

# PROBLEMY EKOROZWOJU

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of Sustainable Development



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### Table of Contents – Spis treści

<b>The Enlightenment Assumptions of the Brundtland Report</b> Oświeceniowe założenia Raportu Brundtland <i>Andrzej Papużyński</i> .....	7-14
<b>The Tradeoff Between Growth and Environment: Evidence from China and the United States</b> Kompromis pomiędzy wzrostem a środowiskiem: przykład Chin i USA <i>Jianjun Li, Jing Xu</i> .....	15-20
<b>Attaining the Energy Sustainability: Analysis of the Ecuadorian Strategy</b> Ku zrównoważoności energetycznej: analiza Strategii Ekwadorskiej <i>Juan Lata-García, Christopher Reyes-Lopez, Francisco Jurado</i> .....	21-29
<b>Sovereign Wealth Funds as a Tool to Invest in Renewable Energy in Africa</b> Narodowe Fundusze Majątkowe jako narzędzie inwestycji w energię ze źródeł odnawialnych w Afryce <i>Olga Rataj</i> .....	31-39
<b>Problems in the Accomplishment of Solar and Wind Energy in India</b> Problemy z pozyskiwaniem energii słonecznej i wiatrowej w Indiach <i>Himanshu Sharma, Pankaj Kumar, Nitai Pal, Pradip Kumar Sadhu</i> .....	41-48
<b>Can Urban-rural Integration Decrease Energy Intensity? Empirical Study Based on China's Inter-provincial Data</b> Czy integracja obszarów miejsko-wiejskich prowadzi do ograniczenia energochłonności? Przykład Chin <i>Shuxing Chen, Renzhong Ding, Biao Li</i> .....	49-58
<b>Evolution of Patterns in the Ratio of Gender at Birth in Henan Province, China</b> Ewolucja rozkładu wskaźników urodzeń według płci w prowincji Henan w Chinach <i>Cangyu Li, Xinhui Wang, Zhixiang Xie, Mingzhou Qin</i> .....	59-67

<b>Indicators of Social Aspects of Sustainable Development in Selected Nationwide Databases</b>	
Wskaźniki społecznego wymiaru zrównoważonego rozwoju w wybranych ogólnokrajowych bazach danych	
<i>Paweł Rydzewski</i> .....	69-74
<b>Pollution, Happiness and Willingness to Pay Taxes: The Value Effect of Public Environmental Policies</b>	
Zanieczyszczenie, szczęście i chęć płacenia podatków: efekt wartości w ramach publicznych polityk ekologicznych	
<i>Nannan Liu, Rong Liu, Lingshuang Chen</i> .....	75-86
<b>From the Genealogy of the Environmental Thought: Marian Raciborski and Jan Gwalbert Pawlikowski</b>	
Z genealogii myśli ekologicznej: Marian Raciborski i Jan Gwalbert Pawlikowski	
<i>Leszek Gawor</i> .....	87-93
<b>A Proposed Model for Green Practice Adoption and Implementation in Information Technology Based Organizations</b>	
Propozycja modelu określania i wprowadzania Zielonych Praktyk w przedsiębiorstwach wykorzystujących technologie informatyczne	
<i>Bokolo Anthony Jnr., Mazlina Abdul Majid, Awanis Romli</i> .....	95-112
<b>Responsible Development and Durable Development</b>	
Rozwój odpowiedzialny i rozwój trwały	
<i>Wiesław Sztumski</i> .....	113-120
<b>An e-Environment System for Socio-economic Sustainability and National Security</b>	
System e-środowiska dla zrównoważenia społeczno-ekonomicznego i bezpieczeństwa narodowego	
<i>Emmanuel Okewu, Sanjay Misra, Luis Fernandez Sanz, Rytis Maskeliūnas, Robertas Damaševičius</i> .....	121-132
<b>Sustainable Water Management in Cities under Climate Changes</b>	
Zrównoważone zarządzanie wodą w miastach w warunkach zmian klimatycznych	
<i>Maciej Mrowiec, Ociepa Ewa, Malmur Robert, Deska Iwona</i> .....	133-138
<b>Filial Churches as a Sustainable Development Constituent</b>	
Kościół filialny jako element zrównoważonego rozwoju	
<i>Aleksandra Repelewicz</i> .....	139-144
<b>What Factors can Influence the Expansion of Protected Areas around the World in the Context of International Environmental and Development Goals?</b>	
Jakie czynniki mogą wpływać na poszerzanie obszarów chronionych na świecie w kontekście międzynarodowych celów środowiskowych oraz rozwojowych.	
<i>Zdeněk Opršal, Jaromír Harmáček, Petr Pavlík, Ivo Machar</i> .....	145-157

<b>Upcycling as a Manifestation of Consumer and Business Behavior that Expresses Sustainable Consumption and Determines the Functioning of the Communal Services Sector</b>	
Upcycling jako przejaw zachowań konsumenckich i biznesowych wyrażających zrównoważoną konsumpcję i determinujący funkcjonowanie sektora usług komunalnych	
<i>Michał Czuba</i> .....	159-163
<b>Forced Migration in Ukraine and Reality of Sustainable Development Goals Achievement</b>	
Wymuszona migracja na Ukrainie a realność osiągnięcia Celów Zrównoważonego Rozwoju	
<i>Inna Semenenko, Olena Khandii</i> .....	165-172
<b>The Impact of the CAP Green Programmes on Farm Productivity and its Social Contribution</b>	
Wpływ <i>zielonych</i> programów WPR na produktywność gospodarstw rolnych i jego implikacje społeczne	
<i>Bazyli Czyżewski, Marta Guth, Anna Matuszczak</i> .....	173-183
<b>Urban Shrinkage and the Identification of China's Shrinking Cities. A study Based on Semi-Industrialized Semi-urbanized Structure</b>	
Kurczenie się miast i ich identyfikacja w Chinach. Badanie oparte na strukturze częściowo-uprzemysłowionej i częściowo-zurbanizowanej	
<i>Chen Shuxing, Ding Renzhong</i> .....	185-195
<b>Antibiotics in the Environment as one of the Barriers to Sustainable Development</b>	
Antybiotyki w środowisku jako jedna z barier dla zrównoważonego rozwoju	
<i>Joanna Lach, Longina Stępnia, Agnieszka Ociepa-Kubicka</i> .....	197-207
<b>Development of Road Infrastructure in Environmentally Valuable Areas – Sustainable Designing</b>	
Rozwój infrastruktury drogowej na obszarach cennych przyrodniczo – zrównoważone projektowanie	
<i>Dariusz Boruszko, Wojciech Dąbrowski, Wiater Józefa</i> .....	209-216
<b>Buddhist Attitude towards Sustainable Development</b>	
Postawa buddyjska a rozwój zrównoważony	
<i>Gyan Prakash</i> .....	217-220
<b>INSTRUCTIONS FOR AUTHORS/ NOTA DO AUTORÓW</b> .....	221-222



# The Enlightenment Assumptions of the Brundtland Report

## Oświeceniowe założenia Raportu Brundtland

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### Abstract

The material subject of the paper is the philosophy of sustainable development, which was presented on the basis of the Brundtland Report. Yet, the formal subject are the Enlightenment assumptions of the strategy elaborated in this report. The purpose of the paper is to reconstruct and characterize these assumptions as constitutive elements of the philosophy of the Brundtland Report. At the beginning of the first part of the paper the state and main directions of the research on the philosophy of sustainable development conducted in Poland were discussed (the country where such discussion is exceptionally extensive). Based on the recounted characteristics, it was described as a version of the Enlightenment philosophy, and new arguments were provided to confirm this thesis. The second part of the paper presents the Enlightenment assumptions of the Brundtland Report. The discussion was limited to the assumptions of anthropology, social philosophy and historiosophy, such as human rationality, progress, and risk.

**Key words:** the Brundtland report, sustainable development, assumptions, the Enlightenment, human rationality, progress, risk

### Streszczenie

Przedmiotem materialnym referatu jest filozofia zrównoważonego rozwoju, którą przedstawiono na podstawie Raportu Brundtland. Przedmiotem formalnym są natomiast oświeceniowe założenia strategii rozwiniętej w tym raporcie. Celem referatu jest rekonstrukcja i charakterystyka tych przesłanek jako elementów konstytutywnych filozofii Raportu Brundtland. Na początku pierwszej części referatu omówiono stan i główne kierunki badań prowadzonych w Polsce nad filozofią zrównoważonego rozwoju (w kraju, w którym ta dyskusja jest wyjątkowo bogata). Na podstawie zreferowanych charakterystyk opisano ją jako wersję filozofii oświeceniowej i dostarczono nowych argumentów na potwierdzenie tej tezy. W drugiej części referatu przedstawiono oświeceniowe przesłanki Raportu Brundtland. Omówienie ograniczono do założeń z zakresu antropologii, filozofii społecznej i historiozofii, jak: racjonalność człowieka, postęp, ryzyko.

**Słowa kluczowe:** Raport Brundtland, zrównoważony rozwój, założenia, oświecenie, racjonalność człowieka, postęp, ryzyko

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### Introduction

On 20 March 1987 the United Nations announced the World Commission on Environment and Development Report, so-called the Brundtland Report. The strategy of sustainable development, by all accounts a cutting-edge one, was presented there. The innovative character of this document is a result of extending international environmental cooperation

to other spheres, and above all, taking into consideration the relations that connect the environment, resources, people and development (*Our*, 1987). In three decades since the publication of the Brundtland Report, the reality has changed in a way that the authors of the document could not foresee. The end of the Cold War, globalization, a reduction of an economic function of the country, a decay of the welfare state, neo-liberal economic changes, a possibility of

transnational capital allocation, international terrorism, etc., echo in subsequent interpretations of the idea of sustainable development.

Nowadays, many different concepts and theories of sustainable development are competing for recognition. As Michael R. Redclift assesses: *Since the path-breaking deliberations of the Brundtland Commission, the expression 'sustainable development' has been used in a variety of ways, depending on whether it is employed in an academic context, or that of planning, business or environmental policy. As a result, during the last twenty years we have been confronted with several different discourses of 'sustainable development', some of which are mutually exclusive* (Redclift, 2009). According to Karl-Werner Brand, opinions on sustainable development have been polarized as a result of differences in viewpoints on a need to modernize the economy supported by the Brundtland Report, especially restructure it in well-developed countries. There were many fierce discussions on issues ranging from a definition of sustainable development to the perspective of an analysis of sustainable development. The aspects of justice, a division of the world's riches and borders of existing forms of economic regulation (Brand, 1997) were brought to the forefront of the debate. For this reason, learning the philosophy on which the Brundtland Report strategy was based has not only historical significance. Reconstruction of a set of philosophical assumptions of this document drives the centre of the current discussion on sustainable development. The emphasis on the Enlightenment parentele of the philosophy of the Brundtland Report provides analytical tools necessary for understanding fundamental problems of today's debate and specificities of the positions and the value of arguments of the parties involved.

### 1. State of the research on the philosophy of sustainable development in Poland

It cannot be expected that the philosophy described on the basis of the content of any political document on sustainable development will, at its theoretical level, be equal to the philosophical treatises. It is only, as described by Zbigniew Hull, the reconstruction of philosophical content – its ontological, historical, axiological character, etc. – which is hidden among the leading ideas and values of various programs, strategies and policies of sustainable development (Hull, 2003). As a reconstruction made on the basis of deduced assumptions, at most it can approximate the philosophical issues involved, without claiming to provide ready-made solutions. The philosophy of the Brundtland Report expresses the general way of thinking in these matters, approaching them cautiously, without the necessity of accuracy and reasoning, it lacks in coherence and unity, and the order of discursive thinking, full of the logical and substantive loopholes that need to be plugged.

Because of such a form, it is a challenge for every description, which necessarily, with no outrage on the material collected, cannot be precise and coherent. Still, the effort of the best possible characterization of this philosophy makes sense. It allows the localization of its constituents on the plan of the aspects of the problem discussed in the philosophy, the assessment of their conceptual maturity and subject absoluteness, and above all, identifying and confronting them with the current philosophical streams of Euro-Atlantic culture. Therefore, reconstruction of the philosophy of the Brundtland Report should lead to a comparison of its philosophical content with solutions adopted in philosophy and end up emphasizing the propositions and aspects that are closest to it.

Philosophical assumptions of the concept of sustainable development have often been the focus of Polish philosophers. Among the publications on this subject, Leszek Gawor's publications should be distinguished, which address this issue explicitly (Gawor, 2004, 2010). Gawor detailed a number of philosophical theses written in political documents and studies on sustainable development, which – as he legitimately claims – give grounds for speaking about sustainable development. Other texts on sustainable development philosophy address philosophical assumptions of the concept of sustainable development indirectly. Their authors – Tadeusz Borys, Zbigniew Hull, Dariusz Liszewski, Zdzisława Piątek, Barbara Piontek, Adam Płachciak, Antoni Skowronski, Włodzimierz Tyburski and Włodzimierz Zięba – write about philosophical assumptions of the concept of sustainable development in very different contexts. It often goes about a project. In such a case, the assumptions are reconstructed on the basis of the objectives that were included in one or other authorial concept of sustainable development. Of course, the focus are only assumptions of one type, namely those that contribute to the values of sustainable development. Studies of this kind are characterized by the desire to ascertain the axiological premises as fully as possible. In descriptive and reconstructive studies, however, the problem of the assumptions of the concept of sustainable development is perceived by the prism of various leading issues. Most often it is about sustainability and education. The first approach leads to a focus on the assumptions underlying the social, economic or environmental aspects of the concept of sustainable development; the second one - to forming sets of values that are consistent with the given, historically and socially defined, educational system and to adoption of assumptions of a pragmatic character that influence the success of educational activities.

A brief discussion of the Polish philosopher's works, as far as philosophical assumptions on the concept of sustainable development are concerned, shows that the problem has already been outlined from many points of view. Why then come back to this issue?

First of all, because none of these presentations provided the grounds for the first version of the concept of sustainable development, which was developed by the Brundtland Commission. Gawor presented the issue on the basis of a variety of political documents and philosophical and scientific papers from a later period. It cannot be ruled out that he discussed a later state, modified due to attempts to adapt the UN concept of sustainable development to the post-Cold War conditions and the launch of a new global war with world terrorism. This can also be referred to other papers mentioned. In addition, some of them are of a general nature, detached from the specific background of political documents in which the concept of sustainable development was defined, and involves more or less successful attempts to add new objectives and principles to this concept, not necessarily consistent with the initial ones. Polish achievements in the philosophy of sustainable development fully support the above-mentioned Redcliffe's opinion.

Because of the task set out in this paper to indicate the philosophical tradition to which the philosophy of the Brundtland Report belongs, it is important to point out Gawor's identification of the historical type of philosophy that, more or less consciously, served as a benchmark for building a sustainable development strategy and for justifying its action programs. This is undoubtedly, as the author maintains, a contemporary version of *the Enlightenment social thought, marked out with such names as Turgot, Condorcet, Herder, Fichte, Kant, and forthcoming: Comte or even Marx* (Gawor, 2004). Such a case is supported by an exceptionally rich and varied set of goals of sustainable development, an academic, or that of planning, business and environmental policy, unknown in the Enlightenment. All, like in the lens, focus at one point. These are *ways in which global development can continue uninterruptedly* (Our, 1987), providing humane living conditions and self-reliance. Extending Gawor's arguments with new elements, it is worth noting that the best evidence for the Enlightenment filiations of the philosophy of sustainable development is its relationship with the strategy to guarantee global stability. It shows that the most important tasks of this philosophy are to overcome axiological dualism between the values desired with regard to reason and the values actually respected in society, which was a prominent theme of the Enlightenment philosophy. Without departing from the pre-Renaissance paradigm of culture, in which a vision of the best reality out of potential worlds dominated, without recognizing a possibility of a contradiction between the values that are in accordance with reason and values actually respected by men, this philosophy could not serve to build a strategy for solving social problems. We can talk about a social problem only when the divergence between desirable social values and social reality is found and defined. The philosophy of sustainable de-

velopment is therefore a contemporary version of the Enlightenment philosophy primarily because it is the basis of the theory of solving social problems, which in another intellectual atmosphere could not even be set up. It is also because it is not limited to appeals to individual morals and its solutions are based on the reform of the system of basic social institutions, that is, a complex of the most important political, economic and social devices that define the rights and duties of people and determine their life prospects. The philosophy of sustainable development is a contemporary version of the Enlightenment philosophy of reasoning, a confrontation of an ideal full of humanity with reality, mutilated human existence, knocked about by anonymous powers, ruling it out of the depths of economic and social relations, especially those of an international character. The philosophy of sustainable development matches the Enlightenment through criticism of existing *status quo*, criticism aimed at harmonizing various spheres of life, under the cover of sustainability.

## 2. Philosophical assumptions of the Brundtland Report

An assumption is an accepted without justification statement that constitutes the basis for the further argument – in other words, it is a condition of a derived theorem. Assumptions in a given theory are part of a paradigm driven by a particular community of a discourse. As an analogy for the Kuhn's concept of the paradigm of science, one can say that they are a set of discourses of beliefs and prejudices typical of a certain community, both instrumental, theoretical and metaphysical ones. The system of philosophical premise of the sustainable development strategy, which was presented in the Brundtland Report, falls within the paradigm of the Enlightenment. Below you will find the assumptions most strongly associated with this paradigm. The group of assumptions that need to be discussed is numerous and varied. It includes ontological assumptions (monism, metaphysical naturalism), epistemological (genetic empiricism, critical realism), methodological (holism, determinism), anthropological, historiophantic and social philosophy. Due to editorial limitations, only the assumptions of anthropology, social philosophy, and historiography, which are most important to the specificity of the philosophical foundation of the Brundtland Report strategy (rationality of human existence, progress, risk), will be addressed. They will not only be identified and located within the structure of branches of philosophy, but also shown in the light of issues considered in contemporary philosophy and social thought.

### 2.1. Rationality of human existence

Among ideas incorporated by the Enlightenment into the veins of Euro-Atlantic culture is the most striking one, rationalism, which expresses full confidence in

human reason and the ability of a man to use their own reason. It is not rationalism in the style of the preceding century, a priori, based on the belief that reason itself contains the nucleus of knowledge, opposed to empiricism. It is related to the philosophy of the 17th century with only one Cartesian conception of reason known as the measure of knowledge. But another use was made of it. Rationalism of the seventeenth century belongs to the theory of cognition; Rationalism of the Enlightenment is more a part of anthropology and social philosophy. It settles disputes between the content of human consciousness judging which of them are relevant and which are not – also in the world being a social creation. Such an understanding turns into the supreme tribunal in terms of the conditions of human life and defines completely new rules of discourse in social, economic and political aspects. From that point on, they began to talk about the standards of conduct that they have accepted or demanded, whether they are rational or not, and therefore are or are not worthy of human endeavour, deserve to be realized and fixed or to be rubbed off. In the philosophy of Enlightenment, reason took over the powers of absolute rulers, who in the previous century embodied the idea of sovereignty, which Jean Bodin had already presented in the Renaissance. He was therefore a judge, who delivered judgements, what is relevant here, according to the rules defined by himself. He acted in the name of the progress of mankind (Nicolas de Condorcet, Adam Ferguson) and to control chaos in the context of social relations (Voltaire) as well as international ones (Immanuel Kant). He was a sovereign who needed autonomy in order to rule effectively. An expression of all these ideas was a notion of emancipation of reason out of all external constraints. The position of the Enlightenment on the sovereignty of reason transformed the old idea of human rationality completely. The concept of rationality is ambiguous and defined in a number of different ways. Nevertheless, it can be assumed that rationality is a positive characteristic of a man. Since ancient times it has been synonymous with the ability of logical thinking, which upholds the certainty of knowledge, finding the truth about the natural and social reality and a way of right conduct. Under the influence of enlightenment, a rational person in this sense is a man who respects the scientific knowledge of the world and follows it in his conduct.

Based on the assumption that a man is a rational existence in the above sense, the authors of the Brundtland Report referred to the theories of science derived from the philosophy of Enlightenment. Apart from descriptive, explanatory, and predictive functions of science, it includes additional functions: educational, persuasive and cultural ones. The inclusion of an educational and persuasive function in the

list of academic functions expresses a conviction of the essential role of scientific knowledge in the justification of social and economic reform projects; adding another cultural one – its huge innovative potential. As a result, the report is characterized by numerous qualities of scientific research. First of all, developing the sustainable development strategy presented in it is based on both the latest research results of those years as well as scientific models of the analysed aspects of reality. Secondly, the argument for the need for a rapid implementation of the sustainable development strategy is based on scientific predictions for further degradation of ecosystems and a biodiversity loss, depletion of energy and natural resources, an industrial and urban growth as well as demographic and food prospects, and so on. Thirdly, proposals indicated in the report to solve global problems have a nature of a scientific action strategy, which sees in learning an engine of the desired civilizational and cultural transformations. The strategy presented there is a translation of the results of scientific research into practice, into the activity of rational entities. In other words, one of the main tasks of the Report is to educate people as rational actors: The people are the target audience for this report. The changes, we ask for, in human attitudes depend on a wide educational action, from discussion and common participation (*Our*, 1987).

Reconstruction of the assumption on the rationality of human existence, which was adopted in the Brundtland Report, sets them on the side of a minimalist approach. Such theories are characterized by separation of human rationality from a particular worldview, from each material concept of good and all ethical expressions. As in John Rawls's<sup>1</sup>, theories, it is about breaking the ethical tradition, in which rationality is transformed into a tool for realizing one or another competitive conception of good and involved in endless disputes about them. In the Brundtland Report, as in the works of the American philosopher, rationality means human ability to formulate their own life plans and openness to their criticism. Just as there, it is inseparable from the sense of justice, understood most simply as an ability to accept and practice the principles of justice. And in lockstep it has regard for maximizing good, including moral good. It characterizes an entity identified in the Rawls's philosophy with a moral subject (Rawls, 2001). In this way, a rational person is a *creative resource* – as it is called in the language of economics – whose potential is necessarily to be used for sustainable development.

## 2.2. Progress

Progress is a basic category of the history of the Enlightenment. It is a process of transformations leading to successive, higher and more perfect stages of

<sup>1</sup> The shown convergence is not accidental. Both Rawls and the authors of the Brundtland Report perform the same task. It involves elaboration of general justice theories, so

that different historical experiences and different cultural values do not hinder its acceptance.

existence. It embodies a promise of continuous development and improvement of humanity in intellectual, moral, social and welfare terms. The Brundtland Report is an expression of faith in the progress, belief in the possibility of continuing progress and a description of the ways in which the progress can be made. It is also a formula for the sustainability of the process of progress. Finally, it is also an expression of the will to spread progress among all the people. In this document, progress has been made in terms of controlling the disease decimating the poor in developing countries, tackling hunger and poverty, increasing life expectancy, eradicating illiteracy, better education, controlling uncontrolled growth of human settlements, especially slums, gender equality, dissemination of more effective and cleaner technologies, effective protection of nature – in general – improving the quality of life of all people in the world, especially the poorest. The way in which these issues are dealt with, especially in terms of achieving these objectives, shows that the idea of progress, which the Brundtland Report's authors pursued, is far from its eighteenth-century pattern. Progress is perceived differently, although on the basis of the aforementioned regarding the rationality of human existence, the relation between human rationality and scientific knowledge is seemed to be stuck with old ruts. Thus, this is not the same idea of the progress that Georges Sorel, a perceptive critic of historical determinism (Sorel, 1969), opposed to a long time ago. But above all it is not an idea of progress, which was criticized by Zdzisław Krasnodębski. It does not mark the equality between the development of cognition and the elimination of the spontaneity and chaos of human life, the elimination of this spontaneity and a rise in the sphere of human freedom and, finally, between a rise in the sphere of freedom and ethical development of humanity in individual and collective dimensions; It does not allow thoughts of the existence of some automatism between development of knowledge and improvement of the overall balance of happiness (Krasnodębski, 1991). It is rather a vision of progress weighed by the doubts that Theodor Adorno implicated after the Second World War with his disturbing question of the possibility of philosophizing after Auschwitz, a question that exposed the whole naivety of an original idea of progress. Despite this, the Brundtland Report vainly sought traces of technical and instrumental reasoning, which in response to this question was taken up in German philosophy by Herbert Marcuse and Max Horkheimer. The Brundtland Report is by no means a manifestation of contestation of prevailing political and economic relations based on this philosophy (Papuziński, 2010). Compared with the ideas of the ideologues of the 1960s counter-cultural movements, the Report shows restraint. At the very outside, echoes of such understanding of technology, voiced by Hans Jonas, are reflected in it. *The internal ambiguity of the technical action*, which Jonas em-

phasizes, with a view to a justified use of the technique, i.e., the use made of it in good faith to meet human needs (Jonas, 1997), is timidly voiced in the technique's enunciations and long-term consequences of its application. In the light of the discussed document, technical and instrumental understanding serve false needs and improper values. Excessive anthropopression, waste of energy and raw materials, high emissivity of harmful substances, a diverse access of different regions of the world to modern technology are the most important international and societal challenges that require an axiological adjustment of technology. This seemingly simple solution, however, presents serious theoretical difficulties. From the perspective of the Enlightenment tradition, which the Brundtland Report refers to, the choice of value lies in the competence of scientific reason. From the point of view of post-war criticism of scientific reason – as a technical and instrumental reason - reason is in the strings of wrong values. Together with the illusions of the Enlightenment theory of progress, institution able to make a right decision disappeared from the Report.

The Brundtland Report is an expression of faith in the possibility of scientific reasoning, but this faith does not include the ability of the mind to play a role of a locomotive of progress. Then, where among the hidden assumptions of the document can we look for what is considered to be a trigger of progress? Among the conditions that guarantee a man freedom to use their own reason. On one hand, this statement is supported by the Report on the philosophy of the Enlightenment, since it refers to the main social slogans of that period. Reconstructing an initial situation which is assumed in this document tacitly in the process of deduction on the desired institutional order of the world, leads to the conclusion that the constitutive character of a situation in which a person has a chance for good use of their or her reason are freedom, equality and brotherhood (global solidarity). Freedom is a condition of progress because, as David S. Landes argues, it revives the spirit of innovation (Landes, 1999). In the Brundtland Report freedom means autonomy of sovereign countries regarding the use of its natural resources, elimination of debt, and effective control over the operations of international corporations within their territory. On the other hand, equality is an access to the global market on the same basis for all. Global solidarity consists in the fight against world poverty, provision of international economic support and, consequently, abolition of a division into developed and developing countries. Yet, the noticed connection between progress and the main social values of the Enlightenment includes the Brundtland Report into the current of philosophical discussions on emancipatory reason. Emancipatory reason is both the opposite and continuation of the demythologized scientific reason. As the opposite, it does not perceive scientific knowledge as a tool for the transformation

of the world; as the continuation, it carries out the task of emancipating a man from the constraints of their beliefs. Progress is therefore such an assumption of the Brundtland Report, which guides this document in the search for a way to liberate mankind from mental limitations of the social world: all the cognitive stereotypes that were confirmed in reality different from ours; economic models that had proven themselves in already non-existent conditioning of the economy; standards of social behaviours that had passed tests in the currently non-existent world of isolated communities. The principle of sustainable development is a proof of progress in terms of emancipation: at the axiological level it proposes a revision of the existing system of perception and evaluation of social relations, at the level of strategic actions, it a proposal of alternative scenarios for economic growth and social development (Kopfmüller, 2001). It signifies emancipation from any constraints that existing, socially and culturally established goals and norms of action on impose on choice. It plays an emancipatory role in a sense of a reflection on human activity, revealing its conditioning and considering its possibilities, showing what it could look like meeting certain criteria, as Robert Kwaśnica writes about the emancipatory function of reason (Kwaśnica, 2007).

### 2.3. Risk

The risk category has recently been introduced into the language of philosophical discussions, as well as historiosophy (Douglas, Wildavsky, 1992), but the problems it regards refer to the Enlightenment discussion about progress as a state of rational thinking over the chaos of events and contingency of human fate. The Enlightenment philosophy of emancipation of reason is a program of risk reduction to zero. The risk it concerns has a universal dimension in the sense that it concerns every society in the history of mankind, and a particular dimension in the sense that every form of social life has its own, typical of itself risk portfolio. Similarly, we can say about the Brundtland Report. Risk is not a category used to describe the issues covered in the document. But it is there what the war is declared on each time it comes to the threats to sustainable human development. As each of them translates into global and local problems, both aspects of risk, i.e. universal and particular one, are taken into account in this document. Historically, risk related to modernization is a key one. This topic is covered a lot in the Brundtland Report. It comes out when a negative impact of modernization on health and life of plants, animals and people, as well as on their serious social, economic and political consequences are spoken about. Pioneers in risk research have also drawn attention to the social nature of risk perception, acting like a screen, which only allows some of the information about actual threats and their real causes to be known to human consciousness. The paradox of contemporary risk, as

they were diagnosed in the early 1980s, lies in the need for rational management of a powerful technological instrument in the absence of sufficient knowledge and uncertainty about the ecological, and hence the social and economic ones, results of decisions and their significance for the future. With this paradox in mind, they claimed that together with positive experiences each social system maximizes the risks that disappeared in the glow of previous successes. Adopting the assumption of risk makes reversed relations between economy and the natural environment approached in a described way in the Brundtland Report. Drastic reduction of ecosystem, species and genetic biodiversity, deforestation and disappearance of other natural areas, desertification, climate change, ozone depletion, etc., are reflected in the prism of harmful consequences of lack of criticism in assessing the effects of industrial revolution and the rules of economic development established at that time.

Context in which the Brundtland Report speaks about risks imparts unique features to this issue. One of them is a result of linking the issues of risk and justice. The specificity of this document lies in the loud claim of equity in the distribution of benefits and losses associated with risk. The Brundtland Report shows that existing global risks are a price that all humanity pays for activities that bring benefits of an ever-smaller handful of people. It also stresses that a lot of negative effects of global risk have been shifted to the shoulders of these people or social groups, who mostly have a negligible share in making decisions regulating their production, including technologies used in the economy (*Our*, 1987). Another feature that determines the specificity of risk coverage in the Report is related to its approach to the relations between risk and progress. For many, such as for aforementioned Beck, an increase in risk in social life is a crowning evidence for a crisis of the idea of progress (Beck, 1986). However, for the Brundtland Commission, it is a signal to mobilize all forces and resources to defend progress. Beck announced his theory of *risk society* in 1986, when work on the text of the Brundtland Report was coming to an end. His thesis did not manage to influence the shape of the document, but it does not seem likely to be otherwise. Modern society as a society of risk is, as Andrzej Kiepas presents Beck's opinion, *a society of stakeholders, where social solidarity is not a result of a unity of poverty and a pursuit of wealth, but a unity of fear and anxiety about dangers of modern development. Civilization* (Kiepas, 2000). Then, the contemporary society referred to in the Brundtland Report is a society of many global threats that act as a magnifying glass, signaling and highlighting the world's divisions. The Brundtland Report is a study of a society infected at various levels by the bug of inequalities – between developed and developing countries, between large landowners and rural workers, between men and women, between transna-

tional corporations and their employees as well as population living within an area of their influence, etc. It is a society divided according to all possible criteria of class differences such as wealth, participation in power and education. The emphasis put on social divisions in this document effectively prevents this text from being reconciled with Beck's position on the dominance of the wealth logic by the logic of risk production (Beck, 1986). The relation between an emphasis placed on the promotion of positive solutions and the play on human fear and anxiety, which is the foundation and the bond of the *community of fear*, which Beck writes about, also argues against an imposition of a conceptual framework of risk society on the Brundtland Report. A conclusion that Helena Ciążela derived from a comparative analysis of the theory of sustainable development and Hans Jonas's theory of *heuristics of fear* relates to the position of this German thinker at full length. It allows Beck's theory to be recognized as a position that excludes the possibility of rational management of human development, which is incompatible with sustainable development projects (Ciążela, 2006). An interpretation of the risk, which was included in the assumptions of the Brundtland Report, is characterized by an autonomy and originality being a result of fidelity to the traditional approach to risk and progress.

## Conclusions

The Brundtland report is an expression of optimism. It spreads the Enlightenment faith in the ability of human reason to overcome the chaos of social life, progress as an improvement in the quality of life of all people, and an ability to restrain the risk of decision-making in a situation of incomplete knowledge of the place of the subject of the decision in the network of social, economic and environmental interconnections. In general, the Brundtland Report, as Michael von Hauff legitimately observes, confidently looks at possibility of such *sustainable growth*, in which technical progress is reflected in growth, social development and preservation of natural conditions of human existence (Hauff, 2014). Despite such close links with the Enlightenment, searching for sources of this optimism in the philosophy of that period is in vain. There is no sign of faith in an automatic transfer of learning achievements to the level of progress, there is no connection with the theory of historical determinism. According to aforementioned Beck, the premise of this optimism could rather be found in the field of collective experience, a contingency of historical, social and cultural determinants. As a result of a peculiar chain of circumstances of the post-World War II reconstruction period, strong ties between technical innovation, increased productivity, economic growth, egalitarianism of consumption and social progress seemed to be confirmed (Beck, 1986). Today, however, this pe-

riod is past. Then, is this optimism a dud? Not necessarily. Zdzisława Piątek legitimately points out that history of open opportunities meets optimism of a sustainable development strategy (Piątek, 2007). A supporter of such an account of history, Karl R. Popper, presents it in short: *Neither history nor nature can tell us what we should do. It is us who place a purpose and meaning into the world of nature and the world of history* (Popper, 1992). This conviction is the most important element of the Enlightenment acquis, after sorting the wheat from the chaff of the ideas of that period by the present. The Brundtland Report takes advantage of this heritage. It is an attempt to make sense of nature and history by setting a goal. This goal is continuous socio-economic development and prospects of future generations to meet needs on an analogous level to ours.

The authors of the Brundtland Report undoubtedly needed optimism. Developing and promoting a sustainable development strategy would be pointless without it. But it has its price. The sustainability theory and strategy outlined in this paper pay for this optimism with partial blindness for new research approaches to the problems they encounter. Consequently, they underestimate the risks that are associated with the processes of economic decision-making and application of powerful technical instrumentation, even when accompanied by good will and the widest possible knowledge of the subject and its place in the network of natural, social and economic interdependence. For the same reason, it does not explicitly account for a difference between responsibility as self-responsibility and corporate responsibility, i.e. responsibility of an individual to their own conscience and responsibility of economic, social and political institutions to so-called external stakeholders.

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# The Tradeoff between Growth and Environment: Evidence from China and the United States

## Kompromis pomiędzy wzrostem a środowiskiem: Przykład Chin i USA

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### Abstract

This paper empirically analyzes individual attitudes on the tradeoff between environment and economy, and factors that might influence such choice for two representative countries: China and the United States. Based on the World Value Survey, the Chinese are found more inclined to support environmental protection, while people from the United States choose economic growth as priority. Considering three sets of correlates of sociodemographics, environmental attitude and social context, variables such as education, political affiliation and environmental consciousness show significance in influencing personal preferences, and the effect of health, age, employment and marital status demonstrates heterogeneity across countries. Such micro-level evidence on how the public weighs the economy versus environment can provide policy guidance for the government to better respond to public opinions.

**Key words:** economic growth, environmental protection, tradeoff, individual preference, public opinion

### Streszczenie

Artykuł poddaje analizie indywidualne postawy odnoszące się do kompromisu pomiędzy środowiskiem a ekonomią, a także czynniki, które mają wpływ na kształtowanie się takich postaw, w odniesieniu do dwóch ważnych krajów: Chin i USA. Według danych World Value Survey okazuje się, że Chińczycy są bardziej skłonni wspierać ochronę środowiska, podczas gdy Amerykanie za priorytet uznają rozwój ekonomiczny. Uwzględniając trzy zbiory korelatów odnoszące się do socjodemografii, postaw wobec środowiska i kontekstu społecznego, zmienne takie jak edukacja, orientacja polityczna i świadomość ekologiczna, okazuje się, że te czynniki odgrywają istotne znaczenie w kształtowaniu indywidualnych priorytetów, a kwestie zdrowia, wieku, zatrudnienia i stanu cywilnego wypadają podobnie w różnych krajach. Dane z takiego mikro poziomu pokazują, jak ludzie indywidualnie rozstrzygają spór pomiędzy ekonomią a środowiskiem, co stanowi polityczną wskazówkę dla rządu, dzięki której można lepiej odpowiadać na nastroje społeczne.

**Słowa kluczowe:** rozwój ekonomiczny, ochrona środowiska, kompromis, indywidualne preferencje, opinia publiczna

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### Introduction

Economic growth and environmental protection are two main issues concerning social welfare. The history of developed and developing countries shows that the process of economic development is coupled with the increase in resource consumption and pollutant emission. The certain incompatibility of envi-

ronment and economy introduces a dilemma between economic progress with the sacrifice of environmental quality, and protecting the environment while tolerating a lower economic growth rate. Different priorities correspond to different public policies. Depending on the stage and plan of a country's development, the political choice plays an important role in influencing social outcomes. As individuals

are heterogeneous (Dolnicar and Grün, 2009) and each is closely correlated with economic and environmental benefits, the micro-level evidence on how the public weighs the economy versus environment and which elements affect their attitudes are crucial for the policy making and implementation.

The tradeoff between environment and economy has long been a debated topic. Starting from the report *The Limits to Growth* in 1972 which suggests a non-sustainable economy, Beckerman (1992) states that economic growth should be given more priority than environmental protection especially for developing countries. Grossman and Krueger (1995) study empirically the relationship between environmental quality and income per capita, and find that economic growth does not necessarily lead to environmental degradation. The environmental quality exhibits a reverse-U shape with respect to personal income, referred to as the Environmental Kuznets Curve (EKC). While Stern (1998), Antweiler et al. (1998) and Azomahou et al. (2006) support the EKC theory, other research papers discover different relationships as linear, N or reverse-N shapes (Gale and Mendez, 1998; Barret and Graddy, 2000; Harbaugh et al., 2002; Cole and Elliot, 2003; Perman and Stern, 2003). The majority of previous studies demonstrate the existence of conflicts between environment and economy at certain point.

Previous research relating to the tradeoff between environment and growth uses mostly a macro framework. Instead, micro evidence, especially on the public opinion towards environment-economy relationship, and its effect on environmental policy making, are relatively scarce. Existing literature with micro-level data concentrates on the determinants of environmental concerns or pro-environmental behavior. In line with Olli et al. (2001), we classify the correlates of environmental concerns or behavior into three groups: sociodemographics, environmental attitudes or knowledge, and social context. The first set of correlates includes age, gender, income, residence, education, etc., where education and income generally prove a consistent and positive relationship with environmental concerns, while the effect of age and gender are more mixed. Barr (2007) summarizes that as a crude stereotype, young, high-income earning as well as well-educated individuals tend to be more environmentally active. However, Scott (1999) and Swami et al. (2011) find that high age to be a significant predictor of household waste management behavior. Regarding the gender differences which in most cases are found uncertain (Davidson and Freudenburg, 1996; Heath and Gifford, 2006), Steel (1996) and Zelezny et al. (2000) have identified a significant relationship where women report stronger environmental attitude and behavior than men, due to higher levels of socialization to be more socially responsible. The second category of determinants represents environmental attitude, values, and in a broad scope, knowledge or recognition

concerning environmental problems. For instance, Steel (1996) finds that attitude intensity is correlated with self-reported environmental behavior and political activism in environmental issues, Barr (2007) and Gadenne et al. (2011) confirm such significant link with respect to waste reduction and energy saving behavior. Moreover, Kaiser et al. (1999) make distinction among environmental attitude, knowledge, value, and intention effect. Lastly, social context refers to not only environmental organizations, but also social influences including family, group, societal, political and cultural influences (Gadenne et al., 2011). Since environmental reforms are generally opposed by business and industry (Van Liere and Dunlap, 1980), political party involvement or political liberals are found more favorable to environmental changes (Olli et al., 2001). Besides, Olli and Wollebaek (2001) incorporate social network in studying environmental behavior, concluding that its effect is comparable to sociodemography, political attitudes and environmental knowledge. In addition to above three sets of correlates, Olli et al. (2011) and Swami et al. (2011) also analyze the effect of psychological traits such as personalities on the waste recycling behavior.

To summarize, the micro-level research proves valuable in understanding environmental consciousness and promoting environmental behavior, however, focusing solely on environmental issues and personal environmental perception may not accommodate the big picture of harmonized development of both environment and economy. Taking economic growth into consideration, environmental preferences are likely to diverge from pro-environmentalism. Rydzewski (2015) looks at multiple preferences including environment, economy, education, health, etc. A related analysis by Heath and Gifford (2006) considers effect of free market ideology on beliefs in climate change, testing the logic that capitalism is inconsistent with environmental preservation and free-market system is supposed to take care of everything. Besides the fact that their research does not directly analyze the binary choice or tradeoff, our study focuses on the preferences between environment and economy, instead of a free-market belief. Therefore, our analysis incorporates a broader scope emphasizing on economic growth, which is irrespective of the market systems and allows for cross-country comparisons. In short, this paper tries to study individual preferences towards economic growth and environmental protection (when possible conflicts may exist between them), and its implications on public policies.

Based on World Value Survey (WVS), we analyze public attitudes on the tradeoff between environment and economy, and factors that may influence such choice. With a sample of two representative countries: United States and China, the analysis can account for a comparison between typical developed and developing countries, and the heterogeneity in

income, education, health, etc. Instead of a macro study on the environment versus economy problem, this paper focuses on individual choices, which not only complements the EKC theory from a micro perspective, but also provides policy implications that accord with public opinions.

The rest of the paper is organized as follows. The next section explains the data source and variables. Section 3 presents the estimation model and results. The final section concludes.

## Data

The data is extracted from the WVS, which is a micro database based on a multi-national survey program, and widely used in sociology, political science and economics. The analysis uses the sixth-period survey data from two countries: United States and China, where the investigation was conducted in 2011 and 2012 respectively. The number of surveyed individuals is 2300 in China and 2232 in the United States.

Regarding the tradeoff between environment and economy, one question posed in the WVS questionnaire is: *Here are two statements people sometimes make when discussing the environment and economic growth, which of them comes closer to your own point of view?* Option 1 writes *Protecting the environment should be given priority, even if it causes slower economic growth and some loss of jobs*, while option 2 states *Economic growth and creating jobs should be the top priority, even if the environment suffers to some extent*. Unknown and other answers are coded in option 3. Table 1 summarizes the responses. In the U.S., the majority of people in the U.S. regard economic growth as priority (60.5%), while more respondents in China prefer environmental protection (46.5%). We use a dummy variable ENEC to represent the preferences toward environment and economy, with value 1 denoting priority in environmental protection, 0 as preferences in economy, and unknown answers dropped. The mean of ENEC is shown higher in China (0.68) than in the United States (0.38). A direct t-test of group means ( $t = 19.77$ ) confirms that the preferences for environmental protection in China is significantly stronger than that in the United States.

