NECI)	Control	M4, M5, M6
Total contrastance antronnon curicil activity (TEA)	Predictor	M1, M2
Total early-stage entrepreneurial activity (TEA)	Dependent	M4, M5, M6
High-growth-expectation entrepreneurship (HEA)	Predictor	M3
Entrepreneurial response (ER)	Predictor	M4, M5, M6
Governmental response (GR)	Predictor	M4, M5, M6

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# 4. Results and discussion

# 4.1. Results

The impact of entrepreneurship on long-term sustainable development is examined by employing the regression model M1. The sustainable development index (SDI) is chosen as a dependent variable. The SDI evaluates each country's total performance on the 17 sustainable development goals, with each goal given equal weight. The score indicates where a country stands in relation to the worst possible outcome (0) and the best outcome (100) (Sachs et al., 2021). Entrepreneurship is measured as GEM total entrepreneurial activity rate (TEA), defined as the percentage of individuals aged 18-64, who are either nascent entrepreneurs or owner-managers of a new business – younger than 42 months (Hill et al., 2021). Control variables used include the level of GDP per capita, inbound foreign direct investments per capita, gross capital formation per capita, and unemployment rate. These data are taken from the World Bank's database. All variables are used as average data for the period 2011-2020. Results are presented in Table 3.

Model 1 shows that an increase in TEA leads to the increase of sustainable development (if the TEA increases by 1%, the SDI will increase by 0.276), and this impact is statistically significant (p<0.05). This model explains 87.1% changes in SDI and F test confirms that it is statistically significant (18.834). The Tolerance and VIF statistics indicate that there is no problem of multicollinearity, whereas Durbin-Watson statistics show no autocorrelation in data. Based on these results we can accept the first hypothesis, i.e., entrepreneurship has positive and significant impact on sustainable development in emerging markets.

Model 1	Coefficient	t	Sig.	Tolerance	VIF		
Constant	54.429	20.077	0.000			<b>R</b> <sup>2</sup>	Adj. R <sup>2</sup>
GDPpc	0.001	4.559	0.000	0.298	3.354	0.871	0.824
FDIpc	-0.001	-0.931	0.367	0.721	1.387	F test	Sig.
GCFpc	0.001	1.551	0.143	0.319	3.131	18.834	0.000
UNE	-0.022	-0.233	0.819	0.877	1.141	Durbin	n-Watson
TEA	0.276	2.624	0.020	0.801	1.249	2	.303

 Table 3. Impact of entrepreneurship on the sustainable development (authors' calculations)

In order to verify the second hypothesis, we created the regression model M2. Since there is no data for the SDI for each year individually, we chose the GDP growth rate as a dependent variable, while TEA was independent variable. In order to measured impact of the COVID-19 pandemic on the relationship between entrepreneurship and economic growth, we included dummy variable for TEA during COVID-19 pandemic. Since the results showed that the impact of TEA on economic growth is not statistically significant, we examined additionally, impact of high-growth-expectation entrepreneurship – HEA (the percentage of entrepreneurs who expect to employ at least 20 people in five years from now) on GDP growth (because previous research showed that it was the form of entrepreneurship that had the largest contribution to the economic growth). Thus, the regression model 3 was created. The GDP growth rate is chosen as a dependent variable, while HEA was independent. The second dummy variable is created in order to capture the effects of the COVID-19 crisis on HEA. These regression models employ data for the period 2011-2021 for 20 emerging markets, comprising a balanced panel. The same control variables are used as in the previous model (M1). Missing values for some of the indicators are estimated based on the values of these indicators in previous years. Test results for choosing the appropriate panel regression model are presented in Table 4.

Table 4. Test results for choosing the appropriate model (authors' calculations)

Model	F-test	Breusch-Pagan LM	Hausman	
	H <sub>0</sub> : Pooled, H <sub>1</sub> : FEM	H <sub>0</sub> : Pooled, H <sub>1</sub> : REM	$H_0$ : REM, $H_1$ : FEM	
Model 2	3.06	14.02	7.54	
	(0.0001)	(0.0001)	(0.2735)	
Model 2	2.75	15.64	2.27	
Model 5	(0.0003)	(0.0000)	(0.8932)	

Note: p values in ( )

Based on the obtained results it is determined that REM is appropriate for fitting analyzed data. The results of the regression models are presented in Table 5.

According to Model 2, TEA has the positive impact on economic growth before COVID 19 crisis (if TEA increases by 1% the GDP growth rate will increase by 0.05%), but it is statistically insignificant. However, due to the COVID-19 crisis TEA has negatively influenced the economic growth. An increase in TEA by 1% leads to the

Dependent Variable: SDI

decrease of GDP growth rate by 0.4% due to the COVID-19 crisis. The model is statistically significant as confirmed by the Wald test (274.44). In this model, the individual specific error can explain 19.5% of entire composite error variance.

	Model 2	Model 3
Constant	4.76176* (4.20)	5.19076* (5.38)
GDPpc	-0.00024* (-4.67)	-0.00024* (-4.38)
FDIpc	-0.00017 (-1.57)	-0.00019 (-1.66)
GCFpc	0.00135* (4.48)	0.00122 (3.72)
UNE	-0.12449* (-2.88)	-0.18291* (-3.74)
TEA	0.05230 (1.41)	
TEAC	-0.45004* (-13.88)	
HEA		0.04958** (2.07)
HEAC		-0.25665* (-12.39)
Θ	0.45942	0.47191
Р	0.19498	0.20545
Wald test	274.44*	224.49*

Table 5. The impact of entrepreneurship on economic growth (authors' calculations)

Note: z values in ()

\*, \*\* at 0.01 and 0.05 significance level respectively Dependent Variable: GDP growth rate

As regards Model 3, HEA has the positive and statistically significant impact of economic growth (p<0.05). If HEA increases by 1%, the GDP growth rate will increase by 0.05%. However, due to the COVID-19 crisis HEA has negatively influenced the economic growth. The model is statistically significant as confirmed by the Wald test (224.49). The individual specific error can explain 20.54% of entire composite error variance.

Three last models were created in order to verify the third and fourth hypotheses. TEA in 2021 is chosen as a dependent variable, while entrepreneurial and governmental response to the COVID-19 pandemic in 2020 were independent variables. The National Entrepreneurial Context Index (NECI) in 2020 is used as a control variable. NECI assesses the average condition of an economy's entrepreneurship environment on a national level. The NECI score for every economy is the arithmetic mean of that economy's EFC scores, therefore it is also assessed on a Likert scale from 0 to 10. A score of 5.0 is often considered as just enough. GEM reacted immediately to the epidemic by adding two additional blocks of relevant items to the NECI. These blocks of questions are intended to emphasize two main areas: first, entrepreneurs' reactions to the pandemic's impacts, and second, governments' reactions to COVID-19's implications. Entrepreneurs are incorporating innovative business models, boosting working from home, modifying their products or services, identifying new possibilities, or intensifying collaboration with other businesses, according to the new questions related to the entrepreneurial response in NECI 2020. Expert responses are then collected into an aggregate reaction, indicating if the entrepreneurial response to the COVID-19 crisis is evaluated as sufficient by the experts. The second set of new questions posed to national experts focused on governmental responses to the pandemic's consequences, including whether governments are effectively assisting businesses in adapting, preventing the loss of firms, protecting employees and consumers, and increasing the digital delivery of regulations (Bosma et al., 2020).

We divided all emerging markets into 2 clusters, based on the response to the COVID-19 pandemic. The first cluster included emerging markets whose government implemented a large number of measures to support entrepreneurs during the COVID-19 pandemic, as well as entrepreneurs themselves introduced a large number of organizational changes in the direction of adapting to the changed environment under the condition of COVID-19 (the grade of 6 or higher is viewed as the sufficient one). The second cluster includes emerging markets whose responses to the COVID-19 pandemic were not sufficient (the grade was up to 6). The list of emerging markets is shown in the Figure 3.



Figure 3. List of emerging markets based on the response to the COVID-19 pandemic (Bosma et al., 2020)

The results of the regression models are presented in Table 6.

Table 6. The impact of entrepreneurial and governmental response to the COVID-19 pandemic on TEA (authors' calculations)

	Model 4	Model 5	Model 6	
	Cluster 1	Cluster 2	All markets	
Constant	-59.695**	-33.077	-39.234**	
Constant	(-2.309)	(-0.658)	(-2.272)	
NECI	5.525	-3.060	-0.806	
INECI	(1.032)	(-0.519)	(-0.316)	
ED	11.551*	10.905	10.269*	
EK	(3.549)	(0.663)	(3.606)	
CD	-5.682	-1.846	-2.159	
UK	(-1.530)	(-0.202)	(-1.248)	
$R^2$	0.650	0.537	0.485	
$Adj. R^2$	0.500	0.288	0.374	
F	4.329**	0.404	4.391**	
Note: t values in ()				

\*, \*\* at 0.01 and 0.05 significance level respectively Dependent Variable: TEA

According to Model 4, ER has the positive and statistically significant impact on TEA, while the impact of GR is negative and statistically insignificant. If ER increases by 1% the TEA will increase by 11.551 (level of significance is 1%). Also, NECI has the positive impact on TEA, but its impact is insignificant. Model explains 50% changes in TEA under the condition of COVID-19. F test confirms that the model is statistically significant (4.329). On the other hand, the impact of ER on TEA is positive, and the impact of GR is negative, but both are statistically insignificant in emerging markets with insufficient response to the COVID-19. Model 5 explains 28.8% changes in TEA under the condition of COVID-19, but it is not statistically significant. Based on these results we can only partially accept the third hypothesis, as the appropriate responses of entrepreneurs to the COVID-19 pandemic have the positive and significant impact on TEA and sustainable development, while the impact of government responses is negative, but statistically insignificant.

According to Model 6, the impact of ER on TEA is positive and statistically significant, whereas the impact of GR is negative and statistically insignificant. If ER increases by 1%, TEA will increase by 10.269 (level of significance is 1%). We can accept the last hypothesis. Model 6 explains 37.4% of changes in TEA under the condition of COVID-19, and it is statistically significant.

#### 4.2. Discussion and policy recommendations

The analysis of the data from GEM on a sample of 20 selected emerging markets confirms that entrepreneurship has the positive effect on sustainable development, as well as on economic growth in emerging markets, but this impact is significant only in case of sustainable development. This is in accordance with the result of prior studies conducted in emerging markets (Valliere & Peterson, 2009; Zaki & Rashib, 2016, Ivanovic-Djukic et al., 2022), but contrary to recent theoretical views (Ramesh, 2018), as well as to our expectations. It can be explained by the fact that the macroeconomic environment in emerging markets has not significantly changed during the last years, and the forms of unproductive entrepreneurship (informal and necessity driven entrepreneurship) are still dominant in TEA. For these reasons, TEA have the significant contribution to the GDP growth is not significant. The significant contribution to the GDP growth in emerging markets has only HEA. The results for relationship

The significant contribution to the GDP growth in emerging markets has only HEA. The results for relationship between HEA and the GDP growth is similar with the results of studies conducted in developed countries, but

different compared to the results obtained by prior research in emerging markets (Vallerie & Peterson, 2009). It can be explained by the fact that the number of these entrepreneurs is increasing rapidly, they are creating great added value and employing a huge number of workers, thus contributing to an increase in economic growth. This is confirmed by the large number of successful start-up ecosystems, especially in China, which is ranked among the top 10 in the world. It is desirable to implement incentive measures in the direction of HEA development. In order to overcome these weaknesses, governments can create start-up ecosystems. The start-up ecosystem encourages the creation and development of HEA thanks to different forms of support, such as mentoring, consulting services, contacts with investors, etc. Also, many high-growth-oriented entrepreneurs included in an entrepreneurial ecosystem create a pool of well-trained and like-minded entrepreneurs. It enables the exchange of knowledge and experiences and creates a culture that encourages innovation and new businesses. By linking technology, capital, and know-how within a protected and enabling environment, the process of business creation can be speeded up, while the probability of failure can be reduced.

The focus of our research was on the impact of the COVID-19 pandemic on entrepreneurship, as well as the link between entrepreneurship and economic growth in emerging markets. The results of regression analysis showed that the COVID-19 pandemic has negatively affected entrepreneurship. During the pandemic, the number of HEA has been reduced. For this reason, TEA and HEA had the negative impact on the GDP growth, which was statistically significant. In order to reorient these negative trends in a positive direction, it is necessary to implement a number of adjustment measures by entrepreneurs, as well as support measures at the state level.

According to GEM data, many entrepreneurs as well as governments responded to the COVID-19 pandemic. Our research has shown that sufficient responses of entrepreneurs to the COVID-19 pandemic have the positive and significant impact on TEA, directly, and on sustainable development, indirectly. This is in accordance with the results of prior studies conducted in developed countries (Block et al., 2020; Fairlie & Fossen, 2021; Belghitar et al., 2021). Also, our analysis has shown that implemented measures by entrepreneurs have a greater contribution to entrepreneurship development during the pandemic compared to supportive measures implemented by governments, which is in accordance with GEM report for 2020.

In order to overcome the consequences of the pandemic and further development of entrepreneurship, it is desirable to implement additional measures. For example, use of digital technology can help entrepreneurs to increasingly sell products on digital platforms, using digital tools like TikTok for marketing and relying on platforms such as Kickstarter for funding. The use of online communities support, can develop opportunities and help entrepreneurs to get assistance with problems, and find collaborators. Working together with entrepreneurs and experts from other countries, through digital social networks, can help entrepreneurs gain valuable experience, find business partners and expand the market. The use of the latest technologies of the so-called Industry 4.0 and robots can help entrepreneurs to offer radically new innovative products and business models, adapted to the changed needs of consumers in the context of the COVID-19 pandemic and improve their business. Finally, digital technology and robots can reconfigure production and service systems, which could be useful even long after the crisis is over (Meurer et al., 2021).

Working from home, as a new business practice, can help entrepreneurs save in costs, but also have a positive impact on the psychological state of their employees during the COVID-19 pandemic. A company's positive psychological state directly influences creative innovation during a crisis. Due to innovation and flexibility, they can quickly engage and implement small-scale creative innovations and thus adapt to the fast-changing circumstances arising from the COVID-19 pandemic (Kuckertz et al., 2020). Also, cooperation with other economic entities could be useful. Positive effects of the cooperation, like information and knowledge gathering (Wall & Bellamy, 2019), mobilization of bricolage (Kuckertz et al., 2020), and joint efforts (Markman et al., 2019), are visible.

## 5. Conclusion

The health pandemic caused by COVID-19 has dramatically changed society, and posed huge challenges for economy. Policymakers are persistently looking for appropriate economic solutions that will enable them to get out of the crisis and encourage sustainable development. Numerous previous studies show that entrepreneurship has a significant contribution to sustainable development in developed countries, which has not been proven for emerging markets. Given the fact that emerging markets have become very serious players in global markets, we have examined relationship between entrepreneurship and sustainable development before and during COVID-19 pandemic in emerging markets, in order to propose appropriate macroeconomic measures and revive economy in post COVID-19 period.

We empirically examined the impact of TEA on sustainable development and economic growth in emerging markets in period before and during COVID-19 pandemic (2011-2021). Using data for 20 emerging markets, we found that TEA has a significant contribution to sustainable development, but its contribution to the GDP growth is still not significant. The significant contribution to the GDP growth in emerging markets has only HEA, but their participation in TEA is obviously insufficient.

We also investigate the importance of various measures implemented by entrepreneurs and governments as responses to the changed environment in the pandemic COVID-19. Our research pointed out that sufficient responses to the COVID-19 pandemic could be useful instrument in order to encouraging the development of entrepreneurship and reviving the economy in the post-COVID period in emerging markets.

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# Do the Outbreak of COVID-19 Influence the China Stock Market?

# Jak COVID-19 wpływa na chińską giełdę?

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# Abstract

This study aims at the impact outbreak of COVID-19 influence Chinese currency and stock market over the period December 2, 2019, to January 04, 2021. The Generalized Autoregressive Conditional Homoscedastic approach captures the most common stylized fact about index returns (such as multivariate to capture the Shanghai and Shenzhen stock exchange). Our finding shows the explosive process and risk premium for the Shenzhen stock exchange (SSE) and Shanghai stock exchange (SZSE) index. And the standard deviation depreciation of the Chinese currency during the COVID-19 equivalent to 0.46% improved stock market return by 81% average returns. These results explain that high volatility of index returns is present in the Chinese stock market over the sample period. According to the analysis results, it can be concluded that the number of new cases and the number of recent deaths have a significant effect on the stock market, causing uncertainty in the sustainability.

Key words: exchange rate, stock return, COVID-19, sustainability JEL codes: E37; F37; E31 Słowa kluczowe: Kurs wymiany, zwrot akcji, COVID-19, zrównoważoność

# 1. Introduction

The debate on the stock exchange rate has been a subject of academic research. With the large volume of papers regarding this matter, the speculation that trade rates impact the stock exchange is customary in the financial system and sustainable development.

We return to the stock exchange rate theory to test how this relationship develops in a tie and assess the current status during the COVID-19 stage 2020/03-2020/09 in contrast with the pre-COVID-19 stage. Normally, when

the financial and sustainable development are shocked like the current COVID-19 as we are currently experiencing, people doubt the relevance of existing speculation and theories. How is the trading activity and index component after the COVID-19 pandemic; has COVID-19 impacted how trade rates have been generally accepted to influence the securities exchange and also sustainability if by what means it is the goal of this research. Our hypothetical establishment on which to look at the stock value-exchange rate connection is grounded and can be retrieved from (Dornbusch & Fischer 1980) work, but specifically in their stream-situated exchange rate framework. The stream on impact is on current records, which is reflected in the impacts they have on real yield and sustainable development. The fundamental principle of these models is the possibility that exchange impacts global competitiveness. The value of stock also responds to exchange rates because they deal with enterprises' present values and future revenues. There will impact future sustainable development as well as current investment and consumption if the stock prices change. According to Branson (1983); Frankel (1983), there are additionally the stock-situated models of exchange rates, as addressed in their craft.

These models see exchange rates as compared to market interest for resources. Given that resource valuation and evaluation depend on present estimations of future sustainable development, exchange rates are straightforwardly identified with asset prices. Empirical examinations have concluded with blended findings on whether or not exchange rates impact stock values. A few works embrace point-by-point writing literature, and interested readers allude to these works (Sui and Sun, 2016; Sha and Sharma, 2020; Chen, 2020; Fang et al., 2020). The literature is broad, but we will not investigate it here. Our theory is that the exchange rate impacts securities exchange all the more firmly after the episode of Coronavirus. The motivation for this theory is demand on recent papers introducing COVID-19 has influenced monetary, sustainable development and financial system, financial framework just as enterprise performances.

One of this paper is that none has inspected how the pandemic impacts the exchange rate connection in Shanghai and Shenzhen securities exchange. We center on the stock exchange index in light of the fact that COVID-19 illness, among developed nations, has been an exception, both as far as governance response to the emergency and results. Firstly, China was the first nation who impose a movement and travel ban. Second China has secured its country and borders. Relatively, the way to deal with individuals' sustainable development inside the nation has been confined. Thirdly, China has encountered minimal passing from the pandemic and figured out how to contain the spread of the infection much better. For example, personal experience during the stage of (SARS illness) has pushed people to wear face marks; this has partially been attributed to China's border, culture, and history. Faced with a COVID-19 pandemic, the Chinese stock exchange has been impacted differently depending on their industry. To be specific, enterprises that are non-state-owned, engaged in foreign trade, or have few assets are more vulnerable to pandemics (Chen, 2020).

Moreover, the pandemic contains risk transmission and risk spillover to other markets. (Fang et al., 2020) analyze the influence of the COVID-19 pandemic on the risk spillover of money market, stock market, and other exchange markets based on event study framework. They find that COVID-19 has an immediate effect on various financial markets, and the risk spillover of each market increases after 3-5 days of occurrence. The (GARCH-M model) generalized autoregressive conditional heteroskedasticity in mean has been employed with daily information to test our hypothesis. The exchange rate on securities exchange has gotten more strong after the outbreak of the COVID-19 pandemic reveal our empirical finding. We contribute to the recent work on the effect of COVID-19 disease on monetary policy, sustainable and financial development in the following ways. First, this study is the primary paper to consider the connection between the exchange rate and securities exchange (stock market) with regards to the outbreak time of Covid-19 illness. Our main contribution is to assess and archive the strength of exchange rate- securities exchange (market returns) connection because of the pandemic. We show that contrasted with ordinary time; the exchange rate has had a lot more grounded on the Chinese financial exchange following the pandemic. But Iyke (2020) looks at how COVID-19 predicts trade rate, informing the practice of monetary policy and financial development from a financial exchange return (market return) perspective.

## 2. Theoretical overview

This paper's inclusion continues with an outline of chosen literature on the disease of COVID19. This literature review is significant because the effect of the COVID-19 pandemic is more serious in the emerging economy. This paper is different from others because it examines the relationship between the stock exchange rate and the number of cases (death and confirmed cases) after the outbreak period of COVID-19. Since the subject of research is new, this literature audit is significant because Coronavirus research is at an early stage, and less is perceived of its role; it encourages us to distinguish our paper commitment and strength. This paper provided empirical evidence of the significant negative effect of the pandemic on stock market performance in the Chinese stock exchange using alternative indictors of financial exchange and the stock market and various econometric methods. Likewise, this paper has various benefits for the executive in developing markets. In fact, it allows these executives to well understanding what happened after the outbreak time of COVID-19. They can as well profit by applying key advices in determine the risk of the financial system to palliate the risk in developing markets.

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The paper is related to two strands of literature. The first strand focuses on the effect of the COVID-19 pandemic on the stock exchange rate and the effect on stock return series. Regarding containing the pandemic, especially when the pandemic is a shocking as COVID-19. The world is stagnant, there is no standard book, no experimental model, which can help to learn from more about this illness (such as the pandemic like a COVID-19), regarding how they contain the pandemic. In this case, the standard of pandemic adjustment is self-study, self-leaned, or gained from different countries' experiences. They are currently developing empirical documents on COVID-19. They cover the influence of COVID-19 on monetary policy and financial development, just as financial development has achieved an undisputed quality, especially considering the availability of information prominent. (Huang and Zhen, 2020; Gil-Alana and Monge, 2020), they worked the influence of pandemic on a securities exchange (stock market) of energy firms. Liu et al. (2020) and Iyke (2020) examined the influence of COVID-19 on energy firm performance. Apergis and Apergis (2020) considered the issue with what COVID19 has meant for the energy market; inside this energy literature, three perspectives have been contemplated, the influence of COVID-19 on oil values or oil price volatility. In their investigation, Gu et al. (2020), with time, energy utilization expanded for certain firms burning-through more than in pre-illness or Pre-COVID-19 time. They use a broad dataset covering (34 thousand) firms and show that Covid-19 brought about 57% decrease in electricity consumption in the principal seven (7) day stretch. They have focused on firm responses to Coronavirus.

As such, there is an unmistakable role recognized for Covid-19 informing performance and volatility of energy markets and affecting the connection among energy and other financial development and macroeconomic components like stock returns. Generally speaking, an indisputable message from these examinations is that Covid-19 has affected energy stock costs and firm performance. Shen et al. (2020) exhibit that while COVID-19 contrarily affected Chinese firm performance, the emergency affected certain industries, like the travel industry (tourism), providing food and transportation, most as estimated by the decrease in their corporate presentation.

The Coronavirus has been affected by various financial development. (Haroon and Rizvi, 2020) they focused on securities exchange (stock market) liquidity. (He and el 2020) analyze what Covid-19 meant for various sectors of a securities exchange. Their finding is fascinating because they show that while the pandemic has adversely influenced a few areas, others (for instance, producing, data innovation, education, and medical care) have endured the emergency in a multi-country investigation. According to studies of (Chen et al., 2020), the role of Covid-19 regarding bitcoin earnings. In their examination, they present that they allude to as the dread notion index (the result of the pandemic). This index presents and interprets bitcoin's negative profits. He presents that COVID-19 is more effective in predicting exchange rate fluctuations than exchange rate gains (Iyke, 2020). The protection markets (insurance market) China has been adversely affected by COVID-19, presented by (Wang et al., 2020) work. During their examination, property and individual insurance were generally affected. They are employing household-level information to indicate that due to the COVID-19 pandemic, (Yue et al., 2020) affirm that households may change their portfolios. According (Liu et al., 2020) in their studies, they presented although the pandemic has decreased consumption of households in large cities, COVID-19 has limited influence on the consumption of provincial households. Vidya and Prabheesh (2020) investigation examine the link between Covid-19 and exchange (trade); they present a critical decrease in trade for different nations. A few investigations have also centered on securities exchange (stock market return) (Al-Awadhi et al., 2020; Zhan et al., 2020). Finally, (Liu et al. 2020) investigated China's financial development and business cycles and presented that those cycles were at that point in the contractionary stage before COVID-19; they contend that China thus, perhaps ready to more readily manage the repercussion of COVID-19. The fundamental message arising out of the literature insinuated above is that the main COVID-19 has reshaped practically all featured of monetary and financial development concentrated to date. One of the roles of this examination that has not been considered recently is the link among currency and financial exchange (stock market) and how Coronavirus disrupts this habitual link. Our contribution to the literature is definitely through tending to this issue.

The remainder of this research is organized as follows: Sections 2 present the methodology and data; the next section presents the results and discussion; the final section concludes with an outline of our findings.

# 3. Data and Methodology

## 3.1. Sample construction

In this section, we discuss our sample construction by collecting the data of a number of confirmed cases and deaths from Covid-19 from the website of (Worlddometer statistics, 2020). Our daily data started from December 02, 2019, to January 04, 2021. Next, we downloaded the daily Shanghai Composite Index and Shenzhen stock exchange index from finance.yahoo.com. Thirdly, we downloaded exchange rate CNY-US dollars and Brent crude oil price in USD dollars per barrel, data obtain from www.investing.com (2020) and finance.yahoo.com (2020), respectively. The first day in our analysis corresponds to the reported positive case of COVID-19. The data depends on normal business days, Monday to Friday excepted holidays.

For diverse reasons, we focused on the Chinese exchange rate and data period. (a) China has been an outlier, both in terms of governance reactions to the crisis of COVID-19 and the outcomes. (b) China was one of the first

countries who imposed a travel ban, locked down country borders and the outbreak, (c) the Chinese have experienced the least deaths from COVID-19 and managed to contain the spread of the disease much better.

#### 3.2. Methodology

To investigate the Chinese currency and stock market and know what happened after the outbreak of the COVID-19 pandemic. These closing prices have been taken from the Shanghai stock exchange and Shenzhen stock exchange. In this research, daily returns ( $\mathcal{F}_t$ ), the compound returns are studied, which is the first difference in the logarithm of the closing price.

$$\mathscr{F}_t = \log\left(\frac{P_t}{P_{t-1}}\right) \tag{1}$$

 $P_t$  and  $P_{t-1}$  are the closing market index of SSE and SZSE at the current day and previous day, respectively. Since the outbreak, SSE and SZSE have been declining; in this study, our full dataset is divided into three sub-periods: the first sub-period, (a) Pre Covid-19 cover December 02, 2019, to March 11, 2020, (b) Covid-19 cover March 11, 2020, to August 31, 2020, and (c) post-outbreak cover September 01, 2020, to January 04, 2021. The results will be demonstrated separately in three stages.

## 3.3. Basis statistic

To determine the distributional of properties of the day SSE and SZSE return during the time of this examination, different clear statistics were calculated. It can be seen from the Table (Appendix A and B) that the normal return in the Shanghai stock exchange is higher than the normal return in the Shenzhen stock exchange. In the daily return of Shanghai and the Shenzhen stock exchange, Skewness and excessive kurtosis are clearly observed, which illustrates the essence of taking off from normal. Moreover, the J-B (Jarque-Bera statistic) as a normality test likewise corroborates that the null hypothesis of the average day-by-day return ought to be rejected at the critical level of 1%. In outline, the SSE (shanghai stock exchange) and SZSE (Shenzhen stock exchange) don't conform to the (typical) normal distribution, but they show positive Skewness in these three periods.

#### 3.4. Testing for stationarity

In order to analyze whether the daily price index and its returns are stationary, the research employed for both of series ADF (Augmented Dickey Fully test), Dickey and Fuller (1981) and PP (Phillips-Peron test) Phillips-Peron, (1998). The outcomes of this test are presented in the appendix. The (ADF) and (PP) test for SSE and SZSE indexes shows that it is a stationary series. It is non-stationary time before the coronavirus outbreak. However, while a similar test was performed on the return, the outcome strongly rejected the null hypothesis of unit roots for all three stages. In this way, we can deduce that in all two cycles, the return series remained stationary. It can be seen from Table (Appendix A and B).

## 3.5. Testing for Heteroscedasticity

Quite possibly, the main issue prior to the application of the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) method is first inspected to check residuals to prove heteroscedasticity. In order to test the presence of heteroscedasticity in the residual of SSE and SZSE indexes returns, we applied the Lagrange multiplier (LM) test with (ARCH) influence proposed by (Engel 1982) (MA) moving average measure or (AR) and (MA) measure of combination and (ARMA) measure in the outline or this part, which can be an (AR) autoregressive measure, the test methodology is performed by first obtaining the residual  $e_t$  from the ordinary least squares regression of the conditional mean condition.

For instance, into (ARMA-1,1) measure, the conditional mean condition will be:

$$r_t = \phi_1 r_{t-1} + \epsilon_t + \theta_1 \varepsilon_{t-1}$$

The next step is regressing the squared residual on a constant and q lags; after getting the residuals,  $e_t$ . According to the following condition:

$$e_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 e_{t-2}^2 + \dots + \alpha_q e_{t-q}^2 + \nu_t$$
(3)

In this investigation, the autoregressive moving average (ARMA-1,1) model was adopted for the first time as for the conditional mean in the return series as an initial regression, at that point, the ARCH effect of the residual series is not into of the test of the null hypothesis. The outcome of this assessment is summed up in the appendix. The strong proof of rejecting the null hypothesis for all lags included is done with the result of the ARCH-LM test. The presence of the ARCH effect in the residual series means that we are rejecting H0; therefore, the variance of the return series is non-constant for all the stages determined.

#### 3.6. Methodology and Model

Applying the approach of Autoregressive conditional heteroscedasticity (ARCH) and its generalization (GARCH) model represent the main approach of modeling and predict stock exchange (stock market volatility). In this study, distinctive univariate GARCH particulars are adopted to present daily SSE and SZSE, and these models are GARCH (1,1) and GARCH-M (1,1) models. There are two different conditions or specifications in introducing

these various approaches. Firstly, the conditional mean and secondly the conditional variance, we briefly review this approach.

#### 3.7. Volatility and Measurement

It is valuable, prior to beginning to describe the volatility, it is necessary to briefly clarify the volatility, in any event with the end goal of clarification the extent of this research. The term volatility alludes to the spread of all presumable results of uncertain factors. Regularly, in the field of financial markets, the spread of asset returns frequently preoccupies. Statistically speaking, the term of volatility is frequently estimated as the sample standard of the deviation:

$$\hat{\sigma} = \sqrt{\frac{1}{T-1} \sum_{t=1}^{T} (r_t - \mu)^2}$$
(4)

 $\mathcal{F}_t$ , The profits (returns) on day t and  $\mu$  is the normal return over the T-DAY period. At times,  $\sigma^2$  is employed additionally as a volatility measure. Volatility is related with, however, not exactly the same as a risk. According to Poon S. (2005), the risk is related to undesirable results, although the strict employ of uncertainty volatility may be a positive result.

#### 3.8. Model

In this paper, the return of security depends on its volatility. The GARCH-M model of (Engel et al., 1987) may be referred for demonstrate such a wonderful model, GARCH in mean is represented by M. The basic GARCH structure is an extension of the model which permits the conditional mean of the sequence to depend on its standard deviation or conditional variance. A basic GARCH-M (1-1) will be as:

$$r_t = \mu + \lambda \sigma_t^2 + \varepsilon_t$$
(5)  
$$\sigma_t^2 = \omega + \alpha \omega_{t-1}^2 + \beta \sigma_{t-1}^2$$
(6)

 $\sigma_t^2 = \omega + \alpha \omega_{t-1}^2 + \beta \sigma_{t-1}^2$  (6) Where  $\mu$  and  $\lambda$  are constants, the parameter  $\lambda$ , is known as the risk premium parameter. A positive  $\lambda$ , shows that the return is emphatically related to its volatility. Increasing in average return is achieved by the expansion of conditional variance as an intermediary for risk expansion. Engel et al. (1987) expect that the function of conditional variance  $\varepsilon_t$ ; is the risk premium an expending; in other hand, the greater of remuneration important to instigate the agent to hold the long-run resource (Ender, 2004). In our examination, the exchange rate influence on stock prices employing the GARCH-M9 (1,1) model estimated can be composed as:

$$SSE_{t} = \alpha + \beta ER_{t} + OIL_{t} + \delta V_{t} + COVID - 19 + \varepsilon_{t}$$
(7)  
$$SZSE_{t} = \alpha + \beta ER_{t} + OIL_{t} + \delta V_{t} + COVID - 19 + \varepsilon_{t}$$
(8)

 $SSE_t$  and  $SZSE_t$  are the Shanghai stock exchange and Shenzhen stock exchange returns, respectively,  $ER_t$  is the CNY-USD dollars exchange rate,  $OIL_t$  is oil price shocks,  $\delta V_t$ , is the conditional variance and model innovation, COVID-19 (confirmed case and death),  $\varepsilon_t$  is normally distributed. The conditional volatility is obtained as  $V_t = \rho_0 + \rho_1 \rho \varepsilon_t^2 + \rho_2 V_{t-1}$  where  $\rho_n$  (n=0,1,2) are parameters to be estimated and the sum of non-intercept terms are less than one (1) (Bollerslev, 1986).

## 4. Results and discussion

For heteroscedasticity, this section introduces the data description. At the point when the residuals are checked, the ARCH-LM test gives strong proof for the ARCH effect in the residual series. This section introduces the estimation results of various GARCH models for the Chinese stock exchange. For all complete pre-COVID-19, COVID-19, and post COVID-19 stages, the maximum likelihood method is used to estimate under the Gaussian assumption, which shows that we can use GARCH to perform index return fluctuations rate modeling method. Normal distribution.

The log probability function utilizes Marquardt's mathematical iteration algorithm to look for the normal parameter to maximize. In order to show that the SSE and SZSE index dropped sharply in the last section, a dummy variable will be presented in the normal state of the whole time frame. The variable is set to zero (0) in the time frame before the sharp decrease and after it is set to (1). In this manner, for a null sample, change to normal condition to: m = u + DIIMMV + s.

$$r_t = \mu + DUMMY + \varepsilon$$

For all stages, the mean condition will in any case, be utilized as previously specified. Notwithstanding the investigated output of various GARCH approaches, the analytic test aftereffects of these models are likewise given to check whether there is as yet an ARCH effect in the investigated approach. See appendix table the results are listed. Among them, the parameter estimates of different GARCH models for SSE and SZSE index returns at specified stages.

The result is presented in the appendix table, the parameter estimates of different GARCH models for SSE and SZSE index returns for the three specified stages. GARCH (1,1) model estimation results are presented here.

Tables 1 and 2 shows that, in this variance equation from this table, GARCH term ( $\beta$ ), ARCH term ( $\alpha$ ), the value of GARCH (1,1) is very significant and has the expected sign for all stages. The lagged conditional variance and squared disturbance have an effect on the conditional variance, which explains the significance of  $\alpha$  and  $\beta$ . In the

second stage of the examination process, the sum of the two regressed ARCH and GARCH coefficients  $\alpha + \beta$  is less than (1), which requires a process with average regression variance.

Table 1. Panel A, Effect	of exchange rate on Shenz	then stock market returns

ample periods	No Controls	DUMMY controls
re Covid-19	0.3999*	3.55E-05*
uring Covid-19	0.6575*	5.82E-08*
fter Outbreak	0.4269*	2.90E-05*

Note: \*Indicates significance at 1% level

Table 2. Panel B, Effect of exchange rate on Shanghai stock market returns				
Sample periods	No Controls	DUMMY controls		
Pre Covid-19	0.327*	8.64E-07		
During Covid-19	0.640*	4.01E-08		
After Outbreak	0.520*	0.0001*		

Note: \*Indicates significance at 1% level

On the contrary, PRE-COVID, during COVID-19 and POST-COVID-19, the sum of these parameters is greater than (1), which indicates that the impact on conditional variance is highly persistent (an example, the conditional variance process is explosive). Therefore, this will confirm that volatility clustering is observed in SSE and SZSE index returns. And other words, this means that large change in the rate of return tends to follow large and small changes. The ARCH-LM test statistics for all stages showed no additional ARCH effect. This presents that the variance condition is clearly defined (see table 3).

Table 3. ARCH-LM Test for residual of returns on SSE and SZSE markets					
	Pre-COVID-19 During COVID-19 After O				
ARCH-LM $(TR^2)$	8.929	45.108	1.632		
Prob. Chi Square	0.0028	0.0000	0.2014		

#### 4.1. GARCH-M (1.1) model estimation

P

Tables 4 and 5 show that the GARCH-M Model is estimated and permitting the mean condition of the returned to depend on the conditional variance  $\sigma^2$ . By estimating the coefficient of  $\sigma^2$  (risk premium) in the mean condition, the coefficient is positive for all the stages, which indicates that the mean value of the return series depends largely on past conditional variance and on past innovation. In other words meaning, the conditional variance used for return risk is positively related to the return level. In this outcome, when the volatility increases, returns increase by a factor accordingly. According to the theory of risk premium, these outcomes are consistent with the positive risk premium of stock indexes, which states that assets with higher risk levels are expected to receive higher returns. In all the periods, the ARCH and GARCH coefficients are significant. No ARCH effect is accepted of the null hypothesis.

#### 4.2. ECARCH (1,1) model estimation

In order to study the leverage effect of SSE and SZSE stock exchange, or stock market index returns during the period of COVID-19, we use the EGARCH (1,1) approach. Tables 4 and 5 show that the Shanghai Stock Exchange and Shenzhen Stock Exchange in the table above presents that all estimated coefficients for all stages are statistically significant at the 1% confidence level, indicating the EGARCH (1,1) model for the stock market returns. Indicating that negative compared with the positive shock of the same, the negative shock means that the conditional variance of the next cycle is higher. The asymmetric (leverage) effect captured by the parameter estimates is also statistically significant (with a negative sign). This means the change in the Shanghai Stock Exchange and Shenzhen Stock exchange (stock market index) during the pandemic of COVID-19 have been observed in the presence of leverage effects. All the periods accept the null hypothesis that is no heteroscedasticity in the residual.

Table 4 Estimation result of GARCH model of SZSE

Tuble 4. Estimation result of Gracert model of SESE					
	GARCH (1.1)	GARCH-M (1.1)	EGARCH (1.1)		
Pre- COVID-19	1.3242*	-0.1931*	-0.1931*		
	0.2561*	0.1126*	0.1125*		
	Wald (274.84)	Wald (112.24)	Wald (112.24)		
During COVID-19	0.8315*	-0.8331*	0.0023*		
	0.2235*	0.7513*	0.0032*		
	Wald (1215.53)	Wald (402.56)	Wald (402.56)		
After the Outbreak	-0.3974*	4.3114*	3.8186*		
	0.0086*	0.6088*	0.0585*		
	Wald (2093.04)	Wald (2093.04)	Wald (2093.04)		

Note: \*Indicates significance at 1% level

Sub-samples	GARCH (1.1)	GARCH-M (1.1)	EGARCH (1.1)
Pre- COVID-19	1.2071*	1.5128*	-0.1013*
	0.2403*	0.0004*	8.31E-06*
	Wald (42.38)	Wald (1.12E+09)	Wald (1.12E+09)
During COVID-19	0.8614*	7.3377*	14194.15*
	0.2452*	0.9863*	1865.05*
	Wald (560.79)	Wald (402.56)	Wald (402.43)
After the Outbreak	-776.3317*	7604.037*	0.8615*
	108.3646*	1901.527*	0.2452*
	Wald (51.32)	Wald (231.72)	(560.79)

Table 5. Estimation result of GARCH model of SSE

Note: \*Indicates significance at 1% level

# 5. Concluding Remarks

Forecasting the volatility of stock exchange returns has become empirical research, particularly in the research field in the financial market. In this study, the exchange rate was evaluated to see the exchange rate's effectiveness in explaining Chinese stock market returns. Motivated by the continuous development of research on COVID-19 and its influence on the global economic and financial market, our hypothesis is that COVID-19 has impacted the link among China's exchange rate and stock exchange returns. Employing China's daily time information series applicable to the GARCH approach (including symmetric and asymmetric models). The approach can capture the most common stylized fact about index returns, for example (volatility clustering and leverage effects), which are consistent with the literature. The exchange rate is a statistically and significant determinant of the stock exchange (stock market returns). Our main contribution is the discovery that the standard deviation depreciation of Chinese currency during the sample period of COVD-19 equivalent to 0.46% improves stock exchange returns by 81% average returns. The paper concludes with strong evidence of exchange rate and daily return during the COVID-19 periods. The existence of conditional heteroscedasticity in the residual series and the Shanghai stock exchange and Shenzhen stock exchange data showed a significant departure from normality. The empirical investigation and the econometric analysis support the symmetric volatility hypothesis. Performing multiple sensitive tests on hypothesis testing means that the rate of return is volatile, and bad or good news (positive and negative shocks) has the same influence on prospective volatility levels. In this research investigation, an example, we only figure out and document how exchange rate change affects stock returns. In other words, a mean increase in volatility would increase returns. Here, our research's implication may trigger further studies, which is an expected and important result. The next Possible extension is to use the finding and develop trading strategies. We do not follow this way; our goals are different. So, we do not take it this way; our goals being different, we leave this way for future research. To briefing, all the explanations of GARCH specification in this article indicate that during the analysis of the COVID-19 stage, the index returns of the Chinese Stock Exchange *change* explosive volatility.

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#### Appendix A

Table 6. Descriptive Statistics of SSE returns series. Here, a full sample of data is observed from December 2, 2019, to January 04, 2021, with 71 observations for the Shanghai stock exchange and 70 observations for the Shenzhen stock market exchange during the investigation. The standard deviation and Skewness are observed.

	CON- FIRMEE_	DEATHS	EX- CHANGE_	OIL_PRICE	SHANG- HAI_SSE
	CASE		CNY_USD		
Mean	25586.00	811.9577	6.973935	51.25014	2693.013
Median	0.000000	0.000000	6.976400	53.77000	2984.390
Maximum	80921.00	3161.000	7.060200	63.27000	3115.570
Minimum	0.000000	0.000000	6.858700	0.000000	0.000000
Std. Dev.	34080.93	1165.811	0.046335	14.35861	900.3380
Skewness	0.752878	1.016053	-0.420562	-2.599945	-2.655922
Kurtosis	1.738896	2.324824	2.672969	9.610970	8.133916
Jarque-Bera	11.41232	13.56491	2.409381	209.2837	161.4445
Probability	0.003325	0.001133	0.299785	0.000000	0.000000
Sum	1816606.	57649.00	495.1494	3638.760	191203.9
Sum Sq. Dev.	8.13E+10	95138119	0.150283	14431.89	56742593
Observations	71	71	71	71	71

Variables	ADF	Phillips-Perron
		test
Shanghai SSE	-3.5857*	-3.6042*
	(0.008)	(0.008)
Exchange CNY	-8.5602*	-8.5795*
	(0.0000)	(0.000)
Oil Price	-7.9505*	-7.9505*
	(0.000)	(0.000)
Confirm Case	-6.1275*	-6.1292*
	(0.000)	(0.000)
Death Case	-11.611*	-6.2885*
	(0.000)	(0.000)

Table 7. ADF Unit Root and PP test for the return series of SSE

\*, \*\*, and \*\*\* indicate rejection of the null hypothesis at 1%, 5%, and 10%, respectively. P-Value is given in parenthesis.

# Appendix B

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	CON-	DEATH	EX-	OIL_PRICE	SHEN-
	FIRMEE		CHANGE		ZHEN SZSE
	CASE		CNY_USD		
Mean	25951	823.55	6.9727	51.147	0.8154
Median	0.0000	0.0000	6.9754	53.565	0.9015
Maximum	80921	3161.0	7.0489	63.270	0.9940
Minimum	0.0000	0.0000	6.8587	0.0000	0.0000
Std. Dev.	34186	1170.0	0.0454	14.435	0.2771
Skewness	0.7306	0.9945	-0.4688	-2.5760	-2.5467
Kurtosis	1.7059	2.2809	2.6754	9.4699	7.7410
Jarque-Bera	11.111	13.047	2.8717	199.51	141.22
Probability	0.0038	0.0014	0.2379	0.0000	0.0000
Sum	1816606.	57649	488.08	3580.3	57.083
Sum Sq. Dev.	8.06E+10	944694	0.1427	14379	5.3001
Observations	70	70	70	70	70

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I aple	δ.	Descri	puve	Statistics	OI SZSE	returns	series
			r				

Table 9. ADF Unit Root and PP test for the return series of SZSE

Variables	ADF	Phillips-Perron test
Shenzhen SSE	-10.631*	-10.649*
	(0.000)	(0.000)
Exchange CNY	-8.5602*	-8.5795*
	(0.000)	(0.000)
Oil Price	-7.9505*	-7.9505*
	(0.000)	(0.000)
Confirm Case	-6.1275*	-6.1292*
	(0.000)	(0.000)
Death Case	-11.611*	-25.441*
	(0, 000)	(0, 000)

\*, \*\*, and \*\*\* indicate rejection of the null hypothesis at 1%, 5%, and 10%, respectively. P-Value are given in parenthesis

# Appendix C

Figure 1. Normal quantile plots for daily stock returns of SSE



Figure 2. Normal quantile plots for daily stock returns of SZSE



Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

# Digitalization and Sustainable Development: the New COVID-19 Challenge Requires Non-standard Solutions

# Cyfryzacja i zrównoważony rozwój: nowe wyzwanie związane z COVID-19 wymaga niestandardowych rozwiązań

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# Abstract

The spread of COVID-19 contributes to changing economic, environmental and social reality around the world. One of the significant consequences of the current pandemic can already be called the accelerated introduction of digital technologies in various fields. Against this background, the article is devoted to the theoretical and analytical substantiation of the feasibility of reorienting traditional production and management systems in the context of COVID-19 to digital ones. It has been proven that digitalization, sustainable development and COVID-19 are new challenges generated by human activity that require non-standard solutions. A composition of non-standard digital solutions is proposed to overcome the problems associated with COVID-19, ensuring sustainable development, allowing to launch new business models capable of smoothing post-Covid consequences and bringing the world economy onto a trajectory of sustainable economic growth.

Key words: sustainable development, Sustainable Development Goals, digitalization, digital technologies, COVID-19

Słowa kluczowe: zrównoważony rozwój, Cele zrównoważonego rozwoju, cyfryzacja, technologie cyfrowe, CO-VID-19

# 1. Introduction

In 2015, with the adoption by 193 UN member states of 17 Sustainable Development Goals (SDGs) until 2030, a turning point in the development of future generations took place. As a result of this event, the discussion of a new model of socio-economic development that meets the challenges of modernity and aspirations for a more just, prosperous and environmentally friendly world was actualized. However, in the presented report *Transforming our World: The 2030 Agenda for Sustainable Development* (2015) digitalization was not mentioned, despite the

fact that most experts in the field of management, business, finance, environmental management, sustainable development agree that digital transformation is not only a tool for achieving sustainable development goals, but also a driver of structural changes in various industries, the main game-changer of the world economy of the XXI century.

So, the leading consultants of Gartner Inc note that *digitalization is a new model of sustainable business development, covering personnel, business processes, things, scalable globally for the whole world through the use of information technology, the Internet, assuming effective personal service for everyone, everywhere and always* (Inter Systems Experts, 2021). eMarketer experts believe that *digitalization is a process involving a global increase in the share of robotic production and automation of many life processes of humanity as a whole, contributing to the formation of sustainable development* (Global Ecommerce Forecast 2021, 2021). According to Rockwell Automation Vice President Mark Bottomley, who has made a significant contribution to the development of *various industries across Europe, sustainable development is becoming an increasingly relevant part of the social agenda, which makes it a critical topic for business and industry. Digitalization allows industries not only to reduce the amount of harmful waste, but also to effectively redistribute resources, increase productivity and create safer, more attractive working conditions for employees* (Rockwell Automation, 2019).

The COVID-19 Pandemic, which has shown the critical importance of digital technologies in the fight against poverty, environmental, economic and social risks, improving the quality of life of people, etc., has contributed more actively to the digitalization of the economies of the countries of the world, while exposing the problem of digital inequality and digital divides. Based on what has been said, digitalization is rightly considered a tool for implementing the sustainable development goals, and COVID-19 is a new challenge requiring non-standard solutions.

# 2. The purpose of the article

The purpose of the study is to formalize the theoretical and analytical aspects of digitalization under the conditions of COVID-19 and to develop non-standard solutions for ensuring sustainable development based on digital technologies.

#### 3. Methodology

The study was based on the use of general scientific methods (in clarifying the essence of digitalization), as well as statistical, comparative and graphical analysis (in substantiating hypotheses and dependencies).

When forming the author's vision regarding the meaning of the category *digitalization*, the scientific statements of the following authors were summarized: H. Albach, B. Berthon, E. Brynjolfsson, M. Jeon, M. Jeong, D. Ernst, B. Kahin, M. Knickrehm, S. Markovitch, T. Mesenbourg, H. Meffert, N. Negroponte, T. Niebel, A. Pinkwart, R. Reichwald, Z. Xiang, D. Fesenmaier, D. Tapscott, P. Willmott, K. Schwab, L. Halkiv, O. Karyi, I. Kulyniak, S. Okhynok, S. Markovitch, P. Willmott, M. Knickrehm, P. Daugherty, N. Martynovych, E. Boichenko, O. Vivchar, N. Myskova, O. Popovych, O. Kasianenko, A. Galkin, Y. Popova, E. Chuprina, D. Shapovalenko.

When substantiating hypotheses and dependencies, the article sequentially verifies four logically interrelated hypotheses: 1) digitalization is a necessary condition, a driving force of sustainable development, 2) the COVID-19 pandemic has contributed to the acceleration of digitalization, 3) the COVID-19 pandemic has negatively affected digitalization 4) digitalization is an effective tool for making non-standard sustainable development decisions in the context of COVID-19, describing the relationship of the analyzed indicators (passenger turnover by air transport, revenues from air transportation, the number of commercial flights, the growth rate of the offer of carrying capacity, aircraft load, the volume of  $CO_2$  emissions into the atmosphere, the volume of electronic sales, the dynamics of downloaded applications for remote work, the world level of falling tourist flow, the number of trips in absolute terms, etc.).

When establishing the relationship between digitalization, COVID-19 and sustainable development, quantitative and qualitative indicators are compared, reflecting positive and negative results and their impact on changing overall well-being.

The statements and conclusions are based on the analysis of official statistical data of various international organizations and companies, such as the United Nations Conference on Trade and Development, International Institute for Applied Systems Analysis (IIASA), Rockwell Automation, International Air Transport Association, Eurostat, World Meteorological Organization, World Tourism Organization, FreightWaves, Global Carbon Project, Pacvue, for 2019-2020 and partly 2021.

#### 4. Findings and Discussion

## 4.1. Digitalization and sustainable development in the context of COVID-19

An analytical review of the study results of the symbiosis of digitalization, sustainable development and COVID-19, as well as the challenges generated by these phenomena, requires clarification of some theoretical aspects, in particular the essence of the digitalization category. A review analysis of previously conducted scientific studies by various authors, such as H. Albach, B. Berthon, E. Brynjolfsson, M. Jeon, M. Jeong, D. Ernst, B. Kahin, M. Knickrehm, S. Markovitch, T. Mesenbourg, H. Meffert, N. Negroponte, T. Niebel, A. Pinkwart, R. Reichwald, Z. Xiang, D. Fesenmaier, D. Tapscott, P. Willmott, K. Schwab et al., allowed us to establish that the category *digitalization* appeared in 1995. This term was first used by a Greek-American computer scientist from the University of Massachusetts, the founder of the One Laptop per Child Association, who studied digital economics, Nicholas Negroponte (Negroponte, 1995). However, scientific circles started talking more actively about digitalization after Klaus Martin Schwab announced the Fourth Industrial Revolution at the World Economic Forum in Davos in 2016, noting that economic growth and well-being for everyone is our common goal, and digital technologies will play the main role therein (Schwab, 2016).

It should be noted that in the works of the authors presented above, digitalization is considered as a result of the natural evolutionary process of economic and social development, which includes computer, information and communication technologies. Agreeing with this opinion, we consider it appropriate to visualize this statement (Fig. 1).



Figure 1. Conceptual vision of the periodization of the formation of digitalization, compiled by the authors on the basis of generalization (Negroponte, 1995; Schwab, 2016)

From (Fig. 1) it follows that information, computer and communication technologies belong to the Third Industrial Revolution, digital technologies – to the Fourth one. The method of measuring the level of development in percentiles is explained by the fact that this scale allows unifying the results of both statistical and empirical studies (polls, marketing research, expert opinions) and presenting them in a generalized form. In this regard, we came to the conclusion that digital technologies are an obligatory component of digitalization, and digitalization, in fact, is the process of introducing digital technologies into all spheres of society (The compact Oxford English dictionary: complete text reproduced micrographically, 1991). This point of view is reflected in the research of the vast majority of scientists in various scientific fields.

Thus, R. Tapscott understands digitalization as revolutionary changes in business models based on the use of digital platforms, which lead to a radical increase in market volumes and competitiveness of companies (Tapscott, 1998).

In the studies of Ukrainian economists L. Halkiv, O. Karyi, I. Kulyniak, S. Okhynok, digitalization is considered as a *new model of business development*, *a new paradigm of accelerated economic development* based on such processes as globalization, transformation, integration (Halkiv, 2020).

S. Markovitch, P. Willmott define digitalization as the process of digitizing all information (and even material) resources (creating digital copies) and the formation of network interaction platforms in order to obtain a predictable and guaranteed result for any control impact (Markovitch, Willmott, 2014).

M. Knickrehm, B. Berthon, P. Daugherty argue that digitalization is a phenomenon caused by the rapid development of information technologies, microelectronics and communications in most countries of the world (Knickrehm, Berthon, Daugherty, 2018).

Relying on the statements of R. Tapscott, L. Halkiv, O. Karyi, I. Kulyniak, S. Okhynok, S. Markovitch, P. Willmott, M. Knickrehm, B. Berthon, P. Daugherty, as well as based on the conceptual vision of the periodization of the formation of digitalization (Fig. 1), it has been established that digitalization should be understood as integration processes taking place at the level of companies, industries, affecting all spheres of society. In addition, we came to the conclusion that digitalization is the core of the digital economy, which the authors understand as a system of economic, social and cultural relations based on the application and use of computer, information and communication and digital technologies. All of the above gives grounds to assert that digitalization is a conductor of economic, environmental, social, cultural and other changes that affect the life of an individual and society as a whole, and also becomes a necessary condition, a driving force for sustainable development. A similar point of view is reflected in the studies of N. Martynovych, E. Boichenko, O. Vivchar, N. Myskova, O. Popovych, O. Kasianenko, focused on the formation of the educational level of the population of Ukraine under the conditions of the information society. The authors note that it is necessary to move to a new level of progress based on renewable sustainability, the implementation of which can be ensured through digitalization, which in turn will allow the formation of a new personality focused on the system of environmental values, and not on the values of consumer society (Martynovych, 2019).

This thesis is confirmed by the analysis presented by UNCTAD, according to which, over the past decades, the relevance of the introduction of digital technologies in industry, agriculture, engineering, construction, real estate services, small and medium-sized businesses, financial and other spheres has increased significantly. Accordingly, for the period of 2010-2020 the number of Internet users increased from 1.6 billion to 4.1 billion (the prevalence rate increased from 23 to 54%); the number of smartphones, that just started to appear on the market in 2007-2008, reached 3.2 billion by 2020, while global Internet traffic increased from 4 thousand to 100 thousand GB per second. Over the period 2015-2020, the volume of e-commerce revenue in the world has grown more than 2.5 times, reaching \$3.5 trillion (UNCTAD, 2020). All this testifies to an unprecedented technological breakthrough, as well as to the fact that the prerequisites for transferring key processes to a digital environment and ensuring their continuity have already been formed.

The COVID-19 pandemic contributed to the acceleration of digitalization. This is stated, among other things, in the report of the United National Conference on Trade and Development *The COVID-19 Crisis: Accentuating the Need to Bridge Digital Divides*, according to which of the six main digitalization trends, three are directly related to quarantine: remote work and the use of technology communication; changing consumer habits; negative impact on some digital platforms (UNCTAD, 2020). As we can see, along with the positive impact of COVID-19 on digitalization, there is also a negative one, which requires additional attention and the development of non-standard solutions, which are presented below. Thus, the author's reasoning and analytical argumentation give grounds to assert that digitalization is one of the conditions for ensuring sustainable development.

This point of view was reflected in several reports of 2019-2020 at once. In particular, the problems of digitalization in connection with the implementation of the sustainable development goals were discussed in detail in the reports: *Digital revolution and sustainable development: challenges and prospects* within the framework of the *World in 2050* initiative; UNCTAD *Report on the Digital Economy 2019* and *The Covid-19 Crisis: Accentuating the Need to Bridge Digital Divides*; the report of the UN High-level Group on Digital Cooperation *Time of Digital Interdependence* (TWI 2050, 2019; UNCTAD, 2019, 2020; UN, 2019). The general thesis of the expert opinions reflected in these reports is that digitalization potentially contributes to the implementation of the SDGs in three main directions (Table 1).

Result	SDG				
1st direction					
Digitalization accelerates the process of transition from	an environmentally hazardous business model				
to a circular eco	nomy				
Reduction of environmental risks, creation of additional jobs in	Improving the standard of living of society around the				
the green sectors of the economy	world, especially in developing countries. Ensuring a				
	healthy lifestyle and promoting well-being for every-				
	one at any age.				
2nd direction	on				
Digitalization contributes to social integration, reducing ir	nequality of opportunities, literacy development,				
as well as increasing fina	ncial inclusion				
Internet connectivity in developing countries. Gaining access to					
financial resources for people living in developing countries	Reducing the inequality of access to the Internet for res-				
through various mobile applications. Electrification of develop-	idents of the countries of the world. Ensuring inclusive				
ing countries and reduction of the cost of Internet traffic Popular-	and equitable quality education and promoting lifelong				
ization of norms and values protecting human rights through the	learning opportunities for all				
Internet					
3rd direction					
Transition of the world economy to sustainable ecological development					
While regulators are not keeping up with the pace of development of the digital revolution and the greening of the global economy, however, digitalization has a high potential to reduce anthropo- genic impact on the environment.	Ensuring the availability and rational use of water re- sources, access to affordable, reliable, sustainable and modern energy sources for all. Promoting the fight against climate change and its con- sequences.				

Table 1. The main directions of SDG implementation based on digitalization, compiled by the authors on the basis of generalization (TWI 2050, 2019; UNCTAD, 2019, 2020; UN, 2019)
Thus, tabular data allow us to conclude that sustainable development is becoming an increasingly relevant part of the social agenda, which makes it a critically important topic for business and industry. Digitalization allows industries not only to reduce the amount of harmful waste, but also to efficiently redistribute resources, increase productivity and create safer, more attractive working conditions for employees.

#### 4.2. Digital management technologies: Aviation and COVID-19

Aviation is one of the industries in which the digitalization of business processes is proceeding at the most active pace. This trend of technological transformation is due to the twenty-year growth in demand for air transportation (Fig. 2), which is associated with the development of tourism, which has had a positive impact on the aviation industry, as well as minimizing costs and the risk of human error. However, despite the prospects of the aviation industry, the coronavirus pandemic has had a devastating impact on its development worldwide. Thus, for the period of 2019-2020, there was a decrease in global revenue in passenger kilometers (RPKs) by 66%, which is comparable to the level of global air traffic in 1998 (Fig. 2).



The IATA Annual Review 2020 report on the devastating impact of COVID-19 on the aviation sector reads as follows: *In 2020, the COVID-19 pandemic was the strongest shock to air transportation and the aviation industry since World War II. Even the terrorist attacks of September 11 and the global financial crisis of 2007-2008 were not so dramatic from an economic point of view* (Fig. 3).



The decrease in passenger turnover, of course, had a negative impact on airline revenues. So, if before the COVID-19 pandemic (2018-2019), the revenues of air carriers were at the level of \$ 600 billion. By the end of 2020, their total incomes have decreased three times, which is comparable to 1993 (Fig. 4).



The domestic aviation market of China suffered the most, which literally in three months (February-April 2019) decreased by 94% compared to the previous year, but closer to 2020 it has already recovered by 60% (IATA, 2020). Unlike the Chinese market, the European one is recovering very slowly. According to Eurostat, there were no significant signs of air travel recovery in the first months of 2021. So, in January 2021, the decline was 68% of the level of 2019, in February -73%, and in March -71%. In April, the reduction of flights was estimated at 70%. Despite the fact that in August 2021, the number of commercial flights to the EU increased by 48% compared to August 2020, this is still much lower than the *pre-pandemic* level (-31% compared to August 2019). (Eurostat, 2021).

Flight statistics at the largest European aviation hubs show a similar picture: Paris de Gaulle Airport and Amsterdam Airport handled 67% less flights, Frankfurt Airport 65% less, and Munich Airport 81% less. The decline in Barcelona was 79%, in Madrid -66%, in Rome -76%, in Vienna -76%, in Dublin -86% and Copenhagen -81% (Eurostat, 2021).

Despite the magnitude of the negative impact of the pandemic, quarantine measures have also brought positive results from the point of view of sustainable development. Thus, according to the analytical reviews of the logistics company Freight Waves, for the period 2020-2021, along with a decrease in the growth rate of the supply of carrying capacity, the loading of aircraft increased, which contributed to an increase in the profitability of airlines from cargo transportation, thereby leveling the negative effects of rising costs, for example, fuel. The highest load rates are observed in Europe (89.0%) and Latin America (85.3%) (FreightWaves, 2021).

In addition, the coronavirus pandemic has led to a record decrease in  $CO_2$  emissions into the atmosphere, causing a *greenhouse effect* and, as a result, global warming. Thus, in the Global Carbon Project studies, it is noted that for 2020-2021, the volume of  $CO_2$  emissions worldwide, it decreased by 2.4 billion tons (7%), which is significantly more than the previous record figures of the end of World War II – 0.9 billion tons and at the peak of the global financial crisis – 0.5 billion tons (GCP, 2021).

However, despite the presence of positive aspects, their share in the total volume is insignificant, which gives grounds to assert that COVID-19 is a global challenge requiring non-standard solutions. This is also evidenced by the forecasts of international analytical centers, according to which the restoration of international passenger traffic will be carried out at a very slow pace. It is expected that in 2021, the volume of international traffic will still represent only a small fraction of pre-crisis indicators and will not fully recover until at least 2023 (Global Ecommerce Forecast 2021).

Therefore, digital technologies and digitalization in the existing reality, according to the author (O. Polishchuk), are an effective tool for making non-standard decisions. For example, due to the digital revenue management technology *Revenue Management*, airlines, under the conditions of dynamic pricing of services, have the opportunity to differentiate services clearly according to customer requests in a short period of time. In addition, this technology allows you to create a client profile once, create personal offers, services and tariffs, as well as make changes and additions at any time if necessary. Attribution of passengers and the formation of personal profiles through the sale of additional services contribute to an increase in the volume of aviation retail and increase competitiveness.

As a tool to combat the consequences of a COVID challenge, we also consider it advisable to use online services that allow you to book a flight from any place in the shortest possible time without unnecessary risks of infection. Among the most popular digital technologies for online booking of air travel, OneTwoTrip, Online, Aviasales metasearch, Kauak (service for booking air tickets for international flights), Travelocity, Rozetka.Travel (popular in Ukraine) can be distinguished.

In the context of a pandemic, the so-called *customization* is becoming increasingly relevant in the passenger air transportation market, which involves the interaction of airlines and aircraft manufacturers in the process of cabin

layout. Thanks to the digital technologies of virtual (VR, virtual reality) and augmented reality (AR, augmented reality), it becomes possible to reproduce a full-scale mock-up of a custom version of the aircraft cabin, and then form a projection of the future design solution and test all the elements until the final assembly of the cabin. Thus, airlines can not only assess the prospects for the development of the air fleet in the medium and long term, but also manage the existing fleet of aircraft in real time in order to work out solutions for the configuration and retrofitting of the cabin.

The trends and directions of development of the global passenger air transportation market outlined above indicate that, under the conditions of current restrictions on air travel due to COVID-19, the aviation industry should show flexibility and adaptability, since the modern world, even after the end of the pandemic, will never be the same. The onset of the Fourth Industrial Revolution, combined with new challenges, dictate different rules, which are based on digitalization. Based on this, not only aviation, but the whole of humanity (present and future generations) needs to be integrated into the transformed reality of sustainable development.

#### 4.3. Digital management technologies: management, economics of organizations and COVID-19

Speaking about digitalization in the context of management, it should be noted that it affects absolutely all spheres of society and industries, enterprises of various forms of ownership and activities, organizations, processes. Digital technologies can be aimed at management and leadership; negotiations and sales; management psychology; formation of critical thinking and personal growth; improvement of managerial qualifications, etc. Digital management technologies require new approaches to the organization of management, including flexible methodologies for project development and management; the creation of mental maps and the use of a single collective information space, etc.

Along with the urgent need to use digital technologies in management on the way to the implementation of corporate digitalization, a number of problems arise related to the unwillingness of managers, employees, consumers to integrate into the digital space, to rebuild their thinking on the course of global sustainable development.

Therefore, digitalization of management of both the enterprise and the state is, on the one hand, a challenge emanating from the external environment, and on the other, creates additional competitive opportunities in the context of the COVID-19 pandemic, against which significant transformations have taken place, leading to one of the deepest economic recessions in the world over the past 100 years. At the same time, the poles in the development of trade and services have shifted, the structure of employment has changed, etc.

On the basis of all that has been said, it follows that COVID-19 had not so much a negative impact, but rather contributed to a change in realities, redirecting the traditional foundations and understanding of production, sales, consumption, education. This fact is also noted in the reports of international organizations. In particular, the Digital economy report united nations conference on trade and development, 2019 talks about changes in consumer habits, expressed in an increase in electronic sales. For example, in the USA in the period of 2019-2020, there was an increase in online sales in the field of food delivery, pet food. Significant growth affected some items of medical products. According to Pacvue, sales of hand antiseptics and antibacterial soap have increased (Pacvue).

According to analytical studies of The COVID-19 Crisis: Accentuating the Need to Bridge Digital Divides over a ten-day period (mid-January – early February 2020), there was an increase in the volume of food products of the Chinese online retailer JD.com by 215% to 15 thousand tons (compared to the same period last year) (UNCTAD, 2020).

Changing habits due to COVID-19 will also be discussed at the upcoming 24th session of the UNWTO General Assembly (Marrakesh, Morocco, November 30 – December 3, 2021). The agenda notes that *The pandemic has revealed the importance of multimedia communications within the new reality. The current shift towards digitalization, as a result of which the habits of viewers and users are changing, and the consolidation of strategies for shifting the focus to mobile devices have accelerated since the pandemic broke out (UNWTO, 2021).* 

Another area in which there has been a sharp increase in user activity over the period of 2019-2020 is streaming services. The closure of theaters, cinemas and schools to quarantine, helped attract a new audience to streaming services and video hostings such as Netflix, HBO, YouTube, etc.

Due to the spread of COVID-19 in the world, more and more people began to work remotely using video conferencing services and messengers. The demand for the use of programs such as Microsoft Teams, Skype, Cisco's Webex and Zoom has increased. Since the end of January 2020, China has seen a significant increase in the use of remote work services such as WeChat, Tencent and Ding (Fig. 5).



Figure 5. Dynamics of downloaded applications for remote work in China 2020 (Sensor Tower, 2020)

Digital tools and online trainings allow teachers to stay in touch with students. Digital technologies have also played a positive role in the activities of the International Organization for Migration. For example, in Belgium and France, under the conditions of the pandemic, they began to use online platforms on which citizens must register if they find themselves in a difficult situation. In Slovakia, consular offices offer a geolocation service via a SIM card in order to contact their citizens and provide them with the necessary information.

The use of online platforms stimulates the development of cloud technologies for data storage and analysis, increases the demand for renting various services of technology companies such as Amazon Web Services, Microsoft, Tencent and Alibaba.

As mentioned earlier, experts also note the positive effects of COVID-19 on the environment, which are manifested in reducing greenhouse gas emissions, improving water quality, reducing noise, improving air quality and, in some cases, restoring wildlife (GCP, 2021). At the same time, in the studies of atmospheric experts from the World Meteorological Organization, it is noted that the *positive impact* from the suspension of economic activity on the level of  $CO_2$  in the atmosphere during a pandemic is extremely small, since the overall picture is made up of annual emissions and represents the entire volume accumulated since the pre-industrial era. On this scale, reductions in emissions in one particular year are unlikely to have an impact on global atmospheric carbon dioxide levels (WMO, 2021). Despite the presence of visible social and economic and environmental benefits obtained during the quarantine, scientists around the world note that during the same period of 2019-2020, the amount of household and medical waste increased, exacerbating the previously acute problem of waste recycling with the disposal of personal protective equipment.

Tourism in general and some digital platforms, mainly in the field of transportation and travel, such as Uber, Lyft, Didi Chuxing (transportation services), Airbnb, Booking.com (housing rental services) suffered significantly from COVID-19. This trend reflects the general decline in the travel and tourism industries during the pandemic (Fig. 6). Thus, according to UNWTO analytical data, in 2020 the number of international arrivals decreased by one billion or by 74% compared to 2019.

Regionally, the Asia-Pacific region suffered the greatest damage from the pandemic in tourism, since the strictest travel restrictions were in effect there -84% (300 million) international arrivals. In the Middle East and Africa, there was a decline of -75% (UNWTO, 2019, 2020).

Europe lost 70% of the tourist flow in 2020, while the European continent recorded the largest drop in the number of trips in absolute terms compared to 2019 -500 million. In the North and South America, the decrease in the number of foreign tourists was 69% (UNWTO, 2019, 2020). The global nature of the COVID-19 consequences in tourism industry, as well as the relevance of sustainable development, is evidenced by the upcoming 24th session of the UNWTO General Assembly (Marrakesh, Morocco, November 30 – December 3, 2021), in which (4. Thematic session: *Innovation, Education and Rural Development to Build Back Better*), issues of restarting tourism through innovation, based on digital technologies, and education for future generations will be discussed (UNWTO, 2021).

The studies of the European Union Agency for Cybersecurity have also established both positive and negative effects of COVID-19 on digital processes and components of sustainable development. The analytical report notes that, on the one hand, the growth of electronic sales contributed to the acceleration of the digital transformation of enterprises, medium and small businesses, accounting for 99% of all companies in Europe, forced to expand their online presence in order to survive under the current conditions. On the other hand, published opinion polls have shown that about 41% of Europeans are concerned about the security of online payments (EUAC, 2020).

In addition, COVID-19 has demonstrated the existing stratification both between countries and within them. According to UNCTAD's analytical data, the least developed countries are experiencing certain limitations in various areas, which are associated with the lack of Internet, which ultimately slows down digitalization. Using the example of education, it is possible to demonstrate more clearly the existing digital divide between states and students.

Thus, according to the Program for International Student Assessment, in countries such as Denmark, Slovenia, Norway, Poland, Lithuania, Iceland, Austria, Switzerland and the Netherlands, 95% of students can use a home computer, while in Indonesia this figure is only 34%. Among low-income states, more than 75% do not offer any form of distance learning, while those that do offer it, cover only 36% of residents with Internet access (PISA, 2021).



Figure 6. The level of decrease in the tourist flow in the world during the pandemic (UNWTO, 2020)

Summarizing what has been said, it should be noted that despite the efforts of the world community to jointly research the origin, behavior, and global influence of the virus, answers to many questions will be received and made public much later. Only one thing is clear, the symbiosis of digitalization, sustainable development and COVID-19 are new challenges generated by human activity that require non-standard solutions.

In this regard, the composition of non-standard digital solutions to overcome the problems associated with COVID-19, ensuring sustainable development, is presented below (Table 2).

Thus, the presented trends will allow launching new business models that can smooth out the post-covid consequences and put the world economy on a trajectory of sustainable economic growth. At the same time, digitalization is a key tool for achieving Sustainable Development Goals.

#### 5. Conclusion

Based on the results of the research, there are theoretical and applied foundations of digitalization under the conditions of COVID-19 are formed in this article, as well as non-standard solutions for ensuring sustainable development based on digital technologies are developed.

- 1. As a result of a review analysis of previously conducted scientific research in the field of digital transformations, it was found that digitalization is the result of a natural evolutionary process of economic and social development, which includes computer, information and communication technologies, which made it possible to deepen the terminological apparatus of the economy and to approach the consideration of applied problems in a substantive way.
- 2. As a result of generalization of theoretical and analytical data, it is proved that digitalization is a conductor of economic, environmental, social, cultural and other changes affecting the life of an individual and society, as well as a necessary condition for sustainable development, which made it possible to identify the main directions of the implementation of the SDGs based on digitalization.
- 3. Comparative analysis of statistical indicators for the period of 2019-2020, made it possible to prove that the COVID-19 pandemic contributed to the acceleration of digitalization, as well as the fact that along with the positive impact of COVID-19 on digitalization, there is also a negative one, which gave reason to assert that the symbiosis of digitalization, sustainable development and COVID-19 are new challenges generated by human activity that require non-standard solutions.

Table 2. Non-standard digital solutions for sustainable development in the context of COVID-19, compiled by the authors according to (IDC's, 2021, Gartner, 2020)

5 year trend (2020 2025)	10 monther (2020)
5-year trend (2020-2025)	To-year trend (2020-2030)
Accelerated transition to cloud technologies	Composite business architecture
I ransition of enterprises of various industries to cloud digital	The transition of enterprises of various industries to a modular
models in order to remain competitive.	lexible business architecture model ( <i>packagea</i> business services,
Transition to autonomous digital operations	data factories, private SG networks and embedded AI, etc.), allow-
The transition of enterprises of various industries to cloud eco-	ing organizations to move from rigid traditional planning to a flex-
systems as a basic structure that will expand the capabilities of	ible response to rapidly changing business needs, which creates
systems as a basic structure that will expand the capabilities of	opportunities for the introduction of innovative approaches, re-
Parin hand commuting	duces costs and improves parmersings.
The transition of extensions is environmental to active the second second	All a south loss to descend
The transition of enterprises in various industries to peripheral	Algorithmic trust
computing and business models that will take into account	The transition of enterprises of various industries to algorithmic models of trust since enterprises and ergenizations can be lenger
demic which will allow for faster and more efficient response to	fully trust management bodies and their place is taken by algo
changing needs	rithms that ansure the confidentiality and coourity of data track
Intelligent digital workspace	their origin and confirm the identity of people and things (SASE
The transition of enterprises of various industries to an intelli	Secure Access Service Edge) as well as hy responsible and expli-
ant workspace, which will allow employees to work more effi-	$\Delta I$ that is an algorithm with traceable stages
ciently both on their own and on joint projects	
Digital legacy of the pandemic	Silicon-free technologies
Transition of enterprises of various industries to a sustainable	The transition of enterprises in various industries to carbon tech-
digital infrastructure. This non-standard solution is associated	nologies involving the use of new materials with expanded capa-
with the technical debt that arose due to forced migration to the	bilities instead of silicon the physical stock of which is being de-
cloud space during the quarantine period so enterprises of all	pleted which make it possible to make technologies more compact
industries will continue to look for opportunities to create sus-	and faster
tainable digital infrastructures.	
	Formative artificial intelligence
Opportunistic expansion of digital opportunities	The transition of enterprises in various industries to formative AI.
The transition of enterprises in various industries to subscription	which is able to change dynamically in order to respond to the sit-
models involving the acquisition of at least one startup to de-	uation, adapt over time to technologies that create new models for
velop a new or adapt an existing technology.	solving specific tasks ( <i>small data</i> and self-monitoring training).
Reassessment of relationships and services	
The transition of enterprises of various industries to optimal dig-	
ital strategies due to the transformation of demand, supply, lo-	Divitalization of normanality
gistics, etc.	These are the technologies of the future that integrate with people
<b>Eco-sustainability</b>	which means that there are more and more opportunities to create
The transition of enterprises in various industries to eco-sustain-	digital versions of a person. These digital doubles of people can
able methods of doing business, based on the reuse of materials	exist both in physical and virtual space which can be used for
in supply chains, ensuring a zero carbon footprint and reducing	identification access navment and immersion analytics How-
energy consumption.	ever, such an interface also represents an additional vulnerability
People are still of paramount importance	that can be used by attackers. Among other technologies, one can
The transition of enterprises of various industries to the use of	note the <i>health passport</i> and digital doubles of a citizen.
crowdsourcing and professional development/retraining of em-	
ployees, the development of digital teams or DevOps groups,	
due to digitalization.	
The transition of entermines in environ in dustries to disited tech	
The transition of enterprises in various industries to digital tech-	
dots that affect them involving face recognition location treat	
ing and hig data, etc.	
Mesh network technology in orborscourity	
The transition of enterprises of various industries to the mesh	
network technology which allows getting access to any digital	
assets, regardless of where the asset is located or the person him-	
self, while ensuring the security of information that is being at-	
tacked due to digital assets going beyond the firewall especially	
when using cloud technologies and remote work	
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4. On the basis of general scientific methods, statistical, comparative and graphical analysis, a composition of non-standard digital solutions to overcome the problems associated with COVID-19 has been formed, ensuring sustainable development, which allow launching new business models capable of smoothing out the post-covid consequences and putting the world economy on a trajectory of sustainable economic growth.

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## Digital Information Security: Coronavirus Crisis Impact on the Accountants, Business Analysts and Auditors Training

## Cyfrowe bezpieczeństwo informacji: wpływ kryzysu spowodowanego przez COVID-19 na szkolenie księgowych, analityków biznesowych i audytorów

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#### Abstract

The article considers the impact of transformation processes on business in the context of digitalization. Equally important is the study of the impact of these processes on the training of professionals whose work has had a direct impact on these transformations – accountants, business analysts and auditors. These specialists are faced with the task of analyzing the impact of the facts and determining the change in business development strategy in the context of global digitalization. The field of audit both in the world was able to adapt extremely flexibly to the new realities of functioning in the digitalized world. In this article, the authors reveal the main trends of digitalization of audit in the conditions of economic transformation and limited business practices caused by this global pandemic of 2019-2020. At the same time, the processes of digital transformation are the driving forces of the

economy. Computer technology is becoming increasingly involved in reforming the audit institution and changing the trajectory of the auditor's role in such a society.

**Key words:** information security, COVID-19 impact; business in the context of digitalization; audit institution; cybersecurity

Slowa kluczowe: bezpieczeństwo informacji, wpływ COVID-19; biznes w kontekście cyfryzacji; instytucja audytu; bezpieczeństwo cybernetyczne

#### Introduction

The global financial crisis, which resulted from the extremely dynamic spread of COVID-19 at the beginning of the year, effectively reformatted all areas of socio-economic relations into two key vectors (depending on how much a particular industry has been affected by the pandemic). There was a clear distinction between the spheres of human activity that were significantly affected by these processes and those that found innovative approaches to their continuous activities, but in fact almost did not succumb to this impact (Oliynyk et al., 2017). At the same time, there is an incredible impact of COVID-19 not only on the health but and the budgetary security of the national economy (Strilets et al., 2020).

The transition of many companies to online mode and digital transformation processes are the driving forces driving change in the corporate world, based on the introduction of new technologies for analyzing large databases, Internet products, cloud technologies or 3D printing. Analog information is being converted to digital data. The constant convergence of the physical and digital worlds encourages companies to integrate, for example, the Internet of goods and services into production processes, create value through analysis and management of big data, which can be used as a competitive advantage. Most of the changes caused by digitalization are destructive and radically change existing industries, companies that occupy a dominant position in the market, face new competitors, existing business models become obsolete and replaced by new ones.

Issues of accounting, analysis and audit and their automation have been studied by many domestic and foreign scientists. In particular, theoretical and practical problems of centralized and decentralized accounting were studied by F. Butynets (Butynets et al., 2002) the advantages and disadvantages of centralized and decentralized accounting in budgetary institutions are covered by M. Kharchenko (2017). K. Naribaeva (1983) in his works expresses the opinion that centralized and decentralized accounting can not exist separately, and T. Popitich (2010) assumes the existence of a combined type of accounting. Such a scientific position certainly deserves attention, but it is not indisputable. Thus, a slightly different position is set out in the work of M. Lazareva (2018) where she concluded that *transaction costs of centralization and integration form system effects, the value of which reflects not only the level of efficiency of the firm, but also the level of its dynamic stability.* She also proposed a formula for calculating the synergistic effect that occurs when centralizing functions. In addition, the issues of centralization and decentralization in their works consider: V. Gorbachuk and A. Lyashko (2019), V. Boyko (2019), A. Fedorenko (2019), S. Kozlovskyi (Kozlovskyi et al., 2019), E. Khodakivskyi (Khodakivskyi et al., 2019), L. Horoshkova (Horoshkova et al., 2018), L. Ivanchenkova (Ivanchenkova et al., 2018), V. Aleksashin and H. Mykhalchuk (2019).

At the same time, the available scientific works do not fully reveal the specifics of centralized and decentralized accounting, analysis and audit in the context of the impact of general globalization processes, the latest trends in the impact of digitalization on the organization of accounting of enterprises. And although the praxeological significance of the use of new opportunities of digital technologies for accounting, analysis and audit is quite high, the dynamics of innovation contributes to the fact that there is a significant lag in the development of competencies of accountant, analyst, auditor.

The purpose of the article is to substantiate the feasibility of centralizing procedures to improve information security in the digital world and the effectiveness of accounting, analysis and audit in the context of the impact of the crown crisis and digitalization on the training of accountants, business analysts and auditors. In accordance with the defined goal, the main objectives of the study are to identify the main disadvantages and advantages of a centralized and decentralized model of accounting, analysis and audit; research of possible directions of use of digital technologies for accounting procedures of the enterprises; development of recommendations for changing the decentralized accounting model by the company to a centralized one, formulating a general conclusion on this study.

#### Research of global trends in information security

In 2018, the annual global survey of the CEO of PwC (2020) revealed a record level of optimism about global economic growth. In 2020, there is a record level of pessimism. For the first time, more than half of the surveyed executives believe that world GDP growth will decline. This caution has led to low confidence in the worldview of their own organization. Only 27% of CEOs are very confident in their revenue growth prospects until 2020, which have not been low since 2009. For the first time, more than half (53%) of business leaders believe that

global economic growth will decrease (Fig. 1). The share of managers who are confident in their growth prospects for 12 months has fallen to 27%, the lowest level since 2009 (Fig. 2). Declining confidence in the CEO contributes to uncertainty over regulation, trade and economic growth. CEOs are divided over whether government legislation will spread online. Only 18% of organizations worldwide report significant progress in developing a training program. Today, leaders globally recognize the greater potential of climate change initiatives than they did ten years ago.

The study of global information security trends (Nazarova et al., 2020) reflects the strengthening of the digital environment against cyber threats. Cybersecurity incidents have become more frequent and regularly appear in the headlines, causing growing concern among consumers and business leaders. Despite the close attention to such cases that has been drawn in recent years, most organizations around the world still find it difficult to grasp and manage emerging cyber risks in an increasingly complex digital environment.



Figure 1. The pace of global economic growth in 2020, developed by the authors based on PwC (2020)



Figure 2. The share of managers, who are confident in the company's prospects for growth over the next 12 months, developed by the authors based on PwC (2020)

Given that the digital environment is becoming more complex every day and our dependence on data and networking is growing, the development of resilience to cyber threats – large-scale events with devastating consequences that develop on a cascading basis – has never been so important. In a study of global trends in information security PwC (2020), 40% of respondents from organizations that use automated and robotic systems, say that disruption of operations will be the most critical consequences of cyberattacks on these systems. Despite the growing awareness and publicity of the events and consequences of cyberattacks, many companies are still not prepared for real countermeasures. Most key cyber risk detection processes in business systems are implemented in less than half of the respondents (Fig. 3). Achieving a higher level of cyber resilience within individual enterprises or society as a whole requires greater efforts to identify and manage the new risks inherent in modern technologies. Organizations need the right guidance and procedures to implement the information security measures that digital progress requires.

When conducting digital transformation, special attention should be paid to the protection of technologies and processes that are implemented, and in some cases to include the transformation of cybersecurity in this process. 29% of respondents claim that the responsibility for ensuring the security of the Internet of Things is the responsibility of the Director of Information Security. Most corporate boards do not take a precautionary approach to developing cybersecurity strategies or investment plans. Only 44% of respondents stated that boards of directors are actively involved in developing and implementing the overall security strategy of their company. Top managers of companies must take responsibility for ensuring cyber resilience. Building a vertical strategy for managing

cyber risks and privacy risks is essential throughout the enterprise. The concept of sustainability must be integrated into commercial activities.





The results of the EY Global Information Security Study (Kessel, 2018) show that the cost of cybersecurity has increased, but organizations need to take more and more action. Companies' spending on cybersecurity has increased – organizations have begun to allocate additional resources to protect information and make more efforts to create reliable security systems (Fig. 4).



Figure 4. Cybersecurity 2020: how difficult is it?, developed by the authors based on Kessel (2018)

More than three-quarters of organizations surveyed (87%) do not have a sufficient budget to provide the required level of cybersecurity. Security measures are not implemented systematically and only a small number of organizations give priority to advanced technologies. For most companies, cybersecurity remains a matter of paramount importance. The survey showed that a significant number of respondents (77%) have a basic set of tools to ensure cybersecurity. Sometimes companies do not know exactly where the most critical information

assets are stored and have no guarantees about their security. 77% of organizations plan not only to install basic cybersecurity tools, but also to configure them according to business opportunities and conditions. Organizations are convinced that cyber risk management and the development of cybersecurity are essential for success in the digital age.

The use of digital audit by companies improves the quality of work and creates additional value for business. The use of technology in the audit of public and private companies increases transparency, improves the risk assessment system, automates routine processes and generally improves the quality of the audit. Digital technology audit uses digital channels from the beginning to the end of all processes. It is based on three solutions: automation, analytics and digital customer experience. The basis of digital audit success is a technology platform that should effectively connect all members of the audit team with each other, with representatives of the client company, as well as increase the efficiency of project management at all stages (Sidhu, 2019).

Creating a favorable business environment, ensuring competition, encouraging entrepreneurship and innovation are drivers of economic growth and increasing its growth rate, improving the investment attractiveness of the country. The competitiveness and innovative potential of the state largely depend on the readiness of business entities and their staff to use new methods and technologies of business management, in particular, digital technologies.

Accounting and audit in digitalization has a number of significant advantages over traditional accounting, due to the efficiency of creation, signing, transmission of information, documents and reports, online monitoring of the financial position of the enterprise, resources and indicators, remote access to information regardless of location (including from a smartphone), environmental friendliness of the process. At the same time, new conditions in the provision of accounting procedures lead to inevitable organizational changes in the accounting services of enterprises, transformation of accounting processes, technologies of operations and, in particular, their centralized management in systems, but with decentralized access to such systems and data.

The advantages of centralized accounting procedures in combination with the use of digital technologies were especially noticeable in the conditions of quarantine, in order to prevent the spread of acute respiratory disease COVID-19 caused by SARS-CoV-2 coronavirus, which caused the activity enterprises and, often, the need for separate work of many employees, including accountants, analysts, auditors.

In March 2020, the Association of Chartered Certified Accountants (ACCA) (2020) decided to investigate the impact of COVID-19 on companies. She conducted a global survey and found that due to the crisis caused by the coronavirus pandemic, such a common action for accountants and auditors as attracting new clients has become a real problem (Fig. 5).



Figure 5. Problems faced by accountants and auditors under the influence of COVID-19, developed by the authors based on ACCA (2020)

Despite the problems associated with COVID-19, the audit should be conducted in full compliance with the standards, although in the circumstances, the completion of the audit may take longer. Therefore, the use of information technology simplifies the work of the auditor and involves conducting audits using computer technology. Some researchers have conducted research on the adequacy of accounting data. For example, studies conducted by A.Tugui and A.-M. Gheorghe (2016) in the form of a survey of 300 accountants in Romania show that 73.98% of professionals confirm that they have encountered insufficient and inability to obtain accounting data when performing specific tasks, while 69.92% link issues of access with insufficient or limited access to data of old or new accounting information systems.

The trend towards the development of centralized models in combination with digital technologies is confirmed by the analysis of the top best accounting programs 2020, published on TechRadar (Williams et al., 2020). The analysis shows that although some accounting packages are downloadable software, cloud work is now more common for applications. However, according to the same analysis, individual businesses may prefer downloadable software, as it often allows better control of their own data, working on their own machines, rather than on third-party clouds. Therefore, this article is based on the tendency to use centralized software that may not be a cloud solution, controlled by the company, but provides access to it to different users from different points and digital devices. Today it is impossible to imagine the economy as a whole, and accounting, analysis and audit of a modern enterprise without the use of digital devices. At the same time, the current state of society is characterized by increasing the rate of innovation, the use of new digital technologies (Fig. 6).

cloud technologies	
artificial intelligence	
electronic document management	
spread of cryptocurrency circulation	
blockchain	
the so-called "internet of things"	
others	

Figure 6. New digital technologies, developed by the authors

Accordingly, there is a growing interest in these issues and their impact on various sciences and enterprises. The field of accounting, analysis and audit is no exception. In general, the article by K. Bagatska and A. Heydor (2019), which is based on research by foreign and domestic researchers, summarizes that *three terms reflect the logical sequence of digital technology implementation in business models and business processes of companies* (Fig. 7).

Digitalization: transfer of data from paper to electronic, automation of calculations

Digitalization: translation of processes, operations, subsystems and management functions into digital format, use of smart-products, services and solutions

Digital transformation: full integration of the company into the digital economy and industry 4.0

Figure 7. The sequence of stages of digital transformation of business, developed by the authors based on K. Bagatska and A. Heydor (2019)

However, analyzing the terminology and stages, it is advisable to propose the following changes to the scheme of K. Bagatska and A. Heydor (2019):

- the first block of the digital *digitization* block;
- in the first block of *automation of calculations* fully replace the *automation of individual actions*;
- in another block of *digitization*, include *automation of processes*, so that you can directly get in touch with it already in the whole process (and not only part of one process).

Vibration of centralized and decentralized models of accounting and accounting of quieter and lower types of procedures as a whole to lay down the windows for the skin and skin (Britchenko & Saienko, 2017). In science literature, in the main, there were three models of accounting organization – centralized, decentralized and combined. Schematically, the order of front-line interaction (structural units) and the introduction of documents and transactions in software for restoration operations for the purposes of analysis, analysis and audit are shown in Fig. 8.

#### The centralization of accounting procedures

For a long time, the model of centralized accounting has not been dominant both in terms of the presence of its supporters in scientists and in practice. And this was entirely due to the fact that it is much more convenient to keep records where such transactions *occur*, ie, depending on the physical location of the objects of accounting and management decisions. This is largely due to the fact that the primary documents for paperwork were paper documents, and accounting software was downloaded to local computers and servers. But often, where primary documents are not required, decentralized procedures have been replaced by centralized ones.

Models for reflecting transactions in accounting and reporting are not stable, so depending on the needs and development of the enterprise may change. The vast majority of accounting services for medium and large enterprises in connection with the development of digital technology is moving from a decentralized and combined model of accounting to a centralized one.



Figure 8. Interactions of front lines and input of documents in the software for registration of operations for the purposes of the account, the analysis and audit, developed by the authors

With a centralized accounting model, the company can make greater use of modern technologies for online accounting of all types of accounting, preparation and submission of reports. Unified software, unified databases in combination with modern capabilities allow to analyze operational accounting and reporting data, solve problems in a timely manner and make relevant decisions. This conclusion is confirmed in the monograph of the well-known expert on digital transformation Dr M. Baker (2014): *Experts on digital transformation often tell directors about the importance of centralized data and gaining control over it. CEOs sadly shake their heads, knowing the years of investment that have been invested in various, incompatible systems, developed without the thought of data unification, and say that it is 'impossible'.* 

In the analysis of centralized and decentralized models, and in the subsequent revision of accounting functions, which is associated with digital transformation in the modern enterprise, the functions should be grouped by blocks (Fig. 9).



Figure 9. Accounting functions in the analysis of centralized and decentralized models in the digital world, developed by the authors

The decentralized approach has a number of significant disadvantages compared to the centralized one. These are mainly the lack of operational and limited available data on the enterprise as a whole, complications to ensure a unified accounting policy, taking into account adjustments in the activities of individual factors for certain operations and actions, the difficulty of maintaining and updating all software in different locations and insufficient interchangeability accounting staff.

That is why the use of a centralized accounting model will minimize most of the above shortcomings and ensure the relevance and integrity of data on the financial condition and performance of the enterprise as a whole and its individual structural units, simplify access to maintaining and obtaining such information, ensure uniform accounting rules and unified forms, simplify software administration, strengthen the specialization of accounting staff.

Currently, the organization of accounting of the vast majority of modern enterprises is based on a combined model, ie there are both centralized accounting procedures, such as financial reporting, and decentralized, such as settlements with suppliers and customers, settlements with staff. At the same time, with the transition of n enterprises to electronic document management, the need to provide remote access to programs and obtain operational data, the situation changes. If previously the primary document was available at the point of its creation, and the transfer to the centralized accounting service required additional time and resources, then due to the introduction of electronic document management at the enterprise (with a qualified electronic signature) created the original document, not a digitized copy, can be immediately available anywhere in the world and on various electronic devices.

This approach is not only convenient, but also leads to significant cost savings.

In addition to making purely administrative decisions to change the accounting model, the centralization of accounting procedures often occurs spontaneously as a result of external or internal changes in the business processes of enterprises – online sales, centralized supply of equipment and inventories. In all such cases, the management of the accounting processes themselves is not simplified, but complicated, and the advantages of centralized models are not always used (Trachenko et al., 2021). To improve the situation, it is advisable to increase the manageability and transparency of accounting procedures, which is achieved by reviewing all accounting functions and technologies used in accounting, developing a strategy for change to further build a centralized model. The main imperatives of this process are shown in Table 1.

#	The imperative of centralization	Content of the imperative (task)
1	Compliance with strategic goals and external / internal challenge of the enterprise	<ul> <li>identification of necessary changes in the processes of interaction and accounting in connection with the presence of other related centralized and decentralized business functions and processes;</li> <li>identification of new opportunities based on digitalization;</li> <li>clear, reliable and comparable reflection of transactions in the reporting;</li> </ul>
2	Analysis and complete review of functions in the field of accounting	<ul> <li>determination of the full list of functions performed in the field of accounting and their distribution between divisions of the enterprise;</li> <li>updating the model of redistribution of functions</li> </ul>
3	Reengineering of internal accounting processes	<ul> <li>full review of accounting procedures taking into account the best practices of their implementation and application of digital technologies;</li> <li>process automation;</li> <li>development of forms of unified accounting documents;</li> <li>review of the organizational structure of the accounting service</li> </ul>
4	Location of the accounting service	<ul> <li>remote location of accounting departments from the objects of accounting;</li> <li>the ability to view the location of structural units of the accounting service, including remote access to the centralized accounting and document management system</li> </ul>
5	Restriction	<ul> <li>the introduction of new technologies requires additional time to improve the skills of accounting staff;</li> <li>certain activities of the enterprise may not be integrated into existing software packages</li> </ul>

Table 1. Imperatives of centralization of accounting functions, developed by the authors

In the table all the elements are interconnected, but an additional, synergistic effect can be achieved by expanding the use of digital technologies. To achieve a synergistic effect for each of our selected areas can be developed a separate roadmap for centralization in terms of digitalization (Koval et al., 2021). The directions of such improvement are shown in Table 2. Under the conditions of centralization of accounting procedures, all primary documents are sent to a single center, processed, accounting documents are formed on their basis and reports are prepared. In electronic document management, primary documents are not received, but in fact already arise and are stored in a single electronic center. For modern enterprises, these are large arrays of documents and data.

Name of the group of accounting functions	Vectors
Accounting	<ul> <li>software update for accounting – centralized software or ERP, access through web resources and mobile applications, integration with other software packages;</li> <li>use of electronic primary and accounting documents;</li> <li>ensuring the signing of documents with a qualified electronic signature (QES);</li> <li>refusal to print documents;</li> <li>establishment of external and internal electronic document management procedures</li> </ul>
Accounting control	<ul> <li>simplification of procedures for access to accounting information;</li> <li>automation of control procedures;</li> <li>formation of operational control reports</li> </ul>
Accounting, financial and other reporting	<ul><li>automation of centralized reporting procedures;</li><li>automation of procedures for signing and submitting reports</li></ul>
Storage of accounting documents and reports	<ul> <li>use of centralized software, cloud technologies;</li> <li>simplification of procedures for the formation of document archives;</li> <li>simplification of procedures for access to documents, information and their processing</li> </ul>
Communications	• simplification of procedures for access to accounting information by setting up individual types of reports for different user roles on the basis of a centralized accounting system

Table 2. The main vectors of centralization of accounting procedures, developed by the au	thors
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It is for managing large data sets that accounting software providers offer cloud solutions where data sets are stored and managed in one central location, allowing even the most experienced professionals to deliver better results faster, better and more efficiently.

In the centralized accounting model, the same employee of the accounting service processes larger volumes of operations, but homogeneous, compared to the decentralized accounting model, when the employee processes a larger range of operations, but in a smaller total number. Thus, the centralized model increases the specialization of workers, ie there is a division of labor with a focus on one or a limited type of operations, which, as has been repeatedly proven by scientists in other areas, leads to increased productivity. In addition, the narrow specialization allows the employee to constantly improve their professional level, achieve excellence, gain knowledge about new digital technologies that can be applied in this area. This is extremely important to correct the current situation with the lag in the level of development of the competencies of accountants, the existence of which, as already mentioned, was confirmed by the study of A. Zhyvets (2018).

An increase in labor productivity means an increase in the number of products produced per unit of time, or savings in working time spent per unit of output. To determine this indicator in the field of accounting for the number of products can be used the number of accounting records, the number of generated reports. As an example, we can consider the results of the transition during 2016-2017, from the decentralized business accounting model of the National Bank of Ukraine to the centralized model based on existing, not new, software products, but in combination with the transition to partial electronic document management. Until 2016, business accounting and reporting to the NBU were carried out both in the central office and in the regions, and since 2017 they have been transferred from the regions to the central office. This allowed the institution to significantly reduce the total number of accounting staff to perform the same volume of operations and increase the productivity of accountants. As a result of the centralization of business accounting functions, the average number of postings per employee has doubled. This effect is achieved by combining changes in the accounting model, partial use of electronic document management, increasing the level of specialization of employees in performing operations.

Digitalization has the greatest impact on such components of the business model as cost proposal, internal infrastructure management and customer relationships (Mikelsone et al., 2021). Mostly changes in the form of new proposals (products, services, solution packages in the form of cloud computing, forecasting services) are the driving factors in the modification of the business model.

In recent years, society is paying more and more attention to audit, because confidence in the information received is a necessary factor in the trust of partners. In this regard, the market of audit services is transformed in the areas and interests of customers who work in different sectors of business and differ from each other in form of ownership, management systems and financial condition. As more and more data is generated due to the digitalization of companies, there is a need to develop the functions of auditors. For example, the audit practice includes procedures in forensics, tax audit, due diligence, management accounting, personnel audit and other related services. These audit and other services require an emphasis on understanding the specific risks of the business and developing an audit approach that can respond effectively to those risks. Computer technology is also becoming increasingly involved in the new role of the auditor as it shifts from testing tasks to more analytical approaches to working with data.

#### Conclusions

The growing amount of information needs to be used effectively to conduct high-quality audits and to enable auditors to pay more attention to identifying risks and understanding the business. The large amount and untapped potential of data generated by new technologies necessitates constant digitalization of the audit. The functions of a professional auditor change in response to the digital transformation of companies. Using automation to increase data can help conduct high-quality audits and allow auditors to focus more on identifying risks and understanding the business. This development of the audit leads to greater interconnectedness and transparency and, as a result, greater stakeholder trust.

Audit automation issues cover the whole range of applied problems related to the use of information technology in the control, audit and analysis of financial statements of enterprises, evaluation of efficiency and reliability of information technology, as well as the organization of audit firms in modern conditions. Given the current high level of use of computer systems in business, the auditor should be competent, including in the field of typical computer information technology. Yes, he has the opportunity to use the services of a specialist in computer information technology, but it should be noted that this increases the risk of non-detection and additional risk and increases the cost of the audit.

Data protection in computer networks is becoming one of the most pressing problems in modern information and computer systems. Modern information technologies create conditions for the growth of unauthorized access to information and allow to perform complex procedures for its processing. To ensure the protective functions of the audit, data protection avoids the abuse of persons who have access to databases, which are especially common in doing business over the Internet. Practice shows that in the conditions of automated information processing systems, thefts of valuables are carried out with the participation of employees engaged in the processing of economic information. Blockchain technologies provide the highest level of protection from external influences. Data contained in the system cannot be deleted or replaced. Such a database is characterized by anonymity, an agreed mechanism, does not belong to a specific entity, is not controlled and regulated by third parties. Blockchain technologies are ideal for accounting and audit, as they track all operations and changes in the system, do not allow manipulation and distortion.

Thus, the advantages and disadvantages of centralized and decentralized accounting models, the development of electronic document management and the appearance on the market of software solutions using cloud technologies and remote access to work in accounting programs from different locations and devices suggest that the trend towards centralized accounting will only intensify with the development of digital technologies. However, it should be noted that the centralization of accounting does not mean the centralization of management decisions or non-use of blockchain technology. For example, the decentralization of power can be fully developed and operate with a centralized model of accounting procedures for one company, as well as accounting by one accounting service for several companies. With the transition to centralized accounting procedures, with the expansion of the use of modern digital technologies, the efficiency of economic activity of enterprises increases, including through accounting, analysis and audit.

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## Transition of Logistics to Sustainable Development Under the Impact of COVID-19

## Zmiany w logistyce w kierunku zrównoważonego rozwoju pod wpływem COVID-19

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#### Abstract

The pandemic has clearly demonstrated the global interdependence of states and contributed to the formation of new trends that have changed the image of traditional logistics. Modern logistics, being in a state of transition, has faced not only short-term challenges such as COVID-19, but also long-term problems ranging from structural shifts in production and marketing processes and globalization patterns, and ending with changes in consumption patterns and resource spending, as well as a broad global agenda in the field of sustainable development. In this regard, there is a need to develop theoretical and applied aspects of the transition of logistics to sustainable development under the influence of COVID-19. The theoretical basis was the scientific works of domestic and foreign authors in the field of logistics, sustainable development, certain provisions of international framework documents. The initial information for analysis, forecasting and drawing conclusions was the official data of the Statistical office of the European Union (Eurostat), the State Statistics Service of Ukraine (Goskomstat), International Civil Aviation Organization (ICAO), International Transport Forum (ITF), United Nations Conference on Trade and Development (UNCTAD). As a result of the generalization of the theoretical and methodological foundations of logistics, the article proposes the author's definition of sustainable logistics, which made it possible to expand the

scientific vision of its content, taking into account modern challenges, as well as to identify its role in ensuring sustainable development. An analysis was made of the development of transport logistics before and during the pandemic. A forecast of freight turnover by type of transport for 2022 has been built. The main trends in the transition of logistics to sustainable development under the influence of COVID-19 are identified.

Keywords: logistics, transport logistics, sustainable logistics, sustainable development Slowa kluczowe: logistyka, logistyka transportu, zrównoważona logistyka, zrównoważony rozwój

#### Introduction

Logistics is a key sector of the global economy and plays a vital role in today's mobile society. Being multifaceted and complex in nature, logistics is associated with a huge number of business-to-business (B2B) and business-to-customer (B2C) logistics fragments. It affects almost all areas of activity, ranging from the mining industry and agriculture, and ending with the supply of goods to store shelves, points of issue of online orders or delivery by a courier. Inconsistency in the interaction of any fragments of logistics chains leads to production delays, increased costs, failure of contracts, reputational losses, which negatively affects the socio-economic development of the regions. Consequently, logistics and its condition are reflected in sustainable development.

This fact is confirmed by experts from various European countries, as well as official statistics, according to which the restriction of passenger traffic within 2019-2021, being a mandatory norm to counter the spread of coronavirus, led to irreversible transformations in logistics processes and significant losses not only in the transport industry, which requires stepping up the actions of the government, science and business in the direction of eliminating post-covid consequences.

Sustainable logistics operations improve the availability of goods, improve urban resilience, urban-rural connectivity and rural productivity with minimal environmental impact, thereby accelerating economic growth. In this regard, the study of transport logistics in the transition period to sustainable development under the influence of COVID-19 is gaining more relevance.

This is evidenced by a set of international norms developed by the Inland Transport Committee of the United Nations Economic Commission for Europe that govern the creation of a sustainable transport sector that will continue to serve the needs of the economy and citizens, while respecting future constraints: oil shortages, increasing congestion, the need to reduce  $CO_2$  and pollutant emission in order to improve air quality, especially in cities. The key aspects of the EU's transport policy are set out in the White Paper *Roadmap to a Single European Transport Area*, which focuses on reducing greenhouse gas emissions by 60% by 2050 compared to 1990 and reducing dependence on imported oil.

As part of the European Green Deal, which according to experts is also a lifeline from the COVID-19 pandemic, strategic priorities have been set for a climate-neutral EU economy by 2050, including the development of multimodal transport, support for the deployment of automated and connected mobility solutions for different types of transport, better removing the external costs of transport activities through pricing, increasing the production and deployment of environmentally friendly alternative fuels for transport, and reducing pollution from it, especially in cities (Official website of the European Union, 2021). Based on the foregoing, the **purpose of the article** is to develop theoretical and applied aspects of the transition of logistics to sustainable development under the influence of COVID-19.

#### 1. Methodology

To solve the problem presented for consideration, the article used a comprehensive and systematic approach that involves taking into account the interaction of diverse processes, events, phenomena that determine the transition of logistics to sustainable development under the influence of COVID-19.

Interpretation of key theoretical positions was carried out on the basis of general scientific methods, namely: deduction, analysis, synthesis, forecasting. Thus, in particular, the deduction method was used to formulate the definitions of *logistics* and *sustainable logistics*, as a result of which it was possible to consistently build a number of conclusions and form the author's vision regarding the interpretation of these concepts.

The identification of the main trends in the development of transport logistics before and during the pandemic was carried out using analysis, synthesis and forecasting. The initial information for the analysis and forecast was the official statistical data of the Statistical office of the European Union (Eurostat), the State Statistics Service of Ukraine (Goskomstat), International Civil Aviation Organization (ICAO), International Transport Forum (ITF), United Nations Conference on Trade and Development (UNCTAD). Freight turnover by motor, railway, river and air transport was taken as a base indicator for analysis.

#### 2. Findings and Discussion

#### 2.1. Formation and development of theoretical and methodological foundations of logistics

Regular research of the authors of this article made it possible to establish the fact that the term *logistics* has been used since the time of imperial Byzantium. Back then, there were *logisticians* at the royal court who were engaged

in the purchase and distribution of food. The term logistics became widespread during the war between Byzantium and the Turks (1422). It was used to describe the comprehensive support of the belligerent parties. The formation of logistics as a new business paradigm dates back to the 80s of the 20<sup>th</sup> century. This fact was due to the deepening of specialization and cooperation, which contributed to the formation of a system of increased requirements of enterprises to their production partners (Krykavskyy Y, 2014).

Despite the six centuries of history, it has been established that so far there is no generally accepted definition of logistics. Such scientists as V. Shishkin, O. Onishchenko, I. Revutskyy (2019), I. Puzanova; B. Anikina (2014), A. Ellaryan (2015), note that the definition of this term is becoming more complicated every year due to the dynamics of its development and the emergence of new directions and principles of logistics. The authors of this study share the point of view of the scientists mentioned above, believing that most of the existing definitions of logistics describe only a certain applied logistics area and is not a universal definition.

Along with economic, social, cultural, technological and other transformations in the world, which led to changes in the vectors of research and interpretation of individual logistics categories, the pandemic of 2019 exposed even more problems of modern logistics. As a result, US Business Schools are updating their supply chain courses to prepare a new generation of logistics managers for future crises. For example, Skrikant Datar, dean of the Harvard Business School, notes that *for many years we took logistics for granted, but the pandemic forced us to rethink it* (Harvard Business School, 2022). Matthew Boyle writes that this is one of the forms of reaction of academic circles as the pandemic devalues the textbooks that have guided the field since the 1990s (Brendan Murray, 2021). In this regard, we consider it appropriate to propose to understand logistics as the area of theoretical and applied knowledge about the optimal management of discrete and continuous flows of integrated support for the production of goods and services, which is at the same time a tool for competition, profit and sustainable development. At the same time, the entire production cycle up to the sale of goods and services to end consumers is considered to be a comprehensive provision in the article.

It should be noted that modern logistics science distinguishes a wide variety of its types. Thus, in the studies of A. Galkin, Yu. Popova, Y. Chuprina, D. Shapovalenko, who considered the interaction of logistics and consumer marketing using ICT, the authors single out transport, procurement, information, production, distribution, warehouse, customs logistics, as well as inventory logistics (Galkin A., Popova Y., Chuprina E., Shapovalenko D., 2019). A similar approach is presented in the studies of I. Sharova (2015), N. Vasilchuk (2016), T. Shulzhenko (2016) V. Shcherbakov, V. Silkina (2017). Based on this, we came to the conclusion that almost every type corresponds to some structural functional unit of the company, each of which is interconnected with logistics.

In addition, studies of scientific publications devoted to this issue have made it possible to establish that with the advent of the concept of sustainable development, science has been replenished with new concepts and definitions. So, in particular, such terms as: *green supply chains, green logistics, environmental logistics, sustainable logistics* appeared. The need to introduce these categories is explained by the fact that logistics has significant potential for environmental control of transport systems, product disposal processes, minimization of environmental pollution, energy and resource saving. Moreover, according to N. Osintsev, A. Rakhmangulov, V. Baginova, the management of material and related flows, based on the principles of logistics, initially includes a reduction in the environmental burden on the environment (Osintsev N., Rakhmangulov A., Baginova V., 2018).

Based on what the authors of this article have said, sustainable logistics is understood as an area of theoretical and applied knowledge about the optimal management of discrete and continuous flows in production, the main goal of which is to meet the needs of all stakeholders of the logistics system while minimizing the negative impact on the environment and achieving a stable balance between environmental, economic and social tasks of the logistics system.

Comparing the definitions of *logistics* and *sustainable logistics*, we came to the conclusion that the goal of *traditional* logistics is to coordinate various types of resources and flows (including informational, material, human, financial, etc.) to satisfy all participants in the logistics subsystem at minimal cost, while *sustainable logistics* is aimed more at coordinating various types of resources and flows (including information, material, human, financial, etc.) to satisfy all participants in the logistics subsystem while achieving sustainability between economy, environment and society.

It is important to note that the implementation of sustainable logistics is ensured through the formation of the sustainability of all the constituent elements of supply chains, which ultimately will not only contribute to ensuring competitive advantages, but will also allow the implementation of the key tasks of the concept of sustainable development. The substantiation of this thesis was reflected in the works of not only the authors of the article, but also other scientists. In particular, this is stated in the studies of N. Parkhomenko, I. Otenko (2018), E. Boichenko, N. Martynovych, I. Shevchenko (2021). In earlier studies of M. Kutsenko (2009) he presented a rationale for the comprehensive optimization of the design parameters of sorting devices for rail transportation, which not only significantly reduce the operating costs of the sorting process, but also contribute to ensuring sustainable principles of rail transportation.

O. Kostiennikov (2010) proposed measures to improve the technologies for regulating rolling stock for the transportation of seasonal goods. P. Yaremovych, in regular studies conducted from 2000 to the present, provides analytical reviews, on the basis of which the author established significant transformations in the field of logistics, which, in his opinion, require an integrated approach for a large-scale transition to sustainable development in general, and implementation sustainable logistics in particular.

Despite the differences in scientific interests, the authors came to the consensus that for the period 2019-2021 significant changes have taken place in the structure of logistics operations associated with the spread of acute respiratory disease COVID-19 caused by the SARS-CoV-2 coronavirus and requiring comprehensive efforts simultaneously in all areas of the supply chains. Further in the paragraphs, fragments of the results of the study of transport logistics (motor and railway transport) are presented, on the basis of which author's developments are formulated to improve transport devices and sustainable logistics operations.

# 2.2. Analysis of the development of transport logistics before the pandemic: identification of the main trends 2.2.1. Analysis of the freight turnover of motor transport

An analysis of the development of transport logistics before the pandemic revealed that the reduction in the volume of road freight transport in Europe began in 2011 and amounted to 1%. At the same time, the trend of tonnage growth and reduction of national, international and intersectoral traffic has been established. More clearly, the freight turnover of road and rail transport before the pandemic, in the context of European countries over a five-year period (million tkm), is presented in (Tables 1-2).

According to the data presented in (Table 1), it follows that since 2013, a steady upward trend in road freight turnover has been observed in such countries as: Greece, Ireland, Spain, Poland, Romania, Slovakia, Slovenia, Croatia. The increase in the volume of transportation occurred due to an increase in the volume of household and office freight, since construction products are the main group by tonnage (Eurostat).

Table 1. Dynamics of freight turnover of motor transport before the pandemic, by European countries for 2013-2017, million tkm, compiled by the authors according to (Eurostat, 2017; Derzhkomstat, 2017)

Countries	2013	2014	2015	2016	2017
Austria	24213	25260	25458	26138	25978
Belgium	32796	31808	36078	35192	34220
Bulgaria	27097	27854	32297	35409	35150
Great Britain	139703	135393	150101	155042	153939
Hungary	35818	37517	38353	40002	39684
Greece	16583	19223	19764	24560	28377
Denmark	16072	16184	15500	16094	15502
Ireland	9215	9751	9900	11616	11836
Spain	192597	195767	209390	216997	231109
Italy	127241	117813	116820	112637	119687
Cyprus	634	538	563	703	826
Latvia	12816	13670	14690	14227	14972
Lithuania	26338	28067	26485	30974	39099
Luxembourg	8606	9599	8850	9324	9414
Malta	_	-	—	-	-
the Netherlands	72081	72338	68900	67779	67533
Germany	305744	310142	314816	315774	313149
Poland	247594	250931	260713	290749	335220
Portugal	36555	34863	31835	34877	34186
Romania	34026	35136	39023	48176	54704
Slovakia	30147	31358	33540	36139	35411
Slovenia	15905	16273	17909	18707	20814
Ukraine	58683	55964	53293	58030	62297
Finland	24429	23401	24488	26846	27966
France	171472	165225	153580	155843	167691
Croatia	9133	9381	10439	11337	11834
Czech Republic	54893	54092	58715	50315	44274
Sweden	33529	41964	41502	42673	41851
Estonia	5986	6310	6263	6716	6189



Steady growth trend in the freight turnover of motor transport

Steady trend of decline in the freight turnover of motor transport

Unstable trend in the freight turnover of motor transport

According to the data in the table, in the vast majority of European countries – 69%, during the analyzed period there was a tendency of slight fluctuations in the freight turnover of motor transport. In addition, the analysis of earlier periods made it possible to establish that in Latvia, Lithuania and Bulgaria in 2011 a significant increase in the transported tkm was recorded. In general, it should be noted that freight traffic for all distance classes in 2013 was below the level of 2007 (Eurostat). Poland achieved growth in all distance classes. Bulgaria has seen an increase for all but the shortest distances, less than 50 km (Eurostat). The negative trend in the period *before the pandemic* was observed only in Italy.

In the period from 2007 to 2011, there was also a decrease in motor freight transport for distances of less than 300 km (-9%) in almost all regions of Europe. This trend, among other things, can be explained by the adoption of a strategy for the formation of a single European transport area in March 2011 by the European Commission, the goals of which are reflected in the White Paper and include a halving of the use of cars running on conventional fuel in urban transport by 2030; phasing them out in cities by 2050; achieving virtually CO<sub>2</sub>-free urban logistics in major urban centers by 2030 (Eurostat, 2021).

In Ukraine, the decline in road freight traffic began in 2012 and lasted until 2015. This is due to the decline in production, which amounted to (-13%) in 2012-2013 and (-37%) in 2014-2015. This trend was mainly due to Russian aggression in eastern Ukraine in 2014. However, already in 2016, there is a gradual recovery, the growth of which amounted to (+ 107.35%). The growth in freight turnover was primarily due to local transportation of clay, peat, granite, agricultural products, mainly grain (Derzhkomstat, 2014, 2015).

#### 2.2.2. Analysis of freight turnover of railway transport

An analysis of the freight turnover of railway transport (Table 2) made it possible to establish that the vast majority of European countries in the period from 2013 to 2017 were characterized by unstable trends in freight turnover, which in percentage terms corresponds to 69%.

Table 2. Dynamics of freight turnover of railway transport before the pandemic, by European countries for 2013-2017, million tkm (compiled by the authors according to (Eurostat, 2017; Derzhkomstat, 2017)

Countries	2013	2014	2015	2016	2017
Austria	19356	20746	20814	21361	22256
Belgium	-	_	-	_	-
Bulgaria	3246	3439	3650	3434	3931
Great Britain	22401	22143	19342	17053	17167
Hungary	9722	10158	10010	10528	13356
Greece	237	311	294	254	358
Denmark	2449	2453	2603	2616	2653
Ireland	99	100	96	101	100
Spain	9338	10385	11028	10550	10549
Italy	19037	20157	20781	22712	22335
Cyprus	-	-	_	-	-
Latvia	19532	19441	18906	15873	15014
Lithuania	13344	14307	14036	13790	15414
Luxembourg	218	208	207	201	213
Malta	-	_	_	_	-
the Netherlands	6078	6169	6545	6641	6467
Germany	112613	112629	116632	116164	112232
Poland	50881	50073	50603	50650	54797
Portugal	2290	2434	2688	2774	2751
Romania	12941	12264	13673	13535	13782
Slovakia	8494	8829	8439	8370	8477
Slovenia	3799	4110	4175	4360	5128
Ukraine	224434	210157	195054	187557	<b>191914</b>
Finland	9470	9597	8468	9456	10362
France	32230	32596	34252	32569	33442
Croatia	2086	2119	2184	2160	2592
Czech Republic	13965	14575	15261	15619	15843
Sweden	20970	21296	20699	21406	21838
Estonia	4722	3256	3117	2340	2325
Steady growth trend in the freight turnover of railway transport					



Steady growth trend in the freight turnover of railway transport Steady trend of decline in the freight turnover of railway transport Unstable trend in the freight turnover of railway transport

However, in the vast majority of countries, this instability can be considered insignificant, since the average deviation of the fall in freight turnover varied within 200-250 million tkm, and also did not have a regular drop in dynamics. So, for example, in Bulgaria, a drop in freight turnover was established only in 2016, and it amounted to 6%. In Hungary such a drop was noted in 2015 (-1.46%), but in 2017 an increase of (+33%) was established. A similar trend is observed in all other countries that were included in the gradation – *Unstable trend in the freight turnover of railway transport*.

Three countries turned out to have a negative trend in freight turnover: Great Britain, Latvia, Estonia -12%, and a positive trend was observed in 19% of countries – Austria, Denmark, Portugal, Slovakia, Czech Republic.

An analysis of the overall dynamics of railway transport freight turnover before the pandemic in the context of European countries indicates that in 2013 there was an increase (+1.2%). This trend continued in the next two periods. So in 2014 it was (+1.1%), and in 2015 it was (+1.2%). In 2016, there was a (-0.9%) decrease in railway transport freight turnover, but it was immediately followed by a significant increase in 2017 and 2018 (+3.1%) and +3.0% respectively), peaking at almost 400 billion ton-kilometres (tkm) (Eurostat).

Being a European state, the trends in Ukraine differ from the general European ones, which, according to the authors of the article, may negatively affect the development of logistics in general in the future. Thus, in Ukraine there is a steady trend to reduce freight traffic. For the period of 2013-2017 structural changes have been established, which are characterized by a reduction in freight turnover by railway and an increase in the share of motor transport. According to official statistics, in 2014, freight traffic by Ukrzaliznytsia decreased from 62.5% to 55.9% in 2017, and vice versa, the share of road transportation increased from 11.3% in 2014 to 12% in 2017 (Derzhkom-stat). Based on the presented analysis, we can conclude that in general, for the period of 2013-2017 there was a positive trend in railway freight turnover in Europe (with the exception of Ukraine).

#### 2.2.3. Analysis of freight turnover of river transport

Analysis of freight turnover of river transport (Table 3) allowed us to establish that this type of transport has a steady tendency to reduce freight turnover even in the *pre-pandemic* period. The UK, Italy and France are marked with a negative trend. All other countries have an unstable downward trend. For example, in Luxembourg and Germany, only in 2017 there was a slight increase in freight turnover (+2.6% and 2.16%, respectively). Even the Netherlands, being the largest country of maritime freight transportation in Europe, showed a decrease in freight turnover by -1.6% in 2015.

Countries	2013	2014	2015	2016	2017
Austria	2353	2177	1806	1962	2022
Belgium	10365	10451	10426	10331	11098
Bulgaria	5374	5074	5595	5477	5279
Great Britain	211	169	120	108	—
Hungary	1924	1811	1824	1975	1992
Italy	89	64	62	—	—
Lithuania	-	-	-	-	-
Luxembourg	313	285	235	190	195
the Netherlands	48641	49327	48535	48798	49015
Germany	60070	59093	55315	54347	55518
Poland	91	110	88	108	115
Romania	12242	11760	13168	13153	12517
Slovakia	1006	905	741	903	933
Ukraine	1387	1358	1572	1465	1423
Finland	121	135	128	103	—
France	9201	8789	8506	8307	7513
Croatia	771	716	879	836	813
Czech Republic	25	27	33	36	25

Table 3. Dynam	ics of freight turnover	of river transport before	the pandemic, by	European countrie	s for 2013-2017,	million
tkm, compiled b	y the authors accordin	g to (Eurostat, 2017; Der	zhkomstat, 2017)	_		

Steady growth trend in the freight turnover of river transport Steady trend of decline in the freight turnover of river transport

Unstable trend in the freight turnover of river transport

This state of affairs is primarily due to the reduction in the freight turnover of maritime transport, which accounts for 90% of the world's freight turnover in world trade. The popularity of maritime transport is explained by its lowest cost compared to other modes of transport. However, this mode of transport is also the least environmentally friendly, which contradicts the main directions of the concept of sustainable development, and in connection with which the marine community, having imposed stricter rules on environmental requirements, has affected the reduction of maritime transport activity.

#### 2.2.4. Analysis of freight turnover of air transport

First of all, it should be noted that the transportation of commercial goods by air is traditionally less common both in Europe and in the world, due to its high cost. Therefore, the air transport freight turnover in the context of European countries is not significant, which makes it difficult to collect data due to the lack of unified regular statistical information, based on which the results of the world air transport freight turnover survey are presented below. According to the official data of the International Civil Aviation Organization (hereinafter ICAO) for the period of 2013-2017, there was a steady trend of growth in the volume of regular air freight transportation in the world (Fig. 1).



Figure 1. Dynamics of global air transport freight turnover before the pandemic in 2008-2017, billion tkm, compiled by the authors according to the ICAO (2017)

Growth of global air transport freight turnover over the past five years took place mainly due to the intensification of trade and amounted to (+9.5%). The share of international air freight transportation accounted for about 87% of the total volume of regular traffic. Almost 40% of international scheduled flights were carried out by airlines of the Asia-Pacific region. For European carriers, this figure was 26%. For airlines in the Middle East -16%, and for airlines in North America -14%. This means that almost 80% of long-haul freight traffic was carried out along the East-West trade corridor connecting Asia with Europe, Asia with North America and Europe with North America (ICAO, 2017).

In addition, it was found that the freight turnover of air transport in 2017 amounted to 351 billion, which is 6.1% higher than in 2016, while the load factor increased from 53.2% in 2016 to 55.4% in 2017. The combination of trade activation and the growth of e-commerce volumes had a positive impact on air freight transportation in 2013-2017. This trend allows us to talk about a steady trend in the growth of air transport freight turnover.

Summing up the four indicators of the development of transport logistics before the coronavirus period (freight turnover, passenger turnover of motor and railway transport) of European countries, a generally positive trend has been established.

In European countries, with the exception of Ukraine, there was a predominance of freight turnover of motor transport over railway. However, this trend tends to change, since there is an increase in freight turnover by rail and a reduction in road transport. In Ukraine, on the contrary, after the restoration of industrial production and an increase in foreign trade turnover, structural changes in freight turnover have been established, characterized by the predominance of railway transport, but its share in the aggregate of transport logistics operations is decreasing in favor of motor transport.

# 2.3. Analysis of the development of transport logistics during the pandemic: identification of the main trends

#### 2.3.1. Analysis of the freight turnover of motor transport

An analysis of the development of transport logistics during the pandemic allowed us to establish that the transport and logistics system turned out to be one of the most affected areas as a result of the COVID-19 pandemic. According to the International Transport Forum, the overall reduction in global transport traffic for the period of 2019-2021 amounted to 36% compared to the pre-crisis level (International Transport Forum, 2021).

European motor freight transport was no exception, which decreased by 0.9% in 2019, thereby breaking the growth trend observed in previous years (Eurostat, 2020). The increase in the drop in freight turnover of motor transport was in the second quarter of 2020. In this connection, international traffic, which makes up a quarter (24.8%) of all road freight traffic in the EU, decreased by (-3.8%). A steady negative trend in freight turnover by road was established in Portugal (-21.8%), Cyprus (-17.4%) and Luxembourg (-16.3%).

However, during the same period, a steady increase in cabotage traffic was revealed, which for the period of 2019-2020 amounted to (+4.4%). The largest freight turnover of cabotage transportation in Europe in 2019-2020 fell on Poland (19.7%), Germany (16.9%) and Spain (13.4%) and amounted to 65%. Positive trend of freight turnover by motor transport for the period of 2019-2020 was also noted in the Czech Republic (+17.0 billion tkm; +43.6%) and Bulgaria (+12.0 billion tkm; +58.5%).

Despite the positive dynamics of cabotage transportation in general, a general trend of reducing freight turnover by all modes of transport has been established over the analyzed period. Thus, in Germany, Spain, Luxembourg, Hungary, the Netherlands, Portugal and Slovakia, there is a drop ranging from -2.3% to -21.8% of the total volume of traffic (Eurostat, 2020). It has been established that in 2020, long-distance motor transport over 2000 km has sharply decreased. The main part of motor transport in Europe was carried out over distances from 50 km to 1,999 km, which accounted for 89.3% of the total volume. This trend was formed due to the blocking and restrictions on border movement introduced in many countries in 2020 to counter the COVID-19 pandemic (Eurostat, 2020).

Based on the presented analysis, we came to the conclusion that the pandemic not only reduced the turnover of goods by road in Europe, but also contributed to a change in its structure. In addition, from the perspective of sustainable development, this type of transport at this stage of the functioning of the logistics system requires the activation of the decarbonization process by updating the existing fleet of cars to more environmentally friendly ones, as well as the introduction of measures to control  $CO_2$  emissions.

#### 2.3.2. Analysis of freight turnover of railway transport

Due to summarizing the analytical data of the statistical office of the European Union for the period of 2019-2020, it was found that the freight turnover of railway transport in 2019-2020 decreased by (-5.9%). The most active phase of the decline was observed in the fourth quarter of 2019 (-8.0%). This negative trend continued in the first three quarters of 2020 with a further significant drop, which by the end of the year was (-29%). On the contrary, in the first quarter of 2019 and the last quarter of 2020, growth was recorded compared to the same quarter of the previous year (+2.4% and +5.6%) (Eurostat, 2020).

A negative trend in freight traffic has been established in Greece, Luxembourg and Ireland, whose freight turnover in 2020 amounted to less than 1 billion tonne-kilometers. Montenegro and North Macedonia are also among the countries with the lowest freight turnover (less than half a billion tonne-kilometers). The largest drop in railway freight turnover was found in Latvia (-46.9%), Estonia (-19.8%), Spain (-16.7%), Slovakia (-15.1%) and Luxembourg (-15.0%) (Eurostat, 2020).

Despite the prevailing negative dynamics of freight turnover by rail during the pandemic, a number of European countries registered an increase in 2019-2020. Among these countries are Bulgaria (+28.9%), Greece (+13.1%), Croatia (+12.6%), Hungary (+9.1%) and Ireland (+2.9%), Norway (+5.3%), Montenegro (+0.1%).

Just as before the pandemic, the leaders of freight railway transport in the EU have become Germany (108 billion tkm) 30% of the total EU volume, Poland (50 billion tkm) and France (31 billion tkm). Nevertheless, despite the leadership, the freight turnover of railway transport in Germany during the pandemic also decreased by 4.7 billion tkm.

To sum up, we came to the conclusion that the COVID-19 crisis had the least impact on freight railway transportation than on transportation by other modes of transport, despite the widespread reduction in freight turnover. In addition, from the perspective of sustainable development, this type of transport is the most promising in the transition period of logistics to sustainable development under the influence of COVID-19.

#### 2.3.3. Analysis of freight turnover of maritime (river) transport

As noted in the article earlier, as a result of the pandemic, sea and air freight transportation suffered the most. Against the background of a reduction in the volume of sea freight transportation, 11 of the 12 largest shipping lines were forced to return leased vessels to their owners. In Europe, the main reductions fell on the Danish company Maersk and the international company MSC (headquartered in Switzerland). In total, they abandoned ships with a combined freight capacity of 236 thousand twenty-foot equivalents (UNCTAD, 2020). For the same reasons, the HMM carrier (South Korea) faced an increase in the number of available vessels, having received back previously leased vehicles, which resulted in a general shift in the vectors of traditional logistics chains.

This fact is also confirmed in the report of the United Nations Conference on Trade and Development *Review of Maritime Transport 2020*, which notes that other transport industries feel more confident under the conditions of COVID-19. So, according to experts, under the current conditions, a promising opportunity opens up for the transportation of goods from China to Europe by rail: given the significantly increased time of cargo delivery by sea and the increase in the cost of air freight, many companies may opt for the railway network, which has been significantly less affected by restrictive measures (UNCTAD, 2020).

According to the statistical office of the European Union, in the period from 2019 to 2020, there was a significant decrease in the volume of freight traffic by inland waterways in Europe, which amounted to (-5.7%) for the analyzed period. In general, the dynamics of freight turnover by inland waterways can be characterized as extremely unstable, which makes it difficult to determine the seasonal pattern for the period of 2018-2020 (Eurostat, 2021).

Thus, a sharp decline in freight turnover by river transport began in the second half of 2018, which amounted to -16.6% in the 3rd quarter and -25.3% in the 4th quarter. At the beginning of 2019, there was another decline, which amounted to -2.8%, but in the second half of 2019 there was an increase in freight turnover by +8.0% in the 3rd quarter and +18.9% in the 4th quarter (Eurostat, 2020). The first three quarters of 2020 showed a negative trend (-7.3% in the 1st quarter; -5% - in the 2nd quarter and -8.0% in the third quarter) and only in the fourth quarter there was an increase of +1.8%.

Despite the general trend of reducing freight turnover by inland waterways during the pandemic, there are also those countries that dismantled the increase, among them: Sweden (+59.2%), Croatia (+8.2%), Bulgaria (+6.6%) and Finland (+4.3%).

Similarly, to the *pre-covid period*, Germany and the Netherlands remained the main suppliers of inland water transport in the EU (in tonne-kilometers), whose freight turnover accounted for 70% in 2020. The largest decrease in freight turnover was found in Lithuania (-98.1%), the Czech Republic (-43.5%), France (-12.6%), Poland (-12.1%), Luxembourg (-11.6%), Slovakia (-11.0%). Being the leader among EU inland water transport suppliers, there was also a reduction in freight turnover in Germany, which amounted to (-9.0%) in 2019-2020. A total of 11 European countries recorded a decline in 2020 compared to 2019. Taking into account the fact that the reduction of freight turnover by sea and river transport began even before the COVID-19 pandemic (in 2018), and the situation worsened during the quarantine period, the sustainability of this type of transport is very doubtful.

In addition, from the point of view of the concept of development of future generations, this type of transport is currently the most toxic to the environment, which requires rethinking of not only existing logistics chains, but also engineering and design innovations. To solve these problems, radical changes in the field of engine building and fuel technologies will be required.

#### 2.3.4. Analysis of freight turnover of air transport

The restrictions related to the COVID-19 pandemic certainly affected air freight transportation, the total freight turnover of which in the EU in 2020 decreased by (-9.7%). The most affected were domestic transportation (-14.3%) and transportation outside the EU (-10.9%) (Eurostat, 2020).

In the regional context, a positive trend has been established in five European countries, namely, in Slovakia (+20.7%), Lithuania (+15.2%), Belgium (+13.4%), Malta (+10.1%) and Luxembourg (+10.1%) (Eurostat, 2020). Among the 20 largest airports in Europe during the COVID-19 pandemic, six showed an increase in total freight turnover, among them: Frankfurt-Hahn (+42.8%), Liege (+26.9%), Maastricht-Aachen (+22.1%) and Leipzig-Halle (+12.2%) (Eurostat, 2020). The negative trend was noted in Munich (-57.0%). In addition, an increase in the number of freight and mail flights was established at 12 airports out of 14. Since in 2020, due to the COVID-19 pandemic, many passenger flights departed without passengers, they were loaded with goods related to COVID-19 (for example, masks, gloves, etc.), which partly explains the growth of freight and mail flights.

Despite the positive dynamics of individual countries and indicators, in general, quarantine measures had a negative impact on the freight turnover of air transport in Europe. Thus, in nine countries, a reduction of more than 20% was established: Czech Republic (-26.9%), Denmark (-25.7%), Spain (-26.4%), Croatia (-29.6%), Italy (-24%), Cyprus (-25.8%), Austria (-27.7%), Poland (-22.2%), Slovakia (-20.7%). The largest drop occurred in Finland (-34.9%), Portugal (-31.5%) and Greece (-30.8%) (Eurostat, 2020).

Based on the presented analysis, we came to the conclusion that the freight turnover of air transport, due to its *not popularity* even before the pandemic, suffered less in comparison with other types of transportation, but this is a fairly short-term trend, which is due to COVID-19 quarantine measures. In addition, as noted earlier, air transportation is still the most expensive mode of transport using fossil fuels, the combustion of which releases <sub>CO2</sub>, which does not contribute to the transition of logistics to sustainable development under the influence of COVID-19.

#### 2.4. Freight turnover forecast by means of transport until 2022

Official data (Eurostat) was used as initial information for the forecast, namely: European freight turnover in dynamics over five years (2016-2020) by modes of transport, with the exception of air transportation due to the lack of statistical data. The freight turnover forecast was based on the generalization of homogeneous phenomena (million/tkm and a period of 5 years). To compare the results obtained, average values were used, which made it possible to generalize the characteristics of mass, qualitatively similar transport and logistics phenomena, which made it possible to scientifically predict the main trends.

The presented calculations were carried out in the following interpretations: optimistic, pessimistic and most likely scenarios. In terms of the forecast period (short-term, long-term, medium-term), the authors present a short-term forecast, since the analyzed period was 5 years, respectively, the forecast interval cannot exceed 2.5 years. Taking into account the fact that there are still no data for 2021, the maximum forecast period can only be for 2022. Otherwise, the reliability of the forecast, due to the high degree of uncertainty of the impact of various factors, will be unacceptably small. The forecast results are presented in (Table 4).

		Deviation for 2020/2022			
Indicators	2022	Absolute	Relative,		
		million/tkm	%		
The m	ost likely scenario				
Freight turnover of motor transport	14 530 974,42	1 521 027	11,69		
Freight turnover of railway transport	1 489 904,284	-7073	-0,47		
Freight turnover of river transport	-34 556 708,98	-	-		
Pess	simistic scenario				
Freight turnover of motor transport	13 516 655,29	506 708,29	3,89		
Freight turnover of railway transport	1 309 173,96	-187 803,04	-12,34		
Freight turnover of river transport	-63 843 185,72	-	-		
Optimistic scenario					
Freight turnover of motor transport	15545293,55	2 535 346,55	19,49		
Freight turnover of railway transport	1670634,60	173 657,6	11,6		
Freight turnover of river transport	-5 270 232,23	-	-		

Table 4. Results of freight turnover forecast by means of transport for 2022, compiled by the authors according to Eurostat

Thus, it follows from the presented forecast that in 2022 the most sustainable modes of transport will be road and rail, therefore logistics companies should take this fact into account when developing strategies and development plans. A negative trend will be observed in relation to maritime (river) and air transport. This situation is due to a number of factors that need to be further investigated in order to identify and minimize the most significant logistical risks (for example, seasonality) that were not taken into account in official statistics, which affected the value of the approximation coefficient  $R^2$ .

Thus, the key trends in the transition period of logistics to sustainable development under the influence of COVID-19 are the following:

- ✓ increasing the volume of delivery by road and rail due to their greater sustainability;
- ✓ transition of key supply chains to shorter and simpler supply chains;
- ✓ applying more flexible and adaptive management strategies and approaches through the introduction of digital technologies;
- ✓ decarbonization of the logistics industry, including through radical changes in the field of engine building, fuel technologies, optimization of the design parameters for the use of vehicles and the abandonment of fossil fuels in favor of renewable energy sources.

#### Conclusions

A review analysis of the formation and development of the theoretical and methodological foundations of logistics led to the conclusion that economic, social, cultural, technological and other transformations have led to changes in the vectors of research and interpretation of individual logistics categories. The emergence of the concept of sustainable development contributed to the replenishment of the theoretical basis with new concepts and definitions, in connection with which the authors proposed to understand sustainable logistics as the area of theoretical and applied knowledge about the optimal management of discrete and continuous flows in production, the main purpose of which is to satisfy the needs of all stakeholders of the logistics system while minimizing negative impact on the environment and achieving a stable balance between the environmental, economic and social objectives of the logistics system.

An analysis of the development of transport logistics before the COVID-19 pandemic led to the conclusion that in European countries, with the exception of Ukraine, there was a predominance of motor transport over railway transport. However, this trend tends to change, since there is an increase in freight turnover by rail and a reduction in road transport. In Ukraine, on the contrary, structural changes in freight turnover have been established, characterized by the predominance of railway transport, but its share in the totality of transport logistics operations is declining in favor of motor transport.

A steady downward trend in the freight turnover of river transport has been revealed. The situation is similar with air transportation. However, the reasons for the reduction in freight turnover by these modes of transport are different. The reduction in the turnover of river transport is primarily due to the reduction in maritime freight turnover, which accounts for 90% of the freight turnover in world trade. The popularity of maritime transport is explained by its lowest cost compared to other modes of transport. However, this mode of transport is also the least environmentally friendly, which contradicts the main directions of the concept of sustainable development, and in connection with which the marine community, having imposed stricter rules on environmental requirements, has affected the reduction of maritime transport activity to certain extent. Unlike sea (river), air freight transport tation is traditionally less common both in Europe and in the world, due to its high cost.

It was determined that during the COVID-19 pandemic, the transport and logistics system was one of the most affected. Based on the presented analysis, we came to the conclusion that the pandemic not only reduced the turnover of goods by road in Europe, but also contributed to a change in its structure towards an increase in the

turnover of cabotage transportation. It has been established that despite the widespread reduction in the volume of freight traffic, freight railway transportation has suffered to no lesser extent. In addition, from the perspective of sustainable development, this type of transport appeared to be the most promising in the transition period of logistics to sustainable development under the influence of COVID-19.

The COVID-19 pandemic has had the greatest negative impact on maritime and river transport, which allows us to consider this mode of transport as the least sustainable. Despite its *unpopularity*, the freight turnover of air transport, in comparison with other types of transportation, suffered to a lesser extent. However, this is a rather short-term trend, which exists due to the COVID-19 quarantine measures. In addition, as noted earlier, air transportation is still the most expensive mode of transport using fossil fuels, the combustion of which releases CO<sub>2</sub>, which does not contribute to the transition of logistics to sustainable development under the influence of COVID-19.

The presented forecast for 2022 indicates that in the near future, the current trend will continue. The most sustainable modes of transport will be motor and railway transport. Therefore, logistics companies should take this fact into account when developing strategies and development plans. A negative trend will be observed in relation to maritime (river) and air transport. This situation is due to a number of factors that need to be further investigated in order to identify and minimize the most significant logistical risks (for example, seasonality) that were not taken into account in official statistics.

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## Tax Policy for Economic Recovery and Sustainable Development After COVID-19

# Polityka podatkowa na rzecz odbudowy gospodarki i zrównoważonego rozwoju po pandemii COVID-19

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#### Abstract

The optimal taxation level and tax structure depend on numerous factors and enormously differ from country to country. However, the two mentioned tax policy instruments could ensure economic recovery and sustainable economic growth. This article aims to examine the effects of tax policy on economic development and evaluate the role of appropriate tax instruments in speeding up recovery. The results showed that tax level harms the GDP per capita growth rate in Central Europe and Baltic states over the 2000-2021 period. Another vital finding is the increase in both overall employment and investment to GDP ratio positively affected the real GDP per capita growth rates. In order to foster economic growth government might use tax cuts and other stimuli both for distortionary and non-distortionary taxes. The tax policy's institutional potential should be improved to neutralize the adverse effects of COVID-19 impact and enhance macroeconomic sustainability.

**Key words:** taxes, fiscal stimulus, COVID-19, employment, economic development **JEL Classification:** H20, H21, O23 **Słowa kluczowe:** podatki, bodźce fiskalne, COVID-19, zatrudnienie, rozwój gospodarczy

#### Introduction

The world economy's performance since the COVID-19 pandemic's start has been extraordinary: global output growth was at -4.4 percent in 2020, including advanced economies at -7.6 percent, emerging market and developing economies at -2.7 percent. All countries tackle problems with temporary lockdowns and economic agent's activity constraints. The nondiscretionary decline in tax revenues and an increase in public expenditures (*e. g., unemployment benefits*) are forecasted to account for 2.5 percent of GDP, even for the most developed countries. Lawmakers intended to accelerate the economic recovery from the last recession. There is a comprehensive discussion of tax policy's impact on economic development, especially during an economic crisis or recession. Using

different fiscal instruments and levers, the government plays a vital role in spurring consumption, investments, and labor supply. Tax structure and the taxation level (tax revenues to GDP ratio) are the fundamental factors in evaluating the output growth's tax effects. Theoretically, taxes on labor and capital negatively influence corporate and household income. Government stimulus packages often included tax cuts to boost aggregate demand and stimulate work effort, production, and investment by lowering applicable tax rates. However, fiscal stimuli have short-term effects on investment and output growth. Tax responses to the current economic downturn aim to preserve and create new jobs at the market, encourage investment activity, and prompt technology development in medicine. To ensure sustainable economic development and provide long-term advantages for the economy, the government has to focus on forming the optimal tax-mix. The crucial task is to ensure significant fiscal changes toward a high-tech and green economy and intensify investments and innovations. Policymakers should formulate tax policy over the business cycle, considering traditional criteria like efficiency, equity, and simplicity. Fiscal policy should not undermine the confidence of economic agents and focus on harmonizing tax relations. The tax structure strongly depends on the social and economic model and institutions' quality. Developing countries can expand the tax base and use moderate tax rates, guarantee better fiscal conditions for sustainable economic growth compared with advanced economies. Governments should concentrate on efficient revenue resources, which have a neutral or slightly negative influence on growth, such as taxes on consumption, environmental taxation, and on inefficient tax expenditures' elimination. In emerging market economies, public authorities have a limited capacity to conduct countercyclical fiscal policy with a massive stimulus package and less access to borrowing. The efficiency of tax incentives is also lower compared with high-income countries. Nowadays, tax responses to the recession mainly consist of deadline extensions, tax payment deferrals, and reduced social security contributions to support the most vulnerable economic agents.

#### Literature Review

Economists and scientists have long asked about the tax policy effects on economic development (Tanzi, 1969; Engen & Skinner, 1992). The answer is central to countercyclical tax policy design while policymakers often use tax-based incentives to foster economic growth over economic weakness and recessions. Romer & Romer (2010) found main reasons for tax changes over time – a) countercyclical changes; b) response for public spending; c) additional sources to finance deficit; d) long-run considerations. The results also indicate that tax policy has an enormous impact on the economy: an endogenous tax increase of 1 percent of GDP decreased real GDP by roughly 2 percent. Based on empirical research, Vegh & Vuletin (2015) concluded that less procyclical tax policy was more common for the economies with significantly better institutional environment and profoundly integration into the global financial markets. Tax and public spending policies are ordinarily conducted in a symmetric way over the business cycle. Mountford & Uhlig (2009) found evidence that a deficit-financed tax cut was the best fiscal policy to stimulate output growth in the short-term. Alesina & Ardagna (2010) identified significant changes in fiscal policy, either expansionary or contractionary. They examined the financial data from the OECD countries over the 1970-2007 period. Using an original approach, they found that fiscal stimuli based on tax cuts were more likely to increase growth than those based on public spending expansion.

The discussion on the tax structure's contribution to economic development is mainly focused on the advantages of direct *vs.* indirect taxes. From the theory, a shift from direct to indirect taxation is associated with the higher long-run economic growth. Arnold et al. (2011) examined how to formulate and conduct tax policy that prompts economic recovery and contributes to the long-run growth. Gradually shift in the tax base towards consumption and immovable property, and improvement in individual taxes' design positively impacts real output growth. The study highlighted that any necessary revenue increases after recovery would be least harmful to growth if they were based on growing recurrent taxes on immovable property and consumption taxes. Ojede & Yamarik (2012) assessed the impact of tax policy on state-level growth in the USA from 1968 to 2008 and found out that property and sales tax rates adversely affected the long-run income growth, while income tax rates did not influence growth dynamics. Fiscal policy could positively affect economic development by harmonizing the tax level and structure, taking the country's income level into account (Pasichnyi, 2017).

Stoilova (2017) investigated the impact of the tax structure on economic growth in the EU-28 member-states from 1996 to 2013. She used descriptive analysis and regressions on pooled panel data. The result disclosed that the tax structure based on consumption taxes, the taxes on income, and the property was more supportive of economic growth. McNabb (2018) used econometric analysis in order to estimate the relationship between tax structures and economic growth in a panel of 100 countries. He found that increases in domestic consumption taxes appeared to be growth-friendly for lower-middle-income countries. Personal income taxes and social contributions appeared the most harmful for the long-run GDP growth rates. The results also suggested that increases in property taxes were good for real output growth for high-income countries. At the same time, Bernardi (2013) outlined the possible risk that, in the short-term, tax shift from direct to indirect taxes could extend the economic weaknesses spreading across the European Union, particularly as an effect of the general adoption of restrictive fiscal policies by almost all the member-countries. Baiardi et al. (2019) investigated the interrelation between economic growth

and tax burden on the OECD's 34 members from 1970 to 2014. The paper's result confirmed the negative relationship between tax revenues and economic growth, while the tax structure was no longer related to sustainable economic development.

**This paper aims** to examine the effects of tax policy on economic development and evaluate the role of appropriate tax instruments in speeding up recovery.

#### Methods and data

According to the Cobb-Douglas functions, the relationship between GDP, capital, and the labor involved interacts with the following:

$$Y = A * K^{\alpha} * L^{\beta}$$

where Y is the real GDP per capita,

A - coefficient of scientific and technological progress;

K – the amount of capital (investment);

L – the labor force;

 $\alpha, \beta$  – coefficients of elasticity of GDP by capital and labor costs;

Endogenous growth models incorporate channels through which fiscal policy impacts economic development in the long-run (Barro, 1995; Benos, 2009). Moreover, those models classify the fiscal policy instruments into taxes and expenditures. Traditionally it takes the form:

$$Y_{it} = a + \sum_{i=1}^{n} b_i T_{it} + \sum_{j=1}^{l} c_j E x_{jt} + \sum_{k=1}^{m} d_k E_{kt} + \varepsilon$$
(2),

where T - taxes;

Ex – public expenditure;

E – non-fiscal factors (economic controllers);

 $b_{it}$ ,  $c_{jt}$ ,  $d_{kt}$  – coefficient of the relevant variable impact on economic growth in country t.

This study explored the impact of the tax burden on economic development. Furthermore, we estimated the influence of tax structure on output growth. The tax structure typically consists of distortionary and non-distortionary taxation. The first category of taxes constrains firms' and households' investment activity, causing a slowdown in the economy. That group of taxes included *taxes on labor* (personal income tax and social contributions) and *taxes on capital*. Theoretically, non-distortionary taxation, which is represented by *taxes on consumption*, has no negative impact on output growth. Public spending defines as general government expenditure. We calculated all fiscal variables as % of GDP.

Capital and labor are the main factors of production in growth models. So, non-fiscal factors (economic controllers) include investment ratio to GDP ( $In_{ii}$ ) and overall employment growth ( $Em_{it}$ ). We apply the OLS technique and use annual observations. Thus, the following model is:

$$Y_{it} = \beta_0 + \sum_{i=1}^{n} b_i T_{it} + \beta_1 \sum_{i=1}^{m} E x_{it} + \beta_2 \sum_{i=1}^{n} I n_{it} + \beta_3 \sum_{i=1}^{l} E m_{it} + \varepsilon$$
(3),

There is a necessity to analyze a homogenous group of countries, according to Barro and Sala-i-Martin (1995) approach to estimate the factor's impact on output growth. The mentioned group consists of economies with a similar quality of institutions, production functions, fiscal space, etc. The European Union countries meet those criteria. This paper investigated the group of Central Europe and Baltic states; all these countries are the EU members – Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Romania, Poland, Slovakia, and Slovenia.