To account for sociodemographic factors which may influence the preferences toward environment and economy, we also include variables of Age, sex (Male=1 if the respondent is male), marital status (Married=1 if married, =0 otherwise), whether the respondent has children or not (Child=1 if the respondent has one or more children), and categorized income (Income is from lowest 1 to highest 10). Health status may also affect personal choices on environmental preference, we transform the answers of self-reported health status to variable Health with value 1, 2, 3, 4 where 1 is poor health and 4 is very good health. Concerning the education background,

it is calculated in number of years (Olli et al. 2001). Variable Education is assigned 0 if no official education received, primary school not finished=3, primary school=6, junior school not finished=7.5, junior school=9, high school not finished=10.5, high school=12, college without a diploma=15, college and beyond=16. In accordance with Olli et al. (2001), the individual employment status is included, since the environmental policies represent extending the welfare state of which employees of the public sector are a part and on which they depend (Eckersley 1989). The questionnaire distinguishes three employment statuses: government or public institution, private business or industry, private non-profit organization, and we define two dummy variables with Public=1 if working in public sectors, and Private=1 where the individual is employed in private business.

Concerning environmental attitude, the survey asks *whether the person looking after the environment, caring for nature and saving life resources is like you*, the answers are categorized in Envimp with integer values 1 to 6 of increasing concerns. Note that regarding environmental preservation an important issue does not necessarily indicate that he or she would prefer environment over economy, it is possible that economic development is an even more important concern. Lastly, we include dummies of environmental organization (Envorg) and political party affiliation (Party) in the social context, where participation in an organization can be viewed as a personal commitment to behaviors (Cook and Berenberg, 1981). To summarize, the descriptive statistics of all variables are displayed in Table 2.

## Estimation results

We set the empirical model as the following:

$$ENE C_i = \alpha + \beta_1 Male_i + \beta_2 Age_i + \beta_3 Married_i + \beta_4 Child_i + \beta_5 Health_i + \beta_6 Education_i + \beta_7 Income_i + \beta_8 Public_i + \beta_9 Private_i + \beta_{10} Envimp_i + \beta_{11} Envorg_i + \beta_{12} Party_i + \varepsilon$$

where  $i$  indicates individuals,  $\alpha, \beta, \varepsilon$  are the constant, coefficients to be estimated and error term. Since the dependent variable ENEC, i.e. the tradeoff between environment and economy, is binary, we apply the Probit estimation. In addition, following Ferrer-i-Carbonell and Frijters (2004), Maddison and Rehdanz (2011), Ferreira et al. (2013), Cuñado and Pérez de Gracia (2013) who study similar matters with both linear probability model and OLS estimation, we also report the OLS results in Table 3. The sign, coefficient and significance of both OLS and Probit estimation are consistent.

Consistent with Olli et al. (2001), education background significantly encourages individuals to prefer environmental benefit instead of economic growth, because more highly educated people are more aware of and able to understand environmental information (Eckersley 1989). Political party also

Table 1. Preferences toward environment and economy in WVS survey

Priority	China		U.S.	
	count	proportion	count	proportion
Environment	1299	46.5%	830	37.2%
Economy	622	27%	1350	60.5%
Unknown	379	16.5%	52	2.3%

Table 2. Descriptive statistics

Variable	China		U.S.	
	mean	s.d.	mean	s.d.
ENEC	0.676	0.468	0.381	0.486
Male	0.490	0.500	0.486	0.500
Age	43.918	14.947	48.906	16.906
Married	0.816	0.387	0.582	0.493
Child	0.430	0.495	0.148	0.355
Health	2.843	0.857	3.063	0.749
Education	9.447	4.276	13.824	2.499
Income	4.416	1.853	5.165	1.914
Public	0.197	0.397	0.174	0.379
Private	0.237	0.425	0.399	0.490
Envimp	4.174	1.151	4.045	1.280
Envorg	0.027	0.161	0.176	0.381
Party	0.082	0.275	0.453	0.498

Table 3. Estimation results on the tradeoff between environment and economy

	China		U.S.	
	OLS	Probit	OLS	Probit
Male	0.0002 (0.01)	-0.0001 (-0.00)	0.020 (1.01)	0.020 (0.90)
Age	0.003*** (2.72)	0.003*** (2.72)	-0.003*** (-5.24)	-0.004*** (-5.16)
Married	-0.059* (-1.82)	-0.061** (-1.90)	-0.031 (-1.49)	-0.034 (-1.41)
Child	-0.018 (-0.74)	-0.018 (-0.75)	0.016 (0.58)	0.018 (0.58)
Health	0.031** (2.19)	0.032** (2.20)	0.004 (0.27)	0.004 (0.27)
Education	0.019*** (5.67)	0.020*** (5.66)	0.012*** (2.79)	0.014*** (2.91)
Income	-0.004 (-0.62)	-0.004 (-0.56)	-0.001 (-0.16)	-0.001 (-0.22)
Public	-0.030 (-0.92)	-0.032 (-0.94)	0.037 (1.30)	0.043 (1.28)
Private	-0.077*** (-2.74)	-0.082*** (-2.84)	0.067*** (3.03)	0.077*** (2.99)
Envimp	0.022** (2.14)	0.023** (2.21)	0.131*** (16.36)	0.150*** (15.14)
Envorg	0.004 (0.05)	0.005 (0.07)	0.137*** (4.98)	0.148*** (4.62)
Party	-0.122*** (-2.93)	-0.131*** (-2.96)	-0.078*** (-3.66)	-0.092*** (-3.75)
C	0.306*** (3.55)	-	-0.177** (-2.24)	-
R-squared/ Pseudo R2	0.037	0.030	0.175	0.143

\*p<0.1,\*\*p<0.05,\*\*\*p<0.01. T-values in parentheses.

shows a strong relationship in both countries, that being affiliated with a political group negatively affect the individual's tendency toward pro-environmentalism. Despite the fact that the concern level on the environment alone (Envimp) is different from balancing between environment and economy, a higher environmental concern does significantly affect individuals' tendency in the tradeoff. The person who cares about environmental quality is more likely to choose environment over economy. Such positive correlation exists in both countries. Some sociodemographic elements may play different roles in different countries. For instance, though Age shows significance in both countries, the sign of

impacts is opposite. Younger people are more probable to favor economic development (Scott 1999; Swami et al. 2011) in China which may correspond to their career or income condition; while in the United States, the tendency towards economy is increasing in the age. Most literature applying U.S. data discovers a negative relationship between age and environmental behavior as in our study. Regarding environmental protection a substantial change and a threatening to the existing social order, younger people, less committed or integrated to the dominant social order, are expected to support environmental reform (Jones and Dunlap, 1992). Similarly, employment in private business significantly

affects individual's preference toward economic growth in China and toward environmental preservation in the United States. The opposite sign may reflect different comparative status between private business and public sectors in the two countries, where the private industry survives in the shadow of state-owned companies, resulting in more economic concern of private sectors in China.

Self-reported health and marital status is slightly significant only in China. Being a member in the environmental organization, no matter due to self-identification or because of peer monitoring and cultural influence, strongly drives individual's choice toward green-environment priority as expected (Olli et al., 2001). Only 3% of respondents belong to an environmental organization, the effect is insignificant in China. Other variables as gender (Schultz et al., 1995; Davidson and Freudenburg, 1996; Heath and Gifford, 2006), the income level, whether the respondent has children, and employment in public sectors (Olli et al., 2001) do not correlate with their choice between environment and economy in any of the countries.

## Conclusion

This paper empirically analyzes individual attitudes on the tradeoff between environment and economy, and factors that might influence such choice for two representative countries: China and the United States. Based on the World Value Survey, the Chinese are found more inclined to support environmental protection as a whole; while people from United States choose economic growth as a higher priority. The logic behind may correspond to different development stage of each country<sup>1</sup>, where the environmental degradation is not a main issue of concern in the United States, but a serious conflict in China. Though the economy has made remarkable progress in China, such growth sacrifices natural resources, biodiversity, water, air quality, etc., which in turn undermines the improvement of social welfare. The micro-level evidence suggests that the majority of citizens would rather prefer a green environment even it may negatively influence the economy or employment. The public opinions, as a crucial basis for governments' policy making, should be seriously taken into account especially involving environmental and economic public policies.

In addition, this paper focuses on individual choices instead of a macro study on the environment versus economy dilemma, which tends to complement the EKC theory from a micro perspective. As a result, the income level does not show significance in the estimation, not supporting any linear or U-shaped relationship between income and environmental qual-

ity as in EKC. However, education, political affiliation and environmental consciousness do play a significant role in influencing the tendency toward either economic progress or a green environment. The effect of health, age, employment and marital status demonstrates heterogeneity across countries. Therefore, depending on different social situations, countries can be able to harmonize corresponding environmental and economic policies to better respond to public concerns.

Due to data restriction, this study does not include effects of urban or rural residence (Olli et al., 2001), environmental knowledge (Arkestejin and Oerlemans, 2005; Heath and Gifford, 2006; Gadenne et al., 2011), and particular party affiliations where support for environmental reform can vary among political groups (Lowe and Rüdiger, 1986; Olli et al., 2001; Hamilton, 2011). Our study does not make distinction between party groups (not able to do so for the United States sample and not necessary to do so for China), but view political party affiliation as a social influence from individual commitment, peer effect or societal influence (Gadenne et al., 2011), which results in a strong relationship for both countries. Lastly, we should note, environmental protection and economic development are not always conflicting, in many cases environmental problems are addressed through technological innovation. This does not compromise the results in this paper, where priorities in the political agenda can always exist, and evidence of public opinions are essentially needed in the policy making process.

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<sup>1</sup> The individual level regressions of two countries are hardly able to take into account the influence of economic development, the business cycle and other country-level

factors. Micro-level data drawn from a sufficient number of countries may address such issue, which can be a venue for future research.

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## Attaining the Energy Sustainability: Analysis of the Ecuadorian Strategy

### Ku zrównoważoności energetycznej: analiza Strategii Ekwadorskiej

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#### Abstract

The exploitation of renewable energy sources is a tactic adopted by several states around the globe to achieve a sustainable development. Many countries are looking forward the integration of this type of energy into the traditional power system by the beginning of the next decade to reduce the greenhouse gases emission and consequently lessen their effect in the climate change. However, this integration involves studies at technical, environmental and political levels. This article aims at identifying and assessing the level of incorporation and performance of the alternatives clean methods for generating electricity into the national energy system. It presents a quantitative analysis of historic data to better understand the gradual insertion of renewable sources to the electric energy production. This study also comprises a qualitative analysis of the projects executed so far by the Ecuadorian Government to accomplish the compliance with the long-term policies defined in the Master Plan of Electrification 2013-2022 released by the Ministry of Electricity and Renewable Energy in 2013. The outcomes of this research shows that the measure taken in the last sixteen years by the administration are aligned with the guidelines stated in the strategic planning proposed for the decade from 2013 to 2022.

**Key words:** Ecuador, capacity analysis, energy supply, renewable resources, sustainable development

#### Streszczenie

Wykorzystywanie odnawialnych źródeł energii stanowi to istotna część strategii rozwoju zrównoważonego. Wiele krajów zamierza w ciągu najbliższej dekady zintegrować te typy energii z konwencjonalnym systemem energetycznym, aby obniżyć poziom emisji gazów cieplarnianych, a poprzez to zredukować negatywny ich wpływ na klimat. Ta integracja obejmuje badania odnoszące się do aspektów technicznych, środowiskowych i politycznych. W niniejszym artykule oszacowano poziom włączenia i efektywności alternatywnych czystych metod produkcji energii elektrycznej w ramach krajowego systemu energetycznego. Dokonano ilościowej analizy danych historycznych, aby lepiej ukazać przebieg procesu wprowadzania odnawialnych źródeł energii do energetycznych systemów produkcyjnych. Przeprowadzono także analizę jakościową projektów wprowadzanych przez rząd Ekwadoru mających na celu osiągnięcie zgodności z długoterminowymi celami określonymi w Planie elektryfikacji na

lata 2013-2022, ogłoszonym przez ministra energetyki i odnawialnych źródeł energii w 2013 r. Przeprowadzone badania pokazują, że działania podjęte w ciągu ostatnich 16 lat przez administrację są zgodne z wytycznymi zawartymi w planowaniu strategicznym zaproponowanym na dekadę 2013-2022.

**Słowa kluczowe:** Ekwador, analiza wydajności, zaopatrzenie w energię, odnawialne źródła energii, zrównoważony rozwój

## 1. Introduction

Nowadays, there is no context in daily life where electricity is not used. The enhanced standards of life, the high dependency of technology and the unceasing increment of the world's population entails a growing demand for energy. The massive utilization of electricity and the progress that it implies have led to consider it one of the most important resource of the modern time (International Energy Agency, 2016). The demand for energy keeps increasing, whereas the nonrenewable sources keep diminishing, what has led to the global search for alternative energy systems that can fulfill the energy supply and demand (Day & Day, 2017). In addition, the widely-discussed effects of fossil fuels to the ecosystem, such as the weakening of the ozone layer, global warming, environment pollution, and health hazards to each living being (Gonenc & Scholtens, 2017) have caused the concern of international entities for cleaner energy production systems that preserve the biosphere but also guarantee energy security and economic feasibility.

The studies of Droege (2008) and Ruggiero and Lehkonen (2016) indicate that international regulation bodies agreed to exploit renewable sources to produce energy since they are ecofriendly and virtually endless, they are becoming economically-speaking more competitive, and they are experiencing a favorable political horizon.

Worldwide, several nations are adopting and promoting the usage of renewable energy (RE) resources and technologies (Hussain, Arif, & Aslam, 2017), including biofuel, biomass, geothermal energy, hydropower, solar energy, tidal power, wave power and wind power. This alternative sources allow achieve a real level of sustainability (Botelho, Pinto, Lourenço-Gomes, Valente, & Sousa, 2016; Chang et al., 2017), ensuring an optimal industrial production that boosts the economy, supporting the living standards as currently known, and caring about the conservation of the Earth's natural legacy. According to the Renewable Energy Policy Network for the 21<sup>st</sup> Century – REN21, around the globe the fossil fuels are the most used resources to produce this vital utility (Kristin Seyboth et al., 2016). As of 2015, 76.3% of the total production of electricity came from non-renewables, while only a 23.7% was renewable electricity. The global final energy consumption is estimated to be arranged as 78.3% of fossil fuels, 19.2% of renewables and 2.5% of nuclear power. Per the International Renewable Energy

Agency – IRENA, the total world capacity of renewable energies was 1964655 kW for the year 2015 (International Renewable Energy Agency, 2016).

Although Ecuador still depends on fossil fuels and has a big unexploded oil reserve, the Yasuni-ITT, it has a bigger ecologic and cultural heritage to protect (Vallejo, Burbano, Falconí, & Larrea, 2015). Since the national territory has abundance of natural resources, the government is betting at alternative sources to become independent of the exhaustible combustibles. The generation, employment and improvement of renewable energies in the country plays an important role in the new framework for the sustainable energy development planned by the current administration.

To cover the objectives set out, this paper starts with a background study that includes the analysis of the strategies and decisions applied in different countries to assess the level of sustainability and a brief review of the history of energy production in Ecuador since the year 2000. This information determined the methodology of the research comprising the replication of the procedures to evaluate the viability of renewables in the country as well as to examine the national historic energy data and indicate whether the inclusion of this alternative form of generation is feasible in the country or not. Then, the following section gives a summary of the national status of renewable generation and it carries out an analysis of the strategies for the energy sustainability proposed by the administration of this Latin American country. After that, and in order to complement the information learned so far, the next section quickly examines some impacts that the insertion of renewable energies into the National Integrated System (NIS) causes to the nation. Finally, it draws out some conclusions about the compliance with the Master Plan of Electrification 2013-2022.

## 2. Background

Before examining the data compilation on energy capacity of Ecuador and drawing an evaluation of its strategy for energy sustainability, it is imperative to learn the outcomes of different strategies and long-term policies applied by some countries to stimulate the investments in renewable energies, such as feed-in tariffs (FIT), net metering, auctions and shares. This researches are going to be reviewed and used as tools to assess the performance and conformity of the renewables in Ecuador.

Currently, the energy regulatory bodies are implementing FITs as a mean to subsidize the cost of energy to accomplish a successful deployment of renewable technologies, even though there are more economic opportunities in non-subsidized business environments. This measure is generally applied since the users are producing part of the energy. Studies carried out in Japan (Dong & Shimada, 2017), South Korea (Koo, 2017), the European Union (Pablo-Romero, Sánchez-Braza, Salvador-Ponce, & Sánchez-Labrador, 2017), India (Tomar & Tiwari, 2016), and the Latin America and the Caribbean Region (Jacobs et al., 2013) demonstrated that FITs are good approach to stimulate the deployment of RE systems. Other work regarding the effect of RE policies on economic growth in Middle East and North Africa countries revealed a positive influence (Kahia, Kadria, Ben Aissa, & Lanouar, 2017; Kahia, Safouane, Aïssa, & Lanouar, 2017).

The new European reference framework is set to evaluate the performance of the RE sources as well as to present the new objectives for the energy sector and the new guidelines to develop circular economy models. The study by D'Adamo and Rosa (2016) reviews this framework but it reveals that both the circular economy models and the objectives are not very reachable for many countries in the continent. It also recommends new target values and a performance assessment viable for each country. To complement the outcomes offered by D'Adamo and Rosa, some studies on the performance of four countries are individually reviewed: Germany (Lutz, Fischer, Newig, & Lang, 2017), Finland (Mälkki, Alanne, & Hirsto, 2015), Croatia (Borozan, 2017) and Ireland (Denny, O'Mahoney, & Lannoye, 2016). The analysis of the performance of the renewables per Erdil and Erbiyik (2015) held in Turkey determined that the compliance of the energy targets had higher priority than the environmental. This study took under consideration all the RE sources, especially hydraulic, and the outcomes certified that REs contribute in a high percentage to the Turkey's electricity generation.

One specific case from Africa is considered, the research carried out by Twaha et al. (2016) suggests alternative generation in Uganda to fight the current challenges faced by the energy sector and to provide the disfavored part of the population with electricity. Uganda has a good potential to develop renewables, however, it is one of the countries with the lowest electricity penetration level, less than 12% of the total population.

One specific case from Asia is considered, the idea of implementing a solar approach at a home level in Bangladesh. The Authors analyzed the energy problems in the country and advised policy developers with a strategy that could maximize the benefits of solar energy to contribute enhance the comfort

of the society and the economy of the country to some extent (Hossain, Hossain, & Uddin, 2017).

The last research considered took place in the most advanced Latin America country regarding energy production by Aquila et al. (2016). According to the researchers, Brazil faces barriers that stop it to perform its full potential. For instance, wind and solar powers are reserved just in the case of hydrological risks, however, they might directly contribute to the generation networks.

As an oil producer country, Ecuador has always depended on fossil resources to fulfill the demand of energy as the rest of Latin America (Brutschin & Fleig, 2016). However, at the very first year of this millennium, the 71.70% of the 3,118.00 MW produced came from hydraulic plants, which was the only RE in the country by that time (Agencia de Regulación y Control de Electricidad, 2001). The rest came from non-renewable thermal sources: 14.25% generated by gas plants, 3.10% by internal combustion engine (ICE) plants and 10.95% by vapor plants. Taking into consideration the research of Shakouri and Aliakbarisani (2016), it is very conspicuous to say that the renewable energies were and will keep being the best option for the sustainable development of this small South American nation due to the natural resources, economic stability and energy regulation.

In 2006 the Ecuadorian government launch a project to expand the number of hydroelectric plants and the inclusion of other type of renewables as well (Agencia de Regulación y Control de Electricidad, 2007). This project intends to build several Eolic, photovoltaic solar, geothermal and biomass plants, as well as eight hydroelectric plants in the national territory.

Table 1. Hydroelectric projects in Ecuador since 2006

Project name	Location	Capacity [MW]
Coca Codo Sinclair	Between the provinces of Sucumbios and Napo	1500
Quijos	In the province of Napo	50
Manduriacu	Between the provinces of Pichincha and Imbabura	60
Toachi Pilatón	In the limit of the provinces of Pichincha, Santo Domingo de los Tsáchilas and Cotopaxi	253
Sopladora	Between the provinces of Azuay and Morona Santiago	487
Mazar Dudas	In the province of Cañar	20.82
Minas San Francisco	Between the provinces of Azuay and El Oro	270
Delsitanisagua	In the province of Zamora Chinchipe	115

Table 2. Historic data of energy production in Ecuador

Energy Source	Power Central	Nominal Power	Year																	
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
RENEWABLE	Hydraulic	MW	1558.80	1722.06	1733.40	1735.49	1732.50	1794.94	1785.73	2030.45	2032.52	2032.16	2215.19	2207.17	2236.62	2236.62	2240.77	2401.52	4418.18	
		%	53.23	56.39	53.07	52.21	51.58	51.13	47.49	49.03	48.62	46.23	46.56	46.02	44.18	43.83	42.29	43.22	58.09	
	Biomass	MW	-	-	-	-	28.00	55.60	63.30	63.30	94.50	94.50	93.40	93.40	93.40	93.40	136.40	136.40	136.40	
		%	-	-	-	-	0.83	1.58	1.68	1.53	2.26	2.15	1.96	1.95	1.84	1.83	2.57	2.45	1.79	
	Eolic	MW	-	-	-	-	-	-	-	2.40	2.40	2.40	2.40	2.40	2.40	18.90	21.15	21.15	21.15	
		%	-	-	-	-	-	-	-	0.06	0.06	0.05	0.05	0.05	0.05	0.37	0.40	0.38	0.28	
	Solar	MW	-	-	-	-	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.08	3.87	26.37	25.50	25.59
		%	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.50	0.46	0.34	
	Biogas	MW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.76
		%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
	Total Renewable	MW	1558.80	1722.06	1733.40	1735.49	1760.52	1850.56	1849.05	2096.17	2129.44	2129.08	2311.01	2303.01	2332.50	2352.79	2424.69	2584.57	4603.08	
		%	53.23	56.39	53.07	52.21	52.41	52.72	49.18	50.61	50.94	48.44	48.58	48.02	46.07	46.11	45.76	46.51	60.52	
	Total Non Renewable	MW	1369.78	1331.76	1532.59	1588.84	1598.54	1659.74	1910.83	2045.33	2050.77	2266.65	2446.38	2492.67	2730.44	2749.96	2874.39	2972.41	3003.03	
		%	46.77	43.61	46.93	47.79	47.59	47.28	50.82	49.39	49.06	51.56	51.42	51.98	53.93	53.89	54.24	53.49	39.48	
TOTAL	MW	2928.58	3053.82	3265.99	3324.33	3359.06	3510.30	3759.88	4141.50	4180.21	4395.73	4757.39	4795.68	5062.94	5102.75	5299.08	5556.98	7606.11		

Table 3. Total energy production and percentage of renewables in each Ecuadorian province

Region	Province	Amount of centrals	Effective power	
			Total [MW]	Renewables [%]
Coast	El Oro	8	258,49	2,32
	Esmeraldas	4	231,32	0,00
	Guayas	19	1372,13	23,74
	Los Rios	3	149,2	37,67
	Manabi	6	197,77	0,75
	Santa Elena	2	122,15	0,00
Highlands	Azuay	6	1327,69	98,7
	Bolivar	0	0,00	0,00
	Canar	2	53,7	100,00
	Carchi	0	0,00	0,00
	Chimborazo	4	15,65	100,00
	Cotopaxi	8	28,86	100,00
	Imbabura	11	106,69	74,41
	Loja	8	38,79	55,75
	Pichincha	25	288,3	46,89
	Santo Domingo de los Tsachilas	0	0,00	0,00
Amazon	Morona Santiago	5	92,55	95,42
	Napo	7	47,77	17,39
	Orellana	72	382,79	0,00
	Pastaza	3	48,59	0,00
	Sucumbios	74	324,94	0,00
	Zamora Chinchipe	1	2,4	100,00
Islands	Galapagos	12	19,02	32,73
Total		289	5556,99	46,51

Figure 1. Percentage of coverage of electricity utility users in Ecuador per year

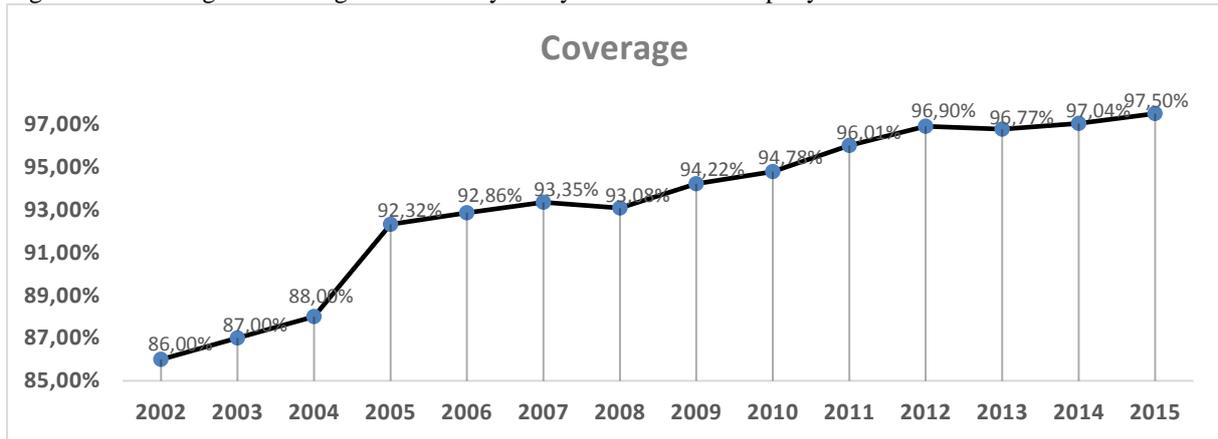
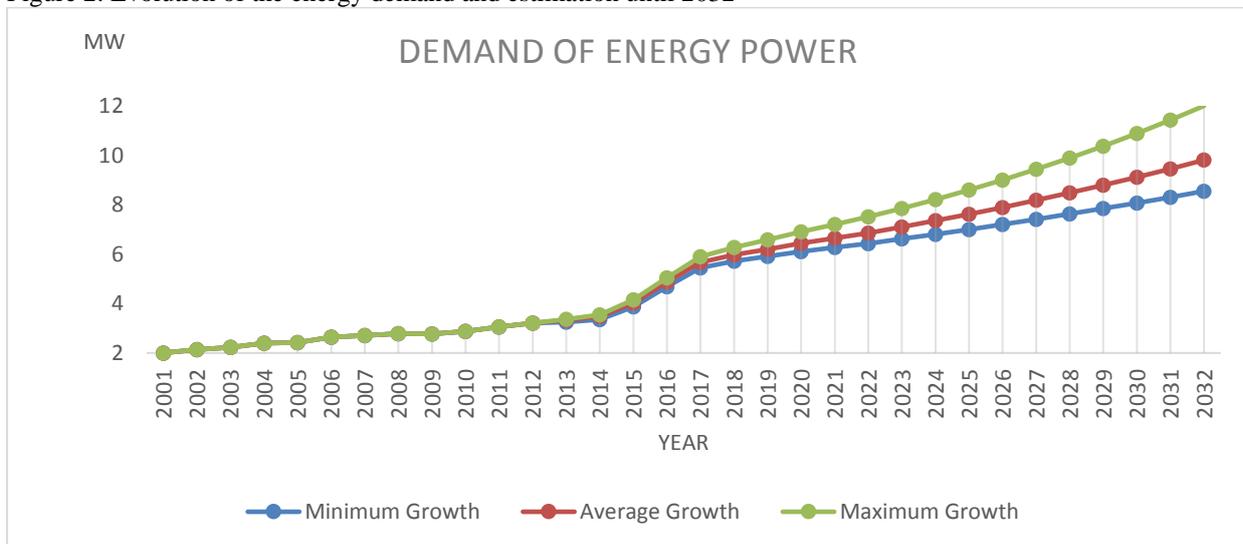


Figure 2. Evolution of the energy demand and estimation until 2032



The table 1 lists the hydroelectric projects and their capacities as presented in MPE 2013-2022 (Ministerio de Electricidad y Energía Renovable, 2013a). Since 2007 the current administration has released the Master Plan of Electrification (MPE) (Ministerio de Electricidad y Energía Renovable, 2007, 2013b) that considers the exploitation of clean energy, in lieu of the conventional thermals, as one of the vital points in the reshape of the energy matrix for greater local and regional development. The MPE is part of the most ambitious national project, which consist in a positive change in the production matrix (Secretaría Nacional de Planificación y Desarrollo, 2009, 2013). This plan intends to serve the whole population but it results particularly advantageous to give service to rural areas without access to the current electric network.

By the year 2015, Ecuador counts with three Eolic, five photovoltaic solar, four biomass and nineteen hydraulic plants. The country produced 5,556.99 MW divided in 53.49% from non-renewable sources (27.82% ICE, 17.60 gas and 8.07% vapor) and 46.51% from non-renewable (0.38% Eolic, 0.46%

photovoltaic solar, 2.45% biomass and 43.22% hydraulic).

The table 2 presents a compilation of data, between 2000 and 2016 (Agencia de Regulación y Control de Electricidad, 2001, 2002, 2012, 2016), about the national energy production that not only demonstrates the growth of energy demand in Ecuador but also shows the progressive addition of renewable energies in the National Interconnected System.

### 3. Ecuador Strategy for Energy Sustainability

Ecuador is currently exploiting alternative supplies coming from inexhaustible resources that incur in much less negative impacts, compared to oil sources, related to social, economic and environmental contexts. The table 3 presents a summary of the total amount centrals in each province of Ecuador, as well as the total energy produced and the percentage of renewable energy contribution.

Per the Ecuadorian Ministry of Electricity and Renewable Energy (MEER), the coverage of the electricity utility reached the 86.00% of the population

in 2002. Whereas it covered the 97,04 % in 2014 (Ministerio de Electricidad y Energía Renovable, 2014). The figure 1 shows this growth of coverage. National and local entities have committed to promote and implement a series of actions to take better advantage of the energy resources. The MEER estimates an increment of 6.864 MW in the electricity demand in 2022 (Ministerio de Electricidad y Energía Renovable, 2013b). The figure 2 displays the estimation of future demand.

The MEER envisions the aggregation of electric public transportation in various cities, the swap of gas stoves by electric ones, the incremented production of diverse industrial sectors, the implementation of energy efficiency models for public buildings and street lighting, and the use of energy-saving appliances by the year 2022 (Ministerio de Electricidad y Energía Renovable, 2013a). This changes will convey to a positive increase of the demand of electricity, which will mostly come from reliable renewable sources that provide low-cost clean energy as stated in the Master Plan of Electrification 2013-2022 (Ministerio de Electricidad y Energía Renovable, 2013c). This plan promotes the effective development of the energy efficiency under the guidelines of the Good Living National Plan set by the Ecuadorian Government in 2013 (Secretaría Nacional de Planificación y Desarrollo, 2013).

Once all the new generation plants are put into operation the regime expect to stop the importation of electricity from its neighboring countries, Colombia and Peru, but also a substantial increment of the exportation instead. A great future for the generation of electricity in a sustainable way is foreseen in Ecuador.

The energy sector has a significant function in the socioeconomic development of each nation. In this sense, the efforts of the Ecuadorian Government to achieve a sustainable energy sector has a higher importance. However, the concept of sustainability may be understood and implemented taking under account the contexts and interests behind each project (Cinelli, Coles, & Kirwan, 2014). Selecting the best option to assess the sustainability of the energy systems are based in several criterion. The most common social, economic, technical and environmental indicators are: cost of investment, global warming, generation of employment and energy efficiency. In the context of mixed dimensions, safety of supply (techno-economic) and visual impact (socio-environmental) are the indicators with the highest frequency of usage (Martín-Gamboa, Iribarren, García-Gusano, & Dufour, 2017).

According to the inventory of the energy resources related to electricity generation carried out by the Ecuadorian Administration in 2015, there exists a total of 114 projects, divided into small, medium and big based in their capacity. The maximum achievable capacity would be 12,319.87 MW (Agencia de Regulación y Control de Electricidad, 2015).

#### 4. Impacts of renewable energies

To complement the information learned so far, it is worth reviewing other impacts that the utilization of renewable energies cause to the country. It follows a short examination of some of these impacts:

##### 4.1. Economic Impact

The performance of the energy sector is a determining factor of the progress of any nation. It is compulsory that providers estimate future demands to supply the required amount of energy continuously and efficiently. According to Edomah (2016), the increment of the participation of renewable sources will not only allow achieve this requirement but it will also allow the reduction of thermoelectric generation to attain a sustainable production in the country.

Per Sen and Ganguly (2015), the economic growth and a higher people's purchasing power will definitely influence in a positive way the increment of the energy demand and consumption. Throughout this new millennium the Ecuadorians have experienced a significant increment (391.56%) of the gross national income (GNI) per capita as the World Bank (2016) has indicated. Because of this raise of the GNI, the energy consumption per capita has also incremented in a 45.14% in 2015 compared to the end of the year 1999. The 46.51% of the 1162.64 kWh/user consumed in 2015 came from RE sources (Agencia de Regulación y Control de Electricidad, 2016). All these changes incur positively in the economy. In a macro vision, the higher purchasing power the inhabitants have, the more energy they consume, dynamizing the cash flow within the country. The industrial sector, including factories and business, represented the 41.15% of the total demand of electricity, which definitely uphold the Ecuadorian economy.

In a micro vision, the MPE considers the reliable supply of clean energy at a reasonable price (Ministerio de Electricidad y Energía Renovable, 2013c). It also contemplates the construction and operation of new generation centrals as well as new factories and companies that will offer new job vacancies to support the current employment demand. For instance, the project Mandariacu alone triggered more than 2400 job contracts. All this enhances the productivity and delivers a long-term economic stability.

##### 4.2. Social impact

The social behavior of the residents of a country are a fundamental aspect for the acceptance of RE generation and its long-term support. As Sheikh, Kocaoglu, and Lutzenhiser explained (2016): assessing the people's reaction, as well as the advantages and disadvantages for the society, when implementing renewables in a country let establish a sustainable energy strategy aligned with the social standards entrenched. The access to high-quality energy is one of the requisites for the human develop-

ment and contributes to increase the number of job opportunities, the enrichment of health services, the upgrading of education and to decrease the poverty level (Kaygusuz, 2007).

The main point identified from a social perspective is development of the local infrastructure which will convey in an enhancement of the communities. For instance, and continuing with the project Mandariacu, it encouraged the construction of new houses and businesses, the provision of utilities and the development of compensation works for the community as well (Odebrecht, 2015). In addition, 800 of the job openings were filled by residents of the local communities. As an effect of developing this project, the workers were trained in safety standards, equipment operation and electric risks to perform an efficient job. Also, the project guaranteed health, road safety, environmental protection and promotion of local culture in each of the communities involved. Nowadays, many of the residents are a part of the work team controlling the hydroelectric operation or are working in other national projects.

#### 4.3. Environmental Impact

Although it is confirmed that RE will reduce the carbon footprint, they will cause collateral effects in the environment. A study on the development of renewable energy in Iran's rural areas demonstrated that several environmental issues might arise (Afsharzade et al., 2016). The study carried out by Sokka et al. (2016) in Finland is a partial assessment of the impacts of the energy generated by renewable sources concerning the life cycle, including toxicity, biodiversity repercussion, soil depletion, water and land use, radiation, plant, pests and diseases.

Environmental global metrics have been instituted in order to take decisions on climate change based on the international regulatory framework. The Environmental Performance Index (EPI) proposed by Yale University suggests two high-priority areas: human health protection and ecosystems conservation. Nonetheless, EPI evaluates nine areas using twenty indicators (Hsu, 2016). According to this index, Ecuador ranks 103<sup>rd</sup> in the year 2016. The MPE shows the estimation of environmental effects but the outcomes does not show any major issues to the Ecuadorian ecosystem (Ministerio de Electricidad y Energía Renovable, 2013a).

## 5. Conclusions

Around the globe the integration of renewables in the energy system is a reality that not only includes the infrastructure but also an important and favorable change in the energy policies. Each nation has to be analyzed as unique, and hence, the new policies should be written regarding the political, economic and environmental status of each country, as well as the culture and social behavior of its inhabitants.

However, specific contemplations from other nations might be emulated if correlations exist.

Ecuador has adopted long-term policies (the Master Plan of Electrification 2013-2022) as a mean to change the energy matrix. It has contributed to raise the awareness of the efficient utilization of the natural resources and encourage the clean generation of renewable energy for the years to come.

Despite all the possible significant benefits this sustainable development might carry out, a variety of economic, political and legal obstacles stop them to reach their full potential. The restructure of the policy of renewable energy would support the development of Ecuador considering the future needs of energy but also guaranteeing a proper environmental preservation.

The inclusion of FIT in several countries' policies tend to be a success, however, it is imperative to analyze its future application in Ecuador because they are not always the best approach to encourage the implementation of renewable energies. The manufacturing of renewable technology in the country might cut prices on projects, unluckily, Ecuador does not make this type of technology. Instead, the release of governmental initiatives for the importation of equipment, including the reduction of customs duty and internal taxes, might stimulate the development of renewable generation. Ecuador and most of the Latin American countries present regulatory uncertainties, being the reason other type of legal initiatives should be set and some incentives should be granted for the generation and efficient use of potential renewable energies other than hydroelectric.

The replication of a mathematical sustainable model in order to evaluate the long-term electricity supply-demand in Ecuador and Latin America might be performed by taking under consideration the modelling proposed by Ouedraogo (2017) for the African Continent.

A positive acceptance of the renewables is expected not only in the country but also in the region to achieve the so pursued South American integration.

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## Sovereign Wealth Funds as a Tool to Invest in Renewable Energy in Africa

### Narodowe Fundusze Majątkowe jako narzędzie inwestycji w energię ze źródeł odnawialnych w Afryce

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#### Abstract

In this paper, the Sovereign Wealth Funds (SWFs) of oil- and gas-rich developing countries in Africa are examined as a potential renewable energy (RE) investment tool. If proved successful in this role, the SWFs could offer a solution to the broadly discussed phenomenon of resource curse. In particular, this research report handles the capacity of SWFs to ameliorate barriers that hamper private energy investments in RE.

**Key words:** resource rich countries, resource curse, resource revenue management, sovereign wealth funds, renewable energy finance

#### Streszczenie

Artykuł podejmuje zagadnienie potencjału Narodowych Funduszy Majątkowych (NFM), które są w ostatnich latach coraz częściej tworzone w bogatych w złoża ropy i gazu państwach rozwijających w Afryce, jako narzędzia inwestycji w energię ze źródeł odnawialnych. Jeśli NFM sprawdziłyby się w tej roli, przyczyniłyby się do rozwiązania szeroko omawianego w literaturze problemu „klątwy surowcowej”. W szczególności, w ramach artykułu analizowana jest zdolność NFM do redukcji barier dla sektora prywatnego, które uniemożliwiają inwestycje w odnawialne źródła energii.

**Słowa kluczowe:** państwa bogate w surowce, klątwa surowcowa, zarządzanie przychodami z wydobycia surowców, Narodowe Fundusze Majątkowe, finansowanie energetyki odnawialnej

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#### 1. Introduction

The oil and gas abundance cannot be directly translated in a country's socio-economic prosperity. On the contrary, the discovery of hydrocarbon riches, in particular in developing economies, often has negative effects on growth indicators. This is due to a phenomenon known as *resource curse* or *paradox of plenty* which has been widely discussed in the literature (Auty, 1993; Sachs and Warner, 1995; Tierney, 2008; Cavalcanti et al., 2011). This issue can be illustrated on the example of petroleum exporting countries. For the OPEC as an organization, in the years 1965-98 GNP per capita decreased by 1,3% per year on average, compared to 2,2% average per capita growth in low- and medium- income countries

(Gylfason, 2000). The *resource curse* can be attributed to multiple causes, e.g. a decline in international competitiveness of other sectors due to high exchange rates (Dutch disease), global commodity market swings which cause volatility of revenues from natural resources, weak public revenue governance, as well as greed of political elites in connection with their lacking accountability (Mikesell, 1997). In response to the issue of *resource curse*, there have been multiple approaches developed to enable the hydrocarbon abundance to be more reliably converted in a sustainable and profitable economic growth. In particular, the appropriate design of public governance institutions and their practices with respect to the resource revenue management has been deemed utmost importance (Eifert, 2002). E.g.,

it has been estimated that if the Sub-Saharan countries improved the quality of their governance institutions to that of developing Asian economies, this would result in a near doubling of the region's per capita GDP (IMF, 2010). As an exceptionally promising instrument of the effective resource revenue governance in the developing world, the Sovereign Wealth Funds (SWFs) have recently gained widespread interest (see Dixon and Monk, 2011a, 2011b). The non-renewables are currently the largest source of electricity production in Africa (Klimstra, 2012). Simultaneously, 25 out of 54 African nations are in an energy crisis – the power is inaccessible, unaffordable, and unreliable for most people (WB, 2014). Due to technological backwardness and related inability to add value to the extracted energy resources domestically, the refined energy products have to be imported at a high price and with volatility risks. In addition, the use of coal and fossil fuels for energy production is associated with multiple negative environmental effects which include global warming, air quality deterioration, oil spills, and acid rains. These problems in turn generate further large-scale global economic, political, and health issues. At the same time, Africa is home to vast clean energy sources which as an alternative to the conventional energy could offer a straightforward solution. According to the estimates of IRENA (2013), the potential of RE in Africa is larger than current and projected power consumption. It is however still untapped due to financial, regulatory, and political barriers which are faced by potential investors. Therefore, this research paper examines the capacity of SWFs to positively influence the investment conditions in the field of RE in Africa.

## 2. Literature Review

### 2.1. Renewable Energy (RE) in Africa

#### 2.1.1. Potential of RE in Africa

Due to diversity of the African continent, it is not possible to undertake a universal assessment of its RE (solar, wind, water, geothermal, etc.) potential. At the same time, each kind of clean energy is associated with different risks and opportunities. Which sources are more promising than the others has therefore to be decided in every single country case. Nevertheless, it is assumed that certain issues are common for the whole continent and therefore can be approached systemically. E.g. due to the proximity to the equator, most of Africa has 325 days of strong sunlight throughout the year (Rotberg, 2013). As a result, Africa as a whole could provide all of the world's energy by producing solar power on only a small portion of the Sahara Desert (EurActiv, 2009), which certainly invigorates imagination and could serve as a starting point for further discussion.