All analysis in this study uses a panel data set. The primary research sources are the World Bank's, the IMF's International Financial Statistics, and the Eurostat database. The period of analysis covers 22 years from 2000 to 2021. Table 1 displays the basic statistics for the variables used in the research.

Variables	Observations	Mean	Standard deviation	Max	Min
GDP per capita growth	198	3.79	4.28	13.02	-14.27
tax revenues	198	31.73	3.38	39.30	25.20
distortionary taxes	198	18.61	3.74	27.57	11.36
non-distortionary taxes	198	13.12	1.59	17.80	10.39
general government expenditures	198	39.78	5.36	60.27	30.79
investment ratio to GDP	198	24.87	5.02	41.59	12.66
overall employment growth	198	0.22	2.54	6.50	-14.30

Table 1. Descriptive statistics, the authors' calculation based on World Bank, IMF and Eurostat data

#### Results

In the current conditions of the coronavirus pandemic it is crucial to create a fundamental basis for ensuring sustainable positive economic dynamics. Tax policy is an effective tool for influencing investment and consumer demand and has a long-term effect. Changes in tax policy should ensure additional investment in the real economy

(1),

and boost employment. Moreover, financial globalization leads to the unification of tax systems, simplifying tax administration mechanisms, and expanding cooperation in combating tax fraud.

From 2000 to 2021, the sampled countries were characterized by uneven economic growth. While the Estonian real GDP per capita was reduced by 14.27 percent in 2009, the Latvian real output growth rate in the pre-crisis 2006 was equal to 13.02 percent. In the last two decades, European countries have faced two major economic crises - the Great Recession and the economic downturn caused by the COVID-19. Therefore, we compared the average GDP per capita growth during the Great Recession (GR), which included 2008–2009 and the coronavirus pandemic (2020–2021). For Bulgaria, Poland, Romania and Slovakia, the pandemic influence on the economy was more substantial than the impact of GR (figure 2). Simultaneously, the tax to GDP ratio in all sample countries except Slovenia was higher during the pandemic than during the Great Recession. For instance, in Slovakia, the tax level over 2020-2021 is higher than over 2008-2010 by 6.8 percentage points, in Latvia by 4.0 percentage points, in Czech Republic by 2.8 percentage points, in Poland by 2.7 percentage points. The main reasons for the mentioned situation are the gradual increase in the taxation level in the EU and a more extensive package of tax incentives from 2008-to 2010. Regardless recession, in 2020 compared to 2019, the tax ratio to GDP increased in all analyzed countries – from 0.3 percentage points in Slovenia to 1.3 percentage points in Estonia. As a result, the average value of growth is 0.68 percentage points. In the last crisis among policymakers existed a fear that tax reductions and deferrals could damage medium-term budget revenue-raising capacity. Instead, public spending on social support and economic affairs increased significantly over the pandemic.



coronavirus pandemic

Over two decades, the observed countries with the lowest average tax burden – Romania (27.77%), Bulgaria (29.13%), Latvia (29.31%), and Lithuania (29.36%) – were characterized by the highest average economic growth rates (that had been exceeding 4.10% annually). Meanwhile, Slovenia – with its average tax share in GDP equaled to 37.94% – had the lowest average real output growth rate (2.15%). Given the above, the empirical dependency should be properly proven statistically. All the sampled countries have unique profiles, yet they tackled at least two common tasks. The first is the constant need to dismantle uncommon for the *old* EU elements of fiscal space. The second is the optional requirement to counteract unfavorable shifts in the economic environment. That's why their experience in the field of tax policy should be adequately investigated.

The investigated Eastern European counties and the Baltic States have successfully passed the uneven yet fundamental financial transformations of the XX<sup>th</sup> century's last decade. The rethinking of the taxation model accomplished the transition from the old-fashioned paradigm to rational economic freedom. Tax revenues are a source to finance socially necessary government functions, its size depends on the country's socio-economic system. The tax revenues to GDP ratio in Central Europe and the Baltic States increased slightly from 32.30% in 2000 to 33.21% in 2021. However, we observed a substitution of growth and reduction of taxation trends during the analyzed period due to the economic cycles. The lowest tax level was observed over 2009-2012 (30.43-30.67%) when the tax incentives to restore sustainable economic growth were purposefully applied. In the taxation structure of the observed sample, the highest share belonged to taxes on labor -46.67%, taxes on consumption -39.14%, taxes on capital -4.19%. Taxes on labor predominated in all countries except Bulgaria, where consumption taxes took 1<sup>st</sup> place. We assessed the impact of employment on economic growth and found out that this factor was the most supportive development. If overall employment was enhanced by one percentage point, an increase in real output equaled 0.874 percentage points. A high employment rate is a significant factor in fostering economic development. The vital goal of Sustainable Development (SD) is decent work and economic growth. This goal is highly correlated with labor taxation. In the EU, the fiscal policy choices influence the allocation of a mobile tax base: the labor force. The significant difference in wages in the EU (in Western Europe and Scandinavia, it is much higher than in Central Europe) necessitates lower taxes on labor for the analyzed sample. Figure 2 shows that over recessions, unemployment rises and, conversely, stimulating employment accelerates economic growth. The highest unemployment and economic decline level were during the Great Recession and 2020, resulting from lockdowns to counter COVID-19. In 2009-2010, we observed the highest employment rate shrink for Baltic states, in 2020 for Bulgaria and Slovakia. Government should address tax policy to stimulate employment, especially for youth. The creation of new jobs and maintaining employment is entirely under the goals of SD - 1) no poverty and 10) reduced inequalities.



Figure 2. GDP growth and employment growth in the Central Europe and Baltic States from 2000 to 2021, %

The total labor cost, including personal income tax and social contributions, is essential in achieving a competitive advantage for the business. Policymakers might use targeted tax incentives and decrease the tax burden to boost employment and attract additional investments. We assessed the annual change (2020/2019) of the indicator tax wedge (as a% of labor costs) in Central Europe and the Baltic States. The result demonstrated a reduction in its value in 6 out of 9 countries: Poland by 0.9, Latvia by 0.9, Lithuania by 0.8, Slovakia by 0.7, Slovenia by 0.1, and Estonia by 0.1 percentage points, respectively. That decline was caused primarily by a decreasing in income tax. Income tax cuts deliver significant output stimuli, particularly in the long run (Faia et al., 2013). One possible scenario is to reduce the tax burden on low-paid workers in order to promote job-intensive growth and use a progressive tax scale. At the same time, it is more appropriate to use a flat rate for income tax in emerging-market economies. The flat rate of 10% operates in Bulgaria and Romania; until 2021, it operated in the Czech Republic at 15% and Estonia at 20%. In the analyzed sample of Central Europe and the Baltics, the top income tax rates are significantly lower compared to other European Union countries. At the same time, Latvia cut the top tax rate from 31.4 percent to 31.0 percent in 2021. The Czech Republic reintroduced progressive tax are also applied in Poland and Lithuania.

The increase in investment to GDP ratio positively affected the real GDP per capita growth. Generally, if the investment ratio to GDP rose by one percentage point, an increase in the real GDP per capita growth rate was equal to 0.118 percentage points (Table 2, OLS1). Meanwhile, considering the exact tax structure was highlighted, real output enriched by 0.109 and 0.087 percentage points in cases if distortionary and non-distortionary taxes were taken into account, respectively (Table 2; OLS2, OLS3).

In the case of fiscal factors, we obtained the adverse interrelations between real output growth rates and public spending and revenues indicators. An increase in general government expenditures equaled one percentage point reduced the real GDP per capita growth rates by 0.136 percentage points. An increase in total tax revenues to GDP ratio by one percentage point diminished real output by 0.304 percentage points. Obtained results proved that enhanced tax burden generally slowed economic development. The adjusted coefficient of determination equaled 0.47. Thus, the model under investigation was adequate, while the interconnection was quite robust.

Variables	OLS1	OLS2	OLS3
general government expenditures	-0.136** (0.051)	-0.165** (0.049)	-0.223** (0.046)
investment ratio to GDP	0.118* (0.049)	0.109* (0.050)	0.087 (0.051)
overall employment growth	0.874** (0.100)	0.801** (0.098)	0.772** (0.100)
tax revenues	-0.304** (0.079)	-	-
distortionary taxes	-	-0.191** (0.068)	-
non-distortionary taxes	-	-	-0.113 (0.152)
R <sup>2</sup> Observations	0.47 198	0.46 198	0.43 198

Table 2. Regressions of economic growth on taxation and controls, the sample of Central Europe and Baltic states, 2000-2021

Notes: The numbers in parentheses are the standard errors of the estimated parameters.

'\*' denotes significance at 5 percent level; '\*\*' – at 1 percent level; R<sup>2</sup> is the adjusted coefficient of determination.

When we take distortionary taxes' impact exceptionally, the respective decline equaled 0.191 percentage points. Even though an increase in the non-distortionary taxes was interconnected with the decline equaling 0.113 percentage points, the interconnection between the variables appeared to be statistically insignificant. It is possible to shift from labor to consumption taxes in order to smooth the negative impact of taxation on the economy. Good scenario is to substitute moderately the tax burden from labor to environmental taxes. This category of taxes is neutral to economic growth. In addition, among the 17 SD goals, considerable attention is paid to environmental issues. Therefore, it is appropriate to gradually increase carbon tax and reduce personal income taxes for low-income households. Pricing carbon through a tax can help enormously pay for the public spending required for greening the recovery (Barbier, 2020). Environmental taxes could finance public spending for green innovation and critical infrastructure investments. The priority is to provide tax incentives to produce new energy-saving technologies and vehicles that correspond to high environmental standards.

Governments provided tax incentives for both distortionary and non-distortionary taxes. That measures aimed to help restore economic growth and maintain social development. An optimal anti-pandemic fiscal policy combines traditional growth-friendly tax incentives and special direct financial measures. The authorities' fiscal response to the COVID-19 challenge primarily included tax cuts, revised tax rates, prolonged deadlines for filing the tax returns, and other special benefits. In particular countries, the role of local authorities as fiscal policymakers has remarkably increased.

In Bulgaria, responding to the COVID-19, the discretionary fiscal policy measures included: a) a reduced VAT rate of 9% for the restaurant and catering services, books and textbooks, baby food and hygiene items from the 1st of July through the 31st of December 2020; b) the extended deadlines for filing the tax returns and the annual payments of corporate tax, personal income tax, and the other taxes traditionally associated with private entrepreneurship until the 30th of June 2020; c) the 5% deduction for the persons who have filed their tax returns and remitted the tax payment by the 31st of May 2020.

In the Czech Republic, the measures to neutralize the effects of the coronavirus pandemic and to stimulate the growth processes included: a) the prolonged terms for filing the income tax returns; b) the suspended penalties for the late payment of the income tax; c) the canceled interest on the amount of the deferred income tax; d) in some cases, the abolished penalties for the late submission of VAT and property tax returns; e) the additional benefits for taxpayers involved in the field of retail trade and services that were forced to close production facilities; g) the exempt from VAT on the supply of certain medical devices for diagnosis, testing, and vaccinations against COVID-19.

In Estonia, an extended cut in excise tax on particular fuels (e. g., diesel), the introduction of tax benefits through 2022, and the postponement for 18 months of the tax debt interest payments should be named primarily among the tax policy features. An essential package of tax incentives was aimed to support the family as a social institute. Special attention was paid to low-income families and the ones with children. Such measures included increased income tax benefits for households with children and simplified requirements for gaining those benefits. The excise taxes on gasoline, natural gas, and electricity have been reduced as well.

From the 1st of April 2020, the introduction of accelerated VAT refunds has supported the business vitally in Latvia. Furthermore, the government has promptly adopted efficient measures to stimulate tax policy: a) for the most affected by the COVID-19 pandemic companies, both current and overdue tax payments have been postponed; b) the municipalities were allowed to extend the real estate tax payments; c) the advance payments of personal income tax for self-employed persons were abolished. Additionally, the tax rate on natural gas used as

propellant has been temporarily reduced.

In Lithuania, the fiscal incentives package for economic development included changes in the taxation mechanisms of legal entities. In particular, the deadline for advance payment of corporate was postponed. The respected taxpayers were allowed to choose the most convenient method for calculating their payments. The possibility to defer the unpaid tax without accrual of the interest has occurred and the mitigation of the penalties in case of late payment or underpayments. For individual taxpayers, the deadline for filing and paying their annual income tax has been prolonged from the 4th of May to the 1st of July 2020. The most affected by the COVID-19 economic agents in Lithuania have been *listed* by the government. The aforementioned taxpayers have been released from the obligation to pay the penalties for the late payment of the liabilities from the 16th of March to the 31st of December 2020. The temporarily reduced VAT rate on certain activities (e. g., catering services, cultural and sports events) from the 1st of July 2021 through the 31st of December 2022 supported domestic business.

In Poland, the main growth-friendly fiscal measures involved: a) the particular tax incentives for the health care providers' charity if their donations have been made responding to the coronavirus pandemic from the 1st of January to the 30th of September 2020; b) the possibility of a one-time tax depreciation write-off from the initial value of fixed assets purchased to produce goods used to combat the COVID-19; c) the exemption – under the certain conditions – from the social insurance contributions' payment; d) the postponed until the 1st of January 2021 payment of retail tax. Poland has approved the extension of the deadlines for the tax returns filing. The advance payments of personal tax transfer terms have been suspended for the subsequent tax periods. According to the IMF, the opportunity to defer social security contributions and other taxes has occurred.

In Romania, the tax stimuli package included: a) until the 25th of October 2020, the exemption from paying the late payment interest and other financial penalties on tax obligations that arose after the 21st of March 2020; b) postponement of the deadlines for paying the taxes on buildings, land and on vehicles from the 31st of March to the 30th of June 2020; c) granting a discount to income taxpayers subject to the advance payments (for the large taxpayers -5%, for small and medium-sized -10%). The additional fiscal incentives involved: a) the 3-months deferral for the real estate tax payment; b) accelerated VAT refund; c) temporary suspension of tax control measures.

The deadlines for filing the 2019 personal income tax returns have been prolonged in Slovakia. For other taxpayers, the above period has been extended from the 31st of March to the 30th of June 2020. The supportive fiscal measures included: a) temporary exemption from the late payment penalties on tax obligations; b) from May 2020, the abolition of the advance income tax payments' obligation for the taxpayers whose income has been decreased significantly; c) suspension in some cases of tax control procedures, including those that were initiated by the taxpayer's application.

In Slovenia, the operative tax stimuli package included: a) from the 1<sup>st</sup> of May 2020, the introduction of additional tax benefits on the amount of donations have been made to eliminate the COVID-19 pandemic's impact; b) from the 3<sup>rd</sup> of April 2020, the abolition of import duties on goods needed to combat the disease; c) the tax filing dead-lines' postponement for the self-employed individuals and legal entities; d) the tax liabilities payments' deferral for up to 2 years; e) the temporary VAT exemption of protective and medical equipment supplies and acquisition.

#### Conclusions

Since the economic recession caused by COVID-19, EU member-states have tackled the challenges of budget consolidation. However, at the same time, governments need to boost aggregate demand and stimulate work effort, production, and investment. Tax policy is one of the most effective instruments to help economic recovery and ensure sustainable economic development. Our study provides evidence and estimation for growth-conductive taxation.

An increase in total tax revenues to GDP ratio by one percentage point crucially diminished real output by 0.304 percentage points in the sample of Central Europe and Baltic states. Both distortional and non-distortionary taxes harm the economy. The empirical research also proved that general government expenditures do not contribute to GDP per capita growth rate and negatively impact it. In this line, it is crucial to reduce the taxation level using target tax incentives and decrease all non-productive public spending. In addition, our results showed that the increase in overall employment and investment to GDP ratio positively affected economic growth. Labor taxation highly corresponds with three goals of SD: no poverty; reduced inequalities; decent work and economic growth. For Bulgaria, Poland, Romania, and Slovakia, the pandemic influence on the economy was more substantial than the Great Recession's impact. The global pandemic has affected tax policy in the short-run and changed its goals for all countries under study. Hence, the current taxation model needs to be promptly adjusted regarding its stabilizing and stimulating functions to increase the fiscal mechanism's efficiency and stimulate economic growth.

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# Renewable Energy and Poverty in Sustainable Development of the European Union

# Odnawialne Źródła Energii i ubóstwo a zrównoważony rozwój Unii Europejskiej

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## Abstract

The current socioeconomic development results in a number of consequences that lead to changes in the environment. These changes are often harmful and are associated with over- or misuse of natural resources. The issue of sustainable development is increasingly taking a prominent place in regional and local development strategies. Access to energy services is essential for social inclusion. Addressing poverty, including energy poverty, can bring a number of benefits related to reduced health expenditures, reduced air pollution, improved comfort and wellbeing, and improved household budgets, among other things. According to the results of the analysis, the utilisation of energy from renewable sources is intrinsically linked with the salary level - on average, a higher salary level is accompanied by a larger scale of utilising energy from renewable sources. In spite of the expected negative value, a similar relationship has been observed in the case of correlating the level of poverty with the use of energy from renewable sources - it is higher when the use of energy from renewable sources is higher. The performed study indicates the lack of adequately constructed support mechanisms for the poor in terms of financing and operating installations generating green energy, as well as the lack of proper education as regards local and global benefits resulting from prosumer energy. The desire to eliminate the abovementioned barriers necessitates the continuation of actions concerning synergistic accomplishment of the first and seventh targets, constituting two out of seventeen foundations of sustainable development.

**Key words:** sustainable development, renewable energy, poverty, energy poverty, decarbonisation **Slowa kluczowe:** rozwój zrównoważony, energia odnawialna, ubóstwo, ubóstwo energetyczne, dekarbonizacja

#### Introduction

The current dynamic development of technology and progressive globalization are increasingly shaping the directions of change in modern societies. The socioeconomic development entails not only benefits but also a number of environmental costs associated with excessive and unsustainable exploitation of natural resources. The issue of sustainable development is more and more often at the forefront of development strategies, on the scale of international organisations, countries, regions, cities, and communes alike. Dynamic technological progress causes a constant increase in energy consumption. Due to the high costs and shortages of non-renewable sources, there is a growing demand for renewable energy (Wang et al., 2021; Sarkar et al., 2021). Actions intended to merge renewable and non-renewable energy are being initiated in the industry with an increasing frequency (Khan et al., 2020). Nowadays, the energy sector constitutes a considerable source of greenhouse gas emissions in the world, and coalfired power stations are the largest source of carbon emissions in this sector (Friedlingstein et al., 2019). An increase in energy efficiency and the reduction of carbon dioxide emissions are key issues for many economies all over the world (Olczak et al., 2021; Liu et al., 2019; Höltl et al., 2017; Ju et al., 2016). In the climate policy of the EU, renewable energy has become a main factor, critical in the process of decarbonising economies, contributing to the alleviation of climate changes by reducing the dependence on fossil fuels and carbon dioxide emissions (Olczak et al., 2021; Burke et al., 2018; Diesendorf et al., 2018; European Commission, 2020a; European Commission, 2020; Galvin et al., 2020). One significant element of sustainable development is complex decarbonisation implemented in all sectors of economy, in which the key role is played by the electricity generation system (Rockström et al., 2017). Decarbonisation can have a considerable impact on employment and economic growth. Synergistic implementation of policy related to energy, climate and economy, can lead to an overall higher GDP and translate into an increase in the standard and quality of life of a given society (Gielen et al., 2019).

In order to standardize action at the national level, in September 2015 the United Nations enacted a set of 17 Sustainable Development Goals (SDGs) with 169 sub-goals and just over 230 indicators. These goals are a continuation of the Millennium Development Goals, whose mission ended in 2015. Governments around the world – national, provincial, and municipal – face the challenge of aligning sustainable development goals and indicators by 2030 (Venkatesh, 2021). This paper discusses whether the implementation of two Sustainable Development Goals (SDGs) – goal one on poverty reduction and goal seven on clean and accessible energy – is being carried out in a synchronized and effective manner.

### 1. Literature review

In the past decades, universal access to electricity has become a component that enabled the dynamic development of modern societies and it still continues to be a key driver of economic growth and poverty reduction in developing countries (Hyun et al., 2021). The ongoing increase in energy demand is associated with continuous exploitation of natural resources and is often linked to greenhouse gas emissions and, consequently, to global warming. Climate change affects the way we use the planet's energy resources. Over the last 150 years, the temperature has risen by almost 0.8 °C globally and by about 1 °C in Europe. It is estimated that the global temperature could increase by another 1.8-4.0 °C by 2100 (Pachauri et al., 2014). Rising temperatures result in a need to use more energy for cooling, so electricity is increasingly being used not only for heating, but also to reduce indoor temperatures. According to the IEA report, cooling will be the main driver of electricity consumption by 2050 (IEA, 2018).

Addressing poverty, the reduction of which is at the top of the political agenda in many developing countries, is also an important challenge for the world today. Poverty is a situation in which individuals (persons, families, or households) do not have sufficient resources to meet their needs and their standard of living decreases beyond the accepted minimum (Panek, 2007) so that these needs are unlikely to be met. Poverty associated with social exclusion prevents full participation in society due to lack of financial resources, lack of basic skills, or as a result of discrimination (Kawiorska et al., 2016). According to the UN definition, poverty is a limitation of choice and opportunities in life, and a violation of human dignity. It means not having the food and clothing a family needs, not being able to go to school or receive health care, not having access to land that can be farmed or work to earn a living, and not having access to credit. Poverty is also a threat and causes powerlessness, produces vulnerability to violence, and often involves living in precarious conditions without access to clean water and sanitation facilities (United Nations, 2021).

Despite the dynamic development and growing awareness of modern societies, poverty is still an important problem addressed in the policies of countries and international organizations. According to the information provided in the description of the first goal, 783 million people currently live below the international poverty line, i.e. on less than USD 1.90 per day. The problem of poverty has a particular effect on small, fragile, and conflict-affected states. An increase in poverty is also the result of natural disasters, which cause huge losses both to the civilian population and to government authorities and businesses; for example, in 2017, the economic losses caused by disasters, including three powerful hurricanes in the USA and the Caribbean, were estimated at more than \$300 billion (United Nations, 2021). The level of importance of the problem of poverty is reflected in the content of the first Sustainable Development Goal of the United Nations: end poverty in all its forms everywhere by 2030 (Wang et al., 2020). That is why it is so important for economic growth to be planned in a coherent and consistent way and to combine actions implemented as part of the sustainable development goals.

A particular form of poverty is energy poverty, a situation where households do not have access to basic energy services. With nearly 34 million people in Europe unable to afford adequate heating in their homes in 2018, energy poverty is a particularly important challenge for EU countries (European Union, 2020). Energy poverty is defined as the inability of an individual or household to provide a minimum amount of energy (Zamfir et al., 2015) due to financial constraints or caused by insufficient access to energy sources and energy distribution services and infrastructure (Thomson et al., 2017; Siksnelyte-Butkiene et al., 2021). Energy poverty is also the lack of physical access to energy services (Castaño-Rosa et al., 2019) and the lack of choice in accessing adequate, affordable, reliable, high quality, safe, and environmentally acceptable energy services (Parajuli, 2011). The term energy poverty is also used to describe a situation where households lack the disposable income needed to meet their basic energy needs (Castaño-Rosa et al., 2019). As stated in recital 59 of the recast Electricity Directive, energy poverty results from a combination of low income, high energy expenditure, and low energy efficiency of residential buildings (European Union,2020; Robinson et al., 2018). Energy poverty is also defined as a situation where a household cannot afford the energy needed to provide adequate heating, cooling, lighting, and appliance use for its members (Thomson et al., 2017). Lack of access to transmission networks and outdated electricity distribution technologies, high energy prices, and costs related to environmental pollution caused by the use of conventional

fossil energy sources result in growing problems in the electricity market and significantly restrict the achievement of individual sustainable economic development goals (Agyekum, 2020). Following the recognition by the European Economic and Social Committee (EESC) that energy poverty has an effect on the energy sector as well as health, consumer affairs, and housing, the Committee suggested that the EU should adopt a common general definition of energy poverty (Bouzarovski et al., 2012) Energy poverty affects about 1 in 10 European citizens and is noticeable in situations involving late payment of energy bills or living in thermal discomfort and social isolation (EPOV, 2018).

Analyses of energy poverty are carried out in different dimensions: some researchers focus mainly on social and health factors (Walker et al., 2016; Gillard et al., 2017; Kahouli, 2020; Thomson et al., 2017), while others study aspects related to economic factors (Kyprianou et al., 2020; Sokołowski et al., 2020) or the political situation prevailing in a particular region (Primc et al., 2020). Research on energy poverty is relevant to both developed and developing countries (Ayodele et al., 2018). The phenomenon of energy poverty involves one common condition: the inability to achieve the socially and materially necessary level of domestic energy services (Bouzarovski et al., 2015). For developing countries, energy poverty is usually understood as lack of access to energy services (Sokołowski, 2019; Sovacool, 2012), while in developed countries it is considered in terms of energy expenditure and income (Buzar, 2007). An additional complication in analyses of energy poverty is its complexity and dependence on time, place, and individual characteristics of households (e.g., household income, habits, and specific type of energy), needs, available technologies, and a number of external conditions (e.g., energy prices, climate conditions, and building energy performance) (Siksnelyte-Butkiene et al., 2021).

Another issue that affects energy poverty levels is the ownership structure. Consumers owning installations that produce energy from renewable sources are more environmentally conscious and motivated to take care of their property and the environment, because they see the direct effects of their actions. In the case of consumers who are not prosumers, i.e. who only use energy resources available in the grid, the tragedy of the commons phenomenon, which is often invoked in climate policy debates, is observed. Consumers who do not participate in the production of green energy become indirectly responsible for the greenhouse gas emissions that result from production of energy from fossil fuels. The concept of ownership on the national scale is also an important consideration. According to research results, with the exception of repressed countries, it can be said that the lower the level of economic freedom in a country, the more harmful the impact of the economy on the environment. The more economic freedom, the more prosperous the society, and thus the greater the likelihood of informed consumer choices and care for the environment and the development of green technologies (Weiss et al., 2019). Economic freedom also has a strong impact on the innovativeness of economies, which can work in favour of the climate. Companies based in countries that have a stable and effective legal system, are open to foreign cooperation, and do not interfere excessively with the activities of businesses are more likely to undertake innovative and sustainable projects (Zhu et al., 2017). Innovation of economies is one of the factors that can have a positive impact on climate in the long term through the emergence of new green technologies in the energy and waste disposal sectors (Barron, 2018).

In the context of climate change and the increasing demand for electricity, energy from renewable sources is becoming increasingly important. According to the definition contained in Article 2(1) of EU Directive 2018/2001, energy from renewable sources or renewable energy means energy from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas (European Parliament, 2018).

The requirement to be proactive in promoting energy from renewable sources is provided for in the seventh Sustainable Development Goal. The seventh goal is to ensure access to affordable, reliable, sustainable, and modern energy for all (United Nations, 2021). The way to achieve this objective is by increasing access to clean energy and innovative technologies for its production; it is also recommended to increase the use of renewable energy sources in buildings, transport, and industry. Action is needed to increase public and private investment in renewable energy and to define regulatory frameworks and innovative business models in transforming the world's energy systems. Energy production continues to be the major cause of climate change, accounting for about 60% of global greenhouse gas emissions. There are still 3 billion people dependent on coal, wood, charcoal, and animal waste for cooking and heating. In 2012, pollution emitted from burning of heating fuel caused 4.3 million deaths, 60% of which involved women and girls. In 2015, the share of renewable energy in the total energy consumption reached 17.5% which means that as much as 82.5% of the consumed energy came from energy sources that were non-renewable and thus not environmentally friendly (United Nations, 2021). According to the Sustainable Development Goals, access to clean, affordable, and reliable energy is one of the prerequisites on the way to alleviation of poverty. The study of the relationship between poverty and the level of renewable energy use creates opportunities for synergistic implementation of the two Sustainable Development Goals through activities involved in identification and development of modern, environmentally friendly ways to meet the needs of modern societies. Access to energy services is essential for social inclusion. Addressing poverty can thus bring numerous benefits, including reduced health expenditures, reduced air pollution, improved comfort and well-being, and improved household budgets. Taken together, these benefits can directly contribute to boosting economic growth and prosperity in the European Union. According to Recommendation C(2020)9600 issued by the Directorate-General for Energy, national long-term energy efficiency strategies should be focused on protecting households affected by energy poverty and on empowering vulnerable energy consumers, while helping them save money on their energy bills, providing healthier living conditions, and reducing energy poverty (European Union, 2020).

The analysis of the topic is based on data for 19 selected European Union countries for the period of 2011-2018. Due to the COVID-19 pandemic and its negative impact on human lives, employment and income, the years 2019-2020 were excluded from the analysis. This period will be analysed in a separate paper by way of a comparative analysis of the pre-pandemic period and the situation during the pandemic. The subject of renewable energy sources, in the context of the pollution associated with the production of electricity from fossil sources, is becoming an increasingly important social issue. In the first hypothesis, H1: renewable energy use is significantly related to wage levels, a discussion was undertaken on whether financial surpluses from wage increases are invested in renewable electricity sources (RES). The second area of analysis was the relationship between the level of green energy and the level of poverty in the respective country, which was formulated as part the second hypothesis – H2: the increase in the use of renewable energy is negatively correlated with the level of poverty (POV). The above assumption is based on the need to make capital expenditures necessary for the construction and start-up of RES installations. Green electricity is produced free of charge and in an environmentally friendly manner, i.e. without polluting the environment or causing additional environmental, health, and social costs. Another problem discussed in the paper is the relationship presented in the third hypothesis - H3: the higher the share of renewable energy in the gross final energy consumption, the lower on average the percentage of the population below the poverty line. The relationship presented in the hypothesis quoted above puts into question whether the target group benefiting from RES are people below or above the poverty line, i.e. whether the assistance programmes launched in individual countries support simultaneously the development of clean and accessible energy and the fight against poverty, or whether they implement the aforementioned objectives separately without verifying the impact of the measures implemented on the remaining sustainable development goals.

#### 2. Methodology

An evaluation of the relationship between renewable energy use and welfare of the population in the studied countries was carried out using panel models. The use of these models is justified due to the fact that the study included a cross-sectional time series in which both the number of countries (n = 19) and the number of periods (t = 8) was small. Panel models were estimated based on a sample of  $19 \times 8 = 152$  observations.

Panel models can take the form of models with decomposition of the free term (fixed effects models, FEM) or models with decomposition of the random element (random effects models, REM). The FEM and REM models can be generally written as follows:

$$y_{it} = m_i + bx_{it} + e_{it} \tag{1}$$

where:

 $m_i$  - a general free term;

*b* - a structural parameter that expresses the effect of the explanatory variable *X*;

 $x_{it}$  - the implementation of the explanatory variable for the  $i^{th}$  object in the  $t^{th}$  period;

 $e_{it}$  - residuals meeting the classical assumptions:  $E(e_{it}) = 0$  and  $Var(e_{it}) = S_e^2$ .

In the FEM model,  $m_i$  is decomposed into free (fixed) terms for each group separately. The model, therefore, takes the following form:

$$y_{it} = a_1 d_{1it} + a_2 d_{2it} + \dots + a_k d_{kit} + bx_{it} + e_{it} = a_i + bx_{it} + e_{it}$$
(2)

where:

 $a_i$  - specific free terms;

di - Boolean variables whose value is equal to 1 when j = i.

In the REM model,  $m_i$  expresses specific random elements. This model can be written as follows:

$$y_{it} = a + bx_{it} + e_{it} + u_i, (3)$$

where:

$$E(u_i) = 0, Var(u_i) = S_e^2, Cov(e_{it}, u_i) = 0.$$

When analysing a univariate model (with group effects), the significance of individual effects must be checked using the Wald test. The null hypothesis is that the conditions imposed on the model ( $\alpha_1 = \alpha_2 = \cdots = \alpha_N = \mu$ ) are true and the model estimation should occur without individual effects. If  $p < \alpha$ , the null hypothesis is rejected in favour of the alternative hypothesis: individual effects are present. The validity of introduction of individual effects into the random effects model is verified by testing whether the variance of the random element is different from zero. Zero variance indicates that there is no variability in the individual element and that it is constant across all test subjects, which makes it possible to replace it with a common free term. LM test statistic is used to verify the hypotheses of the Breusch-Pagan test. If the test statistic converges with the  $\chi^2(1)$  distribution, then there is

no reason to reject the null hypothesis. If the value of the test statistic exceeds the critical value, it is rejected, which suggests the significance of individual effects in the random effects model.

When all assumptions for the fixed effects and random effects models have been met, a decision must be made as to which model is better suited to the phenomenon under analysis. For this purpose, the Hausman test is carried out, which makes it possible to determine the nature of the specific effects present. It examines the correlation between the explanatory variables and the random effects. A value of *p* that is lower than the fixed boundary level means that a fixed effects model (with decomposition of the free term) is preferable. The null hypothesis is that the assumption of independence of exogenous variables from individual effects is met and the random effects estimator is more efficient. Rejection of the null hypothesis means that the fixed effects estimator is unbiased and more efficient than the random effects estimator. The panel model estimation was performed using the Gretl software.

#### 3. Research results

In the first stage of the analysis, which is shown in model 1 (Table 1), the relationship between the electricity capacity of renewable energy (MW) – total [EC] and the average annual wages – constant prices at 2019 [AWW] (in USD PPPs) was evaluated. The model makes it possible to determine what percentage of the variance of EC is explained by the variability of wages. The results of <sup>0</sup>the Hausman test ( $\chi^2$  (1) = 0.014; p = 0.904) indicate that a decomposition of the random element is appropriate. The results of the Breusch-Pagan test confirm the validity of the group decomposition, i.e. by country ( $\chi^2$  (1) = 501.957; p < 0.0001). The time effects (in the Wald test  $\chi^2$  (7) = 20.206; p = 0.005), which were included in the model as binary variables (reference year: 2011), are also significant.

Table 1. Results of the estimation of the model of renewable energy use as a function of wages - model 1: EC = f(AAV), own calculations based on data: OECD.STAT, ESTAT, IRENA (2020), Renewable Capacity Statistics 2020; & IRENA (2020), Renewable Energy Statistics 2020, The International Renewable Energy Agency, Abu Dhabi

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	В	S(B)	z	р	
const	-7,398.71	11,277.60	-0.656	0.5118	
AAW [thousand]	578.70	261.83	2.210	0.0271	**
dt_2	1,548.26	1,280.35	1.209	0.2266	
dt_3	2,399.68	1,279.95	1.875	0.0608	*
dt_4	2,942.82	1,280.27	2.299	0.0215	**
dt_5	3,525.80	1,293.93	2.725	0.0064	***
dt_6	4,086.66	1,322.64	3.090	0.0020	***
dt_7	4,813.37	1,347.38	3.572	0.0004	***
dt_8	5,416.90	1,400.27	3.868	0.0001	***
Breusch-Pagan test	$\chi^2(1) = 501.95$	7; p < 0.0001***	:		
Wald test for time effects	$\chi^2(7) = 20.206$	; p = 0.005***			
Joint test on named regressors	$\chi^2(1) = 4.885;$	p = 0.027**			
Hausman test	$\chi^2(1) = 0.014;$	p = 0.904			

B - regression coefficient, S(B) - standard error, z - Wald-statistics, p - probability in the Wald test.

According to the results of the analysis, renewable energy use (EC, in thousands) is significantly related to wage levels (B = 578.7, p = 0.0271). The correlation is positive: higher wage levels are accompanied, on average, by a greater scale of renewable energy use. Ceteris paribus, wages higher by 1 thousand are associated with renewable energy use increased by 578.7 on average. Time effects for individual years are also significant: this does not apply only to the binary variable for 2012 (p = 0.2266). The results obtained confirm the assumption presented in the first hypothesis, H1: *renewable energy use is significantly related to wage levels*. An increase in the use of green energy, especially in the investment phase, requires certain financial outlays, while an increase in wages makes it possible to find financial resources to invest in installations producing electricity from renewable sources. The described relation is important also due to the increased environmental awareness of the public in the analysed countries. Europeans are increasingly aware of the need to invest in green technologies and are increasingly willing to contribute to an innovative and sustainable economy.

The next step of the analysis shown in model 2 (Table 2) was to evaluate the relationship between the electricity capacity of renewable energy (MW) – total [EC] and poverty (POV). The model makes it possible to determine what percentage of the variance of POV is explained by the variability of EC. The results of the Hausman test ( $\chi^2$  (1) = 60.326; p = 0.904) indicate that a decomposition of the free term is appropriate. The results of the F test confirm the validity of the group decomposition, i.e. by country (F(1; 132) = 1,038.62; p < 0.0001). Also, the time effects are not statistically significant.

(2020), Rene wale Energy Statistics 2020, The international Rene Energy (Egeney, Field Brade								
	В	S(B)	z	р				
const	3,382.44	62.3744	54.23	< 0.0001	***			
EC	0.0066	0.0034	1.93	0.0556	*			
LSDV R <sup>2</sup>	0.9984							
Test F	F(18; 132) = 10	)38.62; p < 0.000	)1***					
Joint test on named regressors	$F(1; 132) = 3.731 \text{ p} = 0.056^{*}$							
Hausman test	$\chi^2(1) = 60.326; p = < 0.0001^{***}$							

Table 2. Results of the estimation of the model of poverty as a function of renewable energy use – model 2: POV = f(EC), own calculations based on data: OECD.STAT, ESTAT, IRENA (2020), Renewable Capacity Statistics 2020; & IRENA (2020), Renewable Energy Statistics 2020. The International Renewable Energy Agency. Abu Dhabi

B - regression coefficient, S(B) - standard error, z - Wald-statistics, p - probability in the Wald test.

Poverty level (POV) is positively correlated with renewable energy use (B = 0.0066; p = 0.0556) – it is higher when renewable energy use is higher. Ceteris paribus, the poverty level increases on average by 0.0066 as EC increases by a unit (Table 2). The model is estimated based on a cross-sectional time series sample and takes into account differences between countries due to both phenomena considered herein. As can be inferred from the correlation coefficients between these variables for each country (Table 4), in most cases the correlation coefficients (determined based on time samples for each country separately and for 152 observations combined) are positive. The expected (negative) value of the correlation coefficient between POV and EC was identified only for a few countries: Finland (r = -0.708), France (r = -0.481), Greece (r = -0.631), Poland (r = -0.663), and Slovakia (r = -0.623). In contrast, the correlation value is weak for the Czech Republic, Ireland, and Portugal. The above results provide a basis for rejecting hypothesis two: an increase in renewable energy use is negatively correlated with poverty level (POV). Despite the expected negative value, the results obtained in the study show that an increase in the level of renewable energy use is positively related to poverty levels. The reason for this may be the lack of systemic financial support programs for individuals and legal entities wishing to use RES installations. Although electricity produced in installations that use renewable energy sources is free, a certain amount of investment is required to purchase and operate such installations. The cost of green energy production has been steadily decreasing, but it is still relatively high, especially for those below the poverty line. The transition to climate neutrality may moderately increase inequality across income classes, with low-income households suffering the most negative effects (Fragkos et al., 2021).

Similar conclusions were drawn for the relationship between the percentage of people below the poverty line (POV\_perc) and the share of renewable energy in gross final energy consumption [SRE] (%) (model 3, Table 3). The model makes it possible to determine what percentage of the variance of POV\_perc is explained by the variation of the share of renewable energy in gross final energy consumption (SRE). The results of the Hausman test ( $\chi^2$  (1) = 0.711; p = 0.399) indicate that a decomposition of the random element is appropriate. The results of the Breusch-Pagan test confirm the validity of the group decomposition, i.e. by country ( $\chi^2$  (1) = 467.382; p < 0.0001). The relationship between these variables is statistically significant (p = 0.0429) and positive (B = 0.0713): the higher the share of renewable energy in gross final energy consumption, the higher on average the percentage of population below the poverty line. Ceteris paribus, an SRE higher by 1 percentage point is associated with an increase in the percentage of poor people by 0.07 percentage points on average.

Refer (2020), Refer waste Effergy Statistics 2020, The International Refer waste Effergy rightery, roa Diabi								
	В	S(B)	z	р				
const	14.3648		12.870	< 0.0001	***			
SRE	0.0713	0.0352	2.025	0.0429	**			
Breusch-Pagan test	$\chi^2(1) = 467.382; p < 0.0001 ***$							
Joint test on named regressors	$\chi^2(1) = 4.099; p = 0.043**$							
Hausman test	$\chi^2(1) = 0.711;$	p = 0.399						

Table 3. Results of the estimation of the model of poverty as a function of renewable energy use – model 3:  $POV\_perc = f(SRE)$ , own calculations based on data: OECD.STAT, ESTAT, IRENA (2020), Renewable Capacity Statistics 2020; & IRENA (2020), Renewable Energy Statistics 2020. The International Renewable Energy Agency. Abu Dhabi

B - regression coefficient, S(B) - standard error, z - Wald-statistics, p - probability in the Wald test.

The correlation between SRE and POV\_perc is positive for most countries. The expected negative value of the correlation applies only to Finland (r = -0.745), France (r = -0.498), Greece (r = -0.624), and Slovakia (r = -0.872). The results obtained contradict the third hypothesis, H3: *the higher the share of renewable energy in the gross final energy consumption, the lower on average the percentage of the population below the poverty line*. An increase in the share of green energy does not lead to a reduction of the number of people below the poverty line, which means that the people who invest in RES are consumers who live above the poverty line and are able to obtain loans or have sufficient financial resources for investment in RES. The analysed data indicates a lack of appropriately structured support mechanisms for the poor in financing and operating green energy installations and a lack of adequate education on the local and global benefits of energy production by prosumers.

The Pearsons' correlation coefficient (Table 4) complements the analysis performed as part of models 1-3. Of the 19 countries studied, special attention should be paid to the correlation values recorded for Finland and France. In the case of these two countries, the values obtained show a negative correlation between renewable energy use and poverty indicators, i.e. a decrease in poverty indicators with an increase in RES use was recorded, while an increase in the value of the wage index shows a positive correlation between the indicators. France and Finland are therefore perfect examples of the assumptions outlined in the research hypotheses.

Table 4. Pearsons' correlation coefficient (r) – total and by country, own calculations based on data: OECD.STAT, ESTAT, IRENA (2020), Renewable Capacity Statistics 2020; & IRENA (2020), Renewable Energy Statistics 2020, The International Renewable Energy Agency, Abu Dhabi

					Kenewai	JIE LIIEI	gy Agen	cy, Abu	Dhaoi						
	EC	EC_pc	SRE	EC	EC_pc	SRE	EC	EC_pc	SRE	EC	EC_pc	SRE	EC	EC_pc	SRE
		Austria		Belgium		Cz	ech Repul	blic		Denmark		Estonia			
POV	0.589	0.557	0.056	0.853	0.849	0.835	-0.235	-0.246	-0.153	0.897	0.890	0.870	0.900	0.901	0.778
POV_perc	-0.518	-0.546	-0.807	0.724	0.719	0.699	-0.301	-0.308	-0.212	0.753	0.746	0.708	0.905	0.907	0.776
AAW	0.967	0.965	0.763	0.728	0.734	0.764	0.614	0.568	0.535	0.875	0.869	0.933	0.815	0.813	0.963
		Finland			France		Germany			Greece			Hungary		
POV	-0.708	-0.705	-0.745	-0.481	-0.473	-0.498	0.479	0.492	0.453	-0.631	-0.655	-0.624	-0.787	-0.788	0.835
POV_perc	-0.760	-0.756	-0.801	-0.762	-0.755	-0.768	-0.180	-0.162	-0.169	-0.547	-0.572	-0.553	-0.740	-0.740	0.818
AAW	0.753	0.757	0.440	0.992	0.991	0.925	0.993	0.991	0.964	-0.909	-0.895	-0.870	0.798	0.798	-0.839
		Ireland			Italy		Lithuania		Netherlands		Poland				
POV	0.295	0.307	0.379	0.551	0.515	0.494	0.830	0.828	0.781	0.935	0.936	0.929	-0.663	-0.663	-0.080
POV_perc	-0.105	-0.091	-0.009	0.271	0.258	0.184	0.923	0.924	0.846	0.920	0.921	0.915	-0.654	-0.654	-0.074
AAW	0.302	0.285	0.196	-0.223	-0.268	-0.281	0.962	0.971	0.833	0.284	0.290	0.166	0.848	0.849	0.248
		Portugal			Slovakia		Spain			Sweden				Total <sup>a</sup>	
POV	-0.415	-0.405	0.068	-0.623	-0.502	-0.875	0.539	0.598	0.696	0.939	0.939	0.926	0.879	0.022	-0.268
POV_perc	-0.192	-0.181	0.297	-0.624	-0.497	-0.872	0.533	0.594	0.696	0.768	0.782	0.778	0.186	-0.013	0.058
AAW	-0.593	-0.596	-0.676	0.288	0.101	0.608	-0.805	-0.765	-0.683	0.983	0.987	0.994	0.328	0.453	0.069

S(B)	
1.115	57
	Negative correlation
	Positive correlation
	Very weak relationship

a n = 152 (estimate for the entire sample, without group and time decomposition)

The situation is slightly worse for Greece and Slovakia, which have a negative correlation between green energy and poverty indicators. In the case of Greece, a negative correlation was also observed for the relationship between energy indicators and wage levels, which contradicts the third hypothesis. Another group of countries with similar correlation levels are Poland and Hungary; for those countries, a negative correlation between green energy (except for the SRE indicator) and poverty was recorded, while wages indicate a positive correlation, which may indicate an improvement in the financial situation of the inhabitants of a country. In the case of Belgium, Denmark, Estonia, Lithuania, and Sweden, the correlation between the studied indicators is positive in all cases, i.e. an increase in renewable energy use coincides with an increase in poverty and an increase in wages. Such a situation may indicate an improvement in the financial situation of those above the poverty line and an increasing poverty of those at the bottom of the wealth pyramid. In the other countries analysed, no clear trend in the correlation between the analysed indicators was observed.

### 4. Discussion

An analysis of the level of electricity capacity of renewable energy (MW) - total (EC) and electricity capacity of renewable energy (MW) per 10,000 inhabitants [EC\_pc] from 2011 to 2018 indicated a high rate of change and high levels of differences between the countries (Table 5). Based on an analysis of only the rate of the change in the EC indicator, the leaders in the ranking showing an increase of more than 100% are the Netherlands (207%), Poland (175%), Lithuania (132%), and Ireland (116%). Such a high increase in the EC indicator was the result of a low level of RES in those countries in 2011, which is also evident in the values of the rate of change of the [EC\_pc] indicator, which in the examined period was equal to 3.79, 1.4, 1.75, and 4,27, respectively. For these four countries, the most favourable situation was found in Ireland, where a 116% increase in RES allowed a 4.27% increase in EC\_pc, and in the Netherlands, where a 207% increase in RES corresponded to a 3.79% increase in the RES share in total energy produced.

Country	2011	2012	2013	2014	2015	2016	2017	2018
	•	Electricity ca	apacity of rend	ewable energy	y (MW) – tota	al [EC]	•	•
Austria	16,708	16,656	17,192	17,839	18,473	19,336	19,596	20,358
Belgium	4,198	5,123	5,766	5,993	6,363	6,735	7,432	8,242
Czech Republic	3,681	3,998	4,095	4,170	4,214	4,212	4,272	4,265
Denmark	5,124	5,949	6,584	6,750	7,109	7,410	8,196	8,925
Estonia	334	441	519	561	594	607	615	609
Finland	5,282	5,329	5,632	5,863	6,258	6,862	7,628	7,698
France	34,788	37,085	38,657	40,543	42,792	44,840	47,814	50,527
Germany	67,421	78,150	83,766	90,325	97,851	104,436	112,514	119,296
Greece	5,521	6,570	7,672	8,010	8,138	8,424	8,686	9,020
Hungary	890	724	749	1,024	1,077	1,048	1,194	1,599
Ireland	1,867	1,999	2,312	2,592	2,760	3,101	3,671	4,038
Italy	40,824	46,721	48,857	49,526	50,417	51,195	52,128	53,161
Lithuania	351	451	527	545	693	768	787	815
Netherlands	3,193	3,555	4,265	4,702	5,727	7,114	7,916	9,803
Poland	3,019	4,094	5,116	5,638	6,919	7,881	7,982	8,300
Portugal	10,548	10,955	11,143	11,573	12,153	13,217	13,555	13,767
Slovakia	2,301	2,335	2,359	2,380	2,384	2,397	2,385	2,330
Spain	43,920	46,413	47,676	47,711	47,742	47,773	47,921	48,257
Sweden	23,469	24,293	24,645	25,528	26,869	27,805	28,337	29,244
	Electricit	y capacity of	renewable en	ergy (MW) p	er 10,000 inh	abitants [EC_	_pc]	
Austria	19.95	19.81	20.34	20.97	21.52	22.22	22.34	23.08
Belgium	3.82	4.62	5.18	5.36	5.66	5.95	6.55	7.23
Czech Republic	3.51	3.81	3.89	3.97	4.00	3.99	4.04	4.02
Denmark	9.21	10.66	11.75	11.99	12.56	12.98	14.26	15.44
Estonia	2.51	3.33	3.93	4.27	4.51	4.61	4.68	4.61
Finland	9.83	9.87	10.38	10.76	11.44	12.51	13.86	13.96
France	5.35	5.68	5.89	6.13	6.44	6.73	7.16	7.54
Germany	8.40	9.73	10.40	11.18	12.05	12.71	13.63	14.41
Greece	4.96	5.93	6.97	7.33	7.49	7.81	8.07	8.40
Hungary	0.89	0.73	0.76	1.04	1.09	1.07	1.22	1.63
Ireland	4.09	4.36	5.02	5.59	5.90	6.56	7.67	8.36
Italy	6.88	7.87	8.19	8.15	8.29	8.44	8.60	8.79
Lithuania	1.15	1.50	1.77	1.85	2.37	2.66	2.76	2.90
Netherlands	1.92	2.12	2.54	2.79	3.39	4.19	4.63	5.71
Poland	0.79	1.08	1.34	1.48	1.82	2.08	2.10	2.19
Portugal	9.98	10.39	10.63	11.10	11.71	12.78	13.15	13.38
Slovakia	4.27	4.32	4.36	4.39	4.40	4.42	4.39	4.28
Spain	9.41	9.91	10.2	10.26	10.28	10.29	10.30	10.34
Sweden	24.93	25.62	25.79	26.47	27.57	28.23	28.35	28.90

Table 5. Electricity capacity of renewable energy (MW) – total and per 10,000 inhabitants, own calculations based on data: IRENA (2020), Renewable Capacity Statistics 2020; & IRENA (2020), Renewable Energy Statistics 2020, The International Renewable Energy Agency, Abu Dhabi

When analysing the rate of changes in the value of  $[EC_pc]$ , special attention should be paid to Denmark (an increase by 6.23% from 9.21 to 15.44) and Germany (an increase by 6.01% from 8.40 to 14.41). The highest value of EC\_pc was observed in Sweden (28.90) and Austria (23.08), which was associated with an increase in RES production of 25% and 22%, respectively.

In the assessment of the changes in the share of renewable energy in the gross final energy consumption [SRE] (Table 6), the highest rate of change was recorded in Denmark (an increase by 12.02%) with a simultaneous relatively high value of the SRE indicator, which ensured the achievement of the target, set in the Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018, that at least 27% of the energy consumed in the EU per year should come from renewable sources (European Parliament, 2018) as early as in 2018.

The countries that met the requirement set forth in the Regulation in 2018 are Sweden (54.64%), Finland (41.16%), Austria (33.81%), Portugal (30.21%), and Estonia (29.99%). However, an important condition to bear in mind is that *the target for renewable energy is binding at Union level and that it will be fulfilled through Member States' contributions guided by the need to deliver collectively the Union target* (European Parliament, 2018a).

In the case of an analysis of the POV\_perc indicator values (Table 7), the largest decreases in poverty levels were observed in Greece and Poland (17%,) and in Hungary (11%). Only Hungary managed to exceed the average value of the POV\_perc indicator, which was equal to 16.08% for the group of the studied countries in 2018. Poland and Greece, despite a large change in the value of the indicator, are still in the group of countries for which the value

Table 6. Share of renewable energy in gross final energy consumption [SRE] (%), own calculations based on data: Share of renewable energy in gross final energy consumption [T2020\_31] ESTAT

	10110 0	uole energy i	in Brobb filliar	mengy combai	inpuon [1202	0_011001111	-	
Country	2011	2012	2013	2014	2015	2016	2017	2018
Austria	31.55	32.74	32.67	33.55	33.50	33.37	33.14	33.81
Belgium	6.28	7.09	7.65	8.04	8.03	8.75	9.11	9.48
Czech Republic	10.95	12.81	13.93	15.07	15.07	14.92	14.80	15.14
Denmark	23.39	25.47	27.17	29.32	30.87	32.05	34.68	35.41
Estonia	25.35	25.52	25.32	26.14	28.53	28.72	29.17	29.99
Finland	32.66	34.34	36.73	38.78	39.32	39.01	40.92	41.16
France	10.86	13.27	13.91	14.42	14.86	15.50	15.90	16.44
Germany	12.45	13.54	13.76	14.39	14.91	14.89	15.48	16.67
Greece	11.15	13.74	15.33	15.68	15.69	15.39	17.30	18.05
Hungary	13.97	15.53	16.21	14.62	14.50	14.38	13.54	12.54
Ireland	6.57	7.01	7.58	8.57	9.04	9.17	10.47	10.89
Italy	12.88	15.44	16.74	17.08	17.53	17.42	18.27	17.80
Lithuania	19.94	21.44	22.69	23.59	25.75	25.61	26.04	24.70
Netherlands	4.52	4.66	4.69	5.42	5.67	5.80	6.46	7.34
Poland	10.35	10.97	11.46	11.61	11.89	11.40	11.12	11.48
Portugal	24.61	24.58	25.70	29.51	30.52	30.87	30.61	30.21
Slovakia	10.35	10.45	10.13	11.71	12.88	12.03	11.47	11.90
Spain	13.25	14.31	15.35	16.16	16.26	17.42	17.56	17.45
Sweden	48.14	50.03	50.79	51.82	52.95	53.33	54.16	54.65

Table 7. At risk of poverty rate (cut-off point: 60% of median equivalised income after social transfers), own calculations

based on da	ta: At-fisk-of-	-poverty rate	by poverty un	tesnoid, age a	110  sex - EU	SILC and EC	ΠΡ surveys, r	LSIAI
Country	2011	2012	2013	2014	2015	2016	2017	2018
			Thousan	d persons [PO	DV]			
Austria	1,207	1,201	1,203	1,185	1,178	1,208	1,245	1,238
Belgium	1,657	1,667	1,652	1,704	1,649	1,730	1,777	1,844
Czech Republic	1,022	990	886	1,002	1,006	1,001	948	996
Denmark	665	662	664	678	686	675	704	728
Estonia	232	233	248	285	281	283	274	286
Finland	725	704	632	688	668	630	621	652
France	8,605	8,707	8,518	8,302	8,474	8,562	8,310	8,497
Germany	12,814	13,030	12,845	13,337	13,428	13,418	13,139	13,048
Greece	2,349	2,536	2,529	2,384	2,293	2,256	2,151	1,954
Hungary	1,382	1,403	1,461	1,458	1,448	1,398	1,293	1,227
Ireland	680	749	723	779	760	799	751	726
Italy	11,889	11,729	11,667	11,790	12,130	12,481	12,235	12,229
Lithuania	586	559	611	564	649	632	652	644
Netherlands	1,816	1,678	1,735	1,937	1,945	2,132	2,230	2,247
Poland	6,623	6,478	6,520	6,424	6,595	6,481	5,609	5,472
Portugal	1,919	1,887	1,966	2,030	2,019	1,960	1,887	1,777
Slovakia	700	716	694	659	643	668	650	655
Spain	9,550	9,656	9,425	10,218	10,178	10,269	9,950	9,950
Sweden	1,442	1,444	1,528	1,505	1,588	1,598	1,578	1,660
		Number of	f persons per	100.000 inhat	oitants [POV_	perc]		
Austria	14.41	14.28	14.23	13.93	13.72	13.88	14.19	14.03
Belgium	15.06	15.05	14.83	15.24	14.67	15.29	15.65	16.18
Czech Republic	9.75	9.42	8.43	9.53	9.55	9.48	8.96	9.39
Denmark	11.96	11.86	11.85	12.05	12.12	11.83	12.25	12.59
Estonia	17.45	17.58	18.79	21.66	21.37	21.51	20.83	21.68
Finland	13.49	13.03	11.65	12.62	12.21	11.48	11.28	11.83
France	13.24	13.34	12.98	12.55	12.75	12.85	12.44	12.68
Germany	15.97	16.22	15.95	16.51	16.54	16.33	15.92	15.76
Greece	21.12	22.87	22.98	21.82	21.12	20.92	19.98	18.19
Hungary	13.84	14.13	14.74	14.76	14.69	14.22	13.20	12.55
Ireland	14.88	16.32	15.68	16.80	16.25	16.91	15.70	15.03
Italy	20.03	19.75	19.55	19.40	19.95	20.57	20.19	20.22
Lithuania	19.20	18.61	20.56	19.16	22.22	21.88	22.89	22.93
Netherlands	10.90	10.03	10.34	11.51	11.51	12.56	13.06	13.08
Poland	17.40	17.02	17.13	16.90	17.35	17.07	14.77	14.41
Portugal	18.15	17.90	18.75	19.47	19.46	18.95	18.30	17.27
Slovakia	12.98	13.25	12.83	12.17	11.86	12.31	11.96	12.03
Spain	20.46	20.62	20.17	21.97	21.91	22.11	21.38	21.33
Sweden	15.32	15.23	15.99	15.60	16.29	16.22	15.79	16.40

of POV\_perc remained above the average value. An unfavourable situation was noted in Belgium, Estonia, Lithuania, the Netherlands, and Sweden, where the value of the indicator increased by 1.12, 4.23, 3.73, 2.18, and 1.08, respectively. The value of the indicator for Estonia is the second highest, which proves that the country has a growing problem of with poverty. The most favourable situation was observed in the Czech Republic where POV\_perc is equal to 9.55.

The analysis of the variability of wages (Table 8) indicated a lower amplitude compared to the rate of change observed for the indicators describing green energy. The highest value of the *Average annual wages – constant prices in 2019* [AWW] in 2018, which exceeded the amount of USD 50,000, was recorded in 5 countries (Austria, Belgium, Denmark, Germany, and the Netherlands) for which the rate of changes in wages over the period of 2011-2018 ranged from 0.2% for the Netherlands to 10.9% for Germany. The lowest value of AWW in 2018, which was less than USD 30,000, was recorded for seven countries, and it is particularly worrying that the group of these countries included countries with a high increase in AWW (Estonia 32.7% and Lithuania 36.1%), as well as in countries with a decrease in wages by as much as 9.6% (Greece). This situation is a consequence of great disproportions in wealth between the Member States of the European Union and indicates a problem related to the lack of a systemic approach to implementation of sustainable development goals, in particular in the context of the first goal.

Table 8. Average annual wages - constant prices at 2019 [AWW] (in USD PPPs), own calculations based on data:

Country	2011	2012	2013	2014	2015	2016	2017	2018
Austria	52,179	52,446	52,510	52,711	53,052	53,589	53,437	53,561
Belgium	53,886	54,295	54,845	55,117	54,737	54,884	54,626	55,066
Czech Republic	24,072	24,060	23,806	24,304	24,970	25,819	26,889	28,360
Denmark	53,668	53,593	53,949	54,978	55,943	56,883	56,277	56,828
Estonia	21,479	21,798	22,333	23,548	24,629	25,841	26,555	28,499
Finland	44,528	44,574	44,138	44,138	44,616	44,976	44,864	45,023
France	43,682	43,975	44,345	44,651	45,088	45,610	46,163	46,256
Germany	47,739	48,392	48,862	49,700	50,878	51,623	52,181	52,930
Greece	30,398	28,972	27,100	27,574	27,449	27,395	27,322	27,480
Hungary	22,543	21,664	21,414	21,148	21,450	21,810	23,527	24,703
Ireland	49,746	49,194	47,972	47,597	48,408	49,030	49,585	49,695
Italy	39,328	38,086	38,205	38,354	38,691	38,982	38,707	38,853
Lithuania	20,106	20,412	21,226	22,180	23,593	24,854	26,258	27,368
Netherlands	56,588	56,820	57,020	56,712	57,378	57,573	57,138	56,709
Poland	24,536	24,320	24,597	25,098	25,648	26,934	28,071	30,091
Portugal	27,385	26,209	26,712	26,253	26,176	26,024	26,141	26,413
Slovakia	21,071	20,813	20,966	21,377	22,230	22,947	23,610	24,254
Spain	40,302	39,176	39,178	39,056	39,638	39,413	38,898	38,554
Sweden	42,180	43,133	43,647	44,240	44,849	45,552	45,818	46,062

In the comparative analysis of the changes in the EC per capita and the changes in wages in the EU-19 countries between 2011 and 2018 (Table 9), no clear trend was observed. The following four basic groups of countries can be distinguished:

- A. Countries where the change in EC per capita significantly exceeds that in AWW and both values are positive (Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Hungary, Lithuania, Netherlands, and Poland).
- B. Countries where the change in EC per capita exceeds that of AWW, both values are positive, and the change in AWW is equal to at least 50% of the value of the change in EC\_pc (Sweden).
- C. Countries where the change in AWW exceeds that in EC per capita and both values are positive (Czech Republic and Slovakia).
- D. Countries where the change in AWW is negative (Greece, Ireland, Italy, Portugal, and Spain).

In the case of countries from groups A, B, and C, a comparison of the changes in EC per capita with the changes in wages in the EU-19 countries in 2011-2018 presents a picture analogous to the results shown in model 1 according to which, on average, a higher level of wages is accompanied by a greater scale of renewable energy use. What sets the groups apart is the difference in the values of the changes in the individual indicators. As for countries in group D, there was a decrease in the value of AWW, while EC per capita increased. The produced results comply with the studies presented in the literature, according to which an increase in salaries is positively correlated with the total consumption of electrical energy, as well as with the level of electrical energy originating from renewable sources (Qiu et al., 2018). The relationship between sustainable economic development and renewable energy is also studied via a bidirectional analysis of primary variables of economic growth and the consumption of renewable electrical energy (Armeanu et al., 2017; Pedroni, 2004). The results of studies performed by Apergis and Apergis (2020) indicate the existence of bidirectional causality of economic growth and the consumption of

electrical energy from renewable sources in a short- and long-term perspective. The economic growth depends largely on energy sources. Most studies point to the existence of positive correlation (Khuong et al., 2020) between the utilisation of electrical energy and the level of economic growth. Another important issue is an analysis of correlation in the context of utilising a specific energy source.

Table 9. Comparison of the change in EC per capita and the change in wages in EU-19 countries, 2011-2018, own calculations
based on data: OECD.STAT, ESTAT, IRENA (2020), Renewable Capacity Statistics 2020; & IRENA (2020), Renewable
Energy Statistics 2020, The International Renewable Energy Agency, Abu Dhabi

а :с /:			Cł	nange compa	red to the pre	vious year [%	5]		2018/2011
Specification		2012	2013	2014	2015	2016	2017	2018	2018/2011
Austria	EC_pc	-0.7%	2.7%	3.1%	2.6%	3.3%	0.5%	3.3%	15.7%
	AWW	0.5%	0.1%	0.4%	0.6%	1.0%	-0.3%	0.2%	2.6%
Belgium	EC_pc	21.2%	11.9%	3.6%	5.6%	5.2%	9.9%	10.4%	89.5%
	AWW	0.8%	1.0%	0.5%	-0.7%	0.3%	-0.5%	0.8%	2.2%
Czech Republic	EC_pc	8.4%	2.3%	1.9%	0.8%	-0.2%	1.2%	-0.4%	14.5%
	AWW	-0.1%	-1.1%	2.1%	2.7%	3.4%	4.1%	5.5%	17.8%
Denmark	EC_pc	15.7%	10.2%	2.1%	4.7%	3.4%	9.8%	8.3%	67.5%
	AWW	-0.1%	0.7%	1.9%	1.8%	1.7%	-1.1%	1.0%	5.9%
Estonia	EC_pc	32.5%	17.9%	8.6%	5.8%	2.2%	1.4%	-1.3%	83.5%
	AWW	1.5%	2.5%	5.4%	4.6%	4.9%	2.8%	7.3%	32.7%
Finland	EC_pc	0.4%	5.2%	3.6%	6.3%	9.3%	10.8%	0.7%	42.1%
	AWW	0.1%	-1.0%	0.0%	1.1%	0.8%	-0.2%	0.4%	1.1%
France	EC_pc	6.1%	3.7%	4.0%	5.1%	4.5%	6.4%	5.3%	40.8%
	AWW	0.7%	0.8%	0.7%	1.0%	1.2%	1.2%	0.2%	5.9%
Germany	EC_pc	15.8%	6.9%	7.5%	7.8%	5.5%	7.3%	5.7%	71.4%
	AWW	1.4%	1.0%	1.7%	2.4%	1.5%	1.1%	1.4%	10.9%
Greece	EC_pc	19.4%	17.7%	5.1%	2.2%	4.2%	3.3%	4.1%	69.2%
	AWW	-4.7%	-6.5%	1.8%	-0.5%	-0.2%	-0.3%	0.6%	-9.6%
Hungary	EC_pc	-18.2%	3.7%	37.2%	5.4%	-2.4%	14.3%	34.1%	83.4%
	AWW	-3.9%	-1.2%	-1.2%	1.4%	1.7%	7.9%	5.0%	9.6%
Ireland	EC_pc	6.6%	15.1%	11.4%	5.6%	11.2%	16.9%	9.0%	104.7%
	AWW	-1.1%	-2.5%	-0.8%	1.7%	1.3%	1.1%	0.2%	-0.1%
Italy	EC_pc	14.4%	4.1%	-0.5%	1.8%	1.8%	2.0%	2.2%	27.8%
	AWW	-3.2%	0.3%	0.4%	0.9%	0.8%	-0.7%	0.4%	-1.2%
Lithuania	EC_pc	30.5%	18.1%	4.4%	28.1%	12.0%	4.0%	5.0%	152.1%
	AWW	1.5%	4.0%	4.5%	6.4%	5.3%	5.7%	4.2%	36.1%
Netherlands	EC_pc	10.8%	19.6%	9.9%	21.3%	23.6%	10.6%	23.1%	197.6%
	AWW	0.4%	0.4%	-0.5%	1.2%	0.3%	-0.8%	-0.8%	0.2%
Poland	EC_pc	35.6%	25.0%	10.3%	22.8%	14.0%	1.3%	4.0%	175.6%
	AWW	-0.9%	1.1%	2.0%	2.2%	5.0%	4.2%	7.2%	22.6%
Portugal	EC_pc	4.2%	2.3%	4.5%	5.5%	9.1%	2.9%	1.7%	34.1%
	AWW	-4.3%	1.9%	-1.7%	-0.3%	-0.6%	0.5%	1.0%	-3.6%
Slovakia	EC_pc	1.3%	0.9%	0.8%	0.1%	0.5%	-0.6%	-2.4%	0.3%
	AWW	-1.2%	0.7%	2.0%	4.0%	3.2%	2.9%	2.7%	15.1%
Spain	EC_pc	5.3%	2.9%	0.5%	0.2%	0.1%	0.1%	0.4%	9.9%
	AWW	-2.8%	0.0%	-0.3%	1.5%	-0.6%	-1.3%	-0.9%	-4.3%
Sweden	EC_pc	2.8%	0.7%	2.6%	4.1%	2.4%	0.4%	1.9%	15.9%
	AWW	2.3%	1.2%	1.4%	1.4%	1.6%	0.6%	0.5%	9.2%

# Conclusions

Despite the synergistic nature of the sustainable development goals, the different action items are carried out in an individual manner. The success of the program requires cooperation in the actions aimed at the achievement of the different goals. The analysis confirmed a coincidence between an increase in the level of use of energy from renewable sources with an increase in the level of wages. In the case of the analysis of the relationship between the renewable energy indicators and the poverty indicators, a negative relationship was observed: an increase in the use and share of renewable energy coincided with an increase in the poverty indicators. This situation is due to fact that certain investment outlays must be incurred in order to launch RES installations and for financial reasons, such outlays are affordable to persons who live above the poverty level. The increase in the number of poor people with a concomitant increase in the level of RES energy indicates a lack of, or deficits in, the mechanisms applied to support poor persons who want to use environmentally friendly renewable energy sources.

On the one hand, consumers can benefit from the lower prices of energy; on the other hand, prior to that, they must pay the costs of installations generating energy from renewable sources. Subsidies and tax reliefs for renewable energy often do not cover the total costs of the assembly and activation of an installation. In addition, an investor's own contribution is required, which cannot be afforded by the poorest. Therefore, it seems extremely important to properly administer support measures for RES by precisely defining the criteria determining the intensity of support for specific social groups (Abrell et al., 2019; Abrell et al., 2019A). Dispersed renewable energy systems are becoming a strong element of local sustainable development strategies (Frank et al., 2018). The construction of a sustainable energy mix on a local scale, with a simultaneous drop in the share of coal, undoubtedly contributes to a decrease in the emission of pollutants into the environment (Kaczmarczyk et al., 2020). A combination of a bottom-up approach for individual countries with actions implemented on the scale of the European Union and globally allows for the creation of a coherent global set of assumptions related to the development of sustainable economic development (Sebri et al., 2014). It is therefore necessary to constantly monitor development trends regarding modern technologies enabling the production of green energy from renewable sources, and to identify barriers obstructing the decarbonisation process of the energy sector, both on a local and a global scale.

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# **Evaluation of Social Protection Performance in EU Countries:** Multiple-criteria Decision Analysis (MCDA)

# Ocena skuteczności ochrony socjalnej w krajach UE: Wielokryterialna analiza decyzji (MCDA)

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# Abstract

The paper aims to rank European Union (EU) countries according to the composite index, which uses selected social protection indicators from the relevant database at EU level – Eurostat. The total score of social performance for 2020 was determined using the CRITIC-TOPSIS framework. The study showed that Austria, Luxembourg and Germany, respectively, had the best level of social protection, while Latvia, Romania and Spain were at the bottom, as the countries with the worst values of indicators. The importance of research is reflected in the fact that the social component of sustainable development is still not sufficiently researched, especially when it comes to the application of multi-criteria analysis methods in the empirical analysis of social sustainability. In this regard, depending on the obtained performance values, socio-economic policymakers can redesign existing measures and programs, as well as the amounts of social transfers to certain EU member states. The authors expect that the results of the study will help build higher social standards and well-being in the EU.

**Key words:** social sustainability, social protection, socio-economic indicators, poverty, unemployment, CRITIC-TOPSIS method, EU countries

Słowa kluczowe: zrównoważoność społeczna, ochrona socjalna, wskaźniki społeczno-ekonomiczne, ubóstwo,bezrobocie, metoda CRITIC-TOPSIS, kraje UE

### Introduction

In general, sustainability is the maintenance of social well-being over time with constant efforts to increase it. Theorists, who deal with the concept of sustainability, mainly emphasize the need to harmonize economic growth and environmental protection in the conditions of upcoming climate change. However, it is a narrow interpretation of sustainable development because it means recognizing only the ecological problem.

In previous decades, the focus has been either on biophysical environmental issues or on trying to balance the economy with overall development (Vallance et al., 2011). Most research aimed to find a compromise between the economy and the problem of pollution, while social sustainability was often unjustifiably neglected. This

situation is explained by the fact that the social component was much later integrated into the concept of sustainability, and therefore both theoretical and empirical works are missing (Eizenberg & Jabareen, 2017; Kamali et al., 2018).

Social sustainability is one of the three basic and interrelated dimensions of the concept of sustainable development. Social sustainability has become especially important with the development of a knowledge-based economy that transforms the old industrial society into a society in which scientists and experts in new intellectual technology have a dominant role (Veselinović & Veljković, 2021). Unlike economic and environmental sustainability, the social component is the least researched (Popović et al., 2018). In the scientific community, there is no consensus regarding the concept and composition of the social pillar of sustainability. Indicators of poverty, unemployment, as well as social and health exclusion predominate.

The EU is one of the largest integrations of countries, having in mind economic, political and other indicators. The subject of the research is the assessment of the performance of social protection of EU countries by the TOPSIS method. The main goal of the research is to rank and compare countries based on performance scores. An additional goal is to form such a model that will include the most important relevant indicators of this multidimensional phenomenon. In addition to the above-mentioned multi-criteria decision-making (MCDM) method, the CRITIC method was chosen to determine the weight of the criteria (indicator or attribute). This approach is characterized by objectivity, because it eliminates the subjective assessments of individuals when determining weight coefficients. The authors selected 11 indicators of social protection based on the official Eurostat database (2022) entitled *Social protection performance monitor – Indicators*. This database is heterogeneous and contains a range of indicators, including indicators of poverty, social exclusion, indicators of unemployment, as well as health care.

The paper consists of several logically connected parts. After an introductory discussion of the subject of research and the relationship between social sustainability and sustainable development, the authors described in detail the applied methodology, performed the necessary analysis and discussed important results. Finally, in the conclusion, a summary review of the study is shown. In addition, recommendations for economic and social policymakers were presented, as well as directions for future research.

### **Theoretical background**

In the literature, there is a lack of research on social sustainability, as opposed to economic and environmental sustainability (Sierra et al., 2018). Scientific studies mainly rely on some broader issues such as: social capital, social cohesion and social exclusion (Dempsey et al., 2011). However, with the emergence of the global economic and financial crisis (2007–2008), as well as the general social crisis due to the COVID-19 pandemic, there was a revival of interest in social sustainability.

The social pillar is one of the three basic pillars of sustainable development (besides economic and ecological). Modern society is full of risks, among which poverty and social exclusion stand out the most at the global level (Krstić, 2018). Under the influence of globalization, there is no doubt that conditions are being created for unstoppable development (Radulović & Kostić, 2020). However, at the same time, there is a deepening of poverty and other social problems in peripheral countries, i.e. underdeveloped countries and transition countries. On the other hand, social exclusion is manifested through the inability of individuals and groups to participate in various socio-economic activities such as education, production, health, political processes. All this shows that the link between poverty and social exclusion is mutual and unbreakable, and in the assessment of poverty, only one indicator is often used, which combines poverty risk and risk of social exclusion.

The basis of social sustainability is the quality of life of people, which is associated with various social performances such as poverty rate (especially children, unemployed, women and pensioners), unemployment (young and older people who have not yet exercised their right to a pension) and social protection of people who are employed in labour-intensive activities and temporary jobs. All these problems are closely related to economic factors, but also to the education of individuals. Stable economic growth and development minimizes social costs. Many studies have shown a positive link between socio-economic development and indicators of the social status of the population (Halaskova & Bednář, 2020). On the other hand, social cohesion provides a sufficient condition for economic prosperity. In fact, countries with low levels of social protection is especially important, because people without income, as well as those with low social assistance, will not be able to educate their children, which opens space for early school leaving and social exclusion, which creates a vicious circle of poverty. It is further connected with the problems of malnutrition, as well as diseases due to the often inaccessible possibility of treatment and living in unhygienic conditions. Borgonovi et al. (2018) point out that the notion of social sustainability means increased availability of health care services to vulnerable categories of the population.