#### 2.1.2. RE Investments and their Challenges

With regard to the global investment in RE (both domestic and FDI), a comparatively small volume has so far been accountable for by Africa. While in 2013 China was the most important investment region with USD 56.3 billion, in Africa and Middle East USD 9 billion were put into clean energy (FS-UNEP and BNEF, 2014). Taking into account the large area covered by the African continent and its enormous RE potential, as well as the trend of falling RE production costs (IRENA, 2012), this result is disappointingly poor. In developing world, the previously raising trend of RE investments was interrupted after 8 years and in 2013 it fell 14% to USD 93 billion (FS-UNEP, 2014). At the same time, the IEA (2011) estimated that from 2011 to 2035 over USD 35.6 trillion would have to be invested in clean energy supply in order to meet the climate goals. This poses a question how to attract the needed capital, and more specifically, how to overcome the constraints which have so far prevented the RE investments. In general, the elements which influence RE investment are broadly classified in the literature as: 1) **financial**, 2) **policy**, and 3) **political** (EIB, 2010; OECD, 2013). In the following, all three factors are shortly reviewed.

With regard to the **financial** aspects of RE investments, it must be noted that the projects are enormously capital-intensive (EY, 2014). In particular, they are associated with high initial financial effort. The up-front capital costs for deployment of RE technology amount to around 80% of the total lifetime costs (RCREEE, 2013). However, due to low annual fixed and variable costs, the investments can lead to reasonably steady, low-risk, and long-term cash flows under a favorable policy framework. From the regulatory policy point of view, in order to opt for investments, the entrepreneurs need therefore assurance that they will be able to secure returns on the projects over their entire lifetimes (IEA, 2011; RCREEE, 2013). Some investments in RE are referred to as *mega projects*, typically costing more than USD 1 billion and attracting public attention mainly because of their substantial impact on the overall country development (Flyvbjerg et al., 2003). Due to their vulnerability to sunk costs, as well as high transaction costs resulting from unique character of assets and complex contractual frameworks, such projects are particularly threatened by the risk of cost overrun (Globerman and Vining, 1996). In addition, the politicized nature of energy pricing makes the exact returns on energy investments barely predictable (Levy and Spiller, 1996). In addition, as large RE projects in developing countries are not a common practice, bankers attach to them a higher degree of risk. This is reflected in high interest rates and a general reluctance to lend money (ICEED, 2006).

The private sector participation is widely regarded as crucial to meet the RE investment needs. At the same time, the mobilization of private capital depends largely upon the ability of the public sector to ameliorate investment uncertainties (IEA, 2014). Therefore, the RE projects fall under category where the OECD identifies the need for *carefully targeted and time-bound incentives* (Thiemann, 2013). So far, African governments have not been able either to provide satisfactory level of green power finance themselves or to attract private sector investment through conducive RE policies (UNECA, 2006). There are two main aspects of the latter failure: an inappropriateness of public policy frameworks, and instability in policy regime (FS-UNEP, 2014).

As exemplified by successful experiences around the world, an appropriate **policy** framework should consist of 3 adequately balanced elements: public financing, regulatory policies, and financial incentives.

A transition to RE in Africa would only be possible with a *system approach*, where actions take place at all relevant policy levels (Liebreich, 2013). E.g., currently in resource rich countries there is a common practice to lavishly subsidize the fossil fuels consumption. This on the one hand lowers their prices, but on the other hand does not allow renewables to have an attractive return on investment. Therefore, some policies, if not designed as parts of a comprehensive sector reform plan, may create more problems than those they intend to address (IMF, 2014). As estimated by the IEA, in 2012 the global fossil fuel subsidies amounted to USD 544 billion, and those for renewables to USD 101 billion.

However, apart from these policy instruments which are specifically aimed at the RE investments and these which pertain to the whole energy sector, an importance should also be attached to the general regulatory trade and investment framework in a given country. According to the WB *Doing Business* report, entrepreneurs in developing regions face a less friendly regulatory environment on average than those in the OECD high-income economies. The report, which is issued on an annual basis, ranks the economies around the world in 10 areas of business regulation (e.g. starting a business, dealing with permits, registering property, getting credit, protecting investors, enforcing contracts, etc.) (WB and IFC, 2012). The Sub-Saharan Africa regularly obtains the worst results.

The third group of challenges which may be faced by the RE investors arises from the overall **political** situation. While regulatory risks result directly from government strategies and more or less carefully deliberated public policies (Butler and Joaquin, 1998), the political framework is reflection of a complex and inconstant blend of various events, actions, and players which in developing countries are usually left uncontrolled (mainly due to a missing system of checks and balances, as well as weak institutions).

The political framework in a broad sense of the word is constructed by elements such as country security, political stability, quality of public governance, attitude of local communities, relationships between government and society, trust in government's actions, accountability, transparency, rule of law, control of corruption, macroeconomic situation, terrorism and sabotage risk, etc. Some of these elements have been used to establish a set of Worldwide Governance Indicators by the WB (2012). According to the UNEP, there are strong links between the country risk, public governance, and levels of private investments: *As vague and all-comprising this category of risk [political risk in the meaning of this research paper] may be, it is critical for foreign investors and financial institutions* (UNEPFI, 2012, p. 42).

## 2.2. Sovereign Wealth Funds (SWFs)

### 2.2.1. SWFs as a remedy for problems faced by Africa

SWFs are state-owned investment vehicles. Usually, they are created as a result of national budget surpluses which have been possible to accumulate due to favorable economic conditions over a certain period of time (Rozanov, 2005). Generally, SWFs can have their origin either in commodities or in non-commodities. In case of resource-rich countries, the funds are recurrently replenished with revenues from commodities which are owned or taxed by the state. The majority of the countries operating SWFs have a positive trade balance, which reflects large receipts from exports. In addition, the creation of funds is positively associated with growing foreign exchange reserves. The SWFs are established outside the regular budget and not influenced by any changes in fiscal or monetary policy, i.e. balance of payments, foreign currency operations, proceeds of privatization, etc. (Das, 2009). SWFs count among the most promising investment tools in the aftermath of global financial crisis. In 2011, the size of SWF assets amounted to about USD 4.9 trillion, of which 2.8 trillion constituted commodity-based and 2.1 trillion non-commodity based SWFs (Tagliapietra, 2013). Despite sustained economic uncertainty, global SWF assets further increased to USD 5.16 trillion in 2012 (Ncube, 2013). The funds are becoming a *must-have* for resource rich countries, evidence of which is the fact that almost every OPEC member already has at least one. More than 30 new funds have been established since 2000 with several countries like Kenya, Liberia, Mozambique, Niger, Uganda, Sierra Leone, Zambia and Zimbabwe considering creating new ones (Revenue Watch Institute, 2013).

The financial resources accumulated in SWFs can be marked for various purposes, e.g. to protect economy from excess volatility in revenue, increase savings for future generations and ensure inter-generational equity, fund social and economic development and to secure social protection or to provide a sustainable

long-term capital growth for strategic purposes. Accordingly, SWFs can be classified into: stabilization funds, savings/future generation funds, pension reserve funds, reserve investment funds, and strategic development funds. Among these five sub-types of SWFs (defined by IMF in 2008) three are of particular importance for the developing countries: stabilization funds, saving funds, and development funds (Dixon and Monk, 2011b).

However, it must be noted that the SWFs cannot replace regulatory reforms and economic or social policies. While they can indirectly support poverty alleviation and increase employment, they cannot be expected to do so independently (Dixon and Monk, 2011b), for which there are two main reasons.

Firstly, the investment decisions of SWFs depend primarily on financial considerations, i.e. they are focused on the expected return on a given investment. Only if a project is financially sound, further aspects are taken into consideration. They include e.g. the social impacts of a given investment, as well as its environmental implications – according to the concept of sustainable development. The preliminary goal is however to maximize the economic profit.

Secondly, in order to benefit the society, the SWFs must be invested domestically. Moreover, they should be diverted to priority sectors (e.g. infrastructure), depending on specific development needs of a given country. If invested domestically in priority sectors, the SWFs could both foster the country development and bring jobs. One of the best examples of how to manage the SWFs in support of domestic social and economic development in Africa is the Nigeria Sovereign Investment Authority (NSIA). It puts 40% of its capital into a Future Generations Fund which is invested in global assets with a horizon of over 20 years. Another 40% are allocated to domestic projects in power, highways and farming. In general, due to the booming population growth and increasing life expectancy, the African continent is experiencing major infrastructure bottlenecks. At the same time, there is a lack of sufficient financing to enable a quick provision of the needed facilities. The SWFs could play an important role in closing this gap.

#### 2.2.2. *Problems associated with governance of SWFs in Africa*

While the benefits of SWFs are evident, it is rather questionable if Africa is ready to reap them yet. It is mainly due to overall public governance problems in resource-rich developing countries, including poor transparency, weak accountability, and corruption. In order to fulfill their functions, SWFs must above all involve an effective asset management. This seems not a simple task, as countries set up SWFs precisely because the functions to be performed by these funds are not capable of being easily integrated in the existing government structures (Dixon and

Monk, 2011b). From this perspective, SWFs are special purpose vehicles which should theoretically have features distinctive from traditional governance apparatus. Unfortunately, the evidence does not support this hypothesis for most of Africa. According to the Linaburg-Maduell Transparency Index, which rates SWFs around the world, many African funds are not transparent or no data is available. In general, opacity is the defining feature of the majority of SWFs in Africa (with some notable exceptions, e.g. Botswana and Nigeria). Little information is available on their size, portfolio holdings, investment strategy, performance, mode of governance, etc. (Guerin, 2013).

To enhance transparency is one of the aims of the so-called Santiago principles which are a set of 24 guidelines on good SWF governance. They were defined by the International Working Group on Sovereign Wealth Funds (IWG). In Africa 5 countries are IWG members (Angola, Botswana, Equatorial Guinea, Libya, Nigeria), among which only Nigeria managed to efficiently integrate the Santiago principles into its SWF governance.

### 3. **Research question and methodology**

Against the backdrop delineated in the introductory paragraph and on the basis of literature review, this research paper focuses on the following research question, which has not been sufficiently discussed so far: *Can SWFs alleviate the financial, policy, and political barriers faced by private RE investors in Africa?*

In an attempt to answer the research question, 10 in-depth interviews (in person or by phone) with key informants were arranged. The respondents included: Diego Masera (Chief, Renewable and Rural Energy Unit, UNIDO), Yasmina Abdelilah (Analyst, Renewable Markets Research, IEA), Sophie Jablonski (Energy Specialist, EIB), Frank Wouters (Deputy Director-General, IRENA), David Goodman (Policy Specialist, FS-UNEP Centre), Michael Maduell (President, SWF Institute), Kirsty Hamilton (Energy, Environment and Resources Associate Fellow, Chatham House), Perrine Toledano (Head of Extractive Industries Research, Columbia Center on Sustainable Investment), Prof. Abubakar S. Sambo (Special Advisor on Energy to the President of Nigeria), Magalie Masamba (Lawyer, Consultancy Africa Intelligence). The expert interviews enabled to 1) further investigate issues identified as not sufficiently covered in the literature, 2) explore the experts' overall perspective on the idea to utilize SWFs as RE investment tools. Following a short introduction to the research questions and literature gaps, the respondents were allowed to freely express their thoughts. The importance of their contribution was enhanced by the mostly critical attitude and the ability to uncover the shortcomings of the author's conceptual approach.

Following limitations of the proposed methodology were encountered: 1) difficulties to identify experts willing to speak about both RE and SWFs, 2) undisclosed information (mainly on SWFs, but also on RE policies), 3) generalizations on which the analytical approach is based and which may constrain the applicability of research results.

#### 4. Results and analysis

Although not deprived of uncertainties, the emergence of SWFs in resource-rich countries in Africa is a promising trend. In spite of the aforementioned shortcomings, there are strong indications that SWFs may play quite an important role in fostering the continent's development. For the sake of clarity of argumentation, the following theoretical analysis is structured in four parts, each of which is introduced with a representative headline being an African proverb.

##### ***The wealth which enslaves the owner is not wealth***

Currently, many oil- and gas-rich developing countries spend public money in form of subsidies to support conventional energy sectors on the production and consumption side (both with the aim to lower energy prices for end-consumers). This policy is motivated by the fact that citizens of oil- and gas rich countries often require an individual share in the hydrocarbon abundance in form of low energy prices. The attempts to abandon or reduce fossil fuel subsidies are regularly echoed by fierce social protests in many African countries, which forces respective governments to restrain from their planned reforms. This occurs in spite of the fact that, taking into account shrinking reserves of non-renewable resources, their rising prices, as well as growing population, fossil fuel subsidies are not sustainable in a long-term perspective (as it can be expected that the extent to which there is a need to subsidize traditional energy will be exacerbating over time, not to mention the climate change issues). Therefore, fossil fuel subsidies are generally claimed a flawed policy. In addition, apart from the fact that they benefit mostly the richest citizens and reduce energy efficiency, most importantly they crowd out other investments, as they constitute a large part of national budget. This is particularly detrimental to development of infrastructure, including RE projects, which require large initial effort in terms of money. From this perspective, SWFs are well positioned to meet the financial gap. One could raise doubts why SWFs should be better than other financing sources, but there are indeed some reasonable explanations for this. Theoretically, private sector could mobilize financial resources for RE projects through three other main channels: 1) from commercial banks, 2) through equity finance, 3) from multilateral development banks and international finance institutions (which have both public sector arms offering financial support to governments and private sector arms assisting commercial companies). E.g. with regard to

commercial banks, their finance decisions are based solely on risk-return considerations. Usually, more risk means higher interest rates, and less risk is commensurate with lower interest rates. A typical risk assessment concerns regulatory and political environments in a given country which, as mentioned earlier with reference to the barriers faced by private investment companies, are generally quite high. Therefore, while the commercial banks could theoretically help investors overcome the large financial effort related to the first investment stage, they have no bearing on the political and regulatory investment aspects, and they are in fact trapped in the same pitfall as private companies. This would result in high interest rates to be repaid, so that the financial barrier is in fact higher but simply redistributed over time.

In addition, the recent global financial crisis contributed to the fact that banks are becoming more reluctant to lend money for infrastructure projects (Justice, 2009). In particular, it is expected that the Basel III regulations will have negative impact on projects requiring long-term financing, as they force banks to hold more equity on the balance sheets for high-risk lending. Hence, investments in RE have become too expensive for them (Kaminker and Stewart, 2012). On the contrary, SWFs may be invested on commercial terms (i.e. according to a purely economic risk-return or cost-benefit analysis), but their managers are also able to consider accepting a below-market return for a certain period of time. This results from the fact that in the decisions about involvement of SWFs not only financial, but also broader social and economic effects are taken into considerations. The non-commercial benefits are to be understood as positive externalities, which only the state has incentives to provide. However, SWFs should not invest in projects justified mainly on the grounds of positive externalities, but look for opportunities with market or close to market financial returns in a longer term. A balanced approach between commercial and public interest would be to rank proposed investments by both their financial returns and according to their impact on wealth creation (Gelb et al, 2014). If this reasoning was followed, it turned out that high-return (i.e. high-risk) domestic investments are most appropriate for SWFs. It has to be emphasized that SWFs are not expected to replace the existing institutions or to duplicate their roles.

The considerations presented above are to a certain degree biased, i.e. focused on the negative sides of available investment tools, in order to expose the potential to be realized by other entities, including the SWFs. However, if there already are successful mechanisms in place to financially support the private investors in the RE sector in a given country, there would not be any point in adding a SWF into the existing institutional framework. The SWFs can also actively seek to establish partnerships with each other, as well as with other financing institutions and private companies. Certainly, as public investors

they can be expected to have a deeper understanding of projects which depend on regulatory policies and political framework. Simultaneously, their comparative advantage is that, unlike some institutional investors (e.g. pension funds or insurance companies), they do not have any long-term debt or future payment obligations.

#### **What you give you get, ten times over**

As opposed to other sources of finance mentioned above, the investment of SWFs in RE is expected to result in following value-addition for the country:

##### 1) Investment return

Typically, SWF could invest in RE project either as lender (i.e. to grant a loan to private company) or as project partner (i.e. to contribute financial resources to a private project and to become its co-owner). The investment returns can be assessed, as mentioned earlier, in terms of financial and broader economic/social value. In case when SWFs invested as lender, they could make money in a manner analogous to commercial banks<sup>6</sup>, i.e. by charging the cost of granting loans in form of interest rates. The loans, unlike other kinds of government spending (e.g. traditional hydrocarbon subsidies which are typical financial transfers), would this way deliver financial returns.

##### 2) Reduction of risks

In traditional public-private partnership arrangements, a private company invests its own financial resources to provide a public service or project, which has a two-fold advantage for the public sector: 1) harnessing the efficiency which the private sector brings, 2) avoiding utilization of own financial resources or borrowing by the public sector, as the majority of costs is incurred by the private partner. The government usually holds ownership of the project, while the private company collects the revenue for a given time period. The main benefit of PPP for both partners is risk-sharing. Typically, the following kinds of risks can be allocated to the government: political (expropriation and nationalization of assets, unstable government, strong political opposition, poor public decision-making process), level of public opposition to the project, risk concerning legislation change (Ke et al., 2010).

The reduction of risks is a considerable encouragement for the engagement of private sector, as it lowers the cost of capital. In a broader sense, the cooperation of public and private sector can take a form of shared service delivery, which apart from risk sharing would also include pooling of financial resources by both parties (SWF resources on the government side). This would further reduce the financial risk incurred by the private sector.

##### 3) Improved country rating

SWFs can have positive influence on the investment risk ratings (Whitehead, 2012). Various rating agencies use different indicators to assess the country's

credibility, e.g. Euromoney's includes following factors: political risk, economic performance/ projections, structural assessment, debt indicators, credit ratings, access to bank finance, and access to capital markets. According to these indicators, Africa is currently not an investment-worthy target (ranked mostly in the Tier 5 and 4 which are least trustful).

However, according to Moody's Investor Service, financial resources accumulated in the funds have a great potential to absorb shocks (e.g. real-estate, banking, financial crises, political risks, etc.). They constitute an important buffer for public finances, as a result of which they enhance ratings. Moreover, SWFs facilitate state's involvement in ambitious infrastructure plans and increase state handout packages, which encourages FDIs. SWF can also be seen as a complement to domestic capital markets (Byrne, 2013).

Monk (2011) goes further and claims that it is not SWFs which enables higher country rating, but conversely, the rating agency inspires the establishment of SWFs. Generally, the agencies recommend governments to keep at least 10% of state revenues in some kind of buffer. SWF are a tool to pursue this advice, which automatically results in higher rating. This in turn lowers the cost of capital. E.g. in case of Angola, the creation of SWF resulted in the improvement of country assessment by Fitch Rating from *stable* to *positive* in 2012. According to the agency, the establishment of fund has reaffirmed that government aims to reduce economy's exposure to volatility in the oil price, and has laid down a foundation for sustainable growth (Altenkirch and Brown, 2012). Also Botswana, whose SWF is rated relatively high in the Linaburg-Maduell Transparency Index, has a corresponding high Standard & Poor (2013) rating of (A-).

##### 4) Improved regulatory framework

The RE investments ensure steady, low-risk, and long-term cash-flows only under a favourable policy framework. Thus, on the one hand it can be expected that the decision on investment of SWFs in green energy will be preceded with a careful examination of the existing policy framework, and on the other hand accompanied by its appropriate improvements, so that the profitability and security of investment are ensured. D. Goodman (FS-UNEP) argues that, as soon as public money is in game, the state may act with greater scrutiny with respect to the investment rules and regulations than in case when only private sector is involved. The political nature of energy pricing implicates the involvement of state anyway. The SWFs simply enable this engagement to be more informed. The reasons why this outcome cannot be achieved by the public sector alone (without creating SWF) are discussed further in this paragraph (*Make some money but do not let money make you*).

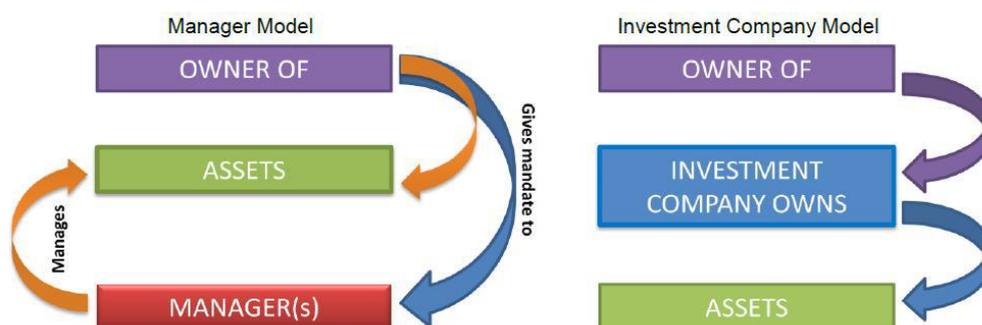


Figure 1. Manager model and investment company model (Al-Hass-an 2013)

### 5) Private sector development

Better regulatory framework further lowers the risk – both for private companies and for financial institutions, which may encourage their more active participation in the developing markets. Due to their long-term investment horizon, the SWFs could also provide an extension of financing terms presented to private companies by commercial banks or offer arrangements for risk-sharing. The SWFs are in general very supportive of involvement of private companies. They crowd in rather than displace them. In addition, SWFs have potential to indirectly foster the private sector development by facilitating sound fiscal and monetary policies, which creates a friendly investment climate.

#### **Make some money but do not let money make you**

An objection to the concept presented in this paper could be that revenues from extractive industry can be spent on green energy investments anyway, without creating an artificial tool which the SWFs are often accused to be. This however does not happen and the evidence suggests that most countries in spite of substantial oil and gas revenues are not able to mobilize the financial resources needed for RE projects. According to Diego Masera, this is not due to lack of an idea to do so, but rather results from the inability to apply the basic rules of good public governance and rational management. At the same time, Mr Masera is skeptical about the capacity of SWFs to overcome this problem, as they are also strongly embedded in the state's financial space. According to him, rolling out the red carpet for SWFs does not mean that corruption, lack of accountability, and greed can be swept under it and forgotten. However, as evidenced in the case study of Nigeria, it is indeed possible to run an exemplary SWF in spite of a generally bad public governance framework. The *management and ownership structure* is a keyword to explain the superiority of SWFs over the direct state investments. The general rule is that the operational management of SWFs must be independent in order to minimize political influence that could hinder the achievement of the SWF's objectives (Al-Hassan,

2013). With that respect, *the manager model and investment company model* are in practice the most common institutional frameworks for the functioning of SWFs. They can be summarized as follows in fig. 1.

The investment company model or the private fund manager model would most probably help minimize the effects of public governance problems in Africa.

#### **One cannot both feast and become rich**

Some opponents of the SWFs claim that they are an expression of state capitalism. The funds give too much power to governments, which could stifle liberalization and market competition. This may indeed be true, but you usually cannot have everything you want at once. The alternative is either to let the market forces work, which in the presence of described financial, regulatory, and political barriers will most probably lead to no economic activity in the field of RE investments, or to undertake a state-dominated policy, which may possibly also end up in a failure, but for which there is at least a chance to turn out successful.

### 5. Conclusions

From the analysis carried out in the framework of this research paper it can be concluded that SWFs have potential to overcome some of the financial, regulatory and political barriers faced by private investors in the RE sector in Africa. In spite of general problems with good public governance, it is possible to build a transparent and accountable fund. SWF are multifaceted tools which may be utilized in many different ways, depending on specific country needs. With regard to clean energy projects, they can substitute or complement other financing sources, serve as a project partner, take risks over, lower interest rates, influence the regulatory framework for RE, etc. As such, they are a promising tool to fight the resource curse in developing countries. Nevertheless, a broader policy commitment is needed to realize their potential. Moreover, the SWFs cannot replace economic and social policies nor regulatory reforms.

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## Problems in the Accomplishment of Solar and Wind Energy in India

### Problemy z pozyskiwaniem energii słonecznej i wiatrowej w Indiach

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#### Abstract

This article focuses on the current energy status and the obstacles related to the development of solar and wind capacity in India. The fast growing demand of electricity exerts huge pressure on the conventional energy sources. Due to the intermittent nature of irradiation and wind velocity, hybrid grid structure is more preferable in the present scenario. The use of alternative energy sources like solar and wind is the measure, which helps to attain eco-friendly, green environment. It decreases the dependency on fossil fuel energy for the highly populated country like India. Elimination of the hurdles discussed in the article works serves as a catalyst for the sustainable development of the country. The proposed paper deals with the problems which need to be solved in order to accomplish the solar wind energy project planned by the government of India.

**Key words:** solar energy, wind energy, barriers, renewable energy

#### Streszczenie

Artykuł przedstawia obecną sytuację i problemy odnoszące się do rozwoju energetyki słonecznej i wiatrowej w Indiach. Rosnące zapotrzebowanie na energię elektryczną oznacza wzrost wykorzystywania konwencjonalnych źródeł energii. Z uwagi na nieregularny poziom nasłonecznienia i zmienną siłę wiatru preferowana jest obecnie hybrydowa struktura sieci energetycznej. Wykorzystywanie odnawialnych źródeł energii prowadzi w kierunku powstania proekologicznego zielonego środowiska. Zmniejszeniu ulega poziom uzależnienia od paliw kopalnych, co jest istotne w krajach o wysokim poziomie zaludnienia, takich jak Indie. Eliminacja nadal występujących przeszkód to znaczący krok w kierunku rozwoju zrównoważonego tego kraju. Artykuł omawia problemy, które stoją na drodze do planowanego przez rząd Indii zwiększenia wykorzystywania odnawialnych źródeł energii.

**Słowa kluczowe:** energia słoneczna, energia wiatrowa, bariery, odnawialne źródła energii

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#### 1. Introduction

Solar energy is the energy which comes directly from the sun in the form of light and heat that is converted in the useful form with the help of variety of technologies, such as solar heating, photovoltaic, molten salt power plants, solar thermal energy, etc. (Tiwari et al., 2016). The radiation of the sun amounts to  $3.9 \times 10^{26}$  W and the average power at the highest point of the Earth's atmosphere is  $1353 \text{ Wm}^{-2}$ , coming at perpendicular angle (Sorensen,

2000). Wind is the form of the solar energy. Power generators are used to convert the kinetic energy of the air passing through wind turbine into electric energy (Sumathi et al., 2015). However, 95% of the world energy production still comes from non-renewable energy or nuclear power, which plays an essential role in fulfilling the energy requirement of the world (Owen, 2006).

The fundamental device used for this application is called solar cells. Semiconductors in the form of P-N junction are used as the fundamental materials for

solar cell devices, which produce electricity using photon from solar rays hitting on its surface. The operation of the solar cell follows three basic characteristics. Firstly, it absorbs the light and frees the electrons from the semiconductor. Secondly, it separates the charge carriers of opposite types. Thirdly, it separates extraction of those carriers to an external circuit.

In wind turbines, there is a wide range of vertical and horizontal axis turbines. The smaller turbines are used in battery charging, bus stands, boats etc. Medium size wind turbines are used in domestic power supply and big wind turbines are used in wind farms operation onshore and offshore in different parts of the world. The biggest wind park in India is in Kanyakumari, Tamil Nadu. It produces 1500 MW, which constitutes 59.3% of the total kinetic energy of the air flowing there through the turbine (according to the Betz's law).

India is facing huge problem of energy crisis and also, the energy demand is increasingly growing day by day. In order to deal with this issue, India needs to generate 3-4 times more energy than that of the energy consumed by India today. Achieving the required amount of energy is possible by exploitation of renewable resources (Kumara et al., 2010).

The present study shows solar photo voltaic (SPV) rooftop capacity of India (figure 1) on the basis of technical, economic and market capacity (Sundaray et al., 2014).

In India, estimated gross wind power capacity is approximately 48,561 MW (Sharma et al., 2012); with the addition of 32.17 GW of wind firm installation by March 2017, India is now fifth largest wind power producing country of the world.

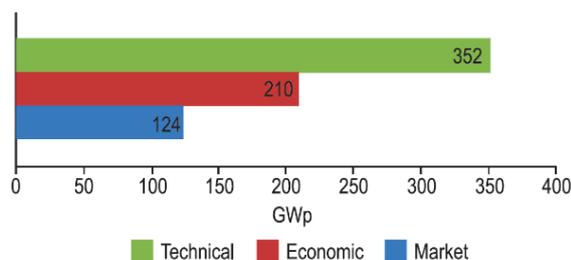


Figure 1. India's potential for rooftop solar PV (Sundaray et al., 2014).

The PV technology finds its applications not only in stand-alone and building connected systems, but also in street lighting, street signaling, garden and transportation stops, water pumping installations, radio and television relay stations etc. Moreover, energy storage devices are used in remote refugee camps, boats, and solar driven vehicles etc. (Chakraborty et al., 2016, Sharma et al., 2015, Sharma et al., 2017). In 2012, Indian government proposed 38,000 crore rupees project for the infrastructure development to enhance green energy corridor in India. It is likely to be accomplished by 2019 (Why India might not achieve its 2020 renewable energy targets, 2017). In

this regard, a solar project of 100 MW is installed in Gujarat, popularly known as a Gujarat solar park (Statewise Solar Parks, 2017). Moreover, major scopes for the accomplishment of the power needs of India's rural poor citizens exists in the process of rural electrification, power sector reforms and advance utilization of sustainable power resources (Chaurey et al., 2004). The safety in the system is also very significant. For the workers working on solar and wind farms, safety management system can be an effective method to save their lives (Transportation Research Board, 2013).

## 2. Current Market Scenario and targets of Solar-Wind Energy Technologies

### 2.1 Solar and wind Energy Technologies

There are two types of solar energy technologies: passive and active. The passive technology uses the solar energy directly from the sun without converting it to another form, like current or heat and active converts it and stores for use in different applications (Chakraborty, 2016).

In the active solar technology, concentrating solar power (CSP) concentrates sunlight at one point to produce heat and temperature and use it to obtain steam from water. With turbines and generators, the steam then is converted into electricity. It is very common in the solar-rich areas of the world, especially South Asia and America (Wolff et al., 2008). Photovoltaic power system is also an active technology which is connected with utility grid. This system contains solar panels, inverters, charge controller and bidirectional meter. It is installed on the roofs of residential and commercial places. Moreover, large utility-scale solar power stations are also grid connected. In some places standalone power systems are used, connected with rechargeable batteries. During the day time, surplus power generated from rooftop solar PV power system, after the consumption, is sold to the utility grid via bidirectional meter.

### 2.2 Current Market Scenario and targets

Solar energy is accepted worldwide as the largest source of renewable energy supply (EPIA, 2011, PVRES, 2010, Mills et al., 2008). Figure 2 shows the dramatic growth of solar energy use throughout the recent years in India and figure 3 shows that the price of the solar cell is decreasing dramatically from 1977 to 2015. The solar energy is a technology, not a fuel. It is limitless and the cost decreases when the demand increases.

As shown in Table 1, Indian government has set the target of 100 GW from solar power, 60 GW from wind, 10 GW from biomass and 5 GW from small hydro power (Riding the Renewable Wave, 2017, Grid connected solar rooftop systems, Indian Rooftop Solar Photovoltaic Landscape – Business Models & Opportunities, German cooperation).

Table 1. Total Installed Capacity and 2022 Target of India

Source	Total Installed Capacity (MW)	2022 Target (MW)
Waste-to-Power	130.08	10,000.00
Small hydropower	4379.85	5,000.00
Biomass power	8181.70	10,000.00
Solar power	12288.83	100,000.00
Wind power	32279.77	60,000.00
Total	57260.23	175,000.00

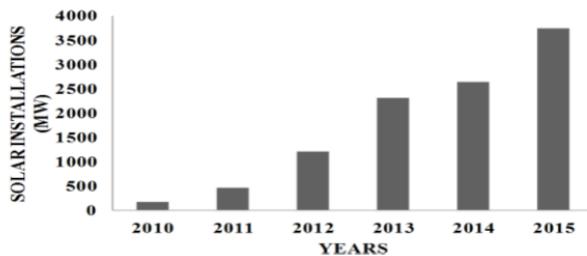


Figure 2. Expansion of Solar installation capacity of India (Chakraborty et al., 2016)

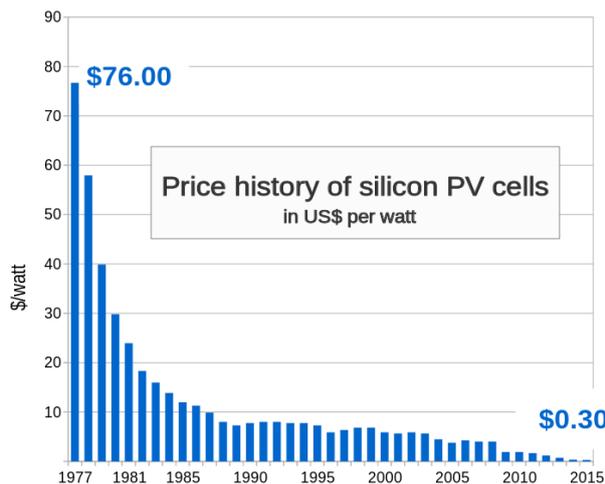


Figure 3. Price history of silicon PV cells since 1977.

Currently, small energy grids and solar home systems together produce about 1 gigawatt (GW) of electricity – a miniscule part of India's total renewable energy targets, 175 GW by 2022 (JNNSM, 2015, Future Perspective for Renewable Energy in India, 2017, Renewable Energy, 2017). According to a 2016 report by the Renewable Energy Policy, India's 2022 target is equal to 22% of the world's cumulative renewable energy capacity in 2015 which is 785 GW and solar capacity targets are equal to 44% of the world's 2015 total solar capacity which is 227 GW. India's current total installed capacity is 57.26 GW. In order to attain the targets, India has to include about 117.74 GW of renewable energy in the next coming six years which is an average of 19.62 GW per year.

### 3. Obstacles towards solar wind renewable energy development in India

The propagation of solar and wind energy technology faces different types of barriers (IDFC, 2010). This paper presents an in-depth description of different types of obstacles to solar and wind energy production technologies.

In India, the most common energy generation fuel is coal, which will last till 2050. The use of coal is the main factor for the global warming and health hazards (Ghosh et al., 2011). Renewable energy is the best solution to overcome these hurdles. If renewable energy plans are implemented in the rural areas, it will not only meet the growing energy needs but also stop them from migrating to urban areas (Kothari, 2000).

The obstacles are classified as: Economic, Technical, Institutional, Environmental and Social.

#### 3.1 Economic Obstacles

Solar:

- 1) The proper financing mechanism is absent in India. Banks provide debt at a rate much higher than what is available in the developed nations. Due to the lack of the funding, many projects are struggling to finish.
- 2) The access to advanced technology is very restricted for a general population, which causes either availability of the technology at very high cost or its unavailability.
- 3) Tax issue is also a dominant hurdle for low cost power tariff based on renewable power generation. Furthermore, trade complication occurs for the import of such power due to its high tax rate.
- 4) For the developing countries like India, it is not economically tolerable to install wind mills and solar modules at high rate. Hence, initial financial funds are required in terms of subsidies at the initial phase of roof top projects.
- 5) High initial and installation costs lead to loss of consumer interest, which causes a decrease in the market size.
- 6) Overseas companies from Europe and China link up with new solar and wind entrepreneurs' which shrinks the indigenous local market. Therefore, the Indian solar and wind projects are more dependent upon import.
- 7) High initial investments for robot technology for the cleaning process of solar panels is required for the project like Kamuthi Solar Power Project commissioned by Adani Power with a generating capacity of 648 MW at a single location at Kamuthi, India.

Wind:

- 1) High initial investment is required to establish a wind energy generation farm.

- 2) Good wind sites are usually located at remote areas, but load centers are located at urban places, hence, extra investments are required to compensate for the transmission & distribution losses.
- 3) High cost and low efficiency is a major drawback of Savonius VAWT.

### 3.2 Technical Obstacles

#### Solar:

- 1) Intermittent nature of solar irradiation is a problem to meet the consumer's power demand.
- 2) Absence of sun position tracking mechanism decreases the overall efficiency of the system.
- 3) Dust over the surfaces of the panel for a long duration causes adverse effect over the generation of electricity.
- 4) PV panels are designed for standard test conditions but, due to diversified weather condition in India during the year, factors like temperature, isolation, humidity, air mass etc. changes, which causes less rated output.
- 5) Natural degradation of solar PV cell can be given as

$$\% P_{\max} \text{ deg Rate} = \frac{(P_{\max, \text{nameplate}} - P_{\max, \text{present}}) * 100}{P_{\max, \text{nameplate}} * \text{Panel Age}}$$

whereas some parts of Gujarat and Rajasthan in the India's are characterized by a very hot and dry climate, which means the highest degradation rate in power generation.

- 6) Component Failure, like cracking of PV panel, is causing the unusual penetration of light into the panel surface, which further reduces the efficiency and maximum energy output of the panel. Hence, a complete replacement of the panel is required to maintain the desired output level of power.
- 7) Visual discoloration occurred in the solar panel due to humidity, very high surrounding temperature and also when panels are installed near oceanic regions. This causes deterioration in the absorption of desired wavelength of light. Subsequently, causes the loss of power and decreases the energy output of the panel.

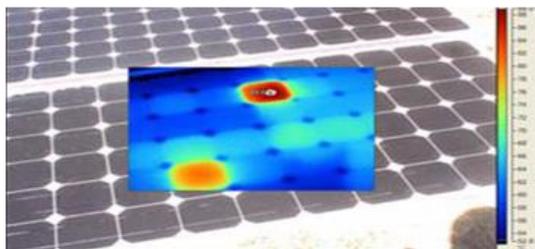


Figure 4. Showing hotspot in a solar panel (Shapiro)

- 8) Problem of hotspots, as shown in figure 4, in PV panel is a noteworthy issue while operation at very high temperature, since panels are configured with the interconnection of PV cells. Even

one small hot spot in a panel can heavily diminish the energy output and the efficiency of the panels.

- 9) Snow that spreads over the surface of panel in some geographical locations does not slide off the panel naturally. This can damage the panel, and also adversely affects the power output of the panel.
- 10) If the panel has been installed in the coal mine areas or the places where environment is dusty in nature, a formation of carbon layer starts over the surface of the panel due to tilt angle less than 5 degree. In order to maximize the gain of solar irradiance, the tilt angle is kept 5 or less than 5 degree which increases the chance of dust formation over the surface of panel, and subsequently decreases the panel efficiency.
- 11) Considering wind with variable speed, large scale frequency of vibration is observed in the corners of the solar panel, because it is the most sensitive part for dynamic wind speed. Therefore, the lifespan of the panel decreases with installation over high wind speed prone region.
- 12) Lack of technical knowledge becomes a hurdle in the selection of PV panels. Considering efficiency and cost, a mono crystalline panel is best suited, whereas thin film panels are a poor choice.
- 13) There are several issues regarding the power inverters used in the system. In continuous overloading, heat sink may overheat. Moreover, inverters may have over or under grid AC voltage mismatch with the grid frequency.
- 14) India is lacking sufficient laboratories and organizations, like National Institute of Solar Energy, to provide certifications, standards etc. for the quality confirmation and its suitability of solar panels and wind turbines for renewable energy technology utilization. This adversely affects the perception of technology.
- 15) Only a skilled and technically sound person can replace a skillful professional. However, developing countries have very much deficiency of such people, which is a big constraint for the entrepreneurship to establish the startups for a solar or wind company.
- 16) Poor quality and reliability of the solar and wind product used for the power generation reduces the market size.
- 17) Irregular cleaning and inspections of the solar panels reduces their lifespan and efficiency.
- 18) The power grid should not be far away from the site. The grid connected to the plants is responsible for very high aggregate technical and commercial losses which are directly proportional to the proximity of the site.
- 19) Power electronics devices used in PV power generation systems inject harmonics to the system which decrease the overall RMS value of the output power. However, harmonics in PE

devices becomes lower if the Photovoltaic generators are located near the transformer.

- 20) Off-grid solar-wind hybrid generation system requires energy storage devices to store the surplus power when the generated power is greater than the demand by the consumer. It constitutes an extra initial investment for the entrepreneur.
- 21) Short life cycle, high maintenance cost, low energy density and smaller power capacity are some major disadvantages of the battery banks used in the system.

Wind:

- 1) Challenges of L3 i.e., low cost, long term operation and low maintenance are required.
- 2) Sometimes, the sound produced by blades in the wind turbine system causes noise pollution. Although, it is less perceptible in comparison with conventional power plant, but it is nevertheless noticeable.
- 3) Due to the intermittent nature of wind energy, its reliability is very low. Therefore, wind energy system requires operation in a hybrid structure with other distributed generation units to maintain its reliability.
- 4) Icing is also a prime concern over the wind farm for cold places. Ice builds up when turbine blades do not move. It causes a change in the turbine blade shape and hence, reduces its overall efficiency.
- 5) When bearings in the turbine are overheated, it causes spark and leads to fire damage to the system. Moreover, lightning is also a natural factor for the fire damage issue in the wind mill.
- 6) Horizontal axis wind turbines (HAWT) used in the system, are not suitable for stormy wind.
- 7) Reliability of HAWT is very low because it is very much sensitive to the force applied by the wind to the blade, which varies in the rotation process. Consequently, it leads to the bending or cracking of blades /and finally the damage of the turbine happens.
- 8) Vertical axis wind turbines (VAWT) are manufactured with low power rating index in order to restrict the installation height for smooth operation. Thus, it is not suited for large turbines for high power ratings above 1MW.
- 9) Vertical axis wind turbines (VAWT) is a self-start unit but Savonius VAWT is a manually starting turbine.

#### 3.4 Institutional Obstacles

- 1) Absence of synchronization and collaboration between government, educational institutes and agencies delays the development and growth of the solar and wind energy projects.
- 2) Lack of research and development environment and infrastructure is the biggest hurdle to attain India technological leadership in solar and wind energy projects.

- 3) Shortage of the better financing infrastructure, models and arrangements decelerate the solar and wind energy industry.
- 4) Lack of institutions to publicize needful information leads to lack of information for the customer as well as the entrepreneurs.
- 5) In India, the stability of macro-economy is not fixed. Therefore, the afore-mentioned scenario raises a high risk and unpredictability for novel investors. Therefore, there are products with high payback period.
- 6) Research and development cultures are lacking in basic research institutions. This causes issues in the transformation of solar and wind energy technologies.
- 7) Although privatization in electricity is growing rapidly in India, the participants of new private companies are not strong enough to establish wind and solar power plants and rooftops. This encourages the monopoly nature of the firm.
- 8) Unavailability of proper skilled training and development of human resources to drive the solar and wind industry.
- 9) There are insufficient numbers of workshops and conferences organized to share technical information to install and run the solar and wind power projects.
- 10) Due to the large number of government agencies like NISE, NIWE, SECI, IRDEA, MNRE, electricity regulatory commission etc., it is complicated for an investor or entrepreneur to obtain authentication for the installation of solar and wind projects.
- 11) Generation Based Incentive scheme takes a long and time consuming process in PPA signing and land allotment.
- 12) There is a lack of closer industry-government cooperation for the technology to achieve big scale projects.

#### 3.5. Environmental Obstacles

- 1) It is a challenge to have an availability of suitable land which must be non-agricultural and unused, with good solar irradiance. It must be free of undulations and trees. Moreover, acquisition becomes the next problem to set up the solar power plant.
- 2) Although traditional silicon panels constitute no chemical hazard after the end of their life, cadmium Tellurium (CdTe) panels become toxic when unused. If these panels are disposed in a landfill, it becomes harmful as cadmium is taken in the process of ingestion.
- 3) Lubricating material in wind turbines ends up in the environment via total loss applications, volatility, spills or accidents. It is a threat to the environment and becomes a hazard for human health.

- 4) Sometimes, a catastrophic event occurs on wind farms, such as fire and explosion, due to high wind speed.
- 5) During the installation and operation, environmental hazards occur to the personnel, including worker's injuries from cranes and heavy lifts, musculoskeletal injuries from lifting, slips and trips.
- 6) Visual impact and landscape perception is a crucial obstacle in the application of wind farm for the power generation. Both are associated with nature and geographical location of the place. Therefore, it varies with the position of the farm.

### 3.5 Social Obstacles

#### Solar:

- 1) With the increase of the population, the total requirement of electricity in India will be of 5,000 TWh in 2040 which is a four-fold increase from 2014. Instead of indulging financial and technical efforts in the growth of solar and wind energy programs, India's priority is to start anti-poverty programs to overcome poverty by providing industries and health care facilities.
- 2) Raw Industrialist faces the problem of high cost capital requirement to establish renewable energy based generation units. At the same time, subsidized government policies on generation units give negative impact over the competitiveness in the market.
- 3) Negative perception about the products reduces the acceptance rate of the technology. This is a major issue of the reduced market size of renewable energy technology.
- 4) Lack of consumer understanding of finance and usage of photovoltaic rooftop system leads to non-recommendation for new houses and buildings by planners.
- 5) Land acquisition is a difficult task in India, if religious places come in between solar power plants. According to the Land Act, 2013, it will take up to five years for acquiring land if all steps followed smoothly.

#### Wind:

- 1) Local wildlife damage is observed with the operation of wind turbine. Flying birds get killed on the spinning blades of the turbine.
- 2) At night time, red light in the wind system disturbs the biological clock of night migrating birds, which causes adverse effects on their lifecycle. It leads to the decrease of their local population.
- 3) Considering the aircraft safety, wind turbines cannot be installed near airport runways and helipads.
- 4) Potential displacement requiring immigration, when land is expropriated for installation of wind farms.

- 5) The shadow flickering effect is observed when turbine blades cut the sun rays causing a reappearance of the shadows. This causes serious health related problems like headache, stress etc.
- 6) For onshore wind farms, the problem of land acquisition is a major obstacle. It occurs in the process of material, prices, penalties and distinction between the voluntary and land owner.
- 7) Loss of income, as well as assets, occurs in the process of potential displacement and resettlement to install a wind farm.

The primary technological obstructions involve low conversion efficiency of the PV modules, performance limitations of energy storage devices and inverters, inadequate supply of raw materials like silicon (Si). The main problem of standalone PV system is the storage of the surplus energy produced. Battery used in the system for this purpose are characterized by a very short life time comparable to that of the PV module (Zhang et al., 2012, Margolis et al., 2006).

On the other hand, applications of wind and solar has major technical barriers, such as increase in the level of onshore wind which can produce a dramatic dip in between 9 am to 4 pm in which low load requires less power from conventional power plants and wind-solar generation at the peak need to ramp up quickly as the sun sets (Luckow et al., 2015)

In some aspects, barriers are linked with the financial measures. Finance resources itself become a leading hurdle (Becker et al., 2000). Wind and solar energy projects as estimated by financial organizations are characterized by a lesser durability, but the payback period is very long and revenue structure is small (Jacobsson et al., 2000, Anthony, 2006, Goldman, 2005).

In order to evade further problems after planting or implementation of the solar-wind projects it is crucial to consider the beliefs, traditions and superstitions of the local society. It is very important for solar and wind plants developers to include local societies and people to know their opinion regarding planned projects (IDFC, 2010).

There are also some hitches in a project under green energy, such as market competition risk, technology up gradation, credit returns and less income risks (Goldman et al., 2005).

## 4. Conclusion

India has a huge capacity of solar and wind energy resources to overcome the rapidly growing demand for energy in the next decade. India's first ever auction of wind power in 2017 shows the decrease of wind tariff and previously, a significant reduction in solar power tariff was also observed. This indicates that the use of solar energy along with wind in hybrid plants is the best alternative to get rid of conventional energy resources in near future. For the incip-

ient of solar and wind technology, it requires more research and development to reduce the renewable energy system's cost. It is essential to concentrate on improved policies, government efforts and private sectors involvements for the further development. For the maximum exploitation of solar and wind energy resources, India needs to overcome the key challenges like lowering the initial investment, enhancing research and development culture, positive consumer perception, boost in funding agency's interest. Assessment of all the proposed issues for the development of this sector reveals that a single window certification system for solar-wind energy projects is required in India. Promotional measures need to be enhanced by the ministry of new and renewable energy, so that the use of conventional resources can be minimized. Without participation of the private firms, proper growth of this industry is not possible. Moreover, the problem of limited access to technology, high initial investment, lack of skilled personnel, poor quality of product, transmission issue of power from generation site to load site, grass route level implementation of government policies, absence of micro grid technology etc. are the major obstacles to the conversion of India into a green country. Additionally, India possesses a huge scope of offshore installation of windmills because the country is surrounded by three seas. By the end of March 2017, 32.17 GW was the total installed wind power capacity of India which lower the tariffs to Rs. 3.46/kWh. Moreover, in rural areas, due to continued growth in international crude oil prices and developments in the hybrid solar-wind energy technologies, standalone power systems are becoming very popular. Development of these industries may not only help to meet the energy demand, but also works as an asset for new job creation.

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# Can Urban-rural Integration Decrease Energy Intensity? Empirical Study Based on China's Inter-provincial Data

## Czy integracja obszarów miejsko-wiejskich prowadzi do ograniczenia energochłonności? Przykład Chin

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### Abstract

The paper discusses the mathematical relationship of Urban-rural integration and energy intensity based on the production function including capital, labor and energy. Then, the empirical analysis on how it affect energy intensity, on the basis of the static and dynamic panel model with China's 30 provincial economic data in 2005-2014 years, using four estimation methods – FE, IV-FE, IV-GMM and MG. As part of integration, urbanization, industrialization and technology are found from the empirical results. Firstly, urbanization can significantly reduce energy intensity in short run, while the effect is positive in long term, as China didn't lastly use the role in saving energy on the process of urbanization. Secondly, industrialization can effectively cut down energy intensity. Thirdly, it is worthy to pay more attention to the ability to improve energy efficiency and lower energy intensity of technology in short and long run.

**Key words:** urban-rural integration, urbanization, industrialization, technology, energy intensity

### Streszczenie

W artykule przeanalizowano matematyczną zależność integracji obszarów miejsko-wiejskich i energochłonności opartej na funkcji produkcyjnej z uwzględnieniem kapitału, rynku pracy i energii. Jest to podstawą do analizy empirycznej odnoszącej się do tego, jak integracja wpływa na energochłonność, na bazie statycznych i dynamicznych paneli odnoszących się do 30 regionów w Chinach, uwzględniając dane z lat 2005-2014 i używając metod szacowania FE, IV-FE, IV-GMM i MG. Jako części procesu integracji, na podstawie danych empirycznych, wyróżniliśmy urbanizację, industrializację i stronę technologiczną. Okazało się, że po pierwsze urbanizacja może znacząco obniżyć energochłonność w krótkiej perspektywie czasowej, jednak korzyści pojawiają się po dłuższym czasie, ponieważ Chiny nie przywiązywały roli do oszczędzania energii w kontekście urbanizacji. Po drugie, industrializacja może efektywnie obniżyć energochłonność wykorzystywanych technologii i to zarówno w perspektywie krótko, jak i długoterminowej.

**Słowa kluczowe:** integracja obszarów miejsko-wiejskich, urbanizacja, industrializacja, technologia, energochłonność

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### 1. Introduction

Energy is an indispensable input factor for the rapid development of economy and society. However, excessive consumption of non-renewable energy resources has berried the sustainable development of the economy. As clean energy or renewable energy

still cannot replace non-renewable energy sources, a possible way to get rid of the energy abuse is to reduce energy intensity and improve energy efficiency. The energy quantity of China is great, but the per capita quantity is relatively poor. The extensive development of China exacerbated the problem between environment, energy and economy. Sustaina-

ble development is particularly desirable to energy saving. At present, China is at a critical stage of modernization. The prominent feature of this process is the accelerated development of urbanization, industrialization and technology. On the one side, will promote total factor productivity as well as economic growth, on the other side it will result in the rise of energy consumption. How positive and negative effects the China energy intensity, which is dominated by the traditional fossil energy, is a topic worthy of further discussion.

Existing domestic and foreign research literatures focus on the relationship between technology, industrial structure, and energy consumption structure or energy efficiency. We believe that urbanization, industrialization and technology are part of urban-rural integration, which affect energy intensity extremely. From the perspective of technological progress, technology innovation and investment increase will often bring energy efficiency improvement, thus it is possible reducing the energy consumption intensity (such as Garbaccio et al., Fisher-Vanden & Jefferson, 1999; K., 2006). However the technological will lead to the increase of energy consumption of the rebound effect was partially offset by the energy savings due to technical progress. The final effect of technological progress on energy consumption intensity becomes more and more complicated (Khazzoom, 1980).

Other scholars are concerned about the impact of urbanization on energy size, energy intensity, or energy efficiency. Sathayo & Meyers (1985) observed that with the development of urbanization, developing countries are speeding up the process of replacing coal with oil. Parik (1995) points out that commuting energy expenditure is related to urban spatial structure, and energy consumption is related to urban scale structure. According to Dzioubinski & Chipman (1999), in developing countries, the development of urbanization will lead to higher energy consumption of residents. Hiroyuki (1997) uses data of year 1980-1993 from several countries, and finds that there is a positive correlation between the proportion of urban population and the logarithm of energy consumption per capita. Gates & Yin (2002) studies the relationship between urbanization in China and residential and commercial energy sources. By analyzing the urban and rural structure of energy type appliances household consumption, the demand for electricity in urbanization is greatly improved. Along with the urbanization advancement, the resident and the commercial energy correspondingly increase. B., R., Wei, et, Al (2003) found that urbanization has two ways of increasing energy consumption and reducing energy consumption.

The impact of industrialization on energy consumption, energy intensity is also a core study of scholars. Industrialization has expanded the scale of energy consumption (Donald, W., Jones, 1989), which is not

conducive to the reduction of energy intensity. Zhu-jun Jiang & Boqiang Lin (2014) found that economic globalization makes the industrialization be shortened, but to promote faster growth in energy consumption, the inverted U curve of energy consumption are likely to be changed. Perry Sadorsky (2013, 2014) pointed out that industrialization will increase energy consumption, and its long-term elasticity of energy intensity is positive, which is about 0.07 to 0.12. The changes of industrial structure and economic growth are reciprocal causation. The change of energy consumption is not only due to the economic growth, but also affected by the industrial structure. In other words, the proportion of the first, second and third industries in the industrial structure has a direct impact on the energy efficiency of a region. The energy factor will flow in different industries for the optimization of industrial structure, and the direction is mainly from the first industry to the second and third industries with high productivity, and high added value. This has been demonstrated by the experience of numerous research results, such as Samuels et al (1984); Richard et al; Liu ET (1999); Ian sue Wing et al (2004).

In summary, this research contributes to three aspects as below.

First, technology is introduced into the conceptual framework. Current papers in this field mainly study the impact of industrialization and urbanization on energy intensity. However, as the three variables (technology, industrialization and urbanization) are intertwined and mutually supportive in affecting energy intensity, it is biased to exclude technology out of the analysis. This paper in contrast, examines technology based on the data measuring technology level sourced from the information statistical evaluation study group, NBS institute.

Second, estimation is made based on a structural model. This paper emphasizes the theoretical base of econometric modeling and is based on C-D production function. Through analyzing the correlation mechanism between the three variables and total factor productivity, their mathematical relation with energy intensity is deduced.

Third, the endogeneity stems from the reverse causality of energy intensity to industrialization. For example, some less developed provinces are inclined to achieve targeted economic growth through extensive industrialization. This potential endogenous problem causes estimation deviation of industrialization. Thus, this paper introduces IV-FE and IV-GMM estimator to solve this problem. Secondly, ordinary panel analysis hypothesizes that each sectional variable is homogenous as the explained variable, when there are too many sections or sections are mutually correlated, this hypothesis becomes too rigid and deviation emerges. This paper adopts a recently prevalent method, Mean Group (MG), to solve this problem. This method can also distinguish the long-run

and short-run impact of the three variables on energy intensity.

The conceptual framework of this paper comprises of four parts. Section 2 deduces the mathematical correlation expression of energy intensity including three variables based on the production function of capital, labor and energy, under the hypothesis that the evolution of technology, industrialization and urbanization is the function of energy intensity variation. Section 3 elaborates the variable declaration and their statistical description. Section 4 tests the long-run and short-run correlation between the three variables and energy intensity through static and dynamic panel models with a sample of economic data from 30 China provinces from 2005 to 2014, based on the constructed expression of energy intensity.

## 2. Theoretical model

It is generally acknowledged that energy intensity is usually measured by the ratio of total energy consumption to total yield. Energy consumed in urbanization, industrialization and technology through various conduction mechanism will ultimately be realized as yield. Therefore, to derive an expression of mathematical correlation between energy intensity and urbanization, industrialization, technology, merging the three with capital, labor and energy in a production function seems feasible.

Based on traditional two-factor production function, the three-factor total production function of capital, labor and energy can be expressed as below.

$$Y = A(\cdot)F(K, L, E) \quad (1)$$

In the expression,  $Y$  stands for total yield,  $K$  for capital input,  $L$  for labor input,  $E$  for energy input,  $A(\cdot)$  for total factor productivity (TFP) which represents all factors affecting total yield except capital, labor and energy. For TFP  $A(\cdot)$ , the impact of urbanization, industrialization and technology is emphatically concerned.

By bringing urbanization ( $u$ ), industrialization ( $ind$ ), and technology ( $tec$ ) into  $A(\cdot)$ , the following expression can be derived:

$$Y = A(\ln u, \ln ind, \ln tec) * F(K, L, E) \quad (2)$$

Further, with C-D production function and productivity in the form of the exponent, expression (2) can be dominated as:

$$Y = A_0 e^{\varphi \ln u + \phi \ln ind + \eta \ln tec} K^\alpha L^\beta E^\gamma \quad (3)$$

In expression (3),  $A_0$  stands for initial productivity,  $\alpha$ ,  $\beta$ ,  $\gamma$  for the yield elasticity capital, labor and energy respectively. By dividing  $E$  from both sides

of expression (3), and naturally logarithmizing both sides, the following expression can be derived:

$$\ln \left( \frac{E}{Y} \right) = -A_0 - \varphi \ln u - \phi \ln ind - \eta \ln tec + \alpha \ln \left( \frac{E}{K} \right) + \beta \ln \left( \frac{E}{L} \right) \quad (4)$$

Expression (4) shows clearly that factors influencing national or regional energy intensity include energy consumption per unit capital, energy consumption per unit labor and TFP, which further include urbanization level, industrialization level and technology level. This is the theoretical foundation for the proceeding construction of empirical models.

## 3. Variable declaration

There are 6 Variables involved in this research, including 1 explained variable which is energy consumption per unit GDP, and 5 explanatory variables including energy consumption per unit capital, energy consumption per unit labor, urbanization level, industrialization level, and technology level. Among the explanatory variables, energy consumption per unit capital and energy consumption per unit labor are control variables, urbanization, industrialization and technology are variables of urban-rural integration.

Energy consumption per unit GDP ( $E/Y$ ) is an index internationally used to measure the comprehensive benefit of national or regional energy consumption, favorable for horizontal or vertical comparison of energy intensity of different locations or time points. This index is directly acquired from *China Energy Statistics Yearbook*, measured in terms of ton coal equivalent (tce) per ¥10000.

Energy consumption per unit capital ( $E/K$ ) refers to the scale of energy that is taken by each unit of capital in production. This is a compound index calculated from dividing the size of the total energy consumption, sourced from *China Energy Statistics Yearbook*, by the size of total capital input. The size of total capital input is roughly measured by the total size of fixed asset investment sourced from *China Statistics Yearbook* over the years<sup>1</sup>, in terms of tce per ¥10000.

Energy consumption per unit labor ( $E/L$ ) is also a compound index referring to the energy consumption taken by each unit of labor in production. This index is measured by the total size of energy consumption sourced from *China Energy Statistics Yearbook* and the scale of local practitioners sourced from *China Statistics Yearbook*, in terms of tce per capita.

Urbanization level ( $u$ ) refers to the level of urban development in a nation or district. It is the main indi-

<sup>1</sup> Given the absence of consensus on the measurement of the stock data of capital, and that capital depreciation in different provinces is unlikely to be defined scientifically, only stream data is used for the estimation. However, the

estimation made after differencing in the empirical research can neutralize the effect of the substitution of stream data for stock data.

cator of urban population intensity level. This index is measured by urbanization rate sourced from *China Statistics Yearbook* over the years, in terms of a percentage (%).

Industrialization level (*ind*) is an important reference to the economic development of a nation or district. Existing peer papers generally measure industrialization by the weight of industrial value added (employment), non-agricultural value added (employment) or service industry value added (employment). Given that China's industrialization is in the middle and late period when non-agricultural industries go servitization, this index is measured by the ratio of service industry value added accounting for non-agricultural value added, in terms of a percentage (%). Technology level (*tec*) is the basis and symbol of the advancement and modernization of post-industrial society. This index is measured by the comprehensive index comprised of five aspects including industrial technology, infrastructure, applied consumption, and knowledge support and development effect.

#### 4. Econometric models & empirical research

##### 4.1. Econometric models

In order to study the impact of urbanization (*u*), industrialization (*ind*) and technology (*tec*) on energy intensity, the following model is built based on mathematic expression (4).

$$\ln\left(\frac{E}{Y}\right)_{it} = \beta_1 \ln u_{it} + \beta_2 \ln ind_{it} + \beta_3 \ln tec_{it} + \alpha_1 \ln\left(\frac{E}{K}\right)_{it} + \alpha_2 \ln\left(\frac{E}{L}\right)_{it} + X'_{it}\Gamma_i + \varphi_i + \varepsilon_{it} \quad (5)$$

In the expression, *i* stands for provinces, *t* for time.  $\ln u_{it}$ ,  $\ln ind_{it}$ ,  $\ln tec_{it}$  is the logarithm of *u*, *ind* and *tec* of *i* province in the year *t* respectively.

$\ln\left(\frac{E}{K}\right)_{it}$ ,  $\ln\left(\frac{E}{L}\right)_{it}$  is the logarithm of *E/K* and *E/L* of *i* province in the year *t* respectively.  $X_{it}$  stands for other control variables. Some scholars found that income level lays significant impact on energy intensity (Jones, 1989; Martinez-Zarzoso and Maruotti, 2011), therefore net income per capita is added into the model as a control variable.  $\varphi_i$  controls the inter-provincial fixed effect.  $\varepsilon_{it}$  is the error term. The estimation coefficient of interest in this research is  $\beta = (\beta_1, \beta_2, \beta_3)'$ . As each variable in the model has been naturally logarithmized,  $\beta$  can be explained as the energy intensity elasticity of *u*, *ind* and *tec*.

In the model above, there is one problem that may cause estimation deviation, which stems from the endogeneity of the variable  $\ln ind_{it}$ . The reason is that the energy intensity of a district can affect its industrialization process. To solve this problem, a two-

stage least square method is employed to estimate the fixed effect estimator (abbreviated as IV-FE below), in which the instrumental variable is the industrialization level with two periods' lag<sup>2</sup>.

Since improvement of energy efficiency takes a fairly long time, energy efficiency in the current period could be affected by the previous period, implying possible accumulated lagging effect of energy intensity. Upon this issue, Sadorsky (2013, 2014) claims that by introducing one-period lagged energy intensity into the model the accumulated lagging effect can be restrained. Thus the dynamic model below is built.

$$\begin{aligned} \ln\left(\frac{E}{Y}\right)_{it} = & \lambda \ln\left(\frac{E}{Y}\right)_{it-1} + \beta_1^0 \ln u_{it} + \\ & \beta_2^0 \ln ind_{it} + \beta_3^0 \ln tec_{it} + \beta_1^1 \ln u_{it-1} + \\ & \beta_2^1 \ln ind_{it-1} + \beta_3^1 \ln tec_{it-1} + \alpha_1 \ln\left(\frac{E}{K}\right)_{it} + \\ & \alpha_2 \ln\left(\frac{E}{L}\right)_{it} + X'_{it}\Gamma_i + \varphi_i + \varepsilon_{it} \end{aligned} \quad (6)$$

In the expression,  $\ln\left(\frac{E}{Y}\right)_{it-1}$ ,  $\ln u_{it-1}$ ,  $\ln ind_{it-1}$ ,  $\ln tec_{it-1}$  stands for energy intensity, and the first-order lag term of urbanization, industrialization, technology respectively<sup>3</sup>. Expression (6) is referred to as ARDL, short for Autoregressive Distributed Lag model.

As expression (6) contains fixed effect, after eliminating the fixed effect with difference method, the difference term of the explained variable will be correlated with error term ( $E[\Delta \ln\left(\frac{E}{Y}\right)_{i,t-1} \cdot \Delta \xi_{it}] \neq 0$ ),

which is referred to as dynamic panel bias (Nickell, 1981). To address this issue, Arellano and Bond (1991) proposed that when error term  $\xi_{it}$  bears no serial correlation, the second or higher order lag of the explained variable can be used as an instrumental variable of the difference term, that is to say, for endogenous variable  $\Delta \ln\left(\frac{E}{Y}\right)_{i,t-1}$ , applicable instrumental variables include  $\ln\left(\frac{E}{Y}\right)_{i,t-2}$ ,  $\ln\left(\frac{E}{Y}\right)_{i,t-3}$ , ...,  $\ln\left(\frac{E}{Y}\right)_{i,1}$ .

When the difference equation does not bear serial correlation, consistent estimation of coefficient  $(\lambda, \beta, \alpha, \Gamma)'$  can be made. This method (IV-GMM) can not only eliminate dynamic panel bias of the equation, but solve multiple issues of variable endogeneity. Besides, when there is another endogenous variable in the regression equation, adding in its lag term as the instrumental variable can eliminate endogeneity.

However, IV-GMM method is limited due to the hypothesis that each cross section has equal elasticity to explained variable it is based on. When the data are cross-sectionally correlated, this hypothesis becomes too rigid and thus estimation deviation arises. To address this issue, this paper adopts a recently

<sup>2</sup> Using the two-period lagged data is in consideration that energy intensity is affected by the current and one-period lagged data, which will be illustrated in the dynamic model.

<sup>3</sup> The first-order lag term is added in order to deduce the error correction model, and study the long-run and short-run impact of the variables on energy intensity.

prevalent method which is mean group (MG) regression method (Pesaran and Smith, 1995; Pesaran, 2006). This method can not only eliminate fixed effect and dynamic panel bias (Pesaran and Shin, 1999), but study the long-run and short-run impact of the variables of interest<sup>4</sup>. Specifically, the idea structure of MG estimation is that regression is made for every cross section, and then the estimation coefficients generated are used as the short-run impact of the variables, the mean value of the estimation coefficients are used as the long-run impact of the variables. Thus MG method allows heterogeneity of the elastic coefficients of different cross sections. corresponding error correction model (ECM) can be deduced as below:

$$\Delta \ln \left( \frac{E}{Y} \right)_{it} = \tau \left[ \eta \ln \left( \frac{E}{Y} \right)_{it-1} - \theta_1 \ln u_{it-1} - \theta_2 \ln ind_{it-1} - \theta_3 \ln tec_{it-1} \right] + \mu_{i\Delta} \ln \left( \frac{E}{Y} \right)_{it-1} + \rho_{i1} \ln u_{it} + \rho_{i2} \Delta \ln ind_{it} + \rho_{i3} \Delta \ln tec_{it} + \alpha_1 \ln \left( \frac{E}{K} \right)_{it} + \alpha_2 \ln \left( \frac{E}{L} \right)_{it} + X'_{it} \Gamma_i + \varphi_i + \varepsilon_{it} \quad (7)$$

In the expression, coefficient  $\tau$  is referred to as error correction coefficient which decides the speed of adjustment to long-run equilibrium. If  $\tau \in (-1, 0)$ , the equation is dynamically stable and feasible to be converged to long-run equilibrium.

$\theta = (\theta_1, \theta_2, \theta_3)'$  measures the long-run impact of urbanization, industrialization and technology. Coefficient  $\rho = (\rho_{i1}, \rho_{i2}, \rho_{i3})'$  measures the short-run impact of the three variables on energy intensity.

#### 4.2. Empirical research

In this section, static and dynamic panel models will be applied to estimate the impact of urbanization, industrialization and technology on energy intensity. In the application of static models, fixed effect estimator (FE) will be first applied to eliminate unobservable inter-provincial heterogeneity, and 2SLS will then be applied to eliminate the endogeneity of industrialization (IV-FE). While applying dynamic models, the estimation method by Arellano and Bond (1991) will first be used to settle dynamic panel bias and the endogeneity of  $\ln ind_{it}$  (IV-GMM), and then MG method will be used to estimate the long-run and short-term impact of urbanization, industrialization and technology.

##### (1) Static panel models

###### a. Fixed-Effect (FE) estimator

Table 1 shows the estimation results generated by the fixed effect estimator based on expression (5). In Table 1, column (1) and (2) illustrates the results from the national sample, column (3) and (4) from the east

sample, column (5) and (6) from the mid-west sample; column (5) and (6) illustrates the regression results from the mid-west sample; column (2), (4) and (6) has controlled provincial GDP per capita.

By analyzing the data above, several findings have been made as below.

Firstly, the rise of urbanization level has prompted energy intensity increase. No matter on which level, national, east or mid-west, the elastic coefficient of urban population proportion to energy consumption per unit GDP is significantly positive. Generally, energy consumption per capita in urban areas is greatly higher than that in rural areas. Ongoing urbanization will essentially spur increase of total energy consumption. Urbanization is always accompanied by massive concentration of population and industries into urban areas, with soaring development of transportation and telecommunication, which substantially drives up energy consumption and energy intensity, naturally hindering decrease of energy consumption per unit GDP. This also implies that years of extensive urbanization that features high energy consumption, high cost and low profit is obstructive to sustainable development. In addition, it is notable that urbanization in the east has laid greater impact on energy intensity than in the mid-west. A potential reason for this situation is that the east has an earlier start and faster development, and higher concentration of urban population and non-agricultural industries. Furthermore, with the accumulative effect of energy intensity, years of high energy consumption due to extensive urbanization cannot be digested shortly, causing higher elasticity of energy intensity to urbanization in the east than in the mid-west.

Secondly, rise of industrialization level can significantly lower energy intensity. The regression coefficients of industrialization level from the total sample and subsamples, which is measured by the proportion of service industry value added to non-agricultural industries, are all significantly negative. This suggests that as industrialization moves on, industrial structure has been gradually upgraded and optimized, energy efficiency has been greatly improved, and the servitization of non-agricultural industries has brought about more yield than the energy increase for this transformation which can effectively lower production energy consumption. Due to the implementation of various energy-saving measures and the promotion of energy-saving technology that results in higher efficiency of energy deployment, rise of the portion of third industry can lower energy intensity, and the total effect of economic structure on energy efficiency is positive. These findings also echo the conclusion that structural adjustment can effectively improve energy efficiency by many other scholars.

<sup>4</sup> Generally, MG method obtains consistent and valid estimation by handling samples with large N and large T. Of the sample in this research, T=8, thus the sample does not fully bear characteristics of long time series. However,  $\sqrt{N/T} = 0.69$ , which is close to 0, and furthermore

lower when analyzing subsamples of the east and mid-west. Pesaran (1999) hold the opinion that even when T is relatively small, MG estimation is still consistent, but less valid.

Table 1. Estimation results of FE

	National		East		Mid-west	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Ind</i>	-0.069** (0.021)	-0.071*** (0.024)	-0.092*** (0.030)	-0.009*** (0.023)	-0.038 (0.094)	-0.019 (0.096)
<i>u</i>	0.472*** (0.056)	0.485*** (0.052)	0.913*** (0.301)	0.909*** (0.298)	0.501*** (0.127)	0.511** (0.178)
<i>tec</i>	-0.339*** (0.097)	-0.304*** (0.101)	-1.546*** (0.214)	-1.166*** (0.276)	-0.330* (0.163)	-0.211 (0.159)
<i>E/K</i>	0.078*** (0.024)	0.059** (0.024)	-0.065 (0.025)	-0.040 (0.024)	0.158*** (0.052)	0.121*** (0.031)
<i>E/L</i>	-0.123*** (0.024)	-0.062 (0.037)	0.026 (0.061)	0.072 (0.059)	-0.182*** (0.034)	-0.164*** (0.032)
GDP per capita		-4.019*** (1.148)		-3.765** (1.799)		-2.503 (1.597)
Constant	-1.316* (0.712)	8.102*** (2.623)	-5.691*** (1.322)	3.432 (5.689)	-2.054 (1.208)	6.341 (4.988)
Observation	300	300	110	110	190	190

Note: \*\*\*, \*\*, \* indicates significance at the level of 1%, 5%, 10% respectively.

Table 2. Estimation results of IV-FE

	National		East		Mid-west	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>ind</i>	-0.054** (0.037)	-0.069** (0.035)	-0.107** (0.029)	-0.118** (0.030)	-0.010* (0.006)	-0.013 (0.227)
<i>u</i>	0.426** (0.070)	0.466*** (0.068)	1.091*** (0.205)	1.117*** (0.205)	0.617** (0.241)	0.743** (0.233)
<i>tec</i>	-0.639*** (0.108)	-0.578*** (0.112)	-1.619*** (0.244)	-1.342*** (0.431)	-0.401*** (0.132)	-0.398*** (0.139)
<i>E/K</i>	0.060 (0.038)	0.040 (0.042)	-0.119* (0.064)	-0.146* (0.077)	0.096* (0.050)	0.080 (0.068)
<i>E/L</i>	-0.123*** (0.046)	-0.116** (0.047)	0.033 (0.071)	-0.002 (0.085)	-0.200*** (0.063)	-0.195*** (0.063)
GDP per capita		-3.255 (2.912)		-6.307 (8.022)		-2.065 (5.027)
Constant	-1.328* (0.686)	5.790 (6.432)	-3.976*** (1.268)	11.103 (19.228)	-0.825 (1.152)	3.856 (11.699)
Observation	300	300	110	110	190	190

Note: \*\*\*, \*\*, \* indicates significance at the level of 1%, 5%, 10% respectively. The instrumental variable is the second-order lag term of industrialization.

Thirdly, the rise of technology is conducive to lower energy intensity. The elastic coefficient of energy intensity to technology is significantly negative. It is observable that the level of technology on different layers is negatively correlated with energy intensity. Technology is particularly crucial for raising energy efficiency and lowering energy consumption per unit GDP. In terms of the energy-saving effect of technology, the east district shows greater capability than the mid-west. To specify, when income per capita is controlled, every 1% rise of technology level will result in a 1.166% decrease of energy intensity in the east, which is 0.304% higher than national average, in contrast to a 0.211% decrease in the west. The reason might be that the east district has achieved the highest economic development and the optimal industrial structure, together with greater concentra-

tion, developing capability and promotion of information industry in the east than in the mid-west. Therefore the east is better at every aspect of applying IT in energy saving such as energy monitoring and managing consumption, precise energy use and so on, which finally results in higher effect of lowering energy intensity of technology in the east than in the mid-west.

#### b. Instrumental Variables-Fixed Effect (IV-FE) estimator

It is possible that the results in Table 1 are biased due to the endogeneity that energy intensity might exert reverse effect on industrialization. To address this issue, two-stage least square is applied to estimate the fixed-effect estimator, with two-period lagged values of industrialization used as the instrumental variable for the current values (see Table 2).

Table 3. Estimation results of IV-GMM

	National		East		West	
	(1)	(2)	(3)	(4)	(5)	(6)
Energy intensity (-1)	0.892*** (0.078)	0.879*** (0.084)	0.864*** (0.107)	0.852*** (0.108)	0.869*** (0.088)	0.870*** (0.089)
<i>ind</i>	-0.043 (0.209)	-0.046 (0.199)	-0.077** (0.031)	-0.064* (0.031)	-0.150** (0.134)	-0.162** (0.137)
<i>u</i>	0.066 (0.266)	0.071 (0.257)	0.038 (0.452)	-0.046 (0.416)	0.062 (0.465)	0.069 (0.463)
<i>tec</i>	-0.371** (0.165)	-0.371** (0.163)	-1.420** (0.242)	-1.474*** (0.245)	-0.725*** (0.036)	-0.736*** (0.028)
<i>ind</i> (-1)	0.038 (0.047)	0.044 (0.051)	0.011 (0.025)	0.008 (0.023)	0.075 (0.133)	0.122 (0.116)
<i>u</i> (-1)	0.808 (0.542)	0.833 (0.564)	0.877** (0.341)	0.825** (0.270)	0.834 (0.593)	0.874 (0.596)
<i>tec</i> (-1)	0.316*** (0.084)	0.305*** (0.076)	0.506 (0.614)	0.432 (0.672)	0.349*** (0.069)	0.342*** (0.070)
<i>E/K</i>	0.052 (0.099)	0.054 (0.098)	-0.091 (0.056)	-0.033 (0.060)	0.001 (0.093)	0.001 (0.092)
<i>E/L</i>	-0.291*** (0.033)	-0.307*** (0.030)	0.106*** (0.054)	0.033 (0.058)	-0.215*** (0.029)	-0.210*** (0.024)
GDP per capita		0.004 (4.269)		1.875 (6.284)		1.394 (5.073)
Hansen <i>P</i>	0.328	0.327	1.000	1.000	0.943	0.946
AR2 <i>P</i>	0.735	0.755	0.449	0.895	0.964	0.953
Observation	300	300	110	110	190	190

Note: \*\*\*, \*\*, \* indicates significance at the level of 1%, 5%, 10% respectively. The instrumental variables are the second and higher order lag terms of energy intensity and the second-order lag term of industrialization.

Table 4. Estimation results of MG

	National		East		Mid-west	
	(1)	(2)	(3)	(4)	(5)	(6)
Long-run impact						
<i>ind</i>	-0.113 (0.108)	-0.127 (0.133)	-0.310** (0.125)	-0.312** (0.127)	-0.282 (0.476)	-0.198 (0.499)
<i>u</i>	1.766** (0.620)	1.819** (0.617)	1.910** (0.911)	2.142* (1.136)	2.531** (1.130)	2.601** (1.302)
<i>tec</i>	-0.412 (0.445)	-0.593 (0.516)	-2.108*** (0.348)	-2.308 (2.445)	-0.226 (0.781)	-0.249 (0.633)
GDP per capita		9.464 (7.251)		33.670 (58.245)		29.886 (42.612)
Short-run impact						
Error correction coefficient	-0.313*** (0.054)	-0.320*** (0.057)	-0.281*** (0.082)	-0.276*** (0.078)	-0.249*** (0.062)	-0.244*** (0.061)
<i>ind</i>	-0.033 (0.092)	-0.034 (0.097)	0.023 (0.034)	0.025 (0.037)	-0.148 (0.134)	-0.177 (0.136)
<i>u</i>	-0.628*** (0.139)	-0.655*** (0.141)	-0.698** (0.349)	-0.701** (0.350)	-0.908** (0.366)	-0.907** (0.367)
<i>tec</i>	-0.331*** (0.096)	-0.329*** (0.100)	-0.675 (0.871)	-0.698 (0.824)	-0.355*** (0.109)	-0.367*** (0.109)
Constant	-1.027** (0.340)	-7.565 (6.265)	-1.809* (1.024)	-19.624 (32.72)	-1.886** (0.899)	-14.476 (19.857)
Observation	300	300	110	110	190	190

Note: \*\*\*, \*\*, \* indicates significance at the level of 1%, 5%, 10% respectively.

Table 2 shows that elastic coefficients of industrialization are between -0.01 and -0.07, lower than that in Table 1, implying upward bias of estimation due

to uncontrolled endogeneity of industrialization. One possible reason is that some less developed provinces are inclined to extensive industrial develop-

ment for expected economic growth. It is found by the regression of the mid-west sample (results unreported) that every 1% rise of energy intensity will cause a significant 0.12% rise of industrialization.

As for the other two variables of interest, urbanization and technology has similar estimation results from IV-FE as those from FE. When the model controls regional income level, the elastic coefficients of urbanization are between 0.47 – 1.12, all significant at the level of 5%. This suggests poor energy efficiency and unrestrained energy intensity in the urbanization of China, and that energy intensity kept rising during the process of urbanization as a matter of fact. Similarly, compared to the mid-west, the east makes higher energy intensity with the same rise of urbanization level. In terms of technology, the elastic coefficients are between -0.40 to -1.34 all significant at the level of 1%. Particularly, every 1% rise of technology level can bring about 1.342% decrease of energy intensity in the east, 0.944% higher than that in the mid-west, again confirming the capability of saving energy by information technology of the east.

## (2) Dynamic models

### a. Instrumental Variables-Generalize Method of Moments (IV-GMM) estimator

The static FE estimator hypothesizes that energy intensity is only affected by the current values of the variables, which is too rigid for the concerned issues in this paper. On one hand, as regional energy efficiency is influenced by cohesive factors such as technology and industrial structure, energy intensity might as well be influenced by the past values of these factors. On the other hand, national or regional energy intensity can possibly possess an accumulative effect, meaning probable impact of the past energy intensity values on the current values. Given the two problems above, IV-GMM by Arellano and Bond (1991) is introduced in this paper to estimate the dynamic model set by expression (6). To eliminate the dynamic panel bias, second and higher order lag of energy intensity is used as the instrumental variable. Meanwhile, considering the endogeneity of industrialization level, the instrumental variable also contains second-order lag of industrialization level<sup>5</sup>. Table 3 illustrates detailed estimation results.

Table 3 gives out several messages. Firstly, the impact of current values of urbanization on energy intensity is obviously smaller than that in Table 2. To illustrate, on the basis of national sample, the elastic coefficient shrinks from 0.47 to 0.07 with insignificance, which, however, does not negate the impact

of urbanization on energy intensity. Instead, it is found that the impact lies with the lag terms of urbanization. As column (2) in Table 3 shows, the elasticity of energy intensity to urbanization is 0.83. The reason is that urbanization has different impact on energy intensity in a short term and a long term, which will be discussed thoroughly in the next section.

Secondly, compared to the results from IV-FE, the impact of industrialization on energy intensity is also greatly smaller, and yet unlike the pattern that the impact transfers to lag terms of urbanization, the elastic coefficients of industrialization lag terms are tiny and insignificant, possibly due to the control on the lag terms of energy intensity in the dynamic model. This confirms the idea that energy intensity lays reverse impact on industrialization in the former section.

Thirdly, the estimation values of technology are between -0.37 to -1.47, all significant at the level of 5%. Technology is more effective in lowering energy intensity in the east than in the mid-west.

Fourthly, significant accumulative effect has been observed in energy intensity. Every estimator has generated similar coefficient estimation values of around 0.87, all significant at the level of 1%, well supporting the hypothesis of accumulative effect in energy intensity. The estimation value is lower than 1, implying a decline with time of the accumulative effect.

Lastly, the last two rows in Table 3 reports *P* values of Hensen over-identification test and autoregressive test on the second-order residual. Relatively high *P* of over-identification test evidences that the model does not reject the selected instruments. Relatively high *P* of second-order autoregressive test suggests that the residual of the difference equation<sup>6</sup> of expression (6) does not bear first-order serial correlation, so that the second-order lag of energy intensity can be used as the instrumental variable for its difference term.

### b. Mean Group (MG) estimation

The IV-GMM estimator has controlled the lag values of energy intensity, industrialization, urbanization and technology. When the model controls first-order lag terms, it equivalently assumes a time limit of the correlation between the explanatory variables and the explained variable. Thus questions arise, is the impact of industrialization, urbanization and technology on energy intensity in long run or short run? Is the long-run and short-run impact the same? MG

<sup>5</sup> Using only the second order without higher order lag terms of industrialization is to cohere with the instrumental variables in IV-FE estimator, so that the results can be comparable.

<sup>6</sup> It is necessary to do a first-order difference when estimating expression (6) by the method of Arellano and Bond (1991). As the right side of the equation contains the dif-

ference terms of the explained variable, it will be inevitably correlated with the difference terms of the residual, which is called the dynamic panel bias. Only when the residual of the difference equation does not bear first-order serial correlation, (immediately the original equation does not bear second-order serial correlation), second or higher order lag terms of explained variable can be used as the instrumental variables for the equation's difference terms.

method can answer to these questions fairly well. Table 4 illustrates the estimation results of expression (7) by MG method.