In addition, there is research that emphasizes the important role of social protection policy in preserving and adequately managing the environment (Asteria et al., 2018). There is evidence in the literature of the negative effects of poverty on the adoption of green technologies (e.g. lack of funds for the purchase of solar panels or adaptation of buildings to increase energy efficiency) which makes it difficult to implement the environmental

dimension of sustainable development (Crabtree, 2005). These examples show a high degree of connection between the economic, social and environmental dimensions of the concept of sustainability. Therefore, studying social sustainability requires a multidisciplinary approach. Partial observation of this phenomenon is the subject of constant criticism (Hale et al., 2019).

Social protection is a part of public policy that is influenced by macroeconomic policymakers. It is considered as one of the criteria of macroeconomic efficiency of the national economy. Also, social protection is aimed at reducing poverty, restoring work capacity and productivity, as well as compensating for the livelihood of people who are unable to earn due to old age or unfavourable social circumstances (Chugunov & Nasibova, 2021). Within the social approach, the following elements dominate: social inequality, justice and fairness. In this way, this policy provides assistance to marginalized groups and alleviates inequalities in income distribution, as well as access to essential medical services. The realization of social goals primarily depends on fiscal policy. Social policy measures require sustainable and adequate funding, while limited resources require good management of social protection policy at the macro level (Hagemejer, 2018).

The basic components of social protection in European countries are social spending and social security. Social spending at EU level ranges from 13.4% of GDP (Ireland) to 31% of GDP (France) (OECD, 2022), while social security contributions are 0.06% of GDP (Denmark) up to 16.8% of GDP (Slovenia) (OECD, 2022a). At the same time, higher levels of social spending are most often the result of rising poverty in the country. It is a potential source of social instability, which is certainly in conflict with the concept of sustainable development. Krstić (2018) emphasizes that the EU has especially recognized the problem of poverty and social exclusion and that it is seriously considering the social protection of vulnerable groups in the population. To achieve social sustainability, social policy, education policy, employment policy and health care policy are sectoral policies of the utmost importance. Ultimately, building sustainable societies must ensure a decent life for all people.

At EU level, The *European Pillar of Social Rights* aimed to bring social sustainability on a par with economic and environmental sustainability (Alexandris Polomarkakis, 2020). It is an initiative of the European Commission that was created in 2017 and whose goal was to establish a socially sustainable Union by respecting social rights, among which the most prominent are benefits to the unemployed. It should be pointed out that poverty is the main problem faced by socio-economic policymakers. Job loss, high housing costs, and early school leaving are key factors that can increase the risk of poverty. Therefore, unemployment and education are often used in studies as indicators of social sustainability (Torres et al., 2016).

In the coming period, it is estimated that the social pillar will become increasingly important because it is a vital factor for the life of the human population (Torkayesh et al., 2021). This statement stems from the fact that solving the accumulated social problems is the backbone of economic and development policies of many countries. Isolated data on the living standard of the population are not enough to draw conclusions about the quality of life of people because do not include non-economic factors. In addition, they do not provide useful (qualitative) information on the social status of the population. Therefore, it is extremely important to research and quantify social performance at the level of national economies, or more broadly, at the level of a group of countries within economic integration (for example). This is the practical significance of this research.

#### Materials and methods

In the scientific and professional literature, there is no consensus on the definition of social sustainability (Missimer et al., 2017). In fact, there is a wide range of factors due to different angles of observation and understanding of this concept. Social sustainability is a long-term concept applicable to a wide range of situations, where the criteria of sustainability largely depend on the context with one common feature (Haller et al., 2020). Regardless of the heterogeneity of the concept of social sustainability and social protection, in this paper we have opted for indicators of the widely used international database Eurostat (2022) that are directly related to the performance of social protection. All data are in relative numbers, i.e. percentages and refer to 2020, as the last available year. Italy is the only one excluded from the analysis of the EU countries, since there are no data for a number of indicators for 2020. As there were no data for 2020 for the indicator Housing cost overburden rate and the indicator Self-reported unmet need for medical care in the case of France and Malta, respectively, the values of the same from the last available year were taken. All indicators are linked to two leading socio-economic issues: poverty and unemployment. Indicators of social sustainability primarily include socio-economic attributes because other performance is difficult or impossible to measure. Eleven indicators were selected from the part of the mentioned database entitled Social protection performance monitor - Indicators, which (in the opinion of the author) is sufficient for the assessment and ranking of EU countries (Table 1). Out of a total of 24 indicators in this database, 11 were singled out that best represent the research problem. The authors were guided by the fact that the indicators come from different dimensions of social protection: poverty rate, unemployment, medical care, cost of living and education indicators.

Indicator/Criteria	Definition	Source
People at risk of poverty or	This indicator includes all persons who are: at risk of poverty after social	Eurostat
social exclusion (in %)	transfers, severely material deprived persons, as well as persons living in	(2022)
	households with very low labour intensity.	
At-risk-of-poverty rate (in %)	The at-risk-of-poverty rate refers to the percentage of the population who,	Eurostat
	after social transfers, have equalised disposable income below the at-risk-	(2022)
	of-poverty threshold. This threshold is 60% of the national equalised	
	disposable income. It is an indicator that identifies low incomes compared	
	to others in the national economy.	<b>F</b>
Severe material deprivation	The rate of material deprivation is an indicator that indicates the inability of	Eurostat
rate (in %)	people to afford (pay) certain things that are desirable or necessary for an	(2022)
	adequate or quality life.	
People living in households	This indicator includes people, under the age of 59 years, living in	Eurostat
with very low work intensity	households where adult family members work less than 20% of their work	(2022)
(in %)	potential during the past year.	
Early leavers from education	Early leavers from education and training, age group 18-24 in relation to the	Eurostat
and training, age group 18–24	population of the same age group. These are people who have not received	(2022)
(in %)	appropriate education (ISCED 0, 1, 2 or 3c short) or have not completed the	
	training.	
Housing cost overburden rate	Percentage of the population whose total disposable household income is	Eurostat
(in %)	burdened by total housing costs of more than 40% at the household level.	(2022)
Youth unemployment ratio	It is a measure of youth unemployment (15 to 24 years) in the total	Eurostat
(15–24) (in %)	population of the same age group (which includes the employed, the	(2022)
	unemployed and the inactive young people)	<b>F</b>
Young people neither in	The indicator refers to young people who are unemployed or have not	Eurostat
employment nor in education	received any education or training.	(2022)
and training (in %)		<b>F</b>
At-risk of poverty rate of	This percentage includes unemployed persons (aged 18 year or over) who	Eurostat
unemployment persons (in %)	earn equivalent disposable income below the at-risk-of-poverty threshold.	(2022)
	I his threshold is defined within the description of the second indicator.	E ()
Long-term unemployment rate	It includes the long-term unemployed (12 months or more) aged $15-/4$ as a	Eurostat
(111 %)	percentage of the active population (employed and unemployed) of the same	(2022)
Salf managerta di summarti mana di fam	age.	E
medical care (in 9())	It is calculated in relation to the person's own assessments (over the age of 16) on whather the new person peeded on examination on the two the set of the	Eurostat
medical care (in %)	10) on whether the person needed an examination of treatment in the	(2022)
	previous year, but did not nave of did not ask for it due to financial reasons,	
	walling list or too far to travel.	

Table 1. Description of indicators

After determining the data that will be used in the research, it is necessary to define the applied CRITIC-TOPSIS method. Diakoulaki et al. (1995) were the first to propose the CRITIC (CRiteria Importance Through Intercriteria Correlation) method for determining weighting coefficients in MCDM. This method is based on an objective approach to weighting the values of the criteria (Adalı & Işık, 2017; Mao & Li, 2022). The essence of this method is to use the standard deviation of the normalized values of the criteria and determine the correlation coefficients between all pairs of criteria (Stanković et al., 2021; Žižović et al., 2020). The CRITIC method consists of the following steps (Diakoulaki et al., 1995):

Step 1. Normalization of criterion values within the decision matrix:

a) for revenue indicators: 
$$r_{ij}^+ = \frac{(x_{ij} - x_{ij}^{min})}{(x_{ij}^{max} - x_{ij}^{min})}$$
 (1)  
b) for cost indicators:  $r_{ij}^- = \frac{(x_{ij}^{max} - x_{ij})}{(x_{ij}^{max} - x_{ij}^{min})}$  (2)

wherein  $x_{ij}^{max} = max(i)x_j$  and  $x_{ij}^{min} = min(i)x_j$ , i = 1, 2, ..., m, j = 1, 2, ..., n.

Step 2. Calculation of the standard deviation  $\sigma j$  for each vector  $r_j$  in the normalized decision matrix. Step 3. Determination of a symmetric matrix with elements  $R_{ij}$  representing linear correlation coefficients between each pair of normalized criteria values.

Step 4. Calculating the measure of conflict between indicator j and other indicators:

$$\sum_{i=1}^{n} (1-R_{ij})$$

Step 5. Determining the quantity of the information  $C_j$  as a product of the standard deviation and the size of the conflict:

(3)

$$C_{j} = \sigma_{j} \sum_{j=1}^{n} (1 - R_{ij})$$
(4)

Step 6. Obtaining the weight of the criteria as follows:

$$w_j = \frac{c_j}{\sum_{j=1}^n c_j} \tag{5}$$

The methods of multi-criteria analysis, in the decision-making process, aim to choose the best among different alternatives. Their application has been intensified due to the growing existence of multidimensional problems in modern society. Multi-criteria methods are particularly suitable in the study of sustainability since sustainability is a multidimensional concept (Benítez & Liern, 2021; Dalampira & Nastis, 2020; Neto & Cunha, 2020; Yi et al., 2019). The TOPSIS method is a technique of multi-criteria analysis developed by Hwang and Yoon (1981). It is a widely used method of multi-criteria analysis in scientific research, especially in the field of social sciences. The method is based on the concept of an ideal point, where the best (optimal) alternative is closest to a positive ideal solution and farthest from a negative ideal solution in the geometric sense (Chen et al, 2020; Marjanović & Marković, 2022; Vasilić et al., 2020). To compare alternatives, the TOPSIS method takes into account both the weighting coefficients of the criteria and the standardized values. It is characterized by clarity and easy interpretation. Yoon and Hwang in their work (1995) define the basic steps in calculating the proximity index using the TOPSIS method:

Step 1. The first step is to calculate a normalized decision matrix:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, i = 1, 2, ..., m, j = 1, 2, ..., n$$
(6)

Step 2. After that, in the second step, it is necessary to form a normalized decision matrix with  $v_{ij}$  coefficients:  $v_{ij} = r_{ij} * w_j$ (7)

Step 3. In this phase, a positive ideal solution 
$$v_j^+$$
 and a negative ideal solution  $v_j^-$  are determined:  
 $v_i^+ = max(v_{ij}), i = 1, 2, ..., m$ 
(8)

$$v_j^- = min(v_{ij}), i = 1, 2, ..., m$$
 (9)

Step 4. This stage represents the core of the method because it calculates the distance between the alternative and both solutions reached in the third step:

$$S_i^+ = \sqrt{\sum_{j=1}^n \left(v_{ij} - v_j^+\right)^2}, i = 1, 2, ..., m$$
(10)

$$S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2}, i = 1, 2, ..., m$$
(11)

Step 5. The last step in the calculation is to determine the proximity index:

$$C_i = \frac{S_i}{S_i^+ + S_i^-}, \, i = 1, 2, \dots, m \tag{12}$$

After these steps, the ranking of alternatives depending on the value of the proximity (composite) index remained.

#### **Results and discussion**

At the beginning of the analysis of the results of the applied research, Table 2 is shown. The table provides an overview of the minimum and maximum values of the selected variables, as well as the mean values and standard deviation of the indicators, taking into account the 26 countries included in the analysis. This is the initial step in any empirical research in order to obtain a systematic overview of the variables and values of the same.

Table 2. Descriptive statistics, authors' calculation

	Ν	Minimum	Maximum	Mean	Std.
					Deviation
People at risk of poverty or social exclusion	26	11,9	32,1	20,70	5,12
At-risk-of-poverty rate	26	9,5	23,8	16,18	3,91
Severe material deprivation rate	26	1,7	19,4	5,94	4,64
People living in households with very low work intensity	26	4,3	12,8	7,65	2,56
Early leavers from education and training, age group 18-24	26	2,2	16,0	8,47	3,39
Housing cost overburden rate	26	1,9	32,6	7,91	6,57
Youth unemployment ratio (15-24)	26	2,2	12,5	6,37	2,49
Young people neither in employment nor in education and training	26	5,7	18,7	12,29	3,45
At-risk of poverty rate of unemployment persons	26	35,4	62,9	48,51	7,12
Long-term unemployment rate	26	0,6	10,9	2,1	2,02
Self-reported unmet need for medical care	26	0,1	13,0	2,75	3,47

Table 3 shows the obtained weighting coefficients of the criteria. They were calculated using the CRITIC method. According to these data, the *Self-reported unmet need for medical care* will be of the greatest relative importance (0.1218), while the *Long-term unemployment rate*, with a weight value of 0.0634, will have the least importance in obtaining the value of the composite index.

Criteria/Indicator	Weights
People at risk of poverty or social exclusion	0,0662
At-risk-of-poverty rate	0,0815
Severe material deprivation rate	0,0742
People living in households with very low work intensity	0,1155
Early leavers from education and training, age group 18-24	0,1025
Housing cost overburden rate	0,0722
Youth unemployment ratio (15-24)	0,1079
Young people neither in employment nor in education and training	0,0872
At-risk of poverty rate of unemployment persons	0,1075
Long-term unemployment rate	0,0634
Self-reported unmet need for medical care	0,1218

Table 3. Criteria weights, authors' calculation

As the final result of the application of the TOPSIS method, Table 4 was created. It contains the ranking of countries depending on the value of the obtained composite index. Austria, Luxembourg and Germany, respectively, are the leading countries in terms of social performance at the EU level. It is important to point out that these countries are among the leading EU countries, bearing in mind the amount of social expenditures per inhabitant. At the other end, Latvia, Romania and Spain show the worst values of social protection indicators. The values of these indicators describe the success of EU countries in implementing economic and social policy measures.

Table 4. Composite index of the social protection performance, authors' calculation

Country	Composite index	Rank	Country	Composite index	Rank
Austria	0,5196	1	Ireland	0,2713	14
Luxembourg	0,5170	2	Denmark	0,2544	15
Germany	0,5035	3	Estonia	0,2519	16
Czechia	0,4706	4	Lithuania	0,2515	17
Netherlands	0,4209	5	Finland	0,2489	18
Malta	0,4005	6	Portugal	0,2480	19
Croatia	0,3902	7	Bulgaria	0,2240	20
Poland	0,3827	8	Greece	0,2162	21
Slovenia	0,3532	9	Belgium	0,2158	22
Cyprus	0,3344	10	France	0,2001	23
Slovakia	0,2906	11	Latvia	0,1984	24
Hungary	0,2890	12	Romania	0,1729	25
Sweden	0,2800	13	Spain	0,1631	26

A more detailed analysis of the obtained values of the index indicates that in addition to the mentioned countries, all the countries of the Visegrad Group (Czech Republic, Poland, Slovakia and Hungary) are highly ranked and they are in the first half of the table. There are also two island countries – Malta and Cyprus, as well as the Netherlands, Croatia and Slovenia, which are also showing good conditions for achieving social sustainability. It is obvious that in the first half of the table, the largest number of countries joined the EU in 2004. It is noticeable that the first three countries, along with the Netherlands, have high levels of GDP per capita, unlike the others that are at the top in terms of the value of social performance, but not in terms of economic development. For example, Croatia recorded favorable values of the indicator *Early leavers from education and training* and *Housing cost overburden rate*, which had a decisive impact on its final position in the table. In contrast, Belgium and France are among the countries with high GDP per capita that unexpectedly found themselves at the bottom of the list. Belgium is a country with a high level of *Long-term unemployment*, as well as a percentage of *People living in house-holds with very low work intensity*.

On the other hand, at the bottom of the list are Latvia, Romania and Spain. According to Eurostat, these are the EU countries with the highest at-risk-of-poverty rates. In addition, Spain and Romania have an extremely high percentage of young people who drop out of school and training early (*Early leavers from education and training*). The best ranked countries among the analysed EU countries, Austria, Luxembourg and Germany, have the lowest values of the indicators *Young people neither in employment nor in education and training*, as well as *Self-reported unmet need for medical care*. Adequate performance of social sustainability and social protection provides a high level of life satisfaction that is present in these countries.

#### Conclusion

The aim of the paper was to use the integrated CRITIC-TOPSIS method to rank EU countries in order to establish the position of countries in achieving social sustainability, taking into account social protection indicators. Social

protection is a broad concept, so it is possible to include a large number of indicators in the analysis. However, the authors opted for social protection criteria based on the Eurostat database. The authors took care to present heterogeneous indicators: those that describe the degree of poverty (primarily young and unemployed as the most vulnerable groups), social exclusion, unemployment, education, housing costs, as well as indicator of access to health services.

The research showed that the best conditions for achieving social sustainability have three highly developed EU countries: Austria, Luxembourg and Germany. In addition to them, the countries of the Visegrad Group also have good conditions, having in mind the composite index of social protection. Particular attention needs to be paid to the worst-placed countries – Latvia, Romania and Spain, either through social transfers or other employment, training and social inclusion programs.

The right to work and a decent life are prerequisites for society to be able to achieve a high level of social performance and, ultimately, sustainability. Adequate and timely recognition of social problems is the key to social protection policy. Social protection measures must be aimed at solving the problem of material endangerment, but also social exclusion and reducing the risk of permanent unemployment. Without the coordination of social, economic and employment policies, as envisaged by the Lisbon Strategy, it is not possible to achieve the set goals at the level of the EU (Zeitlin & Vanhercke, 2014). The European Social Fund, which was established with the task of promoting social inclusion through sustainable and quality employment, also has a significant role (Von Jacobi et al, 2017), as well as the European Union Program for Employment and Social Innovation (Oudeniotis & Tsobanoglou, 2020). More specifically, the goal is to provide skills that will contribute to reducing marginalization, unemployment and poverty through training and the acquisition of new qualifications. Addressing these issues must result in increased life satisfaction and, ultimately, social sustainability and socio-economic welfare (Billan et al., 2020).

The study identifies relevant factors of social sustainability and ranks EU countries according to the level of social protection by applying an adequate methodological (multi-criteria) approach. Due to the obvious complexity, there is no single understanding of the social framework of sustainable development. The authors are aware of the fact that there are a large number of indicators that can be linked to social sustainability and that future studies may look at this problem differently, using a different database or set of indicators (criteria) in a multi-criteria or other model.

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# Environmental Refugees, Suggested Solutions of the Problem in the Framework of International Law

# Uchodźcy środowiskowi, propozycje prawno-międzynarodowego rozwiązania problemu

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## Abstract

Some environmental changes (either natural or anthropogenic usually caused by leaving sustainable management of its natural resources) alter natural conditions to such an extent that individuals and entire communities are forced to leave their place of permanent residence and seek another that would provide them with at least the minimum subsistence level of living. Some of those journeys may be temporary and cover small distances; others may involve crossing the border of one's homeland with no hope of ever coming back. Migrants struggle with not only their precarious financial situation, but also a wide range of legal and administrative difficulties, often compounded by social, cultural, religious, and political issues. Even though the number of people fleeing inhospitable environments is increasing every year, the international community and host countries refuse to grant them status to ensure due protection. This, however, does not relieve anybody from the obligation to search for a viable solution.

**Key words:** Keywords: environmental refugees, climate changes, natural disasters, international law, European law

Słowa kluczowe: uchodźcy środowiskowi, zmiany klimatu, kataklizmy naturalne, prawo międzynarodowe, prawo UE

### Introduction

Adverse climatic phenomena, an escalation of natural disasters, and environmental degradation to some extent form part of the unsustainable human imprint on the environment. Climate changes are among the main drivers of migration and this trend is likely to intensify in the coming years. Persisting problems in tackling the issue of environmental migrants account for the unprecedented topicality of the discussion on the subject. The category of environmental migrants, both internal and international, remains vague in the framework of national and international law alike; hence the grave risk of violations of their fundamental rights at present and in the future. The burden of responsibility for assisting and managing the so-called internally displaced people (IDPs) and international migrants falls on their country of origin and the international community. Yet the lack of any agreement on the issue – even in the scope of the necessary terminology – shows how much remains to be done before a consensus is reached and the problem finds a solution.

First of all this paper aims to inform indirectly about the impact of environmental degradation on escalation of migration phenomenon (and conversely, what seems to be more important in the present situation: the impact of ecodevelopment on its mitigation), and then – simply and directly to analyse the difficulties faced by environmental refugees and to assess the legislative viability of the suggested solutions for regulating the status of such refugees in international law and, consequently, for providing them with appropriate protection and assistance.

#### National law vs. environmental migrations

Difficulties in the internationally effective application of human rights law provoke the question of its recognition and implementation at the national and regional levels. The very existence of such problems warrants a system review and interventions that could remedy the faults identified. In line with the principle of subsidiarity, such a review should first target the national structures and only afterwards the regional and international frameworks. In such an approach, the countries will officially become the first line of support for people who suffered injustice, ideally including losses caused by environmental factors (officially, since countries do, and should, fill this role by their nature).

In the scope of environmental migration, American law foresees the provision of temporary assistance to citizens of other countries residing within the borders of the US if they experience the corollaries of natural disasters or if their country of origin is temporarily unable to arrange their return to their former place of residence (Title II. Immigration, Section 244. Temporary protected status<sup>1</sup>).

Temporary assistance to foreigners is offered by other countries as well. In the European Union, legislation directly targeting people displaced for environmental reasons has been introduced in Cyprus, Finland, Sweden, Denmark, and – in a sense – Italy. The refugee law of Cyprus<sup>2</sup> establishes only subsidiary protection for people at the risk of a serious environmental adversity. Additionally, the measure applies only to those who have been previously granted refugee status. Yet, in a way, the legislation is one step ahead of the Geneva Convention, which fails to recognise environmental factors as a cause of persecution or a threat.

In Italy, environmental migrants face the risk of remaining without legal protection as illegal residents. Officially, the question of whether they should be protected under existing legal provisions or necessitate separate regulations still remains unanswered. Some argue that solutions implemented in other cases can be successfully applied to environmental migrants. For instance, if an island country is flooded, its citizens may be declared stateless and protected under the Convention relating to the Status of Stateless Persons (1954) or the Convention on the Reduction of Statelessness (1961). In other cases, the degradation of natural environment may cause a destabilisation (economic, social, political) grave enough to speak of conditions that are an affront to dignity and pose a risk, including the risk of open conflict. The incomers could then be assisted not as environmental migrants but as persons whose lives are at risk on account of generalised violence (in this case, caused by environmental destruction). Nevertheless, this continued debate on semantics achieves nothing except maybe an additional prolongation of the already protracted international discourse. The currently applicable provisions have been established in 1998  $(Art. 20.1)^3$  and foresee the use of temporary protection measures in the event of a need to provide humanitarian aid to the victims of e.g. natural disasters in non-EU countries. Few opportunities have been found for their application. In reality, only in 2008 did the Italian Ministry of the Interior decide to suspend repatriation processes of Bangladeshi citizens remaining illegally within the borders of Italy. The decision was due to the major crisis caused by Cyclone Sidr, however, it did not grant any special form of protection (even temporary) or even an official residence permit.

In the area of environmental migration, Finland and Sweden stand out as both have established relevant legislation. The Swedish Aliens Act (716/2005) offers subsidiary protection to people unable to return to their countries of origin for environmental reasons. Within the meaning thereof, a person *otherwise in need of protection* is an alien who (except for the cases referred to in pt. 1) remains outside the country of his/her nationality because (s)he is *unable to return to the country of origin because of an environmental disaster* (Chapter 4, Section 2.3)<sup>4</sup>. Seemingly, this provision offers the coveted protection to people displaced for environmental reasons, but in reality, it poses two serious legal problems. According to the Swedish Minister of Justice and Migration, it is a preparatory solution, used only in emergencies (i.e. natural disasters). As such, it does not apply to the consequences of the gradual degradation of the environment. Additionally, it seems that nobody has been granted such protection to date, which raises the question of whether Sweden is truly ready to accept anyone out of a large number of people awaiting such aid.

The Finnish Aliens Act (301/2004) allows granting asylum or providing subsidiary protection if a person cannot return to his or her country of origin or country of former habitual residence as a result of an environmental catastrophe or another threat (Chapter 6, Section 88(a).1)<sup>5</sup>. Finnish regulations seem free of the restrictions imposed in Swedish law. According to the Finnish Immigration Service, the solutions adopted refer specifically to cases where the environment presents too much of a risk to life or health because of the economic activity conducted or an existing natural disaster. Even if the provision is applied rather sporadically, it does show the legislative opportunities (goodwill) of the country in establishing migration policies in a manner ensuring legal protection of environmental refugees.

<sup>&</sup>lt;sup>1</sup> Immigration and Nationality Act, (8 U.S.C. 1254 a).

<sup>&</sup>lt;sup>2</sup> Refugee Law of 2000, No. 6(I) of 2000.

<sup>&</sup>lt;sup>3</sup> Decreto Legislativo No. 286 of 25 July 1998, Testo unico delle disposizioni concernenti la disciplina dell'immigrazione e norme sulla condizione dello straniero.

<sup>&</sup>lt;sup>4</sup> Aliens Act (716/2005).

<sup>&</sup>lt;sup>5</sup> Aliens Act (301/2004, amendments up to 1152/2010 included).

Notably, the Finnish Aliens Act of 2004, Section 109: Temporary Protection also foresees– in the case of a mass displacement of people resulting from a natural disaster – temporary protection which may last for up to three years. During this time, the protection may be replaced by a residence permit if the original place of habitual residence of the displaced people is still unavailable due to the natural causes referred to above (Section 88)<sup>6</sup>. The Swedish Aliens Act of 2005 in Chapter 4: Refugees and persons otherwise in need of protection, Section 2, establishes a similar solution for foreigners displaced for environment-related reasons, including those who cannot return to their country of origin due to the drastic changes and/or destruction (in the place of their habitual residence) caused by an environmental catastrophe. In this situation, they are entitled to a residence permit (Chapter 5)<sup>7</sup>. Section 25 of the same Chapter introduces a *safety measure* by establishing that the government may suspend issuing documentation that allows for legal residence (to people otherwise in need of protection under Chapter 4, Section 2.2 or 2.3) if it deems it necessary due to the limitations in the country's capacity for accepting foreigners. In turn, Denmark accepts refugees – mainly the victims of famines (and their families) – out of humanitarian concerns. The decisions are discretionary in nature and made on a case-by-case basis.

#### **Regional approach to environmental migration**

In light of the diversity of approaches to the status and the management of environmental refugees in the framework of national law, it is interesting to review solutions implemented at the regional level. The Treaty on the Functioning of the European Union foresees a possibility of developing common policies in the area of immigration and granting asylum (TFEU, Art. 77-80). Generally, the rules for legal migration remain at the discretion and competence of national authorities<sup>8</sup>. However, even if environmental migrations are not governed by any specific document of the European law, certain protections *complementary* to national measures do exist and ensure at least temporary support.

Although the EU is not a party to the Geneva Convention, Article 78 of the TFEU confirms that any common asylum policy must abide by the provisions of both the Convention and the Protocol of 1967. It appears that the foundations of the *European asylum law* are being formed under several directives, e.g. Directive 2003/9/EC laying down minimum standards for the reception of asylum in member states; Directive 2005/85/EC on minimum standards on procedures in Member States for granting and withdrawing refugee status, and Directive2004/83/EC on minimum standards for the qualification and the status of third-country nationals or stateless persons as refugees or as persons who otherwise need international protection and the content of the protection granted. Another document considered is Council Directive 2001/55/EC on minimum standards for giving temporary protection in the event of a mass influx of displaced persons and on measures promoting a balance of efforts between Member States in receiving such persons and bearing the consequences thereof.

Although the groundwork was laid in earlier years, the new phase of awarding protection that exceeds the defined minimum began only in 2013. It was preceded by the adoption of the so-called Qualification Directive (2011/95/EU), followed by Directive 2013/33/EU on the standards for the reception of applicants for international protection, and Directive 2013/32/EU on common procedures for granting and withdrawing international protection.

Whereas the first directives were adopted with the intention of establishing and harmonising the existing standards enshrined in the law of the member states, the ones that followed were supposed to provide an efficiency boost and reflect the decisions of the European Court of Human Rights and the Court of Justice of the European Union. Despite all the corrections and updates, the changes are hardly revolutionary. They mainly involve terminology, namely the replacement of *minimum norms* with *norms*. Besides, Directive 2004/83/EC, Art. 2c (as well as Directive 2011/95/EU, Art. 2d) interestingly uses the definition of *refugee* from the Geneva Convention, which fails to consider environmental factors as a criterion in reviewing applications for refugee status. Apart from this provision, there is also another (largely the original version of the one finally included in Directive 2011/95/EU (Art. 6), which seems to offer more extensive protection; Art. 6 sets forth that actors of persecution or serious harm include, apart from states and parties, organisations controlling the State or a substantial part of its territory, or even other entities are unable or unwilling to provide protection against persecution or serious harm (Art. 6). On one hand, this provision could provide an important guarantee for asylum applicants. On the other, difficulties in proving relevant circumstanced with material evidence may almost neutralise potential profits, also for environmental refugees.

Notable changes include Art. 8, which grants the opportunity to exclude a person from protection *if in a part of the country of origin there is no well-founded fear of being persecuted or no real risk of suffering serious harm and the applicant can reasonably be expected to stay in that part of the country (Art. 8.1). The corresponding Art. 8 of Directive 2011/95/EU foresees that such exclusion is possible only if the applicant <i>can safely and legally travel to and gain admittance to that part of the country and can reasonably be expected to settle there* (Art. 8.1b). Thus, Art. 8.3 of the 2004 Directive, declaring that part. 1 may apply *notwithstanding technical obstacles to return* 

<sup>&</sup>lt;sup>6</sup> Aliens Act (301/2004, amendments up to 1152/2010 included).

<sup>&</sup>lt;sup>7</sup> Aliens Act (716/2005).

<sup>&</sup>lt;sup>8</sup> Exceptions related to uniting families, long-term residence, or the re-admittance of the citizens of third countries.

to the country of origin, was amended. Meanwhile, under par. 2 of the 2011 Directive, at the time of taking the decision on the application, the states may have regard to the general circumstances prevailing *in that part of the country and to the personal circumstances of the applicant in accordance with Article 4*. For this purpose, member states are supposed to provide accurate and up-to-date information from appropriate sources (Sitek, 2019), such as the United Nations High Commissioner for Refugees and the European Asylum Support Office.

Regarding matters that have not undergone major changes, first and foremost, there is the definition of *serious harm* from Art. 15. The article in question – important in itself due to the scope of protection offered in a situation of risk (broader than the one foreseen in the Geneva Convention) – is utterly useless in reference to environmental migrations. Even if the cases considered in Article 15c could theoretically offer some room for interpretations covering conflicts for resources or conflicts indirectly related to natural resources, the most obvious proposal for change would be the modification of Art. 15 by adding environmental catastrophes to the list of cases (Kraler, Cernei, Noack, 2011).

Such a proposal was included in the original draft of Article 15c. Offering protection to people displaced as a result of systematic or generalised violations of their human rights, it was much broader in scope than the finally accepted wording. In the original form, the provision could also apply to people displaced for environmental causes, even if in strictly defined circumstances (Kolmannskog, Myrstad, 2009). That could have been its actual purpose. However, a proposal to modify Art. 15c of the Qualification Directive was not accepted; the opponents argued that sufficient protection provisions were included in the European Convention on Human Rights<sup>9</sup>.

In turn, Directive 2001/55/EC on minimum standards for giving temporary protection sets forth minimum requirements for obtaining temporary protection in the event of a mass influx of displaced persons from third countries who are unable to return to their country of origin due to the ongoing conflict and/or acts of violence. Yet, it does not explicitly refer to environmental catastrophes or climate changes as grounds for application. Thus, although the broader interpretation of the Directive would allow protection for environmental refugees, its provisions highlight the document's irrelevance to internal migrations induced by environmental factors. In contrast to Directive 2004/83/EC, the protection offered under Directive 2001/55/EC is not limited to a specific list of cases; it may be granted to people who *have fled areas of armed conflict or endemic violence* or who *have been the victims of, systematic or generalised violations of their human rights* (Art. 2c). There are also other restrictions – the directive applies only in the event of a mass influx of migrants and in extraordinary circumstances. It is also limited in that it fails to provide a clear outline of the protection mechanism and leaves the states relatively free to choose political and financial instruments for implementing practical protection measures based on the – challenged and hardly practical – *solidarity mechanism intended to contribute to the attainment of a balance of effort between Member States* (The Preamble, pt. 20).

Media reports of recent years and months reveal the failure of the application of this directive. Migration waves at EU borders, coming by land and by sea, clearly expose political difficulties related to the implementation of temporary protection mechanisms, particularly those relating to dislocation between states. It turns out that the Council, supposed to order the initiation of a temporary protection mechanism (at the proposal of the Commission), encountered serious impediments of a political nature. Despite the large number of people who arrived after the conflict in Libya and the Tunisian revolution, their influx was not classed as a mass displacement (Kraler, Cernei, Noack, 2011). A similar situation occurred during the so-called Syrian crisis. The Council did not make its decision because, until March 2017, no relevant proposal had been filed by the Commission. The Commission was unable to file the proposal because no member state had come forward with the initiative. Certainly, the *idleness* of the states did not stem from concerns regarding their logistical and infrastructural capacity. Thus, it was motivated by political considerations. Since migration issues constitute the so-called shared or transversal competences, where national governments enjoy extensive autonomy, the powers of the Commission are highly limited. As a result, the reaction of the EU hinges on the political and economic game played by member states with their neighbouring countries, which are constantly plagued by internal difficulties. Thus, despite the mounting crisis, no temporary protection was granted to the incomers; possibly also for fear of interpretations of this measure as an encouragement to further migrations to the European Union (Skorzycki, 2017; Prokurat, 2019; Danilović, Stefanović, 2020). The current system is based on the Dublin Convention<sup>10</sup> signed by member states of the European Community in 1990. It is shaped by the Regulation of the European Parliament and of the Council of 2013 (the so-called Dublin III)<sup>11</sup> which establishes the criteria and mechanisms for determining which EU Member State is responsible for

<sup>&</sup>lt;sup>9</sup> Proposal for a Directive of the European Parliament and of the Council on minimum standards for the qualification and status of third-country nationals or stateless persons as beneficiaries of international protection and the content of the protection granted, Brussels, 21.10.2009, COM(2009) 551 final.

<sup>&</sup>lt;sup>10</sup> Convention determining which EU Member State is responsible for the examination of an application for asylum submitted in one of the Member States of the European Communities.

<sup>&</sup>lt;sup>11</sup> Regulation (EU) No 604/2013 of the European Parliament and of the Council of 26 June 2013 establishing the criteria and mechanisms for determining the Member State responsible for examining an application for international protection lodged in one of the Member States by a third-country national or a stateless person.

the examination of an application for asylum in the territory of the  $EU^{12}$ . In the currently applicable version, it ascribes the burden of responsibility for reviewing the refugee status application to the EU member state which was the first point of entry of the applicant (Art. 3.1)<sup>13</sup>. Since this policy is largely contested by the countries of the Visegrád Group, among others, several other proposals were conceived. They aim to circumvent the automatism of the relocation together with its related burden and are still the subject of debate and new arrangements. Therefore, it is possible that the *old* migration problems waiting for new solutions will become a starting point for a discussion on the more and more conspicuous environmental migrations and the plethora of the accompanying problems (individual, social, political, legal, economic, and ecological).

Some progress has also been observed in the position of the Council of Europe, as exemplified by Resolution 1655(2009), Environmentally induced migration and displacement: a  $21^{st}$ -century challenge, which recognises the growing importance of the destructive impact of natural factors and the escalating degradation of the environment on the increase in migration (pt. 2). The Resolution declares that the problem carries importance on a global scale (pt. 8) and as such should be of interest to the entire international community, rather than only those directly affected by the disaster and facing the greatest risk. Member states are encouraged to take action aimed at mitigating the environmental vulnerability of developing countries and to review their legal solutions in this regard. This policy was supposed to foster the development of synchronised asylum policies (pt. 26) at the international level by addressing the problem in *climate treaties*, and at the regional level, by inscribing it in the framework of the EU migration strategies<sup>14</sup>. Therefore, since the year 2005 – which marks the establishment of the migration policy framework that implemented the so-called *global approach to migration* outlined in the Communication from the Commission of  $2011^{15}$  – EU documents link the problem of growth to environmental changes<sup>16</sup>.

When discussing the regional situation, it is interesting to note legislative attempts to introduce protection measures that would apply only to the internally displaced persons. These attempts mainly include the Protocol on the Protection and Assistance to Internally Displaced Persons in the countries of the Great Lakes Region<sup>17</sup> and the African Union Convention for the Protection and Assistance of Internally Displaced Persons in Africa<sup>18</sup>. The Protocol encourages initiatives to limit the consequences of unavoidable displacements caused by natural disasters. It proposes to initiate intergovernmental coordination aimed at establishing a common legal framework within the Great Lakes Region, which would require member states to create, adopt, and implement guiding principles in the scope of internal displacement, to provide legal protection, to ensure physical safety, and to meet the basic material needs of the IDPs in accordance with the guidelines. Finally, the aim of the Protocol is to oblige the said states to prevent such displacements and eliminate their original causes (Art. 2)<sup>19</sup>.

In the global perspective, there are various hypothetical proposals for incorporating the issue of environmental refugees in the legal framework. They generally involve extending the scope of the Geneva Convention of 1951; extending the Guiding Principles on Internal Displacement; adopting an additional protocol to the existing UN conventions on climate change and refugee protection; adopting a separate and autonomous protocol; implementing temporary protection mechanisms. Although these proposals are accompanied by ideas for relocation plans and cooperation aimed at reducing the vulnerability of those most at risk, the *ad hoc* introduction of a legal framework for displacements caused by environmental changes seems impossible in the nearest future.

#### Suggested solutions to the problem of environmental refugee protection

The overlap between the protection of political and environmental refugees may impair the quality of protection for both types of recipients, mainly due to the lack of understanding of the mutual dependencies between the environment, climate change and migrations (Biermann, Boas, 2010). The concern that with a broader and less precise wording, the definition of political refugees may become fuzzy, are warranted. However, patent idleness (not to say: reluctance) that permeates the discussion on environmental refugees is harder to justify. Never-ending academic debates on the semantics should not divert our attention from the real needs of the moment. The forms

<sup>&</sup>lt;sup>12</sup> It came into full force and effect on 1 January 2014, replacing the earlier Regulation Dublin II, which on 1 September 2003 replaced the Convention of 1990. Council Regulation (EC) No 343/2003 of 18 February 2003 establishing the criteria and mechanisms for determining the Member State responsible for examining an asylum application lodged in one of the Member States by a third-country national (The Official Journal of the European Union, L 050, 25 February 2003).

<sup>&</sup>lt;sup>13</sup> Regulation (EU) No 604/2013.

<sup>&</sup>lt;sup>14</sup> Resolution 1655 (2009) Environmentally induced migration and displacement: a 21st-century challenge.

<sup>&</sup>lt;sup>15</sup> Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

<sup>&</sup>lt;sup>16</sup> In the Stockholm Programme, the climate change is declared a global challenge that has a growing impact on migration and displacements. Therefore, tackling the problem of environmental migration, also by adapting to the harmful effects of climate change, should be a part of the global approach.

<sup>&</sup>lt;sup>17</sup> International Conference on the Great Lakes Region, Protocol on the Protection and Assistance to Internally Displaced Persons.

<sup>&</sup>lt;sup>18</sup> African Union Convention for the Protection and Assistance of Internally Displaced Persons in Africa (Kampala Convention) (2009).

<sup>&</sup>lt;sup>19</sup> Protocol on the Protection and Assistance to Internally Displaced Persons.

of displacement caused by drastic environmental changes should be observed and analysed to establish coherent principles of conduct in such situations.

Extending the scope of the Geneva Convention and its accompanying Protocol would be a task of immense complexity and little practical viability. That is because similar international agreements usually come into being at the initiative of multiple countries forced to tackle a serious and common problem. Without a truly major cause and/or a proposal coming from true authorities in political circles, agreements of this calibre encounter a series of insurmountable difficulties regarding even trivial issues. Additionally, it must be considered that the topic of environmental refugees is not eagerly discussed and that grassroots proposals fail to attract sufficient attention of the decision-makers. Thus, while it is possible to put forward an idea for a new additional protocol to the existing convention or even to draft an *ad hoc* convention, the very idea of a similar initiative would probably face resistance since even the indication of the criteria for defining environmental migrants (let alone determining the scope of protection) defies the interests of the states<sup>20</sup>. Thus, it is the lack of political will that constitutes the main impediment in considering proposals for a new convention that would cover millions of environmental victims; such a legislative initiative would require negotiations (inconceivable in terms of a successful conclusion) regarding the division of the related burden.

However, the Geneva Convention may be of use in the case of trans border migrations. If a person or a community (fleeing the inhospitable environment of their own country) was refused help for racial, religious, political, or ethnic reasons, the Geneva Convention could be invoked due to the international character of the migration and its causes rooted in persecution. The same could happen if the migrants crossed the border because of a conflict for natural resources of which they did not receive their due share – and thus suffered discrimination.

One of the major arguments for extending the scope of the Geneva Convention is the fact that such a solution would provide the parties with a ready-to-use solution streamlining the implementation of new regulations on environmental refugees. Contrarily, what deters from (even) an attempt at extending the Convention's definition of a refugee beyond its political dimension is the certainty that most states will not agree to extend the rights granted to a category that covers a far larger number of individuals. In addition, using a single definition in two different contexts could raise doubts regarding its effectiveness and functionality, as well as provoke a conflict between environmental and political refugees who require a fundamentally different scope of assistance.

Legislation on environmental refugees could also be introduced under a relevant protocol incorporated in the United Nations Framework Convention on Climate Change. The protocol would allow to grant refugee status and offer protection to persons who have no reason to return to their countries and/or nothing to return to, as well as to assist those who still opt for going back. The aid would be provided on the basis of several criteria. The first one would relate to displacements and repatriations. Since modern science can predict the long-term effects of climate change, there is no need to resort in every case to extraordinary forces and emergency measures. Without reducing the overall level of preparedness, responding to long-term effects of climate change should involve rather the implementation of previously prepared plans of voluntary displacement and –circumstances permitting – the resettlement of the previously deserted areas.

The second criterion refers to the *offer* that could accompany the activities discussed above, i.e. a proposal for replacing the right to temporary asylum, granted to an environmental refugee by a host country, with the opportunity to obtain a permanent residence permit. This policy would apply in the cases of permanent degradation of the environment or irreparable damage, i.e. circumstances which render return pointless or impossible<sup>21</sup>.

The third principle would invoke the shared rights of a community forced to escape, which stand in contrast to the individual rights *preferred* by the Geneva Convention (which was created to protect people in the complex realities of the post-war period and refers to collectives only fragmentarily, when considering ethnic or religious groups) (Art, 7)<sup>22</sup>.

The fourth principle would be the (hard to define) presence of international factors in the application of national measures to the incomers by the government (but also local authorities or institutions managing protection and dislocation).

The fifth principle would relate to the international division of burden; a highly complex endeavour as the causes and effects of climate changes are global in nature. The project would require a definition of the scope of individualised responsibility in line with the level of past and current exploitation of global natural resources (Biermann, Boas, 2010). A protocol introducing these principles should be incorporated in the legal framework upon submission to the United Nations Framework Convention on Climate Change. This would allow the use of the existing political support of countries party to the Convention without the need to renegotiate all the points.

 $<sup>^{20}</sup>$  The difficulties indirectly related to this issue are exemplified by the US exit process from the Paris climate agreement (4 November 2019).

<sup>&</sup>lt;sup>21</sup> Temporary asylum is a measure established for political refugees which could return when their presence in their own country no longer posed a risk.

<sup>&</sup>lt;sup>22</sup> The Refugee Convention, 1951.

The suggestions discussed are a clear indication that the Conference of the Parties to the Convention on climate change offers the most appropriate forum for a substantive and political discussion on environmental migration due to the very high number of participating countries and organisations. However, in light of the unfaltering (or maybe even intensifying) resistance in international circles to engage in such a discussion, some countries may attempt to solve the problem through internal regulations, using their own autonomous legislative competence and individually adjusting their capacity to satisfy external needs. This step could become a foundation for further activities on a regional and global scale. Possibly, such *grassroots* solutions – unforced by external authorities – would prove easier to accept. However, this scenario raises doubts as some countries may not be interested in the introduction of any restrictions that could possibly impair their own economy, or in the use of their resources to mitigate the effects of climate change. They may not comply with the agreements of *the majority* in an attempt to make up for a development gap or to improve its position in the competitive global market.

The chances for broader cooperation in the forum of the Convention would be better if a discussion on *refugees* was abandoned and replaced by one on *migrants*, a far less precise term unburdened with any material legal connotations. However, in any case, both the implementation and then the application of any measures would probably present enormous difficulty. This is because the fundamental aim and the subject of the Convention both relate to the effects of climate change and the options for limiting the anthropogenic impact, rather than to the accompanying phenomenon of migration. Consequently, exerting international pressure to ensure the protection of (at least) climate migrants may provoke a more or less concealed opposition, precisely due to the exclusion of migrants for other environment-related reasons.

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# A Brief Analysis of SDG 3 – Good Health and Well-being – and its Synergies and Trade-offs with the other Sustainable Development Goals

# Analiza 3 Celu zrównoważonego rozwoju (SDG 3): Dobre zdrowie i jakość życia oraz jego komplementarności z pozostałymi SDG

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# Abstract

Sustainable Development Goals (SDGs), proposed by the United Nations in 2015, give countries around the world much to work on until 2030. The third SDG – Good health and well-being – surely cannot be pursued in isolation. Far from being a silo, it has strong synergies with other SDGs, notably Gender Equality (SDG 5), No Poverty (SDG 1), Reduced Inequalities (SDG 10) & Clean water and sanitation (SDG 6). Quite counter-intuitively, it has trade-offs with SDG 12 (Responsible Consumption and Production). This is a commentary on these synergies and trade-offs, which looks at Good Health and Well-being as an overarching goal on any government's agenda, impacting and being impacted, to different degrees, by the other goals.

Key words: SDGs, Good health and well-being, synergies, trade-offs Slowa kluczowe: Cele zrównoważonego rozwoju, Dobre zdrowie i jakość życia, synergie, kompromisy

### Introduction

Sustainability refers to a/the desirable state. Sustainable development is a process, which is the means towards this desirable state. Here, it is necessary that the means – the process of development and all that it entails – are sustainable, in order to justify the end. As stated by Kallio, et al (2007), the phenomenon we label as sustainable development can never be exhaustively defined; it would constantly change with time, interpreters, and their needs. We thus have an elusive, impermanent end-goal, which is pursued with a changeable set of ways and means. According to Quental, et al (2011), the introduction of sustainable development as a concept was an intellectual answer to reconcile the conflicting goals of environmental protection and economic growth.

Mundane decisions on familial and individual levels, tend to influence decision-makers at county, provincial and national levels, and vice versa. This is what one may term as a bottom-up approach to change and development. In a way, this throws the balls, so to say, into the courts of individuals and families, as far as the larger cause (sustainability) and the necessary means (sustainable development) are concerned. Not avoiding individual (or citizen) responsibilities will thus make it easier for communities and countries to adopt the desired *means* towards the desired *end* (Venkatesh, 2019) Sustainable development therefore, necessitates the understanding that the *state of the family* is intricately linked to the *fate of the planet*. As far as the geospatial aspect is concerned, we are all connected, through the atmosphere, hydrosphere, lithosphere, asthenosphere, and pedosphere, and the anthropospheric constructs of trade and travel. One person's action at a particular place and time, may impact another person, adversely or favourably at another place and time – recall the *butterfly effect* of the chaos theory introduced by Edward Lorenz. What is important for happiness, to what extent, and to whom, at any given instant of time, is extremely difficult to determine. As reported in an issue of The Economist in 2019, Daniel Sgroi of the University of Warwick and Eugenio Proto of the University of Glasgow have shown that increasing national income is important to happiness, but not as important as ensuring that the population is healthy and avoiding conflict.

### The Sustainable Development Goals - 2015 to 2030

The publication, in 2015, by the United Nations, of a comprehensive and extensive roadmap of targets and indicators underpinning the SDGs, was a milestone for aligning not only developing countries but also developed ones, with the right path of sustainable development, leading to sustainability. However, even before the SDGs were launched in 2015, planning and performance monitoring have been guided by several sets of indicators– starting from the UN Habitats Urban Indicator Programme (1993) to the Commission for Sustainable Development's Sustainable Development Indicators (1995), EU's sustainability indicators (1998) to European Common Indicators (2000) to the Millennium Development Goals (MDG) to OECD's Better Life Index (2011) to ISO 37 120 indicators (Sustainable development of communities, 2014). The SDG framework, in effect, is a more comprehensive and elaborate sequel to the MDGs which had a 15-year timeframe of 2000 to 2015.

Category	SDG	Name	Targets	Indicators
Social	2	Zero hunger	8	14
	3	Good health and well-being	13	24
	4	Quality education	10	11
	5	Gender equality	9	14
	10	Reduce inequalities	10	11
Economic	9	Industry, innovation and infrastructure	8	12
Environmental	13	Climate action	5	7
	14	Life below water	10	10
	15	Life below land	12	14
Socio-economic	1	No poverty	7	12
	8	Decent work and economic growth	12	17
Economic-environmental	7	Affordable and clean energy	5	6
Socio-environmental	6	Clean water and sanitation	8	11
Encompassing all three dimensions	11	Sustainable cities and communities	10	15
	12	Responsible production and consumption	11	13
Governance/Political will	16	Peace, justice and strong institutions	12	23
	17	Partnerships for the goals	19	25

Table 1. The SDGs categorised based on the three pillars of sustainability (categorisation done by the author)

Table 1 provides a glimpse of the 17 SDGs, along with information about the number of targets and indicators within each of them. The measures for the indicators may be quantitative, qualitative or semi-quantitative. SDG 3 (Good health and well-being), in the social category, with 13 targets and 24 indicators, will be the leitmotif of this commentary. These targets and indicators are tabulated in Table 2.

Tuble 2. The ungets and maleutors of 50 0 5, as defined by the Onited Futions (Onited Futions, 2010)
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Targets		Indicato	rs
3.1	By 2030, reduce the global maternal mortality	3.1.1	Maternal mortality ratio
	ratio to less than 70 per 100,000 births	3.1.2	Proportion of births attended by skilled health personnel
3.2	By 2030, end preventable deaths of new-borns	3.2.1	Under-five mortality rate
	and children under 5 years of age, with all coun-	3.2.2	Neonatal mortality rate
	tries aiming to reduce neonatal mortality to at		
	least as low as 12 per 1000 live births and under-		
	5 mortality to at least as low as 25 per 1000 live		
	births		
3.3	By 2030, end the epidemics of AIDS, tubercu-	3.3.1	Number of new HIV infections per 1000 uninfected pop-
	losis, malaria and neglected tropical diseases		ulation by sex, age and key populations
	and combat hepatitis, water-borne diseases and	3.3.2	Tuberculosis incidence per 1000 population
	other communicable diseases	3.3.3	Malaria incidence per 1000 population
		3.3.4	Hepatitis B incidence per 100,000 population
		3.3.5	Number of people requiring interventions against ne-
			glected tropical diseases
3.4	By 2030, reduce by one third premature mortal-	3.4.1	Mortality rate attributed to cardiovascular disease, can-
	ity from non-communicable diseases through		cer, diabetes or chronic respiratory disease
	prevention and treatment and promote mental	3.4.2	Suicide mortality rate
-	health and well-being		
3.5	Strengthen the prevention and treatment of sub-	3.5.1	Coverage of treatment interventions (pharmacological,
	stance abuse, including narcotic drug abuse and		psychosocial and rehabilitation and aftercare services)
	the harmful use of alcohol		for substance use disorders
		3.5.2	Harmful use of alcohol defined according to the national
			context as alcohol per capita consumption (aged 15 years
			and older) within a calendar year in litres of pure alcohol

Targets		Indicato	rs
3.6	By 2020, halve the number of global deaths and	3.6.1	Death rate due to road traffic injuries
	injuries from road traffic accidents		J
3.7	By 2030, ensure universal access to sexual and	3.7.1	Proportion of women of reproductive age (aged 15-49
	reproductive health-care services, including for		years) who have their need for family planning satisfied
	family planning, information and education, and		with modern methods
	the integration of reproductive health into na-	3.7.2	Adolescent birth rate (aged 10-14 years; aged 15-19
	tional strategies and programmes		years) per 1,000 women in that age group
3.8	Achieve universal health coverage, including fi-	3.8.1	Coverage of essential health services (defined as the av-
	nancial risk protection, access to quality essen-		erage coverage of essential services based on tracer in-
	tial health-care services and access to safe, ef-		terventions that include reproductive, maternal, new-
	fective, quality and affordable essential medi-		born and child health, infectious diseases, non-com-
	cines and vaccines for all		municable diseases and service capacity and access,
			among the general and the most disadvantaged popula-
			tion)
		3.8.2	Number of people covered by health insurance or a pub-
			lic health system per 1,000 population
3.9	By 2030, substantially reduce the number of	3.9.1	Mortality rate attributed to household and ambient air
	deaths and illnesses from hazardous chemicals		pollution
	and air, water and soil pollution and contamina-	3.9.2	Mortality rate attributed to unsafe water, unsafe sanita-
	tion		tion and lack of hygiene (exposure to unsafe Water, San-
			itation and Hygiene for All (WASH) services
		3.9.3	Mortality rate attributed to unintentional poisoning
3.a	Strengthen the implementation of the World	3.a.1	Age-standardized prevalence of current tobacco use
	Health Organization Framework Convention on		among persons aged 15 years and older
	Tobacco Control in all countries, as appropriate		
3.b	Support the research and development of vac-	3.b.1	Proportion of the population with access to affordable
	cines and medicines for the communicable and		medicines and vaccines on a sustainable basis
	non-communicable diseases that primarily af-	3.b.2	Total net official development assistance to medical re-
	fect developing countries, provide access to af-		search and basic health sectors
	fordable essential medicines and vaccines, in		
	accordance with the Dona Declaration on the		
	I RIPS Agreement and Public Health, which al-		
	the full the provisions in the Agreement on		
	Trade Paleted Aspects of Intellectual Property		
	Rights regarding flexibilities to protect public		
	health and in particular provide access to med-		
	icines for all		
3.0	Substantially increase health financing and the	3.c.1	Health worker density and distribution
0.0	recruitment, development, training and reten-	5.0.1	ficulti wonter density and distribution
	tion of the health workforce in developing coun-		
	tries, especially in least developed countries and		
	small island developing States		
3.d	Strengthen the capacity of all countries, in par-	3.d.1	International Health Regulations (IHR) capacity and
	ticular developing countries, for early warning,		health emergency preparedness
	risk reduction and management of national and		
	global health risks		

It goes without saying, as pointed out by many researchers, that the SDGs cannot be pursued in isolation. There are no silos or islands of sustainability. Climate change and biodiversity are the core planetary boundaries through which the others operate. As Wright et al (2016) have observed, climate change or the inability to meet SDG 13 in other words, will adversely affect (constrain, counteract or cancel) (Allen et al, 2018) the ability of least-developed countries to achieve the SDGs in poverty (1), hunger (2), health (3), water (6), growth (8), infrastructure (9), cities (11), marine resources (14) and ecosystems (15); while also making the achievement of the other SDGs challenging. They observe, quite interestingly, that *climate change will make combating climate change more difficult* (in other words, while prevention would be difficult, cure would be impossible, and adaptation would be the only way out). While some compromises are unavoidable, some synergies can be harnessed too. Table 3 lists the different types of influences one SDG target can have on another target (which may be within the same SDG or a different one) – Nilsson et al (2016). *Synergistic* would include the indivisible, reinforcing and enabling influences (ordered in decreasing degree of synergism) and *trade-offs* would include constraining, counteracting and cancelling influences – ordered in increasing degree of conflict.

Using SDG indicator data (time series) for 227 countries, Pradhan et al (2017) showed that among the top ten *trade-off* SDG pairs, SDG 12 (Responsible Consumption and Production) figures seven times, conflicting with SDGs 10 (ranked I), 1 (II), 6 (III), 3 (IV), 4 (V), 5 (VII) and 2 (IX). Likewise, the paper also shows that SDG 1

(No poverty) figures five times in the top-ten synergistic SDG-pairs, positively influencing 4 (ranked II), 5 (III), 10 (IV), 6 (V) and 3 (VIII).

Tuble 5. 5DO turgets	hatare of intermikages
Nature of influence of an SDG target on another	Explanation
Indivisible	Inextricably linked to the achievement of another target
Reinforcing	Aids the achievement of another target
Enabling	Creates conditions that further the achievement of another
	target
Consistent	No significant positive or negative changes (neutral)
Constraining	Limits options on another target
Counteracting	Clashes with another target
Cancelling	Makes it impossible to reach another target

Table 3. SDG targets – nature of interlinkages

If we restrict our focus to SDG 3 and its occurrence among the top ten synergy-pairs and trade-off-pairs, 3-10, 1-3, 3-5 and 3-6 are 7<sup>th</sup>, 8<sup>th</sup>, 9<sup>th</sup> and 10<sup>th</sup> in the list of synergies; and 3-12 is 4<sup>th</sup> in the list of trade-offs. Needless to say, SDG 3 does have synergies with SDGs other than 10, 1, 5 and 6; and conflicts with those other than 12, but they are evidently not as marked as the ones observed based on recorded historical data for the 227 countries (and regions). In the SDG India Index report (NITI Aayog, Government of India, 2018), the authors note that SDG 3 has links to SDGs 1, 2, 5, 6, 7, 8, 11 and 13. SDGs 10 and 12, links to which have been uncovered by Pradhan et al (2017) while working with global data, do not figure in the SDG Index India report.

In this commentary, an attempt has been made to discuss qualitatively the links (synergies or trade-offs) that exist between SDG 3 on the one hand, and each of SDGs 10, 1, 5, 6 and 12 on the other.

### Synergies with SDGs 10, 1, 5 and 6

All targets of SDG 10 aim to reduce inequalities that have crept into human society. While the need for gender equality has been emphasized in SDG 5, SDG 10 additionally focuses on age, sex, disability, race, ethnicity, religion, economic status, and country of origin. (Target 10.2 in Table 4). This is the cornerstone of the *Leave No One Behind policy* which the UN has recommended.

Target	Content
10.1	By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate
	higher than the national average
10.2	By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex,
	disability, race, ethnicity, origin, religion or economic or other status
10.3	Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws,
	policies and practices and promoting appropriate legislation, policies and action in this regard
10.4	Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equal-
	ity
10.5	Improve the regulation and monitoring of global financial markets and institutions and strengthen the imple-
	mentation of such regulations
10.6	Ensure enhanced representation and voice for developing countries in decision-making in global international
	economic and financial institutions in order to deliver more effective, credible, accountable and legitimate in-
	stitutions
10.7	Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the imple-
	mentation of planned and well-managed migration policies
10.a	Implement the principle of special and differential treatment for developing countries, in particular least devel-
	oped countries, in accordance with World Trade Organization agreements
10.b	Encourage official development assistance and financial flows, including foreign direct investment, to States
	where the need is greatest, in particular least developed countries, African countries, small island developing
	States and landlocked developing countries, in accordance with their national plans and programmes
10.c	By 2030, reduce to less than 3 per cent the transaction costs of migrant remittances and eliminate remittance
	corridors with costs higher than 5 per cent

Table 4. Targets of SDG 10, as defined by the	United Nations (	United Nations,	2016)
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Target 10.1 can be expressed in terms of the so-called Palma ratio which is the ratio of the expenditures of the 10% of richest households in a region (country, state or city) to that of the last four deciles of households (bottom 40% in other words). If this ratio decreases over time, it implies that the poorer sections of society have greater purchasing power, contribute more to economic growth and are able to provide themselves with the requisite resources (at least all the necessities, if not comforts) needed for good health and well-being.

Target 10.3 addresses equal opportunities and these include opportunities not just to find employment and have a secure income, but also have access to optimum healthcare benefits. Easy access to hospital facilities, pharmacies (including subsidised medicines) and information about healthcare options in the region, for everyone irrespective
of any of the aforesaid differences (10.2), will imply several steps forward towards meeting most of the targets of SDG 3. Asylum seekers who have endured adverse living conditions – physically, emotionally and psychologically – as well as the poor denizens of the developing world, need global support from the developed world (official development assistance), for the world on the whole to advance towards its SDG 3 targets. Targets 10.a, 10.b and 10.c are relevant ones in this respect.

Target	Content
1.1	By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less
	than \$1.25 a day
1.2	By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all
	its dimensions according to national definitions
1.3	Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030
	achieve substantial coverage of the poor and the vulnerable
1.4	By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to eco-
	nomic resources, as well as access to basic services, ownership and control over land and other forms of prop-
	erty, inheritance, natural resources, appropriate new technology and financial services, including microfinance
1.5	By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vul-
	nerability to climate-related extreme events and other economic, social and environmental shocks and disasters
1.a	Ensure significant mobilization of resources from a variety of sources, including through enhanced develop-
	ment cooperation, in order to provide adequate and predictable means for developing countries, in particular
	least developed countries, to implement programmes and policies to end poverty in all its dimensions
1.b	Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gen-
	der-sensitive development strategies, to support accelerated investment in poverty eradication actions

Table 5. Targets of SDG 1, as defined	y the United Nations	(United Nations, 2	016)
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While SDG 10 proposes to reduce inequalities, SDG 1 also strives essentially towards a similar goal, with a strong focus on the economically-disadvantaged section of the population (just as SDG 5 does the same, but with a strong focus on women's welfare). Indeed, a rise in employment-related earnings (link to SDG 8), transfers and government benefits (in cash or kind) will provide additional income to spend on essentials for good health (in addition to education). Social protection systems referred to in Target 1.3 (refer Table 5) includes, inter alia, healthcare benefits (subsidised or free).

Climate change will bring in its wake a plethora of challenges. Abatement is among the goals obviously (SDG 13), but adaptation is key. Here is where, one must think about the economically-disadvantaged sections of society and those living in regions of the world which are vulnerable to floods, droughts, forest fires and rise in sea levels (islanders, especially). Adapting to sudden changes brought about by climate change phenomena will be much more difficult for them vis-à-vis the richer segments of the population who would have *saved for a rainy day*. The said natural disasters (and indeed, rising temperatures), tend to precipitate outbreaks of water-, air- and food-borne epidemics (Targets 3.3 and 3.9). In addition to physical health, psychological well-being is extremely important, especially for the indigent. Combating poverty and enabling the impoverished to feel that they are an integral and important part of society, cared for and considered as fellow-citizens along with the better-endowed, will contribute to the achievement of Targets 3.5 and 3.a. Substance abuse /addictions and psychological disorders are indeed closely linked.

More intuitively, improving health and well-being among the poor will enable them to work, earn, care for their children, and gradually emerge out of poverty. Enabling them to rise out of poverty, can improve health outcomes in general and in particular, enable poor parents to care better for the health and well-being of their progeny. However, there is a limit beyond which money does not guarantee good health and well-being – as is seen in rich urban households around the world. Depression, obesity, cardiovascular diseases, and diabetes are often the fallouts of the fast-paced lives the rich and affluent live in the postmodern world's cities (which now hold more than half of the world's population).

As mentioned earlier, SDG 5 aims to efface another inequality from the social fabric of the world. Unfortunately, even in the 21<sup>st</sup> century, male dominance and patriarchy have not just deprived womenfolk of their well-deserved rights and place of pride in society, but through this deprivation, has affected the general well-being of entire populations. It is a well-known and indisputable fact that mothers, daughters and wives spend a lot of their time (often in all these capacities, at the same time), providing care and support (Target 5.4; refer Table 6). These efforts, are not accounted for as productive work in a country's GDP. It is long overdue for this fact to be accepted and appreciated.

SDG 5 surely sets out 9 ambitious targets, and at first read, any reader will agree that even a little progress every year in each of these, will bring about perceptible change in overall human health and well-being. For children to live through the challenging first few years of their lives (Target 3.2), mothers ought to be healthy (Targets 3.4, 3.5, and 3.7), and supported by family, society and government. Women also need to be well-informed about family planning. Therefore, at least primary education, state-sponsored whenever possible, is extremely important for girls. This leads to the irrefutable conclusion that child marriage and teenage pregnancies must simply become

things of the past (Target 5.3). Perpetrators of domestic violence and rape must be punished severely, and the deterrents must be firmly in place in legal systems of all the countries of the world (Target 5.2). Such crimes affect the victimized woman's health and well-being and also has an adverse impact on her near and dear ones (not to mention those of the perpetrator as well). Man and woman are two pillars supporting the edifice of humankind. Weakening one of them (as is happening in many parts of the world), will have the most obvious ramifications.

Table 6. Targets of SDG 5	as defined by t	the United Nations (	United Nations.	2016)
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Target	Content
5.1	End all forms of discrimination against all women and girls everywhere
5.2	Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking
	and sexual and other types of exploitation
5.3	Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation
5.4	Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and
	social protection policies and the promotion of shared responsibility within the household and the family as nation-
	ally appropriate
5.5	Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-
	making in political, economic and public life
5.6	Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the
	Programme of Action of the International Conference on Population and Development and the Beijing Platform
	for Action and the outcome documents of their review conferences
5.a	Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control
	over land and other forms of property, financial services, inheritance and natural resources, in accordance with
	national laws
5.b	Enhance the use of enabling technology, in particular information and communications technology, to promote the
	empowerment of women
5.c	Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the em-
	powerment of all women and girls at all levels

Table 7. Targets of SDG 6, as defined by the United Nations (United Nations, 2016)

Target	Content
6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, pay-
	ing special attention to the needs of women and girls and those in vulnerable situations
6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazard-
	ous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recy-
	cling and safe reuse globally
6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and
	supply of freshwater to address water scarcity and substantially reduce the number of people suffering from
	water scarcity
6.5	By 2030, implement integrated water resources management at all levels, including through transboundary
	cooperation as appropriate
6.6	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers
	and lakes
6.a	By 2030, expand international cooperation and capacity-building support to developing countries in water- and
	sanitation-related activities and programmes, including water harvesting, desalination, water efficiency,
	wastewater treatment, recycling and reuse technologies
6.b	Support and strengthen the participation of local communities in improving water and sanitation management

Water's role in sustaining ecosystems, human societies and economies, is very well-known to all of us. Water is one of the primary necessities for sustaining life. Although over 75% of the earth's surface is covered with water, only 3% of the total  $H_2O$  available is freshwater found in lakes, rivers, springs, and in aquifers below the ground. This may still be enough for humankind's survival if all this water is either of good quality or of a quality suitable for adequate purification by advanced water treatment technologies. Efficient and responsible use of the available water is also vital (Targets 6.1 and 6.4; refer Table 7). In the absence of good wastewater treatment and sanitation facilities, if the source of drinking water is also the sink for treated or untreated wastewater, the risk for contracting water-borne diseases is exacerbated; making Targets 6.2, 6.3 and 6.b critical, going forward.

Climate change (SDG 13) however, will tend to intensify droughts in some parts of the world, and floods in others. The latter, as we discussed earlier, not only causes damage and destruction, but also results in the outbreak of water-borne diseases (linked to Target 3.3). Here, transboundary cooperation for water sharing, large-scale investments in desalination (to harness the 97% water which is found in our oceans), water harvesting, and wastewater recycling will be not just advisable but necessary (Target 6.a).

Target 6.6 has a link to general well-being. Thriving aquatic ecosystems with luxuriant plant and animal life will contribute to psychological well-being.

### **Trade-offs with SDG 12**

It may, *prima facie*, seem counter-intuitive that there are trade-offs between SDG 12 (Responsible Consumption and Production) and SDG 3 (Global Health and Well-being). But a deeper understanding of the targets and the impact of efforts to achieve them provides insights into these conflicts. More and more resources, needless to say, are needed in order to promote good health and well-being. However, one must bear in mind, that sustainable production and consumption is first an environmental goal (having a favourable impact on meeting SDG 13), and a socio-economic goal thereafter. Improved healthcare relies on reaching out to larger sections of the population over time, and thereby generating the capacity to provide different kinds of resources such as medicines, clean water, good food, and protective clothing. This may call for diversification into more types of products and thereby consume more resources and generate waste beyond the capacity of the existing waste collection, recycling and reuse systems (Target 12.5). Hence, assigning a greater priority to *Good Health and Well-being* will constrain the ability of national governments to attain SDG 12 targets. For example, increasing the capacities of hospitals in the world to accommodate more patients in keeping with the SDG 3 targets, will lead to the generation of increasing hospital wastes needing responsible handling. In the absence of adequate handling capacities, the environmental media may get stressed, thereby adversely impacting SDG 6 and SDG 3.

Table 8. Targets of SDG 12, as defined by the United Nations (United Nations, 2016)

Target	Content
12.1	Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all
	countries taking action, with developed countries taking the lead, taking into account the development and ca-
	pabilities of developing countries
12.2	By 2030, achieve the sustainable management and efficient use of natural resources
12.3	By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along
	production and supply chains, including post-harvest losses
12.4	By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle,
	in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil
	in order to minimize their adverse impacts on human health and the environment
12.5	By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
12.6	Encourage companies, especially large and transnational companies, to adopt sustainable practices and to inte-
	grate sustainability information into their reporting cycle
12.7	Promote public procurement practices that are sustainable, in accordance with national policies and priorities
12.8	By 2030, ensure that people everywhere have the relevant information and awareness for sustainable develop-
	ment and lifestyles in harmony with nature
12.a	Support developing countries to strengthen their scientific and technological capacity to move towards more
	sustainable patterns of consumption and production
12.b	Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates
	jobs and promotes local culture and products
12.c	Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distor-
	tions, in accordance with national circumstances, including by restructuring taxation and phasing out those
	harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific
	needs and conditions of developing countries and minimizing the possible adverse impacts on their development
	in a manner that protects the poor and the affected communities

Consumption of food after the *best-before* date is looked upon as being deleterious to health and this results in greater food waste (non-sustainable consumption; Target 12.3). The 7-*billion-dollar question* then, is if one can sustainably ensure good health and well-being, while minimizing the adverse impacts on the environment. Seemingly, countries (especially developing ones) will end up *putting the cart before the horse* by, assigning a very high priority to SDG 12, at the expense of SDG 3. However, as long as all the production and consumption oriented towards satisfying SDG 3, does not end up defeating the very purpose (by causing water pollution and challenging Target 3.9), the trade-offs in the developing countries can very well be in favour of SDG 3.

### The die is cast

It is imperative for the sake of genuine sustainable development to appreciate and incontrovertibly agree that judged against the SDGs, all countries are developing countries. Therefore, what is needed now for any actor in the world is to conceive a new and different, truly universal concept of international cooperation for sustainable development that addresses all types of entities, rich and poor alike. In the modern world with all its complexities, cooperation is essential if breakthroughs are to be made. One can be inspired by the work done by the 2019 Nobel Economics laureates – Abhijit Banerjee, Ester Duflo and Michael Kremer. They shunned the high-theory ap-

proach, which is the default favourite of economists, in favour of randomised trials, to understand the less-understood relationships among different aspects of (sustainable) development – healthcare, education, entrepreneurship and skills development.

Transformative change is needed to attain the SDGs and this, as proposed by Randers et al (2015), is feasible with accelerated renewable energy growth, accelerated productivity in sustainable food chains, new development models in poor countries, unprecedented inequality reduction, and investments in education for all, gender equality, health and family planning – all being prioritised equally and implemented simultaneously. Countries like Costa Rica, for instance, can show the way ahead even for the developed world – it has ended extreme poverty and posts high levels of nutrition, life expectancy, education, sanitation, and access to energy (exceeding SDG thresholds) with GDP per capita of only USD 11,000, less than one fifth of that of the United States. This is undeniable evidence that human development objectives can be achieved by distributing existing GDP more fairly, and by investing in social services (healthcare, education, etc.) (Hickel, 2019).

Collaboration and cooperation are paramount. If one takes India for instance, several government ministries relevant to SDG 3 are in the fray, responsible for the strategies and actions towards the attainment of different targets. One finds the Ministry of Health and Family Welfare, Ministry of Tribal Affairs (link to SDG 10), Ministry of Drinking Water and Sanitation (link to SDG 6), Ministry of Housing and Urban Affairs (link to SDG 12), Ministry of Petroleum and Natural Gas (link to SDG 7), Ministry of Social Justice and Empowerment (links to SDGs 10 and 16), Ministry of Home Affairs, Ministry of Road Transport and Highways (link to SDG 9), Ministry of Commerce (links to SDGs 8 and 9), Ministry of Science and Technology (SDG 9), and the Ministry of Shipping (SDG 9) (NITI Aayog, Government of India, 2018). Thus, achieving the targets set for SDG 3 alone entails working collaboratively.

It is quite like everything being One before the Big Bang, and over the aeons, assuming multifarious forms, each tracing its origin to the One. Respect for these interlinkages is indispensable. There is no point arguing against them. A cynical perspective may paint the scenario as a *zero-sum game*. When everyone wants all of everything, all the time, then it can at best be a zero-sum game, and more often than not, a net-negative-sum affair. If sustainable development approaches employ total awareness and strive to achieve the optimal balance, one can even make things net-positive.

And yes, as the old saying goes, health indeed is wealth!

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# Impact of Financial Globalization on Environmental Degradation in the E7 Countries: Application of the Hybrid Nonparametric Quantile Causality Approach

# Wpływ globalizacji finansowej na degradację środowiska w krajach E7: zastosowanie hybrydowego nieparametrycznego podejścia kwantylowej przyczynowości

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# Abstract

Despite their economic success, the E7 countries have not been able to provide environmental protection. These countries, on the other hand, will not be able to maintain their economic progress if they do not also protect their natural resources. In this regard, the goal of this research is to examine the impact of financial globalization on  $CO_2$  emissions in the E7 countries. Utilizing a quarterly dataset between 1990Q1 and 2018Q4, we applied the novel quantile-on-quantile regression (QQR) and nonparametric causality in quantiles approaches to assess these interconnections. Furthermore, the quantile cointegration outcomes revealed cointegration between financial globalization and  $CO_2$  in each of the E7 nations. Furthermore, the QQR outcomes disclosed that in the majority of the quantiles, the effect of financial globalization on  $CO_2$  is positive for Brazil, China, India and Turkey, thus validating the pollution-haven-hypothesis. Moreover, for Indonesia, Russia and Mexico, in the majority of the quantiles, the effect of financial globalization on  $CO_2$  is negative, therefore validating the pollution-halo hypothesis. Moreover, the novel causality in quantiles approach disclosed that financial globalization can predict  $CO_2$  emissions for the E7 nations. Therefore, any policy channeled towards financial globalization will have a significant influence on  $CO_2$  emissions in the E7 economies. In light of these significant observations, the research suggests that Mexico, Russia, and Indonesia should be more financially interconnected, whereas China, India, Turkey, and Brazil should reevaluate their financial globalization policies.