In the short run, urbanization has negative impact on energy intensity. When the local income level is controlled, the elastic coefficients are between -0.66 to -0.91. As in the early stage of urbanization, it is possible to quickly integrate industries, intensively using resources and forming a competitive labor market to increase yield fast, so that energy efficiency is improved, which echoes the conclusion of Sadorsky (2013, 2014). However, in the long run, the impact of urbanization on energy intensity is positive. When the local income level is controlled, the elastic coefficients are between 1.82 to 2.60, all significant at the level of 5%. The diametrical results have revealed the abnormality of China's urbanization that after achieving fixed advantage in the early stage of urbanization, districts failed to maintain the energy saving advantage from urban concentration and intensity, especially to reconcile energy consumption and urban development. Therefore rapid urbanization has always been accompanied by wasteful consumption. It can be foreseen that China trades energy efficiency for urban development in the long run, the potential and sustainability of urbanization is undermined greatly.

The impact of industrialization on energy intensity is insignificant in both short and long run, except that it is significantly negative in the east. It is notable that MG method cannot possibly control the endogeneity of industrialization, so the estimation of industrialization elasticity will be upward biased. Therefore, the estimation results of industrialization elasticity in Table 4 are more acceptable.

The impact of technology on energy efficiency is positive in both short and long run, while it is greater in the long run, and yet more significant in the short run. To illustrate, based on the national sample, the long-run impact of technology is -0.59 compared to -0.33 for the short-run impact, but the latter is significant on the level of 1% while the former is not. The east is more effective in applying technology in energy saving in both short and long run, coherent with previous findings. In the short run, the technology elasticity in the east is 1.90 times of that in the west, but in the long run this number rises up to 9.27.

##### 5. Research conclusion and policy suggestion

China has a large stock of energy, but its per capita stock is poor. Years of extensive development in China have aggregated the conflicts between energy consumption, ecological environment and sustainable economy. The economic and intensive use of energy, reduction of energy intensity and realization of sustainable development has become an issue of common concern in Chinese political and academic

field. The acceleration of China's urban-rural integration is doomed to cause higher energy consumption and greater burden on energy conservation and consumption reduction. However, on the other hand, urban-rural integration can improve the energy intensity through the urbanization, industrialization and technology. The compound of the positive and negative effect makes the trend of Chinese energy intensity appear to be complicated and confusing.

Proceeding from Chinese national condition of economic development mode transformation and against the backdrop of accelerated and integrated development of urbanization, industrialization and technology, this research discusses the mathematical relationship between energy intensity and urbanization, industrialization and technology by relying on the production function of three factors, namely capital, labor and energy. Based on that, the static and dynamic panel models are established. Four estimation methods, including FE, IV-FE, IV-GMM and MG are used to analyze the economic data of 30 provinces and cities from 2005 to 2014, which empirically demonstrate the relationship between energy intensity and urbanization, industrialization and technology. The research findings show that, first, urbanization can significantly reduce energy intensity within a short period of time, but Chinese government fails to continuously employ its positive role in energy conservation, thus resulting in the positive long-run influence of urbanization on energy intensity. Second, after the endogeneity of industrialization is controlled, IV-FT and IV-GMM suggests that the acceleration of industrialization level could effectively improve energy intensity. Third, the short-run and long-run role of technology in promoting energy efficiency and reducing energy intensity is worth more attention.

Based on this research, the following policy suggestions can be put forward. First, Chinese government should emphasize on the lagging and cumulative effective, actively coordinate the short-run and long-run relationship between energy consumption in the past, present and future, between economic and social development and energy consumption, and strive to build an energy-saving and environmental-friendly society. Second, Chinese government should handle well the short-run and long-run conflicts in the urbanization development, improve the urbanization develop path, and innovatively transform the short-run growth advantage of talent, techniques and industry into long-run energy saving and cost-effective advantages, and vigorously promote the construction of environmental-friendly, low-carbon and intensive urbanization. Third, Chinese government should strengthen the transformation of its industrial development mode, accelerate the upgrade of industrial structure, build a modern energy-saving industrial system and fully release and promote the structural bonus of energy efficiency in the dynamic

promotion of new type industrialization. Forth, Chinese government should emphasize the role of technology in energy-saving fields, dig the potential of technology-based energy conservation in the big data era and contribute to the reduction of energy intensity.

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## Evolution of Patterns in the Ratio of Gender at Birth in Henan province, China

## Ewolucja rozkładu wskaźników urodzeń według płci w prowincji Henan w Chinach

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### Abstract

The imbalance in the ratio of males to females at birth is one of the major challenges facing modern China. It is a problem that cannot be overlooked, especially in the context of the socioeconomic development being experienced in China. Based on data of the sex ratio at birth in 2000 and 2010, and using exploratory spatial data analysis and geographical detector methods, this paper systematically explores spatial patterns, evolutionary characteristics and the mechanisms for the analysis of this ratio in Henan province. The results show that: (1) the degree of imbalance between the sexes is exhibiting a downward trend, while significant differences in the levels exist in internal county units and these variations are increasingly expanding; (2) areas exhibiting extreme levels of imbalance are located in the north, east and south of Henan. The remaining areas had a mixed distribution and were widely spread in the central and western regions of the province; (3) according to the spatial correlation characteristics, there exists an obvious aggregation phenomenon in sex structure at birth which has moved northwest in the decade under review; and (4) there are many factors affecting the distribution of the ratio between the sexes at birth, including natural environmental conditions, levels of education, population stress, economic development and population migration. In addition to these factors, urbanization, living conditions, social development, traffic conditions, income level, reproductive potential and health factors have also influenced the proportion of males to females to different degrees.

**Key words:** sex ratio at birth, sex structure, country scale, space evolution pattern, Henan province

### Streszczenie

Dysproporcje w liczbie urodzeń mężczyzn w stosunku do liczby urodzeń kobiet stanowią jedno z głównych wyzwań współczesnych Chin. Jest to problem, który nie może zostać pominięty, szczególnie w kontekście trwającego w Chinach rozwoju społeczno-gospodarczego. Niniejszy artykuł podejmuje metodyczną analizę wzorców przestrzennych, cech ewolucyjnych i mechanizmów analizy wskaźnika urodzeń według płci w prowincji Henan w oparciu o dane z lat 2000 i 2010 oraz z wykorzystaniem danych przestrzennych i metod detekcji geograficznej. Wyniki badań pokazują, że: (1) stopień dysproporcji pomiędzy liczbą urodzeń według płci wykazuje tendencję spadkową, a znaczne, coraz bardziej widoczne, różnice istnieją w wewnętrznych jednostkach powiatowych prowincji; (2) północne, wschodnie i południowe obszary prowincji Henan odznaczają się najwyższym stopniem tych dysproporcji. W pozostałych obszarach prowincji dysproporcje rozkładały się w sposób mieszany i były szeroko rozpowszechnione w regionach centralnych oraz zachodnich; (3) zgodnie ze specyfiką korelacji przestrzennej,

istnieje oczekiwane zjawisko agregacji w strukturze urodzeń według płci, które na przestrzeni dekady przemieściło się w rejon północnego-zachodu; (4) istnieje wiele czynników, które mają wpływ na rozkład proporcji płci podczas narodzin, należą do nich: warunki naturalne, poziom wykształcenia, poziom stresu ludności oraz rozwoju gospodarczego, migracja ludności. Oprócz powyższych czynników, wpływ na odsetek mężczyzn wśród kobiet miały w różnym stopniu: urbanizacja, panujące warunki mieszkaniowe, potencjał reprodukcyjny oraz czynniki zdrowotne.

**Słowa kluczowe:** wskaźnik urodzeń według płci, struktura płci, skala krajowa, wzorce ewolucji przestrzennej, prowincja Henan

## Introduction

The sex ratio at birth of the populations of 18 countries and regions around the world is higher than the upper limit of what is considered to be the normal value. In China, the sex ratio at birth (SRB) has been in imbalance since the 1980's, and China has become the country facing the most serious issues as a result (Nhfpcprc, 2015). Although China's gender ratio imbalance at birth has declined for the seventh consecutive time since 2009 due to the continuous adjustment of population policy, the problem of the imbalance in births is still severe due to traditional concepts of fertility and an aging society. A series of social phenomena may arise as a result of this combination of factors, including *high price bride price*, the increase in *transnational brides*, *marriage refugee* and even sexually motivated crime. All of this could prove to be serious obstacles to continued economic growth, social stability and sustainable managed population development, and China is large enough that significant difference in environmental and socio-economic conditions are possible in various regions within the country. The deep-rooted traditional concepts of fertility not only leads to an imbalance in the spatial distribution of population in terms of age structure (Wang et al., 2016), but also causes significant spatial differences in the ratio between sexes at birth. The study of these ratios has gradually drawn the attention of more and more scholars, both at home and abroad, to the issue. Foreign scholars tend to focus on the studies related to theory and practice. Anantharan et al. (1989) analyzed the relationship between the sex ratio at birth and birth rates, and found that they showed an inverted U-shaped curve (Anantharam and Premi, 1989). Park et al. (1995) found that an imbalanced sex ratio at birth exacerbates marriage squeeze and changes the marriage model. Empirical evidence from the 2000 Census in China revealed that the number of *missing girls* in the relevant cohorts is approximately 12 million (Cai and Lavelly, 2003). Li et al. studied gender preference in Hebei province, from 1979 to 1989, and argued that sex-selective abortion may be responsible for half of the high levels of imbalance in the ratio of male to female births in China in this period (Li and Cooney, 1993). Guilmo used population projections based on the gender ratio at birth, and concluded that the population in China and India will reduce by 28 and 24 million, respectively, by 2050 (Guilmo, 2012). In China,

the research has been focused particularly on the measurement of the gender ratio at birth (Shen, 2014; Wang, 2008), trends in variations (Peng and Chen, 2015), space-time patterns (Liu and Li, 2014; Shi and Mi, 2015; Liu and Zhu, 2015), mechanisms (Liu et al., 2014), the consequences of imbalance (Liu and Li, 2010; Guo et al., 2016), and governance measures (Shi, 2009; Wei, 2011; Shi, 2016).

Previous literature on scale indicates that there are alternative geographic units that can be used for spatial analysis, such as blocks, tracts, cities and states (Qiu and Li, 2016). Scholars have completed extensive work on the pattern of gender birth in China at the city and state levels. However, research related to the county level is rare (Messner et al., 1999; Guo et al., 2013; Luo et al., 2016). As for research methods, the development of spatial analysis technology, statistical analysis, spatial statistics methods and geographic information technology has widened the researcher's available tools (Zhang, 2001; Liu, 2014; Li, 2015). From a disciplinary perspective, the research on gender imbalance focuses on demography, sociology, economics, psychology and criminology, but studies based on geographic factors are not currently available (Feng, 2012).

In this paper, spatial patterns and the evolution of the characteristics of gender balance at birth in Henan province, based on the county-wide data and using exploratory spatial data analysis methods, are analyzed in detail. The mechanisms for determining spatial patterns are analyzed by means of geographical detectors, which provide guidance for population policy adjustment, gender structure optimization and sustainable development of a population's health.

## 1. Material and methods

### 1.1. Study area

China had a population of 1.361 billion at the end of 2013, and the gender imbalance at birth had resulted in an average sex ratio of 117.60. Henan province has a large population matching many countries, with 106 million people in 2013. It is located in the eastern part of China, around the middle and lower reaches of the Yellow River, between 110 ° 21 ' ~ 116 ° 39'E and 31 ° 23 ' ~ 36 ° 22'N (Figure 1). The province is 550 km long from south to north and 580 km wide from east to west. The sex ratio at birth was imbalanced at 116.54. There are many similarities in the evolutionary trends, concepts of fertility, and the stage of development of sex structure at birth between China and Henan prov-

ince. In other words, Henan province can be seen as the epitome of China itself (Ding et al., 2015; Liu et al., 2016). Therefore, the choice of Henan province as the typical area in which to study issues of gender imbalance sex structure at birth was a logical and appropriate one.

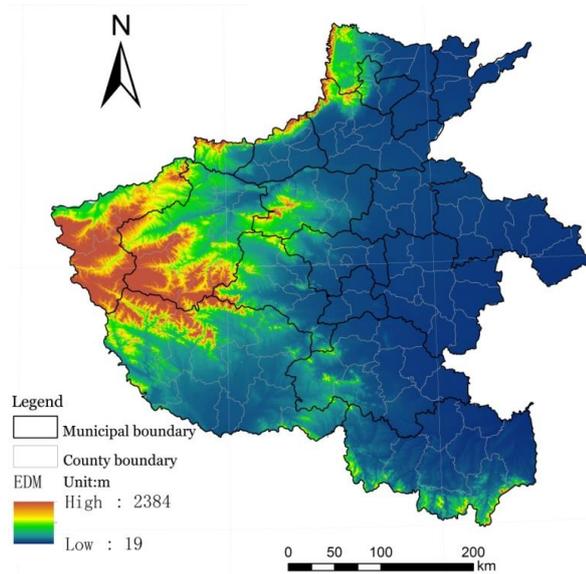


Figure 1. Location of study area

### 1.2. Exploratory spatial analysis method

The exploratory spatial analysis method was used to test whether the observations of a unit is related to the observations of the neighboring unit. Moran's I was used to estimate the global spatial autocorrelation as a whole, and the local indicators of spatial association (LISA) used as a measure for determining the local spatial autocorrelation. Using LISA to analyze the spatial pattern has consistently provided reliable and stable results, in part, because they can be standardized, so significance levels can be tested (Fu et al., 2016). The formula (Li et al., 2013) is:

$$I = \frac{\sum_{i=1}^K \sum_{j=1}^K (X_i - \bar{x})(X_j - \bar{x})}{S^2 \sum_{i=1}^K \sum_{j=1}^K W_{ij}} \quad (1)$$

$$I^* = \sum_{p \neq q} W_{pq} Z_p Z_q$$

Where  $X_i$  and  $X_j$  denotes the observed value at locations  $i, j$ , and  $W_{ij}$  is the spatial weights matrix for locations  $i$  and  $j$ , defined as 1 if the location  $i$  is contiguous to location  $j$  and 0 otherwise.  $W_{pq}$  is the standardized spatial weight matrix,  $Z_p, Z_q$  represent standardized values of  $p, q$ , respectively.

### 1.3. Geographic detector method

The geographic detector is often used to test the association between explained variable  $Y$  and factor  $X$  according to the consistency of their spatial distributions, to explore the determinant of factor  $x$  for variable  $y$ . The formula (Liu and Yang, 2012; Ding et al., 2014) is:

$$P_{D,G} = 1 - \frac{1}{\sigma_G^2} \sum_{i=1}^m (n_{D,i} \times \sigma_{D,i}^2) \quad (2)$$

Where  $P_{D,G}$  is the detection force of the detection factor  $D$ ,  $m$  is the number of sub-region,  $\sigma_{D,i}^2$  stands for the discrete variance of the sex ratio of a population in sub-regions, and  $\sigma_G^2$  indicates the discrete variance of the gender ratio in the whole region.

### 1.4. Data analysis with computer software

Moran's I and LISA values were measured using software ArcGIS (version 10.2). All maps were produced using GIS software ArcMap® (version 10.2).

### 1.5. Data sources

Based on 1: 4,000,000 databases for National Fundamental GIS and the base map of the administrative division of Henan province in 2010, 126 geographical units were obtained and used as the research object. As for the principle of comprehensiveness and comparability, data for sex ratio at birth at the county level in 2000 and 2010 was available and reliable, while data in other years was collected through a sample survey, though they were difficult to obtain and record. Therefore, the data used in this study was derived from the fifth and sixth national censuses conducted at a county level in 2000 and 2010, and the sex ratio at birth calculated, based on a population aged 0. In addition, the national economic and social data extracted from *Population Census of China* and *Henan Statistical Yearbook* was consulted. DEM data came from the National Basic Geographic Information Center and traffic network data was from *Henan and neighboring provinces high-way traffic atlases*.

### 1.6. Classification standard of sex structure at birth

Sex ratio at birth (SRB) is defined as the number of boys born per 100 girls. In a large population, the average SRB ranges between 102 and 107 because the mortality rate of boys is usually higher than that of girls. Figures over 107 or less than 102 are considered to indicate an imbalance. In this study, sex structure at birth is divided into five types according to the characteristics of the gender of the population at birth in Henan province: a balanced SRB is one between 102 and 107, a mild imbalance has an SRB between 107 and 112, a moderate imbalance is an SRB between 112 and 117, a severe imbalance has an SRB between 117 and 122, and an extreme imbalance has an SRB above 122.

## 2. Results and discussion

### 2.1. Characteristics of spatial structure of relating to gender balance

#### 2.1.1 Changes in spatial layout characteristics

Spatial distribution of the sex structure at birth in Henan province at the county level was shown in Figure 2.

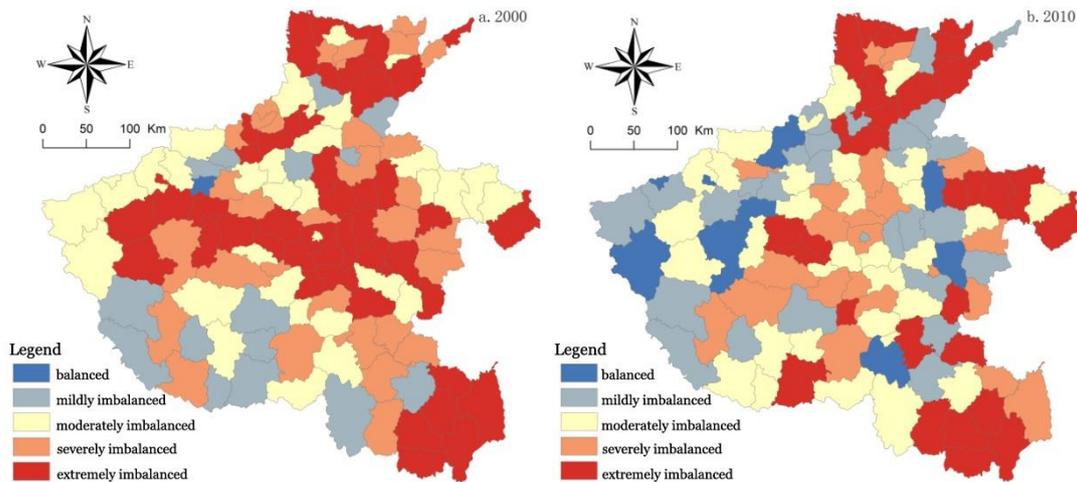


Figure 2. Spatial distribution of the sex ratio at birth in 2000 (a) and 2010 (b) in Henan province

In 2000, the number of county units in which the sex structure at birth was balanced, mildly imbalanced, moderately imbalanced, severely imbalanced and extremely imbalanced was 1, 15, 33, 31 and 46, respectively (Figure 2a). The results indicated that the gender balance was optimal in only one county unit in Henan, while the rest of the 125 county units were imbalanced to a greater or lesser extent. Among the 125 unbalanced county units, there are 77 (61.11%) with severe imbalances and above, indicating that the problem of the imbalanced sex ratio at birth in Henan province has been severe. Xinxian had the highest sex ratio at birth, at 136.03, while Luoyang had the lowest, at 105.96. The difference between them was 30.07. This significant difference was mirrored among the counties in Henan. In 2010, there were 11 (8.73%), 28 (22.22%), 32 (25.40%), 22 (17.46%) and 33 (26.19%) county units, where the sex structure at birth was imbalanced, mildly imbalanced, moderately imbalanced, severely imbalanced and extremely imbalanced, respectively (Figure 2b). The number of imbalanced county units account for 91.27% of the total. Compared to 2000, the number of county units that were in the severe and extreme imbalanced categories has reduced to 55, while those in the balanced and mildly imbalanced groups have increased to 39. The results illustrate that, although imbalances in sex ratio at birth has been alleviated to some extent, the imbalanced situation persists. Yongcheng had the highest SRB of 144.98 and Yima had the lowest at 102.03 in 2010. The difference between the two counties was 42.95, which was larger than that in 2000, indicating that the differences between counties in Henan increased.

In 2000, the severe and extreme imbalances in SRB in different parts of Henan tended to be most marked in Anyang, Hebi, Puyang (north Henan), Zhoukou, Kaifeng (east Henan), Xuchang, Luohe (Yuhong), Luoyang, Jiaozuo (west Henan) and Xinyang, Zhumadian (south Henan). Other areas of notable imbalance were scattered around them. In 2010, the mixed nature of the distribution in SRB was more obvious

than that in 2000. Severely and extremely imbalanced areas were concentrated in Xinxiang, Anyang, Puyang (north Henan), Xinyang (south Henan), Shangqiu (east Henan) and Nanyang, Luoyang, Pingdingshan (west Henan). Moderate imbalances, mild imbalances and balanced figures were widely distributed in the central and western regions of Henan province and the spatial pattern was decidedly that of mixed distribution.

#### 2.1.2. Changes in spatial correlation characteristics

##### 2.1.2.1. Global spatial autocorrelation

Moran's I index of sex ratio at birth in 2000 and 2010 in Henan province was calculated (Table 1).

Table 1. Moran's I value of the sex ratio at birth in Henan province

Index	2000	2010
Moran's I	0.2685	0.2340
P value	0.0003	0.0004
Z value	4.7081	4.1352

Moran's I global value of sex ratio at birth in 2000 was 0.2685 with P value < 0.05. Positive spatial autocorrelation was observed for the sex ratio at birth, revealing that the spatial distribution of sex population at birth in 2000 in Henan province was clustered. Moran's I global value of SRB in 2010 was 0.2340 with P value < 0.05, which was also greater than 0. This result showed that the sex structure at birth in Henan province in 2010 demonstrated the characteristic of spatial clustering. It is worth noting that Moran's I values of SRB in 2010 was lower than those in 2000, which indicated that the SRB was still dominated by aggregated distribution in that decade, but there was potential spatial randomness in its spatial distribution.

##### 2.1.2.2. Local spatial autocorrelation

The results of a LISA analysis were illustrated in Figure 3.

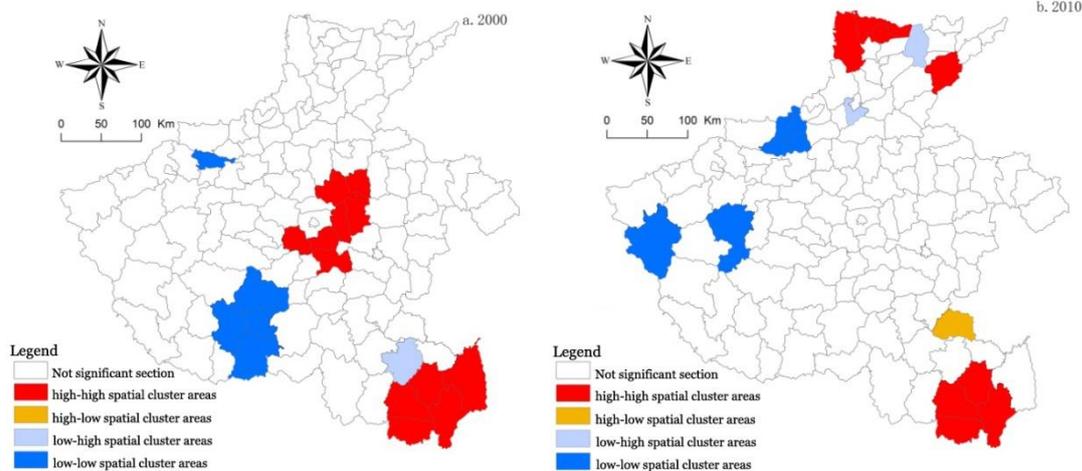


Figure 3. Spatial autocorrelation: the birth sex ratio in Henan province in 2000 (a) and 2010 (b)

Large high-high spatial cluster areas of sex ratio at birth in 2000 were observed in the south-eastern and middle part of Henan province, mainly in Weishi, Tongkou, Yanling, Fugou, Linying, Xiangcheng, Luohe, Luoshan, Guangshan, Xinxian, Huangchuan, Shangcheng and Gushi. Relatively small low - high spatial cluster areas were mainly located in Zhengyang. The low-low spatial clusters were distributed in the western part of the province, such as Fangcheng, Sheqi, Tanghe and Nanyang (Figure 2a). In 2010, the high-high spatial clusters were found in the southeast and north, in Linzhou, Anyang, Anyang city districts, Puyang, Guangshan, Xinxian, Huangchuan and Shangcheng. The high-low spatial cluster areas were to be found in Xin Cai. The low-high spatial cluster areas were mainly located in Neihuang and Xinxiang, and low-low spatial clusters were to be found in Qinyang, Mengzhou, Wenxian, Boai, Lushi and Ruyang (Figure 2b). The number of high-high spatial cluster areas reduced by five, while the number of high-low, low-high and low-low spatial cluster areas increased by 1, 1, and 2, respectively. The spatial distribution of SRB in high-high and low-low spatial clusters has not changed fundamentally in the past ten years. The data also showed that the local spatial autocorrelation of SRB in Henan province was positive, but the clustering distribution revealed a weakening of that tendency.

There are two obvious characteristics of the high-high spatial clusters in Henan province: (1) the distribution range of the southern region has decreased; (2) the regions have gradually moved from the middle in a northerly direction throughout the province. In 2010, the high-low spatial cluster areas were mainly distributed in the southern region, which had no distribution in 2000. The low-high spatial cluster areas have moved from the southern region to the northern region. The low-low spatial clusters were mainly found in the southwest in 2000, while in the west and northwest region in 2010 there were different factors in play that resulted in different low-low

spatial distributions. The low-low spatial clusters in 2000 were located in the Nanyang Basin, because economic development there was particularly fast, external traffic was relatively convenient, and people's concept of fertility was more aligned to scientific and rational ideas. Many mountainous counties were located in the western region of Henan province and external travel was problematic. In addition, the west region was being drained of young adults due to the lower proportion of secondary and tertiary industries and decreasing employment, which not only reduced the number of those of marriageable age within the population, but also caused increases in *bride price*, putting a large number of unmarried young men into a group for whom marriage was virtually impossible. These reasons were responsible for the low-low spatial clusters in 2010 in the west region of Henan province. In the northwest of Henan, industrial development started relatively early and accounted for a large proportion of the population who were employed in the industrial sector. However, with the parallel transformation in energy conservation and emission reduction policies in recent years, this region's economic growth has lagged behind other regions so that the area has gradually transformed from one experiencing a population net inflow into one where there is population net outflow.

## 2.2. The formation mechanism of spatial structure of sex structure at birth

The spatial distribution of the sex structure at birth is potentially influenced by a number of factors. This study has concentrated on the state of the natural environment, traffic conditions, population mobility, fertility potential, economic development, living conditions, educational levels, urban development, population stress, medical conditions, resident income and social development as the major contributors (Table 2), using the sex ratio at birth in 2010 at the county level in Henan Province as a detected fac-

Table 2. Indicators of potential determinants for sex ratio at birth

Detection factor	Potential determinants	Indicators	Data Sources
X <sub>1</sub>	Natural condition	Average altitude (m)	Henan Province 90m resolution SRTM DEM data
X <sub>2</sub>	traffic condition	Road network density (km / square kilometers)	2010 Henan and neighboring provinces highway traffic map book
X <sub>3</sub>	Migration	The number of floating population (person)	2010 census data
X <sub>4</sub>	Fertility potential	Number of women aged 15 to 49 ears (person)	2010 census data
X <sub>5</sub>	economic development	GDP (Million)	2011 Statistical Yearbook of Henan Province
X <sub>6</sub>	Education level	Average years of schooling (year)	2010 census data
X <sub>7</sub>	living condition	Per capital housing area (m <sup>2</sup> )	2010 census data
X <sub>8</sub>	Town development	Population urbanization rate (%)	2011 Statistical Yearbook of Henan Province
X <sub>9</sub>	Population stress	The proportion of the population over 65 years (%)	2010 census data
X <sub>10</sub>	Medical condition	The number of beds per thousand people (piece)	2011 Statistical Yearbook of Henan Province
X <sub>11</sub>	residence income	Per capita Savings Balance (RMB)	2011 Statistical Yearbook of Henan Province
X <sub>12</sub>	Social development	Survival rate of child-bearing children (%)	2010 census data

Note: (1) Highways in Henan province occupy a dominant position in traffic systems.

tor. From there, then, the formation mechanism of the spatial pattern of sex ratio at birth in Henan province was analyzed.

The text refers to the road network density as only high-speed, national highway, provincial highway and county road grade 4 road network density. (2) The number of floating population by the resident population minus the number of registered population. (3) In general, the number of women aged 15-49 years of age, that is, childbearing age, is higher, indicating a greater risk to newborns in the region. Therefore, the number of women of childbearing age, 15 to 49, is used to express fertility potential. (4) Different social stages have different levels of development of productive forces. The history of human society shows that the survival rate of children is, to some extent, linked with the development of productive forces. Any improvements in infant mortality rates will have an impact on the birth gender ratio and could result in a change from a balance to a situation of imbalance. Infant survival rates can be seen as a reflection of the comprehensive development of social indicators.

The spatial distribution of classified potential determinants was plotted using ArcGIS10.2 software (Figure 4). The  $P_{D,G}$  values ( $p < 0.05$ ) were calculated to analyze the ability of each detection factor to determine the spatial distribution of sex ratio at birth in Henan province. The geographic detector disclosed the influence of detection factors on the sex ratio at birth which was ranked by  $P_{D,G}$  value as follows: natural condition (0.860) > population flow (0.365) > urban development (0.271) > living conditions (0.234) > social development (0.231) > traffic conditions (0.182) > household income (0.176) > education level (0.744) > population stress (0.705) > economic development (0.600) > fertility potential (0.086) > medical conditions (0.051).

The geographic detector method utilized is novel in that it identifies the interrelationships between gender ratio at birth in Henan province and a number of factors based on the correspondence of their spatial distribution. Results were obtained according to  $P_{D,G}$  values as follows: (1) environmental condition was the primary factor that affected the spatial distribution of the gender structure in the province. In general, economic development lags behind other areas, external relations were consequently underdeveloped, as were social security systems. The belief in the necessity of raising sons in order to provide for parents in old age was deep rooted, and a large number of local young men could not find women of marriageable, childbearing age, to marry. Consequently, *marital squeeze* was greatly exacerbated in these areas, resulting in the gender ratio being imbalanced due to the decreasing numbers of newborns. (2) Educational level was the secondary determinant of differences between areas in the gender ratios. With the development of education, ideas such as *boys and girls are the same, a daughter is also a descendant, and a daughter can hold up half the sky* have gradually become more and more accepted and in some areas created a social consensus. This

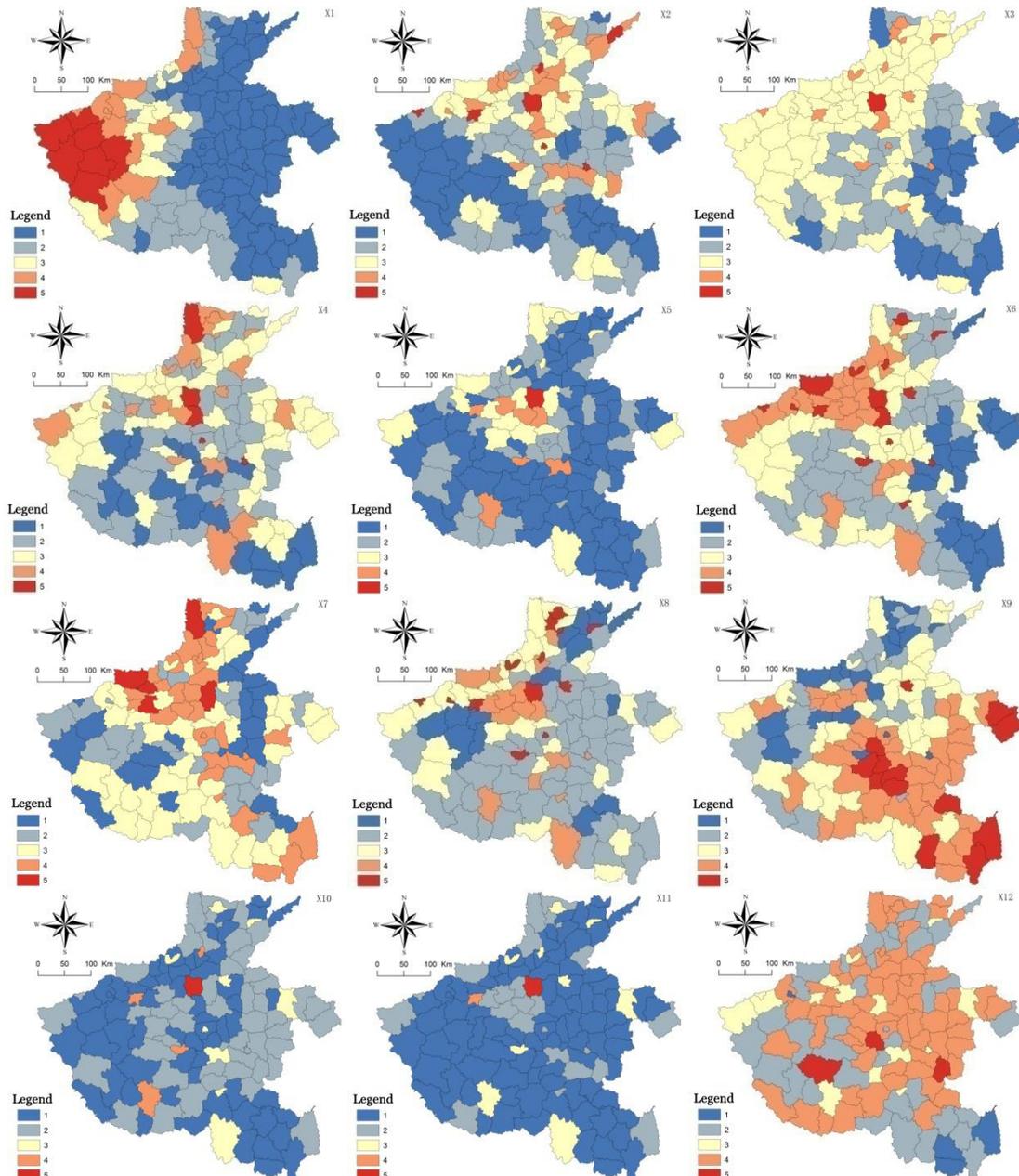


Figure 4. Spatial distribution of classified potential determinants

change in attitudes could account for changes in gender preference and might be responsible for the spatial distribution of the sex ratio at birth. (3) Population stress was the third most important factor as the more serious the level of the aging of a population, the weaker the fertility of that population. Traditional concepts of family planning, mixed with traditional ideas of procreation, also impact on the ratio. (4) Economic development and population flow both had an overwhelming effect on how the gender ratio was distributed in the province. Economic development attracted mass migration movements, especially of young people. On the one hand, this resulted in an increasing number of the elderly being left behind, along with women and children in those areas which experienced net outflows of population.

On the other hand, the economic condition of those who moved for economic reasons was improved, ideas were changed and immigrants to the regions that experienced an inflow of population created situations that changed spatial patterns of gender balance at birth. (5) Urban development, living conditions, social developments, traffic conditions, income, fertility potential and health care also contributed to the pattern of distribution of gender at birth. Among these, urban development, living conditions, social developments, traffic conditions, household income and health care represented comprehensive development levels in the counties, and fertility potential had an effect on the distribution of the ratio at birth through affecting the population structure.

### 3. Conclusion and countermeasures

#### 3.1. Conclusion

Based on census data from 2000 and 2010, we analyzed the sex at birth of children born in Henan province, the specific locations of those births, and the changes in proportion of males and females within those areas. The determinants for the spatial distribution of SRB in Henan province were obtained and the following conclusions were reached. Firstly, although the balance between males and females at birth in Henan province from 2000 to 2010 showed fluctuations and exhibited a degree of imbalance, the extent of that imbalance had decreased. Secondly, the distribution of sex at birth evolved from what might be termed concentrated distribution to one more akin to a mixed distribution. The areas where a severe imbalance occurred, SRB reduced, and those remaining at the severe level were in northern, eastern and southern Henan. Thirdly, the spatial autocorrelation of sex at birth was, for the most part, clustered. The spatial cluster areas in 2000 were in the middle, the southwest and southern regions of Henan province. In 2010, they were located in the southern, western, northern and northwest region of the province. Finally, natural conditions, education levels, population stress, economic development and population flow were important factors that contributed significantly to the sex ratio at birth of the population in Henan province.

#### 3.2. Policy implications

The government plays a leading role in alleviating or reversing gender imbalance in the birth population, and this paper has outlined some suggestions that appropriate authorities might take into consideration in planning their strategies. The first of these is to promote sustained and rapid economic growth since winning the fight against poverty is fundamental to any attempt to manage population growth effectively. Economic development is the prerequisite and guarantee for the development of social factors, such as residents' income, progress in educational terms, improvements in medical care, the social security system, and the construction of an infrastructure that meets the needs of a modern society. Under normal circumstances, the higher the level of economic development in a given area, the less likely it is that young men of marriageable age will suffer from *marriage squeeze*. The willingness of people to procreate, and their ability to raise their children relative to higher levels than they themselves achieved, is enhanced. Poverty and misinformation leads to personal and societal gender preferences; consequently, the government should implement a strategy of balanced regional economic growth, adjusting industrial structures, increasing investment in science and technology and improving the infrastructure, all aimed at promoting sustained economic growth. Secondly, it is crucial to strengthen publicity

and guidance and improve the general social security system. The gender imbalance in births is often the result of a totally unscientific concept of fertility, especially in rural, poor areas and remote areas. Social security coverage in these areas is relatively limited while *support* and *family*, along with the concept of *son preference*, are deeply rooted. The government should expand pension, medical, unemployment and other social insurance schemes in the region, while at the same time address the issues created by poor educational levels. Concepts of innovation and change have to be promoted and appropriate adjustments made to supporting policies, such as increasing one-child families in rural areas and the promotion of family planning. Finally, it is important to combat fetal gender identification and selective pregnancy termination. Due to a long tradition of acceptance of the *son preference* in China there are many fetal sex determination and sex-selective termination practices that are illegal and carried out only for profit. Some institutions involved in such practices cover their activities with a veneer, attempting to provide legitimacy under the cloak of medical considerations. This, in itself, makes it difficult to assess the true, natural, levels of sex imbalance in different areas. The government has to be much more proactive in legislating, implementing and enforcing policies that reduce illegal behavior. A multi-disciplinary approach to the enforcement of regulations, utilizing the resources of all involved, and relevant agencies, has to be adopted and effective sanctions imposed on those institutions and individuals who behave inappropriately. At the same time, incentives to encourage the population to act responsibly, including informing on those not adhering to guidance should be introduced.

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## Indicators of Social Aspects of Sustainable Development in Selected Nationwide Databases

### Wskaźniki społecznego wymiaru zrównoważonego rozwoju w wybranych ogólnokrajowych bazach danych

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#### Abstract

The aim of the article is to present indicators of the social pillar of sustainable development used in databases that come from large nationwide social science surveys conducted consistently over decades. For this purpose, the following research projects were selected: the American General Social Survey (GSS), the British Social Attitudes (BSA), the German General Social Survey (ALLBUS), and the Polish General Social Survey (PGSS). A Human Wellbeing Index (HWI) developed by the World Conservation Union (IUCN) was adopted as a conceptual basis, in its version put forward by Robert Prescott-Allen. The article includes a compilation of indicators which describe selected aspects of the social pillar of sustainable development and which are used in all of the research projects mentioned.

**Key words:** sustainable development, indicators, Human Wellbeing Index, GSS, BSA, ALLBUS, PGSS

#### Streszczenie

Celem artykułu jest ukazanie wskaźników społecznego filaru zrównoważonego rozwoju, które stosowane są w bazach danych będących efektem prowadzenia dużych, ogólnokrajowych sondaży społecznych, realizowanych od dziesięcioleci. Dla ilustracji wybrano następujące projekty badawcze: amerykański General Social Survey (GSS), brytyjski British Social Attitudes (BSA), niemiecki German General Social Survey (ALLBUS) i polski Polish General Social Survey (PGSS). Za podstawę koncepcyjną przyjęto Human Wellbeing Index (HWI) wypracowany przez The World Conservation Union (IUCN), w wersji zaproponowanej przez Roberta Prescott-Allena. Artykuł zawiera zestawienie wskaźników niektórych aspektów społecznego filaru zrównoważonego rozwoju dostępnych w każdym z wymienionych projektów badawczych.

**Słowa kluczowe:** rozwój zrównoważony, wskaźniki, Human Wellbeing Index, GSS, BSA, ALLBUS, PGSS

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#### Introduction

Three pillars of sustainable development are commonly distinguished: environmental, economic, and social (Pawłowski, 2008). An extensive body of theoretical, methodological and research literature exists on the first two pillars, while the social dimension has been neglected in all these aspects. Methodological aspects that come into play when attempting to measure sustainability indicators by means of empirical studies are specific to each of the

three pillars, although some common points can be identified (e.g. the indicators of attitudes towards the natural environment, which combine the issues of environment protection and sociology).

The purpose of this article is to identify indicators of the social pillar of sustainable development that are used in large nationwide social science surveys designed for long-term continuous observation of the most important trends in demography, economy and sociology. This is done on the basis of the following research projects (the year in brackets refers to the

year when the collection of data was started): the GSS (1972), the ALLBUS (1980), the BSA (1983), and the PGSS (1992). The projects of this kind enable frequent and regular monitoring of key indicators connected with the social pillar of sustainable development. Obviously, it is not possible to have a large set of such indicators in cross-sectional social science surveys, which have their distinct goals. However, researchers of sustainable development can use them along with those of other disciplines, trying to find what can be learned from a wide variety of variables.

### Dimensions and elements of the social aspect of sustainable development

Indicators of the social pillar of sustainable development may theoretically constitute diverse and quite capacious sets. Hence, some way of ordering this potential diversity is necessary. To do so, it is crucial to conceptualise, and subsequently operationalise the concept of *social pillar of sustainable development*. At this point the conceptualization of the concept will be discussed, while the operationalisation will be dealt with in the section concerning indicators.

Theorists and practitioners of sustainable development now agree that it is necessary to develop synthetic measures that could be applied practically. One-number indicators should provide clear and accessible information on the progress made in implementing the policy of sustainable development, and serve as a source of information for continuous social control (Stanny, Czarnecki, 2011). Different attempts to describe and measure sustainable development have been made, one of them being the Common European Indicators of Sustainable Development, which were developed under the aegis of the European Commission, the European Environment Agency and the Expert Group and were empirically tested in 2001-2003. Worthy of mention is also the work of the United Nations Commission on Sustainable Development (CSD), which involved selecting and testing of 58 indicators, including the ones that describe the social dimension of sustainable development. The World Economic Forum put forward the Environmental Sustainability Index (ESI), which is a compilation of 68 indicators for 148 countries. Partial indicators were grouped into 5 components and 20 key indicators, including the social ones. A still different proposal is the Human Wellbeing Index (HWI). It was developed by the World Conservation Union (IUCN) and consists of 88 indicators for 180 countries. They are aggregated there into two sub-indexes – human wellbeing and ecosystem wellbeing. The first one is a collection of indicators related to population, health, wealth, knowledge, culture and justice, while the latter includes indicators concerning land, water, air, biodiversity, and resource use (Stanny, Czarnecki, 2011).

The HWI is a realistic measure of socio-economic conditions and covers many aspects of human well-being. It incorporates five dimensions (health and population, wealth, knowledge and culture, community, and equity), which can be further split into the following 10 elements (Prescott -Allen, 2001), presented in table 1.

Table 1. Dimensions and elements of the Human Wellbeing Index (Prescott-Allen, 2001)

Health	People enjoy long lives in good health
Population	while keeping their numbers within the bounds of human and natural resources.
Household wealth	Individuals and households have the material goods and income to secure basic needs and decent livelihoods,
National wealth	and the community has the resources to support enterprise and maintain prosperity.
Knowledge	People have the knowledge to innovate and cope with change, live well and sustainably, and fulfill their potential,
Culture	with avenues for spiritual growth, creativity; and self-expression.
Freedom and governance	Human rights are fully respected, and individuals are free to choose how decisions are made and who should make them. Decision-making bodies are open, clean, and effective
Peace and order	Communities coexist peacefully and protect their members from crime and violence.
Household equity	Benefits and burdens are shared fairly among households and groups
Gender equity	and between males and females.

### Databases

The GSS (General Social Survey) gathers data on contemporary American society in order to monitor and explain trends in attitudes, behaviours and attributes. It has been conducted since 1972. The GSS contains a standard core of demographic and behavioural questions, as well as topics of special importance for the functioning of modern society. Among the topics covered are: civil liberties, crime and violence, tolerance, morality, national spending priorities, social mobility, and many others. The GSS is one of the best sources of data on the attitudes and trends in the United States. It allows researchers to examine the structure and functioning of society as a whole, as well as the role played by subgroups, and to compare the United States with other nations. Its aim is to provide easy access to high quality data that can be used by researchers, students, policy makers, and others. The experience of the GSS serves other large research studies; for example, the ALLBUS (Die Allgemeine Bevölkerungsumfrage der Sozialwissenschaften), which has been conducted since 1980 to examine trends and consequences of social changes in Germany, or the PGSS (Polish General

Social Survey) conducted since 1992. Both the ALLBUS and PGSS are based on the GSS. The British Social Attitudes (BSA) survey began in 1983, and has been conducted every year since then, with the exception of the years 1988 and 1992<sup>1</sup>.

Research samples in these studies are highly representative for national populations, randomly selected, and consist usually of 1500-2500 respondents each year<sup>2</sup>.

### Indicators

The research projects mentioned above share many common features, also in regard to indicators of the social aspect of sustainable development. All of them include indicators of such elements as: health, household wealth, and knowledge. Some contain also indicators of peace and order, as well as those of gender equity. On the other hand, indicators of the following elements are not included: population and national wealth (these are available from official statistics), culture, freedom and governance, as well as household equity. So it is possible to obtain information on 3 to 6 elements from databases alone, or on 8 to 10 indicators from official statistics.

Each of the listed elements of the social aspect of sustainable development is represented in the databases by some indicators. The biggest number of indicators are available for household wealth and health (from 3 to 8). There are slightly fewer indicators for knowledge (from 3 to 5), and much fewer for peace and order, household equity, and gender equity (1-2).

Table 2. Number of indicators in a given research project

Measured element	Project (database)			
	GSS	ALLBUS	BSA	PGSS
Health	3	8	3	3
Household wealth	5	8	3	7
Knowledge	4	3	2	5
Peace and order	1	-	-	-
Household equity	2	-	-	-
Gender equity	1	-	-	1
Total	16	19	8	16

It should be emphasized that the indicators' scopes combined do not cover in full the scope of any element, even in the case of household wealth and

health, not to mention the remaining ones – in particular peace and order, household equity and gender equity. Hence, the choice of indicators is necessarily arbitrary. This is a drawback of using secondary rather than primary data. On the other hand, the information obtained in this way comes from nationwide surveys and covers a considerable period of time.

Below a list of indicators grouped by elements and databases is presented. Rather than referring to variable names or codes, relevant questions from questionnaires are given (some of them are slightly modified due to their original broader context).

#### Health:

#### GSS

- Would you say your health in general is excellent, good, fair, or poor?
- Taken all together, how would you say things are these days – would you say that you are very happy, pretty happy, or not too happy?
- Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?

#### ALLBUS

- How often did it occur during the past four weeks that, due to physical health problems, you accomplished less than you wanted to at work or in everyday tasks?
- How often did it occur during the past four weeks that, due to mental health or emotional problems, you accomplished less than you wanted to at work or in everyday tasks?
- Here we have a list of common illnesses. Please tell me which of these illnesses or health problems you have been suffering from for at least 12 months or which ones you suffer from chronically?
- If you think back on the past three months: for what reason or reasons have you seen a doctor in the past three months?
- In total, how often have you seen a doctor in the past three months?
- What about receiving in-patient treatment in hospital in the past twelve months? Have you been admitted to hospital for any over-

<sup>1</sup> The most up-to-date measuring tools that are available were used: the 2016 GSS, the 2015 BSA, the 2014 ALLBUS (a newer version is available in German, but the English translation comes from 2014), and the 2010 PGSS (there is no more recent version). The list of indicators was reconstructed on the basis of the tools mentioned above. This is important as the content of the databases changes

(slight as these changes are). For example, the 1992-1998 PGSS included an indicator for the peace and order element, which was the same as the one used in the GSS, but in the surveys from 2010, this indicator was no longer used.

<sup>2</sup> Only the basic information is provided here. More details on these projects are available on their websites.

night treatment once or several times in the past twelve months (excluding admission for reasons of childbirth)?

- In total, how many nights did you spend in hospital in the past twelve months?
- Do you smoke? If yes how many cigarettes or other tobacco products do you smoke per day?

#### BSA

- Do you have a long-standing physical or mental health condition or disability? By long-standing, I mean anything that has lasted at least 12 months or that is likely to last at least 12 months?
- Does this condition or disability have a substantial adverse effect on your ability to carry out normal day-to-day activities?
- Have you ever been told by a doctor or other health professional, that you personally have had one or other of the specific mental health problems?

#### PGSS

- Would you say your health in general is excellent, good, fair, or poor?
- Have you received in-patient treatment in hospital in the past twelve years ?
- Have you been incapable of carrying out your job or everyday tasks due to illness or injury in the past twelve months?

#### Household wealth:

#### GSS

- Compared with American families in general, would you say your family income is: far below average, below average, average, above average, or far above average?
- During the last few years, has your financial situation been getting better, getting worse, or has it stayed the same?
- In which of these income groups did your total family income, from all sources, fall last year before taxes?
- In which of income groups did your earnings all sources for 2015 fall? That is, before taxes or other deductions?
- We are interested in how people are getting along financially these days. So far as you and your family are concerned, would you say that you are pretty well satisfied with your present financial situation, more or less satisfied, or not satisfied at all?

#### ALLBUS

- How high is your own net monthly income? By this I mean the amount remaining after

deductions for tax and social security contributions.

- How high is the total net monthly income of your household? By this I mean the amount remaining after deductions for tax and social security contributions.
- Would you say that your household's current total income is: very much lower than what you need, somewhat lower than what you need, roughly what you need, somewhat more than what you need, very much more than what you need?
- This is a list of sources of income a household may receive. Please specify all the sources of income that apply to your household.
- And which of these sources of income is the main source of income in your household?
- Just assuming you wanted to sell this property: How much money would you have left over roughly after paying off any debts you might have on your property. Please estimate as exactly as possible
- The next question deals with the accommodation you/your family live in. Which of the categories on the card applies to you/your family?
- How large is your flat/house approximately?

#### BSA

- Which is the main source of income for you (*and your spouse / partner*) at present?
- Which of the letters on this card represents the total income of your household from all sources before tax?
- Which of the letters on this card represents your own gross or total earnings, before deduction of income tax and national insurance?

#### PGSS

- Taking into account the last 12 months, what was your average monthly net income (earnings) from your current job?
- Compared with Polish families in general, would you say that your family's income is: far below average, slightly below average, average, slightly above average, or far above average?
- Taking into account the last 12 months, what was your household's monthly income from all sources? Please give the average monthly income after taxes.
- Do you think that the total income of your household compared to your needs is: very much lower than what you need, slightly lower than what you need, roughly what

you need, somewhat more than what you need, or well above than what you need?

- Please give some information about your housing. Under what terms are you living in your present flat/house?
- How big is your flat/house (in square meters)?
- How much money would you roughly have left after selling your flat/house and paying off any debts you might have on your property e.g. mortgage, loan?

Knowledge:

GSS

- Do you have any college degrees?
- What degree or degrees do you have?
- What is the highest degree you have earned?
- In what field was that degree?

ALLBUS

- What general school leaving certificate do you have?
- What vocational or professional training do you have?
- What type of university of applied sciences degree do you have? Please only tell me the highest qualification you have obtained.

BSA

- How old were you when you completed your continuous full-time education?
- Have you passed any of the examinations shown on this card?

PGSS

- What level of education have you completed until now?
- In what area (field, profession) did you get your education (at school/university)?
- Was it (or is it) a state, community, or private school/university?
- How many years in total did you spend at school (including university)? Please do not count years of study that you repeated, gap years and other breaks in your education, and skills improvement courses.
- What type of certificate, diploma, vocational or academic title did you receive at the end of your education?

Peace and order:

GSS

- Is there any area right around here – that is, within a mile – where you would be afraid to walk alone at night?

Household equity:

GSS

- Over the past five years, have you been discriminated against with regard to work, for instance when applying for a job, or when being considered for a pay increase or promotion?
- In your opinion, what was the main reason for the discrimination?

Gender equity:

GSS

- Is it much better for everyone involved if the man is the achiever outside the home and the woman takes care of the home and family?

PGSS

- Should it be more important for a wife to provide such conditions that would facilitate developing successful professional career by her husband, or to develop her own professional career?

### Concluding remarks

In conclusion, let me present a few remarks of a more general nature. The first one concerns indicators. Indicators are very often, if not usually, selected on an arbitrary basis. This is also the case here. However, as Stefan Nowak writes, *from a range of indicators, we can often choose the one that suits us best to maximise a particular type of indicator*. When using ready databases, the choice of indicators is further limited to the variables that are available in a given survey. Therefore, the indicators selected are often narrower than their theoretical counterparts. However, indicators and their indicators are seldom equivalent in empirical studies, and it is often the case that *some phenomenon is treated as an indicator of a set of phenomena, of some syndrome understood in such a way that an indicator constitutes one of its elements* (Nowak, 2017). Hence, there is no choice but to accept this arbitrariness – at least in the secondary data.

Another issue concerns the sources of information. In the last years, there has been a growing tendency to use secondary research; analyses based on the data that come from large, nationwide surveys are becoming more popular, replacing primary research designed *from the scratch*. This approach seems to be a positive trend: although it involves sacrificing your own research ideas, it has considerable advantages: analyses are conducted on large random representative samples and advanced data analysis methods are employed. Moreover, large research projects are often carried out over many years, or even decades,

which enables to track trends over time. The disadvantage of this type of research is that it is (in many cases) limited to a few variables, those that are important for researchers in general and cross-sectional surveys.

Finally, the data for the environmental and economic pillars of sustainable development come mostly from official statistics or other desk research analyses. On the other hand, information for the social aspect must be obtained from empirical studies, with secondary data serving as a supplement (though often, quite a significant one). It is impossible to imagine the measurement of indicators of the social pillar without empirical social research, especially since datasets – unlike official statistics – are potentially dynamic. For example, apart from the information on household incomes that is obtained from them (this can be also obtained from reliable statistical documents), it is also possible to examine the factors influencing household income and how this affects other elements of the pillar. It is possible to develop multivariate models of dependency between variables, which no document can provide.

The following main conclusion can be formulated: if it is possible to collect a large amount of relatively reliable information (that also takes into account the dynamics of changes) on the environmental and economic pillars, then the social pillar requires information of the same type, i.e. reliable (derived from large samples of high representativeness) and presented over a period of time. Despite their obvious shortcomings connected with the incompleteness of the indicators we are interested in<sup>3</sup>, the importance of nationwide social science surveys carried out for decades, cannot be overestimated. However, what is necessary is the cooperation between sustainable development researchers, sociologists, demographers and economists responsible for the final set of varia-

bles. This cooperation could in time lead to increasing the number of indicators that are of interest to us.

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<sup>3</sup> Unfortunately, the ISSP Environment datasets which are of great value, are collected not frequently enough – only every 10 years. They contain much interesting data mainly

on social attitudes towards environmental protection and to a lesser degree, on the social pillar itself.

## Pollution, Happiness and Willingness to Pay Taxes: The Value Effect of Public Environmental Policies

### Zanieczyszczenie, szczęście i chęć płacenia podatków: efekt wartości w ramach publicznych polityk ekologicznych

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#### Abstract

As China's economic development pattern is marked by an excessive consumption of fossil fuels, environmental pollution problems in China are getting increasingly serious and threatening residents' fundamental demands for a high quality of life. It has become a handicap to sustainable economic development and social well-being. In this paper, the happiness index method were used, and models depicting the relationship between residents' sense of happiness and environmental pollution factors and between the willingness to pay taxes and environmental pollution factors have been established. The results show that environmental pollution, especially air pollution, significantly affects the residents' sense of happiness. To improve residential environment quality and reduce pollution, residents are willing to pay the relevant taxes. If pollution control is considered a public policy, there exists a substantive weight of government between residents' income and environmental quality. This will influence the choice of environmental public policy.

**Key words:** environmental pollution, sense of happiness, Willingness to Pay Taxes, public policy

#### Streszczenie

Rozwój ekonomiczny Chin powiązany jest z nadmiernym zużyciem paliw kopalnych, a zanieczyszczenia środowiska osiągają poziom, który stanowi zagrożenie dla oczekiwanego przez obywateli wysokiego poziomu życia. Stało się to przeszkodą dla zrównoważonego rozwoju gospodarczego i dobrobytu społecznego. W niniejszym opracowaniu wykorzystano metodę wskaźnika szczęścia. Opracowano modele obrazujące związek między poczuciem szczęścia mieszkańców a zanieczyszczeniami środowiska oraz między chęcią płacenia podatków a czynnikami zanieczyszczenia środowiska. Wyniki pokazują, że zanieczyszczenie środowiska, w szczególności zanieczyszczenie powietrza, znacząco wpływa na poczucie szczęścia mieszkańców. Aby poprawić jakość środowiska mieszkańców i zmniejszyć zanieczyszczenie, obywatele są skłonni zapłacić odpowiednie podatki. Jeżeli kontrola zanieczyszczeń jest uważana za politykę publiczną, rząd odgrywa istotną rolę w kształtowaniu relacji między dochodami mieszkańców a jakością środowiska. Wpłynie to bowiem na wybór polityki publicznej dotyczącej środowiska.

**Słowa kluczowe:** zanieczyszczenia środowiska, poczucie szczęścia, podatki oparte na gotowości do zapłaty, polityka publiczna

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## 1. Introduction

In the 30 years since reforms and opening-up policies were implemented in China, fossil fuel consumption has become the main route for the economic development. While the energy-based economic pattern brought rapid development, it also increased environmental pollution, thus causing environmental deterioration. The pollution problem has become a major hurdle to the sustainable economic and social development of China. According to World Bank data, the annual economic losses caused by air and water pollution in China range from 8% to 12% of GDP (Zhang et al., 2009). Fu Miao and Huang Zhuoming (2008) analysed the relationship between China's economic development phase and environmental pollution. Their findings suggested that the conflict between economic development and environmental deterioration is increasingly serious and the pollution problem must be solved in the early phase of industrialization. In addition, a good ecological environment is an essential condition for survival and a sense of happiness. However, environmental pollution threatens the most fundamental factors that ensure a high quality of life for Chinese residents. In China, 86% residents believe that environmental pollution significantly harms their health. Hence, environmental pollution has become a major issue hindering economic development and improvement of social well-being in China. Therefore, formulating effective environmental public policies, assessing the effects of such policies and addressing environmental pollution problems are the need of the hour.

Considering that environmental pollution is a negative externality, both the neoclassical and institutional economic theories suggest that the external costs of an enterprise should be internalised, the use of environmental resources should be linked with economic benefits and pollution control should be market-based. According to the Pigovian tax theory, if a producer causing a negative externality is taxed at the rate equal to the value of the negative externality, his private cost will rise in accordance with the social cost. In this case, the profit maximization principle will enable the producer to limit his output level to the level where the price is equal to the marginal social cost, and this is the condition for effective allocation of resources (Pigou, 1932). Xiaoying Zhang and Jinwen Zhong (2011) pointed out that the carbon tax, as a Pigovian tax, can reduce CO<sub>2</sub> emissions. It may impede economic growth in the short run, but it is beneficial for the sustainable development of the economy in the long run. Xiangju Li and Na He (2017) found that under the fiscal decentralization, the environment tax burden exerted positive influence on the environment pollution, but less elastic. Meanwhile, the level of tax collection and administration had negative influence on the environmental pollution. According to the Coase theorem,

when transaction costs are very low or zero, no matter how property rights are distributed, the market can solve the externality problem such that the emission of pollutants is controlled. When the transaction cost is not zero or very high, different allocations of rights may result in resource configurations with different efficiencies. Therefore, it is important to clarify property rights and determine a property rights system (Coase, 1960). The Coase theorem provides two pollution control measures. The first measure is environmental governance or emission standards, where the government specifies statutory restrictions to the emission of pollutants. If enterprises exceed these restrictions, they will face severe economic and legal penalties. Zhengge Tu and Xiao Geng (2009) estimated China's environmental efficiency based on the industrial statistics of 30 provinces in China from 1998 to 2005 by using the directional distance function. The result showed that environmental total factor productivity (ETFP) has become the core driving force for high industrial growth and pollution reduction in China. Environmental governance has not substantially impeded industrial growth. Neng Shen (2012) assessed the influence of environmental governance on the growth of productivity based on China's two-digit industrial data by using the regression analysis method. The result showed that environmental governance based on pollution control cost reduces the productivity of pollution-intensive industries in the short run but increases it in the long run. The second measure is the emission rights system, where the government issues pollution permits to enterprises. The number of pollution permits is determined by the amount of pollution, considering a socially optimum level of pollution. The permits are distributed among enterprises and only the enterprises holding these permits are entitled to discharge pollutants. The amount of pollutants they discharge should not exceed the number of permits they have; otherwise, they will face severe punishment. Stavins (1995) and Abeygunawardena (2000) pointed out that the emission rights system can reduce the environmental pollution at the minimum social cost and is thus a useful way to control environmental pollution using a market-based method. In addition, seeking new environmental innovations to reduce emissions at their source is also a solution. Malin Song and Shuhong Wang (2013) shows that a reliable solution can result from transferring the advanced environmental protection technologies from East China to Central and West China and strengthen the environmental governance of the central and western provinces. Jinzhen Ye and Husen An (2017) found that three conclusions: first, the environmental tax that was in the market-oriented reasonable rate would have positive influence both on controlling environmental pollution and maintaining steady growth of welfare. Second, the polluting industries would transfer with the regional differentiated environmental tax policy. However, the national united

policy had a better impact than the regional policy in the long time. Third, administrative intervention that was unreasonable would decrease the positive influence of environmental tax.

The above public environmental policies solve environmental pollution problems by *commanding and controlling* enterprises to use state-of-the-art environmental protection technologies, or by internalizing the external costs of enterprises through taxation and emissions trading. These studies focus on the economic value effect of public environmental policies, but they do not analyse the social value effect of public environmental policies. Studies showing the benefits of environmental pollution control policies on social well-being are lacking. Furthermore, the operability of the above method is restricted, and the actual effect of environmental pollution control is not obvious. The paper argues that government, enterprises and individuals are the stakeholders in environmental pollution and in pollution control policies. Therefore, a rational and effective assessment of the value effect of environmental pollution, assigning the environmental protection responsibilities of every party concerned, are the pre-condition and basis for the government to formulate public environmental policies. In this study, the happiness index method is introduced to assess the value effect of public environmental policies on a personal level and explore the microcosmic foundation for the control of pollution. This is different from the existing studies in which pollution control is studied from the point of view of government or enterprises.

The happiness index method is a new assessment method based on a happiness survey. Easterlin (1974) introduced the subjective psychological indicator, happiness, into economic research as a method for pricing public goods. According to the understanding of happiness by the New Economics Foundation, environment is one of the three factors that affect the sense of happiness of residents, and environmental pollution has a significant impact on the sense of happiness (New Economic Foundation, 2017). On one hand, residents' sense of happiness directly reflects on environmental quality. On the other hand, environmental quality may affect health, and thus human capital, income and the sense of happiness. Welsh and Kühling (2009) state that many factors exert more influence on residents' sense of happiness, and environmental pollution is one of them. Studies reported that noise (Van Praag and Baarsma, 2005), climate (Rehdanz and Maddison, 2005), natural disasters (Luechinger and Raschky, 2009) and other environment problems considerably affect residents' sense of happiness. According to a survey of Chinese residents, 67.9% of respondents think that environmental protection is closely related to an individual's sense of happiness, and 82.3% of respondents are willing to pay environmental protection fees. This suggests that Chinese residents are

strongly aware of environmental protection, and environment quality has become a major factor in their sense of happiness. In this study, China's 1994–2012 data from WVS are used to establish a model depicting the relation between residents' sense of happiness and environmental pollution factors. A relationship model of environmental pollution and residents' willingness to pay environmental taxes is also established to investigate whether residents are willing to pay taxes for pollution control. Finally, building a relational model of objective indexes between happiness and environmental pollution can enable an indirect evaluation (as a monetary value of public goods) of the tax price that residents are willing to pay for reducing environmental pollution.

## 2. Literature review

It was Welsch (2002) who first proposed that air pollution caused by lead and NO<sub>2</sub> emissions has a measurable influence on the subjective sense of happiness of residents, and the improvement in air quality has substantial monetary value. Welsch (2005) further investigated how the individuals' subjective well-being scale varies with wealth and environmental conditions in ten European countries. Reducing lead and NO<sub>2</sub> emissions would bring monetary value of \$1400 and \$750 per capita respectively every year. There is synergy among different pollutants. Debra Israel and Arik Levinson (2003) found that different pollutants may have different degrees of influence on residents' sense of happiness. More specifically, the sense of happiness declines with an increase in water pollution per capita but is not closely related to Total Suspended Particulates (TSP) in air. Susana Ferreira et al. (2006) estimated that Irish residents are willing to pay €1100 to reduce PM10 by one unit. Katrin Rehdanz and David Maddison (2007) surveyed the influence of air pollution and noise pollution on residents and found that residents' subjective well-being scale declines with increase of air pollution and noise pollution levels when other relevant factors remain constant. Russell Smyth (2008) showed that when air pollution changes by 1%, individuals' subjective well-being scale moves up or down by one grade on the five-point well-being assessment table. The influence of air pollution is the greatest among all the environmental pollution variables. Di Tella and MacCulloch (2008) found that the suffering of American residents as a result of increases of SO<sub>2</sub> emissions by one unit is equivalent to a reduction of total income by 17%. Simon Luechinger (2009) estimated that German residents are willing to pay €183 to €313 to reduce SO<sub>2</sub> concentration per capita each year. George MacKerron and Susana Mourato (2009) estimated that whenever the NO<sub>2</sub> concentration in air in London, UK rises by 10ug/m<sup>3</sup>, the life satisfaction score declines about 0.5 (the full score is 11). Marconi (2010) pointed out that solely adopting

an environmental protection tax policy may accelerate technical modification but slow down the reduction of pollution. Tobias Menz noticed (2011) that health disorders caused by suspended particles were emerging. Residents may be, to some extent, accustomed to the local air pollution, so the level of pollution may be underestimated. According to the unbalanced datasets of 48 countries from 1999 to 2006, he found that the previous pollution level significantly lowered the current life satisfaction score. However, the emerging PM10-related diseases exceeded the possible habitual effect, and control of the past pollution increased the value coefficient of clean air by approximately 2.5. Arik Levinson (2012) established a measurement model between residents' sense of happiness and the logarithms of PM10 and resident income based on the air pollution problems in USA. By using the OLS estimation method and marginal rate of substitution theory, it was estimated that whenever the air pollution rises by one unit, the resultant negative effect on the American residents' sense of happiness is equivalent to an annual average income reduction of \$459-\$1.26 every day. Zhangtao Li, Henk Folmer and Jianhong Xue (2014) studied the residents in the Jinchuan region. They indicated that residents' happiness was more influenced by atmospheric pollution, and measures should be immediately taken to reduce atmospheric pollution. Rong Tingting and Zhao Zheng (2015) studied the residents in the Long River Delta region. They indicated that residents' happiness was more influenced by the regional environment, age and education levels. They suggested that the government should implement green environmental protection measures. Since the 1970s, economic studies have focused on the relationship between wealth and happiness. The existing foreign literature shows that residents' sense of happiness is closely related to environmental quality. Assessment of the value of pollution control by using the happiness index method has great theoretical and practical significance. It not only quantifies the economic value of environmental pollution but also provides options for pollution control. The Chinese literature in this field has the following two short points: 1. previous studies only focused on the influence of pollution control on the economy, and Chinese scholars did not pay sufficient attention to the relationship between environmental quality and a sense of happiness.

Like, Qingquan Fan et al. (2016) found that the dynamic environmental tax policy had two benefits. First, increasing the tax ensured economic growth and protecting environment. Second, the tax could maximize the social welfare on the saddle path. Government should choose the optimum timing to levy the dynamic environmental tax, which was same with the timing of environmental pollution increasing. Pu Liao and Sujin Zheng (2016) studied the environmental tax with considering the relationships between environment and life expectancy, and issu-

ing an optimal environmental tax which have given consideration to the dual benefits of reducing environmental pollution and economic growth. Hongyou Lu and Yunchan Zhu (2017) found that the current environmental tax and fee policies in China exerted little influence on reducing environmental pollution, but these policies had better influence on economic transformation and upgrade of industrial structure. Hong Li and Zhenxing Xiong (2017) used CGE model to study the policies of levying environmental tax and decreasing enterprise and individual income tax policies in eastern, central and western regions, and found that the environmental tax burden would exert negative influence on the use of natural resources and energy resources, not the cleaning inputs such as capital and labor. They suggested that the environmental tax had a good effect on restraining ecological excess occupation. They also suggested that the environmental tax rate should be less than 5%, and the corresponding tax revenue should be used to reduce enterprise and individual income tax in the same proportion, thus accelerating the transfer of economic development motivation to capital and labor elements.

2. Previous studies maintained a normative analysis level, but empirical studies based on actual data are lacking, especially studies that use economic methods to assess the relationship between environmental pollution and a sense of happiness and environmental tax policies. Like Shan Ye (2016) found that owing to the increasing economic cost of dealing with the pollutant, taxpayers of the environmental tax had less motivation to use excess energies and nature resources. Therefore, the environmental tax might attain the better effect of prohibition. She also issued the criterion to whether the design of the environmental tax burden was rational. This criterion was that whether taxpayers were more tend to induce environment-friendly techniques and high-technique for tax-cost reason. Revenues from the environmental tax she issued belonged to local governments and divided between the provincial government and city-level government and county-level government at a fixed ratio. Ming Su et al. (2016) found that three conclusions: first, the revenue from environmental tax should be shared between central government and local government as a shared tax, not be allocated to local governments as a local tax. Second, the revenue from environmental tax should be induced into the general public budget, not be earmarked. Third, the county government was the major for the implementation of the environmental tax policy. Therefore, they proposed that the county-level government should have a good guarantee of the fiscal expenditure, if the county-level government wanted to handle the environmental protection well. Hongyou Lu et al. (2017) studied the relationship between the preferential tax policy in enterprise income tax and corporates in polluting industries, and found that preferential tax policies had little

influence on corporates in polluting industries to invest the green production.

In this paper, environmental pollution control is treated as a public policy. Models depicting a relationship between pollution control and sense of happiness and between pollution control and willingness to pay environmental taxes are established, and Order-Logit, Order-Probit and FGLS measurement analyses of a series of data are performed. On the one hand, the associated relationship between water pollution, atmospheric pollution and happiness is clear and definite. In particular, a detailed analysis of all kinds of pollution sources is conducted so that the effect, degree, source and manner of environmental pollution on residents' happiness can be established. On the other hand, according to the measurement and analysis results of the relationship between pollution control and residents' willingness to pay environmental taxes, a substantial balance between government taxation and environmental quality improvement is found. The value effect of public environmental policies is assessed, breaking through the bottleneck that emission and pollution reduction only rely on government or enterprises. Effective and practical public environmental control policies are proposed.

### 3. Analytic framework

#### 3.1 Model setup: relationship of subjective indexes among happiness, Willingness to Pay Tax and environmental pollution

A sense of happiness refers to the residents' subjective feeling for their external living environment, their economic condition and their social condition. Environmental pollution considerably affects residents' external living environment and social condition and thus affects their sense of happiness. Guided by this factor, we further investigated whether the residents were willing to pay the corresponding taxes for the prevention and treatment of environmental pollution so as to pursue more happiness. In this paper, subjective and objective indexes are the ordinal and categorical data. Therefore, the Ordered Choice Model (OCM) is adopted in this paper to estimate the relationships among happiness, willingness to pay tax and the subjective and objective evaluations of environmental pollution, whereas the subjective and objective evaluations of environmental pollution are taken as criteria to calculate the price residents are

willing to pay for environmental protection. The model details are set as follow:

$$H_{ijt}^* = \alpha P_{jt} + \beta Y_t + \gamma X_{ijt} + j^* + \varepsilon_{jt} \quad (1)$$

$$U_{ijt}^* = \mu P_{jt} + \vartheta X_{ijt} + \sigma_{jt} \quad (2)$$

where  $H_{ijt}^*$  is the happiness of resident  $i$  in region  $j$  at time  $t$  and has four values 1, 2, 3 and 4, from low to high.  $U_{ijt}^*$  is the willingness of resident  $i$  in region  $j$  to pay taxes for the prevention and treatment of environmental pollution and has four values 1, 2, 3 and 4, from low to high.  $P_{jt}$  shows each index of environmental pollution in region  $j$  at time  $t$ . It mainly includes the subjective perceptions of residents on the aspects of pollution, as well as some observable objective indexes of atmospheric pollution, which mainly include a comprehensive index of atmospheric pollution and emission concentration levels for the main pollutants such as PM10 NO<sub>2</sub> etc.<sup>1</sup>  $Y_t$  means residents' income levels, which are valued by four values 1, 2, 3 and 4, from low to high.  $X_{ijt}$  expresses the control variable, which mainly controls the influence of residents' personalities and emotional characteristics on their decisions. Individual characteristics include age, gender, degree of education, health condition, employment, religious beliefs, marital status, number of children and resident region size. Emotional characteristics include the residents' satisfaction with their recent family life and family property, as well as their freedom and control in decision making.  $\varepsilon_{jt}$  and  $\sigma_{jt}$  are independent, identically distributed random variables. Meanwhile, the regional effect is controlled in this paper's model, which is expressed as  $j^*$ .

Two estimation methods, Order Probit and Ordered Logit, will be adopted to estimate the different models. Furthermore, in the model of happiness, the tax payment price of residents for the prevention and treatment of environmental pollution under the subjective data will be calculated as the partial derivative of income and the environmental pollution index. The calculation formula is as follows:

$$\frac{\partial y}{\partial p} \Big|_{dH=0} = \frac{\partial \left( \frac{dH}{dY} \right)}{\partial \left( \frac{dH}{dP} \right)} = - \frac{\alpha_{jt}}{\beta_t}$$

#### 3.2 Model setup: relation between Sense of Happiness and Environmental Pollution

About the relation model between happiness and atmospheric pollution, this paper will refer to Arik Levinson (2012) to set the model as  $H_{ijt}^* = \tau P_{jt} + \varphi \ln Y_t + \omega X_{ijt} + j^* + \delta_{jt}$  (the corresponding esti

<sup>1</sup>In estimating the model details,  $P_{jt}$  in Model (1) respectively means the subjective perceptions of residents on atmospheric pollution, water pollution etc, namely, Models 1-4 in Table 2.  $P_{jt}$  in Model 2 separately means the subjective perceptions of residents on atmospheric pollution, water pollution etc., namely, Models 1-4 in Table 3. In addition, it is pointed out in the paper that  $P_{jt}$  in Model (1)

also means the objective indexes of some atmospheric pollutants. Since their data types are the order type, the order will still be adopted to choose the models, namely, the two models of 2001 and 2007 in Table 4. Due to length limitations, and to reduce the tedious degree of text representation, only the basic model is shown in this paper and the sub-model set is introduced in the footnotes.

mated results of this model is the model of 2012 in Table 4)<sup>2</sup>. Inside,  $P_{jt}$  expresses the atmospheric pollution index of region  $j$  at time  $t$ , which mainly means the emission concentrations of main pollutants, such as PM10, NO<sub>2</sub> etc. in units of  $ug/m^3$ .  $Y_t$  means the income level of residents. Due to the unavailability of data, the annual average disposable income of region is taken as the substitute variable in this paper.  $\delta_{jt}$  is an independent, identically distributed random variable. The variable sets of  $H_{ijt}^*$ ,  $X_{ijt}$  and  $J^*$  are the same as those above.

Furthermore, the tax payment price of residents for the prevention and treatment of environmental pollution under the objective data will be worked out by calculating the partial derivative of income and environmental pollution index. The calculation formula is  $\frac{\partial Y}{\partial P} |_{dH=0} = -Y \frac{\tau}{\varphi}$ . In this paper, the FGLS method will be adopted to estimate the model.

## 4. Empirical analysis

### 4.1 Specifications of variables and data

The data used in this paper are from the World Values Survey (WVS) on China and the China Environmental Statistics Yearbook. The WVS recorded the survey data on Chinese values across the last three time waves, namely, 1999-2004, 2005-2007 and 2010-2014. The sample year of the first wave is 2001, the second is 2007, and the third is 2012. The number of respondents in the first wave is 1000, the second is 1991, and the third is 2300. In combination with the relevant environmental pollution indexes from the China Environmental Statistics Yearbook, there are 24 variables across three years (2001, 2007 and 2012), which constitute the pooled cross-sectional data of the study (see table 1).

#### 4.1.1 Choice of explained variables

In response to the needs of the model setting, this paper will select happiness and WTP environmental tax as the two variables to be explained.

Happiness is a subjective feeling that is difficult to quantify. Therefore, WVS used the question *Taking all things together, would you say you are happy or not?* to measure the residents' happiness. WVS required respondents to use a four-item scale to state their unhappiness or happiness level (1= not at all happy, 2 = not very happy, 3 = rather happy, 4 = very happy). The residents' willingness to pay for environmental protection can be measured by their WTP environmental tax. WVS designed a four-item scale to assess residents' willingness level (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree).

#### 4.1.2 Choice of explanatory variable

##### Choice of independent variables

The income variable is an important factor influencing residents' happiness. It mainly includes two indexes: the level of residents' income, which is set by four levels, and residents' disposable income. As there were no specific income data available in WVS, this study used the per capital disposable income level in districts where the respondents live in as a substitute for the income variable.

The environment variable has two dimensions; namely, the subjective variables and objective variables. The subjective variables encompass residents' subjective feeling and comments on the water and air pollution. They have four options: not serious at all, not very serious, somewhat serious and very serious, respectively, evaluated as 1, 2, 3 and 4. Objective variables are mainly derived from the air pollution index, including the air pollution index of our country's cities as well as the annual average concentration and pollution index of main air pollutants. Data are mainly from *The Environmental Statistics Yearbook of China* (2001, 2007, 2012). According to the WVS data, environmental monitoring points where the surveyed population live can be determined and air quality data can be collected according to the surveyed years. Meanwhile, since the short-term change of atmospheric environment is not sufficient to draw attention, the happiness and willingness to pay tax will not be greatly changed. Therefore, the annual report data for each environmental monitoring point are used as the environmental pollution index in this paper.

##### Choice of control variables

Happiness is a subjective sensation largely influenced by the individual characteristics of residents. If the real relation among environmental pollution, happiness and willingness to pay environmental taxes is going to be investigated, then the effects of some factors must be controlled. These factors mainly include residents' individual personality characteristics. Inside, individual characteristics mainly mean age, gender, education level, health status, employment status, religious belief, marital status, number of children and regional size. The personality characteristics are mainly emotional characteristics. In this paper, three variables will be chosen to express the emotional characteristics of residents: the happiness of residents with their recent family life, happiness with family property and the degree of freedom and control residents have in decision making.

<sup>2</sup> The corresponding estimated results of this model is the model of 2012 in Table 4.

On the treatment of age data, in this paper, the ages of respondents provided by the WVS are classified as youth (18-40) middle age (41-60) and old age (over 60 years), with assigned values of 1, 2 and 3, respectively.

On the treatment of gender data, female respondents are denoted by 0 and males by 1.

On the treatment of education level data, respondents are assigned a value of 1, 2, 3 or 4, respectively, for non-education, primary school, junior-senior high school and university.

Health data are categorized as poor health, not too healthy, healthy and very healthy, with assigned values of 1 to 4, respectively.

On the treatment of WVS employment data, two indexes of 1 and 0 are set, respectively, for employment and unemployment. Inside, employment status includes full-time job, part-time job, self-employment and retirement. The unemployment status includes unemployment, housewife, student and others. In this paper, we classify the retirees as employed since the psychological states of respondents are mainly considered here. Because they normally have their retirement pay or subsidies, the psychological states of retirees in China are more tended to the employed persons and are different than the psychological states of real unemployed persons.

On the treatment of religious beliefs, three classes are ordered from 1 to 3, respectively, as atheist, non-religious but theist and religious.

On the treatment of marital data, two indexes are set as single (0) and married (1). In the WVS data, single means the individual resident status of respondent, which includes unmarried, divorced and widowed, whereas married includes married and cohabitating with the goal of marriage.

On the treatment of the number of children, data are ordered and valued 1 to 4, respectively, for no child, one child, 2-3 children and more than 4 children.

On the treatment of regional size where the respondent lives, two indexes are set for regions larger than 50,000  $m^2$  (1) and regions less than 50,000  $m^2$  (0).

WVS data for satisfaction degree of respondent with the recent family life and family property are assigned a value of 1 to 4, respectively, for very dissatisfied, dissatisfied, satisfied and very satisfied. The two indexes indicate residents' satisfaction with family life and family property in the last year. They can be regarded as the first-lagged variables of two factors that influence happiness and can be taken as the control variables of residents' emotional characteristics.

In addition, it is also important to measure the personality characteristics of residents and the degree to which they can independently judge or choose something, which is further ordered from low to high and assigned values of 1 to 4, respectively.

## 4.2 Empirical results

### 4.2.1 Relation analysis between happiness and Subjective Index of Environmental Pollution

Two subjective feeling indexes for environmental pollution are chosen in this paper: subjective perceptions on the degree of atmospheric pollution and of water pollution. According to the basic model between happiness and the subjective index of environmental pollution, two models waiting for estimation are set in this paper. They are shown as the vertical number sequence in Table 2. The parameter estimation results of models are expressed as the crosswise sequence of numbers in Table 2. The results under the Order-Probit estimation method show that first, a reverse relation appears between residents' perceptions of atmospheric pollution and their happiness. When the subjective perception of residents on atmospheric pollution goes up by one unit, the probability of happiness dropped down will be 0.095. Second, a reverse relation appears between residents' perceptions of water pollution and their happiness. When the subjective perception of residents on water pollution is higher, the probability of happiness decreases to 0.042; however, the results are not very significant.

A significant correlation appears between the variables of income level, health condition, marital status, A significant correlation appears between the variables of income level, health condition, marital status, age, happiness of residents with their family life status and satisfaction degree of residents with their family property and the happiness of residents. Inside, there exists a significant positive correlation between income level and happiness. When the income level is increased by one unit, the probability that the happiness of residents will be raised with the increased income level is 0.14. A significant positive correlation appears between health status and happiness. When the health status is increased by one unit, the probability that the happiness of residents will be raised with increased health status is 0.43. There exists a significant positive correlation between marital status and happiness, namely, the perception of happiness for married residents is higher than that of single ones. A positive correlation appears between age and residents' happiness, namely, the older the respondent the happier they feel. The higher the degree of satisfaction with family life the happier they feel. The reaction coefficient between both is 0.47. The higher the degree of satisfaction with the family property status the happier they feel. The reaction coefficient between both is 0.21. The influences of gender, the ability of free choice, employment status and degree of education on happiness all fail the significance test. This shows there is no significant correlation between each of these factors and happiness.

Table 1. Explanation of Variables, source: WVS Database; China Environment Statistics Yearbooks; CEInet Statistics Database.

Depended variables				
Happiness	Not at all happy, 1	Not very happy, 2	Rather happy, 3	Very happy, 4
Pay to environment: income	Disagree strongly, 1	Disagree, 2	Agree, 3	Agree strongly, 4
Independed variables				
Poor water quality	Not serious at all, 1	Not very serious, 2	Somewhat serious, 3	Very serious, 4
Poor air quality	Not serious at all, 1	Not very serious, 2	Somewhat serious, 3	Very serious, 4
Scale of incomes	Lowest, 1	Second, 2	Third, 3	Highest, 4
Control variables: Individual characteristics				
Age	18-40, 1	41-60, 2	>60, 3	
Gender	Female, 0		Male, 1	
Education	No formal school, 1	Primary, 2	Secondary and high, 3	University & above, 4
Health state	Poor, 1	Fair, 2	Good, 3	Very good, 4
employment	No, 0		Yes, 1	
Size of town	Small(< 50000), 0		Big(≥ 50000), 1	
Children number	None, 1	One, 2	Two and Three, 3	Four and more, 4
Marital status	Single, 0		Married, 1	
Religious denomination	Atheist, 1	No religious, 2	Religious, 3	
Control variables: Emotional characteristics				
How satisfied with your life	Dissatisfied strongly, 1	Dissatisfied, 2	Satisfied, 3	Satisfied strongly, 4
How satisfied with financial situation	Dissatisfied strongly, 1	Dissatisfied, 2	Satisfied, 3	Satisfied strongly, 4
Freedom of choice	None, 1	Second, 2	Third, 3	Highest, 4
Real air pollution variables and the income variable				
	Year	Mean	Min	Max
PM10 density( $ug/m^3$ )	2012	93	60	136
NO <sub>2</sub> density( $ug/m^3$ )	2012	42	26	54
PM10 index	2007	1.39	1	2
NO <sub>2</sub> index	2007	2.43	1	3
Air pollution index	2007,2001	2.29	0.73	3.65
Income(Ln-value)	2012	10.06	9.75	10.6

Table 2. Evaluation Results of Relation Model between Happiness and the Subjective Index of Environmental Pollution (according to the availability and integrity of data, the estimated results in Tables 2 and 3 are obtained from the related data in 2007).