Key words: financial globalization, CO<sub>2</sub> emissions, environmental sustainability; E7 nations; Quantile-on-Quantile Regression

**Słowa kluczowe:** globalizacja finansowa, emisje CO<sub>2</sub>, zrównoważoność środowiskowa, kraje E7, regresja kwantylowa

### 1. Introduction

The notion of sustainable development can be viewed in several ways, but at its foundation, it is a strategy of development that attempts to reconcile many, often conflicting needs against an understanding of our society's environmental, social, and economic constraints (Adebayo & Kirikkaleli, 2021). All too frequently, development is powered by a single need, without taking into account the broader or future consequences. Over the years, humans have witnessed the consequences of this strategy, from large-scale financial crises induced by reckless banking to global climate changes induced by our reliance on fossil-fuel based energy sources (Shahbaz et al. 2018). As a result, the longer we chase unsustainable development, the more common and severe its repercussions will become, necessitating immediate action.

Global warming is often regarded as the most serious ecological issue that civilization has ever encountered. This phenomenon will have disastrous implications on human lives, the environment and economies if it is not properly

controlled (Fareed et al. 2021). These repercussions will be long-term and far-reaching. Climate change is the outcome of human activity and behavior, and  $CO_2$  emissions ( $CO_2$ ) are the primary cause of global warming. The significant upsurge in  $CO_2$  from emerging and developed nations is one of the primary causes of the recent fast growth in global  $CO_2$  emissions. Climate change, on the other hand, has serious effects on nations (Adebayo and Kirikkaleli, 2021). Recognizing the need to act against global warming, leaders of the world gathered together in 2015 to sign the Paris Agreement, committing to collaborate on combatting this issue. This cooperation between people from other nations sharing expertise and ideas, as well as governments cooperating, is an example of globalization at its best.

Furthermore, globalization is the most contentious issue in the 21st century, specifically in the area of global financial integration. The most important aspects of accelerating openness and economic liberalization are finance, investment, and trade (Koengkan et al., 2020). By lowering rules and expanding their economies, all governments are promoting foreign investment and the international stock of liabilities and assets (Shahbaz et al., 2018). The growth of financial markets is aided by financial globalization. It offers extra resources that may be utilized to invest in ecologically-friendly initiatives in agriculture, construction, communications and information, renewable energy, technology and other sectors (Ahmed and Le, 2021). Financial globalization, on the other hand, may supply funding to polluting industries and boost economic activity, leading to the deterioration of the environment. Globalization can also enhance environmental conservation movements globally, and these efforts are helpful for the protection of the environment in nations at various stages of development (Rahman, 2020).



Figure 1. Trend of Financial Globalisation between 1990 and 2018

In the E7 countries, the degree of financial globalization has risen over time (Brazil, China, Mexico, India, Indonesia, Russia and Turkey) nations. The E7 nations' financial globalization index has grown on average from 33.589 in 1990 to 50.096 in 2018 (See Figure 1). With a score of 60.471 in 2018, Mexico is the most financially open economy amongst the E7 nations. Furthermore, the average financial globalization index of the E7 nations during the previous 29 years was 46.776. As a result of the rapid increase in the levels of financial globalization, it is meaningful to presume that financial globalization (FGLO) will play a significant role in impacting ecological quality across the E7 nations. Furthermore, it should be emphasized that these nations account for a significant share of overall worldwide FDI inflows (World Bank, 2021). As FDI is a primary mechanism of FGLO, ecological problems connected with financial globalization in the E7 nations can also be investigated using the Pollution Haven Hypothesis (PHH) as a theoretical framework. Per the PHH, an increase in foreign financial inflows causes host nations' environmental quality to degrade (Adebayo et al., 2021). The PHH would apply in this case if financial globalization has negative environmental consequences in the E7 nations.

The relationship between globalization and environmental deterioration has been examined in the current environmental economics literature. For instance, the studies of Yuping et al., (2021), He et al., (2021), and Ahmad et al., (2021) established a negative interconnectedness between globalization and environmental degradation, thus validating the pollution-halo-hypothesis. On the other hand, some studies such as Cole, (2004), Solarin et al., (2017), Murshed et al., (2021) and Balsalobre-Lorente et al., (2021) established a positive interconnectedness between globalization and environmental degradation, therefore validating the pollution haven hypothesis. Thus, it is clear that the prior literature unveils an unstable relationship between globalization and environmental degradation. The mixed outcomes above warrant additional investigation. Specifically, none of the prior studies have examined the impact of globalization on  $CO_2$  in the E7 nations utilizing the KOF Swiss Economic Institute's newly constructed financial globalization (de facto and de jure) index (Gygli et al., 2019). In light of the foregoing, the purpose of this research is to examine the ambiguous relationship between financial globalization and  $CO_2$  emissions in the E7 nations. The E7 nations are chosen for analysis for a multitude of reasons. As a result, the present investigation bridges the gap by assessing the impact of financial globalization on  $CO_2$  in the E-7 countries from 1990Q1 to 2018Q4. The E7 nations are chosen primarily because they are huge developing nations that have achieved significant progress during the previous two decades. The margin between the E7 and the G7 countries is closing, and by 2032, the E-7's economic expansion may surpass that of the G7. The E7 nations are forecasted to grow at a pace of 3.5% per year over the next 40 years, compared to 1.6 % for the G7 nations (Hamilton, 2011). Furthermore, the E-7 countries are major energy users, contributing to more than 40% of global energy consumption. Resultantly, examining the variables that contribute to  $CO_2$  in the E7 nations is crucial.

Furthermore, advanced econometric methodologies are employed to determine the relationship between financial globalization and  $CO_2$  in this study, as well as to gain a deeper insight into the impact of financial globalization on  $CO_2$  emissions. Several empirical works have endeavored to create a linkage between globalization and  $CO_2$ . The results, on the flipside, are frequently limited to traditional empirical approaches (Ahmad et al., 2021; He et al., 2021; Solarin et al., 2017; Yuping et al., 2021). Addressing this dilemma, Balciliar et al. (2016) asserted that techniques are critical in producing impartial research results and emphasized the need to use creative econometric approaches.

Based on the above understanding, the current research utilized the cutting-edge quantile-on-quantile regression (OOR) technique to evaluate the financial globalisation-CO<sub>2</sub> emissions nexus in E7 economies. The primary intention of the research is to contribute to the ongoing body of studies in 3 folds. (i) This research assess the financial globalization-CO<sub>2</sub> emissions nexus by applying the novel QQR approach initiated by Sim and Zhou (2015). The distinctiveness of QQR approach lies in its capacity to amalgamate the fundamentals of non-parametric estimation and analysis of quantile regression. Therefore, the technique regress one variable the quantile into another and the outcomes have the prospect to react the inquiries probing the association between financial globalisation and CO<sub>2</sub> emissions. (ii) Moreover, the results gathered from the current paper will offers an inclusive illustration of the vital financial globalization–CO<sub>2</sub> emissions interrelationship which the traditional approaches cannot detect. (iii) This research also utilizes the causality in mean and variance initiated by Balciliar et al. (2018) to capture the causality between the two time series in all quantiles of the conditional distribution. This approach has the following novelties: first, it is resistant to misspecification issues since it recognizes the inherent dependency structure between the time series in question; this could be especially useful because high-frequency data is known to have nonlinear dynamics. Second, we can use this approach to test for causality not just in the mean (1st instant), but also in the tails of the joint distribution of the variables, which is extremely noteworthy if the dependent variable has a fat tail.

The next section presents the synopsis of related studies followed by the theoretical framework in Section 3. Data and methodology is presented in Section 4, findings and discussion are depicted in Section 5.

#### 2. Summary of Past Studies

The evidence sufficiently supports the long-run relationship between globalization and the environment; yet, the path of their impacts is always contested. This is because the link between globalization and ecological deterioration is intertwined with business practices, degree of innovation, renewable energy utilization, and the capacity of the nation's natural resource (Kirikkaleli et al., 2021). On the flipside, the contentious issue over whether the expansion of worldwide economic connections in the form of globalization is linked to enhanced quality of the environment or if a high degree of globalization has culminated in ecological degradation merits more examination. Grossman and Krueger, (1991) provided a fascinating justification for the theoretical relationship between globalisation and ecological pollution, stating that globalization in the form of trade openness has both detrimental and favorable consequences on the environment. The positive relationship, also referred as the income effect, is observed as a result of increased economic activity resulting from international trade, which spreads dangerous CO<sub>2</sub> around the globe and, as a corollary, has severe environmental consequences (Cole, 2004). Globalisation, on the other hand, can have a beneficial impact on the environment due to the technique effect. It is accomplished as a consequence of globalisation-induced energy efficient technology all over the globe, which underpins the ability to increase local output while lowering CO<sub>2</sub> without limiting usage of energy (Cole, 2004; Shahbaz et al., 2018). As a result, empirical studies into the causal interrelationships between globalization and CO<sub>2</sub> are littered with both negative and positive (Acheampong et al., 2019; Cole, 2004) causal claims, resulting in a lack of consistency in identifying the appropriate interrelationship between the variables, limiting the power to assess the connection using sophisticated econometrics approaches.

In Australia, Shahbaz et al., (2015) explored the globalization-emission interrelationship using Bayer-Hanck and VECM approaches between 1970 and 2012. The study outcome disclosed a positive interrelationship between globalization and  $CO_2$ ; thus validating the pollution-haven-hypothesis. Likewise, Acheampong and Adebayo, (2021) assessed the globalization-emission nexus in Australia utilizing a dataset from 1970 to 2018 and novel QQR approach. The outcome from the research uncovered positive globalization-emission interconnectedness

across all quantiles (0.1-0.95). Using developing and developed countries, Leal and Marques, (2021) assessed the nexus between globalization and  $CO_2$  using a dataset from 1995 to 2017. The outcomes from the research disclosed that in developed nations, globalization impact  $CO_2$  negatively while for developing nations, the effect of globalization on  $CO_2$  is positive. Likewise, the study of Solarin et al., (2017) on the emissions-globalization interconnection in Malaysia utilizing yearly datasets from 1980-2013 demonstrated that a surge in globalisation in  $CO_2$ .

On the flip side, some studies established a negative globalization-emission association. For instance, (Rahman, 2020) in their research on the globalization-emissions nexus in top 10 electricity consuming countries using a dataset from 1971 to 2013 reported that globalization helps in curbing emissions. Similarly, data from using 1990 to 2014 and 18 Latin American and Caribbean countries as a case study, the research of Koengkan et al., (2020) reported negative emissions-globalization connection. Similarly, globalization contribute to sustainability of the environment as disclosed by the study of Yuping et al., (2021). Similarly, Bashir et al., (2021) found that globalization is adversely connected to the emissions of harmful gases in nations in a panel of top 10 new globalized nations.

In general, the literature on the relationship between globalization and environmental deterioration is ambiguous. The absence of definitive results necessitates further academic investigation, potentially using a more precise scientific approach. Identifying the path of interaction could provide policymakers with extra information to help them create appropriate environmental policies in a globalized society.

### 3. Theorethical Underpinning, Data and Methods

### 3.1. Theoretical Framework

Aside from economic growth, several other variables, such as globalization, may impact the technique, scale and composition effects, which may specifically influence these effects. Globalization, as a result, is a significant element that can influence the association between  $CO_2$  and economic progress.  $CO_2$  rise in a variety of ways as a result of financial globalization. Firstly, due to scale effects, FGLO may promote economic activity and consumption. Financial globalization fosters cross-border economic operations that boost industrial activity, which, in turn, worsens ecological degradation. Furthermore, the stock exchange's strong performance suggests an increase in economic development, which promotes consumer and business confidence, promotes spending and production and contributes to ecological deterioration. Financial globalization, on the other hand, may improve the quality of the environment by offering more eco-friendly initiatives as a result of technique and composition effects. Based on the above idea, the following economic function is formulated as follows:  $CO_{2t} = f(FGLO_t)$ (1)

### 3.2. Data

The current paper assesses the effect of financial globalization on carbon emissions in E-7 nations (Brazil, China, Mexico, India, Indonesia, Russia and Turkey) using a dataset stretching between 1990Q1 and 2018Q4. The data for financial globalization (FGLO) is gathered from KOF database and it includes the international stocks of assets and liabilities and capital flows. The dependent variable is carbon emission ( $CO_2$ ) which is calculated as metric tons per capita is gathered from the British Petroleum database.



Figure 2. Flow of Analysis

#### 3.3. Methodology

As previously stated, the current investigation adopts the Quantile-on Quantile (QQ) approach in accordance with the description and guidelines provided by (Sim and Zhou, 2015). This approach, also known as the modification of the conventional quantile regression approach, allows for the evaluation of the impacts of the quantile of one parameter over the other. Furthermore, it is a blend of two processes: first, quantile regression, in which the approach examines the influence of a parameter on the quantiles of another parameter, while the second, as to do with the estimating in a non-parametric process. The quantile regression analysis, introduced by (Bassett and Koenker, 1978) is an improved extension of classic OLS-based regression analysis wherein the estimate of one variable is pales in comparison to the estimate of another parameter, although the Quantile regression can clarify more fluctuation of the quantiles and thus allows statisticians to anticipate with minimal errors. Furthermore, standard regression, as explained and advocated by (Stone, 1977) and (Cleveland, 1979) consolidates the dimension of the feature in order to match a linear regression framework, hence reducing predictive capacity. On the contrary, whenever the quantiles of a parameter are evaluated to the quantiles of another variable, as permitted by the QQ approach, the predictive potential improves as more variance among the components is addressed. According to the study's goal, the nonparametric QQ regression analysis is:

$$CO_{2t} = \beta^{\theta} FGLO_t + \varepsilon_t^{\theta}$$

(2)

From Equation (1), CO2 indicates carbon emission of a country over the period under review and FGLO indicates the financial globalization of a country over the period under review (t).  $\theta$  Indicates the conditional distribution of  $CO_2$  in the qth quantile, and  $\mathcal{E}$  indicates the error term of the quantile wherein the conditional qth is exactly zero. Finally,  $\beta^{\theta}$  depicts a function that is unknown due to inadequate of knowledge on the association between CO<sub>2</sub> and FGLO. The QQ approach is based on the aggregate behavior of the constructs when assessing the association between two variables. Also, in a situation where there are any disturbances in FGLO, either favorable or adverse, they will have a proportional impact on CO<sub>2</sub>. For illustrate, the pattern of disruptions in FGLO can be either favorable or unfavorable, and in such a case, the CO<sub>2</sub> may respond properly or asymmetrically. As a result, in evaluating the impacts of the qth quantile of  $CO_2$  on the tth quantile of the FGLO, symbolized as  $FGLO_{t1}$  (equation (1),  $FGLO_t$  is estimated alongside the  $FGLO_t$  using linear regression. Furthermore, because  $\beta^{\theta}$  is uncertain, the estimated first-order Taylor advanced function is indicated in equation (2).

 $\beta^{\theta}(FGLO_t) \approx \beta^{\theta}(FGLO^t) + \beta^{\theta'}(FGLO^t)(FGLO_t - FGLO^t).$ (3)

Where:  $\beta^{\theta'}$  indicates the partial derivative of  $\beta^{\theta}(FGLO_t)$  in relation of  $FGLO_t$  that is referred to as the marginal influence, which denotes the standard regression analysis' slope. Also, it is observed in equation (2) that the indicators were indexed doubly i.e.  $\beta^{\theta}(FGLO^{t})$  and  $\beta^{\theta'}(FGLO^{t})$  in relation of  $\theta$  and  $\tau$ . However, the function of  $\theta$ and  $FGLO^t$  are  $\beta^{\theta}(FGLO^t)$  and  $\beta^{\theta'}(FGLO^t)$ . However,  $FGLO^t$  is a function of t, that reveals that  $\beta^{\theta}(FGLO^t)$  and  $\beta^{\theta'}(FGLO^t)$  can be expressed as:

$$\beta^{\theta}(\text{FGLO}_t) \approx \beta_{\theta}(\theta, \tau) + \beta_1(\theta, \tau)(FGLO_t - FGLO^t).$$
(4)  
In addition, by substituting Equation 4 for Equation 1, the subsequent equation is displayed:

In addition, by substituting Equation 4 for Equation 1, the subsequent equation is displayed:

 $(\text{FGLO}_t) \approx \beta_{\theta}(\theta, \tau) + \beta_1(\theta, \tau)(\text{FGLO}_t - \text{FGLO}^t) + \mathcal{E}_t^{\theta}$  (\*) (5)In Equation 5, (\*) indicates the CO<sub>2</sub>'s qth provisional quantile. The provisional quantile differs from the ordinary conditional quantile in that the variables are indexed doubly, i.e.,  $\beta_0$  and  $\beta_1$  in regards of q and t, respectively, and it reflects the qth quantile of  $CO_2$  with the tth quantile of FGLO. There is a potential of a discrepancy in variables between the qth quantile of  $CO_2$  and the tth quantile of FGLO. Furthermore, a linear relationship between parameters is expected at all times. As a result, equation (4) analyzes the model's aggregate interconnections depending upon that distribution-based reliance of the researched variables. Furthermore, in equation (4), FGLO<sub>t</sub> and FGLO<sup>t</sup> should be substituted by their computed equivalents,  $\widehat{FGLO}_t$  and  $\widehat{FGLO}^t$ . As a result, the evaluations from the localized linear regression analysis of the variables  $\beta_0$  and  $\beta_1$ , which are evaluated by  $\beta_0$  and  $\beta_1$  that may be computed as the minimization issue illustrated below:

$$Min_{\delta_0\delta_1} \sum_{t=1}^{n} \sigma_{\phi} \left[ CO_{2t} - \delta_0 - \delta_1 (\widehat{FGLO}_t - \widehat{FGLO}^{\tau}) \right] \times L \left[ \frac{M_n (\widehat{FGLO}_t) - \tau}{h} \right]$$
(6)

Where:  $\sigma_{\phi}$  indicates the loss of the quantile, which is explained as  $\sigma_{\phi}(u) = u(\theta - 1(u < 0))$ ,  $L^{(*)}$  is the kernel function and the kernel parameter bandwidth is indicated as h. The Gaussian kernel is employed in this research to determine the weight of the neighborhood observations of  $CO_{2t}$ , which is among the most commonly adopted, prominent, and discussed kernel functions, due to its ease of computation and processing. The advantage of this kernel is that it is symmetrical as it reaches zero, and the distant samples are assigned minimal weights. In this current research, the previously stated weights and the distance between the function's distributions of  $\widehat{FGLO}_t$  are negatively proportionate, and are symbolized as  $F_n(\widehat{FGLO}_t) = \frac{1}{n} \sum_{k=1}^n I(\widehat{FGLO}_k) > \widehat{FGLO}_t$ , wherein the reward of the stochastic process that will come to terms with the quantile FGLOt is symbolized by t. Choosing bandwidth is critical when utilizing non-parametric approaches. This is because it controls the smoothing of the computed results by determining the magnitude whereby the neighborhood estimates fluctuate around the specified position. Furthermore, if the bandwidth is set to a little amount, it will result in more variation, whilst setting it to a big

value would result in prejudice. As a result, while determining the bandwidth, the values that fall between variance and biasness must be chosen. Following the suggestions of Sim and Zhou (2015), the current investigation used the bandwidth parameter value of h = 0.05.

### 4. Findings and discussion

### 4.1. Pre-Estimation Outcomes

Table 2 presents the summary of  $CO_2$  and financial globalization (FGLO) for the E7 nations. For  $CO_2$ , the mean of Russia (11.412) is the highest which ranges from 9.858 to 17.194. This is accompanied by China (4.365) which ranges from 2.031 to 7.046, Mexico (4.024), which ranges from 3.553 to 4.471, Turkey (3.908) which ranges from 2.781 to 5.259, Brazil (1.908) which ranges from 1.359 to 2.595, Indonesia (1.519) which ranges from 0.762 to 2.278 and India (1.146) which ranges from 0.652 to 1.957. The skewness value uncovered that all the  $CO_2$  values for the E7 economies are skewed positively. Furthermore, all the kurtosis values of the E7 economies are leptokurtic with the exemption of Russia which is platykurtic. The JB probability outcomes unveiled that CO<sub>2</sub> for China, India, Indonesia, Russia and Turkey do not conform to normality while Brazil and Mexico align with normality. Regarding financial globalisation (FGLO), the mean of Indonesia (59.712) is the highest which ranges from 46.398 to 78.694, Russia (51.783) which ranges from 16.010 to 63.595, Turkey (50.982) which ranges from 40.163 to 58.259, Brazil (43.493) which ranges from 24.732 to 55.500, China (40.860) which ranges from 25.861 to 50.990 and India (32.811) which ranges from 10.084 to 45.524. Furthermore, Brazil, China, India, Russia and Turkey are skewed negatively while Mexico and Indonesia are positively skewed as disclosed by the skewness value. In addition, Brazil, China, Mexico and India are leptokurtic while Indonesia, and Russia are platykurtic. Moreover, FGLO for all the E7 nations does not align with normality with the exemption of Mexico. We also assess the variables (CO<sub>2</sub> and FGLO) stationarity attribute for all the E7 nations using both ADF and PP unit root tests and the outcomes unveiled that all the variables are I(1) (see Table 3).

Table 2. Descriptive Statistics								
		Carbon Emissions (CO <sub>2</sub> )						
Country	Brazil	China	India	Indonesia	Mexico	Russia	Turkey	
Mean	1.908	4.365	1.146	1.519	4.024	11.412	3.908	
Median	1.839	3.875	0.996	1.502	4.015	11.166	3.658	
Maximum	2.595	7.046	1.957	2.278	4.471	17.194	5.259	
Minimum	1.359	2.031	0.652	0.762	3.553	9.858	2.781	
Std. Dev.	0.329	1.926	0.383	0.380	0.238	1.612	0.750	
Skewness	0.306	0.261	0.630	0.205	0.030	2.434	0.169	
Kurtosis	2.247	1.364	2.060	2.047	2.263	8.637	1.689	
JB	4.550	14.253*	11.944*	5.197***	2.641	268.120*	8.862**	
			Financia	l Globalisatio	n (FGLO)			
Mean	43.493	40.860	32.811	59.712	47.792	51.783	50.982	
Median	46.011	41.154	39.742	59.680	46.321	55.312	51.443	
Maximum	55.500	50.990	45.524	78.694	61.075	63.595	58.259	
Minimum	24.732	25.861	10.084	46.398	29.693	16.010	40.163	
Std. Dev.	9.149	7.100	11.437	6.951	7.683	10.748	4.698	
Skewness	-0.529	-0.313	-0.631	0.691	0.126	-1.129	-0.595	
Kurtosis	1.928	1.852	1.828	3.173	2.452	3.412	2.648	
JB	10.953*	8.257**	14.339*	9.378*	1.762	25.471*	7.452**	

Note: 1%, 5% and 10% level of significance are denoted by \*, \*\* and \*\*\* respectively

Table 3. ADF and PP Unit root Tests

	Financial Globalisation (FGLO)				Carbon Emissions (CO <sub>2</sub> )			
Country	ADF		PP		ADF		PP	
	Level	Δ	Level	Δ	Level	Δ	Level	Δ
Brazil	-3.761**	-4.284**	-2.036	-4.276*	-1.021	-3.327***	-2.793	-7.601*
China	-1.471	-4.514*	-2.560	-4.562	-2.562	-4.4497	-1.747	-4.362*
India	2.0676	-3.706**	-1.229	-6.003*	-0.414	-3.691**	-0.4762	-6.055*
Indonesia	-2.331	-3.516**	-2.587	-5.371	-2.741	-6.206	-3.398***	-5.479
Mexico	-0.081	-3.289***	-0.3814	-5.865*	-2.987	-3.671**	-3.017	-5.870*
Russia	-1.252	-4.696*	-3.730**	-6.488*	-6.837	-3.248***	-3.416***	-5.650
Turkey	-2.537	-5.001*	-2.088	-5.054*	-2.109	-3.787**	-2.720	-5.614*

Note: 1%, 5% and 10% level of significance are denoted by \*, \*\* and \*\*\* respectively

We proceed by exploring the variables (CO<sub>2</sub> and FGLO) nonlinearity attribute for the E7 economies. As a result, we utilized the BDS nonlinearity test suggested by Broock et al. (1996). The BDS results are presented in Table 4 and the outcomes disclosed that all the variables (CO<sub>2</sub> and FGLO) are nonlinear for all the E7 economies. Based

on this understanding, utilizing linear approaches such as OLS, VECM, DOLS, ARDL, FMOLS and others will produce outcomes that are bias. Therefore, we use quantile approaches (quantile-on-quantile regression and nonparametric causality) to scrutinize the effect of financial globalisation on CO<sub>2</sub> emissions in the E7 economies.

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Table 4. BDS Test Outcomes									
		Financial Globalisation (FGLO)							
Country	Brazil	China	India	Indonesia	Mexico	Russia	Turkey		
M2	37.131*	50.102*	37.881*	23.785*	30.957*	25.427*	24.306*		
M3	39.502*	53.092*	40.348*	24.342*	32.002*	26.947*	24.819*		
M4	42.359*	56.684*	43.371*	25.127*	33.620*	28.851*	26.001*		
M5	46.481*	61.884*	47.735*	26.519*	36.269*	31.690*	28.140*		
M6	52.038*	69.249*	53.705*	28.708*	40.142*	35.691*	30.817*		
			Carl	bon Emissions (	<b>CO</b> <sub>2</sub> )				
M2	36.982*	42.400*	36.785*	40.485*	35.446*	16.992*	50.160*		
M3	39.117*	45.157*	38.904*	42.316*	36.444*	17.926*	52.920*		
M4	41.761*	48.796*	41.822*	45.034*	38.032*	19.052*	56.602*		
M5	45.668*	54.216*	46.246*	49.230*	40.881*	20.706*	62.239*		
M6	51.295*	61.722*	52.452*	55.134*	45.172*	23.001*	70.194*		

Note: 1% level of significance is denoted by \*

### 4.2. Cointegration Outcomes

In the next phase, we assess the cointegration between financial globalisation and CO<sub>2</sub> emissions for each E7 nation using the Quantile Cointegration suggested by Xiao, (2009). Table 5 reports the Quantile Cointegration outcomes. We observed that the null hypothesis of no cointegration is rejected for each E7 nation. Therefore we confirmed proof of interconnection between financial globalisation-CO<sub>2</sub> emissions for each E7 nation in the longrun.

Table 5. Quantile Cointegration Test Outcomes

Model	Coefficient	$Sup_{\tau} V_{\pi}(\tau) $	CV-1%	CV-5%	CV-10%
Brazil	β	5661.08	4170.29	2702.19	1670.29
CO <sub>2t</sub> Vs FGLO <sub>t</sub>	γ	857.537	680.825	470.129	277.506
China	β	7961.35	5808.25	4380825	2175.04
CO <sub>2t</sub> Vs FGLO <sub>t</sub>	γ	966.108	770.129	574.237	377.504
India	β	4309.24	3684.69	2156.15	1654.94
CO <sub>2t</sub> Vs FGLO <sub>t</sub>	γ	566.675	461.469	291.522	152.773
Indonesia	β	7355.57	5043.94	3919.22	2674.56
CO <sub>2t</sub> Vs FGLO <sub>t</sub>	γ	866.675	642.833	492.954	227.973
Mexico	β	2864.66	1966.29	1261.59	954.752
CO <sub>2t</sub> Vs FGLO <sub>t</sub>	γ	365.627	278.495	190.558	103.139
Russia	β	3013.96	2824.66	2062.57	1356.34
GDP <sub>t</sub> Vs TO <sub>t</sub>	γ	403.588	318.475	206.479	99.933
Turkey	β	5617.21	3919.15	2628.57	1756.34
CO <sub>2t</sub> Vs FGLO <sub>t</sub>	γ	760.735	610.998	492.171	278.473

### 4.3. Quantile-on-Quantile Outcomes

After the cointegration between financial globalisation and CO<sub>2</sub> emissions has been established, we proceed by assessing the effect of financial globalisation (FGLO) on carbon emissions (CO<sub>2</sub>) in each E7 nations. Figure 3 (af) presents the FGLO effect on CO<sub>2</sub> in each E7 nations. Fig 3a presents the FGLO effect on CO<sub>2</sub> in Brazil. Across all quantiles (0.1-0.95) of both FGLO and CO<sub>2</sub>, the effect of financial globalization on CO<sub>2</sub> is positive and weak; however, in the middle tail (0.45-0.75) of both financial globalization on CO<sub>2</sub>, the influence of financial globalization on CO<sub>2</sub> is positive and strong. This implies that in all quantiles financial globalization contribute to degradation of the environment across all quantiles (0.1-0.95). The effect of financial globalization on CO2 in China is presented in Figure 3b. Across all tails (0.1-095) of financial globalization and lower and middle tails (0.1-0.65) of CO2, the effect of financial globalization on CO2 is positive and weak. Furthermore, in the upper tail (0.70-0.90) of CO<sub>2</sub> and all quartiles (0.1-0.95) of financial globalization, increase in CO<sub>2</sub> is caused by financial globalization. In summary, we observed that financial globalization contribute to decrease in environmental quality in China.

Figure 3c disclosed impact of financial globalization on CO<sub>2</sub>. Across all tails (0.1-0.95) of both financial globalization and  $CO_2$  the effect of financial globalization on  $CO_2$  is weak and positive; though in the upper tail (0.80-(0.95) of CO<sub>2</sub> and all quantiles (0.1-0.95) of financial globalization, we observed positive and significant impact of financial globalization on CO<sub>2</sub>. In summary, the financial globalization contribute to India's ecological deterioration across all quantiles. Figure 3d presents influence of financial globalization on  $CO_2$  in Indonesia. In the lower tail (0.1-0.30) of both financial globalization and  $CO_2$ , the financial globalization on influence on  $CO_2$  is positive and weak. However, in the middle and upper tails (0.35-0.95) of  $CO_2$  and across all tails (0.1-0.95) of financial globalization, an upsurge in financial globalization enhance the quality of the environment. Therefore financial globalization play a crucial role in improving the quality of the environment in Indonesia.

Figure 3e presents the influence of financial globalization on  $CO_2$  in Mexico. In the lower and upper quantiles (0.1-0.40 and 0.85-0.95) of  $CO_2$  and all tails (0.1-0.95) of financial globalization, the influence of financial globalization on  $CO_2$  is weak and negative suggesting that financial globalization improve quality of the environment. However, in the middle tail (0.45-0.75) of  $CO_2$  and middle and upper tails (0.50-0.95) of financial globalization, the effect of financial globalization on  $CO_2$  is positive. In summary, negative influence of financial globalization on  $CO_2$  is dominant. Fig. 3f depicts the effect of financial globalization on  $CO_2$  in Russia. In the lower tail (0.1-0.35) of  $CO_2$  and all quantiles (0.1-0.95) of financial globalization, the effect of financial globalization on  $CO_2$  is weak and positive; however, we observed negative effect of financial globalization on  $CO_2$  in the middle and higher tails (0.40-0.80) of  $CO_2$  and across all tails (0.1-0.95) of financial globalization. In summary, the negative effect of financial globalization on  $CO_2$  is more pronounced; though heterogeneous effect is also visible.

Lastly, Figure 3g presents the effect of financial globalization on  $CO_2$  in Turkey. In the lower and middle tails (0.1-0.50) of financial globalization and lower tail (0.1-0.40) of  $CO_2$ , the effect of financial globalization on  $CO_2$  is weak and negative; however, positive effect is observed in the upper tail (0.70-0.95) of both financial globalization and  $CO_2$ . Moreover, positive effect of financial globalization on  $CO_2$  is observed in the middle and upper tails (0.50-0.85) of  $CO_2$  and upper tail (0.60-0.95) of financial globalization. In summary, the effect of financial globalization on  $CO_2$  is positive. Thus, financial globalization degrade the quality of the environment in Turkey.



### 4.4. Nonparametric Causality Outcomes

This research also utilizes the causality in mean and variance suggested by Balciliar et al. (2018) to capture the causality in mean and variance between financial globalization and  $CO_2$  in the E7 economies. The causality-inquantile approach has the following novelties: first, it is resistant to misspecification issues since it recognizes the



inherent dependency structure between the time series in question; this could be especially useful because highfrequency data is known to have nonlinear dynamics. Second, we can use this approach to test for causality not just in the mean (1st instant), but also in the tails of the joint distribution of the variables, which is extremely noteworthy if the dependent variable has a fat tail.

The outcomes of the causality-in-quantile are illustrated by Figure 4. Figure 4a presents the effect of financial globalization on  $CO_2$  for Brazil. The influence of financial globalization is significant in the middle quantile (0.40-0.60) of the provisional distribution of  $CO_2$ . A t-statistic of 1.80 reveals that the impact grows bigger and more significant in the middle quantiles. The effect of volatility is significant across all quantiles (0.1-0.85) at the 5% and 10% level of significance. For China, The influence of financial globalization is significant in the middle quantile (0.35-0.50) of the provisional distribution of  $CO_2$  (see Figure 4b). A t-statistic of 1.72 reveals that the impact grows bigger and more significant in the middle quantiles. Furthermore, the effect of volatility is significant across all quantiles (0.1-0.85) at the 5% and 10% level of significance. Figure 4c discloses the effect of financial globalization on  $CO_2$  for India. The influence of financial globalization is significant in the lower and middle quantiles (0.30-0.60) of the provisional distribution of  $CO_2$  at 10% level of significance. A t-statistic of 1.81 reveals that the impact grows bigger and more significant in the middle quantiles. The effect of volatility is significant in the lower significant in the impact grows bigger and more significant in the middle quantiles (0.30-0.60) of the provisional distribution of  $CO_2$  at 10% level of significance. A t-statistic of 1.81 reveals that the impact grows bigger and more significant in the middle quantiles. The effect of volatility is significant in the induce of significance. A t-statistic of 1.81 reveals that the impact grows bigger and more significant in the middle quantiles. The effect of volatility is significant in the lower quantile (0.1-0.55) at 10% level of significance.

Moreover, Figure 4d presents the effect of financial globalization on  $CO_2$  for Indonesia. The influence of financial globalization is significant in the lower and middle quantiles (0.25-0.55) of the provisional distribution of  $CO_2$  emissions. A t-statistic of 1.84 reveals that the impact grows bigger and more significant in the middle quantiles. The volatility effect is significant lower and middle quantiles (0.1-0.45) at the 5% and 10% level of significance. For Mexico, The influence of financial globalization is significant in the lower and middle quantiles (0.10-0.55) of the provisional distribution of  $CO_2$  at the 5% and 10% level of significance (see Figure 4e). A t-statistic of 2.21 reveals that the impact grows bigger and more significant in the lower quantiles. Furthermore, the effect of volatility is significant in the lower and middle quantiles (0.20-0.60) at the 5% and 10% level of significance. Figure 4f discloses the effect of financial globalization on  $CO_2$  for Russia. The influence of financial globalization is significant in the lower quantiles (0.20-0.40) of the provisional distribution of  $CO_2$  at 10% level of significance.

A t-statistic of 1.82 reveals that the impact grows bigger and more significant in the lower quantiles. The effect of volatility is significant in the lower quantile (0.1-0.65) at the 5% and 10% level of significance.

Lastly, Figure 4g discloses the effect of financial globalization on  $CO_2$  for Turkey. The influence of financial globalization is significant in the lower and middle quantiles (0.20-0.35 and 0.55) of the provisional distribution of  $CO_2$  at 10% level of significance. A t-statistic of 1.73 reveals that the impact grows bigger and more significant in the lower quantiles. The effect of volatility is significant in the lower quantile (0.1-0.70) at the 5% and 10% level of significance.



### 4.4. Discussion of Findings

This portion of the empirical analysis presents a precise discussion based on the outcomes gathered from QQR. In the majority of the quantiles, the effect of financial globalization on  $CO_2$  is positive for Brazil, China, India and



Turkey, thus validating the pollution-haven-hypothesis. This implies that the rapid increase in economic globalization in Brazil, China, India and Turkey contributes substantially to  $CO_2$  emissions. This outcome is supported by the studies of Shahbaz et al. (2015) for Australia, Acheampong & Adebayo (2021) for Australia, Leal et al. (2020) for developing and developed countries and Solarin et al. (2017) for Malaysia, who reported a positive interconnectedness between globalization and  $CO_2$  emissions. According to Adebayo et al. (2021), trade openness has a wide-ranging impact on ecological deterioration because fast improvements in the degree of openness lead to pollution. Furthermore, as a result of globalization, nations demand more resources, which has a huge impact on the environment. Rapid economic growth also causes increased energy demand, resulting in environmental deterioration over time.

Moreover, for Indonesia, Russia and Mexico, in the majority of the quantiles, the effect of financial globalization on  $CO_2$  is negative, therefore validating the pollution-halo-hypothesis. The studies of Koengkan et al., (2020) for 18 Latin American and Caribbean nations, Yuping et al. (2021) for Argentina, Rahman, (2020) for the top 10 electricity consuming countries reported similar findings. The beneficial ecological effects of financial globalization could be due to the fact that it aids in the transition to renewable energy sources by incorporating sustainable and environmentally-friendly energy sources into the national energy mix (Ahmed et al., 2021). Likewise, a number of previous studies have shown the negative ecological consequences of various kinds of financial globalization (Murshed et al., 2021). Furthermore, financial globalization can have a green technology spillover effect, which can help to mitigate damage to the environment. As a result, the fact that financial globalization reduces  $CO_2$  emissions in the E7 nations suggests that financial globalization is a critical mechanism for achieving the technique and composition impacts required to phase out the economic growth-ecological damage trade-off. Furthermore, this conclusion shows that financial globalization promotes the quality of the environment in the E7 nations, which could be attributable to technological diffusion resulting from sustainable FDI inflows.

Moreover, we applied the novel causality in quantiles approach and the outcomes disclosed that financial globalization can predict  $CO_2$  emissions for the E7 nations. Therefore, any policy channeled towards financial globalization will have a significant influence on  $CO_2$  emissions in the E7 economies.

### 5. Conclusion

At COP 21 in Paris, the Members of the United Nations Framework Convention on Climate Change (UNFCCC) struck a significant agreement to combat climate change and to hasten and reinforce the investments and actions required to secure a viable low-carbon future. The Paris Accord expanded on this by bringing all countries together for the first time to establish coordinated measures to combat and adapt to climate change, including increased support for impoverished nations. This also sets a new course for the international climate strategy. The E7 nations face the same problem of reducing  $CO_2$  emissions, and as a result, are staunchly dedicated to a climate of sustainable growth. Thus, this research assesses the interrelationship between financial globalization and the  $CO_2$  emissions of E7 countries between 1990Q1 and 2018Q4 by utilizing the BDS test, quantile cointegration, quantile-on-quantile regression and quantile regression (QR) as a robustness check.

The outcomes of the BDS nonlinear test affirmed utilization of nonlinear approaches. Furthermore, the quantile cointegration outcomes revealed cointegration between financial globalization and  $CO_2$  in each of the E7 nations. Furthermore, the QQR outcomes disclosed that in the majority of the quantiles, the effect of financial globalization on  $CO_2$  is positive for Brazil, China, India and Turkey, thus validating the pollution-haven-hypothesis. Moreover, for Indonesia, Russia and Mexico, in the majority of the quantiles, the effect of financial globalization on  $CO_2$  is negative, therefore validating the pollution-halo-hypothesis. The financial globalization—environment nexus's heterogeneity between nations can be attributed to a number of factors. It is dependent on the degree to which financial globalization is viewed as a critical component of economic growth, as well as the operational efficiency and

technical level. In addition, we applied the novel causality in quantiles approach and the outcomes disclosed that financial globalization can predict  $CO_2$  emissions for the E7 nations. Therefore, any policy channeled towards financial globalization will have a significant influence on  $CO_2$  emissions in the E7 economies.

This research offers the following policy recommendations predicated on the results obtained. Firstly, Indonesia, Mexico, and Russia should become more financially integrated into the global economy, as financial globalization has been shown to reduce the deterioration of the environment. In addition, the authorities in Indonesia, Mexico, and Russia should encourage financial liberalization, which means that their political structures should welcome more international capital inflows. However, this foreign cash should be deployed in eco-friendly processes of production. On the other hand, financial globalization contributes to the deterioration of the environment for Brazil, China, India and Turkey. Therefore, policymakers in Brazil, China, India and Turkey should re-strategize their policies on financial globalization, since it deteriorates the quality of the environment.

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# International Trade, Corruption and Economic Growth: Evidence from Selected Sub-Saharan Countries

# Handel międzynarodowy, korupcja i wzrost gospodarczy: dowody z wybranych krajów subsaharyjskich

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## Abstract

Sustainable development goal 17 emphasizes the importance of international trade in achieving inclusive growth. Likewise, countries with high level of corruption will experience limited growth. In order to examine the causality, this study considers the impact of international trade and corruption on the economic growth of selected sub-Saharan African countries (Angola, Ghana, Kenya, Nigeria, and South Africa) from the period 2000-2019. The granger causality test and fixed effect method of estimation were adopted. The result of the granger causality tests shows that there is no causality between import and economic growth, there is unidirectional causality between export and economic growth and there is no causality between control of corruption have a positive impact, 25.4%, 32%, 45.5% respectively, on the economic growth of selected sub-Saharan African countries. Hence from these findings, policies to curb corruption should be encouraged as export is crucial for the economic growth of these countries and policies to curb corruption should be implemented in order to promote economic growth in the selected sub-Saharan African countries.

Key words: international trade, corruption, economic growth, export, import, Sub-Saharan Africa Slowa kluczowe: handel międzynarodowy, korupcja, wzrost gospodarczy, eksport, import, Afryka Subsaharyjska

# 1. Introduction

The need for countries to create partnerships is bigger than ever in a world that is fast evolving. In line with the SDG 17, which is partnership for the goals which seeks to promote and strengthen global partnership among nations of the world, this goal helps to encourage international trade by enabling a fair trading system and increasing volume of export of all countries especially developing countries to help contribute to their economic growth and development. Okenna and Adesanya (2020) states that the importance of international trade begins with resource disparity and restrictions that is, the fact that no country can fully produce all the products and services that the people require for their consumption. International trade is thus a core part of any economy that enables countries to specialize in the production of specific goods and serves as a major source of revenue to most developing countries that actively participate in trade.

International trade is defined in the 2030 Agenda for Sustainable Development as *an engine for inclusive economic growth and poverty reduction which contributes to the promotion of sustainable development*. Increase in poverty rate in African countries has contributed to the increasing crime rate and corruption which impedes growth rate in the region. It has also been observed from reviewed literatures that one of the causes of the limited economic growth in sub-Sahara African countries is corruption. According to World Bank, Transparency International and International Country Risks Guide, sub-Sahara Africa deals with a high level of corruption in comparison to other regions of the world. Countries with high level of corruption are unable to adopt sound redistributive policies and

are unlikely to benefit from long-term economic development. This in essence may hinder the achievement of sustainable development goal if necessary actions and policies are not put in place.

Despite several policies focused on encouragement of trade in Sub-Saharan Africa, trade did not achieve the desired purpose and the failure to achieve the objective can be attributed to the nature of government. Sub-Saharan countries have adopted numerous policies and schemes to aid and increase their openness to trade. Observing from a superficial point of view, as much as international trade is a core part of the economies of developing countries there are several factors that affect economic growth that has been overlooked. The improper functioning of the legal framework can hinder the effectiveness of the contracts, a fact that discourages international transactions and can discourage economic activities (Anderson and Marcouiller, 2002).This tends to point to the fact that the institutional framework in sub-Saharan African countries may not be very supportive for economic activities when compared to other regions of the world (Osabuohien, 2011). Countries in sub-Saharan Africa lose billions of dollars each year through corruption, the local and international efforts to reform governance have been inconsistent (Hanson, 2010).

International trade has with no doubt helped in speeding up the economic growth and development in sub-Saharan African countries. While international trade and economic growth has often been linked together in many researches, there has been many controversies regarding the importance of international trade on economic growth (Obadan and Elizabeth, 2013). There is also little evidence existing in relation to the nexus between international trade and economic growth. Therefore, this study examine the causality between international trade and economic growth in selected sub-Saharan African countries, the impact of international trade and economic growth in the selected Sub-Saharan African countries.

### 2. Literature Review

Several studies that have contributed to a better understanding of the economic growth of the selected sub-Saharan African countries by identifying the role of international trade and corruption none of which have examine the link between the three. This study therefore fills the gap in literature by examining the nexus between international trade, corruption and economic growth in selected sub-Saharan African countries.

Egunjobi (2013) examined the impact of corruption on economic growth in Nigeria, it made use of time series data from 1980-2009 by using the regression analysis. It was discovered that as corruption increased it reduced the foreign direct investment and the expenditure on education also reduced. The study recommended policies to reduce corruption by creating incentives to encourage honest behaviour and penalties for corrupt practices

Mazin (2019) investigated the relationship between trade openness and economic growth using a panel data analysis on selected developing countries from 1998-2017. The empirical result shows that trade openness has no effect on economic growth, the policy recommended is that the government should focus on the development of this countries and that trade openness should be adopted but with adequate regulations.

Osabuohien (2011) analysed the impact of institutional framework on international trade performance in sub-Saharan African countries. The study made use of the fixed effects model and two-stage least squares technique for the period 1996-2008 using 34 selected sub-Saharan African countries. The result of the study showed that political institutions and financial institutions have positive relationships with international trade performance.

In a country study by Chitauro and Khobai (2015) on the impact of trade liberalization on the economic growth of Switzerland, the study made use of annual data from 1990-2014. The result of the Auto-Regressive Distributive Lag (ARDL) showed that there exist a positive relationship between trade openness and economic growth of Switzerland to test the existence of a long run relationship among the variables.

Rahman and Mamun (2016) investigated the energy use, international trade and economic growth nexus in Australia. This research employs econometric techniques like the Auto-regressive distributed lag bounds testing approach of co-integration, the granger casualty test and impulse response functions. This study finds the evidence of no long-run co-integration between the variables of interest. The Granger causality test confirms bidirectional causal relationship between international trade and per capita GDP growth, but does not find any Granger causal relationship between energy use and per capita GDP growth.

### 3. Methodology

This study adopted the endogenous growth model to examine the impact of international trade and corruption on the economic growth in the selected Sub-Saharan Africa countries because it allows for policy variables in the economic growth equation. A typical production function in the endogenous growth model is specified as: Y=f(A, K, L) (1)

Y=f(A, K, L)Where, Y=Output (gross domestic product (GDP), K=Physical capital input, L=Labour capital input.

Given the theoretical relationship, the model is specified as:

GDP=f (EXP, IMP, CC, TLF, GFCF)

Where f= functional relationship, GDP=Gross domestic product, Exp=Export, IMP=Import, CC=Control of corruption, TLF=Total Labour force, GFCF= Gross fixed capital formation.

(2)

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The linear equation is expressed as

 $GDP_{it} = \alpha_0 + \alpha_1 (EXP)_{it} + \alpha_2 (IMP)_{it} + \alpha_3 (CC)_{it} + \alpha_4 (TLF) + \alpha_5 (GFCF) + \epsilon$ (3)  $\alpha_0$  represents the intercept of relationship in the constant

 $\alpha_1$  to  $\alpha_6$  represents the coefficient of export, import, control of corruption, total labour force and gross fixed capital formation,  $\epsilon$ =stochastic variable or the error term, i= country and t=time trend

From equation 3, the constant of the model and the coefficient of the independent variable are shown .All the variables in the model except from control of corruption are in log form. This study employed the use of a balanced panel data for analysis, the time period observed is from 2000-2019. The econometric methodologies used in this study are the Panel Unit-Root, Fixed effect model and the Granger Causality tests.

### 4. Results

## 4.1. Granger Causality

Testing of the hypothesis regarding causality between international trade and economic growth involved testing the hypothesis for causality between export and GDP and between import and GDP. This was because both exports and imports constitute international trade in the context of this study. The null hypothesis of the Granger causality test is there is no causality while the alternative hypothesis is that there is causality.

Hypothesis 1: Causalilty between International trade and economic growth.

### 4.2. Causality between Exports and GDP

Table 1 provides evidence of causality running from exports to GDP and not vice versa. This is because a statistically significant chi-square statistic (6.889) is obtained regarding causality running from value of exports (EXP) to GDP. The computed chi-square statistic is statistically significant at the 5% level of significance, this implies that export causes economic growth through the generation of revenue from goods exported thus contributing to the GDP. On the contrary however, the chi-square statistic of 0.04308 for causality running from GDP to exports is insignificant at the 5% level of significance.

Causality	DF	Chi-Sq	P-Value	Decision
EXP→GDP	1	6.889	0.000	Causality
EXP←GDP	1	0.04308	0.836	No Causality

Table 1. Granger causality test between exports and GDP, authors computation (2021)

### 4.3. Causality between Imports and GDP

Table 2 provides no evidence that import causes GDP or GDP causes imports. The chi-square statistic regarding causality in either direction between imports and GDP is statistically insignificant at the 5% level of significance. This suggests that import does not cause the economic growth neither does GDP cause import.

Table 2. Granger causality test between imports and GDP, authors computation (2021)							
Causality	DF	Chi-Sq	P-Value	Decision			
IMP→GDP	1	0.00658	0.935	No Causality			
IMP←GDP	1	0.45632	0.499	No Causality			

Table 2. Granger causality test between imports and GDP, authors computation (2021)

In conclusion, it was found that only exports causes GDP for the selected sub-Saharan African countries reflecting that the causality between exports and GDP is uni-directional. Imports does not cause GDP, and neither does GDP cause imports.

Hypothesis 2: Causality between Corruption and Economic Growth

Table 3 provides evidence that there is no causality running from control of corruption to GDP or GDP to control of corruption. In conclusion the F-statistic regarding causality in either direction between control of corruption and GDP is statistically insignificant at the 5% level of significance. This implies that the presence of control of corruption in this selected sub-Saharan African country does not translate into higher economic growth in their economy and economic growth does not cause control of corruption in those economy.

Table 3. Granger causality test between corruption control and Economic Growth, authors computation (2021)

(	Causality	DF	Chi-Sq	P-Value	Decision
(	CC→GDP	1	0.09750	0.9072	No Causality

In summary, it was discovered in this study that there is no flow of causality between import as a component of trade and economic growth among the selected Sub-Saharan African countries which contradicts the findings of Owolabi-Merus, Odediran, Inuk (2015) that found that economic growth Granger cause Import. The lack of causality between import and economic growth shows that import does not cause economic growth neither does economic growth cause import that the two variables are independent of each other. Also, it was revealed in the results of the study that there is a uni-directional causality between export and economic growth in the selected sub-

Saharan African countries, this implies that export causes economic growth, but economic growth does not cause exports. This finding was supported by Hailegiorgis (2012) whose result showed an evidence of uni-directional causality between export and economic growth. Control for corruption reduces embezzlement of money, bribery, nepotism and misallocation of resources. This study provides evidence that there is no causality running from control of corruption to GDP or GDP to control of corruption. Yapatake, Abeid and Ngaba (2017) supports the finding there is no bi-directional relationship between control of corruption and economic growth as the two variables are independent of each other.

This study carried out fixed and random effect analysis as well as Hausman test on the data. The result of the Hausman test indicated the validity of fixed effect method of estimation result over the random effect. Table 2 shows that the estimated panel data fixed effects regression has a high goodness of fit as the R-squared of the model is 0.9564 which implies that 95.64% of changes are explained by the estimated model. Hence the estimated model is valid and may therefore be interpreted.

Furthermore table 4, a one percent rise in exports will result in a 0.25 percent increase in GDP. Thus, exports as a component of international trade is important for economic growth of sub-Saharan Africa countries. This is in line with the findings of Otinga (2009) and the view of the International monetary fund (IMF) who believe that developing countries should focus on export led growth. A one percent rise in imports will also result in a 0.320 percent increase in GDP which implies that imports as a component of international trade is important 32 percent increase in economic growth. This finding was in line with the results of (Okenna and Adesanya, 2020; Azeez, Dada, Aluko, 2014; Ratombo, 2019) who found that import has a positive relationship with GDP. The endogenous growth theory also posits that developing countries can benefit from international trade by importing superior technologies and other resources from foreign markets which will result into increase of domestic competition and productivity.

Table 4. Panel Data Fixed Effects Estimation of the impact of International Trade and Corruption on Economic G	rowth,
authors computation (2021)	

Dependent Variable: Log GDP				
Independent Variables	Coef.	Std. Err.	Т	P- Value
С	-10.312	2.038	-5.06	0.000
Log EXP	0.254	0.0696	3.65	0.000
Log IMP	0.320	0.0788	4.06	0.000
CC	0.455	0.0917	4.96	0.000
Log TLF	0.830	0.162	5.12	0.000
Log GFCF	0.348	0.0659	5.28	0.000
R-Squared: 0.9564				
F Statistic (5, 90) = 590.95			P-value	= 0.0000
No. of $Obs = 100$			No. of Count	tries: 5

Control of corruption has a statistically significant coefficient of 0.455 which indicates that a one percent rise in control of corruption will result into 0.455 percent increase in GDP. This supported the findings of Yapatake, Abeid and Ngaba (2017). This implies that effective control of corruption is crucial to the economic growth of sub-Saharan African countries because the presence of corruption in the economy disrupts investment, trade, and other economic activities which in turn affects economic growth adversely thus an effective control of corruption helps to ensure accountability and transparency across all sectors in the economy which helps promote their economic growth. Furthermore, a one percent rise in total labour force will result into a 0.830 percent increase in GDP. Therefore increase in total labour force is important for the economic growth of selected Sub-Saharan Africa countries. This supported the findings of Ogundimu (2019) that total labour force has a positive impact on economic growth. A one percent increase in gross fixed capital formation will also lead to a 0.348 percent rise in GDP. This is in line with the findings of Matthews and Adegboye (2014) which showed that gross fixed capital formation has a statistically significant impact on economic growth. The implication of this result is that when there is a fall in capital it will result into a fall in investment in the SSA countries.

### 5. Conclusion

This study has exhaustively covered the main objective which is to determine the effects of international trade and corruption on economic growth of selected sub-Saharan African countries. It was discovered that international trade, control of corruption, total labour force and gross fixed capital formation have positive relationship with economic growth.

The presence of good trade policies and effective control of corruption is important for the economic growth of these selected sub-Saharan Africa countries. Thus, in order to achieve sustainable development goal 17 which emphasizes international trade for inclusive growth to occur in any country, this study recommends that necessary steps should be taken by the government to promote international trade and combat corruption for the attainment of continuous economic growth and advancement in these countries.

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# Corporate Entrepreneurship in the Pursuit of Sustainable Development: Creating a More Sustainable Future

# Przedsiębiorczość korporacyjna w dążeniu do zrównoważonego rozwoju: w kierunku zrównoważonej przyszłości

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## Abstract

In recent times, the world has faced environmental challenges like deforestation, Global warming, soil erosion, water pollution, air pollution, and water scarcity. In order to solve the stakeholder demands and challenges, business houses must find answers. Companies must incorporate sustainability into their operations and operate with an entrepreneurial attitude. Sustainably oriented business operations may help firms reduce negative environmental impacts while simultaneously creating shared benefits for themselves and society, called sustainable corporate entrepreneurship. Such entrepreneurial activity helps an organization to achieve sustainable development goals. This research analyses the importance of sustainable corporate entrepreneurship in attaining the United Nations' Sustainable Development Goals in a developing country like India through a case study methodology. The study integrates several aspects of sustainable innovation concerning various areas of sustainable development goals. Further Implications, Limitations, and future research directions have been considered.

Key words: corporate entrepreneurship, sustainable innovation, Sustainable Development Goals, India Slowa kluczowe: przedsiębiorczość korporacyjna, zrównoważone innowacje, Cele zrównoważonego rozwoju, Indie

### 1. Introduction

Deforestation, Global warming, soil erosion, water pollution, air pollution, and water scarcity all provide problems and challenges in the natural environment. The corporate sector must come up with answers to these challenges in the face of rising demands and pressures from many stakeholders (Lober, 1998; Miles et al., 1999; Menguc and Ozanne, 2005; Tseng, & Tseng, 2019). Researchers have argued that significant corporations should adopt sustainable business strategies to decrease negative environmental consequences while offering social and economic benefits. (Cohen and Winn, 2007; Miles et al, 2009; Schaltegger and Wagner, 2011; Atiq, & Karatas-Ozkan, 2013). Companies may engage in sustainable corporate entrepreneurship by taking an entrepreneurial approach to their sustainable business operations, which can help them decrease their adverse environmental effects while also producing shared value, which implies a value for themselves and society. In order to enhance both general social welfare and company profitability, Corporate entrepreneurship must be understood and implemented in practice. Further, in today's competitive economic climate, a focus on innovation alone is insufficient for long-term success. Environmental awareness, social effects, and economic factors all pressure businesses to contribute to long-term sustainability. When an innovation focuses on both environmental and social problems, it is referred to as sustainable innovation. Moreover, Sustainability-oriented innovation (Adams et al., 2016) and socio-ecological innovation (Edgeman and Eskildsen, 2014) are examples of this sort of innovation. These innovations do not aim to maximize any single dimension(Hall et al., 2012), but rather aim to find a solution that meets all three dimensions, namely the economic, environmental, and social (Elkington, 1997).

Further, The role of innovations in increasing sustainability is one of the main topics that has been addressed by the Sustainable Development discourse (Silvestre and Silva, 2014a). This is because innovations are constantly changing the external world and the way of life (Huisingh et al., 2013). They are critical components for implementing sustainability in companies supply chains, organizations, neighbourhoods, regions and nations. So, sustainability should be approached through innovative methods (Silvestre, 2015b).

Researchers, industry experts, and government officials all agree that sustainable innovation is a good idea. This is because, It is an urgent issue that needs rapid action and adjustments from authorities, corporations, and society (Mulder, 2007). As a result, academics, business leaders, and policymakers have started paying more attention to Sustainable Development (European Union, 2014; United Nations, 2016).

Furthermore, there is a lack of research about how corporate entrepreneurship may contribute to the Sustainable Development Goals and how their implementation would affect enterprises. This is due to various factors, including the recently announced Sustainable Development Goals and the rapidly increasing and changing global economic, social, and environmental issues (Apostolopoulos et al., 2018). To overcome the complexity of these global issues, corporate entrepreneurship can act as a catalyst for change. So, the present study investigates the importance of corporate entrepreneurship by analyzing the case of Indian conglomerate Tata and sons regarding its sustainable innovation, popularly known as one form of corporate entrepreneurship. This article explores and illustrates how corporate entrepreneurship leads to sustainable development goals. The study's purpose is followed by a literature review on Corporate entrepreneurship, Sustainable Innovation, and Sustainable Development Goals. The following section explains the methodology, followed by the Tata and Sons case study. Finally, the findings, conclusions, limitations and future research directions of the study are also discussed.

### 2. Literature Review

### 2.1. Corporate Entrepreneurship

Many scholars have researched the concept of corporate entrepreneurship (Huse et al., 2005; Morris et al., 2010; Amore et al., 2013; Sharma and Chrisman, 2007; Tian and Wang, 2014; Bai et al., 2016). Vesper (1984) defined corporate entrepreneurship as an employee initiative from below to undertake something new. The subordinates innovate without being asked, expected, or even permitted to do so by superiors. It is the creation of new goods and markets. Entrepreneurial organizations create more manufactured innovations and markets than usual. (Jennings & Lumpkin, 1989).

Further, Chung & Gibbons (1997) defined Corporate entrepreneurship as an organizational process for transforming individual ideas into collective actions by managing uncertainties. It is a type of proactive behaviour that can stimulate desired innovation using formal and informal activities (Kuratko, 2012). It is also a vision-led, organizational dependence on enterprise conduct, which deliberately and continually revitalizes the organization and defines its activities' scope through recognizing and utilizing entrepreneurial opportunities. (Ireland et al., 2009) Institutional learning is a key component of corporate entrepreneurship, helping employees to analyze markets and develop new products. (Zahra et al., 1999; Zahra, 2015; Tseng, & Tseng, 2019). In addition, corporate entrepreneurs may be encouraged by creating an environment of support and encouragement, providing intra-capital for corporate entrepreneurs, and reducing organizational borders to allow top management help.

According to Han and Park (2017), corporate entrepreneurship is defined as transforming an existing firm, creating a new business organization, and invention. To summarise, corporate entrepreneurship plays a role in distinguishing between a first mover and a latecomer. So, corporate entrepreneurship plays a critical role in inspiring sustainable innovation and thus accomplishing Sustainable Development Goals.

#### 2.2. Sustainable Innovation

Sustainable innovation and economic performance have become increasingly important in the previous five years. (Aghion et al., 2009). The corporate sector has made sustainability a priority. Several historically significant forces contribute to this interest. Firstly, the world faces numerous long-term issues, such as population ageing, climate change, pollution, desertification, water scarcity, and critical raw material shortages (Boons et al., 2013). Secondly, the global economic environment has shifted into a multipolar period with new competition rules. Traditional policies that have governed international competitiveness are quickly changing. Leading economies and entrants to global markets have acquired not only the know-how for cost-driven competitiveness, but they have also become creative in conventional and high-tech industries (Contractor et al., 2010). Firms and regions aim to differentiate themselves to become leaders in world trade through innovation and intelligent specialization (Foray, 2009). Lastly, following the economic collapse of 2007-2008, governments in numerous advanced economies can no longer rely on the electorate's trust and legitimacy in policy objectives to secure social welfare and employment. The increased active involvement of stakeholders prompted organizations to embrace sharing their duties in contributing to the social environment and minimizing the negative influence on natural environments in parallel with profit production (Miles et al., 1999; Klassen and Whybark, 1999; Fombrun et al., 2000). Sustainability is defined as adopting business methods that benefit the environment, society, and economy in the long run. As a result, the three components of sustainability are environmental responsibility, social duty, and economic responsibility. It

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involves the process, product, management method, and policy orientation adaptation and modification (Silvestre, 2015a; Silvestre, & îrcă, 2019). Although the phrase *sustainable innovation* has gained popularity in recent years, few scholarly definitions are available (Boons et al., 2013). It may be defined as *innovation that improves sustainable performance* in ecological, economic, and social considerations (Carrillo-Hermosilla et al., 2009).

Moreover, from idea generation to research and development (R&D) and commercialization, sustainable innovation is a process in which environmental, social, and economic sustainability problems are included into company operations. This is true for new products, services, and technologies, as well as new business and organizational structures (Charter and Clark, 2007; Charter and Tischner., 2017). The researchers suggested that sustainability considers three factors: monetary income, the environment, and society. Rantala et al. (2018) discovered that prioritizing the economic part of sustainability increases the likelihood of adopting sustainable technologies.

Similarly, Przychodzen and Przychodzen (2018) found various firm-level features that distinguish and contribute to sustainable innovation. The study concluded that environmental innovations are significantly and statistically related to sustainable innovation activities. Furthermore, according to Bos-Brouwers (2009), sustainable innovation is *the improvement or renewal of goods, services, and processes that improves not only economic performance but also improves environmental and social performance in the short and long term.* 

Moreover, corporate entrepreneurship plays a crucial role in fostering sustainable innovation in organizations, and the existence of innovation provides a path to the marketplace by transforming ideas into viable goods (Coakes et al., 2011).

### 2.3. Sustainable Development Goals

Economic, ecological, and social advancements all contribute to sustainable development. However, the capacity to optimize these advances is heavily reliant on the availability of technology, innovation methods, and the institutional circumstances established by government policies. In various academic disciplines, including business and management, research on the Sustainable Development Goals has begun to develop (Annan-Diab and Molinari, 2017; Storey et al., 2017; Schaltegger et al., 2017). In 1982, The term sustainable development originally appeared in the World Charter for Nature in United Nations. In addition, the term *triple bottom line* is identified as social, environmental, and economic factors (Elkington, 1998). These three components of the sustainability vision were reiterated in 2002 at the Johannesburg Sustainable Development Conference. In addition, the Open Working Group at the U.N. General Assembly in New York created the Sustainable Development Objectives (S.D.G.s), a collection of global goals and targets that include 17 goals and 169 targets. Their goals include ending poverty and hunger, building peaceful communities, empowering women, and protecting the environment. The S.D.G.s outline global development goals through 2030, and they are critical for tackling the global economic, social, and environmental issues that communities confront.

In policy circles, these S.D.G.s are frequently referred to simply as *The Global Goals*. Even though they are intergovernmental obligations, the S.D.G.s have quickly gained support and importance among players outside the 193 united Nations member states who jointly endorsed them, including public policy agencies, N.G.O.s, and other public and private sector organizations. The S.D.G.s promote Government and private sector actions to stimulate economic growth in innovative and creative ways. These S.D.G.s are interdependent and, in some ways, inseparable (Le Blanc, 2015; Nilsson, Griggs, & Visbeck, 2016; Apostolopoulos et al., 2018). Corporate entrepreneurial activities typically address many S.D.G.s (Urbano, Aparicio, & Audretsch, 2018). Further, This study seeks to identify and develop the energizing benefits of committing to a Sustainable Development Goal framework in influencing corporate policy and activity.

#### 2.4. Corporate Entrepreneurship and Sustainable Development Goals

Sustainable corporate entrepreneurship has gained popularity as a viable strategic option. It is identified under the name of ecopreneurship, social entrepreneurship, sustainable innovations, and the hypothesis that entrepreneurship linked to sustainability fosters some future ideas and contributes to long-term development (Schaltegger, 2002; Dean and McMullen, 2007; Patzelt and Shepherd, 2011; Shepherd and Patzelt, 2011; Schaltegger and Wagner, 2011; Murthy & Naidu, 2012; Luke and Chu, 2013; Ruebottom, 2013; Belz and Binder, 2015; Jolink and Niesten, 2015; Smith and Woods, 2015; Provasnek et al., 2017)

Further, it is defined as the existence of considerable innovation in the firm's products, processes, strategies, domain, or business model, as well as evidence of all three sustainability components – responsible environmental management, social accountability, and long-term economic success (Miles et al., 2009). Moreover, it is a type of entrepreneurship that develops inside existing businesses, although it may also be used for new businesses.

Corporate entrepreneurship positively affects one of the vital pillars of the Sustainable Development Goals identified as pro-environmental behaviours. Since Employee psychological empowerment is increased due to corporate entrepreneurship, and as a result, employees create more new, valuable, and practical ideas (Lumpkin, Cogliser, & Schneider, 2009; Park, Choi, & Kim, 2012; Swoboda and Olejnik, 2016; Teece, 2014). Their values may be transformed into pro-environmental behaviours through corporate entrepreneurial skills, which provide a dynamic element to the process. As a result of such proactive and risk-taking company culture, workers participate in pro-environmental behaviours (Bierwerth et al., 2015).

Several researchers have identified approaches that foster sustainable corporate entrepreneurship. (Saha and Darnton, 2005; Glavič and Lukman, 2007; Steiner, 2008; Baumgartner, 2011; Schaltegger et al., 2012; Zollo et al., 2013; Provasnek et. al, 2017). For example, Miles et al. (2009) offer a new paradigm for corporate entrepreneurship called sustainable corporate entrepreneurship, which acknowledges the need for firms to be ecologically and socially responsible while being entrepreneurial. The term sustainability entails social responsibility, environmental management, and economic performance. Each of these aspects of sustainability should be given equal weight, and none of them should be prioritized above the others. Following sustainability principles may lead to new lucrative opportunities for the Company and value creation for all stakeholders. It is defined as actions seeking innovative methods to create goods, services, or processes while openly managing economic, environmental, and social obligations (Miles et al., 2009; Shepherd and Patzelt, 2011; Schaltegger and Wagner, 2011; Provasnek et al., 2017). Similarly, Atiq & Karatas-Ozkan (2013) also offers a sustainable entrepreneurial conceptual framework that integrates a business mindset with environmental considerations. The researcher states that an entrepreneurial mindset should drive a sustainable business strategy to produce shared benefits for both the firm and society.

Further, Cheema et al. (2020) found corporate entrepreneurship as a moderating factor in one of the Sustainable Development Goals, namely pro-environmental behaviour. The study has done over a sample of 479 employees and 122 department managers from different hotels in Pakistan. The author concluded that there is a moderate link between pro-environmental behaviour and corporate entrepreneurialism.

Furthermore, Menon and Menon (1997) and Varadarajan (1992) characterized sustainable corporate entrepreneurship as *enviropreneurial marketing*. It is defined as an innovative culture integrating environmental concerns with marketing strategy goals. Enviropreneurial marketing is defined as *the process of formulating and implementing entrepreneurial and environmentally beneficial marketing activities to create revenue by providing exchanges that satisfy a firm's economic and social performance objectives*, It aims to enhance a company's reputation while both boosting sales and profit. They argue that corporate entrepreneurship promotes environmental marketing because it involves risk and demands proactiveness and innovation.

Further, Lober (1998) defined sustainable corporate entrepreneurship as 'environmental entrepreneurship,' defined as *the development of new goods, services, or organizations in response to commercial possibilities in the environmental sector*. It requires the Company to be proactive and helps it to gain a competitive advantage. The launch of new goods that meet environmental performance requirements and thus stakeholder expectations is one of the most prevalent kinds of environmental entrepreneurship.

Similarly, Miles et al. (1999) defined sustainable corporate entrepreneurship as *enviropreneurship*, which uses entrepreneurial skills and behaviours to discover environmental possibilities. They argue that by engaging in enviropreneurship, a company may build a strong reputation and competitive advantage.

According to Miles and Covin (2000), stakeholders such as governments, consumers, and strategic partners are increasingly pressuring businesses to enhance environmental performance and minimize pollution. Furthermore, customers expect high-quality products that adhere to environmental regulations, and strategic partners seek out firms that adhere to these regulations. As a result of all of these considerations, firms are compelled to engage in environmental marketing in order to increase their reputational advantage, which may lead to improved financial and market performance (Gago and Antolin, 2004)

Similarly, Menguc and Ozanne (2005) identified sustainable corporate entrepreneurship in the name of the natural environmental orientation (N.E.O.) as a higher-order concept covering three components viz.: entrepreneurship, corporate social responsibility, and environmental sustainability. When it comes to developing new and creative products for green markets, the author argues that using an entrepreneurial strategy will help the Company achieve its goals.

In terms of environmental factors and Sustainability, Dean and McMullen (2007) describe sustainable entrepreneurship as *the process of finding, analyzing, and utilizing economic possibilities that exist in market failures that detract from sustainability, particularly those that are environmentally relevant*. The authors argue that entrepreneurs with an environmental emphasis may capitalize on environmental-related market failures by combining two disciplines, entrepreneurship and environmental economics. As a result, they may benefit from such mistakes, minimize negative environmental consequences, and shift markets toward sustainability by exploiting such flaws. Similarly, Pacheco et al. (2010) defined Sustainable entrepreneurship as *the discovery, production, assessment, and exploitation of possibilities to generate future commodities and services that are consistent with Sustainable Development Goals*. Only when individual and social objectives are aligned within the larger economic environment, they believe, can sustained entrepreneurship takes place. The benefits of sustainable entrepreneurship include improved brand image and reputation and more significant sales and profitability. Based on the above literature review following model has been developed:



Figure 1. Model of the research

### 3. The Objective of the Study

The study's objective is to investigate the Sustainable Development Goals in Indian conglomerate Tata and sons by sustainable corporate entrepreneurship through the case study approach.

### 4. Research Methodology

The current study used a qualitative research approach by the case study research technique to investigate the Sustainable Development Goals in Tata and sons. The case study is the most commonly utilized approach in qualitative research (Yin, 1984; Barnes, 2001). According to Yin (2014), A case study is a research approach used to understand a complex issue in its real-world setting. It is a well-established research strategy, especially in the social sciences. It may be used to describe events in the context of daily life.

Moreover, Case studies can use an embedded design, which means that many levels of analysis can be conducted inside single research (Yin, 1984). Thus, it enables researchers to preserve real-world events' holistic and significant human life cycles, organizational and management processes, neighbourhood changes, international relations, and industry development (Yin,2013). Furthermore, case studies may be utilized to accomplish a variety of goals, including providing description (Kidder, 1982), testing theory (Pinfield, 1986; Anderson, 1983), and generating theory (Gersick, 1988; Harris & Sutton, 1986).

### 5. Tata & Sons Group Initiatives

The Tata group, founded by Jamsetji Tata in 1868 and headquartered in India, is a worldwide conglomerate with 30 firms spanning ten industries. Tata Sons is the Tata Group's primary investment holding firm and promoter. The Philanthropic trusts of the Tata group own 66% of Tata Sons' equity share capital, which supports education, health, livelihood generation, and art & culture. The group operates in more than 100 countries on six continents, with the purpose to *increase the quality of life for communities worldwide via long-term stakeholder value generation based on Leadership with Trust*. Tata enterprises collectively generated \$106 billion in revenue in 2019-1920. These firms jointly employ approximately 750,000 people. Each Tata company or enterprise works autonomously, with its board of directors guiding and supervising it. As of August 31, 2021, 28 publicly traded Tata companies with a total market capitalization of \$300 billion (Livemint, 2021). These companies include Tata Steel, Tata Consultancy Services, Tata Chemicals, Tata Motors, Titan, Tata Consumer Products, Tata Advanced Tata Power, Systems Tata Capital, Tata Communications., and Indian Hotels

### Case 1. 'Gaon Chalo' Initiative for Rural Livelihood<sup>1</sup>

T.G.B.'s (Tata Global Beverage) *Gaon Chalo* initiative began in 2006 in northern India's Uttar Pradesh. It is a rural distribution method that encourages people to sell Tata Tea in their communities. This enabled the Company to cope with the final step of rural distribution while also increasing rural revenue. *Gaon Chalo* is presently available in 18 Indian states, reaching 70,000 villages.

In this rural distribution approach, channel partners such as rural distributors, rural mobile distribution partners, and rural traders played an important role. The product was sold at large shops, wholesale outlets, and local haats, among other places. It also took N.G.O. presence in rural Uttar Pradesh to identify rural businesses and supply rural merchants. The Tata Tea was subsequently provided to the project affiliates at pricing to make good M.R.P. profits. Additionally, the initiative partnered with Self-Help Groups in order for it to be more effective and penetrate deeper into society.

Tata Global Beverages promotes its mass-market brands, including *Kanan Devan and Chakra*, as part of the *Gaon Chalo* campaign. Tata Global Beverages promotes its mass-market brands, including *Kanan Devan and Chakra*. As a result, Tata Tea's rural market share grew from 18% to 26.66%. Further, The rural stores were easily accessible, and sales fluctuated less. It also offers an effective platform for establishing brand recognition and handling the intricacies of local markets. As a result, Tata Tea now has 20,000 retailers in 10,000 villages. The concept was created by a sales team member and was driven by the steering committee, aiming to increase the rural market and generate revenue for rural stores.