	Order-Probit		Order-Logit	
	Model 1	Model 2	Model 1	Model 2
Air pollution	-0.095*** (0.041)		-0.16*** (0.075)	
Water pollution		-0.042 (0.038)		-0.077 (0.067)
Control variables				
Health	0.43*** (0.04)	0.427*** (0.036)	0.79*** (0.07)	0.78*** (0.07)
Marital status	0.24*** (0.1)	0.21*** (0.1)	0.35*** (0.11)	0.32* (0.18)
Freedom of choice	0.1** (0.044)	0.12** (0.044)	0.18** (0.08)	0.2** (0.08)
Life satisfied	0.47*** (0.053)	0.48*** (0.053)	0.88*** (0.1)	0.89*** (0.1)
Finance satisfied	0.21*** (0.049)	0.21*** (0.049)	0.37*** (0.1)	0.36*** (0.1)
Gender	-0.11 (0.072)	-0.12* (0.072)	-0.16 (0.13)	-0.17 (0.13)
Age	0.15*** (0.059)	0.15*** (0.058)	0.29*** (0.1)	0.29*** (0.1)
Education	0.072 (0.051)	0.067 (0.05)	0.11 (0.09)	0.11 (0.1)
employment	-0.01 (0.097)	0.01 (0.06)	-0.02 (0.097)	0.004 (0.17)
Income scale	0.14** (0.057)	0.14*** (0.057)	0.21** (0.1)	0.2** (0.1)
religious	0.02 (0.58)	0.02 (0.58)	0.02 (0.1)	0.01 (0.1)
Area effect	controlled	controlled	controlled	controlled
Obs	1301	1297	1301	1297
LR chi2	Prob>chi2=0	Prob>chi2=0	Prob>chi2=0	Prob>chi2=0
Pseudo R <sup>2</sup>	0.252	0.25	0.255	0.257

Standard errors in parentheses \* P<0.1, \*\* P<0.05, \*\*\* P<0.01

Meanwhile, the robustness test is carried through for the results of models. The Order-Logit method is utilised to carry through the parameter estimation again for the two models which are awaiting estimation. It

is found that the estimated coefficient results of Order-Logit method are in accordance with the results of Order-Probit method. This shows that the results obtained in this paper are robust.

#### 4.2.2 Relation analysis between Willingness to Pay Tax and the Subjective Index of Environmental Pollution

According to the basic model between willingness to pay tax and the subjective index of environmental pollution, atmospheric and water pollution are still taken as the study objects to set two models for estimation. They are shown as the vertical number sequence in Table 3, whereas the parameter estimation results of two subjective index models are expressed as the crosswise number sequence in Table 3. The results show that under the Order-Probit estimation method, a positive correlation exists between residents' perceptions of atmospheric and water pollution and their willingness to pay environmental tax. Inside, when the perception of residents on atmospheric pollution goes up by one unit, the probability that the residents are willing to pay the treatment taxes for the pollution will be 0.05. When residents' perceptions of water pollution are increased by one unit, the probability that the residents are willing to pay the treatment taxes for the pollution will be 0.086.

As for the control variables, there exists a positive correlation between the two variables of life satisfaction and ability of free choice and the willingness to pay environmental tax. The results show that the higher the degree of life satisfaction the more willing the resident is to pay the tax for environmental pollution treatment. The stronger the residents' ability for free choice the more willing the resident is to pay the tax for environmental pollution treatment. Meanwhile, the robustness test is carried through for the results of models. The Order-Logit method is utilised to carry through the parameter estimation again for the two models which are waiting for estimation. It is found from the results that the estimated coefficient results of all variables are in accordance with the results of the Order-Probit method. This shows that the results obtained in this paper are robust.

#### 4.2.3 The Tax Payment Willingness of residents for atmospheric pollution treatment

By the relation analysis between happiness and the subjective index of environmental pollution, the reaction of residents on the influence of atmospheric pollution is most significant. Therefore, the relation between happiness of residents and objective atmospheric pollution levels will be further investigated in this paper and the willingness to pay tax of residents for the treatment of atmospheric pollution will be calculated.

According to the annual division, three models will be given out for the relation analysis between resi-

dents' happiness and objective atmospheric pollution level. In the three models, the objective indexes of atmospheric pollution will be expressed by the different types. For example, in the two models of 2001 and 2007, the objective indexes of atmospheric pollution are the classes of pollution, with standards set by *The Environmental Statistics Yearbook of China*. In the 2012 model, the objective indexes of atmospheric pollution are the specific pollutants such as the emission concentrations of PM10 and NO<sub>2</sub>.

According to the data shown in Table 4, atmospheric pollution in China has a significant negative effect on residents' happiness. In the 2001 model, once the atmospheric pollution level is increased by one unit, the probability that the happiness of residents will be reduced with increased atmospheric pollution levels is 0.114. However, in 2007, the probability increased to 0.269. This shows that the problem of atmospheric pollution in China has become more serious over time. In the 2012 model, when the emission concentration of NO<sub>2</sub> is increased by one unit, the happiness of residents is decreased by 0.01 levels; hence, NO<sub>2</sub> pollution has a negative effect on the happiness of residents. A positive correlation appears between PM10 and residents' happiness. However, it is found that such a positive correlation is weaker and the reaction coefficient is only 0.005. Therefore, it is presumed in this paper that the reaction of residents to PM10 before 2012 is not very obvious.<sup>3</sup>

#### 4.2.4 Estimation of environmental tax price

According to the formula of marginal willingness to pay the environmental tax derived from the theoretical parts, the tax levels paid by the residents for environmental governance in 2001, 2007 and 2012 are calculated as the price residents are willing to pay for environmental protection. Since the same estimation method is used, there is comparability between the environmental tax prices of 2001 and 2007. It can be seen from the results that in 2001 the price residents were willing to pay for the prevention and treatment of atmospheric pollution was 0.36 units. By 2007, the price residents were willing to pay had increased to 1.21 units. This shows that the awareness and ability of residents to prevent and treat environmental pollution have increased while the environmental problem has become more serious day by day.

In the 2012 model, the data of real income are used. Therefore, the actual payment price of residents for the prevention and treatment of environmental pollution can be calculated. According to the results of data in Table 4, the willingness-to-pay price of residents for the prevention and treatment of NO<sub>2</sub> pollution is an annual average of 1009 RMB.

<sup>3</sup> The robustness test is carried through for the results of models. Due to space limitations, the paper will no longer be listed.

Table 3. Evaluation Results of Relation Model between Willingness to Pay Taxes and the Subjective Index of Environmental Pollution

	Order-Probit		Order-Logit	
	Model 1	Model 2	Model 1	Model 2
Air pollution	0.05*(0.029)		0.086*(0.05)	
Water pollution		0.06**(0.026)		0.11**(0.047)
Control variables				
Health	-0.02(0.032)	-0.02(0.032)	-0.03(0.06)	-0.03(0.057)
Marital status	-0.067(0.092)	-0.075(0.091)	-0.15(0.17)	-0.17(0.16)
Freedom of choice	0.08**(0.038)	0.075**(0.038)	0.16**(0.07)	0.15**(0.07)
Life satisfied	0.12*** (0.039)	0.12*** (0.039)	0.19*** (0.07)	0.2*** (0.07)
Children number	-0.01(0.048)	-0.02(0.048)	-0.003(0.09)	-0.02(0.09)
Gender	0.063(0.06)	0.068(0.06)	0.14(0.11)	0.15(0.11)
Age	0.047(0.052)	0.05(0.053)	0.09(0.09)	0.1(0.09)
Education	-0.001(0.038)	-0.008(0.034)	0.01 (0.07)	-0.001(0.07)
Town size	-0.043(0.06)	-0.032(0.06)	-0.096(0.11)	-0.07(0.11)
Religious	0.034(0.047)	0.04(0.046)	0.075(0.08)	0.085(0.08)
Obs	1516	1515	1516	1515
LR chi2	Prob>chi2=0	Prob>chi2=0	Prob>chi2=0	Prob>chi2=0
Pseudo R <sup>2</sup>	0.01	0.01	0.255	0.01

Standard errors in parentheses \* P<0.1, \*\* P<0.05, \*\*\* P<0.01

Table 4. Evaluation Results of Relation Model between Happiness and Atmospheric Pollution (affected by the data type, models at 2001 and 2007 data are estimated by method of Order-logit, and the model at 2012 data is estimated by the method of FGLS).

	Coefficients (2001)	Coefficients (2007)	Coefficients (2012)
Air pollution index	-0.114*(0.068)	-0.269*(0.15)	--
PM10 index	--	0.125(0.15)	--
NO <sub>2</sub> index	--	0.124(0.14)	--
PM10 density	--	--	0.005**(0.001)
NO <sub>2</sub> density	--	--	-0.01*** (0.002)
Income(Ln-value)			0.23*** (0.077)
Control variables			
Income scale	0.28*** (0.113)	0.23*** (0.087)	--
Married	0.294(0.233)	0.4*** (0.15)	0.1*** (0.035)
Freedom of choice	--	0.13*(0.07)	0.25*** (0.02)
Life satisfied	1.16*** (0.125)	0.81*** (0.09)	--
Finance satisfied	0.053(0.112)	0.42*** (0.08)	--
Age	--	0.26*** (0.09)	--
Gender	--	--	-0.04*(0.024)
Employment	0.54** (0.27)	--	-0.067*(0.04)
Education	-0.16(0.14)	--	0.057*** (0.015)
Number of obs	843	1450	2154
LR chi2	225	693	F statistics=37, Prob>F=0
Prob>chi2	0	0	Heteroskedasticity test: P=0.1
Pseudo R <sup>2</sup>	0.14	0.22	R-squared=0.14
Marginal coefficients and the willingness income to govern pollution			
	Marginal coef. (2001)	Marginal coef. (2007)	Marginal coef. (2012)
Air pollution index(p)	-0.01(0.11)	-0.029*(0.017)	--
Income scale(y)	0.028(0.36)	0.024** (0.01)	--
$\partial y/\partial p$	0.36	1.21	1009RMB

Standard errors in parentheses \* P<0.1, \*\* P<0.05, \*\*\* P<0.01

## 5. Conclusions

This paper demonstrates that the environment has become one of the most important factors influencing residents' subjective well-being. By respectively building the relationship models between happiness, residents' willingness to pay environmental tax and the environmental pollution, it can be concluded

from the validated empirical analysis that environmental pollution, especially atmospheric pollution, has a strong impact on the happiness of residents. The residents are willing to pay tax to reduce atmospheric pollution. The two main conclusions are as follows: 1. Compared with water pollution, atmospheric pollution has the most remarkable impact on the happiness of residents in China. When the atmos-

pheric pollution index goes up by one unit, the probability of happiness dropped down will rise to 0.269 in 2007 from 0.114 in 2001; in other words, the negative influence of atmospheric pollution on the happiness of residents is increasing. When the emission concentration of NO<sub>2</sub> is increased by one unit, the happiness of residents will be reduced by 0.01. 2. In the estimated results from the relation models between residents' willingness to pay environmental tax and environmental pollution, it is found from the study that if the problems of atmospheric and water pollution need to be treated, then the residents are willing to pay some environmental taxes. It can be seen from the actual results that to prevent and treat atmospheric pollution, the price residents are willing to pay was increased to 1.21 units in 2007 from 0.36 units in 2001. In 2012, the price that the residents are willing to pay for the prevention and treatment of NO<sub>2</sub> pollution is annual average 1009 RMB. Combined with the aforementioned empirical results, this paper suggests that the nation should treat environmental pollution control as an important public policy and formulate and implement policies accordingly. Actively promote environmental tax reform and establish a long-term and effective fundraising mechanism for environmental pollution and prevention to ensure the efficiency of pollution control. The study demonstrates that residents are willing to pay a certain amount of tax and fees and that their willingness to pay rises as the environmental pollution increases. Therefore, the study also suggests that the state should encourage people to actively participate in local environmental pollution control efforts and mobilize the public to co-manage environmental pollution while making public policies.

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## From the Genealogy of the Environmental Thought: Marian Raciborski and Jan Gwalbert Pawlikowski

### Z genealogii myśli ekologicznej: Marian Raciborski i Jan Gwalbert Pawlikowski

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#### Abstract

The article presents the views of two pioneers of environmental thought: Marian Raciborski and Jan Gwalbert Pawlikowski. The former was the author of a conservation programme of protecting nature which conceptualised valuable phenomena and objects of nature as natural monuments. The latter was the author of a peculiar *ecological manifesto* which demanded that nature should be treated as humans' partner in the world, a partner deserving respect combined with care for its existence. In Poland, these were the first autonomous reflections at the beginning of the 20<sup>th</sup> century on the necessity of protecting nature and of humankind's relationships with nature.

**Key words:** environmentalism, natural monument, nature protection, Pawlikowski Jan Gwalbert, Polish environmental thought, Raciborski Marian

#### Streszczenie

Artykuł prezentuje poglądy dwóch pionierów myśli ekologicznej: Mariana Raciborskiego i Jana Gwalberta Pawlikowskiego. Pierwszy z nich był autorem konserwatorskiego programu ochrony natury konceptualizującą wartości zjawisk i obiektów natury jako pomników przyrody. Drugi był autorem specjalnego *ekologicznego manifestu* domagającego się traktowania natury jako ludzkiego partnera w świecie, zasługującego na szacunek i troskę o jego egzystencję. W Polsce początku XX wieku były to pierwsze autonomiczne refleksje nad koniecznością ochrony przyrody i humanitarnych związków z naturą.

**Słowa kluczowe:** environmentalizm, pomnik przyrody, ochrona środowiska, Pawlikowski Jan Gwalbert, polska myśl ekologiczna, Raciborski Marian

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The contemporary idea of environmental protection first appeared at the end of the 19<sup>th</sup> century. It happened also in Poland<sup>1</sup> however environmental thought from this country is not so much known as it deserves. It was related to grassroots initiatives launched in Galicia, especially in Cracow and Lviv. It was then that Associations and organisations were founded which saw as their principal goal popularising the protection of the environment. The most im-

portant of them were: the Commission on Physiography at the Academy of Learning (1865), the Tatra Society based in Cracow (1873), the Polish Copernicus Society of Naturalists founded in Lviv in 1874, the Galician Society for the Protection of Animals, founded in 1876 and based in Lviv, and Galician Forestry Society (1882). Scientists and social activists concentrated in these organisations used the magazines they published (*Kosmos*, *Miesięcznik*,

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<sup>1</sup> Though Stanisław Staszic needs to be remembered here; in his *Ziemorództwo Karpatów i innych gór i równin Polski* from the year 1805 he included remarks concerning

taking care of nature, writing, among others, that it is a duty to *sacredly preserve the natural characteristic features of the Polish lands* (Lenkowa, 1986, p. 90-91).

*Sylwan*) or conference reports to signal the threats to the well-being of nature (e.g. erosion of soil caused by deforestation), they called for the protection of the endangered components of the natural environment (e.g. chamois and marmots in the Tatra Mountains); they also put forward projects of legal regulations in terms of the management of natural resources (e.g. in the question of afforestation; Szafer, 1973; Lenkowa, 1986; Łapiński i Abdurakhamanov, 2005).

These valuable actions undertaken in order to protect nature were at that time organised in an ad hoc manner and had a practical character. The theoretical framework for the idea of environmental protection was only constructed at the beginning of the 20<sup>th</sup> century. The authors of the first Polish concepts of nature conservation were Marian Raciborski and Jan Gwalbert Pawlikowski. To a large extent, their reflections referred to similar ones which emerged at the end of the 19<sup>th</sup> century and at the turn of the 19<sup>th</sup> and 20<sup>th</sup> centuries around the world (R. W. Emerson, H. D. Thoreau, J. Muir) and in Europe (A. von Humboldt, H. Conventz) (Lenkowa, 1986a, p. 43-84).

Marian Raciborski<sup>2</sup>, a botany professor at Lviv and Jagiellonian Universities, is considered to be the pioneer of Polish in-depth reflection on the environmental protection. This opinion is based on his publications: *Ochrony godne drzewa i zbiorowiska roślin* [*Trees and Plant Communities Worth Protecting*], and the more important – *Zabytki przyrody* [*Natural Monuments*] (Raciborski, 1900; 1908). This work is treated as the first one in Poland presenting the programme of nature conservation (Szafer, 1947, p. 8). Apart from the description of Polish natural monuments, it puts forward three main ideas.

The first one is a statement about the increasing destruction of the environment and the resulting necessity of nature conservation, together with an emphasis on its social significance. In an invocation, as it were, the Polish scholar writes: *Across the vast spaces of Europe, [man – lg] has transformed the old landscape, vegetation and animals. It is only now, and this is a significant detail, that the minds of our generation in many places around the globe almost*

*simultaneously understood the loss, and efforts began to be made in order to save what remains; it was understood what role the homeland landscape as well as our knowledge of it play in terms of education and science, as it is our duty to future generations to know and to preserve the monuments of our homeland nature* (Raciborski, 1947, p. 11). What deserves special attention here is Raciborski's manner of arguing, as he emphasises the value of pristine nature, which should be preserved for the future; he also highlights its role in the process of shaping the young generation and man's cognitive activity.

Secondly, Raciborski introduces in this text the notion of natural monuments, fundamental for his project: *Natural* monuments are these objects of inanimate nature and wildlife which provoke curiosity because of their rarity, and, at the same time, due to their advanced age they are witnesses of times and relationships long gone, sometimes even of climates past, and as valuable demonstrative specimens they deserve attention and care. We also count among them usual places which are made unique by the beauty of their location. These can be rocks, waterfalls, lakes, rare animals, gigantic or rare trees or even assemblages of plants differing from usual ones, such as the remnants of steppes, gypsum sinkholes, mires. They can be cared for only as long as we are aware of their value; otherwise, we will pass them indifferently as we have done so far (Raciborski, 1947, p. 12-13). This concept clearly uses an analogy to historical monuments. Therefore, it has been referred to as museum-like care for nature (Okraska, 2010, p. 21), or conservation activities. The latter term for an attitude towards nature preferred by Raciborski is especially accurate, as it was aimed at adopting measures limited to preserving and caring for the existing components of the environment which are deemed valuable. What lacks here, it needs to be mentioned, is the factor of actions taken up in order to *repair* the damages man has inflicted on nature.

Thirdly, the conservation approach to the problem of environmental protection as presented by Raciborski performed one more function apart from caring for natural monuments. It was to constitute, through

<sup>2</sup> Marian Raciborski (1863-1917) studied (1881-1891) natural sciences and medicine at the Jagiellonian University, and subsequently (1892-1896) at the universities in Berlin, Bonn, Munich and Wrocław. In the years 1896-1900, he studied the flora of Java. After his return to Poland, in the years 1900-1909, he was the head of the Chair of Botany at the Agricultural University of Dublany near Lviv. In the years 1904-1905, he was the president of the Polish Copernicus Society of Naturalists in Lviv. From 1909, as a botany professor at Lviv University, he organised the Biological-Botanical Institute. In 1912, he became a botany professor at the Jagiellonian University. From 1900 a corresponding member and from 1913 a working member of the Polish Academy of Learning. In the years 1915-1917 he was the chair of the Commission on Physiography at the Academy of Learning. In 1912, he was appointed the

director of the Botanic Garden in Cracow. In 1913, he created the Institute of Botany at the Jagiellonian University. Raciborski published over 300 works on the cytology, anatomy, morphology and physiology of plants. He also wrote works concerning floristry. He devised methods of propagating plants, growing tissues in trees, and he described in detail the phenomenon of photosynthesis. He also published pioneering works in the area of paleobotany and he was the creator of the Polish school of phytogeography. He was one of the forerunners of environmental protection in Poland, representing the conservation current. He introduced in Poland A. Von Humboldt's term of *natural monument*, extending it to include objects of inanimate nature (rocks, waterfalls, lakes), see: *Marian Raciborski: Studia nad życiem i twórczością naukową*, ed. Koronas J., the Jagiellonian University, Cracow 1986.

learning about the nature of one's homeland, a significant element of patriotic education. He wrote about it in the following words: *a nature-related manner of understanding life and its phenomena is entering our world more and more boldly, exercising young minds not only with a spiritual word, but also by making connections between observations, by performing experiments, with a final test of truth. Observations, in turn, must concern, self-evidently, mainly the homeland and its creations. The feeling of love for one's homeland, community with the society and the land, provoked only by tradition, reading, history or poetry, can be very strong indeed, but if one lacks a closer knowledge of things* [i.e. of homeland nature, it will turn out to be (lg)] *something vague and barren* (Raciborski, 1947, p. 12). In this perspective, environmental protection becomes a social and national duty.

Without prejudice to the Polish scientist's views on nature protection, it needs to be noted that he followed to a large extent the German pioneer of nature conservation, known in Europe at the turn of the 19<sup>th</sup> and 20<sup>th</sup> centuries – Hugo Conwentz from Gdańsk (Lenkowa, 1986, p. 61-63), with whom, by the way, he worked in close scientific cooperation. Such a conservation attitude in the understanding of care for nature was at that time a dominant phenomenon in Europe and North America. He is the one to whom we owe, among others, developing in that period the idea of natural national parks and nature reserves, which is still popular today.

A few years after Raciborski's ideas were first presented, a much richer concept of protecting the environment was developed by his associate from the Agricultural University of Dublany – Jan Gwalbert Pawlikowski<sup>3</sup>. In *Lamus* yearbook in 1913, he published a text entitled *Kultura i natura* [Culture and nature] (Pawlikowski, 1913), which, according to later researchers, deserves to be considered the first ecological manifesto in Poland due to its broad and deep perspective on the matter (Sebesta, 2001, p. 53; Okraska, 2010, p. 20-22).

Pawlikowski's starting point was the conviction that *Contemporary culture includes elements which contribute to the degeneration of man to a much higher degree than it used to be in former times* (Pawlikowski, 2010, p. 49). This conclusion was based on a crisis, widely felt in Europe at the turn of the 19<sup>th</sup> and 20<sup>th</sup> centuries, which revealed the decline of the traditional society and the related values, as well as the appearance of entirely new phenomena, such as rapidly growing industrialisation and urbanisation. It was especially these processes that, according to the Polish writer, were the causes endangering, on the one hand, human physical and psychological life, and on the other – they were the factors of the destruction of the environment. At the same time, he noted the mental trend prevalent in Europe, dated from the times of Rousseau and especially the age of romanticism, which added a considerable emotive significance to nature in human life. In relation to that, he wrote: *One of the reasons why the feelings*

<sup>3</sup> Jan Gwalbert Pawlikowski (1860-1939) was the leading Polish intellectual figure of the first decades of the 20<sup>th</sup> century. He studied law at the Jagiellonian University, where he was awarded a Ph.D. in 1885. In the years 1885-1887, he studied agricultural sciences and economy in Dublany and Vienna. From 1887, he managed a large family estate near Medyka. At the same time, in 1889 he began his research and teaching work at the Agricultural University of Dublany near Lviv as a lecturer in agricultural and economic subjects. That was where he began his cooperation with M. Raciborski. Living in Lviv, he was active in various areas. In the field of economy, he worked in agricultural organisations and in banking; as an activity organiser of educational and cultural life he was the founder of the School of Political Science in Lviv (1907), he supported publishing companies and the initiatives of theatrical movement in Galicia; he was active in the political life in Galicia, representing the moderate wing of the local National Democracy party as its vice chairman; he was a prolific author of numerous scientific texts in the field of agricultural sciences, but also literary studies, which brought him great acclaim in the country, especially for his distinguished knowledge of the works of Słowacki (*Mistyka Słowackiego/The Mysticism of Słowacki*, 1909) – for the achievements in this area he became a member of the Polish Academy of Learning; finally, he was a very devoted member of the Tatra Society and a leading ideologist of mountaineering in the Tatras (he is remembered in this

area as an excellent climber). It is this last area of Pawlikowski's activities that his work for the protection of the environment is related to. As a leading activist of the Tatra Society, he was instrumental in founding as its part the Tatras Protection Section (1902), later transformed into the Mountain Protection Section (1930). It was the first formal initiative in Poland whose main aim was to protect the environment. He was one of the co-founders of the League for the Preservation of Nature (1926), a mass organisation guarding the natural heritage. In independent Poland, he performed the function of the vice-president of the Polish State Council for Nature Conservation, significantly contributing to passing the environmental protection law (1934) as well as numerous legal acts in this respect. He was a long-time editor of magazines which popularised the idea of conservation: *Wierchy* (from 1923) and *Ochrona Przyrody* (from 1920). He wrote many press articles devoted to the care for the environment; his special concern in these was the inviolability of the natural state of the Polish Tatras. For these activities, he received state awards (e.g. the Order of Polonia Restituta), and by the decision of the Polish State Council for Nature Conservation, a collection of his works was published in 1938, entitled *O lice ziemi. Wybór pism Jana Gwalberta Pawlikowskiego* and including his most important treatises in such areas as: protection of nature, of the environment, of landscape and of folk culture. See: Okraska R., *Rycerz przyrody*, 2010; *Dom pod Jedłami i jego twórca. Studia i wspomnienia*, ed. W. A. Wójcik, Znak, Cracow 1997.

for nature are presently being rekindled is the awoken awareness of how much we have distanced ourselves from it (Pawlikowski, 2010, s. 58) and subsequently adds that *today's emotional attitude to nature has the feature of being opposed to culture* (Pawlikowski 2010, p. 48). In the light of that last remark, the title of Pawlikowski's work *Culture and nature*, it may seem, is of contradictory character. Culture, as the whole of humankind's civilizational achievements in the spiritual (mental) sphere, material sphere (the whole of the creations of human activeness) and social sphere (forms of collective life), stands in contradiction to nature – to the natural environment humans come from and with which they are still connected. Indeed, Pawlikowski particularly emphasised the fact that in his times the relation between culture and nature was asymmetrical and brought unfavourable results to both its elements. But the Polish writer goes much further and puts forward the fundamental thought that a new, non-contradictory relationship between man and nature needs to be built. This appeal, arguing against the opposition between nature and culture, concludes his manifest.

A way of implementing the idea of combining nature and culture into a harmonious whole is, according to Pawlikowski, taking up activities aimed at protecting nature as the weaker and mercilessly exploited side of the discussed relationship. At the same time, these relationships are to serve humans, contributing to the improvement of their living conditions. This project constitutes the foundation of his multifaceted ecological reflection.

One of the more important threads of the ecological thought of the Galician author was his strong criticism of the utilitarian treatment of nature. In relation to that, he wrote: *The idea of protection of nature begins only when the one who protects does not do so for material gains or for historical or other sentimental value related to a creation of nature and alien to it as such, but for nature itself, for one's liking for it, for the ideal values found in it* (Pawlikowski, 2010, p. 69-70). He sees as an ideal value all that is untouched by human interference. In relation to nature, objects of ideal value are old trees, wild forests, uncommon geological formations (natural monuments) or natural landscapes. The rarer such objects, the greater their ideal value. Nature's ideal values are, according to Pawlikowski, the fundamental basis of the protection of the environment. He considered a misunderstanding the demands for protecting

nature made due to economic reasons (as natural resources will become exhausted too fast) or utilitarian reasons (the values of nature need to be preserved as they are beneficial for people's holiday trips). Nature should be protected exclusively on the basis of the autotelic values of which it is an autonomous bearer. From this axiological point of view, Pawlikowski developed his stance on the conservation concept of protecting nature. In his view, the idea of natural monuments and nature reserves is insufficient. Care for natural monuments only does not amount, after all, to the protection of entire nature; creating nature reserves (*national parks, islands of protection*) makes entire areas of the country which are not subject to special care fall outside the requirement of protecting nature (Pawlikowski 2010, p. 76). The idea of caring for nature should assume, according to him, treating it as a whole and taking into account all its manifestations.

The idea which was much closer to his views was that of preserving the values of the natural landscape<sup>4</sup>. According to Pawlikowski, this concept was treated as a link between culture and nature. On the one hand, it has to take into account transformations of landscape resulting from human activities (e.g. power lines, roads, tracks, industrial landscape). On the other, he wants the natural environment to be preserved in the most pristine state possible. Thus the necessity of such a way of shaping the landscape (land use planning) that would combine these two considerations. In relation to that, his words (which, it needs to be pointed out, were written in 1913) sound visionary indeed: *The art of adapting oneself to the aesthetic character of landscape (...) should be introduced in schools. What might have seemed impossible or even ridiculous yesterday will become a serious requirement tomorrow* (Pawlikowski, 2010, p. 87). And it was what happened: presently, a subject called *The Protection and Shaping of Landscape* is taught at universities.

Nature protection is not only the question of caring for the landscape, but also for plants and animals, threatened by the civilizational development of agriculture and industry, as well as the growing demand for materials obtained from animals (meat or skins). In this respect, Pawlikowski appeals for moderation in using green areas for agricultural, industrial or urban purposes, for preserving the flora and fauna characteristic for a given area and for care for all species of plants and animals and not only for those which are endangered (Pawlikowski 2010, p. 94-99).

<sup>4</sup> In Poland, this concept was later popularised especially by Adam Wodziczko (1887-1948), a botany professor at Poznań University (from 1920), a distinguished activist and promoter of nature protection. He was the first in Poland to introduce university lectures in nature protection called *physiotactics* – a new science he suggested, dealing with the process of shaping people's proper attitude to the natural environment. He was the initiator of founding na-

tional parks: Wielkopolska, Wolin and Słowiński. As a result of his efforts, the first Department of the Protection of Nature and Landscape Management was created in Poland at the Chair of General Botany at Poznań University (1945). He was the author of over 200 scientific works and articles on the subject of conservation. See: Łoborzewska A., *Adam Wodziczko*, Zarząd Główny LOP (League for the Preservation of Nature), Warsaw 1981.

To use modern language, he calls for preserving natural biodiversity to the largest extent possible; it is what constitutes for him the primary objective of conservation activities. It is a programme which is still applicable to the contemporary concepts of nature conservation.

The author of *Culture and nature* was especially critical of tourism, quickly developing in his times, and of the fashion for visiting places with attractive natural environment. He did not oppose this social tendency, but he disapproved of behaviours which sometimes accompanied it, such as littering the natural environment or *decorating* the places one visited with tourists' initials carved in tree bark or rocks and other *souvenirs* of their stay; he drew attention to the practice of blazing hiking trails with brightly coloured signs; all this together had a negative influence on the state of local natural environment, its flora and fauna. He was especially critical of the quickly developing *tourist industry* manifesting itself, among others, in erecting hotels in more picturesque areas, or in building aerial tramways facilitating the movement of masses of tourists up to mountain peaks. On the other hand, it needs to be added that as far as the work of protecting nature is concerned, Pawlikowski saw an ally in responsible tourism that is conscious of threats to nature. He especially emphasised such an attitude of respect and self-restraint in mountain tourism and Alpinism he promoted, arguing that destroying nature means that these forms of humans' presence in the world of nature should be eliminated (Sebesta 2001, p. 58).

Pawlikowski's journalistic activeness concerned to a large extent the questions of exploiting nature by *tourism economy* (Pawlikowski 2010a), his writings in this respect were provided with a primary motto: *The values discussed here are the values which are still growing as the spiritual culture is advancing; are we allowed to reject in the name of the society this constantly growing rent [here in the sense of 'costs' (lg)] for a momentary minor benefit of just one or a few generations? It is a robbery committed on the future – an economy of until-tomorrows* (Pawlikowski, 2010, p. 107). The motto speaks directly about *generational egalitarianism*, or about the responsibility for the state of nature left in legacy for the future generations – one of the main slogans of the contemporary environmentalist thought.

When presenting Pawlikowski's environmental reflections, it is necessary to draw attention to his clear perception of the values of people's direct contact with nature. The significance of the natural environment (as intact as possible) for human existence cannot be overestimated. He also used on occasions this argument to propagate the idea of protecting nature, even though he criticised the utilitarian approach in this respect. It could be presumed that in doing so, he tried to present the favourable influence nature has on culture. Conservation activities, according to

him, are favourable from the individual, social, national and moral point of view.

People's contact with nature, especially with the value of *the inherent beauty of the landscape*, satisfies their aesthetic sensitivity; at the same time, it gives them respite from everyday cares, which is indispensable for the human psyche. *Nature is a refreshing bath which restores the strength exhausted in the human world; it is a secluded temple in which the soul, away from everyday tasks, meets itself face to face and reflects on itself; it is a place of purification from all that has clung to us as something alien and imposed. It is a place of looking from the distance with respect to seeing the eternity. Finally, it is a place where one's own free thought, rested, not shrunk or shrivelled by considerations and circumstances can soar (...). Only thoughts – as Nietzsche says – reached by walking (ergangene Gedanken) in free nature have value* (Pawlikowski 2010, p. 48). Pawlikowski was especially fond of quoting this maxim from Nietzsche's *Twilight of the Idols*, and he did so a number of times, seeing in it an adequate description of one of the sources of intellectual creativity. Contact with nature has also, according to the writer, a socio-economic character – rest in natural surroundings regenerates strength and makes a person willing to work. It contributes, through learning about one's homeland nature, to strengthening the love of one's country; it is a very important factor of the sense of national identity. It is also manifested on the moral plane – the loss of nature's values leads to upsetting the moral balance (Pawlikowski 2010, p. 89-90).

The introduction to Pawlikowski's abovementioned remarks on nature protection includes his words about the crisis of culture, resulting among others in the degradation of the natural environment, and about the simultaneous raise in the awareness of man's breach with nature. They refer the reader to a broader theoretical context, which is presented in the final parts of his ecological manifesto.

To begin with, the writer from Galicia draws a vision of the human evolution and of the history of the relationship between culture and nature: *The primitive men lived with nature and from nature. They constructed their houses like beavers do, they hunted their prey like a lynx or an otter, they fed on fruit and seed like birds, they stored provisions like a hamster and processed them like a bee. They lived from nature, but they did not destroy it. But once they bred excessively and became more powerful, they became what mice or locust are to it. Then, seeing it stripped of the cheerful greenery, they realised what they had done and stopped. They decided to protect it from their own pillage and restore its beauty and health. But what they wanted to achieve cannot be achieved – the former state is gone forever; the one that will come will be quite different* (Pawlikowski 2010, p. 100). This quotation highlights an outline of three

stages of human development assumed by Pawlikowski: 1. man's unity with nature – the stage of harmonious coexistence; 2. the emancipation of the human species from the natural environment and gaining control over it – this is the stage of exploitation of nature according to the *Old Testament* principle of *subdu[ing] [the earth]* and the utilitarian attitude; 3. reevaluation of the humans' place in the world and their relation with nature – renunciation of anthropocentrism in the relationship between man (culture) and nature in favour of equivalence of both these components of existence, though it does not amount to an automatic return to the first stage. The new attitude of man to nature is *filtered* through culture, or through the whole of what humans have achieved through the ages in the spiritual and technological sphere. [By the way, an identical three-stage plan was employed by Henryk Skolimowski in his ecophilosophy (Gawor, 2012)].

The most significant part of this scheme is the third stage. It is about it that Pawlikowski writes: *Culture originated in nature and had its features for a long time: later, it turned against it. And now that it is making an alliance with it again under the modern slogan of 'protection', then, under the influence of this trend the renewed nature will not be what it used to be: it will inevitably have the characteristics of a product of culture* (Pawlikowski, 2010, p. 100). It needs to be noted that the Polish writer accurately predicted the direction in which the culture of his times would evolve, determined by the perspective of an increasing exploitation of nature and the growing significance of the idea of protecting it. According to this direction, the attitude to nature and the demand for its protection are to give culture its future shape. The contemporary fruit of this process is ecologism – a more and more common mental and cultural attitude emphasising relationships between humans and nature, and endowing these relationships with a dimension of a moral obligation to protect nature (see entry *ekologizm*, in: [encyclopedia.pwn.pl](http://encyclopedia.pwn.pl)). In this context, Pawlikowski was especially accurate in saying that *the idea of protecting nature, like a moral principle, is like salt which does not constitute a separate dish, but should be added to every dish* (Pawlikowski, 1938, p. 32). These words are a significant motto of the contemporary culture. They indicate that the tendency to return to nature does not amount to fighting culture; it only indicates (or it even indicates) making the idea of protecting nature an immanent component of culture with moral undertones.

In his manifesto, Pawlikowski did not confine himself to highlighting the significance of the idea of nature protection and its moral dimension. He ascribed great significance to nature conservation activities based on legislation and the involvement of the administrative organs on the scale of the whole country. What he saw as a good example of such an approach was the administrative model of nature pro-

tection functioning at the beginning of the 20<sup>th</sup> century in Prussia and constructed by Conwentz (Pawlikowski, 2010, p. 71-75). This dimension of Pawlikowski's activeness was fully revealed in the years of the Second Polish Republic, when from the year 1919 he strove to create a legislative framework of nature protection in Poland. His actions found their culmination in the year 1934, when a nature protection act was passed which he was the main creator of (Okraska 2010, p. 17-18). The act was quite innovative for its times, and Pawlikowski's text *Culture and nature* constituted its important ideological element.

The threads of Pawlikowski's ecological reflection discussed here show unambiguously its pioneering character not only on the scale of his native country. The significance of contacts with nature for the quality of human existence; the negative effects for the natural environment caused by thoughtless economy oriented solely on profit; endowing the idea of protecting the natural environment with the dimension of moral duty; the perspective of shaping a new stage of the development of culture, taking into consideration the protection of the natural environment – all that sounds surprisingly modern. If only for that reason, and for his literary achievements as well, Jan Gwalbert Pawlikowski deserves a prominent place in the historic and cultural memory of the future generations.

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Władysław Szafer (1886-1970), an eminent Polish botanist, a distinguished activist in the field of the protection of the natural environment in the times of the Second Polish Republic and after the Second World War, wrote in 1946: *Marian Raciborski finds together with Jan Gwalbert Pawlikowski the Polish ideology of protecting nature, which both of them – with a joint effort of spirit – construct like a golden bridge linking the natural and the humanistic culture* (Szafer, 1947, p. 7). These words pay due tribute to the pioneers of Polish environmental thought, and accurately present the significance of their concepts concerning the theoretical bases of nature protection in Poland.

Indeed, Raciborski and Pawlikowski combined the principles of Haeckel's ecology with human sciences. Their concepts of protecting nature clearly accentuate *the humanistic factor*, be it in highlighting the significance of the natural environment for the social (national) awareness, or in placing a strong emphasis on the moral obligation to care for nature. Moreover, both authors point to the role pristine natural environment plays for the psychological and physical condition of contemporary people, who already in the times of the two scholars lived largely in the surroundings of an industrial landscape. Preserving an attitude of pietism towards pristine nature, Raciborski and Pawlikowski at the same time real-

ised that its transformation happening as a result of human activity is inevitable. Being aware of it, they put forward the principle of respecting both sides of the relationship between nature and humans, which should have the character of a harmonious marriage. Raciborski with his idea of conservation care for natural monuments and Pawlikowski with his project of the protection of the natural environment based on axiological foundations created the basis for future Polish reflections on protecting nature. It was thanks to their concepts that in later years Polish environmental thought was enriched by such scientists as, among others, the author of the theory of landscape protection – Adam Wodziczko (1887-1948, see *Na straży przyrody/ Guarding Nature*, 1946); the creator of the idea of sozology (a science concerning itself with environmental protection) – Walery Goetel (1889-1972, see *Sozologia – dział nauki, jej treść i zadania/ Sozology – a Branch of Science, Its Content and Objectives*, 1971); the promoter of the prevention of diseases of affluence through nature protection – Julian Aleksandrowicz (1908-1988, see *Sumienie ekologiczne/ Ecological Conscience*, 1979); or a world-class thinker, a co-founder of modern eco-philosophy – Henryk Skolimowski (1930, see *Ekofilozofia jako drzewo życia/ Living Philosophy: Eco-philosophy as a Tree of Life*, 1981).

Moreover, it needs to be noted that the concepts of the Polish forerunners of environmental thought, especially Pawlikowski's manifesto, are still relevant, which proves their profundity as well as the accuracy of the diagnoses they give and the demands they make in terms of conservation activities, which both scholars considered to be a fundamental necessity. In this respect, it needs to be sadly concluded over one hundred years after their ideas were first presented that not much has changed for the better.

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# A Proposed Model for Green Practice Adoption and Implementation in Information Technology Based Organizations

## Propozycja modelu określania i wprowadzania Zielonych Praktyk w przedsiębiorstwach wykorzystujących technologie informatyczne

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### Abstract

Green Information technology system offers opportunity for IT based organizations to act proactively in terms of environmental preservation as well as to mitigate effects of global climate change and other environmental problems. Green Information technology system adoption and implementation is a plausible attempt for IT based organizations to resolve the current environmental issues and also enhance their economic performance and possible social benefits. Currently several models and frameworks have been developed to address sustainability in various research domain. However, there are few models that can support decision making of practitioners in adopting and implementing sustainable practices in IT based organization. Therefore there is need to develop a model to assist practitioners adopt and implement sustainable practices. The proposed model comprises of Green variables, Green process and a hybrid technique of software agents and case bases reasoning. Findings from this paper shows the model variables, process, techniques applied and derived prepositions. Ongoing work involves adopting a mixed research (case study and survey) to verify the model variables, process and validate the model prepositions.

**Key words:** sustainability, Green Practice, IT based organization, Case Based Reasoning, Software Agent

### Streszczenie

Zielone technologie informatyczne ułatwiają firmom wykorzystującym technologie informatyczne (IT) podejmowanie działań na rzecz ochrony środowiska, a także tych prowadzących do zmniejszenia skali zagrożeń związanych ze zmianami klimatycznymi i innymi współczesnymi wyzwaniami ekologicznymi. Wdrażanie zielonych technologii informatycznych stanowi właściwe podejście dla firm IT nie tylko z uwagi na możliwość rozwiązywania bieżących problemów środowiskowych, ale także zwiększenia efektywności ekonomicznej i możliwych korzyści społecznych. Obecnie rozwija się wiele modeli odnoszących się do różnych aspektów zrównoważoności, jednak tylko nieliczne z nich nadają się do wykorzystania w procesie decyzyjnym firm IT. Z tej przyczyny istnieje potrzeba opracowania takiego modelu, wspierającego wprowadzanie zrównoważonych praktyk na tym poziomie. Zaproponowany model uwzględnia Zielone zmienne, Zielone procesy i połączenie techniki programowania agentowego z wnioskowaniem w oparciu o studium przypadku (CBR). Dzięki przyjęciu rozszerzonego podejścia (studium przypadku, ankieta) możliwa jest weryfikacja zmiennych modelu, procesów i potwierdzenie przyjętych założeń.