### Case 2. Global Stem Skills Crisis: Inspiring Tomorrow's Engineers

A programme called *Jaguar-Land Rover-Inspired Tomorrow's Engineers* promotes students to learn about STEM (Science, Technology, Engineering, And Mathematics) subjects and participate in them. The initiative encourages young people to choose engineering and manufacturing jobs through a partnership with schools and universities. It is essential to encourage talented youth to become the next generation of technicians and engineers to solve the lack of skills. This will allow organizations to meet their long-term business requirements.

The global scarcity of freshly trained engineers has been a severe problem for the automobile sector. In order to inspire young people to pursue professions in engineering and manufacturing, Jaguar Land Rover created the *Inspiring Tomorrow's Engineers* programme in 1998. Education centres, classroom exercises, and fieldwork were

<sup>&</sup>lt;sup>1</sup> All cases were discussed after materials from the Internet page: www.tatasustainability.com.

all part of the programme, reinforcing learning in a real-world context. Further, Students were also encouraged to participate in STEM challenges, build and race cars, and simulate actual engineering processes as part of the curriculum. However, The implementation of key aspects is currently underway in schools throughout the world. The project's outcomes are favourable. There are currently 2.9 million young people participating. The 165,000 students worldwide participated in STEM challenges outside of the U.K. J.L.R.'s employability initiative drew 200 jobless young people from the U.K. and Brazil, and many of them now work for J.L.R. or in the car sector. Since 2014, 50 young people who took part in *Inspiring Tomorrow's Engineers*, including 30 women, have joined J.L.R. A growing number of nations, like Australia and South Korea, provide STEM challenges to students. The United Kingdom is one of the most popular countries to offer STEM challenges. Further, Global participation in an online STEM challenge programme was boosted by using the cloud. In addition, the Company uses education centres to support additional programmes to assist jobless youngsters and retired military people in preparing for career prospects.

### Case 3. Development of a Model Village

The model Tribal Village Development Project was created by Rallis India Ltd. In order to achieve this, the project seeks to establish a sustainable eco-system in which everyone has access to basic infrastructure, livelihood opportunities, government benefits, capacity-building, economic progress, education, excellent health, and other essential resources that will enhance their amount of happiness and well-being. Furthermore, Rallis believes that social development should be participatory and demand-driven. Therefore, a baseline study was conducted to understand better the difficulties that tribal villages face and the prospects for development. Then, with the community's help, a committee was created to execute the village's priorities and survey findings. Such Prioritization was done based on a third-party requirement assessment to complete critical projects in three years.

Rallis decided to electrify the community with renewable energy, remove suspended silt from the existing check dam for drinking and irrigation water, implement watershed projects and build individual toilets and bathrooms for all households to end open defecation. The villages will also contribute 20% of Shramdaan's budget as part of the participatory approach.

As a result, Villagers have access to clean drinking water after the first year of intervention, and they may borrow water for 12 months for home and agricultural usage. In addition, street lights have been installed, and households have access to power. As a result, open defecation loads have decreased significantly, resulting in better health effects. Following the success of the Rallis Hybrid system, the government has begun roadwork and agreed to supply power to the community. Moreover, Pukka homes have increasingly replaced existing hutments.

The project's actions are based on an expert-led evaluation of community needs. Beneficiaries took ownership of the project through *Shram Daan*, which offered services for community work and maintained the infrastructural development. In addition, several projects focused on specific components such as agricultural modernization, water, healthcare and hygiene power, and education and awareness-building activities were established as part of an integrated development plan that addressed a wide range of community needs.

### Case 4. Smart Water Solutions: Smart Engineering and Science

Voltas Water Solutions (V.W.S.) declared in 2014 that it would meet the country's rising water and sewage treatment needs. Voltas Ltd. and Dow Chemical Pacific (Singapore) Pvt. Ltd. have a 50:50 joint venture called Voltas Water Solutions (V.W.S.). In order to fulfil this promise, V.W.S. has expanded its product line to include packed R.O. purified water, skid-mounted water treatment systems, and packaged sewage treatment facilities.

They are using V.W.S.'s G.E.T. S.E.T. R.O. is one of the most secure ways to obtain purified drinking water. It may be used in offices, schools, and urban infrastructure. When compared to household water purifiers, it is distinguished by high water recovery using FILMTECTMRO components, resulting in little wastage. As a result, it is a more cost-effective and ecologically friendly alternative. The Sewage Treatment Plants are planned to provide a cost-effective water reuse option.

They are also designed to meet the strictest physical and biological criteria for reusing water in washing, cleaning, and gardening. The advantages include compactness, energy efficiency, ease of installation, economy, durability, and almost no odour. The Water A.T.M. is a coin or smart card controlled dispenser that may provide clean drinking water cheaply when linked to any water source. This water vending machine is intended for use in urban and rural areas where safe drinking water is not readily available. In addition to providing maximum output and performance, the new V.W.S. devices have been developed to have the smallest footprint in their class, making them space and cost-efficient. The Voltas Water Smart Monitoring App and web access via P.C.s or tablets allow users to monitor the system from any place.

Men and women can save time obtaining water from the Water A.T.M. This Water A.T.M. provides communities and public areas with a safe, long-lasting, and secure source of purified drinking water. In addition, V.W.S. seeks to provide dependable, long-term, and branded solutions in a market dominated by unorganized companies. As a result, V.W.S. Point Of Entry is a great alternative to bottled water in commercial and institutional environments.

India has mandated that corporations spend at least 2% of their annual earnings on corporate social responsibility (C.S.R.) for the first time globally. In addition, most N.G.O.s and corporate social responsibility programmes work together to improve health results through Corporate Social Responsibility efforts in water and healthcare. V.W.S. began its Water A.T.M. programme in this spirit, intending to provide rural areas with an accessible and affordable supply of clean drinking water. Within the Tata group, there is a big chance to expand this project in-house.

### Case 5. Big: Beautiful is Green

This initiative demonstrates Tata Housing's dedication to environmental excellence across its value chain. As a result, Tata Housing accounts for over a third of India's eco-friendly buildings, with 55 million square feet of the total 1.55 million square feet.

Tata Housing's initiatives include the design and production of green goods recognized by the Indian Green Building Council/LEED that optimize the use of resources like cement, water, steel, and electricity while building properties utilizing cutting-edge technology. At its offices and project locations, Tata Housing tracks its carbon impact. The energy-efficient certified Bureau of Energy Efficiency lights, solar lighting, drought-tolerant plant types, appropriate landscape irrigation, and rainwater collection are some of the ways to lower carbon footprint. Furthermore, The Company also supports ecological balance by protecting soil, utilizing local resources, recycling, employing wind turbine ventilators, and scheduling light-off times. In addition, to reduce its carbon footprint, the Company uses air conditioners set at a comfortable temperature, rail travel rather than flying, carpooling, and video/audio conferencing, among other things. Furthermore, to decrease its carbon footprint, the Company is planting trees and establishing green zones around its facilities. In addition, Many conservation projects have started with World Wildlife Fund-India, including Red Panda Protection and Nature Wake Up.

The initiative saves 54 million gallons of water and decreases carbon emissions by 1,593 tonnes. Moreover, these recycled components of materials account for at least 20% of the overall cost of the materials. In producing green goods, It was awarded the Golden Peacock Eco-Innovation Award. Further, It actively tracks carbon emissions at all projects, sets carbon reduction objectives per square foot, and educates consumers about the benefits of green buildings.

### Case 6: A Value Chain With a Closed-loop

After reviewing its vehicle's life cycle, Jaguar Land Rover (J.L.R.) has effectively adopted the circular economy concept. The REALCAR (Recycled Aluminum Car) is a project that focuses on creating a closed supply chain. J.L.R. partnered with its primary supplier (Novelis) to develop a one-of-a-kind closed-loop method. Rather than joining the typical aluminum recycling system, J.L.R. sold scrap metal from automobiles back to the source. In addition, J.L.R. ensured project flexibility, allowing additional sub-innovations to be explored as independent initiatives.

Third-party organizations such as the government and industry associations can provide the necessary support to enable such innovation. Further, Senior stakeholders also have provided unwavering support and advocacy for the programme. Moreover, The dedicated stakeholders fostered Fresh thinking and fresh ideas.

Due to REALCAR, Novelis has cut its greenhouse gas emissions by 13%. In addition, Jaguar Land Rover's closed-loop recycling facility in the United Kingdom collected roughly 30,000 tonnes of press shop aluminum trash. Consequently, the Company saves up to 95% on energy by using recycled aluminum instead of raw aluminum.

### Case 7: Hisarna – Looking to the Future

The World Steel Association recently ranked Ijmuiden (Netherlands) as one of the world's most carbon-efficient steelworks. At the IJmuiden plant, the energy needed to create a tonne of steel has decreased by 31% since 1989. Tata Steel keeps improving operating efficiency, but reducing  $CO_2$  emissions on a large scale is thermodynamically difficult. So, The chemical steel manufacturing process in a conventional blast furnace employs carbon as a reducing agent. The laws of physics eventually preclude future substantial improvements in  $CO_2$  efficiency for blast furnace technology. However, Tata Steel has recognized the need to invest in cutting-edge technologies that will significantly increase  $CO_2$  efficiency in steel production.

Tata Steel proved that the Company is a crucial player in ULCOS, a European-wide project to minimize carbon emissions in the steelmaking process. In 2010, IJmuiden received a  $\in 20$  million Hisarna pilot plant. The furnace streamlines the blast furnace process considerably since fine raw materials may be handled directly without agglomeration. Iron ore and coal are actively converted into iron using Hisarna's cyclone converter-based ironmaking technology. Its energy-efficient manufacturing process can cut CO<sub>2</sub> emissions by 20% compared to a blast furnace. It should be feasible to achieve CO<sub>2</sub> reductions of up to 80% when combined with carbon capture and storage systems. It can also take advantage of lower-cost raw resources. The second phase of the ULCOS project is underway. The goal is to show that it can be done on a big scale in an industrial setting. In the second phase, Tata Steel will assess the process's suitability for removing zinc from zinc-coated scrap steel. In 15 to 20 years, this technology might play a significant role in creating a low-carbon circular economy.

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number	Development Goal	Company	Case Study	GOAL INI AUD	Cot pot ate Entrepreneurship Initiative	ACSUL
1	No Poverty	Tata Global Beverages	Gaon Chalo' Initiative for Rural Livelihood	1. Income 2. Employment	Innovative ideas of the sales team	The No poverty Sustainable development Goal ends proverty. It can be achieved through increase employement. The Tata Global Beverages increase employment through its innovative rural distribution strategy. As Corporate Entrepreneurship is implemention of innovative ideas within the organization. The slaes team of ata Global Beverages provide such innovative idea through which Sustainble Goal No. 1 can be achieved.
4	Quality Education	Jaguar Land Rover	Global STEM Skills Crisis: Inspiring Tomorrow's Engineers	<ol> <li>Promoting STEM- related</li> <li>Promote social mobility</li> <li>Actively recruiting talent</li> </ol>	<ol> <li>Engaged passionate people</li> <li>Global growth</li> <li>Employee Training for innovative performance</li> </ol>	The Goal No. 4 is quality education which is Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all. This goal is implemented by Jaguar Land Rover through its 'Inspiring Tomorrow's Engineers': initiative which encourages learning and participation in STEM (science, technology, engineering, and math) disciplines. By such learning the organization Engaged passionate people and provide Employee Training for innovative performance. By this initiative the organization create corporate entrepreneurial culture through sustainable development goals.
9	Clean Water and Sanitation	Rallis	Development of a Model Village	<ol> <li>Ensure socially disadvantaged groups' equality</li> </ol>	Frugal innovation	Clean Water and Sanitation Sustainable development Goal Ensure availability and sustainable management of water and sanitation for all. The Rallis create a sustainable eco-system in which everyone has access to basic amenities/infrastructure. This is one type of Frugal innovation which can be achieved through the corporate entrepreneurial culture.
6	Industry, Innovation and Infrastructure	Voltas Water Solutions	Smart Water Solutions: Smart Engineering and Science	<ol> <li>Safe drinking water for the community</li> <li>Less wastage of water</li> </ol>	1. Innovation 2. Resource efficiency	Goal No. 9 is Industry, Innovation and Infrastructure which is Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. The Voltas Water Solutions provides the Safe drinking water for the community with Less wastage of water through Smart Water Solutions. This is the corporate innovation can be acheived through Resource efficiency that helps to achieve the sustainable development goals.
11	Sustainable Cities and Communities	Tata Housing	BIG: Beautiful Is Green	<ol> <li>Green buildings</li> <li>Clean energy systems</li> <li>Conserve biodiversity</li> </ol>	1. Innovation 2.Cost Reduction	The Sustainable Cities and Communities goal Make cities and human settlements inclusive, safe, resilient and sustainable. Tata Housing implement a innovative program under the named BIG: Beautiful Is Green for the development of Green buildings, Clean energy systems that helps the Conservation of biodiversity. This is the innovative low cost trategy which can be achieved only through the corporate entrepreneurship initiatives.
12	Responsible Consumption and Production	Jaguar Land Rover	A Value Chain with a Closed Loop	<ol> <li>Environmental benefits</li> <li>Resource conservation</li> </ol>	<ol> <li>Environmental Innovation</li> <li>Cost Reduction</li> </ol>	Goal No. 11 is Responsible Consumption and Production that Ensure sustainable consumption and production patterns. The Jaguar Land Rover develop a A Closed Loop Value Chain that benefits the environment through Resource conservation. Such . Environmental Innovation through Cost Reduction is an example of corporate entrepreneurship initiatives within the organization.
13	Climate Action	Tata Steel	Hlsarna – Looking to the Future	Reduced CO2 emissions	1. Innovation	Climate Action is the Taking urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy. Tata Steel through its corporate innovation strategy reduced CO2 emissions in its manufacturing process on Ijmuiden (Netherlands) plant. It is an example of achieving sustainable development goals through corporate entrepreneurship.
15	Life on Land	T ata Global Beverages	Sustainable Beverages	<ol> <li>Forest management that is environmentally friendly</li> <li>Product effect reduction</li> <li>Optimise resource utilisation</li> </ol>	1. Environmental innovation	Goal no. 15 is Life on Land which is Protection, restoration and promotion of sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reversing land degradation and halt biodiversity loss. The corporateentrepreneurial culture of the Tata Global Beverages develops Sustainable forest management by Reduction of product impact and Optimization of resource efficiency

Table 1. Summary of the research

The collaborative approach can achieve such corporate innovation strengthened and made more result-oriented by pooling resources and knowledge. Further, the appropriate mix of talents improved development. Moreover, Out-of-the-box thinking and tenacity are essential elements for success.

### Case 8. Sustainable Beverages

For many years, Tata Global Beverages (T.G.B.) has been committed to sustainably obtaining raw teas. T.G.B.'s goal is to acquire teas from growers worldwide who adhere to high social and environmental standards. In 1997, they joined the Ethical Tea Partnership (E.T.P.) as a founding member to accomplish this goal. As a result, by 2016, T.G.B. will only acquire Tetley-branded teas from Rainforest Alliance Certified farms in Europe, Middle East, Africa, Canada, Australia, and the United States. Also, in India, they are founding members of the Trustea project, a multi-stakeholder effort coordinated by the Tea Board of India that aims to sustain reform the Indian tea business.

Tata Global Beverages has launched the Sustainable Plant Protection Formulation project to create environmentally friendly plant protection solutions for tea. The initiative partners with three Tata companies: Tata Chemicals, Tata Global Beverages, and Rallis, to develop and implement environmentally friendly tea plant protection solutions. The project aims to create a commercially viable portfolio of tea-specific SPPFs while identifying environmentally acceptable pest management solutions in Indian tea estates.

The project's outcomes, Independent third-party certifications, Integrated pest management (I.P.M.), Farmer Field Schools are educational opportunities for farmers. It supports the employment of non-chemical approaches such as biological, cultural, physical, mechanical, and chemical ways to battle tea pests. In addition, it Encourages farmers to use I.P.M. and decrease pesticide use by educating them on sustainable agriculture practices and certifications.

T.G.B. convinced them through Farmer Field Schools, which allow farmers to develop their course material and learn by experience on demonstration plots. In addition, the Company used a *Train the Trainer* strategy, in which a group of designated lead farmers were trained and then went on to teach a smaller subgroup. Tata Global Beverages is a founding partner in the Tea Board of India's Trustea initiative, aiming to improve India's tea industry sustainably. By 2017, the project hopes to generate 500 million kg of tea through 600plus firms and enhance the lives of 500,000 tea plantation employees and 40,000 smallholders.

### 6. Conclusions

This section highlights the most important conclusion from the analysis. First, the authors examined all 17 S.D.G.s and discovered a relationship between them and corporate entrepreneurship. Only some of them related to corporate entrepreneurship. Second, the authors examined the Tata conglomerate's numerous cases in the context of sustainable development and established their link with corporate entrepreneurship. The author found that out of 17 S.D.G.s, only nine S.D.G.s related to corporate entrepreneurship. These 8 S.D.G.s are viz. *No Poverty; Quality Education; Clean Water and Sanitation; Industry, Innovation and Infrastructure; Sustainable Cities and Communities; Responsible Consumption and Production; Climate Action; Life on Land.* 

Further, the author found that these S.D.G.s can only be possible due to the innovative organizational culture and Management support. Therefore, corporate entrepreneurship is essentially required for attaining the S.D.G.s. Table 2 summarizes the findings.

The paper established the theoretical link between S.D.G.s and corporate entrepreneurship through case studies. Corporate entrepreneurship has been highlighted as a critical component in attaining the S.D.G.s. It illustrates how entrepreneurial activity may address various economic, social, and environmental issues globally and locally. Or-ganizations must prioritize sustainability in their stated vision and mission to achieve sustainable development goals through corporate entrepreneurship. For example, the organization's vision and strategy are essential at that level since they will guide its decisions. In addition to management's vision and foresight, an entrepreneurial culture must exist across the Company. Sustainability must be integrated into business operations and combined with an entrepreneurial mindset to produce shared value. Moreover, Entrepreneurs see sustainability as an opportunity rather than a burden imposed by the government and society.

The study adopted the case study approach, which is different from the empirical research. It has some limitations. For research purposes, case studies are less desirable than empirical research. Furthermore, one specific criticism of case studies is that they lack a solid foundation for generalization. In other words, a single case study cannot be used to generalize something (Yin, 2013). A future study might use a grounded theory method to conduct interviews with managers about corporate entrepreneurship towards S.D.G. achievement since the article focuses on a single company, Tata and sons. As a result, the generalizability of our findings is restricted. Comparative research in the context of other Companies might be used to learn more about it.

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# **Circular Economy as a Model of Achieving Sustainable Development**

# Gospodarka o obiegu zamkniętym jako model osiągania zrównoważonego rozwoju

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# Abstract

The essence of the concept of circular economy was determined. The processes of transition to a circular economy are analyzed, as a result of which three levels are distinguished: efficient use of materials; product life extention; smart production and use of products. The connection between the circular economy and sustainable development was implemented. The main business models of the circular economy are considered: Resources recovery, Sharing platforms, Product life extension, Product as a service, Circular suppliers. Strategies and tools of circular economy are developed. The world experience of waste utilization is considered.

Key words: circular economy, model, sustainability, sustainable development, Sustainable Development Goals Slowa kluczowe: gospodarka o obiegu zamkniętym, model, zrównoważoność, rozwój zrównoważony, Cele zrównoważonego rozwoju

# Introduction

The circular economy is a new economic and environment-oriented concept that harmonizes between economic growth and environmental sustainability, creates new opportunities for prosperity and is the main driver for achieving the goals of sustainable development of society.

The depletion of non-renewable resources, which has become a global problem for humanity, is accompanied by serious environmental and social consequences, and the irrational use of resources and products leads to significant economic losses. Therefore, it is advisable to move to a more sustainable economic model – the circular economy. The transition to a circular economy cannot take place quickly enough, as its implementation requires a thorough modernization of production and a certain rethinking of environmental problems. Based on the principles of resource recovery, prevention and reduction of waste and reuse of used products, it should be the basis for improving environmental and economic conditions and ensure sustainable development of the country.

### Literature review

The idea of a circular economy is a relatively new concept, and therefore scientists express their own vision of the content and objectives of a circular economy. According to Carrez D., Van Leeuwen P. (2015), the closed-loop economy is designed to change the classical linear model of production, focusing on products and services that minimize waste and other types of pollution. Investigating the essence of the concept of circular economy, scientists Kirchherr J., Reike D., Hekkert M. (2017) found a large number of definitions that describe this concept. In his generalized researchers used R-typology and received ten *R*: recover, recycle, repurpose, remanufacture, refurbish, repair, reuse, reduce, rethink, refuse. They formulated their vision of the circular economy as an economy that provides a number of value creation mechanisms that are separate from the consumption of limited resources; in a circular economy, growth comes from within, which increases the value derived from existing economic structures, products and materials. It is noted that the philosophy of closed-loop economy seeks to return as much material as possible back into the production cycle, in contrast to the linear model, which always ends in waste.

Bastein T., Roelofs E., Rietveld E., Hoogendoorn A. (2013) define the circular economy as an economic and industrial system based on the reuse of products and raw materials and the renewable capacity of natural resources to minimize destruction of value in the whole system and maximize value creation in each link of the system. Zvarych I. Ya. (2017) believes that the circular economy distinguishes between economic growth and the use of natural resources and ecosystems, emphasizing the effective use of these resources.

Anisimova G.V. (2018) emphasizes the problem of the balance between economic growth and the use of resources through which such growth is provided. According to Deineko L.V. and Tsyplitskaya O. O. (2018) the introduction of a circular economy should be based on basic market laws – in the absence of demand for recycled waste and products, it loses its economic viability.

Suetnov E.P. and Lazebna A.V. (2020) indicate that in order to implement a circular economy in the context of the sustainable development goals it is advisable to be fully inclusive and to ensure that everyone has access to the benefits of such development. In a true circular economy, each entrepreneur is a separate link in a chain that forms a circle in which there are no redundancies (10 Key Indicators for Monitoring..., 2017).

Shkurenko O.V. (2021) believes that the circular economy as an innovative platform for sustainable development is focused on reducing the amount of resources used, the introduction of reuse or closed production cycle, modernization and renewal, recycling, visualization of products to ensure a long life cycle.

Zvarych I. Ya. (2019) proves that an inclusive circular economy solves two global problems: waste disposal and overcoming poverty, which are the consequences of human life. The scientist proves the existence of global recognition that the system in which we live was developed with a narrow economic approach, and its expansion through embedding other dimensions will encourage innovation. Vovk O. B., Voitsekhovskaya V. V., Zagoretskaya O. Ya., Lesyk L. I., Pashkevich V. Z., Simak A. V. (2019). consider the problems of the circular economy by studying the process of waste disposal and utilization.

We can note that the methodological approaches that form the basis of the circular economy are not new. The modern circular economy concept follows from the research of scientists in the field of ecological economy, which was studied by Costanza R., de Groot R., Sutton P., Ploeg S., Anderson S. J., Kubiszewski I., & et al. (2014), economy of nature management Cherevko G.V., Cherevko I.V., Vasylenko N.I. (2012) and others. Therefore, the main essence of the circular economy is the economic use of all types of resources. According to Geissdoerfer M., Savaget P., Bocken N., Hultink E. (2017) in a comprehensive inclusive circular economy, growth should be based on human capital and not instead of extracting natural resources.

The purpose of the research. The purpose of the article is to substantiate the theoretical, methodological foundations and develop conceptual approaches to the theoretical, methodological and practical support of the circular economy, considered as a model of achieving sustainable development goals.

Research methodology. In the article both general scientific and economic methods of cognition were used: logical, inductive, deductive, tabular methods of interpreting information, methods of analysis, due to which the essence of the concept of circular economy was determined, the connection between the circular economy and sustainable development was proved, conclusions were formulated.

Results. The concept of *circular economy* arose to address such important issues as lack of resources and environmental degradation. It emerged in the early 1990s with the implementation of the Sustainable Development Strategy. The circular economy is a component of the ecological economy and aims to maintain the value of products and resources for as long as possible by returning them to the production cycle while minimizing waste generation, while reducing the eco-destructive impact of man on the environment.

Ecological economics has a number of principles: environmentally friendly business; ensuring sustainable development; expediency of approval of ecological lifestyle; circularity, etc. The direction of the ecological economics should focus on achieving certain goals of sustainable development. By 2030, the world's countries aim to achieve 17 Sustainable Development Goals, some of which are closely linked to circular practices (table 1).

The transition to a closed-loop economy (circular economy) is global, according to experts from the Ellen
MacArthur Foundation (2015) in 2025, the circular economy can provide annual revenue growth of more than 1 trillion dollars. In addition, the transition to a circular economy will create huge opportunities for modernization of production and implementation of industrial innovations, providing an annual GDP growth of 7%. Three levels of transition processes to a circular economy can be divided: the efficient use of materials; product life extention; smart production and use of products (Figure 1).

 Table 1. The relationship between sustainable development goals and circular practices, developed by the authors based on

 The Goals of Sustainable Development of Ukraine (2019) and UN Sustainable Development Goals (2015)

Sustainable Development Goals	Circular practices
Goal 6.	Fine water treatment, sustainable sanitation, wastewater treatment,
Ensuring accessibility and sustainable management	water reuse and recycling, nutrient recovery, biogas systems, etc. can
of water resources and sanitation	help increase access to safe drinki-ng water and fair sanitation, reduce
	pollution and improve water quality
Goal 7.	Renewable energy systems, including second generation low biomass
Providing access to low-cost, reliable, sustainable	and biofuel technologies, energy recovery (heat) and improved use in
and modern energy sources for all	industrial systems
Goal 8.	Circular business models are a major potential source of efficiency
Promoting sustainable, inclusive and sustainable	and resource efficiency, waste valorisation and green jobs
economic growth, full and productive employment	
and decent work for all	
Goal 12.	The implementation of a circular economy is a separation of economic
Ensuring the transition to rational models of	activity from the use of resources and related environmental impacts
consumption and production	and society
Goal 15.	The practice of circular economy is based on the restoration of natural
Protecting and restoring terrestrial ecosystems and	capital, which involves the adoption of sustainable and restorative
promoting their sustainable use, sustainable forest	agricultural and agroforestry methods that cover and protect
management, combating desertification, halting and	biodiversity and return biological material back to the soil as nutrients
reversing the land degradation process	– practices that are essential for restoring terrestrial ecosystems.
and halt the loss of biodiversity ecosystems.	



Figure 1. Analysis of processes at the levels of the circular economy, developed by the authors based on Ellen MacArthur Foundation (2015); Accenture (2015)

The circular economy proposes the use of business models that can increase the resource and energy efficiency of production and consumption of goods, as well as to reduce the negative impact on the environment.

The main tools of the circular economy model based on the principles of sustainable development are ecological innovations and *environmentally friendly* technologies. Companies can choose any business model. Consider the basis of business models classified by specialists of Accenture (Accenture Strategy, 2015).

Resources recovery model is based on the use of technological innovations to recover and reuse resources and helps to eliminate the loss of these resources by reducing waste and increasing the profitability of production from reverse flows. This model can be useful for companies that produce large amounts of by-products and have the ability to effective recover and recycle waste.

Sharing platforms are designed to promote platforms for interaction between users of the product, which helps to increase the level of its use. This model is most suitable for companies that have not fully used capacity or low utilization of the product.

Product life extension model ensures the preservation or improvement of the product through repair, modernization, reconstruction or restoration. It is most suitable for industrial equipment manufacturers.

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Product as a service is a model in which customers use the alternative of buying a product, providing it for use, for example, through a lease or lease agreement, and thus increases the incentive to create a product with a longer life cycle.

Circular suppliers – this model provides the supplier with delivery of resources that are completely recycled or biodegradable.

We will reveal in more detail the content of each of the approaches, as well as list some companies that use this approach (table 2).

Approach	Description	List of companies
Circular Suppliers	Provides the supplier with fully recyclable or biodegradable	Ford, Fairphone, 3D Hubs,
	resources that are at the heart of the circular production and	Desso,Toyota, Cisco
	consumption	
Recovery Resources	Helps eliminate resource losses due to waste generation and	Coca-Cola, Maersk, Michelin,
	increases the profitability of production from returned flows	Philips, Walt Disney World
		Resort
Sharing platforms	Used to promote platforms for interaction between product users,	Patagonia, BlaBlacar, Nearly
	individuals or organizations	NewCar, BMW, Drivy, Daimler,
		Lyft
Product life	Provides for the preservation or improvement of a used product	Bosch, Caterpillar, Volvo,
extension	through its repair, modernization, reconstruction or restoration	Renault, Apple, BMA
		Ergonomics, Michelin
Product as a service	An alternative to buying a product, providing it for use, for	Rolls-Royce, Mud Jeans,
	example, through a lease, etc., which increases the incentives to	De Kledingbibliotheek
	create durable products, extend its life cycle	

Table 2. Business models of the circular economy at the micro level, developed by the authors based on<br/>Pakhomova N. V., Richter K. K., Vetrova M. A. (2017)

The introduction of innovative business models can be aimed both at the modernization of the existing model of the company, and in the case of new startup projects, the development of a fundamentally new business model. Companies implement the common principles of the circular economy through different strategies and tools (Figure 2).



Figure 2. Strategies and tools of circular economy, developed by the authors

The circular economy involves not only responsible management of resources and the introduction of innovative technologies into production, but also the rational waste management. Solving waste management problems is the first step towards a circular economy, one of the tasks of which is to focus on the introduction of innovative technologies in the production, development and implementation of low-waste and non-waste technologies. The circular strategy and policy of enterprises should be based on the best practices of the EU and the world in the field of circular economy and bioeconomy. Research in recent years has shown the significant potential of the *circular* economy to improve the global climate. The circular economy model, where the value and life cycle of resources are maintained for as long as possible and waste generation is minimized, reduces the pressure on natural resources and thus stimulates the decarbonisation of the world economy.

In 2020, the European Commission adopted an Action Plan *Circular Economy Action Plan*, which aims to reduce consumption in the EU and double the reuse of resources in the coming decades, while contributing to economic

growth.

Today raw materials are becoming increasingly scarce, energy is becoming more expensive and, at the same time, the amount of waste is growing. In addition, pollution of soil, air and water poses a risk to sustainable development worldwide. Less than 10% of consumed materials are processed. Problems of waste disposal are exacerbated by changes in the structure of consumption, industrial development and urbanization. Many developing countries have faced the challenge of improving waste management.

Let's focus on the world experience of waste disposal. Based on the analysis of literature sources, we systematize the different approaches in table 3.

Table 3. World experience of waste disposal, systematized by the author on the basis of Recyclemag (2021)

Country	Disposal approaches
Germany	Germany is one of the world leaders in the volume of recycled waste. 66% of garbage is reused. The
	reason for such a large share of recycled waste is that Germany is one of the leaders in waste generation
	and already in the 80's all landfills were overcrowded. Therefore, the government of this country has
	obliged producers to label goods according to the category of waste. The introduction of collateral
	value of packaging, multi-colored containers for waste of different types contribute to waste disposal
	processes. Campaign work also played an important role. For Germans, it is a civic duty to help sort
	garbage.
USA	In the United States, one of the first interested in waste management - in 1895 in New York opened the
	world's first center for waste management. But full-fledged work with waste began only in the 2000s.
	The main prerogative of the government during these years was propaganda work. The Garbage
	Recycling Festival was introduced, on the day of which the results that most contribute to waste
	recycling are summed up and awarded. Extensive propaganda work is carried out in schools, there are
	special hours of volunteering. Also, the United States has introduced separate garbage disposal (waste
	that has been sorted by the owner is removed free of charge). As in Germany, there is a collateral cost
	of packaging. Innovative technologies of waste processing and disposal should be noted.
China	Waste recycling processes have also intensified in China in recent years. First of all, it should be noted
	the country's significant potential in this area – China has a large number of recycling plants. At this
	stage, the government promotes recycling by introducing a fee for separate waste. For example, for a
	couple of dozen bottles you can enter the subway for free. The government plans to impose fines for
	unsorted garbage. Also, waste recycling is facilitated by special garbage collectors, who buy it from
	ordinary people and resell it to special institutions. Campaigning work is implemented to a lesser
	extent.
Japan	In Japan, the problem of waste recycling is especially relevant given the area of the country. But the
	approaches used are quite unique. Extensive propaganda work is not necessary due to the peculiarities
	of religion (Shinto) and the worldview of the Japanese, for whom excessive waste of goods is a sin,
	because all earthly goods are given by heaven. The division of waste into 4 categories is quite unusual:
	suitable for incineration, unsuitable for incineration, suitable for recycling, large. Violations of
	recycling rules may be imposed on the entire housing cooperative. State-of-the-art technologies are
	used in processing and incineration. Unusual measures are also used, for example, in some cities
	garbage cans are intended only for certain categories of garbage and therefore have specific holes. In
	general, Japan is one of the world leaders in waste disposal.
United Kingdom	For a long time, the UK was an outsider in waste disposal. But in recent years the situation has
	improved significantly. Waste sorting system introduced. The government has chosen a slightly
	different strategy for campaigning. All violations of waste sorting rules are punishable by significant
	fines. To violations include even the excess weight of waste. All disposable polyethylene packages
	became paid. Food for which the expiration date has not yet expired is collected separately and sent to
	specialized dormitories, canteens for the poor and other similar establishments.

As we can see, different countries have different approaches to waste disposal. But we can identify several features that are common to the countries:

- waste sorting by different categories;

- special garbage collection points;

- collateral value of packaging;
- stimulating the extension of the service life of goods;
- educational and information campaigns.

So, it is important now to prevent waste from entering uncontrolled landfills and illegal dumps, burning in the open, as this leads to the release of greenhouse gases that deplete the ozone layer and damage the climate. In addition, it is necessary to suspend the entry of waste into waterways, because they cause significant damage to flora and fauna and enter the human food chain (Establishing Waste Management, 2021). According to the World Bank, 33% of the world's 25% of all waste is disposed of in illegal and official landfills, respectively. Only 13.5% of waste is recycled and 5.5% is composted, and 11% is incinerated (Figure 4).

Governments are increasingly recognizing the risks and costs of landfill disposal and sustainable waste management practices. The Slovak company Sensoneo, which offers smart waste management services, has

developed the Global Waste Index, which ranks 36 member countries of the Organization for Economic Cooperation and Development (OECD) according to the efficiency of their waste management. per capita through indicators such as waste generation, recycling, incineration, official and illegal landfills (Sensoneo Global Waste Index, 2019) (table 4).

According to The Global Waste Index 2019, the largest amount of waste was generated by such countries as the United States (5), Denmark (4.72), New Zealand (4.17), Canada (3.96), Switzerland (3.96).



Figure 4. Share of waste disposal methods in 2019 (%), built by the author according to the World Bank Global Picture of Solid Waste Management 2020

Table 4. OECD ranking of the Global Waste Index in 2019, (points), compiled by the author based on data from The Global Waste Index 2019

		Volume of	Recycling of waste	Incineration of	Waste on	Final
No	Country	waste generated		waste	landfills	index indicator
1	South Korea	0,45	3,79	0,36	0,40	100,00
2	Sweden	1,39	2,66	0,92	0,02	93,09
3	Japan	0,32	0,32	1,11	0,03	92,48
4	Switzerland	3,96	4,11	1,36	0,00	89,14
5	Netherlands	2,00	2,30	0,99	0,05	87,43
6	Germany	3,22	5,51	0,79	0,01	87,32
7	Finland	1,97	2,61	0,96	0,40	87,18
8	Belgium	0,96	2,56	0,73	0,03	85,44
9	Norway	1,08	2,01	0,89	0,10	84,97
10	Poland	0,00	0,00	0,15	0,87	84,74
11	Denmark	4,72	3,88	1,67	0,06	84,43
12	Czech Republic	0,29	1,60	0,22	1,15	82,22
13	Australia	2,48	4,29	0,22	1,88	80,85
14	Iceland	3,45	6,67	0,12	3,31	80,10
15	Luxemburg	2,96	3,14	0,85	0,76	80,01
16	Hungary	0,71	1,82	0,21	1,39	79,32
17	France	2,02	2,08	0,70	0,89	79,10
18	Portugal	0,73	1,14	0,38	1,53	75,48
19	Austria	2,58	2,66	0,85	0,11	73,77
20	Great Britain	1,55	2,32	0,61	0,75	72,60

According to The Global Waste Index 2019, the largest amount of waste was generated by such countries as the United States (5), Denmark (4.72), New Zealand (4.17), Canada (3.96), Switzerland (3.96). The ranking of countries for waste recycling is led by Iceland with a score of 6.67, and for waste incineration – Denmark (1.67), as shown in table 5.

Table 5. Rating of OECD countries on recycling and waste incineration compiled by the author according to The Global Waste Index 2019

Country	Recycling, (points)	Country	Incineration, (points)				
Iceland	6,67	Denmark	1,67				
Germany	5,51	Switzerland	1,36				
USA	5,10	Japan	1,11				
Australia	4,29	Netherlands	0,99				
Switzerland	4,11	Finland	0,96				

As a result, the final value of the Global Waste Index is the highest value for South Korea (100), 93.09 for Sweden, 92.48 for Japan, 89.14 for Switzerland and 87.43 for the Netherlands.

In its Environmental Performance Reviews, the OECD examines a number of policy instruments that are being introduced for waste and material management. Thus, the following policies can be used to develop waste management, such as:

- 1. Regulatory tools
  - linking regulatory instruments to economic instruments and raising awareness to build strong policies (Prohibition of landfills in the Netherlands);
  - standardization of goods and services aimed at recycling and the circular economy (EU Waste Vehicles Directive);
  - Capacity building measures, where necessary to ensure the implementation of key bodies (municipal waste management reforms in Poland).
- 2. Economic instruments
  - full reimbursement of waste management costs for the implementation of the polluter pays principle (Netherlands, Norway);
  - ongoing improvement of prices for household waste management services to improve cost recovery and avoid detrimental incentives (Colombia);
  - use of the income received from the provision of household waste management services to build the capacity of municipalities to perform their waste management functions (Poland);
  - differentiation of disposal taxes depending on the environmental damage associated with different types of waste recycling (Norway);
  - the use of the fee for non-organic products hinders the use of environmentally harmful products (Hungary).
- 3. Extended producer responsibility (further EPR) tools
  - mechanisms of intermediary services for coordination of EPR;
  - certification of EPR to ensure compliance with environmental standards (Norway);
  - prepayment for the disposal of small waste streams for which the removal program will be too expensive (Korea);
  - consultations with stakeholders during the development of schemes and their ongoing activities to ensure the involvement of industry and relevant authorities (Netherlands);
  - landfill taxes for transformational changes in waste management.
- 4. Green public procurement
  - use of eco-labels for public procurement (Korea);
  - assistance to governments in reducing waste (Norway);
  - use of procurement as a tool for the circular economy: support for secondary goods and *circular procurement* (Netherlands);
  - monitoring of green public procurement in order to prosecute procurement agencies (Czech Republic).
- 5. Informing the public and raising awareness
  - inclusion of waste reduction and recycling in environmental education programs (Colombia);
  - encouraging and supporting the activities of non-governmental organizations to raise public awareness, such as cleaning activities (Estonia, Colombia).
- 6. Monitoring and reporting
  - comprehensive monitoring and reporting on waste generation and recycling to support policy development and revision (Norway);
  - introduction of modern information systems for tracking industrial and other waste (Korea);
  - elimination of information gaps to improve the understanding of international flows of materials for the production of goods (Japan, the Netherlands).

7. Promoting the implementation of legislative acts

- coordination mechanisms between executive bodies (Israel, Poland);
- promoting compliance in order to ensure awareness among polluters and waste management entities (Norway); and
- specialized units for the investigation and prosecution of waste management violations (Colombia, Norway) (Environmental Performance Reviews, 2017).

#### Conclusions

Thus, achieving the goals of sustainable development is possible through the transition to a circular economy, which aims to restore and rational consumption of resources. Unlike the traditional model of economic development, the circular model is the best way to conserve resources and materials, as it is based not only on efficient waste disposal, but also global environmental principles, which include recycling and reducing resource

use. Waste management plays a fundamental role, especially in developed and developing countries. The larger the population and the more developed the economic activity, the greater the amount of waste due to the traditional linear economic model. Appropriate waste management policies reduce the negative impact of waste on the environment.

The circular economy is an economic development strategy with appropriate legal and economic instruments, and its implementation is based on innovation. The introduction of the circular economy will have a positive impact on companies, consumers and society, as its goal is to improve the quality of life without excessive use of waste and natural resources.

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# International Tourism as a Tool of European Integration within Eastern European Countries

# Turystyka międzynarodowa jako narzędzie integracji europejskiej w krajach Europy Wschodniej

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#### Abstract

The article is devoted to researching the links between European integration processes and the development of national markets for tourist services. Particular attention was paid to the situation in international tourism in those countries that integrated with the EU in 2004 and 2007. In addition, the article discusses the main modern types of international tourism, as well as factors affecting its development. Finally, attention was also paid to identifying promising directions for the development of international tourism in Eastern European countries – potential candidates for accession to the EU (Republic of Moldova and Ukraine).

Key words: European Union, European integration, international tourism, international tourist flows, inbound tourism, forms of international tourism, prospects for international tourism Slowa kluczowe: Unia Europejska, integracja, turystyka międzynarodowa, międzynarodowy ruch turystyczny, turystyka przyjazdowa, perspektywy turystyki międzynarodowej

#### Introduction

Integration processes have always been and remain the most important tools for shaping the image of modern Europe. Strong foreign policy ties, economic partnership, diplomatic relations, scientific and technical cooperation. All this is the basis for the success of modern European countries. At the same time, despite the fact that the structure of the European Union as a whole can be considered formed, integration and disintegration (unfortunately) still continue. On the issue of disintegration, the rather ambiguous situation with Brexit should be noted, which potentially poses more threats than benefits for the United Kingdom. On the other hand, we see the motives behind the expansion of the European Union to the East.

Some of the Eastern European countries are now on the way to European integration and, in turn, are of certain interest to the European community. Moreover, such joint work to prepare for integration is already underway. It is not only about adopting reforms or framework laws, without which integration is impossible by definition, not about the derivation and maintenance of macroeconomic indicators to the level acceptable to the European Union, but various kinds of cooperation in different sectors of the national economy. However, not everything is so simple and unambiguous here either. Obviously, the countries of Eastern Europe, which are not members of the European Union, find it very difficult to compete with enterprises operating in accordance with European standards (Tatsyi et al., 2010). Moreover, it is difficult for them to compete not only on the external but also on the internal market. Therefore, it is too early to talk about full-fledged competition in the branches of heavy and light engineering, light and food industries, the agro-industrial complex in the field of high technologies.

At the same time, in our opinion, there is a rather specific sector of the national economy, which not only can develop in parallel (within the process of integration), not only can create powerful incoming and outgoing international financial flows. By one way or another, can indirectly stimulate the development of other sectors (Petrov

& Serdyuk, 2008; Prokopenko et al., 2019). We consider international tourism to be such an area. International tourism has given a powerful impetus to the development of almost all economies among the active European Union member states as well as countries that are also considering the possibility of European integration.

Today the French Republic, the Kingdom of Spain, the Italian Republic, the Hellenic Republic, the Portuguese Republic as well as the Republic of Malta, Republic of Cyprus have become real centers of recreational tourism, which makes it possible to develop both small and large businesses in these countries (Yaroshenko et al., 2018; Havierniková et al., 2017). Furthermore, countries such as Montenegro and the Turkish Republic receive great financial benefits from European tourists.

There are, indeed, some problems in this area. The particular interest for the development of international tourism introduces not the entire territory of the country but only certain of its regions. For example, due to the fact that Turkey has been a candidate for EU membership since 1999, the number of tourists who annually visit its territory has grown 4.5 times over 20 years (Number of international visitors..., 2021). More interestingly, the share of the total contribution of international tourism to Turkey's GDP in 1999 was 7.4%, and in 2001 it was already 15.5% (Turkey – Tourism..., 2021). Accordingly, the direction towards European integration yields colossal results for the development of tourism. At the same time, we know about the problems in this country. Economic development in Turkey is catastrophically uneven. Jobs exist mainly in tourist regions and are seasonal. Infrastructure is being built and also modernized in tourism centers.

We consider this situation unacceptable for the countries-potential members of the European Union since we see their potential not only in the field of recreational tourism but also in its other forms. From these foundations, we consider the determination of the main cooperation forms between the European Union and the countries of Eastern Europe, which would give the maximum economic effect, at least for the main territory of the country, an extremely urgent and important scientific problem.

Purpose of the article is to determine the role of European integration processes in Eastern Europe and highlight promising forms of international tourism, which would maximize the mutual economic effect of such cooperation.

#### Materials and methods

We decided to divide our research into 3 blocks.

**Block 1.** First, we decided to trace the connection between the dynamics of foreign tourists and the period of the country's de facto integration into the European Union. For this purpose, we decided to take 2 periods for research:

- 2004 enlargement of the European Union. The result of which was the entry into this economic and political union of the following countries: Hungary, Republic of Estonia, Republic of Cyprus, Republic of Latvia, Republic of Lithuania, Republic of Malta, Republic of Poland, Slovak Republic, Republic of Slovenia and the Czech Republic.
- 2007 enlargement of the European Union. This time, the structure of the European Union was replenished with the following countries: the Republic of Bulgaria and Romania.

In addition, in this case, we decided to use the hypothesis method. At the same time, **a hypothesis** was formed that: European integration processes have a quick positive effect on the dynamics of inbound tourism. In order to test this hypothesis, we posed a number of questions (Figure 1).



Figure 1. Questions that we set up before our research in order to test the hypothesis put forward (Authors` research)

As could be seen from Figure 1, we posed 5 questions to test the hypothesis. We propose to evaluate its validity according to the following principle (Table 1). We deliberately excluded from our research another rather curious task: *Is there a connection between the tourist specialization of a country, the process of its integration into the EU and the dynamics of inbound tourism?* We have raised this issue as a separate one since, in our opinion, it does not correlate with the goals of the hypothesis put forward. Therefore, this question should be set as the main goal

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of a separate study. However, we will try to offer certain conclusions. Further, when considering Block 2, we will conventionally call this question *Question 7*.

	Table 1. The principle of determining the reliability of the advanced hypothesis (Authors development).											
				Question	Pacult							
		1st 2nd 3rd		3rd	4th 5th		Result					
	1	Negative	Negative	Negative	Negative	Negative	The hypothesis is totally invalid					
	2	Positive	Negative	Negative	Negative	Negative	The hypothesis is generally invalid					

Negative

Negative

Negative

Positive

Negative

Negative

Positive

Positive

Table 1. The principle of determining the reliability of the advanced hypothesis (Authors' development).

To search for such connections and in order to check the hypothesis formed, we decided to analyze the growth rate in the dynamics of growth in inbound tourism to the countries, which were entered to EU in 2004 and 2007 (Table 2). In addition, we've been compared the results obtained with the dynamics of Ukraine and Moldova.

Table 2. The growth rate of inbound tourism in the countries admitted to the European Union during its expansion in 2004 and 2007, %, authors` research based on (Number of inbound overnight tourists..., 2021; Estonia, 2020; Hungary – Number of arrivals, 2021; International tourism..., 2021; Latvia, 2021; Poland – Arrivals of non-resident tourists..., 2021; Number of arrivals in tourist accommodation..., 2019; Slovak Republic..., 2017; Number of arrivals..., 2020; Tourism in Slovakia, 2021: Estonia, 2021: European Union, 2021).

-	,, _,																		
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	2004 enlargement of the European Union																		
1.	Estonia	0.7	3.8	0.5	2.4	3.2	4.0	2.6	0.2	14.0	12.3	2.0	14.6	1.2	-1.9	4.3	3.4	-1.8	1,2
2.	Hungary	3.5	-1.0	8.0	6.6	5.9	2.8	0.4	2.7	-1.8	3.5	5.5	0.1	5.4	5.1	9.4	3.9	4.9	6,5
3.	Cyprus	-12.2	-3.2	2.6	7.2	-1.1	1.6	-1.5	-9.9	3.4	7.2	0.3	-0.3	-2.6	8.7	18.2	14.1	7.3	2,3
4.	Latvia	11.5	9.9	23.9	21.2	22.6	12.0	5.5	-14.0	6.7	9.8	0.6	4.5	7.3	9.5	-0.7	13.7	0.6	7,3
5.	Lithuania	-4.7	-9.1	6.3	3.3	3.6	2.8	4.9	-10.3	1.8	10.6	10.5	5.7	-0.9	-3.2	5.4	5.0	9.4	0,6
6.	Malta	3.1	2.0	-5.6	3.9	2.5	13.3	6.3	-12.2	12.9	5.6	4.7	0.3	7.4	10.2	8.8	13.6	9.8	8,9
7.	Poland	-17.4	2.7	18.8	4.3	0.8	1.7	-9.5	-10.2	8.4	4.1	10.9	7.3	2.0	5.4	3.5	4.1	2.6	3,0
8.	Slovenia	6.8	5.5	9.2	3.7	4.0	8.3	11.8	-6.8	12.3	9.1	6.3	5.3	6.9	13.0	12.4	17.5	10.9	6,3
9.	Slovakia	19.0	4.8	6.1	76.1	24.7	5.5	7.7	-17.0	0.7	5.1	5.5	7.2	-7.8	16.1	15.4	7.1	3.7	14,2
10.	Czechia	0.9	5.2	18.4	3.9	1.4	-9.9	-3.4	6.6	-5.8	4.0	12.9	2.3	3.2	9.0	9.8	6.7	4.5	3,1
						2007	7 enla	rgeme	ent of t	he Eu	ropea	n Unio	on						
1.	Romania	-2.9	16.7	18.0	-11.5	3.4	27.9	14.8	-14.5	-1.0	1.5	4.3	1.0	5.3	10.5	9.6	6.9	7.3	9,3
2.	Bulgaria	9.0	12.2	11.9	4.3	3.0	3.0	10.4	-7.7	6.4	4.0	1.8	3.7	2.4	-1.0	13.8	9.4	6.7	1,5
Not members of the European Union. Countries of Eastern Europe																			
1.	Ukraine	7.7	18.5	22.6	10.3	6.0	20.5	10.2	-16.6	0.3	1.7	2.1	3.8	-49.2	-1.5	5.4	6.2	-1.6	-4,4
2.	Moldova	12.5	16.7	228.6	-2.9	-6.0	11.1	4.3	-17.8	6.7	17.2	18.7	7.4	-1.8	0.5	28.2	19.8	10.3	8,7
							Tota	al for	the Eu	ropea	n Uni	on							
	FII *	37	17	53	31	47	17	-0.8	-3.0	18	49	22	32	32	33	41	47	31	34

\* for the European Union, we took data on the number of domestic tourists. As we wanted to clarify how the new members are contributing to the development of tourism in general.

Let us explain the logic behind how Table 2 is built:

each number is a relative indicator that was obtained by calculating the growth rate using the following formula (Karpenko, 2019):

$$Gr(\%) = \frac{Y_c}{Y_c} \times 100,$$

where

Variant

4

5

Positive

Positive

Positive

Positive

Positive

Positive

Positive

Positive

Negative

Positive

Positive

Positive

 $Y_c$  – data for the current year, in units

Y<sub>p</sub> – data for the previous year, in units

- the basis for the calculation was the statistics of inbound tourism to each of the countries, in units (number of arrivals);
- highlighting is only relevant for rows. Since it shows how much the growth rate of inbound tourism changes every year. At the same time, the dark green color corresponds to the highest growth rate for the entire sample per country. Consequently, dark red corresponds to the lowest tempo
- also, it is necessary to explain why we have chosen only Ukraine and the Republic of Moldova among the countries of Eastern Europe. Firstly, these countries are not members of the EU; therefore, it makes sense to study the consequences for tourism during and after their European integration. Secondly, these are the countries that, in principle, strive for European integration. Since Ukraine signed an Association Agreement with

Very low quality of the hypothesis put forward Low quality of the hypothesis put forward

High validity in the hypothesis

The hypothesis is completely valid

(1)

the EU in 2014 (EU-Ukraine relations, 2021), the Republic of Moldova signed an Association Agreement with the EU in 2016 (Full entry into force..., 2016).

For the purposes of our research, we took into account exactly inbound tourism. Inbound tourism, in our opinion, is:

- stimulating the development of the country's infrastructure as a whole;
- development of new tourist routes and tourism goals;
- development of related industries within the national economy;
- the inflow of foreign exchange resources into the country's economy.

At the same time, outbound tourism largely depends on the macroeconomic situation in the country itself. In truth, a country that is going to enter or has already entered the EU is obliged to maintain target macroeconomic benchmarks (inflation rate, stability of the national currency), as well as political and social aspects at an acceptable level for the European Community. Not all of this can be achieved at the same time. Accordingly, outbound tourism, and specifically its dynamic growth, is a matter of comparably long prospect.

#### Results

Analyzing the data in Table 2, we came to the following conclusions according to the list of our questions distinguished in Figure 1 in order to check the hypothesis put forward:

 $1^{st}$  and the widest **question.** The accession of countries to the European Union as a whole has a positive impact on the dynamics of inbound tourism to the countries – its new members. Moreover, for some of them, it is quite tangible. In this aspect, the following countries should be characterized:

- Significantly, the Republic of Latvia is a leader among the growth in the rate of inbound tourism The growth rate of inbound tourism in the year of this country's accession to the EU increased by almost 2.5 times (from 9.9% for 2002-2003 to 23.5% for 2003-2004). The growth rate of 21-22% continued for another 2 years.
- Hungary generally had a negative pace a decline, before joining the EU (-1%). However, after that, she received a positive denomination: 8% for 2003-2004.
- The Republic of Poland and the Czech Republic represent quite a familiar situation. Before joining the EU, they showed a low but positive growth rate of inbound tourism: 2.7% and 5.3% in 2002-2003, respectively, but increased this rate to more than 18% in 2003-2004.
- A rather curious situation can be characterized for the Republic of Cyprus. Its tourism industry reacted to the country's accession to the EU with a lag of 1 year 2.6% in the year of accession and 7.2% the following year.
- The same situation is with the Republic of Malta. However, in the year of entry, it demonstrated a 5.6% reduction in inbound tourism, but the following year, this rate was already positive and amounted to 3.9%. In this aspect, it should be noted the Republic of Estonia, the statistics of the growth of inbound tourism which is very similar to the situation in Malta.

Separately, it is worth noting the situation with the countries that entered the European Union in 2007:

- The Republic of Bulgaria. Its inbound tourism industry reacted with growth with a lag of 1 year, from 3% in the year of entry to 10% the following year.
- Romanian inbound tourism has shown a significant increase in dynamics already in the year of EU accession. For the year, Romania received almost 28% more foreign tourists than last year.

The situation with the tourism within European Union, in general, is showing us quite an ambiguous situation. On the one hand, we see the increasing dynamics of domestic tourism after entering of new members (The EU accepted 5.3% of tourists more in 2004 than a year before). On the other hand, indeed, 5.3% is an insignificant increase in tourism, and it can be easily explained by other reasons (redistribution of tourist flows in the EU itself and the market situation).

The dynamics of tourism in 2007, after the next stage of expansion, looks even worse. This growth is characterized by only 1.7%, which, in addition, was exacerbated by the decline in the next two years.

It is indicative that for Ukraine, both years under consideration (2004 and 2007) are characterized by a significant increase in inbound tourism 22.6% and 20.5%, respectively. Moreover, these years differ significantly in growth rates with both subsequent and previous years. In the Republic of Moldova, the situation is generally the same. However, it is worth pointing out that in 2004, the inflow of inbound tourism to this country doubled.

 $2^{nd}$  question. Analyzing the data presented in Table 1, we can make an unequivocal conclusion that the effect is positive, at least for 1-1.5 years after entry. It is evidenced by statistics for all new EU members that joined it in 2004 and 2007. For the EU as a whole, this effect can hardly be considered positive since it is obvious that the pace of tourism will decrease slightly in the following years. However, such a decrease (on 30-40 thousand tourists) with a total number of 650 million can be considered within the margin of error.

 $3^{rd}$  question. From the obtained analysis, we see that the growth dynamics of inbound tourism is not only positive but also quite strong. Nevertheless, there is one nuance here. The dynamics of inbound tourism increases sharply either in the year of entry or in the next year. Further, the rates are leveled, made flatter.

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**4<sup>th</sup> question.** We understand that this issue is inextricably linked with the previous ones and is largely based on them. At the same time, it formulates the problem in a slightly different way. Suppose the previous questions spoke about the fact of interconnection, its character and strength. Then this question considers the reaction time of the tourism market is such a fundamental event in the history of an integrated country. Accordingly, the integrating countries need to prepare their infrastructure for a sharp increase in the number of tourists arriving in the year of obtaining EU membership and next year. If they do not take advantage of this short period and do not earn the status of a tourist center, it will be much more challenging to achieve this in the future.

 $5^{th}$  question. Here we can say that there are general trends in international tourism in the integration processes in addition to the periods of EU enlargement. Here we can say that there are general trends in international tourism in integration processes in addition to the periods of EU enlargement. It is evidenced by the results of the tourism sector between the EU members in the period 2008-2009. We see a sharp drop in tourist flows in 2009 (this is due to the aggravation of the consequences of the 2007 global financial crisis). On average, for the countries that joined the EU in 2004 and 2007, the decline is about 10%. However, here we can also note the existence of a lag (approximately 1-1.5 years) for individual countries. For example, if the drop in inbound tourism in the Republic of Slovakia, according to the results of 2009, was 17%, after which the growth began. That tourism to the Czech Republic in 2009 increased by 6%, after which it decreased by 5.8% in 2010.

The decline in the countries that joined the EU in 2004 and 2007 in the tourism sector in 2009-2010 changed to a slow-growth trend. However, it can also be considered a general trend. Conclusions which we've made based on assumed questions:

 $1^{st}$  question. The link between European integration and the dynamics of inbound tourism to the new member states generally exists. It is evidenced by the statistical data on the years of their entry. However, at the same time, this conclusion is blurred by the dynamics of growth in tourism to Ukraine and the Republic of Moldova, which at that time did not even have an association agreement. In addition, we see that the situation with the growth of tourist flows in the EU itself during this period cannot be considered significant. Therefore, we will assume that the answer to this question is positive.

 $2^{nd}$  question. All countries that have joined the European Union receive positive dynamics in terms of inbound tourism. Accordingly, we consider the answer to this question positive.

 $3^{rd}$  question. The fact of the country's accession to the European Union has a serious impact on the increase in tourist flows. Moreover, this increase occurs several times. Therefore, the answer to this question can also be considered positive.

**4**<sup>th</sup> **question.** Analysis shows that this lag is not just short; it is extra short. It is explained by the excitement of citizens of other included in the European Union countries. A new member country means new tourist destinations. It, in particular, forms the sharp increase in tourist flows that we analyzed within the previous questions. Moreover, according to the dynamics of the growth of inbound tourism for 2-3 years after integration, the efficiency of the tourism industry, the quality of its infrastructure, the diversity of tourist destinations can be judged. The answer to this question is also considered positive.

 $5^{\text{th}}$  question. This question confirms the correctness of the conclusions we made in the previous questions. We see that European integration has a fast, strong, but rather a short impact on the international tourism of the integrated countries. In addition, we see that since tourism is harmonized within the EU, the negative changes in the financial and economic climate in the world have a parity effect on these countries. It could be considered a negative fact. However, at the same time, tourism begins its growth also on a parity basis. Not so much and not so fast, but we have confirmed this fact. Therefore, we will also consider the answer to this question positive.

Based on the data obtained during the analysis and the conclusions that we made on their basis, we can assess the correctness of our hypothesis (Table 3). The result of testing the hypothesis is put forward in Figure 1.

Tuble 5. The festil of testing the hypothesis put forward carrier (Fathors' development)											
				Decult							
		1st	2nd	3rd	4th	5th	Result				
Variant	6	Positive	Positive	Positive	Positive	Positive	The hypothesis is completely valid				

Table 3. The result of testing the hypothesis put forward earlier (Authors' development)

We see that all the answers to the 6 questions posed are positive. It means that the hypothesis put forward by us is fully confirmed and valid and that there is a link between European integration and the dynamics of the tourism market in countries that are integrating with the EU. This connection is positive, strong and rapid.

**Block 2.** At this stage, we decided to pay more attention to the forms of international tourism that is developing today in European countries and to determine the centers of tourist flows concentration. An additional task here we set ourselves is to find at least indirect answers to Question 7, while outlining the directions of further research. For starters, it should be noted that the tourism market has always been very volatile. It is facilitated by many factors, among which it is worth noting:

- policy and opportunities in the field of tourism of leading countries.

- integration processes;

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- the macroeconomic situation in the world, as well as in its regions and countries;
- dynamics of the social tension centers;
- aggravation and development of global problems.

In this aspect, if each of these factors (except for the last) more affects this area in the form of redistribution of tourist flows and not a change in total volumes. The last among them, which is the aggravation and development of global problems, directly impacts the volume of tourism. In order to confirm this conclusion, we present statistics on the global volume of international tourism (Figure 2). In Figure 2, we see that the dynamics of world tourism as a whole is growing, but there are clear periods of decline that correspond to global financial and economic trends:

- The crisis can explain the decline in tourism dynamics in the world in 2003 the *dot-com bubble*, which occurred in the United States in 2000-2002 (A revealing look..., 2018).
- A certain decrease occurred in 2009 as well, as a result of the reaction to the aggravation of the consequences of the global financial crisis of 2007-2008.





Figure 2. Dynamics of international tourism in the World (Authors' development based on (International tourism..., 2021a; Number of inbound overnight tourists..., 2021)

In addition, we were quite curious for us to add to Figure 2 data on the dynamics of inbound tourism in the Republic of Malta. We did this due to the fact that it is one among few countries that have published reliable data on the results of the tourism business in 2020 – the year of the COVID-19 pandemic. Comparing the resulting graph, we see that the data of these two numerical series completely coincide in dynamics and differ only in volumes. Today, the world is still calculating the exact figures for losses in 2020; however, it can be argued with confidence that the drop occurred several times compared to 2019 (The number of inbound tourists to the Republic of Malta in 2020 decreased by 4 times compared to 2019).

All these data lead to the fact that the process of the formation of a new international tourism market is taking place in the world today. New both in terms of content and directions. Consequently, the countries of Eastern Europe striving for European integration, such as Ukraine and the Republic of Moldova, now have the opportunity to declare themselves as new centers of tourism. However, here the question remains: what forms of international tourism to develop and what to offer a more demanding foreign tourist after 2021? According to data of 2019, the most popular tourist centers in the EU were (Explore Travel Trends..., 2021):

- French Republic 86.9 million visitors;
- Kingdom of Spain 81.8 million visitors;
- Italian Republic 58.3 million visitors;
- United Kingdom 37.7 million visitors (EU membership was terminated at midnight from January 31 to February 1, 2020) (Brexit..., 2021);
- The Federal Republic of Germany 37.5 million visitors;
- The Republic of Austria 29.5 million visitors;
- Hellenic Republic (Greece) 27.2 million visitors;
- Portuguese Republic 21.2 million visitors.

To a greater or lesser extent, the represented countries are not only European but also world centers in the spheres: Adventure Tourism; Beach Tourism; Cultural Tourism; Eco Tourism; Health Tourism; Working Tourism. Therefore, the Republic of Moldova and Ukraine need to compete with the countries that are full members of the European Union. Therefore, the determination of promising forms of development of international tourism in these countries will be devoted to Block 3.

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The second problem we posed for solving in Block 2 was the search for indirect conclusions on *Question* 7 regarding the countries entering the European Union. To solve this problem, it is necessary to return to the data in Table 2 and build causal relationships based on the available data. Unfortunately, Eurostat, the World Bank, as well as other auto-prestigious sources (National Statistical Organizations) systematize mainly statistical information for countries as a whole, without breaking it down into separate industries. However, even the available data is sufficient to confirm the fact that there is no direct connection between the country's specializations in tourism, the process of its European integration and the synergistic influence of these factors on the tourism dynamics.

In support of this, we will put forward the findings of the analysis presented in Box 1, as well as the following facts by type of tourism (Taking into account the sample from Table 2):

- 1. Adventure Tourism. Tourism for adrenaline, tourism for fun and risk. All represented countries are characterized by it. It can be rafting on mountain rivers, survival in the forests, climbing mountains, fields on paragliders, racing on sports cars and other. Therefore, this type of modern tourism cannot serve as a decisive factor.
- 2. Cultural Tourism. Historical monuments, various sights, iconic places, architecture, folk art. All this exists in all countries. Of course, certain cultures are more attractive to foreign tourists, some to a lesser extent, but this form cannot be decisive.
- 3. Health Tourism. Healthcare today is a vital motive for travel and tourism. All represented countries, integrated into the EU in 2004 and 2007, have medicine at the level of European standards. However, in general, they cannot be considered fundamental centers for the development of medicine. For example, the Federal Republic of Germany, the French Republic and Scandinavian countries are considered centers of medicine not only in Europe but throughout the world.

However, this type of tourism does not necessarily mean some kind of treatment. It might just be rehabilitation. In this aspect, natural resources, like the climate, of each country can be useful for certain purposes. Therefore, these factors are also not the national advantages in this aspect.

- 4. Eco Tourism. Life without the benefits of modern digital society: without electricity, without modern gadgets, without cars and cities in a natural environment. Possibly in any of these countries. Everything depends only on the tastes of each tourist, his travel experience. It is also not a decisive form.
- 5. Working Tourism. Quite a specific branch of modern tourism. It is traveling to other countries to find temporary work. This problem is typical for all countries in general (to a degree of separation). It is especially true for countries that are joining the union with more developed countries. In this case, all countries that joined the EU in 2004 and 2007 and which are members of the Eurozone, according to the IMF, should be considered developed countries (World Economic outlook, 2021). However, labor migration from non-Eurozone countries to Eurozone countries does exist. At the same time, this has almost no effect on statistics. For example, Romania and the Republic of Bulgaria show the same rates of inbound tourism as the Eurozone countries that joined the EU in 2004.
- 6. Beach Tourism. It is recreation near the sea swimming, tanning, development and the hotel and restaurant business concentrated in certain points. This form of international tourism is the most striking for the purposes of our study.

We propose to focus especially on beach tourism. Since such tourism, for objective geographic reasons, cannot be equally characteristic of countries. Some of them (the Hellenic Republic, the Republic of Malta, the Republic of Cyprus) have the opportunity to develop this form of tourism actively. Others do not have such opportunities. However, returning to the statistics, we will issue:

On the one hand: The Republic of Cyprus with an increase in tourism in the year of entry at the level of 2.6% (7.2 – in the next); The Republic of Malta with a 5.6% decline in 2004, which was not offset by the growth in the following year: 3.9%.

On the other hand: Hungary is generally landlocked with tourism growth of 8% in the year of accession (growth continued further); The Republic of Poland and the Republic of Latvia with growth in 2004 at the level of 18.8% and 23.9%, respectively.

It should be noted that the average water temperature in the Baltic Sea in July near Gdansk is 18.9°C, near Riga 18.4°C (Baltic Sea water temperature in July, 2021). Moreover, the water temperature in the Mediterranean Sea in July near Paphos (Republic of Cyprus) is 28.3°C (Mediterranean Sea water temperature in July, 2021). The conditions for the development of beach tourism are obviously different.

Based on these facts and statistics, we conclude that the country's tourism specialization does not significantly impact the dynamics of inbound tourism in the process of its European integration.

Several more conclusions can be drawn from this:

Firstly, there is no and cannot exist a universal form of tourism that would provide an unambiguous increase in European tourists to a country that is integrating into the EU.

Secondly, success in international tourism can provide the country with any of its forms. However, this conclusion is valid only if the country itself and its infrastructure are ready for its development.

**Block 3.** Determination of promising forms of international tourism that would stimulate the European integration processes in the Republic of Moldova and Ukraine.

First, The Republic of Moldova. Despite the natural resource's diversity, the economic and geographical position of this country has serious disadvantage – lack of access to the sea. It would give opportunities for the development of international beach tourism. Therefore, it objectively does not have the opportunity to develop international beach tourism.

In addition, the country's territory is not crossed by the Carpathians, so the development of mountain recreational tourism on the hilly plains is not possible. Ancient European cities (Chisinau, Balti, Orhei), medieval settlements (Old Orhei), resorts on the rivers (Vadul-lui-Voda), monasteries, the largest wine cellars in Europe (Malye Milesti, Cricova) are of tourist interest. All this, in fact, forms the basis of the country's tourism industry (Attractions Moldova, 2021).

In addition, the Republic of Moldova is considered one of the poorest European countries. For comparison, GDP per capita, according to the World Bank, in the Republic of Moldova in 2019 was \$4494, while in the Czech Republic \$23.489, in the Republic of Poland \$15694, in the Republic of Bulgaria \$9829 (GDP per capita..., 2021). All this means that today, the shit does not have internal financial reserves for the rapid development of tourism on a republican scale. Based on these facts, we believe that at the moment this country as well as its private business should be concentrated on the development the speres of:

- 1. Investment tourism. Not a classical economic category. By it, we propose to understand the attraction of investors to visit the country's territory. The purpose of such visits should be to demonstrate those opportunities and infrastructure that may be of interest to international tourist flows. With the creation of an appropriate investment climate at the legislative level, the country will gain access to financial resources, as well as the experience of developing tourism in Europe.
- 2. Wine tourism. The Republic of Moldova is known for its vineyards and wine-making traditions. The consumption of wine (as well as alcohol in general) products in Europe is traditionally quite high. Therefore, instead of simple wine export to European countries, the country can stimulate private companies to design special wine tours. This industry will pull up others as well: hotel and entertainment, gaming, catering, banking, and other representatives of the service sector.
- 3. Beach tourism on rivers. Despite the fact that the natural resources in this country are not so attractive for the sophisticated European tourist, there are still opportunities for their commercial use. The largest rivers possible for developing resorts in this country can be considered: Dniester (with its tributaries Byk, Botna, Ikel, Reut) and Prut. The Danube, in this aspect, is not so attractive. The hotel business development in luxury regions on the river banks can also be considered a promising area for attracting foreign tourists.

The second discussed country is Ukraine. Ukraine has the richest and most diverse natural resources, which, coupled with a large territory, can create an outstanding international tourism potential. All the forms of tourism considered above, both widespread and those that we proposed for the Republic of Moldova, can be developed in Ukraine as well. At the same time, the difficult economic situation, as well as voluntary actions in the East of the country, predetermine the dynamics of inbound tourism. According to statistics, we see that after 2014, the number of foreign tourists is only falling.

However, this is not the only reason that the types of foreign tourism that are classical for Europe cannot be considered promising in Ukraine. As each among the classic types of tourism generates oncoming tourist flows from Ukraine itself. Competition in this aspect is very ambiguous. Since we see statistics of inbound tourism to Ukraine (in 2019, it amounted to 13.7 million people) and statistics of outbound tourism from Ukraine, in 2019 29.4 million people (International tourism..., 2021b). From these positions, we see the prospects for the development of tourism in those industries that, on the one hand, would be attractive for foreign tourists, and secondly, possible for implementation in Ukraine or collaboration between the EU and Ukraine. As part of such initiatives, we want to propose the following directions:

1. Trade union international tourism projects. Despite the fact that the economic situation in Ukraine as a whole tends to improve, the purchasing power of Ukrainian citizens continues to be at a level that excludes ample travel opportunities. It is especially true of the public sector, in which the employee's annual income is quite low.

Trade union international tourism projects can be considered promising in this aspect. We proposed to understand them as tours organized according to a clearly established schedule, route, estimate and paid in part: by the employee himself; by the trade union foundation; by subventions from the state budget; in the long term - by the host side.

Such tours can also be thematic – for representatives of certain professions: pilots, railroad workers, teachers, doctors, police and fire officers, utility workers and others. It will combine tourist and professional value – the opportunity to relax, see other countries and learn from foreign experiences.

Indeed, we must provide the European side with responsive tourism opportunities for its citizens. Therefore, such a mechanism cannot be considered positive solely for building up statistics in inbound tourism. Nevertheless, this is necessary for tourism purposes in general and the provision of tourism opportunities, particularly for the development of recreation and professional interests.

We consider the development of such tours extremely relevant and necessary in modern Ukrainian realities from these positions.

2. Urban tourism. Today, among European citizens, there is significant popularity for visiting large and significant industrial enterprises and their infrastructure, power plants (primarily hydroelectric power plants), abandoned zones and cities, museums built on former military facilities. All this exists in Ukraine and can develop by leaps and bounds. Among the abandoned cities, it should be noted: Kyiv region – Pripyat, Lyubech-1, Poliske; Cherkasy region – Orbita; Zaporizhzhia region – Stepnogirsk; Kirovograd region – Dolinske, Tsukrovariv (Seven abandoned cities of Ukraine..., 2021).

In case of quarries we may indicate Quarries in Kryvyi Rih as well as in Kirovograd, Kharkiv, Zhytomyr regions etc. are huge workings that will be interesting to visit for many European tourists.

Among hydroelectric power plants let's point out at Dnieper and Dniester cascades of hydroelectric power plants headed by Dnipro HPP These are not only outstanding enterprises but also monumental structures, a miracle of engineering.

The Chernobyl exclusion zone as a whole is extremely interesting for foreign tourists. Therefore, more active development of the tourism industry in this place would also bring a serious additional contribution to the inbound tourism of Ukraine.

I case of former military facilities let's mention Pobuzke Museum of Strategic Missile Forces (Kirovograd Region). The largest military monument with collected unique exhibits, a demonstrator of functioning underground base and original hulls of intercontinental ballistic missiles (Strategic missile forces museum in Ukraine..., 2021).

In fact, there are a lot of such objects throughout Ukraine and, in our opinion, they represent a huge potential for the development of inbound tourism.

3. Space tourism. The most promising industry for the development of international tourism, as well as international scientific and technical cooperation.

Ukraine has a unique *Yuzhmash* enterprise specializing in the production of Zenit launch vehicles. Moreover, the company has experience of international cooperation in the programs *Sea Launch, Land Launch*, etc. (Yuzhmash, 2021). At the same time, today in Ukraine not a single project on space tourism is being implemented in general and with the European Union in particular.

The development of space tourism in cooperation with the European Space Agency will give a new round in the construction of bilateral political and economic relations *Ukraine-EU*, serve as a basis for the development of hundreds of enterprises on the Ukrainian territory. It, in turn, will create tens of thousands of new jobs and stimulate the development of the country's economy as a whole. It will also be another strategic step on Ukraine's path to European integration.

Nevertheless, despite the conclusions and proposals that we have identified for the development of foreign tourism for the Republic of Moldova and Ukraine, this does not mean abandoning its other, more classical forms. However, the market laws are not shaken, which means that for a worthy entry into the European Union, these countries must prepare their infrastructure for new realities and offer the demanding European tourist truly unique opportunities.

The global crisis in the tourism, caused by the COVID-19 in 2020, has led to an increase in domestic tourism. According to the United Nations World Tourism Organization (UNWTO), the pandemic decreased the number of international travel by 74% (one billion people) year on year in 2020. For example, the market has fallen even more in Ukraine – by 88%, and such a tendency continues. The number of tourists who came to Ukraine decreased by 9% in 2021 and amounted to just over 3 million people compared to 13.7 million in 2019. It is enough to draw the following comparison in order to understand how immense is the scale of the catastrophe. The global financial and economic crisis led to a decrease in international tourist traffic by only 4% (60 million international tourists) in 2009.

At the same time, travelers began to explore much more within their countries due to closed borders and numerous restrictions. Domestic tourism in Italy, for example, reached the highest levels of all time in the summer of 2021. The increased demand for Ukrainian resorts is still holding on, as summer 2021 showed. However, a decline is expected since countries are gradually opening, and restrictions are becoming less severe.

Vaccination against COVID-19 has taken on a global scale since 2021, and the situation with tourism has, consequently, improved in all areas as vaccinated people could cross borders. Each country has established its entry rules for tourists. Thus, a tourist must have a vaccination passport or a negative test for COVID-19 or spend some time in observation, etc. Even though there are innovations in tourism, many were able to integrate into this system, thereby increasing the flow of tourists and improving the economic performance of different countries (Stezhko et al., 2020). Moreover, not less important is that the modified Omicron has turned out to be not as contagious and deadly as the original virus. In addition to this, vaccination and immunity are becoming important factors for countering the pandemic.

#### Conclusions

Making a general outline of the integration transformations associated with the European Union, we can conclude that such a fundamental process for each country will seriously impact the national tourism sector. In our research, we fully proved the hypothesis that the connection between the European integration processes and the development of national tourism markets does not just exist. However, it is also strong (several times change, compared to the pre-integration period). The reaction of the markets of new members is very rapid (lag is 1-1.5 years from the year of integration) and transient (the positive effect lasts for 2-3 years from integration).

Based on the collected statistical data on the inbound tourism of the countries that joined the EU in 2004 and 2007, we proved that in 2-3 years, the market of each of these countries becomes *Solidary* with the common tourism market in the EU. It is evidenced not only by the parity decline in the industry at the turn of 2009-2010 (the aftermath of the 2007-2008 global financial crisis), but also by the solidarity rise – at the same pace and at the same time intervals. Special attention in the article was paid to identifying the main influencing factors on the development of international tourism. Among them, we highlighted the factor *aggravation and development of global problems*. The global financial and economic crisis and the COVID-19 pandemic have an incomparably greater impact on the sphere than, for example, the macroeconomic situation in the country. The authors of this article have taken into account that the integration time fell under the pandemic and certain restrictions. However, the situation has become much better since 2021 due to the world's exit from the pandemic period through vaccination and gaining natural immunity.

Additionally, we have proved that there is no connection between the European integration of the country, the rate of inbound tourism development on the one hand, and its tourist specificity on the other. It has been proven that in this aspect, factors of a different kind have a special role. We set the task of identifying these factors for further research. We devoted a separate block in the article to define the prospects for foreign tourism development in Eastern European countries. We included the Republic of Moldova and Ukraine in this group since only these countries from Eastern Europe have strategic guidelines for European integration. We proposed the development of investment tourism, wine tourism, as well as beach tourism on rivers as a promising way of developing international tourist trade union tours, the development of urban tourism, as well as space tourism.

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## **Eco-innovation and Sustainable Development**

### Ekoinnowacje I zrównoważony rozwój

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#### Abstract

The paper aims to encourage the creation of innovation policy by individual states and state institutions, management of companies in the energy sector, with the synergy of national and interstate institutions, to apply an integrative approach to eco-innovation. The purpose of this paper is to expand the existing potential for the development of eco-innovation in the business sector and industrial enterprises. The method used is based on the descriptive method, synthesis, and analysis of data collected by international organizations, as well based on research in academic circles. Appropriate incentives from governments to innovate green business models, to reduce greenhouse gas emissions (GHG), would ensure a higher level of environmental quality, adequate quality of life for all people, and a greener future. To achieve the goals, future directions of development should be focused on the development of technology and knowledge, with an adequate policy of creating a green strategy for decarbonization and sustainable development.

Key words: eco-innovation, GHG, sustainable development, green energy, natural environment Slowa kluczowe: ekoinnowacje, gazy cieplarniane, zrównoważony rozwój, zielona energia, środowisko naturalne

#### Introduction

The development of energy production and the introduction of new ones is causing increasing environmental pollution due to CO<sub>2</sub> emissions, which are in the largest percentage of greenhouse ingredients. The large amount of gas produced by burning fossil fuels – coal, oil, and natural gas, causes air pollution, which is a serious threat to humanity, quality of life, and sustainable development. The consequences of the use of fossil fuels are reflected in the degradation of the natural environment, climate change, human health and pose a serious threat to future generations. Numerous problems of sustainable development from the aspect of ecology are related to the environment, to the depletion of stocks of natural resources, i.e. fossil fuels, the impact on global warming, environmental pollution, waste, growing dissent towards the environment, and human health. For these reasons, the United Nations has defined global goals of sustainable development (SDG), which are political goals for the future that are in line with nature, sustainable energy system, and human needs. The UN Agenda 2030 document emphasizes the importance of sustainable energy, which is defined in SDG 7: Ensure access to affordable, reliable, sustainable and modern energy. In SDG 9 the global request is highlighted: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. The SDG 13. calls for combating climate change and mitigating climate catastrophic consequences: Take urgent action to combat climate and its impacts. Sustainable development implies a responsible attitude towards the environment. The essence of sustainable development and the highest goal of development is the harmonious relationship between man and nature. The Sustainable

Development Strategy emphasizes the need for a harmonious relationship between all human beings, as well as between humanity and nature. In 1987, in the document Our Common Future of World Commission on Environment and Development (WCED) was given the definition: Sustainable development is development that meets the current needs of society without compromising the ability of futuregenerations to meet their own needs. Sustainable development includes three dimensions of sustainable development: economic, environmental, and social: 1. an economic system is sustainable when agricultural and industrial production is balanced and continuous; 2. an ecological system is sustainable when non-renewable resources are not endangered and their excessive exploitation is not applied; the stability of biodiversity, atmosphere, and other ecosystems is maintained; 3. the social system is sustainable when it provides adequately social services, such as health (SDG 3: Ensure healthy lives and promote well-being for all at all ages), education (SDG 4:Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, etc. (Rajković, 2020). According to Udo, Pawlowski (2011) sustainable development can be viewed from three aspects of sustainability: 1. social sustainability (global human rights, human transparency, human development, human survival, income equity, human freedom), 2. technological sustainability (energy efficiency, industrial balance, research resources) and development, basic human existence, disaster management), and 3. environmental sustainability (clean air, water use, land conservation, environmental protection, resource use, sanitation/health) (Udo, Pawlowski, 2011). There are expectations in the world that the application of appropriate international legal regulations and standards in the field of environmental protection will reduce the burning of fossil fuels. It is estimated that a large number of premature deaths will be achieved and billions of euros will be saved, increasing energy efficiency in the use of fossil fuels, i.e. reducing carbon dioxide emissions, which is a global environmental problem (Stepanović, Kokić-Arsić, 2011).

#### 1. The concept of eco-innovation

The concept of eco-innovation is the development with the application of innovative business models and innovative business strategies, with a top-down management process, to enable sustainable development based on the impact assessment on the production cycle, in cooperation with stakeholders. Along with eco-innovations, new solutions and connections between products (goods and services), production processes, organizational structure markets are modified and adopted, to improve the quality of business of a company or enterprise and competitiveness.

Unlike environmental technologies, technological eco-innovations are all innovative environmental technologies that are more efficient and have a less harmful effect on the environment than existing alternatives. In addition to technological eco-innovations, there are other types of eco-innovations, such as: 1. production of innovative products (insulation materials, compostable plastics, etc.); 2. innovative production processes and methods, e.g. car clubs, use of interchangeable chemicals; 3. development of new resources in the supply chain, e.g. use of waste that is in the second production process of raw materials; 4. collaborative recycling, etc. (OECD, 2009). Calza et al., (2017) emphasize that green eco-innovations are important for sustainable environmental protection, through which improvements in production processes and product portfolio are achieved. The effect of innovative green products is reflected in the achievement of environmental goals. Innovations can be applied to the green product portfolio in the green industry; in recycling and storage companies or sectors; in companies for the production of renewable energy sources, but also in companies that do not belong to the green industry, i.e. in a portfolio of non-green products.

Innovations can be technologically related to institutional or organizational innovation, or marketing, or be guided by the interests of shareholders or stakeholders. There are innovations according to the specific purpose: 1. environmental technologies – which are for wastewater treatment, i.e. pollution control, 2. green energy technologies, for cleaner production, 3. organizational innovations which are for new methods and management systems related to protection environment and production and products, 4. innovations of green products and services that contribute to the environmental benefits of green development (Kemp, Pearson, 2007). The authors of Calza et al. considered the importance of eco-innovation. They pointed out that all technologies that manage pollution (air control, water control, waste disposal, monitoring equipment, solar energy, hydropower, environmental protection equipment) and processes and ways to more efficiently manage water supply, energy, saving technology, represent green energy that is, ecological green technology.

Based on a case study, Calza et al., suggest that cooperation of large companies with other business partners and companies is important for the sustainability of eco-innovation in the green growth sector, i.e. useful for achieving better environmental performance. In addition, cooperation facilitates access to innovative business models for small and medium-sized enterprises, to develop technological or green innovations at lower costs. Eco-innovation management should enable all firms to access different technological competencies and share knowledge through digital networks to develop a green innovation process (Calza et al., 2017). According to Vicanova et al. (2017), eco-innovation shows significant progress towards sustainable development with reduced use of environmental resources, including water and energy, through their more responsible use. The concept of eco-innovation, according to Kemp, Pearson (2007), is a broader concept than the concept of technological innovation, which is often equated. However, technological innovation is only one aspect of eco-innovation, while eco-innovation is viewed

from multiple aspects of innovation and technology (Kemp, Foxon, 2007). Eco-innovation means technological, organizational, or institutional innovation and development that takes place by companies or non-profit organizations, where there are conditions for trade in the markets (Cai, Zhou, 2014).

#### 2. Drivers of eco-innovation and sustainable growth

Internal drivers, according to Cai, Zhou (2014), are the ability, i.e. the capacity of the company to introduce ecoinnovation: 1. physical capital, i.e. the internal knowledge base and education of employees; 2. investment in research and development R&D; 3. technology 4. environmentally friendly products that are acceptable to the market: such as the design of green products; 5. organizational activities: reduction of pollution sources and recycling, which has positive effects on reduced costs; 6. activity management and management's commitment to environmental innovation, because it influences companies to align their business with social norms, values, and expectations for building a *green image* of the company. The integrative capacity of the company includes internal and external drivers that are connected, where the external regulatory framework has a positive impact on the development of eco-innovation (Cai, Zhou, 2014).

External drivers are external pressures that include environmental regulations, green requirements, and competitiveness. The competition of successful companies, which have innovative products, technologies, or equipment, encourages other companies to apply innovative technologies to their internal capabilities. External pressures of eco-innovation competition are driving other companies to improve their environmental performance, i.e. product quality, which has positive effects on the growing demand for eco-innovation to improve their innovative capabilities. External competitive pressures that require improved environmental performance and product quality are contributing to the growing demand for companies' internal eco-innovation capabilities (Hicks, Dietmar, 2007). According to Stajić et al., 2021., there are significant concerns in the world about the emission of greenhouse or carbon dioxide caused by the use of fossil fuels. Natural gas, i.e. green gas is the main source of energy in many economies in the world because it is a cleaner source of energy than other fossil fuels, such as oil and coal. It has an environmental advantage over other fossil fuels, and because of that replaced oil at the beginning of the twentyfirst century (Stajić et al., 2021). To make innovative progress in the industrial sector and the environment, social awareness and responsibility are important. If external pressures on companies/enterprises are greater, if they are more exposed to external pressures, companies/enterprises will have a higher level of awareness and a greater willingness to allocate more financial resources, to improve their business and environmental performance. Cleaner products, an adequate strategy for cleaner production, and pollution prevention contribute to accelerated sustainable development (Hicks, Dietmar, 2007). Financing is a key driver for new innovative ventures, as it drives a company to undertake innovative projects, which has positive implications for its productivity and efficiency, for the working capital of the company, and market satisfaction. Due to insufficient financial resources, there is a

financial gap between companies, where small companies, which are in the initial phase of innovation development, are exposed to high risk in the capital market (Madžar, 2021). Sotiriadis et al. (2018) suggest that the driving factors of eco-innovation are: customer requirements, legislation, and regulations, company reputation, savings in the form of reduced operating costs, corporate social responsibility, and commitment to successful results. Positive results are achieved through appropriate financial performance and investments for eco-innovation. In addition, successful companies are motivated to adopt eco-innovation and

and investments for eco-innovation. In addition, successful companies are motivated to adopt eco-innovation and have better business performance than non-eco-innovation companies that are *non-eco-innovative* (Sotiriadis et al., 2018). Bossle et al. (2016), pointed out that in addition to motivation, in academic circles, the regulatory framework and efficiency are mostly cited as very important driving factors. Besides, government incentives and the green market with innovative products are emphasized, as conditions are created for the green market with eco-innovation to become a motivation for many other companies. External factors have a positive impact on internal capabilities such as knowledge and skills and motivation, which creates the conditions for the adoption of eco-innovations that have a positive impact on company performance (Bossle et al., 2016).

Analyzing the interrelationships of: 1. physical resources, competencies, and dynamic capabilities of enterprises – RCCs (Resources, competencies, and dynamic capabilities), and 2. eco-innovation (EIs), Kiefer et al. (2018), found that different RCCs have different effects on different types of EIs; that radical and systemic EIs differ from those that develop successively. The drivers are considered to be physical RCC, green supply chains, corporate culture, market attraction, and technology advancement. Kiefer et al., distinguish the following eco-innovations according to the type of EIs: 1. Systemic, characterized by a high degree of environmental innovation, leading to increased competitiveness and greater environmental benefits; 2. Externally managed EIs, which were introduced under pressure from society and regulatory measures and have non-specific characteristics in the field of ecology and technology; 3. Radical and technological EIs, which under radical and technological pressures of science and technology have abolished obsolete technology and introduced radically innovative technological solutions; 4. Continuously improved EIs, created within the company, have improvements in business solutions and non-specific environmental and technological characteristics; 5. Environmentally efficient EIs are those that affect the increased efficiency of a product, service, or process and which contribute to the benefits of a better environment and sustainable development.

Fernando and Wah (2017) stated that eco-innovation has a positive impact on the environment, based on research by Malaysian company GreenTech, where they found that there is a positive correlation between the dynamics of eco-innovation and environmental impact. Regulations, technology, and market orientation have positive effects on life, i.e. resource savings, pollution prevention, and adequate recycling (Yurdaku, Kazan, 2020). The business conceptual model of eco-innovation indicates that eco-innovation contributes to improving the financial performance of the company, which includes: 1. economic performance, such as market, profitability, quality of new products, and 2. cost performance, such as energy and materials costs per product of the enterprise. The authors assessed the environmental impact as part of resource savings, pollution prevention, and recycling in the observed 500 companies in Turkey as a developing country. Thus, Yurdaku and Kazan proved that the introduction of eco-innovation reduces material costs and reduces energy consumption, thereby reducing pollution and affecting the improved quality of life and the environment and sustainable development.

Yawson (2009) pointed out that innovation models generally do not include a comprehensive view, as policy attention is focused on input factors, such as human resources, R&D, capital, which are represented by GDP per capita. However, although the important policy position that indicates the above factors for the introduction of innovation, new models of innovation are needed, which are developed by national centers for science and technology policy around the world, or innovation have different names depending on the specifics of the national environmental innovation system (ESI – Ecological System of Innovation). The development of environmental innovation should be initiated with a goal that contains competencies and perspectives: 1. government, 2. academic circles/researchers, 3. public, and 4. industrial sector. EIS should be based on an assessment of success factors, indicators for all four perspectives. The creativity of citizens, exchange of knowledge, formal and non-formal learning, are just some of the main drivers of eco-innovation. Governments have a great influence on the innovation process and a decisive role in various domains, in terms of: 1. types of research and development; 2. uncertainty; 3. education; 4. technological innovation; 5. funding; 6. national competitiveness; 7. wealth of all citizens, and 8. strategies and line policies (Yawson, 2009).

Costantini et al. (2015) determined, during an empirical analysis, how the internal political mix and foreign policy regarding the introduction of eco-innovation in the energy sector are correlated. They came to the following conclusions: 1. that if there is too large a set of complementary policy measures without sufficient funding for environmental innovation in the energy sector, there is increased imports of technology from abroad, because there is no development of the domestic financial capacity to introduce innovative technology; 2. innovative environmental technologies are negatively affected by an unbalanced policy mix and therefore additional efforts are needed to achieve balance through different policy instruments; 3. adopting innovative strategies to balance instrumental policy leads to a positive response from the creative society to embrace eco-innovation. Foreign countries have a positive impact on national *innovation patterns and innovation behavior* because domestic policy, through interaction with foreign policy, embraces eco-innovation and technological dynamics (Costantini et al., 2015). The pressure of international institutions is growing in all countries of the world, on the introduction of environmental policies and regulations for environmental protection, following the United Nations Sustainable Development Goals (SDG) and other documents.

Flachenecker et al. (2021) suggested that public financial support through subsidies, tax credits, grants, etc. was effective in achieving eco-innovation and economic ambitions, thus reducing negative pressures on the environment. Targeted financial support focused on supporting eco-innovation makes a major contribution to regional development. Adequate national programs create the conditions for achieving the triple dividend: environmental sustainability, sustainable economic growth, and territorial cohesion, thus reducing regional disparities between countries and potential EU members (Flachenecker et al., 2021).

Policy-technology interactions in the diffusion of eco-innovation play an important role in initiating technological eco-innovation concerning climate change (Janicke, 2013). Political activities have an impact on the spread of innovation. Accelerating the diffusion of pure innovative technology is a potentially powerful option for tackling the effects of climate change. There are four mechanisms of the diffusion pattern, such as: the mechanism of innovation in politics, the mechanism of technological innovation, the mechanism of political diffusion, and the mechanism of technological diffusion. Also, there are some other climate policy mechanisms, such as e.g. falling prices of renewable sources with the simultaneous growth of fossil fuel prices, which contribute to the introduction of innovations (Janicke, 2013).

#### 3. Eco-IS (European Innovation Scoreboard) - EU Eco-Innovation Index

The Eco-Innovation Index is a composite index that measures the level of application and development of ecoinnovation technology and green energy. The index contains certain thematic areas: 1. Inputs; 2. Activities; 3. Outputs; 4. Socio-economic results; 5. Resource efficiency results; 6. Environmental results of resource efficiency. *Inputs* include: a) the total value of green investments in the initial phase in USD per capita, b) investments in R&D in the field of energy and environment (in % of GDP), and c) the total number of employed researchers in the field of R&D, % total employees. *Activities* include: a) existing number of sustainable SME products, % of surveyed enterprises, b) existing number of ISO 14001 certificates (per million inhabitants), and c) implemented activities related to energy and renewable energy efficiency. *Outputs* are: a) publications that are thematically related to eco-innovation, per million inhabitants, b) media coverage, per million inhabitants, and c) patents for eco-innovation, per million inhabitants. *Socio-economic results* have the following components: a) employment in the environmental sector, in %, b) value-added in the environmental sector, in% of GDP, and c) export of products resulting from eco-innovation (% of GDP-a). *Resource efficiency results* include: a) commodity productivity (GDP/domestic consumption of goods), b) water productivity (GDP/total freshwater abstraction), and c) GHG greenhouse gas emission intensity (CO<sub>2</sub>e/GDP). 6. *Environmental results of resource efficiency* include: a) material productivity (GDP/domestic material consumption), b) water productivity (GDP/total freshwater intake), c) energy productivity (GDP/gross domestic energy consumption), and d) emission intensity GHG (CO<sub>2</sub>e / GDP) (EIS, 2022).

In the European Union, many countries have recognized the importance of the harmful effects of greenhouse and taken appropriate measures to mitigate their effects on human health and the environment. The governments of successful countries have responsibly committed themselves to support eco-innovation to decarbonize and to make eco-innovation policy central to the strategic planning of their economies. The progress made and the performance of Member States on eco-innovation is measured by the composite Eco-Innovation Index, which ranks countries at three levels: highest, average, and lowest. The leading European countries, in terms of the Eco-Innovation Index in 2021, as stated on the portal of the European Commission, are: Luxembourg, which is in the first place, and the eco-leader, whose value is ECO-I, 175, followed by Finland, Austria, Denmark, Sweden, Germany, France, Spain, and the Netherlands. Countries with average values were Italy, Portugal, Slovenia, the Czech Republic, Ireland, Belgium, Greece, Estonia, and Latvia. Countries in the *catching up below of EU counties in Eco-EIS* phase are in the phase of catching up with the eco-innovations of EU countries, which are below average, namely: Lithuania, Croatia, Slovakia, Cyprus, Romania, Hungary, Malta, and Poland, while Bulgaria has the lowest value of Eco-I, 50. The results obtained through the indicators show the achieved efficiency of eco-innovation of EU countries. Eco-innovations have positive effects on the efficiency of natural resources, because they increase the generated economic value and reduce the harmful impact on the environment, i.e. the natural environment (EIS, 2022).

#### 4. Future drivers of eco-innovation

Al-Aylani et al. (2021), concluded that there are interrelationships between holistic sustainable growth, natural environment, and well-being, as well as the priority importance of eco-innovation in the European agenda. Eco-innovation is key to monitoring the progress of innovative (green), EU competition policy, and the carbon neutrality of all Member States and candidate countries. It was concluded that the leading countries of eco-innovation had the support of the government, which was committed to eco-innovation and decarbonization of the country. In the ten years, the countries that have invested the most in the R&D sector show significant improvements in some of the *inputs* of eco-innovation. Government support is important in the field of research in the ecology and energy sector, as it contributes to its engagement, improvement of results, especially with (green) investments in the initial phase of research, as well as engagement of expert team and academic researchers (Al-Ajlani et al., 2021).

Machiba (2012) concluded that innovation is a driver of economic and social progress at the national macro-level, or a driver of business success and competitive advantage at the micro-level of the company. The report *The Future of eco-innovation* emphasized the promotion of specific areas of innovation, which contribute to an ecologically healthier and more prosperous society. In this way, opportunities are created for solving environmental problems, reducing the consumption of energy and resources such as fossil fuels, thus establishing an economic activity called eco-innovation or green innovation (Machiba, 2012). Eco-innovation requires certain activities, a political mix, which is related to adequate policies that have a wide range of actions. Innovation policy should focus on stimulating economic growth and development of new technologies, productivity, and innovative functional areas (Sustainable manufacturing and eco-innovation, 2009).

According to the Technology Executive Committee (TEC, 2021), future directions of climate technology development should be based on the following activities: 1. to inspect existing green technologies, i.e. the state and potential impact on climate change mitigation and adaptation; 2. to analyze the existing possibilities for solving the problem of introduction of technology, its development, application; 3. to analyze social acceptability; 4. to analyze access to new markets; 5. to identify potential possibilities of national policy for support for the application of technologies, which includes continuous analysis for access to new technologies, innovation, commercialization; 6. to take actions to reduce market risks, thus creating conditions for the sustainability of new offers for technologies. These activities aim to provide all relevant information to policy-makers and stakeholders to establish an energy green transformation in the field of eco-innovation and green technology. It is necessary to adopt innovative regional/national strategies for the accelerated introduction, application, and expansion of innovative technologies. Thus, decarbonization technologies for energy use would have positive effects on the environment, reducing  $CO_2$  and reducing greenhouse gas (GHG) emissions. In this way, multiple social, environmental, and economic benefits would be achieved, such as revenues at the local and regional/national level, employment in the field of green economy/energy, reduced impact on air, water, land, biodiversity, that is, the benefits of the entire ecosystem and sustainable development would be realized. (TEC, 2021).

#### 5. Conclusion

At a time of global energy shortages and the COVID-19 pandemic, gas prices have risen, leading to the conclusion that action is needed as soon as possible to develop a green economy, energy efficiency, and renewable energy sources. Regarding green transformation, trends in the world are increasing towards decarbonization, clean energy, and eco-innovation, which contributes to a more economical perspective on the use of energy fuels and sustainable development. All countries as signatories to the Paris Agreement have committed themselves, under Article 4, to make efforts within their nationally determined contributions (NDCs) to reduce the greenhouse and  $CO_2$  effects. Achieving ambitious climate and low-carbon goals is important for ecosystem adaptation and sustainable development over a certain period. All countries should be guided by the guidelines of the Agreement; to eliminate the greenhouse effects through gas sinks or  $CO_2$  storage; to develop long-term strategies for accelerating the green transition, taking into account that some less developed and poorer countries need more time to apply modern scientific knowledge and climate technology. In that way, all countries would contribute to the achievement of global goals regarding climate change for the benefit of the population and all humanity.

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# Intangible Heritage and Sustainable Development Strategies

### Dziedzictwo niematerialne a zrównoważony rozwój

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#### Abstract

This paper analyses in detail the problems of protecting cultural heritage in rural regions and small towns, in traditional rural landscapes and in the context of the revival of rural settlements. The paper substantiates the necessity and possibility of measures for the preservation of tangible and intangible cultural heritage by measures of both organisational and technical nature. The international experience of safeguarding cultural heritage by organisational measures and digital preservation is considered; the need to correct this experience in accordance with local specifics is substantiated. The existing technical approaches to the digital preservation of cultural heritage are analysed. An original approach is proposed that most fully simulates complex objects such as artistic reliefs with painting – the method of synchronised laser triangulation, combined with the method of laser-induced break-down spectroscopy.

Key words: digital preservation, preservation of cultural values, protection, modern technologies, the Middle East region

Slowa kluczowe: konserwacja cyfrowa, zachowanie wartości kulturowych, ochrona, nowoczesne technologie, region Bliskiego Wschodu

#### 1. Introduction

Traditional agricultural landscapes are rapidly disappearing around the world, and the Middle East is no exception. Previously, this was a consequence of accelerated industrialisation and urbanisation. However, attempts to reverse the industrialisation through various projects of revitalising rural regions also pose a threat to traditional culture in recent decades. The environmental and food security implications of this trend are enormous. Politicians at the international and national levels have recently recognised this pressing issue. For example, the Food and Agriculture Organisation of the United Nations (FAO) launched the Globally Important Agricultural Heritage Systems (GIAHS) project in 2002 to mobilise global awareness and support for the dynamic conservation and adaptive management of agricultural systems (Fakhouri and Haddad, 2017). Likewise, Japan's Ministry of the Environment and the United Nations University's Advanced Research Institute jointly launched the Satoyama Initiative in 2010 to promote and support the conservation of socio-ecological production landscapes that have evolved over time through mutually beneficial collaboration, the interaction between humans and nature (Jamhawi and Hajahjah, 2017). The GIAHS project and the Satoyama Initiative represent positive steps towards harmonising the relationship between conservation and development (Zalloom and Tarrad, 2020).

At the local level, however, it is difficult to maintain a balance, as rapid socio-economic changes pose challenges for cultural heritage sites. The UNESCO global report (Culture: Urban Future..., 2016) notes that the situation with intangible cultural heritage is generally characterised by a difficult situation. There are threats to cultural heritage, and, although the problem is recognised and attempts are made to preserve the intangible cultural heritage, in the light of the growing speculation of land and the widespread privatisation of territories in settlements, public places have become the focus of efforts to preserve and restore small towns. An example is the case of the Ifugao Rice Terraces. A difficult lesson learned from the degradation of the Ifugao Rice Terraces is the lack of participation of local communities in the design and implementation of tourism development plans (IMPACT: The Effects..., 2008). As custodians of the rice terraces on which tourism is based, the share of host communities in the economic benefits of the tourism industry is disproportionately small. This has accelerated the migration of farmers, resulting

in a shortage of labor to grow and maintain rice terraces (The Ifugao Rice Terraces..., 2008). In addition, uncontrolled tourism has also caused irreversible damage to physical and cultural heritage resources (Alazaizeh et al., 2019a; Alazaizeh et al., 2019b).

In Banaue, the first tourism destination developing in Ifugao, unplanned construction projects have destroyed large areas of muyong (traditional private/clan forest areas that support irrigation water to the terraces), causing soil erosion and river pollution (IMPACT: The Effects..., 2008). In addition, the growing demand for traditional wood products has led to deforestation at the watershed. The depletion of water supplies in the rice terraces has contributed to the infestation of giant earthworms that erode the walls of the terraces and dams. The cultural heritage is also being commoditised. To satisfy the curiosity of tourists, agricultural rituals are performed at the wrong time of the year (IMPACT: The Effects..., 2008). Ethnic cultural performances are exclusively aimed at tourists and are not necessarily faithful reproductions of the culture of the host community. This confirms that tourism is in fact an *existential authenticity* experienced by tourists, not the authenticity of the places visited (Shqairat et al., 2018). Most of the performers are local residents, but only a small number of young, pretty villagers qualify for them. Other contributors to tourism-related activities include casual guides and those who run family guesthouses and gift shops. Together, they represent less than 5% of the total population of a region like Qingkou, in which the Chinese authorities have attempted to revitalise rural settlements by stimulating local tourism and exploiting local intangible cultural heritage (Cozzolino et al., 2019).

Souvenir shops are mostly owned by migrants from Dali, a well-developed tourist destination in northwest Yunnan. Few souvenirs are produced locally, indicating a lower level of community participation. Tourists who visit Qingkou are mostly of the *take photos and go* type, without much interaction with the host community. This is a key challenge for the sustainable development of rural areas of national minorities, namely, how to balance the need to preserve traditional cultural landscapes and the need to improve living standards in rural areas. Therefore, the challenge is to adopt a new strategy that will enable local residents not only to participate and benefit economically from tourism development, but also to maintain the physical and cultural landscape. Since the discussed rural communities will inevitably face challenges to the traditional way of life, it is necessary to immediately carry out digital preservation of intangible cultural heritage objects. This includes the development of new organisational approaches to continue cultural traditions also in architecture, with the development of regions.

#### 2. Materials and methods

In the field of tangible cultural heritage, a number of studies have already addressed the potential of technology not only for conservation but also creation of innovative learning environment. And in the intangible cultural heritage sector – the number of studies related to the potential of technologies for teaching and learning is very limited. In 1990, the Digital Michelangelo project, launched at Stanford University in the United States, prioritised the digital protection of cultural heritage (Bodzek et al., 2019). Recent advances in laser rangefinder technology, combined with algorithms for combining images with multiple ranges and colours, now allow the shape and surface characteristics of many physical objects to be accurately digitised. Laser triangulation technology is a noncontact measurement method that overcomes the limitations of traditional measurement technology, offering fast scan speed, high real-time accuracy, high precision and intelligence. It has been widely used to create digital models of cultural relics. The use of laser triangulation technology is one of the most common 3D measurement methods, which usually includes a point laser and a line laser. There are two kinds of point cloud acquisition methods such as probe movement and laser wobble. The method of moving the probe consists in fixing the laser triangulation probe in the moving parts and scanning the object along the spatial movement of the moving parts. The laser swing method implements two-dimensional scanning by laser movement, rotating a vibrating mirror and other methods. However, when measuring a large-scale scene, the probe must be fixed in large moving parts; thus, the accuracy of the moving parts affects the final measurement accuracy; and if the laser oscillation method is used, the horizontal and vertical scan areas are mutually limited, which will significantly affect the scan range. To solve the horizontal and vertical scanning limitation of traditional triangulation B. Dweik and I. Abdelkhaleq (2020) propose a synchronised scan measurement method. The receiving light and the transmitted light are synchronised by placing the scanner on both optical paths. When the scanner rotates an angle, the receiving light and the transmitted light have the same angle change. Due to this mechanism, the depth of field and the measuring range are greatly expanded. Following this technique, in the literature (Bala'awi and Mustafa, 2017; Richard et al., 2019; Kersel and Hill, 2020; Zhang et al., 2018), the characteristics of a laser synchronised scanning triangulation system were additionally studied and the general meaning of the equation of the trajectory circle, as well as the parameters of the system maximum and minimum range, distance resolution and other system parameters. In (Drzewiecki and Arinat, 2017) the accuracy of the synchronised scan triangulation system was studied and errors caused by the deviation of the system parameters, such as the mirror angle, were obtained. The authors (Cozzani et al., 2017) have developed a laser triangulation system based on synchronised scanners with LiDAR, which takes full advantage of triangulation. Triangulation can be very accurate at close range, while Pulse Ladar technology is capable of very long-distance measurements. D. Tu, P. Jin and X. Zhang (2018) proposed a new method using a prismatic optical structure to correct the nonlinear problem of measuring the displacement of laser triangulation,

and the results showed that the nonlinear problem was greatly improved. Moreover, A. Ababneh (2018) has developed a three-dimensional shape measuring system with linear structure and light based on laser triangulation with automatic synchronous scanners that reduce the weight and size of the system. The above study establishes a 3D scan path circle model which is of great importance for describing a synchronised sweep triangulation measurement mechanism.

#### 3. Results and discussion

#### 3.1. Analysis of methods for protecting the intangible cultural heritage of Jordan

Jordan has a UNESCO-listed Intangible Cultural Heritage Region, a Bedouin cultural space in the Petra and Wadi Rum regions. To understand what may appear to be a contradiction in cultural heritage preservation policies due to the overlap of tangible and intangible heritage in Petra, we need to focus on cultural heritage as a practice first and foremost, a practice that consolidates Petra as the epicentre of the Jordanian heritage, not as an object as such. To preserve the appearance of traditional rural culture and its cultural heritage, we believe it is correct to interpret the entire set of cultural artefacts as intangible cultural heritage, since after the adoption in 2003 of the *Convention for the Safeguarding of the Intangible Cultural Heritage* a clear definition of intangible cultural heritage was given, that is, intangible cultural heritage means customs, representations and expressions, knowledge and skills – and associated tools, objects, artefacts and cultural spaces – recognised by communities, groups and, in some cases, individuals as part of their cultural heritage. Such a verbose interpretation can be briefly expressed as a *way of life*, namely the way of life of the people in all its originality. It includes samples of material culture, social rituals, and industrial practices aimed at reproducing the society under discussion in time and reproducing material and intangible culture of society is intangible cultural heritage.

This intangible cultural heritage, passed down from generation to generation, is continually recreated by communities and groups depending on their environment, their interactions with nature and their history, and gives them a sense of identity and continuity, thereby promoting respect for cultural diversity and human creativity. The composition of various social practices, ideas, expressions, forms of knowledge, skills and related tools, objects, crafts and cultural objects is thus now recognised as such that it requires preservation, what has been said is also true for the cultural space of the Bedouins in the regions of Petra and Wadi Rum. The Bedouin tribes around Petra, which were resettled under the slogan of developing and protecting the UNESCO heritage in 1985, were inscribed on the UNESCO List of Masterpieces of the Oral and Intangible Heritage of Humanity in 2005. Along with the Bedouin tribes around Wadi Rum, they were chosen for their particularly rich oral traditions, nomadic pastoral skills and landscape-based religious practices, rooted in the landscape and impossible without the landscape they (especially in the case of Petra) no longer inhabit, due to the *UNESCO material heritage*. This process of using Bedouin culture or attributes in discussions about identity rather than way of life has become widespread in the Arab world in recent years, and thus the very way of life and the cultural space of the Bedouin now requires protection.

There are two types of methods for safeguarding *intangible cultural heritage*, namely revitalisation protection and development protection. Revitalisation is carried out as a government initiative, and therefore gravitates towards large-scale, iconic objects, it lacks a *community* standard of living. Therefore, intangible cultural heritage projects that relate to the daily cultural life of members of local communities should be included in the model of development protection. Since every ancient rural house, and even more so a nomad's dwelling, cannot be recognised as an architectural monument with a corresponding protected status, and the development of a settlement may require the restructuring of areas with traditional architecture, in order to preserve the cultural heritage, such an architectural tradition should be interpreted as an intangible cultural heritage.

Moreover, the traditional dwellings of the Bedouins and other nomadic tribes over the centuries have undergone a significant influence of Arab culture, but they find their individual appearance in the traditional patterns of wall painting or wood carving. Of course, models of cultural objects appeared long before digital copies. This was done as part of a simple copying of text, descriptions and images for distribution. As early as the 1970s, researchers and scientists used technologies such as photography and sound recording to record and preserve various cultural heritage sites (such as cultural relics and archaeological discoveries) (Cozzani et al., 2017). However, an image, description or even a photograph cannot capture the complex shape of such an object as carved wood, a pattern can be depicted, but the image will not convey its full shape. Also, photography will tell nothing about the chemical nature of pigments in the case of pattern recognition in wall paintings. Since the analysed object is native art, cultural heritage objects in this case can have an extremely multifaceted structure.

Historically, copies of volumetric reliefs were made by hand from the original material, but later technologies appeared based on the manufacture of a plaster model, followed by casting a copy from a corresponding material, including polymer concrete. This technology has a number of significant disadvantages. In the process of work, the original relief is exposed to significant chemical, physical, and mechanical impact. This is manifested in the fact that after the manufacture of the mould, moulding material often remains on the surface of the original, to remove which it is necessary to use alkaline washes or mechanical cleaning methods. In addition, when removing the form, damage to individual relief elements is not excluded, which can manifest itself in the form of chips or

fractures of small and thin parts. In this situation, a question arises: are there any more modern, *non-traumatic* methods of copying? Recently, rapid and progressive advances in technology have opened new ways of protecting intangible cultural heritage. They allow for new user interactions, potentially going beyond the encyclopaedic approach that has so far characterised most of the ongoing projects aimed at safeguarding intangible cultural heritage.

#### 3.2. Developing a method for digital preservation of Jordan's intangible cultural heritage

This paper proposes, as a toolkit for digital preservation of intangible cultural heritage, a synchronised scanning trigonometric model of geometric parameters based on an unfolded light path combined with a chemical analysis of the surface. The angular and absolute coordinates of various parts of the processed object are accurately described by 14 system parameters, and then the relationship between three-dimensional points in space and the system parameters is expressed. In simulation, the system error can reach 400 mm when the thickness of the double-sided reflector is 2 mm. The results of this analysis confirm the importance of the thickness of the rotated mirror. The parameters are then ranked in terms of their influence on measurement accuracy, which is instructive for system design. Finally, the experimental results show that the system can scan an object and display its point cloud. According to the triangulation principle, the coordinates are determined by the position of the converging image spot on the camera. M3 and M4 are driven by a motor to perform plane scanning. When M3 oscillates around the axis, the light spot Q scans the surface of the measured object along the X-axis; Likewise, light spot Q scans in the Y-axis direction and M4 oscillates around the axis (Figure 1). The surface of the object to be measured can be scanned when the two motors are running synchronously (Tu et al., 2019).



Figure 1. Schematic diagram of synchronised laser triangulation; compiled by the author

The chemical analysis method is based on measurements of the secondary emission spectrum excited during the formation and development of plasma as a result of exposure of matter to the radiation of a powerful pulsed laser. At typical plasma temperature values (10.000 ... 20.000 °K), the substance is atomised and ionised. As a result, almost all of its atomic and ionic transitions are excited. The first stage of this process coincides in time with the action of laser radiation on the plasma, in addition to the intense continuous spectrum of thermal radiation that covers the entire visible, ultraviolet, and near-IR region, the spectrum of the laser spark contains lines corresponding to multiply ionised atoms, including lines located in the x-ray area. After the termination of the laser pulse, the plasma expands and cools down for several microseconds, and then it emits the spectra of neutral and/or one- and two-fold ionised atoms. This radiation can be registered with a spectrometer, and the elemental composition of the substance can be determined from the results of the analysis of the obtained spectra. To create a laser spark on the surface of the materials under study, Q-switched solid-state Nd: YAG lasers with very short pulse duration (about 10 ns) are usually used. By using nanosecond pulses, it is possible to avoid significant heat transfer over the volume of the sample under study (there is only local heating in the focusing zone of the laser beam) and screening of laser radiation by plasma, the formation of which occurs after the end of the laser pulse.

Using the LIBS method, it is possible to determine the elemental composition of the base material of the monument, the coatings on it (for example, polychrome) or surface contamination practically without contact. The method allows studying various objects made of metal, stone, glass, ceramics, minerals, as well as paintings. Recently, interest in this method of conservation has increased significantly, mainly due to the emergence of compact portable universal instruments capable of analysing any samples with a size of 10 microns and determining chemical elements with almost any atomic number. Such analysers have high spatial resolution (both over the surface and depth), and the study itself can be carried out without any preliminary sample preparation in real time. The shape of the craters formed provides additional information on the composition of the surface layer. LIBS is an express, relatively inexpensive method of analysis and allows the registration of emission spectra within a few seconds. Moreover, in comparison with XRF, it has a higher sensitivity and allows the identification of elements with a low atomic weight. The proposed hybrid combination of laser-induced breakdown spectroscopy and synchronised laser triangulation allows to create the most complete picture of extensive historical relics, with information not only about the colour, shape of the surface of the paintings/reliefs, but also about their chemical composition, which allows to reproduce these objects in the future, even if the original structures/sculptures/murals are lost. Thus, the proposed approach most fully corresponds to the content of the practice of digital preservation of cultural heritage sites.

#### 4. Conclusions

The present paper stated the need for digital preservation of the Bedouin cultural space in the Petra and Wadi Rum regions. Along with the need for protection, the technical possibilities for digital preservation were analysed. The authors considered the international experience of digital preservation and substantiated the need to correct this experience in accordance with local specifics. The existing technical approaches to digital preservation of cultural heritage are analysed, an original approach is proposed that most fully simulates complex objects such as artistic reliefs with painting – the method of synchronised laser triangulation, combined with the method of laser-induced breakdown spectroscopy (LIBS method). The authors believe that the laser spark spectroscopy method makes it possible to reproduce the composition of dyes with the accuracy of IR spectrometry methods with selective sample preparation, which is very good for an express method that allows automated data collection from large and numerous objects, such as rural architecture, native decorative household items, other items of native art and decoration of the cultural space of nomadic peoples. Having tested the elements of the proposed approach, the subsequent studies will involve a large-scale field data collection, but in view of the vastness of the work front, the authors want to encourage other researchers to join the work.

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# Sericulture in Terms of Sustainable Development in Agriculture

## Jedwabnictwo w ujęciu zrównoważonego rozwoju w rolnictwie

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#### Abstract

Sericulture is a branch of agriculture specializing in the cultivation of silkworms and cocoon production as well as the cultivation of white mulberry, which is the sole source of food for silkworm caterpillars. Due to the ecological nature of farming both mulberry silkworm and mulberry cultivation, as well as the possibility of managing and processing waste generated in the breeding process, it is fully in line with the trend of sustainable development. Raw materials obtained from silkworm farming constitute the basis for products valued by consumers due to their environmentally friendly production methods and an organic source of raw materials. Silk production can successfully contribute to the increase in popularity and practical application of the idea of sustainable development in agriculture.

Key words: sericulture, sustainable development, organic farming, circular economy Slowa kluczowe: jedwabnictwo, zrównoważony rozwój, rolnictwo ekologiczne, gospodarka o obiegu zamkniętym

#### Sustainable development in agriculture

There have been many attempts to define the concept of sustainable development in agriculture (Adamska and Minta, 2017). The concept of sustainable development was made important by the Our Common Future Report, which were defined as development, as appropriate, should not be supported by meeting customer needs (Brutland Report, 1987). Many, created later, definitions share a common ground – the development of agricultural production with a simultaneous reduction of the negative impact on the natural environment and positive socio-economic effects.

Agriculture is also connected with Sustainable Development Goals, especially Goal no 2: Zero Hunger.

The idea of sustainable development in agriculture assumes effective development of agricultural production without unnecessary and excessive burdening the environment (Robertson and Harwood, 2001). The assumptions of such a method of farming guarantee the long-term acquisition of agricultural crops while limiting the degradation of natural resources. Sustainable development in agriculture emphasizes the elimination or as much as possible limitation of the exploitation of the natural environment by activities such as minimizing chemical treatment and heavy mechanization (Kutkowska, 2007). These measures are expected to produce organic farming crops free of pollutants and pesticides, which will provide the farmer with a reliable source of income. In this way, the economic needs of agricultural producers and the quality requirements of consumers will be met, while avoiding the degradation of the natural environment. Also worth attention in the context of sustainable development is the concept of the circular economy, which minimizes the consumption of raw materials and reduces the amount of waste generated in the production process thanks to the management of waste as substrates for subsequent processes (Shevchenko et al., 2021). Sericulture, despite its niche importance in both Polish and European agriculture, is an excellent example of the practical application of sustainable development in agricultural production and the circular economy (Grześkowiak and Łochyńska, 2021). Taking into account the fully ecological nature of obtaining silk raw materials, silk production should become an important direction in modern agriculture. The aim of this work is to present the mulberry silkworm breeding process and the multidirectional use of silk raw materials and the directions of waste management generated by silk production, while presenting the social dimension of the development of silkworm.

# Breeding of mulberry silkworms in terms of sustainable development, organic farming and circular economy

Silk-making was born in ancient China, from where, after nearly 2,000 years of exclusivity in the art of silkworm breeding and silk fabric production, it spread to Japan, India and Korea, from where it reached Europe (Dening, 2020). Silkworms were bred to obtain silk, from which prized fabrics were made and sold at a gold price. Nowadays, silkworm farming enables the multi-track use of raw materials obtained during the breeding process and the management of waste as raw materials for the production of other products (Manjunath et al., 2020). It is worth mentioning that all products obtained in this way are fully organic. The insect's life cycle lasts about a month and falls in June, so it does not interfere with most agricultural work (Łochyńska, 2016). The life cycle consists of eggs, five larval stages, a pupa and a butterfly (imago) (Figure 1).



Figure 1. The life cycle of mulberry silkworm: 1 – eggs, 2 – 4 caterpillars, 5 – pupae, 6 – cocoons, 7 – butterfly on cocoons, 8 – mating butterflies, 9 – female laying eggs (Fot. J. Grześkowiak)

The only feeding stage is the caterpillars, whose food source is mulberry leaves (Grześkowiak and Łochyńska, 2017). Maintaining silkworm farming requires adherence to hygiene rules that prevent the spread of diseases to endanger the breeding caterpillar population. An effective way to prevent epizootic diseases is regular cleaning of the litter boxes and the observance of sanitary rules by breeders. Caterpillars are bred on various types of bedding (Grześkowiak and Łochyńska, 2021). So far, recycled or paraffin paper has been popular. There are reports of the use of alternative breeding methods using banana leaves as bedding (Das, 1994). It is a fully biodegradable raw material that decomposes quickly, which translates into the reduction of waste generated in the breeding process. The silkworm caterpillars, due to their intensive growth from only 1 mm after hatching from the eggs, to 12 cm in the fifth larval stage, are considered to be one of the most voracious animals. It is assumed that for the rearing of caterpillars from 10 grams of eggs, 530 kg of fresh white mulberry leaves should be provided (Łochyńska, 2016). Breeding from 10 grams of eggs will provide about 270 kg of excrement and breeding waste, which can be successfully used as an organic fertilizer. Literature data indicate the content of valuable micro- and macroelements in silkworm excrement, which can be successfully absorbed by plants – N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, CaO, MgO, Cu, Mn, Zn (Łochyńska and Frankowski, 2020). In addition, studies using silkworm manure in fertilizing plant crops increased

the absorption of nutrients and organic matter in the soil, which translated into improved soil fertility and, consequently, an increase in yields. The research on the effect of fertilization of hemp with silkworm manure showed the effect of increasing the biomass yield (applied dose 15 t / ha) and higher seed yielding (dose 30 t / ha) (Łochyńska and Frankowski, 2021). The use of silkworm manure as fertilizer is not only an effective way of managing breeding waste, but also an effective alternative to commonly used inorganic fertilizers, which translates into limiting the chemicalization of the natural environment (Kociszewski, 2013). In addition, it is possible to fertilize mulberry with silkworm excrement, which is an ideal example of a circular economy. The waste from silkworm farming becomes fertilizer for the host plant for silkworm larvae (Stephan-Giermek, 2019). Another, also effective and efficient way of managing waste - both excrements and breeding waste, is the production of biogas. Łochyńska and Frankowski (2018) showed that both types of waste have a high potential for obtaining biogas. Fermentation in mesophilic conditions allows for the production of 167.32 m3 / Mg TS of methane and 331.97 m3 / Mg TS of biogas from silkworm excrements and from silkworm farm waste to 256.59 m3 / Mg TS of methane and 489.24 m3 / Mg TS of biogas, respectively (Łochyńska and Frankowski, 2018). At the end of the fifth larval period, the caterpillars begin the spinning process that takes about a week. In this period, the necessary equipment are mountages for spinning – most often made of wood, but also of plastic and straw. There are reports of the use of used plastic bottles as dispersants (Singh et al., 1994). It is a way to reuse plastic packaging. The result of spinning process are cocoons, which are a raw material source for both the textile and cosmetics industries. Processing cocoons to obtain silk fabrics and silk proteins - sericin and fibroin requires inhibition of the insect development cycle by subjecting the cocoons to high temperature (Łochyńska, 2016). This is necessary in order to maintain the continuity of the silk thread. It is necessary for the proper course of the silk fabric production process. Silk is a naturally derived animal protein fiber. Due to numerous properties, such as hygroscopicity, gloss, resistance to creasing, flexibility and durability, it is appreciated by consumers all over the world, but due to high production costs, it remains a luxury good (Grześkowiak and Łochyńska, 2017). Taking into account the environmental burden resulting from the excessive production of clothes and textiles made of artificial fibers and problems with their disposal, silk, although relatively expensive compared to textile products made of artificial fibers, is not only a very durable material that can be used for years, but also in fully biodegradable (Łochyńska, 2018). Estimated data show that the fashion industry generates about 92 million tons of waste each year, and by 2030 an increase of as much as 60% is forecast (Dalton et al. 2020). Due to the problem with textile waste, natural fibers should gain popularity due to sustainable production methods, lower consumption of environmental resources in the production process and longer life of textiles based on natural fibers and their full biodegradability. After uncoiling the cocoons and obtaining a silk thread, pupae remain as waste. Due to the high content of protein (21,5%) and fat (25-30%), pupae can be successfully used as an alternative source of protein in animal and human nutrition (Wu et al., 2020). As mentioned earlier, cocoons can be used as sources of silk proteins - sericin and fibroin, valued for their unique properties in the cosmetics industry, bioengineering and medicine (Mondal et al., 2007). Cocoons are an organic source of silk proteins free of impurities. Due to the moisturizing, smoothing, firming and antiseptic properties, they are successfully used as an ingredient in cosmetics and biomaterials (Padamwar and Pamar, 2004). Failure to break the life cycle leads to the escape of butterflies from the cocoons. After leaving the cocoons, butterflies immediately start mating, after which the female lays eggs (about 2,500 eggs from one female), which, after appropriate storage, will be used for hatching in the next breeding season (Grześkowiak and Łochyńska, 2021). It is important that all products based on silk raw materials are fully organic and obtained using ecological methods. In turn, waste generated at various stages of the breeding process is processed and reused (Figure 2).



Figure 2. Management of waste from mulberry silkworm breeding and white mulberry cultivation in a circular economy system (own study based on Sękowski, 2016).

The host plant of the mulberry silkworm caterpillars – white mulberry, due to the low soil requirements and low susceptibility to diseases and pests, does not require fertilization, which means that the feed for silkworm larvae is free from pollutants, heavy metals and pesticides (Łochyńska and Oleszak, 2011). In addition, white mulberry can also be used as a herbal raw material, constituting an additional source of income for farmers. Due to the need for annual pruning and shaping of white mulberry bushes, methods for the management of wood chips for energy purposes have also been developed, due to the high energy potential of mulberry (Frankowski et. al, 2021). Pellets and mulberry-based briquettes can be both a source of ecological fuel for growers and an attractive product to offer to consumers. In addition, mulberry is known to be used as a plant used in environmental protection to eliminate contamination from degraded soils (Jiang et. Al., 2017). Both the possibility of multi-directional use of silk raw materials and the management of breeding waste and mulberry plantation make silk not only not negatively affecting the natural environment, but also a source of raw materials for various industries, while improving the socio-economic conditions (Figure 3).



Figure 3. Multidirectional use of raw materials and management of silk waste (own study).

#### The social dimension of silk production in the context of sustainable development

In ancient China, a few had the honor of breeding silkworms. The breeders were faced with numerous demands (Dening et al., 2020). Women played a special role in the breeding of silkworms. Usually, they were responsible for both silkworm breeding and the collection and processing of cocoons. Also, further work related to obtaining the fabric remained the domain of women. Contemporary silk production also remains dominated by women. Due to the short development cycle of the insect and the breeding period that does not interfere with the timing of most field work, it allows women living in rural areas to combine silkworm farming not only with carrying out other tasks on the farm, but also with the simultaneous fulfillment of household duties. Research conducted by scientists from India shows that there is a clear division of responsibilities related to silkworm farming and white mulberry cultivation according to gender. The activities of women in terms of breeding are focused on feeding the caterpillars, keeping the nursery clean and collecting cocoons. These are activities that can be performed where you live, and can help you combine extra work with housework. The collection of white mulberry leaves, work on plantations related to tree formation and fertilization remain the domain of men (Feyso et al., 2021). In addition, studies have shown that silkworm breeding in India contributes to women's income growth despite low education and to improving their socio-economic situation (Raveesha et al., 2016). Due to the simple and clearly defined breeding methods and principles of plantation, as well as the repeatability of the activities performed, silk production may

become an effective method of activating the community living in rural areas. The possibility of creating producer groups and cooperatives associating silkworm farmers, mulberry growers and processing cocoons may improve the socio-economic situation of rural inhabitants. The association of farmers, breeders and growers brings many benefits, including common use of equipment, mutual assistance, obtaining higher prices for the offered products and increasing their quality (Pilichowski, 2018). Undoubtedly, a significant advantage of cooperation is the exchange of experiences in terms of farming, mulberry cultivation and cocoon processing. It is also worth mentioning the sociological dimension of the association of agricultural producers, which results in the deepening of social ties and the elimination of competition for cooperation, which brings more benefits compared to individual activities (Pilichowski, 2018). Fully ecological methods of silkworm breeding and white mulberry cultivation make the offered raw materials and products based on them fully organic and environmentally friendly. In addition, many of them are handicrafts, which significantly increases their economic value. Undoubtedly, the development of silk production in rural areas is also conducive to establishing social contacts and integrating the environment of a given community (Vathsala, 1994). The family character of farms dominating in Poland (Sobiesiak-Penszko and Pazderski, 2019) favors the development of silk production. Moreover, thanks to the variety of work, sericulture is an activity that engages all generations and can be a factor preventing social exclusion of older people. In turn, the growing interest in honey bee breeding observed in recent years can be successfully used to increase interest in silkworm breeding (Popovych, 2019). Silk industry may become an effective way to raise the economic status of farms and an attempt to take steps to transform activities into organic production, while creating new jobs in various sectors (Figure 4).



Figure 4. Professional activation by creating new jobs in the silk sector (own study).

In Poland, the silkworm breeder was entered on the official list of professions, where the position, working conditions and requirements for breeders were characterized. Moreover, the profile of professional and social competences necessary to perform the profession with the possibilities of professional development was defined (Ministry of Family, Labor and Social Policy, 2018).

#### Conclusions

Both global and European economies relied heavily on a linear model that used raw materials to produce products that turned into unnecessary waste after use (Sekowski, 2016). This method of world production has led to an imbalance between the availability of raw materials and the amount of generated waste. Similarly, agriculture aimed at increasing the efficiency of plant and livestock production has led to the excessive exploitation of the natural environment and its pollution. Currently, the process of transforming the world economy, including agriculture, into a circular economy model based on assumptions that waste from one production process becomes a raw material for another process is underway (Shevchenko et. al., 2021). In this way, the amount of waste is significantly reduced and the negative impact of economic development on the natural environment. In the case of agriculture, a good direction is the further development of organic farming, which, due to the practices used in both plant cultivation and animal husbandry, significantly reduces the negative effects of agricultural activity on the natural environment (Jarecki et al., 2019). The ecological aspect, however, is insufficient to talk about sustainable development in agriculture due to the need to prove positive impacts in the socio-economic sphere. It is important that the development of agriculture is consistent with the social interest, which indicates many values of the rural environment, including clean air, cultural heritage, landscape and food security (Kołodziejczak, 2015). The deepening phenomenon of rural disagrarisation (the decreasing role of agriculture in generating jobs and income for the rural population), resulting in a decline in the links between the rural population and agriculture, results from changes taking place in rural areas (Kłodziński, 2012). Sericulture may turn out to be an opportunity for the integration of rural communities inhabited by both multigenerational farmers and people who came to rural

areas from cities. On the one hand, many years of practical experience of farmers in the field of animal and plant production, and on the other, support in the field of marketing, formal and legal or accounting activities offered by newly arrived rural residents may constitute an opportunity for effective integration of the rural environment. Sericulture seems to be an ideal example of the application of the idea of sustainable development in agriculture in a practical sense. Thanks to the use of fully natural breeding methods, it is a source of organic raw materials used in various sectors of the economy. Both biodegradability and the possibility of processing livestock waste mean that silk production does not pose a threat to the natural environment, while at the same time reaping economic benefits for employees in the silk sector. The undoubted value of silk production is the possibility of simultaneous development with respect for the environment and providing additional jobs and activation of rural environments (Biernat-Jarka and Trebska, 2018). Sericulture, which is part of the trend of organic farming and sustainable development, requires promotion, so that it can also be used in European countries, following the example of Asian and African countries, to provide an opportunity to improve the socio-economic conditions for people with lower education, socially excluded and unemployed. The chances of a successful silk-making development depend on several factors. Optimal soil and climatic conditions for mulberry cultivation are considered to be of key importance. Due to the low soil requirements of mulberry, it is a plant that is successfully cultivated even in degraded areas, which allows it to be planted in areas that cannot be fully used for agricultural crops (Caccam and Mendoza, 2010). Due to the favorable climatic conditions for mulberry cultivation in India, it is possible to derive several (from 5 to even 8) silkworm breeding cycles per year due to the availability of food – mulberry leaves (Stephan-Giermek, 2019). This is an important factor that not only influences the increase in profits for breeders compared to European breeders, who can derive a maximum of 2 silkworm development cycles during the year, but also reduces the risk of failure of the project from one breeding cycle by compensation in the next, which due to climatic conditions is not possible in Europe. Due to clearly defined breeding methods, silk production under appropriate soil and climatic conditions conducive to the development of mulberry may become a popular form of activation and additional income in rural areas, as shown by the example of one of the Indian provinces (Maharashtra), in which, despite the lack of previous silk traditions, but with favorable environmental conditions, silk-making was introduced in 1959, which became an integral part of the local agriculture (Patil et. al., 2009). Also, examples of African countries show that, despite the lack of previous experience in both mulberry cultivation and silkworm farming, silk-making is becoming an occupation that is gaining popularity and developing due to the generated income under favorable climatic conditions (Abayneh et.al., 2021). Undoubtedly, the advantage of the geographical location of some regions compensates for the shortcomings of long silk traditions and translates directly into a lower price of the offered raw materials and products from these markets. Nevertheless, for many consumers, European silk remains synonymous with centuries-old traditions and the manufacturing process of silk-based products, which means that they are able to offer a higher price for them. Also, the economic aspects of silk production are based on a multifactorial basis. The efficiency of cocoon production, which is considered the basic product resulting from silkworm breeding, depends on the climatic conditions, the experience of breeders, the necessity or lack thereof in adapting the premises to the needs of breeding, the possibility of implementing several breeding cycles per year, and labor costs (Kumaresan, 2008). In addition, issues related to the susceptibility of silkworm caterpillars to diseases that can lead to a reduction in the reared population, which ultimately translate into a lower number of cocoons produced, should also be taken into account. The differences related to the costs incurred for the purposes of breeding, largely affect the price of silk. Due to both favorable climatic conditions and lower than European labor costs in Asia and Africa, the prices of silk offered by local producers are lower compared to European producers. It is worth mentioning that the favorable climatic conditions in Asia and Africa make it possible to derive several breeding cycles per year, compared to a maximum of two in Europe. The main difference in the scale of silk production between Asian and European countries is mainly due to the fact that in Europe, silk production has a niche character, while in Asia it is an important sector of both agriculture and industry (Caccam and Mendoza, 2010). However, it should be noted that also in Asia and Africa, silkworm farming is an additional activity, constituting an additional source of income for households despite favorable climatic conditions (Kumaresan et. Al., 2008). The organization of silkworm farming on a larger scale is associated with the improvement of the breeding process through its mechanization, which in turn entails additional costs for breeders, and this is a solution practiced in large farms with a larger area (Stephan-Giermek, 2019). An important factor is the price offered to breeders for cocoons produced in stores. The vast majority of breeders do not process cocoons themselves to obtain fabric, but sell them to collectors, where they are further processed or exported (Abaynneh et. al., 2021). Due to the large number of breeders in Asian countries, the availability of the raw material is greater than in Europe. Nevertheless, it is a raw material considered to be of lower quality compared to that offered on European markets. Many European growers breed and cultivate mulberry under the convention of organic farming, which requires the fulfillment of numerous conditions, including restrictions on the use of plant protection products, ensuring appropriate conditions for farm animals, etc. For many consumers, certificates confirming the quality of the offered products are synonymous with sustainable production for which they are ready to pay a higher price. At the same time, one should not forget about the cultural dimension of silk production. It is China that is the cradle of silk production and has the longest tradition in the world related to the
cultivation of silkworms and the cultivation of mulberries. Nowadays, it is China and other Asian countries that, due to the role of potentates in silk production, are at the fore in introducing innovations and extensive research on silkworms, mulberry and silk. Undoubtedly, silk production, on the one hand, due to its long and rich traditions and ecological production methods, and, on the other hand, the ease of its implementation in areas not previously associated with silkworm breeding, is an effective activity aimed at the simultaneous development of rural areas while maintaining the identity of the countryside by referring to its traditions while respecting the natural environment.

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# Arsenic Contamination of Groundwater in Bhojpur District of Bihar, India: A Threat to Sustainability

# Zanieczyszczenie wód gruntowych arsenem w dystrykcie Bhojpur w Bihar w Indiach: zagrożenie dla zrównoważonego rozwoju

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# Abstract

Arsenic contamination of water is now a global problem. More than 100 countries, including India, are facing the problem of a high level of arsenic in the groundwater. There is a wide range of negative impacts of arsenic contamination on society and the economy, threatening sustainability in the contaminated areas. To examine the magnitude and effects of arsenic in the Shahpur block of the Bhojpur district, Bihar, India, we tested groundwater samples from many different locations. Household surveys and personal interviews were conducted to find out the societal response to this problem. Sample testing results confirm a high rate of arsenic contamination in the area. Our study found that; the low education level of the area is hampering the sustainable solution to the problem. We came to know that people who are suffering from arsenic diseases are discriminated against the society. Further, we have also found that the economic burdens of arsenic contamination are more on the marginalized section of the community. Since crops are irrigated with high arsenic concentrated water, soil quality is degrading, responsible for poor agriculture output and economic loss. It has also been found that most of the mitigation measures employed are not sustainable in the long term. Awareness regarding arsenic toxicity is needed for the sustainable intervention of this problem. After examining all the mitigation measures, we concluded that rainwater harvesting and rooftop rain harvesting is the most sustainable and cost-effective measure to tackle this menace.

Key words: sustainability, arsenic contamination, groundwater, water accessibility, socio-economic burden Slowa kluczowe: zrównoważony rozwój, zanieczyszczenie arsenem, wody gruntowe, dostępność wody, obciążenia społeczno-ekonomiczne

# 1. Introduction

The word sustainable was originated from the Latin word *sustinere*, which implies to hold up, to support and maintain. In the oxford dictionary, sustainability is defined as an ability to keep something going on for a long time without compromising quality. The current form of the concept of sustainability was established during the UN conference for Human Environment held in Stockholm in 1972. The idea was further developed with a holistic approach by World Commission on Environment and Development (WCED), also recognized as Brundtland Commission. According to the WCED, sustainable development is the development that meets the needs of the present generation without compromising the needs of the future generations to meet their needs (WCED, 1987). In this regard, for a sustainable water supply, the water resources should be appropriately managed, protected, and utilized so that future generations do not have to feel the scarcity of both quality and quantity. Access to a safe water supply is a fundamental right of every human being. The quality and quantity of water available affect the health and socio-economic development of an individual and society. Hence, water available should be sustainable in terms of quality and quantity.

Water has a high priority in the Millennium Development Goals (MDGs). Its target 7C is to ensure half of the world population has a safe and sustainable water supply (UN, 2000). In the 2030 agenda for sustainable development goals (SDGs), a dedicated plan for water and sanitation aims to *ensure availability of sustainable management of water and sanitation to all* and to address water more holistically (UN, 2015). The target text in MDGs and SDGs addressing water is similar, referring to *safe drinking water*. However, a key difference is that safety was measured only indirectly through the proxy of improved sources in MDGs. In contrast, water quality is also included in the indicator in SDGs. The SDGs indicator of safely managed drinking water service will provide a more accurate presentation of drinking water quality because improved sources mentioned in MDGs are often faecally contaminated. The SDGs prioritize supplying chemically safe water to populations. The priority chemical contaminants considered in the definition at the global level are fluoride and arsenic. These are the two chemicals that occur widely in the drinking water, resulting in a substantial burden of disease globally. Monitoring of arsenic will be required for tracking target 6.1, but reducing exposure to arsenic will also be essential for progress towards other SDGs targets, especially within Goal 3 (*Ensure healthy lives and promote well-being for all ages*).

Due to the increase in population, both quality and quantity of water resource have been continuously deteriorating. Over the year, unsustainable groundwater and surface water exploitation has caused a severe water pollution problem. According to the Falkenmark indicator, a country or a region is water-stressed when water availability goes below 1700 cubic meters/person/year. In India, more than 800 million people in 12 river basins have per capita water availability below 1000 cubic meters/person/year, which is a threshold for water scarcity. The per capita availability of water in 1951 was 5177 cubic meters which went down to 1544 cubic meters at the end of 2011. It is estimated that the per capita availability of water will remain only 1341 cubic meters by 2025 and will remain 1140 cubic meters by the end of 2050. According to NITI Aayog, 163 million people do not have safe water near their premises, and more than 70% of the surface water in India is contaminated (NITI Aayog, 2018). Since the potential to harness surface water for beneficial purposes and infrastructure is not adequate for the supply of surface water, there is immense pressure on the groundwater resources in India. It has led to overexploitation and unsustainable use of groundwater resources, making India the largest extractor of groundwater globally (Saha et al., 2017). The untenable and illogical extraction and use of groundwater resources have led to the problem of groundwater contamination in more than 200 districts across 20 states of India (CGWB, 2018). Various agents and sources are responsible for groundwater contamination, but all can be grouped under three categories: geogenic, biogenic, and anthropogenic (Figure 1). Contamination such as salinity, iron, fluoride, and arsenic can be grouped under geogenic. These are responsible for moderate to severe health impacts and diseases. Most of the common contaminants in groundwater worldwide are fluoride and arsenic. Drinking and consuming water with an elevated level of arsenic (>0.5 mg/L) can cause skin pigmentation and skin cancer. Consuming water with a high level of fluoride may prove responsible for tooth day and crippled bones. Therefore, even if the water is available in plenty, it is indirectly scarce due to the problem of contamination.

Arsenic with atomic number 33, atomic mass of 74.92, and a melting point of 816.8°C is the 20th most abundant element in the earth's crust and 53<sup>rd</sup> most abundant element found on the planet. It is a metalloid that can combine with both metals and non-metals to form inorganic and organic compounds. It also shows metallic properties and co-exists with other metals like Fe, Cu, Ni, Zn, etc. as sulfide and oxide ores (Boyle and Jonasson, 1973). Incidences of elevated levels of arsenic concentration in groundwater have been reported many countries worldwide. It has been estimated that more than 200 million people worldwide are exposed to an elevated level of arsenic in drinking water (groundwater) (Naujokas et al., 2013). Different countries have different guidelines for the maximum permissible limit for arsenic in drinking water based on convenience. According to the World Health Organization (WHO) 2011 guidelines, the maximum limit should be 0.1 mg/L. Most developing countries keep the upper limit close to 0.5 mg/L. Because of the resource constraints in these countries, lowering the limit will put an extra burden on water companies to meet the given standards. Many studies have already been done on arsenic in drinking water and its effect on human health (Adeloju et al., 2021; Huang et al., 2019; Jha and Tripathi, 2021). Arsenic can cause problems in reproductive systems and congenital disabilities and harm the central nervous system (Abdul et al., 2015). Some studies also find the relation between consuming elevated levels of arsenic and children's mental health (Genuis, 2009; Wasserman et al., 2007). Several studies are available related to economic costs imposed on households due to arsenic contamination of groundwater (Das et al., 2016; Thakur and Gupta, 2016). The studies found that low-income families incurred the most significant number of sick days. After getting infected by the disease, the poor household is further pushed into misery and poverty. Their savings are exhausted for the treatment, and they face difficulties in earning their livelihood.

# 2. Arsenic Contamination

# 2.1. Arsenic Sources and Mobilization

Arsenic is found in the natural environment in plenty in the earth's crust and small magnitude in rock, soil, water, and air. It is always present as compounds with oxygen, chlorine, Sulphur, carbon, and hydrogen on the one hand, and with lead, gold, iron on the other hand. Therefore, arsenic sources can be categorized into three categories: geogenic, biogenic, and anthropogenic routes (Sparks, 2005).



Figure 1. Different sources of arsenic in the ecosystem (Thakur and Gupta, 2016)

In Bihar, the arsenic content in the groundwater is determined mainly by the geological formation. Bihar is located in the Gangetic plains and covered by the Quaternary sediments of recent to sub-recent age (CGWB, 2016). In all these areas, a multi-tire aquifer system is present. The sediment of the central Gangetic basin differentiates into Holocene and Pleistocene depositions. The arsenic hotspots are confined to younger alluvial deposits (Holocene) aquifer depths 50-60 meters below ground. The aquifers of older depositions (Pliocene-Pleistocene) are mainly free of arsenic contamination (Smedley and Kinniburgh, 2002). A layer of clay that protects the deeper aquifer can be used for community drinking water supply by deep tubewells having a yield capacity of 150 cubic meters per hour (Saha et al., 2017).

The arsenic in Bihar and Shahpur block (Study area) probably originates from the ore zones of the Himalayas. After that, it is eroded by the Ganges River and its tributaries. The eroded materials are then transported and deposited along their course. Mukherjee et al. (2012) described that rainfall received on the flood plains of Bihar facilitates the percolation of organic carbon to the groundwater, which stimulates microbial respiration, triggering a reductive dissolution of Arsenic and iron in the solid phase (Mukherjee et al., 2012). These hydro-geochemical phenomena produce bicarbonate (HCO3) in shallow groundwater that helps further mobilization of Arsenic in the groundwater (Saha and Sarangam, 2010; Sahu and Saha, 2014). It is to be noted that the affected aquifers are the most used and popular source of drinking water in both Shahpur block and the state of Bihar.

# 2.2. Spatial Distribution of Arsenic Problem

The elevated level of geogenic arsenic contamination in drinking water has been identified in more than 105 countries (Singh, 2017; Singh and Stern, 2017). Every year new locations are being discovered where arsenic is present in the elevated level against the WHO (2011) and BIS (2012) recommendations (0.1 mg/L) (BIS, 2012; WHO, 2011). Most of the arsenic vulnerable areas are found in the river basin and the deltaic regions. The places with the tropical climate are more susceptible to arsenic contamination of groundwater because this type of climate favors the mobilization and release of arsenic from its compounds (Nickson et al., 2000; Ravenscroft et al., 2009). The spatial distribution of arsenic contamination in shallow aquifers worldwide can be assessed from my previous work (Ranjan, 2019).

Currently, 20 states and 86 districts of India (Figure 2) are facing the challenge of elevated levels of arsenic (>0.1 mg/L) contamination in groundwaters (CGWB, 2018). In India, Ganga-Brahmaputra and Meghna (GBM) plains are the hotspot zones of arsenic contamination (Figure 3). Around 80% of the affected area of India lies in this plain. Bihar is also part of this plain where arsenic-contaminated sediments are deposited by the river Ganga. More than 1.6 million people in 19 districts of Bihar are facing this severe menace. The most affected (Figure 4) district (>0.5 mg/L of arsenic concentration) are Begusarai, Bhagalpur, Bhojpur, Buxar, Darbhanga, Katihar, Khagaria, Kishanganj, Lakhisarai, Munger, Purnea, Samastipur, Saran, and Vaishali (CGWB, 2018).



Figure 2. Spatial distribution of arsenic contamination of groundwater across India (Central Groundwater Board, 2018)



Figure 4. Spatial distribution of arsenic contamination of groundwater in the State of Bihar, India (Central Groundwater Board, 2018)

### 3. Objective of the study

The current study investigates the magnitude of groundwater arsenic contamination in the Shahpur block of Bhojpur district, Bihar, India. The objective of the study can be summarized in the following points:

- 1. To analyze the socio-economic impact of arsenic contamination of groundwater in the study area.
- 2. To assess the sustainability of the arsenic mitigation interventions in the contaminated areas.

#### 4. Methods and Methodology

# 4.1. Data collection and data analysis tools

150 groundwater samples were collected and tested from seven habitations of the Shahpur block of Bhojpur district in Bihar, India. These samples were collected in polyethylene bottles pre-washed with nitric acid (1:1). The samples were collected from the handpumps, tubewells, and borewells after operating and pumping them for at least 2-5 minutes. After collecting the samples, they were tested on-site using the field test kit (FTK) developed by National Chemical Laboratories, Pune, India, and Prerna Laboratories, which WHO and BIS recognize. The impact of arsenic contamination on society and the economy was evaluated by surveying 382 households. This survey was conducted using stratified random sampling. The first level of categorization was done based on social and educational disadvantages (General, SC & ST). Equal representation was given to every section of the society based on their relative population (Table 1). To know the society's response towards arsenic patients, we have personally interviewed the affected persons. Furthermore, we have used the remotely sensed data for analyzing the terrain characteristics of the study area. These data were collected from the Survey of India, Google earth pro, and Landsat 8. The primary data was analyzed and represented using ArcGIS, SPSS, and MS-Excel tools. Data regarding the aquifer system, magnitude, and spatial distribution of arsenic in groundwaters in India has been obtained from the Central Groundwater Board (CGWB). Data regarding drinking water standards to know if the quality of groundwater available in the study area satisfies the minimum permissible level of arsenic in waters. The World Health Organization (WHO) 2011 guidelines for drinking water and Bureau of Indian Standards (BIS) 2012 guidelines have been referred to these data.

Village name	Population	SC	ST	% of the total	Represe	Representation in sar	
		Population	Population	population of the		ple size	
				study area	Total	SC	ST
Isharpura	4461	405	47	11	42	4	1
Deomalpur	6773	801	47	16.51	63	7	1
Sarna	5568	434	0	13.57	52	4	0
Semaria Ojha Patti	5788	1071	0	14.11	54	10	0
Lachchhutola	3223	229	0	7.88	30	2	0
Parariya	730	20	0	1.77	7	1	0
Shahpur (N.P.)	14469	1914	21	35.27	134	17	1
Total	41012	4874	115	100	382	45	3

Table 1. Determination of sample size in the study area

#### 4.2. The Study area

The study area, i.e., the Shahpur block of Bhojpur district, Bihar, India, is located on the southern bank of river Ganga in the northwestern part of Bhojpur district roughly between  $25^{0}44'0''$  N and  $25^{0}34'40''$  N latitude and between  $84^{0}19'40''$  E and  $84^{0}32'0''$  E longitude (Figure 5). The total area of this block is around 205 square kilometers. Due to its location, newer alluvium is deposited annually by the river Ganga, making it a younger flood plain. The general slope of the area is towards north and north-east. The general elevation of the area is around 50-60 meters above mean sea level. The gradient is 0.5 m/km, approximately from south to north. The northern part of this area is pitted with the oxbow lakes, meander scars with point bars left over by the old Ganga channels. According to Koppen's climatic classification, the area falls under the *Cwg* type of climate. This type of climate with dry winters. The average temperature varies between 39 degrees Celsius in January. Most of the rainfall received is from the summer monsoon between mid-June to the end of September. The area's average annual rainfall is around 1080 mm, which varies between 1025 mm and 1106 mm (CGWB, 2013).

The Bhojpur district of Bihar, is divided into 14 blocks. Each block is again composed of several clusters of villages known as gram panchayat (GP), and each GP has several villages. Shahpur block has a total of 22 GPs. Out of these, we have selected 7 for our study (Figure 5). The area's total population is 194486 persons, out of which 102702 are males, and 91784 are females. The sex ratio of the whole block is 893.6 females per 1000 males.

The effective literacy rate<sup>1</sup> is 70.2 %, whereas the crude literacy rate<sup>2</sup> is 58.53%. A detailed description of the demographics of Shahpur blocks and seven habitations under study are given in the following table 2.



Figure 5. Location map of the study area

Table 2. Demographic	profile of the study a	rea (Census of India.	2011)
			- /

Parameters	Name of village (habitations)							
	Isharpura	Deomalpur	Sarna	Semaria Ojha	Lachchhutola	Parariya	Shahpur	
				Patti		-	(N.P.)	
GP	Isharpura	Deomalpur	Sarna	Semaria	Lachchhutola	Karza	Shahpur	
Total area sq. kilometer	22.8	6.64	51.6	2.19	0.98	1.02	10.2	
Total population	4254	6773	5568	5788	3223	1454	17767	
Population density (Pop/m <sup>2</sup> )	187	1020	107	2642	3288	1425	1741	
Sex ratio (females/1000 males)	878	910	863	925	841	968	912	
Literacy rate (%)	59.5	64.4	54.2	65.5	59.1	62.9	59	
Female literacy rate (%)	49.9	54.8	47.4	57.2	46.7	54.6	46	
SC population	405	801	434	1071	229	20	1914	
ST population	47	47	0	0	0	0	21	
Totalworkers	1155	1359	1497	1359	676	268	3838	
Total Female workers	90	144	267	165	16	84	664	
Main workers	1036	1212	1200	1102	265	125	3205	
Marginal workers	119	147	297	257	411	143	633	
Cultivators	487	463	515	380	177	50	1020	
Agricultural labourers	406	543	570	617	474	81	1228	
Non-workers	3306	3722	3946	3817	2049	462	10631	

### 5. Results and Discussion

The primary source of drinking water in the area is groundwater sources pumped mainly through handpumps (Table 3). The piped water connection and household taps are available in significant amounts only in Lachchhapur and Parariya. In Lachchhapur, more than one-fourth of the household uses tap water from treated sources for drinking purposes. In Parariya, around one-third of households use tap water from the treated sources, but approximately 17 % of homes use tap water from untreated sources (Table 3). Due to the high percentage of use of groundwater sources for drinking purposes, it is necessary to use these sources sustainably. The contamination of the groundwater sources is a significant concern for these areas.

Table 3. Percentage distribution of significant sources of drinking water (Census of India, 2011)

<sup>&</sup>lt;sup>1</sup> Effective literacy: It is the total number of populations aged 7 and above which are literate.

<sup>&</sup>lt;sup>2</sup> Crude literacy: It is total number of populations which are literate.

Village/			Percenta	age distr	ibution of	major so	urce of dri	nking wat	ter	
habitations	Tap water from treated source	Tap water from un-treated source	Covered well	Un-covered well	Hand pump	Tubewell/ Borehole	Spring	River/ Canal	Tank/ Pond/ Lake	Other sources
Isharpura	1.2	0.3	0.7	3.1	94.7	0	0	0	0	0
Deomalpur	5.4	1.2	0.8	0	91.3	0.8	0	0.1	0.1	0.2
Sarna	2.2	0.8	0.8	0.2	90.9	0.5	0	0	0	4.6
Semaria Ojha Patti	0	0	0.3	1.6	97	0.1	0	0	0.4	0.4
Shahpur (N.P.)	3.1	0.8	1.1	3	88.4	0.3	0	0.1	0.3	3
Lachhatola	26.6	0	0.3	0	68	0	0	0.3	0	4.8
Parariya	32.2	16.6	0.5	5.4	44.9	0	0	0	0.5	0
Shahpur Block	3.4	0.9	0.6	1.5	91.8	0.2	0	0	0.1	1.5
Bhojpur District	2.7	1	0.7	1.1	92.3	0.8	0	0.1	0.1	1.1

In the last two decades, the trace of elevated level of arsenic has been found in the drinking water, irrigation water, and food products in Various places of Bihar (Suman et al., 2020). Various government and non-government organizations have tried to estimate the number of populations potentially exposed to arsenic contamination. However, it is a challenging task as arsenic exposure is probable through food products. Cases of exposure have been found from many places where geogenic arsenic has not been confirmed to date. The food crops grown locally and irrigated with arsenic-contaminated water are sold in the open market and consumed by the people far away from the place of production. There is also evidence of arsenic in dairy products. The possible reason for this is that the fodder is grown in arsenic-contaminated soil and irrigated with contaminated water. A recent study finds that the total number of people exposed to arsenic contamination in Bihar is around 9 million (Bhattacharya, 2019). Another study done in 2016 by the Ministry of drinking water and sanitation n the Ministry of Jalshakti, Government of India, reported that 16 million people are at risk from arsenic contamination in the State of Bihar alone (Ministry of Drinking water and Sanitation, 2016). Arsenic contamination has an acute negative impact and far-reaching consequences on all aspects of life, health, social, and economical.

After the test of the samples, the magnitude of arsenic contamination of groundwater in the Shahpur block seems to be very high. We have tested 150 samples from 7 habitations using the FTK. In our current study, it has been found that (Table 4) most of the samples (more than 80%) have arsenic concentration exceeding the WHO, 2011 and BIS, 2012 guidelines about the maximum permissible limit for arsenic in drinking water (0.1 mg/L) (WHO, 2011 & BIS, 2012).

Village	Number of	Arsenic Contamination (mg/L)		Mean	WHO Standard
	samples tested			Concentration (mg/L)	(2011)
		Maximum	Minimum		0.1 mg/L
Isharpura	25	1.2	0.1	0.65	
Deomalpur	20	1.0	0.1	0.55	
Sarna	30	0.7	0	0.35	
Semaria Ojha Patti	15	0.5	0	0.35	
Lachchhatola	5	1.4	0.2	0.80	
Parariya	5	1.2	0.1	0.65	
Shahpur (N.P.)	50	0.5	0.1	0.35	

Table 4. Result of samples tested for arsenic contamination in groundwaters, (sample tested both in pre-monsoon season in June 2021 and in post-monsoon season of November 2020)

# 5.1. Effect of Arsenic contamination on Health

The first report of adverse health effects from consuming arsenic-contaminated water came from Poland in 1898 (Mandal and Suzuki, 2002). Keratosis, hyper, and hypo-pigmentation are the most common diseases caused by arsenic ingestion in the human body. Exposure to a high level of arsenic for a long time may affect the respiratory system, causing laryngitis, bronchitis, rhinitis, and tracheobronchitis (Parvez et al., 2010; Sanchez et al., 2016). Consuming arsenic-contaminated water alters myocardial deportation and cardiac arrhythmia, leading to heart failure (ATSDR, 2019; Chen et al., 2007). Arsenic also harms both peripheral and central nervous systems. Some studies found that arsenic affects the mental health of children. Log time continued exposure to arsenic may be responsible for the children's low IQ, slow cognitive development, and consequently poor memory (Syed et al.,

2012; Wasserman et al., 2007, 2004). There is information on the connection between consuming arsenic-contaminated water (>0.5 mg/L) and adverse pregnancy outcomes. The report reveals the high rate of spontaneous abortions, stillbirths, and neonatal death (Ahmad et al., 2001; Kwok et al., 2006; Vahter, 2009). We have found many patients sufferings from arsenic skin lesions in the studied villages. We have not performed any medical testing on them because it is beyond the aim of this project. We have physically tried to identify the symptoms and compared them with the past study on health information. It can be estimated that more than 10000 people from the Shahpur block may be suffering from the diseases manifested by consuming arsenic-contaminated water.

# 5.2. Impact of Arsenic on Society

The arsenic problem significantly affects socio-economic structures (Das et al., 2016; Thakur and Gupta, 2016). It has been found that social issues are linked with health and economic problems. The social issues start with the lack of knowledge and awareness directly coupled with the education of an individual and society. As we can see (Table 2) that the average literacy of the study area is around 45%, and the female literacy rate is below 30%, there is a dearth of knowledge and awareness regarding arsenic contamination among the inhabitants. Most households in the area do not use any filtration option (Table 5). Due to the lack of knowledge, people boil water before drinking, which often increases the concentration of arsenic in the water.

Table 5. Percentage distribution of households using different filtration options and distance of water sources from the	neir house-
holds (Household survey, 2021)	

Percentage	e distribution of households	Isharpura	Deomalpur	Sarna	Semaria Ojha Patti	Shahpur (N.P.)	Lachchhtola	Parariya
	Boil	0.7	0.9	0.4	1.1	1.7	0.6	0.9
Water	Strain through cloth	0.5	1.2	1.4	1.7	1.1	0.9	1.3
Treat- ment	Use ceramic, sand or another filter	1.8	2	2.7	3	8.4	1.1	1.7
Methods	Electronic Purifier	1.2	1.7	0.8	2.2	8	0.9	1.1
	Other treatment	0.8	0.9	0.6	1	1.5	0.7	0.5
	No treatment	95.1	93.3	94.1	91	79.1	95.8	94.5
Distance of water sources	Within premises	79.8	61.7	81.5	69.3	79.2	59.8	44.9
	Near Premises	10.6	32.8	13.3	17.5	15	29.9	46.3
	Away	9.6	5.5	5.2	13.2	5.8	10.3	8.8

Due to the lack of knowledge, people often mistake symptoms of arsenic poisoning as leprosy or other contagious skin disease and start practicing untouchability and discrimination. Lack of education makes people superstitious, and they believe that this disease is due to the curse of evil or the act of God. Lack of information creates the problem of marriage, employment, and even the simplest social interaction. The Father of the bride does not want to marry their daughter in the villages where the problem of arsenic contamination is prevalent. Similarly, a groom does not want to marry a girl from arsenic hit villages. Our study found that the people suffering or showing the symptoms of arsenic poisoning on their bodies are debarred from society, ostracized, and are not allowed to participate in social gatherings. They do not allow to visit places of worship. When women get infected, they are sent back to their maternal house because families fear getting this disease. In some cases, women have to face a situation of divorce. It has been found that people with poor socio-economic conditions who are economically marginalized and living below the poverty line are most likely to get diseases manifested by arsenic contamination.

# 5.3. Economic Impact of Arsenic contamination

Arsenic contamination in groundwater has a severe economic impact on the people residing in the arsenic-affected areas. Studies (Bhattacharya, 2019) have found that the poor population is more exposed to such problems.On the one handthey are unable to adopt the mitigation measures to reduce the risk of a health threat, and on the other, they do not have access to adequate nutritional intake. All these factors ultimately increase the economic burden of poor households in the form of medical expenditure. Moreover, arsenic-free water is not only an expensive blot but also a financial burden. Research finds that by reducing the arsenic concentration to 0.5 mg/L, the monthly and annual gain per household can be calculated to be around INR 290 and INR 3500, respectively.

Similarly, if the concentration is reduced to half of the current level, the economic benefit would be around INR 161 per month and INR 1934 per annum (Roy, 2008). Poor households witnessed a maximum number of sick days. In such a case, people find it challenging to work for more than 3 hours/day compared to 8 hours/day work by a healthy person. Studies found that the threat of melanosis and keratosis increased with cumulative exposure,

more commonly found in economically poor class individuals. Poor people cannot afford advanced filtration options, and they also find it difficult to buy bottled drinking water from the market.

Another aspect of the economic impact of arsenic contamination is in the context of agriculture productivity. Most of the irrigation in the middle Gangetic plains is done from the waters pumped from the shallow aquifers. As a result, rice, vegetables, and dairy products get affected by arsenic contamination. Bhattacharya (2019) found and reported arsenic concentration in potato, brinjal, arum, amaranth, radish, lady's finger, cauliflower, and relatively low level of arsenic in beans, green chili, tomato, bitter gourd, lemon, and turmeric. Arsenic contaminated water used for irrigation impacts the quality of food grains, adversely affects soil quality and reduces the quantity of food production. Due to arsenic in the food products, cultivators find it challenging to sell their products because people avoid products from these places to the best of their knowledge. When cultivators cannot sell their crops, they face substantial economic loss and often go into debt when they do not get the correct prices. It can be said that arsenic contamination in groundwater puts a question mark on the sustainability of agriculture production and the associated livelihood and health of the affected population.

# 6. Sustainable mitigation measures for arsenic contamination

The sustainability of arsenic mitigation interventions can be stated as *the capacity to continue to be implemented for a long term and delivering the output without compromising the quality*. Arsenic mitigation techniques being presently used in Bihar are multi-village piped water supply scheme through a conventional treatment plant from the safest aquifers. The intake water is treated with activated alumina (AA), granular ferric hydroxide, cerium oxide-metallic iron or iron-coated sand or brick dust, ion exchange media and coagulation, flocculation and sedimentation/filtration. These mitigation measures can be assessed and evaluated against the parameters of environmental and socio-economic sustainability.

#### 6.1. Environmentally sustainable measure

The strategy for drinking water supply based on surface water, which is common in the Bhojpur district (Shahpur and Barahara block), has been identified as a long-term solution by the NRDWP framework and can pose limitations to environmental sustainability. About one-fifth of the Indian population is estimated to be exposed to arsenic contamination. If all these populations are served with the piped water supply through the surface water treatment plant, then water available in the rivers, dams, ponds, lakes, etc., may go down. Over exploitation of these surface water resources may harm the aquatic ecosystem and prove fatal to the flora in the catchment areas. Several examples exist in the country where rivers and lakes have dried up due to the over-abstraction of water and lowered catchment flows (Saleth, 2011; Singh and Singh, 2020; Singh et al., 2015).

Similarly, the water supply from the deep aquifers is being promoted in the Bhojpur district (also all over the state of Bihar) through *har ghar nal ka jal* (tap water to every household) scheme, an ambitious project of the Government of Bihar is not sustainable. Drawing large amounts of water from the deep aquifers will lower the water table in the long term. Furthermore, the clay layer, which acts as a barrier between shallow aquifer (arsenic-contaminated) and deep aquifer (non-arsenic-contaminated), can leak due to void created by drawing a large amount of water. It will convert an arsenic safe aquifer into an arsenic-contaminated one.

From the above observation, there are always some drawbacks in the mitigation interventions in the context of environmental sustainability. Technologies must be designed and implemented, keeping local conditions in consideration. Rainwater harvesting in the Gangetic plains where rainfall is adequate in the monsoon is the best option in this regard. It can be incorporated in combination with the rooftop rainwater harvesting system, which is new to the local people but may prove sustainable in the long run.

#### 6.2. Socially sustainable measures

Social sustainability in terms of arsenic contamination is rooted within the question of arsenic-free accessibility of water. Neither policy nor approaches in the arsenic mitigation have been considered and incorporated the social realities of arsenic impacted communities for which mitigation techniques are implemented. Policies and programs are based on assumptions that mitigation interventions would serve each person and household equitably. The efforts are being made in searching for a suitable place for the installation of a water supply system. Still, there is no monitoring of whether all beneficiaries have an equitable right of access to mitigation technologies. When people are given choices between arsenic-contaminated handpumps at home and arsenic-safe water supply systems located at some distance, people most of the time choose the nearest options. It is true in the case of women who have to do all household work and fetch water. The time she will spend fetching water from a distant location may have been utilized in completing other works or doing something to earn money. It is also hampering the capability of an individual.

Apart from physical accessibility, social accessibility is an important concern in Indian villages. Still, there are several villages where caste-based discrimination is prevalent. People of the dominant caste have a monopoly over the water resources, and they do not allow the people from the socially marginalized sections to collected water from that system. The question of social accessibility is also true in the case of household piped water connections.

Despite the household connections, the water may not reach the houses of marginalized sections. The dominant group either breaks the pipe so the water cannot reach the socially deprived people's house, or they use water for irrigation and consequently pressure drops too much, or no water remains in the system.

#### 6.3. Economically sustainable measures

The economic sustainability of a water delivery system depends on its affordability. The piped water supply system is either a single village scheme or a multi-village scheme, is very expensive to install and operate. When stake-holders do not recover their operation and management (O & M) costs, they do not remain sustainable in the long run. There are instances in the study area when a community-based water supply system is transferred to local inhabitants for O & M, and then the scheme failed miserably. It is due to two reasons: the irregular supply of electricity and the high diesel prices. In both cases, poor inhabitants cannot pay for the operating pumps either through diesel or electricity. Another problem observed in the Shahpur block was the affordability of the bottled water, which is claimed to be safe and arsenic-free, supplied by private agencies. In most cases, buying bottled water from private agencies puts an extra burden on the household's monthly budget. It was analyzed that the monthly charges of the community-based supply system run by government agencies are affordable and manage-able to some extent by the inhabitants.

# 6.4. Sustainable Potential Option for Safe Drinking Water

Considering all the mitigation strategies, we have concluded that most arsenic mitigation efforts are least sustainable when put against the environmental, social, and economic perspectives. In Bihar, the average annual rainfall is around 1200 mm, out of which more than 85% is received during the monsoon period (June to September); rainwater harvesting could be a sustainable solution for the supply of arsenic-free water. Surface water and rainwater harvesting have been recognized as a solution for getting arsenic-free water in quality affected areas (Giri et al., 2011; Planning commission of India, 2007). Only a fraction of the rainfall is preserved in India, and the rest is wasted in surface runoff. A significant amount of runoff can be preserved by the arsenic hit villages at the local level in the ponds and Ahar-Pyne systems (Indiawaterportal). This water can be filtered locally can be used for cooking and drinking. When considering rainwater harvesting to tackle the arsenic problem, the local condition regarding the environment, climate, social system, cultural acceptability, and economic affordability should be considered. Decentralized use and management of rainwater offer a sustainable prospect for solving the problem of arsenic contamination. Accessibility to safe drinking water enables women, men, and children to enjoy their life without any fear. The money and time saved after the availability of safe drinking water to their premises may enhance their skills and capability, which will make way for a developed society.

#### 7. Conclusion

This study finds that the most popular and widely used source of drinking water in the study area is groundwater. Due to the low level of education (less than 50%) in the study area, superstition is prevalent in society. People are not aware of the problem of arsenic contamination and its related toxicity. Though there is an elevated level of arsenic in groundwater, people do not find it necessary to filter the water before use. More than 90% of the house-hold do not treat water before consuming. Due to unawareness and less knowledge, people also boil water before use, proving harmful rather than beneficial. Further, it has also been found that the bottled water business, which is claimed to be arsenic-free, is growing in the area. The economically marginalized people cannot afford bottled water and do not have money to install good quality electronic filters. Hence, most of the burdens associated with arsenic contamination if put on poor people.

The burdens put on by arsenic contamination are a threat to society's social sustainability. The community's social structure is degrading because people showing symptoms of arsenic manifested diseases are being socially discarded, discriminated and ostracized. When people have a disease, they lose their physical strength, and they remain sick. It puts a two-way burden on them – one through medical treatment and the other through job loss. Further, arsenic contamination is placing a question mark on the sustainability of agriculture production. Farmers are getting less yield per unit of land; contaminated products, and they cannot sell their contaminated products. These issues are putting a negative economic impact on the area's farmers and proving to be fatal to their livelihood. The mitigation measures employed until now have not proved sustainable on the grounds of environment, society, and economy. The wastes released from the water treatment plants in the arsenic-contaminated areas are dumped on the ground or in ponds, further increasing the arsenic concentration in soil and water in that particular place. In India, people are often discarded and discriminated against by caste, color, and religion. The public water supply system delivering safe and arsenic-free water is captivated by the dominant community of the habitations, and marginalized sections are devoid of the facilities. Further, the multi-village and the single village system for supplying arsenic safe water is not economically sustainable in the Shahpur Block (study area) and other places in India. The poor peasants find it hard even to pay the operation cost for these systems, and hence it is becoming hard for stakeholders to recover their O & M cost.

To reduce socio-economic problems and develop cost-effective mitigation techniques, community participation is necessary. There is an urgent need to make people aware of groundwater's arsenic contamination and toxic effects. Considering the geography of the study area, the best mitigation interventions could be rainwater harvesting and rooftop rain harvesting. These interventions are cost-effective, easy to maintain, socially acceptable, and environmentally and economically sustainable in the long term.

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# How Humble Leadership Affects Voluntary Green Behavior and Green Performance? The Roles of Job Autonomy and Green Supporting Climate in Hotels

# Jak pokorne przywództwo wpływa na dobrowolne ekologiczne zachowanie i ekologiczną wydajność? Rola autonomii pracy i ekologicznego klimatu wspierającego w hotelach

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# Abstract

The relationship between the humble behavior of leaders and the voluntary workplace green behaviors (VWGB) of their employees is critical to affecting the overall green performance of an organization, particularly in the situation of the COVID-19 pandemic. Traditionally, most studies focus more on the importance of leadership effectiveness, but few research studies investigate the leadership approach and its psychological mechanisms that motivate voluntary positive behavior and the efficiency of the overall performance. Thus, the authors conceptualize a research model of humble leadership that investigates the impact of humble leadership on voluntary green behavior and green performance via job autonomy and the green supporting climate. To verify the research hypotheses, 692 online and in-person questionnaires were analyzed using SmartPLS-SEM. The results showed a positive association between humble leadership and green performance, and VWGB mediates this relationship. In addition, job autonomy and green supporting climate were confirmed to mediate the association of humble leadership and VWGB; and moderate the relationship between VWGB and green performance, respectively. Notably, this study is one of the few studies in the hotel sector that look at green performance through the lens of humble leadership and VWGB.

Key words: humble leadership, voluntary green behavior, green performance, job autonomy, green supporting climate, green hotels

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Slowa kluczowe: pokorne przywództwo, dobrowolne ekologiczne zachowanie, ekologiczne działanie, autonomia pracy, zielony klimat wspierający, zielone hotele

# 1. Introduction

Developing the hotel sector is a key component of the tourist industry. Despite recent advances, the hotel sector continues to have significant environmental consequences. This, in turn, emphasizes the necessity for continuous green performance improvement (Yusof & Jamaludin, 2013). As a result, sustainability becomes a popular topic in many industries, including the hotel sector, where it is a key issue for future growth (Shen et al., 2020). Since it is a key driver of socio-economic progress in all nations worldwide, tourism is evolving toward sustainable tourism since it has a detrimental influence on the environment (Abdou et al., 2020). Nonetheless, the efforts exerted by the hotel operators to practice green approaches are an indicator of the hotel's concern about sustainability issues (Yusof & Jamaludin, 2013). However, in most of the hotel sector, the idea of sustainability creates a perplexing dichotomy. On the process level, for example, the sector is increasingly looking to incorporate sustainability into both advertising message and the guest experience, while the headline emphasis is frequently on conspicuous consumption and spending, which is the opposite of sustainability in many respects (Jones et al., 2014). Low-level voluntary green practices have an impact on company green performance, resulting in an increase or decrease in green performance activities because there is a link between green performance and achieving sustainability in different business companies (Nejati et al., 2017). Sustainability is founded on a basic rule: everything we require for existence and well-being is dependent on our natural behavior, either explicitly or implicitly. Pursuing sustainability entails creating and maintaining conditions that allow nature and humans to coexist in productive harmony for the benefit of the current and future populations (Šerić & Šerić, 2021). Sustainability and leadership style, according to Raineri and Paillé (2016), can facilitate cooperation because leadership can help shape sustainable employees' behavior and influence employees' beliefs and attitudes, whereas commitment to sustainability can help companies distinguish themselves from competitors by improving green performance and developing a successful brand image, particularly following the onset of the COVID-19 crisis. Although the COVID-19 crisis has created a devastating impact on human health as well as economies and societies across the world, some commentators have emphasized the importance of recognizing the environmental improvements generated by the COVID-19 crisis and the need to look to build strong structural green measures into any scheme of life (Jones & Comfort, 2020). However, there are concerns that the COVID-19 crisis would cause the hospitality industry's engagement in sustainable development practices to dwindle. Here, the hotel industry's key players may declare that they will amass the financial resources necessary to maintain, or more reasonably, renew, their commitment to sustainable practices (Elshaer, 2021). Therefore, the COVID-19 crisis has provided an opportunity for business sustainability practices while simultaneously posing some challenges (Alsetoohy et al., 2021). For example, the crisis may be regarded as emphasizing the need to employ green behaviors and practices in terms of adopting more renewable energy sources and committing to material recycling and cyclical economic and operational facts (Jones & Comfort, 2020). Green performance and corporate sustainability have grown in importance as relevant priorities for many large corporations in the business world. At the same time, in many less-developed nations where the tourism and hospitality industry is a major component of the economy, the need to move on sustainable development principles is even more critical. Jones et al. (2014) argued that the hospitality industry contributed to this trend by developing sustainability initiatives at several of its leading corporations. However, according to Ertuna et al. (2019), assuring employees' commitment and engagement in sustainability practices, which can reflect company and leaders' objectives and values, is a key problem for the hotel industry. However, such shifts have significant ramifications for the traditional business structures of the hospitality industry.

Recently, most businesses and their leaders aim to enhance resource efficiency while decreasing negative human health, productivity, and environmental impacts. In this essence, there is an increasing awareness of the need to integrate environmentally friendly practices into the actual hotel operations and ledgers (Su et al., 2020), but most studies discuss guest behaviors (Elshaer, 2021). Hotels, therefore, need to motivate workplace green behavior and the green performance of their employees (Chan et al., 2014), to reinforce the environmental capacity that affects hotels' sustainability. This, however, need leaders who can lead and establish behaviors that are appropriate and successful in dealing with these challenges and attaining green performance and growth (Ibrahim & Daniel, 2019). So, organizations are increasingly being called to develop new business and leadership models for sustainability that can meet the social, economic, and environmental pillars of sustainability (Fry & Egel, 2021). In response, leaders and their teams have emerged as the heart of enterprise growth due to their important contributions to sustainable development (Ren et al., 2020). Accordingly, CEOs now have the increasingly challenging task of fostering favorable employee emotions and behavior toward their organization (Elshaer & Marzouk, 2019), to engage in pro-environmental activities. In an open system that emphasizes the growth of subordinates and encourages valuable participation, effective leadership can result in achieving organizational goals with less effort, time, and cost, not to mention encouraging continuous improvement and organizational support for individuals (Koohang et al., 2017).

In leadership practices, leaders' conduct is critical for companies to achieve development and high performance since they deal with employees and oversee the day-to-day operations of an enterprise. So, psychological characteristics of leaders such as humility and enthusiasm, are one of the primary influencing determinants of the decision-making, which have direct or indirect effects on employees' behavior and the overall firm's green performance (Petrenko et al., 2019). According to Ren et al. (2020) humble and subordinate-oriented leadership styles, in particular, are more likely to foster trusting relationships between leaders and subordinates, which in turn motivate followers to take good and proactive activities while reducing negative intentions and acts (Owens et al., 2013). Therefore, in such dynamic and changing environments, humility is becoming increasingly necessary for running businesses (Owens et al., 2013). So, humble leadership has gotten more attention from academics and practitioners because of its emphasis on leading from the bottom and its impact on the role of followers (Ou et al., 2018; Owens et al., 2013). According to Owens and Hekman (2012), humility is viewed and recommended in everyday life as a virtue because humble leaders are more objective in their assessments of themselves, more respectful of others, and more receptive to new knowledge or ideas. Thus, humble leadership goes beyond the *hero myth* and *great man* conceptions; humble leaders show their humanity by being honest about their knowledge and ability limitations, and they pay more attention to how workers influence the leadership process (Mazutis & Zintel, 2020).

A major proposition of this study is that humble leadership is essential for the transformation and long-term success of any organization. Given that green behavior is genuinely rooted in the sanctity of humans, we also propose that the employee Voluntary Workplace Green Behavior (VWGB) and green performance are particularly important outcomes of humble leadership, as these reflect a critical role by followers, whose consciousness role is influenced by interactions between green humble leadership practices and organizational green outcomes, as well as on how job autonomy and green supporting climate affects employees' perception and motivation to engage in green activities in the organization. Although prior studies have studied the behavioral and attitudinal effects of humble leadership, none has addressed green behavior and performance (Li et al., 2016; Pham et al., 2020a). In the same line, Orlitzky et al. (2011) claimed that a significant weak area in the literature is the absence of studies connecting individuals to business sustainability. For this reason, this study examines how humble leadership influences workers' task-related and VWGB and performance in the hotel sector. From the authors' perspective, humility is necessary for motivating VWGB and performance, as well as enabling the organizational environment for more job flexibility and a green supportive atmosphere. Indeed, some studies have proposed that psychological factors may be a key mechanism for defining the role of humble leadership in employees' performance (Owens et al., 2013). In practice, the aim of the study is to show how humble leadership behavior can be effectively implemented in organizations to achieve VWGB and a green supporting climate that encourages green performance.

Theoretically, this study will contribute to the human resource management and green performance literature by gaining insights into the integration of leadership style, individual behavior, and green practices, which have all been identified as key factors in the success of organizations. Furthermore, the findings of this study will give new information and evidence on humble leadership behavior and its outcomes in hotels, which have been understudied to date (Pham, et al., 2020b), including:

- review and synthesize the relevant literature on humble leadership for evolving green behavior and performance,
- reflect some of the changes caused by the role humility-related psychological motives play in sustainable business development following the outbreak of the COVID-19 crisis,
- explore how humble leadership as a source for job autonomy, VWGB, and other factors that support green performance, and
- develop a model that combines current generally acknowledged ways to humble leadership.

# 2. Literature Review and Theoretical Model

2.1. Humble Leadership and Voluntary Workplace Green Behavior (VWGB)

Historically, humility has been seen as a basis for virtues and character integrity (Morris et al., 2005; Yang et al., 2019). While traditional views about humility emphasize the intrapersonal advantages of humility in the development of other positive personal characteristics (Kesebir, 2014), recent research on humility focuses on the psychological role of humility and its social impact on subordinates (Ou et al., 2018). According to Chen et al. (2018), humble leaders' emotions have a direct impact on workers' attitudes at work, which is the psychological aspect of cognition. As a result, leaders' thoughts and attitudes are contagious and are passed on to their subordinates (Avey et al., 2012). In this study, humble leadership behavior is proposed as a major predisposing factor that motivates employee VWGB (Liu & Zhao, 2019). VWGB refers to any individual conduct that contributes to reducing environmental consequences beyond individual responsibilities (Norton et al., 2015). Green conduct in the workplace has usually been viewed as a voluntary behavior in studies of green behavior in the workplace (Paillé & Boiral, 2013), in which individuals can also opt to go beyond what is needed by the company in terms of environmental behavior (Norton et al., 2015). This includes prioritizing environmental interests, initiating environmental practices, lobbying and activism, and encouraging others. To encourage voluntary green behavior, it is necessary to

influence and modify the behaviors of workers so that they adhere to the aims of sustainable environmental organizations. Research shows that organizational and managerial efforts consolidate in a holistic framework that determines employee engagement in extra-role pro-environmental behaviors (Alsetoohy et al., 2021; Elshaer, 2020; Raineri & Paillé, 2016) This reciprocal idea emphasized the importance of relationships, particularly reciprocity between individuals and organizations or leaders. The assumption is that the behavior is motivated by duties deriving from reciprocal interactions, such as those between leaders and followers (Cropanzano & Mitchell, 2005). When employees realize that leadership worries about others, pays attention to the values of green behavior, and maintains sustainable development, they may want to appear in environmentally friendly ways at work as a voluntary behavior, which will be supported by humble leaders' behavior, emotional spirit, and encouragement (Liu & Zhao, 2019). Green behavior and humble leadership go hand-in-hand, according to the social learning theory, particularly that employees are influenced by their leaders' behavior patterns, which they then imitate. Therefore, humble leaders who display high standards of morality will influence employees' attitudes and behaviors. The reason is that employees working with such leaders will think that ethical leaders do not stab them in the back. They will think that moral leaders seldom cheat (Bauman & Skitka, 2012), and hence, it is safe to work with such leaders without the fear of threat to their status, image, or career. We, therefore, suggest the following hypothesis: **Hypothesis 1.** The leader's humble behavior will have a positive effect on employee VWGB.

# 2.2. VWGB and Green Performance

Due to its high consumption of water, electricity, and non-durable products, as well as the discharge of significant amounts of raw and solid waste in varied proportions, the hotel sector is one of the numerous components of tourism whose operations pose a major danger to the environment (Kasim, 2009). If these resources are not adequately controlled (Abou Kamar & Alsetoohy, 2021), they will have a negative influence on the environment and the overall performance of an organization (Mensah, 2006). However, in recent years, many pressures have motivated the hotel sector to become more environmentally friendly (e.g., growing consumer environmental awareness, establishing a favorable image, minimizing hotels' negative effects on the environment, and achieving economic gains (Han & Chan, 2013). Going green has a variety of effects on individuals and their businesses. When a hotel implements green practices, it sometimes necessitates more responsibilities for its staff (Chan et al., 2014). So, in order to deal with greening, individuals may need to be environmental champions to keep proactive and voluntary green activities (Renwick et al., 2013). According to Bissing-Olson et al. (2013), employee green behavior is divided into two categories: task-related green behavior carried out within the scope of employee duties and voluntary green behavior carried out beyond the scope of employee responsibilities. Employees' green behavior when executing the fundamental activities required by companies is referred to as task-related green behavior (e.g., environmental protection regulations stipulated in conducting duties, compliance with environmental measures, and others) (Farooq et al., 2021). While we use the concept of voluntary workplace green behavior to describe discretionary employee behaviors that contribute to the organization's environmental sustainability but are not governed by any official environmental management policies or procedures (Boiral, 2009).

In the hotel sector, green performance has many different meanings and connotations. Green performance, according to Kim et al. (2017), is a value-added management approach that helps a hospitality organization that participates in environmental protection activities. Similarly, Myung et al. (2012), stated that green performance entails decreasing negative environmental effects by implementing environmental measures such as waste reduction and the use of sustainable products and resources. Likewise, green hotels are characterized as environmentally friendly establishments whose teams are eager to implement initiatives that conserve water, electricity, and solid waste – all while saving money – to help the environment (Abdou et al., 2020; Alsetoohy et al., 2021). Meanwhile, employees play a critical role in arranging their efforts to achieve a certain aim. During this process, individuals actively engage in green behaviors, demonstrating their dedication to green performance aims (Kim et al., 2017). It is the responsibility of all of a company's employees to ensure efficient green performance. When employees attempt to engage in altruistic green behaviors that are consistent with their work values, they express a voluntary approach that contributes to evolving green performance. Therefore, we suggest the following:

Hypothesis 2. Employee VWGB will have a positive effect on hotel green performance.

**Hypothesis 3.** *Employee VWGB mediates the relationship between humble leadership behaviors and hotel green performance.* 

#### 2.3. The Role of Job Autonomy

The conventional top-down leadership paradigm stresses rigorous superior-subordinate management and overemphasizes the leader's power and influence over individual work engagement (Howell & Shamir, 2005), limiting the important role of personnel in the leadership process to some extent (Chen et al., 2018). Humility in leadership, on the other hand, provides employees with enhanced intrinsic psychological incentive to be proactive by emphasizing subordinates' talents and contributions while also recognizing their own limits (Chen et al., 2018). These characteristics imply that humble leaders value subordinates' opinions and growth; offer psychological freedom for followers, and highlight subordinates' talents and contributions. According to Nielsen and Marrone (2018), leaders who are humble can encourage learning and progress; humility behavior allows one to transcend the comparative-competitive response when interacting with others and instead acknowledge and admire the strengths and contributions of others without feeling threatened by them (Exline & Geyer, 2004). Therefore, humble leadership behavior, based on self-determination theory, helps unlock subordinates' maximum potential by developing individuals' innate tendencies toward self-actualization and growth by satisfying basic psychological demands for autonomy (Zhou et al., 2019). Conversely, Hackman and Oldham claimed that jobs with greater autonomy provide employees more flexibility, discretion, and independence in determining how to divide their workday and other parts of their jobs, cited in (Zhou et al., 2019). When individuals believe they have control over their actions or they can engage in specific activities in a discretional manner, they will be strongly inspired to work hard and always aim to grow and prepare for the best (Ryan & Deci, 2000). According to previous studies, greater job autonomy can provide employees with more time, energy, and flexibility Ryan to engage in specific activities, resulting in increased enthusiasm for good job attitudes and increased job efficiency (Humphrey et al., 2007). Individuals' autonomous conduct demonstrates that they are capable of engaging in environmentally beneficial proactive behaviors. As a result, we argue that job autonomy may inspire employees to positively engage in volunteer work. Job autonomy, in particular, allows employees to devote their time and effort to operate individually, as well as gives them the autonomy to decide on working approaches and to choose the way with which they connect with their coworkers. Employees may have a higher degree of proactive-work desire and view their job as sustaining their organization if they believe they have more freedom in determining how to carry out their work. Their internal motivation would increase and their enthusiasm for work would be sparked. As a result, they may act more proactively and come up with more ideas and practices that will benefit them and the business. Since employees have greater freedom in their jobs, they may come up with more creative solutions for improving their work, as well as improve processes and create developmental objectives for future needs. On the basis of this, we propose:

Hypothesis 4. Job autonomy mediates the relationship between humble leadership behavior and employee VWGB.

#### 2.4. The Role of Green Supporting Climate

Green-supporting climate may be described as the extent to which a company supports its workers in completing their tasks in a sustainable manner (Martins & Terblanche, 2003). More precisely, green supporting climate refers to a climate in which people are acknowledged and awarded for their green initiatives, are given job-related tools that promote green practices, and are motivated to be proactive in adjusting to change or addressing a problem (Kim & Yoon, 2015). In addition, a green supporting climate involves distributing information about the company's green policy, prioritizing individual green values in recruiting and selection, and fostering green values via leadership approaches (Renwick et al., 2013). According to Pless (2012), environmentally-friendly job design, as well as green training methods that increase employees' skills and green performance, are essential procedures for creating a green-supporting climate, which eventually contributes to increased organizational green performance. Therefore, an organization's green supporting climate is determined by the extent to which employees are keen to voluntarily participate in green creative practices, and to what extent they are motivated to engage, and continually educate themselves on the latest environmental issues (Dumont et al., 2017). In this context, Zientara and Zamojska (2018) verified that a green-supporting climate is mostly controlled by the employees' personal beliefs, psychological variables, and the environment in which they work (managerial and institutional regulations) (Kuenzi & Schminke, 2009). As a result, the green-supporting climate, which is described as employees' behaviors, rules, practices, and procedures, is dependent on the collective sense-making (Schneider et al., 1998). The conclusion is that climate, or more specifically, its constructive components, establish a normative framework that communicates to employees what their business values and wants, and, as a result, what behavioral and attitudinal responses they should anticipate. Hence, when an organization publicly recognizes voluntary employees' contributions to the environment and allocates a budget for green projects and activities, we can conclude that a climate for green support has been created and is yielding the intended returns. Subsequently, we developed the following hypothesis:

**Hypothesis 5.** *Green supporting Climate moderates the relationship between employee VWGP and hotel green performance.* 

# 3. Materials and Methods

# 3.1. Measurements

A quantitative approach was deployed to test the research hypotheses. The questionnaire was established on the basis of a thorough revision of related studies. The questionnaire consists of six categories; namely, humble leadership, employee voluntary workplace green behavior, hotel green performance, job autonomy, green supporting





climate and respondents' profiles. First, humble leadership was measured by nine items adapted from (Owens et al., 2013). Second, the employee's voluntary workplace green behavior was measured by six items retrieved from (Cai et al., 2020). Third, seven items adapted from (Nisar et al., 2021) were deployed to measure the hotel's green performance. Further, measures of job autonomy (three items) and green supporting climate (eight items) were adapted from (Iplik, 2014) and (Norton et al., 2014), respectively. Finally, the last section contains the profiles of respondents. Additionally, all of the items for the questionnaire were assessed by five-point Likert scales ranging from *strongly disagree* = 1 to *strongly agree* = 5).

The pilot study was conducted to check the validity and reliability of the questionnaire on a sample of hotel employees in Egypt. Mixed methods, online and in-person surveys, were used to collect the data during the research pilot study. Thus, online and in-person questionnaires were disseminated to the hotels' employees. Snowball procedures were employed in the online questionnaire through key respondents in these hotels (n= 132). Additionally, in-person questionnaires were handed out to the employees to fill out (n=103). About 235 questionnaires have shown slight modifications such as We avoid in voluntary workplace green behavior was replaced with I avoid to be more focused.

Characteristics	Frequency	%	Characteristics	Frequency	%
Ger	nder			Experience	
Male	389	55.4	< 5 years	173	24.6
Female	277	39.5	5- < 10 years	296	42.2
Other	5	.7	10 - < 15 years	198	28.2
Prefer not to answer	21	3.0	>15 years	25	3.6
Marita	l status			Country	
Single	298	42.5	Egypt	235	34.0
Married	327	46.6	US	51	7.4
Separated	24	3.4	Canada	29	4.1
Widow	16	2.3	Chile	32	4.6
Other	27	3.8	China	47	6.8
А		Botswana	13	1.9	
20 - < 30 years	230	32.8	France	9	1.3
30 - < 40 years	344	49.0	Germany	10	1.5
40  to < 50  years	73	10.4	UK	30	4.3
50 - 60 years	42	6.0	India	72	10.4
Over 60 Years	2	.3	Italy	25	3.6
Educ	ation		South Africa	16	2.3
< College	193	27.5	Australia	37	5.4
Bachelor	442	63.0	Slovenia	35	5.1
Master Degree & MBA	50	7.1	Portugal	25	3.6
Doctorate	7	1.0	Estonia	11	1.6
			Poland	12	1.7
			Malta	3	0.4

Table	1.	Sociode	emograr	ohic	charad	cteristics	of the	partici	nants
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#### 3.2. Sampling and Data Collection

Employees of hotels are the participants of the current study. The online survey was employed through Amazon's Mechanical Turk (MTurk), targeting only 500 employees representing virtually all hotels' employees all over the world. MTurk is considered fast, low-cost, flexible, and more representative, and it allows researchers to target specific populations (Alsetoohy et al., 2021; Alsetoohy & Ayoun, 2018). A screening question was used to ensure

compliance with the study's requirements (i.e. Are you currently working in a hotel?), if the answer is yes the participant will be transferred to complete the survey, if the answer is no the respondent will receive a thanks message and the link will be automatically closed within 5 seconds. Moreover, each participant was compensated with \$1. Of the 500 respondents who filled the online survey out, we received 476 completed surveys (response rate = 0.95%), and only 457 were eventually usable. Roughly, nineteen questionnaires were invalid due to missing data (16 questionnaires) and answering with one value (3 questionnaires). Additionally, due to the slight modifications of the pilot study's sample, we added it to the online sample. Thus, the final number of the research sample reached 692 valid questionnaires. The participant's demographics of the study were presented in Table 1.

# 3.3. Data Analysis and Hypotheses Testing

The SmartPLS-SEM software, version 3.2.8, was run to analyze the research data and test the hypotheses. The PLS technique has been extensively operationalized in the field of tourism and hospitality research for several reasons (Alsetoohy et al., 2019, 2021; Alsetoohy & Ayoun, 2018). PLS is more suitable for small sample size, prediction, and development of theories in research studies. Further, PLS is non-sensitive to the normality of data distribution. Finally, the PLS technique is working well with models that have a large number of indicators. A two-step process was deployed to test the research hypotheses using smart PLS\_SEM software; the measurement model and the structural model (Hair et al., 2012).

# 3.4. The Measurement Model (Outer Model)

The validity and reliability of all latent variables of the study were assessed and checked to validate the research model relationships. To verify the internal reliability of the constructs, the Composite Reliability (CR) and Cronbach's alpha were checked. The convergent validity of the model was assessed by the item loadings of the indicators, CR, and the average variance extracted (AVE). Furthermore, the Heterotrait-Monotrait (HTMT) ratio of correlation and AVE were utilized to establish the discriminant validity. Finally, the variance inflation factor (VIF) was calculated to assess the collinearity of the constructions.

Table 2 illustrates that the Composite Reliability (CR) and Cronbach's alpha values for all latent variables were above the floor of .7 (Hair et al., 2012). Thus, the internal consistency of the research model was achieved. Additionally, the item loadings were above .7 (Hair et al., 2010) and CR values were greater than 0.7 (Hair et al., 2012) and the AVE values were above the value of 5 (Abou Kamar & Alsetoohy, 2021; Alsetoohy et al., 2021; Fornell & Larcker, 1981) which establishes the convergent validity. Likewise, the HTMT values ranged from 0.111 to 0.670, less than the floor of 0.80 (Hair et al., 2012), and all constructs correlations were lower than the square root of AVE of their respective constructs (Alsetoohy et al., 2019, 2021; Fornell & Larcker, 1981), see Table 3. Therefore, the discriminant validity was achieved. Eventually, the values of VIF are lower than 5, confirming that there are no multicollinearity issues between the model constructs (Ringle et al., 2015).

## 4. Results

To assess the structural model of the research, the R<sup>2</sup>, the *p* values, and the significance of the path coefficient ( $\beta$ ) were used. Figure 2 shows that the R<sup>2</sup> values have a substantial explanatory power (Chin, 2010), with values achieved 50.2% for the dependent variable. Figure 2 indicates that the values of *p* and the path coefficients refer to statistical significances between the research variables. The results of the study indicated that humble leadership has a positive influence on VWGB ( $\beta = 0.282$ , *p* = 0.000). Thus, **hypothesis 1** is supported. Furthermore, the employee VWGB has the strongest positive effects on the hotels' green performance ( $\beta = 0.688$ , p = 0.000). Hence, **hypothesis 2** is further supported.

To check the significance/insignificance of the indirect effects of the research model, bootstrapping tests with 5,000 samples in SmartPLS were conducted to calculate the Bias- Corrected-Confidence Interval (BCCI), T-statistics, component weights, and observed significance values in path coefficients to check and assess the mediating effects of both VWGB and job autonomy across the theoretical model. The findings indicate positive indirect significant relationships between humble leadership (IV) and hotel green performance (DV) through VWGB; and humble leadership (IV) VWGB (DV). Moreover, BBCI does not straddle zero between: [LL 0.192, UL 0.336] and [LL 0.118, UL 0.230] identified the significant mediations respectively. The results reported that VWGB (T= 6.966, p = .000) mediate positively the relationship between humble leadership and hotel green performance, indicating validation of **hypothesis 3**. Also, job autonomy (T= 5.868, p = .000) was found to mediate positively the relationship between humble leadership and employee VWGB, which supports **hypothesis 4**.

Finally, the green supporting climate was found to positively moderate the relationship between employee VWGB and hotel green performance ( $\beta = 0.127$ , p = 0.000). In order to further verify the moderating effect of green supporting climate in the relationship between employee VWGB and green performance of hotels. The simple slope test, plotted interaction in Figure 3, (Preacher et al., 2006), reported that green supporting climate enhanced hotel green performance to a higher degree when employee VWGB was at a high level (one standardized deviation above the mean) than when it was at a low level (one standardized deviation below the mean). These empirical

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Table 2. Item loadings and construct	t reliability and	l validity		
Construct/ Item	Item	Cronbach's	CR	AVE
	Loadings	Alpha		
Humble leader behaviors Our leader		0.917	0.931	0.602
HL1: actively seeks feedback, even if it is critical.	0.802			
HL2: admits it when they don't know how to do something	0.800			
HL3: acknowledges when others have more knowledge and skills than	0.841			
him- or herself.	0.041			
HL4: takes notice of others' strengths.	0.763			
HL5: often compliments others on their strengths.	0.767			
HL6: shows appreciation for the unique contributions of others.	0.811			
HL7: is willing to learn from others.	0.713			
HL8: is open to the ideas of others.	0.729			
HL9: is open to the advice of others.	0.744			
Voluntary workplace green behavior (VWGB)		0.894	0.919	0.653
VWGB1: I avoid unnecessary printing to save paper.	0.767			
VWGB2: I use personal cups instead of disposable cups.	0.810			
VWGB3: I use stairs instead of elevators when going from floor to	0.700			
floor in the building.	0.799			
VWGB4: I reuse paper to take notes in the office	0.804			
VWGB5: I recycle reusable things in the workplace.	0.841			
VWGB6: I sort recyclable materials into their appropriate bins when	0.007			
other group members do not recycle them.	0.827			
Hotel green performance Our hotel has	•	0.907	0.927	0.645
HGP1: reduced wastes	0.735			
HGP2: conserved water usage	0.764			
HGP3: conserved energy usage	0.821			
HGP4: reduced purchases of non-renewable materials, chemicals, and	0.542			
components	0.743			
HGP5: reduced overall costs	0.896			
HGP6: improved its position in the marketplace	0.864			
HGP7: helped enhance the reputation of our hotel	0.785			
Job autonomy		0.805	0.884	0.718
JA1: When I communicate with consumer. I have freedom and inde-	0.050			
pendence to act in ways I think fit the situation.	0.859			
JA2: I have a lot of freedom to decide how I should deal with consum-	0.070			
ers.	0.860			
JA3: My job denies me much chance to use my personal judgment	0.000			
when communicating with consumers	0.822			
Green supporting climate Our hotel	•	0.907	0.925	0.605
GSC1: is worried about its environmental impact.	0.776			
GSC2: is interested in supporting environmental causes.	0.732			
GSC3: believes it is important to protect the environment.	0.781			
GSC4: is concerned with becoming more environmentally friendly.	0.811			
GSC5: In our hotel, employees pay attention to environmental issues.	0.831			
GSC6: In our hotel, employees are concerned about acting in environ-				
ment-tally friendly ways.	0.749			
GSC7: In our hotel, employees try to minimize harm to the environ-	0 = (1	7		
ment.	0.761			
GSC8: In our hotel, employees care about the environment.	0.780	1		

able	2.	Item	loadings	and	construct	reliability	and	validit
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# Table 3. Correlation matrix and Fornell-Larcker Criterion

	Green support climate	Hotel Green Performance	Humble Leaders	Job Autonomy	VWGB
Green support climate	0.778				
Hotel Green Performance	0.420	0.803			
Humble Leaders	0.068	0.430	0.776		
Job Autonomy	0.372	0.517	0.358	0.847	
VWGB	0.439	0.689	0.454	0.580	0.808

The square roots of AVEs for the research variables are in Bold

results stated that green supporting climate strengthens the positive relationship between employee workplace green behavior and hotel green performance. Therefore, hypothesis 5 is supported.



climate

behaviors, employee VWGB, and hotel green performance as long as the mediating and moderating roles of job autonomy and green supporting climate respectively. This relationship is critical because studies in the field of hospitality ignore examining the role of leadership styles (e.g. humble leadership) in promoting sustainable development, particularly; the role of employee voluntary workplace green behavior is highly required in light of the COVID-19 consequences. In general, all hypotheses of the current study are supported and indicated positive relationships between all the research variables (i.e. independent, dependent, mediator, and moderator). Thus, these findings validate and support the conceptualized model of the study. The findings of the study indicate that humble leader behaviour is positively related to VWGB in green hotels in Egypt. This empirical finding is in accordance with the findings of the previous studies (Nielsen et al., 2010; Owens & Hekman, 2012; Yang et al., 2019), which asserted the positive influence of humble leader behaviors on the employee behaviors such as innovation and creativity. It was acknowledged that a leader's behaviors can promote employee VWGB. Given the fact that behavior is motivated by duties deriving from reciprocal interactions, ethical and positive leadership is a must. Humble leaders, with a moral managerial style and a strong sense of social responsibility, would inspire employees to do their best in paying greater attention to green and employee VWGB. Consequently, this study confirms that humble leaders in green hotels can encourage and promote employees to engage in VWGB in the workplace. The interpretation of this finding is that humble leaders optimize trust, communication, innovativeness, creativity, and mutual awareness among their employees. Since the study is conducted in green hotels, employees' duties are more related to task-role, and required tasks, such as green practices. Thus, humble leaders inspire and motivate employees to go beyond their tasks and extra-role activities to voluntary behaviors to sustain green behaviors. Thus, for the hospitality establishments which seek voluntary behaviors in their operations, especially green behaviors, attracting humble leaders is a win-win relationship.

Figure 3. The moderating effect of green supporting climate

Low Employee voluntery High Employee voluntery workplace green behavior workplace green behavior

2

1,5

1

Interestingly, the findings of the study also indicate that VWGB has the strongest positive effects on the hotel's green performance. Additionally, the findings reveal that VWGB mediates positively the relationship between humble leadership behaviors and hotel green performance. This finding supports the findings of (Kim et al., 2019; Nisar et al., 2021; Pham, et al., 2020b), who also confirmed that the higher the green behavior of employees, the better the environmental performance is achieved. This finding is aligned with Singh et al. (2020) and Al-Swidi et al. (2021) who asserted the indirect relationship between a leader's behaviors and the organizational environmental performance. Thus, green hotels should not only focus on improving their environmental performance and minimizing the negative effects of their activities, but they must also instill VWGB among their employees. Consequently, reshaping the green behaviors of hotel employees through leaders' behaviors would be, in turn, mirrored in green performance.

Moreover, this study's findings indicate that job autonomy mediates positively the relationship between humble leader behaviors and VWGB. This finding is in line with the previous study by Cai et al. (2020). Also, the study of Lee et al. (2021) indicated that employee job autonomy positively mediated the relationship between the positive feedback of leaders and employees' innovative behaviors. This result assumes that to gain VWGB in these green hotels, providing greater job autonomy to employees is required along with humble leaders' motives. This is because trials, experimentation, making mistakes, and making changes to the workplace require more flexibility and autonomy which are advantages derived from humble leaders to employees.

Finally, the findings of the study stated that green supporting climate positively moderates the relationship between VWGB and hotel green performance. The finding is consistent with the study of (Zientara & Zamojska, 2018) who mentioned that a green psychological climate influences both green outcomes and moderate a chain effect of green outcomes. The hospitality environment features fluctuations in demand (Alsetoohy et al., 2019, 2021) which, in turn, creates constraints for employees to do their tasks. These constraints may be reflected in employees' failure to behave voluntarily green in the workplace. Accordingly, a green supporting climate strengthens and encourages employees to engage in VWGB by outweighing workplace constraints. Thus, for hotel operators, support for employee VWGB under a green climate is considered a dominant driver to achieving green performance in hotels and vice versa.

# 5. Implications

While the consequences of globalization and pandemic have certainly prioritized the need for successful and prompt operational recovery of the hospitality industry, it has also encouraged the transition to sustainable employee practices (Gössling et al., 2020), implying that we might be exerting strong sustainable efforts while transitioning to new normalcy (Jones & Comfort, 2020). Therefore, it has become necessary for organizations to develop leadership approaches that promote moral and green proactive behavior and performance as they are the major contributors to sustainability and also increase the job satisfaction of leaders and employees, respectively (Norton et al., 2015). Our findings have many practical insights for both leaders and followers that we hope to be considered during their daily workplace interactions. In this regard, the existing study found that humble leadership could promote the concept of *greening* in terms of employees' behavior and organizations' performance. To begin with, it has been demonstrated that the humble leadership style is ideal for personnel working in service organizations, such as hotel staff. It was found that hotel employees' respect and response, as well as their voluntary green behavior, are positively influenced by the treatment they receive from their humble CEOs.

On the basis of stimulating the voluntary green behavior of employees, Jones and Comfort (2020) asserted that such voluntary behavior, whether directly or indirectly, would decrease the negative impact of a pandemic on the hotel business, with social and economic ramifications. Therefore, organizations can enhance their environmental performance by maintaining and cultivating a humble leadership style. Because of the leaders' humility, employees are more likely to engage in voluntary green behavior as a result of their moral drive. Hence, leaders should remain cautious about their behavior in their workplace. More ethical, fair, and humble behavior will elicit more favorable reactions. Also, it was found that humble leadership behaviors would serve as a vital antecedent of job autonomy, implying that if a company wishes to improve its employees' job autonomy, its CEOs must display humble behaviors. Subsequently, this study provides a clear signal of the function that a humble leadership style plays in fostering workers' job autonomy despite the fact that little attention has been devoted to this role in HRM studies. Studies suggest that improved job autonomy will lead to several important outcomes such as job satisfaction, high motivation (Ryan & Deci, 2000), sustainable development (Zhou et al., 2019), etc. In this study, we suggest that employees' job autonomy which is a key outcome of humble leadership behavior, encourages the voluntary green behavior of employees within their organizations. Gössling et al. (2020) and Ertuna et al. (2019) discussed main tourism trends and sustainable tourism development after the pandemic and identified responsible and sustainable tourism as a major travel trend. Drawing on this conclusion, our study introduces employees in those autonomous jobs to be more likely to engage in voluntary green behaviors and encourage others to support the concept of sustainable tourism. Therefore, our research adds to the predictors of employee proactive behavior studies. Our research suggests that organizations and managers should enable a job autonomy design in order to allow genuine and enduring development within organizations. Since followers need autonomy and more flexibility to do their jobs, leaders should go the extra mile. As a result, leaders should inspire intrinsic motivation in their subordinates so that they feel that they have greater freedom when doing their duties (ideally in more proactive and ethical ways). So as to better encourage employee independence and further enhance the company's pro-environmental to accelerate development in different aspects, leaders should try to reject the traditional authoritative top-down approach and adopt more *bottom-up* humble leadership styles. Another practical aspect is that with evolving ethical behaviors (humility and voluntarism), it is expected that the performance of the organization will be pro-environmental, i.e. green policies and practices. Given that leaders' actions are viewed as indicative of organizational policies and practices, a feeling of enthusiasm at work will arise among employees to build green supporting practices that will result in improved green performance. Likewise, our research highlights the significance of humble leadership style and moral behaviors in the organization. Team members' voluntary behavior could nourish employees' intrinsic motivation that in turn can contribute to a green supporting climate. In order to relate the good impacts of humble leader conduct on green performance, leaders should attempt to nurture staff to offer suitable circumstances supporting a green performance. This style of team-building approach grows exponentially when it comes to the hospitality industry owing to worries about environmental protection associated with hotel operations. From the perspective of hotel strategy, hotels may train CEOs at all levels and departments of the hotel to have proactive moral behavior and to know how to respect others, and these might be teachable so as to build a humble culture across the hotel.

# 6. Limitations and Future Recommendations

Despite these contributions and consequences, the current study has some shortcomings that might be used as research ideas in the future. First, this study's focus was on the hotel business because many of the goods and services it offers are *resource-intensive*, leading to substantial *environmental costs* and generating a lot of waste. Future studies may conduct similar research on tourism and travel organizations to determine if the results may be similar or not. Second, only one moderating variable and two mediators i.e. job autonomy and employee VWGB were tested on the relationship between humble leadership and green performance. Future studies may also examine additional variables such as perceived organizational support, green training, green creativity, etc. Finally, this study followed a single quantitative approach and used a structured survey to collect data; therefore, qualitative analysis or a mixed-methods methodology that applies a comprehensive and in-depth data collection is strongly recommended.

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# Storytelling for Behavior Change: Use of Folktales for Promoting Sustainable Behaviors

# Opowiadanie historii i wykorzystanie baśni ludowych do promowania zrównoważonych zachowań

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# Abstract

Our Earth has been entangled in different adverse effects resulting from the excessive human interference into the territory of nature. The habit of extracting and consuming indiscriminately is moving them to a situation, where their own future generation would not be able receive benefits of the natural resources. It has also been recognized that human action is perhaps the most significant contributor to this. And therefore, a proper equilibrium, i.e., sustainable development, could only be achieved by bringing about a change in human behavior in general. We explore the possibility of using indigenous knowledge for encouraging sustainable behaviors. We propose a model for behavior change through storytelling by using folktales. We argue that folktales serve three functions – epistemic, motivational, and ethical – which make them potent tools for promoting sustainable behavior. We conclude by pointing out limitations and suggestion for future research.

Key words: folktales, storytelling, behavior change, sustainability, environment Slowa kluczowe: bajki ludowe, opowiadanie historii, zmiana zachowań, zrównoważoność, środowisko

# Introduction

Humans fulfill their needs through resources found in the environment. With advances in technology, they developed tools that could harness the environment for large scale utilization of resources. This led to widespread material progress and development but it also brought about an imbalance – humans used up more resources than what could be replenished naturally. This pursuit for development became *unsustainable* as it led to harmful changes in the nature. Perhaps the most striking part of these changes is climate change. Seriousness of the situation can be gauged from the fact that by the end of the 19<sup>th</sup> century, the air temperature on Earth has risen by 0.8 <sup>o</sup>C, and in the past twenty-five years the rise was by 0.2 <sup>o</sup>C per decade (Kristl et al., 2020). This global warming has led to climatic variations which brought droughts, floods, cyclones, heat-waves, crop-failures etc. in many areas that were largely dependent on their natural environment for economic activities. Even the controlled environments like the metropolitan areas have been severely affected by these climatic variations (Bloomberg Green, 2021). These devastating impacts do not just lead to the above-mentioned undesirable phenomenon but may extend to corporal damages or may even lead to socio-economic deprivation (Kristl et al., 2020). Thus, our path to development seems to be unsustainable in the long-term.

To address this issue of unsustainable development, two points must be recognized. First, the consequences are not restricted to the place where environment is being harmed. It can have far reaching changes extending, both in space, and in time. Second and perhaps more critically, the main hindrance to pursuing a sustainable development path are the humans themselves. The Inter-governmental Panel on Climate Change (IPCC) recent report (Masson-Delmotte et al., in press) concludes that there is no doubt that human action has to take the blame for global warming. Rapid and far-reaching changes have occurred in the atmosphere, ocean, cryosphere and biosphere largely in pursuit of material progress by humans. Therefore, any serious solution to counter this anthropogenic problem must focus on understanding unsustainable behaviors.

Recent studies have found that a person's attitudes to the environment is determined by variables such as values, political ideology, world-view rather than education, knowledge of climate change, experience of extreme weather events or even sex (Hornsy et al., 2016). Furthermore, in today's world we have the *development focused* ideology which has made humans knowledgeable and skilled in the use of technical equipment for utilizing the natural resources, at the same time, it has dragged people to be lost in only looking after one's own material and tangible contentment. This has resulted in developing an attitude in a significant number of humans who do not bother about sustaining the environment at least when it is in conflict with material progress. In terms of values or world-views, aspiration for material progress takes center-stage even at the cost of the natural heritage or sustainability. The stiff resistance by developing countries such as China and India to adhere to Kyoto protocols is a case in point. These developmental aspirations coupled with shallow understanding of religious instruction have made case for sustainable behaviors more complex. Many of those who oppose affirmative action for climate change interpret their religion to conclude these phenomena as a consequence of the divine will and therefore no action on part of human is required. Thus, the psychological resistance to encouraging climate change behaviors is high because, it requires to change behavior (therefore effortful) and is in conflict with materialistic aspirations (values).

Past few decades have seen a growing literature reporting effectiveness of behavior change on a range of human problems like health, education etc. (Hagger et al., 2020). Behavior change involves either replacement of undesirable behaviors (such as smoking) with desirable behaviors (such as physical exercise) or engaging in a desirable behavior (such as compliance in medicine). Several theories and techniques have been proposed and tested for behavior change (Mitchie et al., 2013). One such technique for behavior change is storytelling (Passon, 2019). Storytelling is emerging as a powerful technique to encourage those behaviors that are generally resistant to persuasion. For example, Niederdeppe and colleagues (2015) conducted a study that had asked people to read a story about Cynthia and her daughter – who tries her hand at smoking in one of the scenarios and struggles with weight loss due to consuming soda in another. Just reading these stories increased the participants' resistance to the various kinds of messages industries use to oppose healthy policies. Another example (bbcmediaaction, 2014) was a media campaign used to deal with tuberculosis in India. This utilized humor and was found to be more effective than traditional information providing campaigns. Storytelling seems to work for persuasion as it by-passes the psychological resistance during persuasion (De Wit et al., 2008). Stories are also easier to retain and therefore work better than facts in the long term. Therefore, storytelling seems to be a promising tool for encouraging behaviors compatible with sustainable development and is worth the exploration. This paper looks at the mechanisms through which folktales, a common type of storytelling, may lead to behavior change in general.

## Folktales as Tools of Behavior Change

Storytelling has many different forms and types. We will not attempt to define and categorize types of storytelling here. We will focus on one form of oral storytelling that has survived throughout human history – *folktales*. A folktale, is a type of folklore, that is passed from one generation to another usually in the form of an oral story. This oral form of sharing and preserving information predates writing. Several scholars have documented the varied dimensions of life that are influenced by folktales. The folklores were not only a part of oral tradition but they were also a part of special performances, a form of visual art, where people gathered to watch them could understand the stories in a much better way (for examples see Ghosh, 2003). Folktales are remembered over life time and are characterized by motifs and themes that aim to transmit a positive message to its audience. These messages often serve as guide to individual and collective behavior. An individual ponders over these messages to derive underlying lessons or moral at various points. The ease with which they can be communicated and comprehended make them an extremely powerful medium for transmitting ethics and values.

#### Why folktales work?

In our understanding, from the findings in development psychology, social psychology and behavioral economics folktales should work for persuasion because they serve three functions (see figure 1). First function may be called the epistemic function. Epistemic function helps to provide information about the environment/surrounding in the absence of objective measures. This function is very effectively captured in what has been called Traditional Ecological Knowledge or TEK. Samuel Phillips Huntington, an American political scientist, mentioned that TEK to be the knowledge and insights acquired through extensive observation of an area or species. This part of knowledge is generally passed on from one person to another in the form of oral communication. It has been ages since the natives from a particular region has applied this TEK to not only put it in the form of a life force but also to construct and give a permanent seat to it for becoming a part of their unique cultures. In Melanesia, which is a sub-region of Oceania in the southeastern Pacific Ocean, the TEK and customs related to their cultural background is the result of their long preserved unique mastery that they have acquired about their environment. The wisdom gained have helped them in having an optimistic interaction and relationship with the ecosystem *that are based on time-depth, qualitative, holistic and oral approaches* (Pollard et al., 2015). Similarly, they can be used to obtain a rough estimate of how things should be in the absence of objective measures. For example, many Indian folktales feature the sparrow (for example, Chibi from Punjab). However, the population of sparrows has declined rapidly

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over the past few decades or so (Vijayan, 2003). A curious mind is bound to ask, why we do not see sparrows anymore. This would also motivate them to do something for preservation of sparrows.



Figure 1. Summarized Diagram of Three Functions/Features of Folktales Related to Behavior Change

Second function is the power of folktales to motivate by lowering the psychological resistance and thus we call it motivating function. This idea about folktales is very well articulated in one of the native American proverbs which states, tell me the facts and I'll learn. Tell me the truth and I'll believe. But tell me a story and it will live in my heart forever. Social psychologist Melaine Green (Green & Sestir, 2017), explained the function and effectiveness of storytelling in convincing individuals for any particular thing or action, through the theory of narrative transportation. She explains how a person engrossed in listening to any story, gradually starts dissolving in it, in order to create a link with the story and understand it better. The listener remains unaware that how the worldly realities keep fading as they sink deeper into the narrative of the story. As a consequence of this, the mind expands its realm to absorb in more new belief systems and behavior changes, that the story propagates. Thus, at this juncture, the resistance of that person gets diminished. A person may also be prepared with counter-arguments when the held beliefs are threatened. The art of story-telling evades this defensive behavior and subsides pre-established opinions thus making room for the newer thoughts. Because of the deep immersion in the narrative of the story, the whole procedure takes place without allowing the listener to having a hint about how the story is engaging with the mind and thereby transmitting the message (Mitra, 2017). Although, narrative transportation can work for any story, we believe, that most probably it is the case with folktales because they are able to engage the listener emotionally. Another important aspect of folktales is that they are born out of the cultural background and intrinsic knowledge of the indigenous people. And therefore, contain the motivating and guiding principles for the people since ages about the ways through which nature and its natural inhabitants could be preserved and protected. A similar argument can be made based on findings in moral psychology. Johnathan Haidt (2012) in his Moral Foundations Theory proposes two modes of moral cognition – an effortful one and another automatic. He uses the metaphors of rider and elephant for the effortful and the automatic processes respectively. Several studies have shown that chances of persuasion are increased significantly if the appeal is made to the elephant i.e., automatic processes. These processes are those that appeal to emotions, imagery, habit, values etc. It is by engaging that these automatic routes that the folktales advocates, through their storylines, persuade any individual respond to ordinary rhetorical persuasion. But persuasive appeal based on facts and arguments without a narrative structure appeal to the effortful processes which require a lot of effort to change. One excellent metaphor demonstrating this was proposed by Jonah Berger (Nussbaum, 2015). He equates effectiveness of stories in motivating individuals through the tale of Trojan Horse. Here the symbolism of the wooden horse has been used to explain the psychology that how individuals seem to let their guard down, when they are enough satisfied with the arguments presented in the storyline (Nussbaum, 2015). Facilitating natural learning, narrative transportation and appeal to automatic processes are the properties of a folktale that, in our opinion, can be used to encourage people to behave in sustainable ways. It may even inculcate in them aspirations that prioritize nature and environment over material luxury. We call the third function - the ethicizing function because the story and message within a folktale provide concrete ethics for ideal behavior. This function is very similar to what is similar to teachings in religious literature (for example see Okyere, 2011; Prakash, 2021). The folktales have a story which is a concrete example of how to behave in a particular situation. Additionally, they have the underlying message that is meant to be absorbed. Even if one argues that level of comprehension of the message in a folktale may be not be adequately understood by each individual. This objection misses the logic of why folktales have survived for generations. The concrete example in the story can be understood and emulated even by children. This is in accordance with the theory of Jean Piaget, the well-known developmental psychologist, that, children are able to work with concrete objects

before going on to form mental formulations and abstractions. Similarly, Lawrence Kohlberg, an American psychologist, proposed stages of moral development explaining how the experiences in the form of teaching, which the child learns at their early age, goes on to form a permanent part of their character (*Levine at al., 1985*). The steps which are included in the theory proceeds to describe how gradually the moral instincts are adapted in the life of an individual. This can be easily facilitated using folktales.

Function	Components	Process
Epistemic	Traditional Ecological Knowledge	Provide knowledge about environment in absence of objective measures
	Natural way of learning	Enabling learning at various ages and levels of comprehension
Motivational	Engagement through transportation	Narrative transportation disarms counter arguments
	Appeal to automatic processes	Emotional contents by-pass rational route
Ethical	Behavioural examples	Exemplify desired behaviour that can be imitated
	Underlying themes	Provide moral codes to govern behaviour

Table 2. Table summarizing the mechanisms of behavior change related to functions of folktales

# Conclusion

Folktales have been used since ancient times to transmit messages from one generation to the next. They have been successful in this regardless of age. In this paper we have attempted to present folktales as possible tools for persuading to opt for sustainable behaviors. Storytelling is already established as an effective tool for behavior change (Passon, 2019) and has been successfully applied in various settings such as health, management and education. Folktales, being a type of storytelling, thus holds immense potential. There are additional features in folktales that amplify the engaging power of storytelling. We presented three of such features – epistemic, motivational and ethicizing (see table 2).

Folktales have been customized and used for achieving desirable behavior for example by being easily implemented in curriculum. Stories can be included in literature class or almost anywhere. For example, in Indonesia, comics were developed from local folktales to teach concept of physics (Pathoni et al.,2020). There is also a case of preservation of a Costa Rican staple dish called Gallo pinto. The origin of the dish is based on a legend which has continued and the dish itself took a national character (Jiménez, 2012) such that today there is an active effort to promote behaviors to reduce the impact of climate change. Because climate change disturbed the rainfall patterns and production of rice, the Gallo Pinto was being harmed and motivated people to take action. This last point on Gallo Pinto points to the most of the mechanisms of changing behavior for sustainability that we have argued for in this paper.

A good example of an approach which is similar to our model comes from the work of 19<sup>th</sup> century Indian educationist Ishwar Chandra Vidyasagar who designed the Bangla premier - Barnoporichay. The mastery of this book lies with its integration of Kohlberg's Theory of Moral Development. The first part introduces the children to the alphabets, letters, metrical works, and rudimentary sentences, on the other hand the Second part contains moral embedded within the text. The portrayal of good being helped in framing a paradigm, based on which a child would decide as to what actions should be performed and what should be forbidden. Thus, it helps them in resolving their first confrontation with *Ethical Dilemmas* at the stage of their early childhood. We see a similar function in folktales as well with other oral literature, including religious motivational stories, fables etc. We believe that these traditional tools can and should be customized to sensitize children to issues about sustainability. Understanding of the old is vital if one is planning to ring in the new. In the educational era there are constant changes taking place, therefore, there is ardent requirement to review, analyze and make amendments in the older educational policies. In respect to this, there is a requirement to redirect the lost adroitness in an embedded form with all dimensions of educational engineering. This would help in developing of expertise amongst individuals which would in turn, lead to awakening of their feeling of responsibility, become farsighted, flexible and also obedient. With all these capabilities they will be proficient enough to accept and handle any task that they might be given. The paper does suffer from some limitations. First of all, the model presented here has not been tested empirically nor have we outlined any ideas for testing them. Our objective was to bring out the potentialities of this tool for promotion of behavior in-line with sustainable development. Future research must test these ideas empirically. Secondly, we suggest future research should do a thematic analysis and explore the possibility of using themes in a different form of narration, for instance comics or mobile app. Also given the alarming situation of

development and issues of sustainability, every effort must be made to find solution at all levels. Most importantly we need to find ways to address issues of human behavior for sustainability just as it is being done for health. We believe that the wisdom that the natives have regarding environment could be a help in protecting the ecosystem from facing complete destruction and also renewing the lost resources. Thus, this work would be an exploration of indigenous knowledge which had been part of the folklores and serving mankind since a long time. But it is we who had failed to identify their emphasis in safeguarding the environment. Therefore, going back to these treasures which are lying deep inside the folktales related to a particular region can be of great help in not only enabling the protection of the ecosystem but also paving path for sustainable development.

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