**Słowa kluczowe:** zrównoważoność, Zielone Praktyki, przedsiębiorstwa IT, CBR, programowanie agentowe

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## Introduction

Green relates to processes and technologies that are environmentally friendly, which have a less negative effect on the environment than conventional ones. The environmental influence of Green technologies and practices refers to the resultant effect on the ecology during product lifecycle, while the environmental effect of Green processes refers to the reduced need for resources and the reuse of materials to decreased pollution (Fabian, 2013). However due to immensely utilization of natural resources, there is insubstantial balance of the future of the ecological system and this has resulted to increased CO<sub>2</sub> emissions. Currently, sustainability problems are dominant and enterprise, governments, academic institutions and cross-national organizations are revolving their attention to the enquiry of how to make the world a better place, thus sustainability has been deliberated as a crucial research domain within IT based organization. Sustainability is a multi-complex term which incorporates issues associated to the environment, economy and society. In fact, sustainability refers to preservation deployment and the ethical use of resources.

According to the United Nations Report on World Commission on Environment and Development; sustainable development in enterprise is development that meets the needs of the present day without compromising the ability of future generations to meet their own needs (WCED, 1987). Lately, emphasis of environmental concerns has transformed from the local scale to global scale and has become the main concern of IT based organizations as well as non-governmental institutions, governments institutions and society (Nicky, Henning and Lutz, 2014; Mohammad, Mehrbakhsh, Azizah, Amir and Nor, 2015). There are three dimensions to sustainability; social, environmental and economic generally known as the triple bottom line. IT based organizations need to develop sustainability strategies that balance societal, environmental and commercial goals by ensuring that all three dimensions are adhere to simultaneously (Hart, 1997; Fabian, 2013; Daphne and Anol, 2014; Alemayehu, Ahmad and Vanessa, 2014). Sustainable development in IT based organizations entails a long term vision, which does not compromise the capability of future generations to meet their wants and needs (Chris, Jean and Carolyn, 2014). According to Chris et al. (2014); Fabian (2013) academic contributions to the domain of Green information technology system (ITIS) have evolved since 2008. Green ITIS continues to gain recognition as both academicians and practitioners look for pioneering ways of utilizing ITIS based systems to aid attain Sustainability goals in IT based organizations. IT based organizations is an organization that involves more than two people or group of people working together to accomplish same goal

and objectives, e.g. a university planning on implementing Green technologies in their laboratories or an organization using biodegradable materials in producing goods and services to their consumers. Information technology (IT) usage in IT based organizations has resulted to two order effects. The first order refers to the negative effect of IT use, production and disposal on the environment. This perception sees IT as part of the problem, this however resulted to the notion of making IT product usage and disposal more environmentally friendly and Greener, termed as Green Information Technology. The second order consequence refers to the positive effect of IT on the environment which sees IT as part of the solution by utilizing IT to make business procedures and strategies Greener known as Green Information Systems (IS). Green IT and Green IS are still in their infancy and have just begun to be understood and implemented in IT based organizations (Mohammad et al., 2015; Ibrahim and Alok, 2015). IT based organizations going Green has become a main topic of concern in the modern world. Where Green IT in IT based organizations aims to decrease energy consumption and waste related with the use of both hardware and software infrastructures. Green IS in IT based organizations is the use of information systems to support environmental sustainability strategies and goals (William, Philip and Mak, 2014). In this paper, we use *Green ITIS* as a derived term covering all efforts to reduce the environmental damage initiated by the use of IT, or to use IT in ethical and positive ways to help in the accomplishment of environmental aims and goals.

It has become widely recognized that the emanation of Greenhouse gases is having a cumulative impact on the climate. Additional it is a known fact that natural resources are speedily being exhausted and the unconcerned disposal of waste poses a severe threat to human health (William et al., 2014). Decision making has long been acknowledged as an issue of great significance within IT based organizations domain and, in recent years, considerable attention has been dedicated to its impact on the adoption of Green initiatives by practitioners. William et al. (2014) argued that for enterprise to systematically incorporate environmental strategies into their business activities, they require major change of enterprise decision making process. However there are few models that support decision making of practitioners in adopting and implementing sustainable practices in IT based organization. This research study concept of decision making support is similar to research carried out by Tom (2011) who researched using case study to study how Green IS can support organizational sense-making, decision making and knowledge sharing and creation around the design and manufacture domain. However the authors did not utilize Green variables, Green process and techniques which are very important as states by Alemayehu (2009a) in his

research on the reach (process) and richness (variables) of Green IT and also their research is based on design and manufacture domain, whereas this research study is based on IT based organizations domain. Thus this research study propose a model to support practitioners in IT based organizations in making Green decisions on how to adopt and implement sustainable practices in their organizational process. The model comprises of Green variables, Green process and a hybrid techniques comprising of software agents and case bases reasoning (CBR). The Green variables comprises of independent variables (IT governance, IT practitioners, technologies and system, motivating forces, IT strategy and information availability), moderating variable (age, gender and education), control variable (timing, country, size, sector and revenue) and Green Adoption and Implementation as dependent variable which is based on pollution prevention, product stewarded and sustainable development as mention by Hart (1997). The Green process includes design, distribution, procurement, operation and end of life.

The dependent variable in this research study is based on the findings of Hart (1997) who presented the concept of environmental sustainability related to the theory of the Natural Resource-Based View. Hart (1997) identifies three goals that must be considered by practitioners to progress the environmental sustainability of IT based organizations and they includes pollution prevention, which is attained through minimization of waste and emissions, product stewardship, addressed by thoughtfulness of stakeholder optimization of product lifecycles and lastly sustainable development, accomplished through lessening of enterprise's environmental footprint and obligation to a continuing sustainability vision (Hart, 1997; Fabian, 2013). Information technology (IT) and information systems (IS) are of particular significance in realization of these three goals stated above. Thus the proposed model support practitioners in making decision to achieve each of these three goals (pollution prevention, product stewarded and sustainable development) in IT based organizations only through software agents to benchmark, assess and rate how Green the enterprise process currently is case based reasoning to provide support for making Green decisions based on past successful Green cases inputted by domain experts.

The positive social consequences of Green practices in IT based organization is complex to achieve and engages both practitioners and management to be adaptive and flexible in infusing Green initiatives and standards. Positive social consequences towards Green practice adoption and implementation requires practitioners to cultivate a sustainable IT organizational culture, set IT social-sustainability objectives, goals and transform IT services, products and processes. For implementing social-sustainability initiatives and strategies, management should follow several social-sustainability practices according

to Hart (1997) these positive social consequences can lead to be reduction of emissions, wastage of water electronic waste decline, minimizing the total environment footprint of organizational development and lastly improving efficiency. Green practice in IT based organization socially aims to diminish environmental footprint during usage by utilizing clean technologies that consumes energy from renewable power sources to decrease the use of polluting materials and improve environmentally friendly know-hows (Vanessa and Alemayehu, 2012). However for any IT based organization to benefit from the positive social impacts, they are required to invest in technologies of the future. Since such technologies can cause substantial changes in the enterprise development process with a vision to decrease the negative environmental effects derived from the design to consumption of IT organizations products and services

The outline of this paper is organized as follows: section 2 presents the materials and methods. Section 3 is the proposed Green decision support model. Section 4 is the discussion of the paper. Section 5 is the research implication and limitation of the research and the final section is the conclusion and future work of the research.

## Materials and methods

This section discuss on the methodology adopted in this research paper; which is desk based research executed by utilizing secondary data source by reviewing existing industrial, practitioners and academicians publications relating to Green sustainability practices in IT based organizations in discussing the concept of Sustainability in relation to the environment. Also research publications relating to Green ITIS practice and lastly existing Green sustainable models and frameworks was reviewed.

## Sustainability in IT organizations

Sustainability was defined by the (WCED, 1987) as development that meets the needs of the present without affecting the ability of future generations to meet their needs. However, this definition has been criticized by some researchers such as (Viet, Ian and Jerry, 2011; Alemayehu, 2013) as being extensive and challenging for enterprise to comprehend and apply. As a result much of the attention on sustainable development inclines toward environmental perception without considering the social and economic aspects of sustainability. More lately, a triple bottom line (TBL) viewpoint of sustainability has been embraced which considers enterprise sustainability to include three modules: society, natural environment, and economical state of enterprise.

Figure 1 shows the dimension to be considered in attaining sustainability. The balancing of social responsibility, economic profitability and environ-

mental obligations is commonly known as the triple bottom line (Viet et al., 2011; Alemayehu, 2013). By considering the planet (effects on the environment), people (society) in relation to enterprise profit (economic) sustainability can be attained in enterprise (Elkington, 1997).

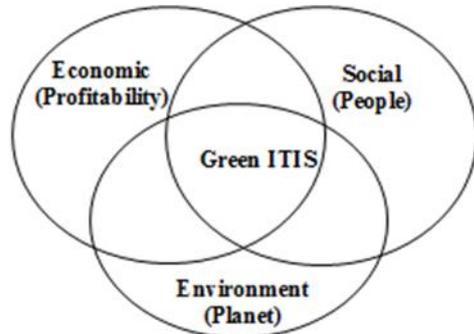


Figure 1. Triple bottom-line target in IT based organizations (Viet et al., 2011)

In fact, it is maintained that long-term viability in enterprise is best accomplished by balancing it with environmental and social goals (Elkington, 2004; Hart and Milstein 2003). The Sustainability of IT based organizations is viewed as a planned shared response to address environmental issues caused by enterprise's operations and activities aimed at improving the eco-friendliness of its occupational procedures (Alemayehu, 2013).

IT based organizations can implement Green practices in attaining Sustainability. These Green practices can be support enterprise control and prevent pollution throughout its operations and production activities by incorporating eco-environmental strategies throughout the system lifecycle. This implies that while the achievement and benefit of adopting Green strategies by practitioners could contribute to enterprise's environmental as well as financial value, the accomplishment itself could be subjective by enterprise's overall Green strategy (Hart and Milstein 2003; Alemayehu, 2013).

### Green IT and Green IS concept

Information Technology refers to computer software, hardware and peripheral infrastructures, whereas Information Systems is an extensive concept that involves the human activities and technology components related to the running and management process of technology across enterprise. IT conveys, processes, or stores and provides information, whereas IS is an integrated set of software utilizing IT to support practitioners, group of professional, enterprise (Stoney, Xuequn and Saonee, 2012). IS comprises of IT such as office computers, physical servers, network devices as well as shared facilities such as business applications and IT human resources in relation to skills, knowledge and database storage. The present concern on ecological ef-

fect of human activities is ever increasing and numerous efforts have been introduced to lessen increase energy efficiency and energy consumption. Currently, Green ITIS is grounded on the first order and second order effects.

The first-order effect relates to the adverse environmental impact of IT use, design and disposal. This perception addresses IT as adversely impacting Sustainability. Thus the use, design and disposal of IT in an environmental manner is coined as Green IT. The second-order effect refers to the positive effect of using IT on economic and business processes. This perspective sees IT as part of the solutions to Sustainability. Thus utilizing IT to make enterprises Greener is known as Green IS (Murugesan, 2008). Green ITIS aims to reducing the negative ecological impact of IT using IS to resolve ecological problems (Vanessa and Alemayehu, 2012). Green ITIS is a systematic processing of Sustainability benchmarks such as product stewardship, pollution prevention and use of clean technologies to the design, procurement, operation and disposal of the IT related infrastructure (Vanessa and Alemayehu, 2012).

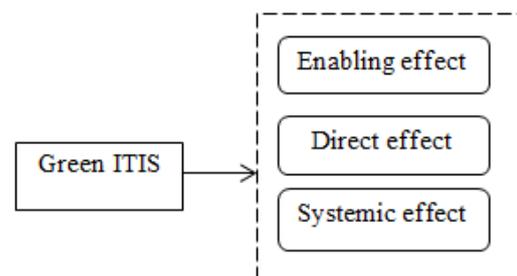


Figure 2. Green ITIS effects in IT based organizations (Yulia and Chulmo, 2012)

Likewise, Tom (2011) mentioned that Green means, least amount of harmful materials, power efficient during IT use, and proper disposal or recycling with minimum effect on human health and environment. Based on several reviewed literatures Table 1 shows a few contributions of Green IT and Green IS towards sustainability in IT based organization. Figure 2 shows that Green ITIS is anticipated to address the environmental issues and fundamentally change human behavior towards the environment by re-solving global warming and producing a sustainable society based on three effects. The purposes of Green ITIS can be distinguished into enabling effect, direct effect and systemic effect. As an enabling effect, Green ITIS aids to decrease environmental effects of other economic regions such as enterprise and domestic households. As a direct effect, Green ITIS aids to reduce negative effects of technologies and systems. As a systemic effect, Green ITIS aids to develop and design innovative IS improved processes and products which can intensely changes the social attitude, behavior and result in restructuring of consumption deployment and behavior towards enterprise being more sustainable (Yulia and

Table 1. Existing Green ITIS Model and Framework in IT based organization.

Authors, Year and Contribution	Variables/Process	Problem addressed	Research method applied
1. Qi and Shaobo (2015) presented a theoretical framework on organizational Green IT adoption.	Independent variables comprises of external drivers which includes <i>technological context</i> and <i>institutional pressure</i> and the <i>Internal motivations</i> . The mediating variable is <i>organizational Green IT adoption and sustainable competitive advantage</i> as dependent variable.	Provides managers and policy makers with a systematic analytical framework to guide enterprise business decisions.	The researchers plan to test model with empirical data in future.
2. Sulaiman, Muzamil and Shahin (2015) investigated the impact of adoption of Green IT practice in organization.	The model comprises of <i>institutional pressure, consideration of future consequences and openness</i> as independent variables and <i>adoption of Green IT practices</i> as dependent variable, where <i>the industry type and size of the enterprise</i> are the control variables.	Examined the factors that affect the adoption intensity of Green IT practices in firm's performance.	Structural equation modeling (SEM).
3. Ijab and Molla (2012) studied Green IS from the theory of practice perspective.	The framework comprises of <i>top management, environmental steward, IS manager and professionals</i> as independent variables and <i>Green IS practices (pollution prevention practice, product stewardship practice and sustainable development practice)</i> as dependent variable.	Aimed at understanding how Green IS emerges and also creates an understanding of IS in organizations for Sustainability.	No empirical data was stated.
4. Tracy, Webster and McShane (2011) proposed a framework for Green IT and IS Research.	The framework comprises of <i>motivating forces, Green IT/IS strategies, Green technologies and system as independent variable, organization and employee as mediating variable and environmental impacts as dependent variable</i> .	The researchers aimed to addresses environmental sustainability in management.	No empirical data was stated.
5. Daqing (2011) developed a model based on the adoption of Green IT IS.	The model comprises of <i>organization, business strategy, technology and environment</i> as independent variable and <i>Green IT IS adoption intention</i> as dependent variable.	Addressed the role of business strategy in the process of Green ITIS adoption.	Proposed using survey to validate model in future.
6. Alemayehu and Vanessa (2009) designed a Green IT readiness framework.	The framework comprises of <i>attitude, policy, practice (sourcing, operations and end of IT life), technology and governance</i> .	Helps organizations evaluate their readiness for adopting Green IT.	Case study.
7. Alemayehu (2009a) introduced the reach (Green process) and richness (Green variables) of Green IT.	Therefore the researcher proposes a framework comprises of <i>Green process (creation, sourcing, operation and disposal) and Green variables (policies, practices, technologies and system)</i> .	Assist in the conceptualization of Green IT and the definition of Green IT phenomenon.	Survey.
8. Alemayehu (2009b) developed Green IT matrix and motivation models.	The matrix consists of <i>Green process (sourcing, operation and end of IT life management) and variables (policies, practices, technologies and system)</i> .	Explore the extent of Green IT in business consciousness. Also identified the influence of institutional forces and organizational motivations in the adoption of Green IT.	Survey.
9. Alemayehu et al. (2009b) suggested a Green IT Readiness Model.	The G-readiness model comprises of <i>Green IT attitude, Green IT policy, Green IT practice, Green IT technologies</i> .	Helps to identify key dimensions for Sustainability.	Structural equation modeling (SEM).
10. Alemayehu and Vanessa (2009) presented a Green IT readiness framework.	The framework comprises of <i>attitude, policy, practice (sourcing, operations and end of IT life), technology and governance</i> .	Helps organizations evaluate their readiness for adopting Green IT.	Helps organizations evaluate their readiness for adopting Green IT.

Chulmo, 2012). It can be seen that both derived concepts of *Green IT* and *Green IS* has attracted the attention of both researchers and academicians and has moved from a smaller idea and strategy of energy efficient data center to include approaches that improve the environmental footprint of the design, creation, use and disposal of IT such as servers, computers and related subsystems that controls the actions and beliefs practitioners in preventing environ-

mental pollution, enhancing product stewardship and supporting sustainable development (Vanessa and Alemayehu, 2013). Green ITIS substantially ensures that enterprise products and services are environmentally sustainable (Watson, Boudreau, Chen and Huber, 2008; Tom, 2011). Green ITIS are inter related thus our research focuses on both Green IT and Green IS as seen in the research title as Green Information Technology Systems.

## Related works

Numerous studies suggest the potential of Green ITIS to incorporate environmental initiatives into enterprise operations, thereby enhancing enterprise's social, economic and environmental targets. Each of the reviewed work addressed sustainability issue by addressing different issues. Table 1 briefly summarizes ten previous Green ITIS studies related to this research study.

Hence Table 1 shows related works that has been carried out, aimed at achieving sustainability in enterprise.

Based on the reviewed 10 researched it is clear that Green ITIS offers opportunity for IT based organizations to act proactively in terms of environmental preservation as well as to mitigate the effects of environmental problems and other global climate change. Green ITIS adoption and implementation is a plausible attempt for IT based organizations to resolve the current environmental issues, and can also enhance the economic performance of IT based organization. Therefore practitioner's adopting and implementing sustainable practices can lead to economic, social and environmental benefits to IT based organizations and humanity. However none of the model or framework reviewed can support decision making of practitioners in adopting and implementing sustainable practices in IT based organizations utilizing Green variables, Green process and technique(s). Therefore there is need to develop a decision support model to assist practitioners in IT based organizations to adopt and implement sustainable practices in promoting sustainable IT based organization.

## Proposed Green Adoption and Implementation Model

This section presents the model proposed to assist practitioners in decisions making and provides support in adopting and implementing sustainable practice in IT based organization. The model comprises of Green variables, Green process and a hybrid techniques comprising of software agents and case bases reasoning (CBR).

The Green variables comprises of independent variables (IT governance, IT practitioners, technologies and system, motivating forces, IT strategy and information availability), moderating variable (age, gender and education), control variable (timing, sector, size, country and revenue) and Green Adoption and Implementation as dependent variable. The Green-process includes creation, distribution, sourcing, usage and end of life.

Figure 3 shows the proposed model which comprises of the Green process (GP), Green variables (independent variable (IV), control variable (CV), moderating variable (M) and dependent variable (DV)) and

Green techniques (GT). P1 to P9 are the models' prepositions.

## Model variables, process, techniques and prepositions

This section describes the proposed model in term of the model's variables, process, techniques applied and justification of each derived prepositions.

### Independent variables (IV)

The independent variable (IV) is the input or the case of something in relation to Green practices in IT based organization. The independent variables identified from the literature include; IT practitioners, IT governance, motivating forces, technologies and systems, information availability and IT strategy. Also this research develops the prepositions to theoretically justify and explain the relationships in the proposed model. The prepositions were developed based on the review of literature and on-going research.

### IT practitioners

These includes IT professionals, IT experts, environmental stewards and top management. IT practitioners' commitment is required for IT based organizations in planning deploying, implementing, maintaining and validating enterprise system with environmental deliberations in mind. Thus IT practitioners' collaboration is based on their stakes and shared interest in fulfilling the required objectives of the enterprise. Thus IT practitioner's actions influence how Green practices are implemented and diffused to achieve sustainability in their enterprise. According to Tracy et al. (2011) IT practitioners' attitude, ethics and social culture will determine how he/she will care for the environment. Also previous researcher such as (Stan, Vanessa, Hepu, Alemayehu and Siddhi, 2010; Sachin, Pradeep, and Mukesh, 2014; Mohammad, Azizah and Nor, 2014; Qi and Shaobo, 2015) mentioned that IT practitioners' capability, beliefs, knowledge, commitment and experience are determinants which influence IT practitioners' decision to go Green in their enterprise, thus, we propose:

*Proposition 1 (P1). IT practitioner's personality in relation to environmental sustainability will positively influence his/her action toward the adoption and implementation of Green IT IS practice.*

### IT governance

Green ITIS practices can support practitioners in redesigning how enterprise advances their future Sustainability strategies. Enterprise management can work together with practitioner in order to achieve

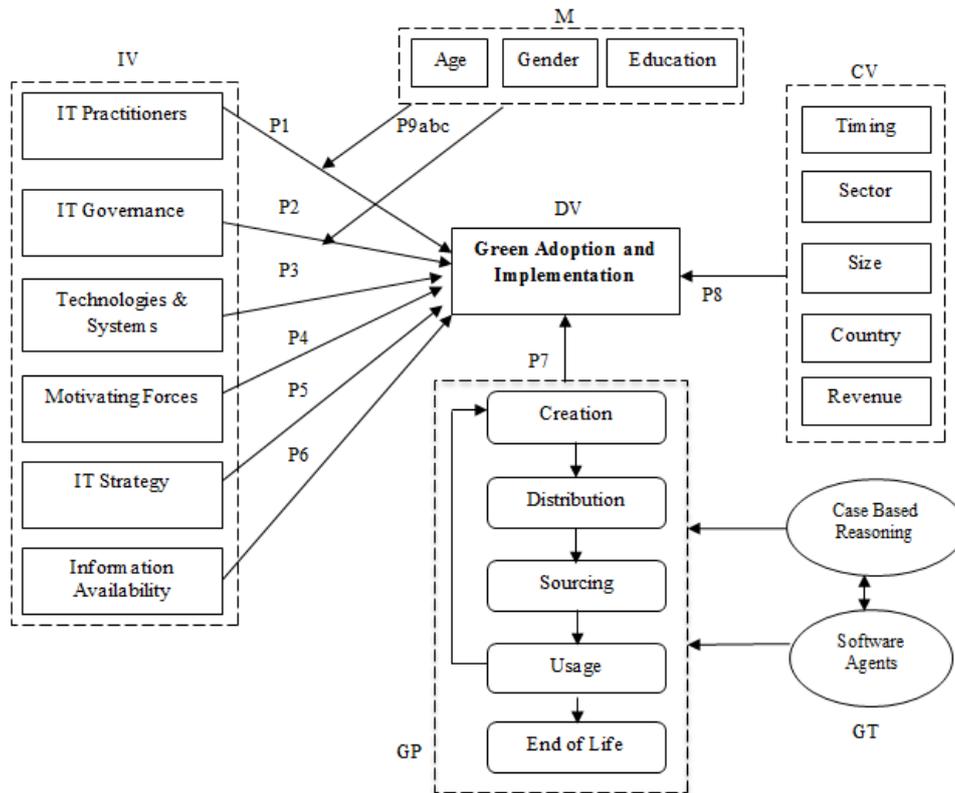


Figure 3. Proposed Green Adoption and Implementation model in IT based organization

social, economic as well as environmental benefits in achieving the goals and aims of enterprise. IT governance are rules, regulations and guidance stated by management in enterprise to ensure that practitioner implement and adopt Green initiatives in their enterprise. Therefore this variable determines the rules and regulation initiated by management ensuring that practitioners in the enterprise adopt and implement Green practices in their enterprise process.

IT governance is also concerned with the inspirations that affects social and enterprise policy, leadership structure, financial consideration and behavior of IT enterprise management (Alemayehu, 2008; Grant and Sam, 2012; Tracy et al., 2011; Stan et al., 2010; Sulaiman et al., 2015; Alemayehu, 2009b). IT governance offers a medium for defining the enterprise process. It is the operating pillar that defines the administration of Green initiatives in IT based organization. IT Governance is a variable that defines the management administrative decision making (roles, responsibilities, accountability and control) of Green initiatives (Stefan, Recker, Pimmer and Vom, 2010; Adela, Richard, Marie-Claude and Elena, 2011; Stefan, Markus, Eva and Timo, 2011; Alemayehu and Ahmad, 2012; Watson et al., 2008; Katrina, Anni-Kaisa and Paavo, 2014; Jens, Roman, and Martin, 2011; Chin-Jung, Chengli and Wei-Lun, 2015; Sulaiman et al., 2015). Thus, we propose the following:

*Proposition 2 (P2). IT governance structure will have a positive effect on the adoption and implementation of Green practice in enterprise.*

### Technologies and systems

Technologies and system defines the features of IT technical infrastructures which affect Green ITIS adoption and implementation. Therefore technology and systems refers to infrastructures that facilitate sustainable enterprise process, these technologies and systems are utilized by practitioners and management in processing the knowledge and skills required in implementing Green ITIS practices in their enterprise. Technologies and systems used in enterprise process are identified as an important variable in attaining sustainable decision making in IT based organization. These technologies and systems include hardware, software, database, network communication and infrastructures (Stan et al., 2010; Carolyn and Jean-Paul, 2014). The technologies and systems also involve acquiring more environmentally effective Greener technologies. Thus technologies and systems are key driver of Green IT IS practice in IT based organizations (Qi and Shaobo, 2015; Deepti, Ibrahim, and Alok, 2014; Ibrahim and Alok, 2014). There is need for efficient low energy technologies and system to reduce cost and CO<sub>2</sub> emission. Thus, we propose:

*Proposition 3 (P3). Green practice adoption and implementation is positively influenced by energy efficient, cost reduction technologies and systems.*

### **Motivating forces**

Motivational forces control how IT based organizations carries out product and service development in relation to adopting and implementing Green practices based on standard set mostly by non-government industries and governmental institutions. These standards and regulation are enthusiastic to sustain external groups and would include responding to pressure from regulatory bodies, governmental and staffs of enterprise. Moreover, these regulations refer to supplementary actions targeting the long term sustainability, avoiding levies, penalties and also conserving the environment when mitigating environmental risk. However, these regulation and policies are put in to place to confirm practitioners and managers respond to environmental issues and integrate it into their enterprise process.

Motivating forces is thus a variable that influences sustainability decision making goal in IT based organization. These forces are mostly commercial pressure and mainly stems from increasing energy costs, leading to the need for enterprises to lessen power consumption of IT hardware. Lowering energy costs is often associated with the aim to achieve economic advantage. Another motivation forces stated previously is governmental pressure for Green ITIS principally which stems from various forms of environmental standards and regulations enforced by governments around the world. Social pressure is employed by the cumulative clients/end users' call for Green solutions and the increased positive public awareness of Green initiatives (Jens et al., 2011; Sachin et al., 2015; Mohammad et al., 2014; Qi and Shaobo, 2015). Thus pressure can also influence practitioners' integration of Green practices, such pressures includes mimetic (pressure derived when IT based organizations go Green because other enterprise go going Green), coercive (pressure from governmental and non-governmental bodies), and normative pressure (pressure from the management in the enterprise). Also Incentives from going Green and consequences from not going Green also influence Green practice adoption and implementation (Grant and Sam, 2012; Mohammad et al., 2015; Bokolo and Noraini, 2016; Tracy et al., 2011; Stan et al., 2010; Sulaiman et al., 2015). Thus we propose that:

*Proposition 4 (P4). Interaction between management, governmental and non-governmental organizational pressure will have a positive effect on the adoption and implementation of Green ITIS.*

### **IT strategy**

Mainly involves depiction of IT based organizations in terms of the organizational routine, scope and management structure. This variable determines how practitioners implement their enterprise strategies. The strategy applied by IT based organizations in accomplishing their objectives is very vital in the Adoption and Implementation of Green practices. IT strategy mainly aims to support enterprise in decrease their operating expenses in product and services design and development. Thus Green ITIS can be used as a strategic decisions tool, since IT strategy is the most prominent variable of Green ITIS diffusion and implementation aimed at diminishing expenses and CO<sub>2</sub> emissions to achieve a sustainable strategic implementation in enterprise. Enterprise wanting to adopt Green practice must first develop a suitable IT strategy that acknowledges the importance of environmental issues by enacting environmental practices (Tracy et al., 2011; Stan et al., 2010; Sulaiman et al., 2015). Thus there is need to substitute a culture that encourages practitioners to tryout ideas about environmental issues reduction aligned with business integration. Furthermore research by Alemayehu (2008) found out that when practitioner notice a strong signal from their enterprise management regarding environmental issues, they are more likely to be involved in adopting and implementing environmental friendly initiatives. The initiatives, procedure routine and services of an enterprise will determine if they intend to go Green or not (Alemayehu, 2008; Carolyn and Jean-Paul, 2014; Decio et al., 2015; Roya, Ainin and Alemayehu, 2013; Mohammad et al., 2014; Qi and Shaobo, 2015). Thus we propose that:

*Proposition 5 (P5). Green ITIS practice is more likely to emerge if there exist a shared Green strategy in IT based organization.*

### **Information availability**

According to Watson et al. (2008) the need for information by practitioners leads them to seek IS that offers ubiquity such as the usage of systems to communicate with other practitioners, uniqueness such as enterprise resource planning (ERP) systems to manage the transportation of developed products/services to end users. Unison, which is involved when all practitioners in a project uses corresponding schedule, and lastly universality which involves services that has more functionality such as systems that provide practitioners with the latest Green information relating to the environment and climate. Sustaining these four information drives (ubiquity, uniqueness, unison and universality) is a key component in creating a successful IT based organization,

hich is also critical to implement sustainable systems and applications in enterprise (Watson et al., 2008; Tom, 2011). Helen, Alemayehu and Vanessa (2012) contributed by saying that information usage via ITIS can assist to moderate energy consumption, which is one of the aims of IT based organizations going Green, as there is a clear cost saving that comes with the use of less power as energy prices reduces.

Green ITIS aims to support enterprise achieve environmental sustainability initiatives and outcomes. Development toward enterprise going Green cannot be successfully undertaken without specific information provided through an established Green knowledge source (Watson et al., 2008; Adele et al., 2011; Albert, 2009). Lack of information, therefore, becomes a hindrance to achieving environmental outcomes and improving environmental performance in IT based organizations (Nigel and Stephen, 2010; Richard, Marie-Claude, Adele, Hector, 2011; Tom, 2011; Helen et al., 2012; Grant and Sam, 2012; Jeramy, Lisa, Kenneth and Vikram, 2013) thus we propose that:

*Proposition 6 (P6). Green ITIS practice is more likely to emerge if there exist a shared enterprise Green repository in enterprise to provide Green information.*

### **Green Practice (GP)**

Practice can be defined as collections of recurrent and planned human activities. Green process is the current sustainable activities carried out by practitioners in their enterprise (Ninlawan, Seksan, Tossapol and Pilada, 2010; Khalid, Patle and Sandeep, 2012; Joseph, Chulmo and Richard, 2013; Krishnadas and Radhakrishna, 2014). Green sustainable practices in IT based organizations are implemented by practitioners carrying out Green activities in IT based organization.

The process were derived based on works by (Alemayehu and Vanessa, 2009; Alemayehu et al., 2009b; Mohamad, Alemayehu, Kassahun and Teoh, 2010; Alemayehu, 2009b; Robert, Hsu, Chen and Chang, 2012; Bokolo and Noraini, 2015; Nathalia, Minsani and Karen, 2011; Alemayehu, 2008; Xiuna and Lin, 2009; Markus, Jakob, Eva and Stefan, 2013; Biswajit, 2014; Stefan et al., 2011; Murugesan, 2008; Chandani and Anamika, 2015; Nuttapon and Gabriel, 2012; Ijab and Molla, 2012; Alemayehu et al., 2009b; Khalid et al., 2012; Ninlawan et al., 2010; Joseph et al., 2013; Krishnadas and Radhakrishna, 2014; Deepti et al., 2014).

The Green ITIS process, lifecycle or reachness as mention by (Alemayehu and Vanessa, 2009; Alemayehu et al., 2009b) involved in IT based organizations comprises of creation, distribution, sourcing, usage and end of life.

### **Creation**

Creation also known as design in Green ITIS domain refers to the role of IT and IS in supporting enterprise's sustainability initiatives. This is implemented when practitioners utilize IT based systems for their enterprise process, carbon foot print analysis and environmental management development activities. It also encompasses IT based low CO<sub>2</sub> enterprise solutions such as telecommuting, IP telephony, web based business services, thin client, virtual collaboration and videoconferencing (Khalid et al., 2012; Ninlawan et al., 2010; Joseph et al., 2013; Krishnadas and Radhakrishna, 2014).

### **Distribution**

This phase involves developing systems with automated components, computers and other auxiliary subsystems with limited impact on the environment. This phase emboldens operative processes and increases the reutilization and reuse proportion of developed products. Moreover, this phase also involves sterile delivery systems to encourage minimal unwanted materialization that increases the competence of enterprise, thereby lowering resource consumption (Alemayehu and Vanessa, 2009; Nuttapon and Gabriel, 2011; Hong-Mei and Rick, 2012; Alemayehu and Ahmad, 2012; Alemayehu, 2013; David, 2013; Biswajit, 2014; Nadinastiti and Kridanto, 2014; Mohankumar and Anand, 2015; Chandani and Anamika, 2015).

### **Sourcing**

Sourcing also referred to as procurement, entails the practice of eco-sustainable preferable IT infrastructure purchasing in enterprise. This involves eco-sourcing practices such as, evaluation of the Green track record of software application, assimilating Green issues such as recyclable design and packaging in merchant assessment, enquiry of environmental foot print of IT hardware and ICT services providers and addition of social concerns such as the presence of harmful materials in IT hardware that are procured for IT based organizations usage (Alemayehu and Vanessa, 2009; Alemayehu et al., 2009b; Mohamad et al., 2010; Alemayehu, 2009b; Robert et al., 2012).

### **Usage**

Usage also known as operation includes reducing IT induced CO<sub>2</sub> emissions, structural avoidance results in reducing installed power capacity, enhancing energy efficiency in powering and cooling of enterprise IT assets. This process aims to bring about energy consumption decrease by optimizing of power utili-

zation without decreasing the installed power base (Xiuna and Lin, 2009; Markus et al., 2013; Biswajit, 2014; Stefan et al., 2011; Murugesan, 2008; Chandani and Anamika, 2015; Nuttapon and Gabriel, 2012; Ijab and Molla, 2012; Khalid et al., 2012; Ninlawan et al., 2010; Joseph et al., 2013; Krishnadas and Radhakrishna, 2014; Deepti et al., 2014).

### End of life

This is the most common process implemented in IT based organization. Based on finding from Alemayehu et al. (2009b), most organization dispose or recycle their enterprise redundant or obsolete IT hardware. Thus End of life also called disposal denotes practices in reusing, recycling and disposing of IT hardware in an ethical ecological environmental manner (Alemayehu et al., 2008; Alemayehu and Vanessa, 2009; Alemayehu et al., 2009b; Alemayehu, 2009b; Xiuna and Lin, 2009; Mohamad et al., 2010; Nathalia et al., 2011; Robert et al., 2012; Markus et al., 2013; Bokolo and Noraini, 2015).

Albert (2009) contributed by saying that it is important for practitioners to carry out each process in order to achieve sustainable enterprise, because some enterprise only practice one or two process and claim they adopt Green process which is wrong, thus we propose that:

*Preposition 7 (P7). Interaction between creation, distribution, sourcing, usage, end of life practice will have a positive effect on the adoption and implementation of a Green practice in IT based organization.*

### Control variables (CV)

The control variables are variables that are constant in the enterprise over a period of time. The control variables identified from the literature include sector, timing, size, country and revenue.

### Enterprise size

This variable was mentioned by (Chin-Jung et al., 2015; Jens et al., 2011; Katrina et al., 2014; Sulaiman et al., 2015; Alemayehu and Ahmad, 2012; Schmidt and Kolbe, 2011; Savita, Dominic and Ramayah, 2014; Sachin et al., 2014; Mohammad et al., 2014; Jack and Lucky, 2015; Oriana and Elena, 2014). Thus, the present study includes enterprise size based on enterprise's total assets in terms of the practitioners in the enterprise. According to Sulaiman et al. (2015) sustainable enterprise strategic adoption varies according to the size of the enterprise. Smaller enterprise have less sophisticated understanding of technical issues while larger enterprise are usually in possession of more infrastructure, finance and human resources. Although, bigger enterprises are also disadvantaged as they tend to be less agile and flexible than smaller enterprise. In

contrast, smaller enterprise are anticipated to be more innovative, they require less of communication, organization and external impact to make decisions.

### Enterprise sectors

This variable was suggested by (Chin-Jung et al., 2015; Katrina et al., 2014; Adela et al., 2011; Sulaiman et al., 2015; Alemayehu and Ahmad, 2012; Chris et al., 2014; Krishnadas and Radhakrishna, 2014; Savita et al., 2014; Sachin et al., 2015; Mohammad et al., 2014; Carolyn and Jean-Paul, 2014; Deepti et al., 2014; Jack and Lucky, 2015; Oriana and Elena, 2014). IT based organizations in diverse industry sectors may accomplish differently in terms of Green sustainable practice adoption and implementation. As enterprise in different industry sectors have different needs, it appears that those in more information intensive sectors are more likely to adopt Green initiatives than those in less IT intensive sectors. Enterprise such as industries such as banking, courier services, airlines, etc. which tend to have more information content in their products and services are more likely to shift to a more sustainable enterprise than those in engineering sector. Current adopters of e-commerce from the industrial sector tend to face more setbacks than other sectors. Enterprise type could affect how practitioners adopts and implements sustainable practices (Sulaiman et al., 2015).

### Timing

This variable was mentioned by (Chin-Jung et al., 2015; Jens et al., 2011; Sachin et al., 2015; Mohammad et al., 2014; Jack and Lucky, 2015; Oriana and Elena, 2014). The time an enterprise first adopt Green initiatives may affect its implementation due to first mover benefit. Thus this research includes timing as a control variable to recognize when the enterprise starts to adopt and implement Green sustainable practices.

### Country

Jens et al. (2011) proposed this control variable in their research stating that the topographical site of the country effects the adoption and implementation of Green practices in any enterprise, thus the administration decisions in countries will differ from one country to the other.

### Revenue

This variable was mentioned by (Adela et al., 2011; Schmidt and Kolbe, 2011; Fabian, Koray, Felix and Ruediger, 2012; Daqing, 2011) as a control variable in their research asserting that enterprise with suitable financial resources are able to examine new prac-

tices and cope with implementation failures. Hence, the income acquired by an enterprise over a period of time will influence if the enterprise adopts and implements Green strategies in its enterprise process. Therefore IT based organizations supporting Green practices in their business process is based on several variables, known as control variables which comprises of the time duration the enterprise originated, the sector of the enterprise such as educational sector, telecommunication sector, etc. The size of the enterprise also influence if practitioners will go Green or not. The location of the country is also a control variable since different county has different policies and lastly the revenue or profit generated by the enterprise will determine if the management will encourages and promotes Green initiatives or not.

An enterprise that makes more income will easily go Green unlike an enterprise that makes less income (Chin-Jung et al., 2015; Jens et al., 2011; Katrina et al., 2014; Sulaiman et al., 2015; Alemayehu and Ahmad, 2012; Bokolo and Noraini, 2015; Schmidt and Kolbe, 2011; Oriana and Elena, 2014). Thus we propose that;

*Proposition 8 (P8). The adoption and implementation of a Green IT/IS varies due to how long the enterprise has existed, enterprise sector, enterprise size, location of the enterprise and revenue made by the enterprise.*

### **Moderating variables (M)**

Moderating variables are variables that regulate certain independent variables. The moderating variables identified from the literature include age, sector, gender and education. The moderating variables in this research are derived from (Alemayehu, Vanessa, Hedu and Stasys, 2009d; Alemayehu et al., 2014; Deepti et al., 2014; Mohammad and Azizah, 2015). These sociodemographic variables (age, gender, and education) are critical in understanding how practitioners and management make decisions about adopting and implementing Green practices. This implies that, in attempting to understand how practitioners in IT based organizations make Green decisions, it is important to consider how the demographic variables moderate practitioners and management decisions in adopting and implementing Green initiatives.

### **Gender**

The relationship between gender and practitioners and management Adoption and Implementation of Green practices has produced diversified results. For example, Alemayehu et al. (2014); Deepti et al. (2014) reported that practitioner and management's gender does forecast Green attitude. Further, gender differences have been found not to have an effect on practitioners implementing and adopting Green practices in their enterprise. However, other re-

searcher such as Alemayehu et al. (2009d) has detected substantial differences in environmentally responsible behaviors because of gender differences. Alemayehu et al. (2009d) reported that women have more favorable attitudes toward the environment and are more involved in recycling activities. Thus the researcher believes that females are more likely to be engage in environmentally friendly and recycling behaviors than men. In addition, Mohammad and Azizah (2015) indicated that men pay meaningfully less attention to greenhouse gas (GHG) reduction activities other than women. Women are also more likely to characterize global climate change as the most significant environmental concern than men (Alemayehu et al., 2009d).

### **Age**

A number of researchers have explored the relationship between practitioners and management age toward Green practices adoption and implementation in IT based organization. Some have reported the relationship between age and the environmental attitudes of practitioners and management (Alemayehu et al., 2009d; Deepti et al., 2014). However environmental issues awareness is higher and more stable among practitioners and management members aged 55-60 years, those aged between 25-35 years have strong but unstable concern, and middle-aged citizens manifest a stable subset of concerns for the environment (Alemayehu et al., 2014). As the age of individuals 'increases, their engagement with reuse, reduce; recycle activities increases, although others have found an important and negative relationship between age and practitioners and management going Green (Mohammad and Azizah, 2015).

### **Education**

Several studies have examined the influence of education on sustainable practice in enterprise. However, the findings are indecisive. Some found negative correlation between the educational levels of practitioners in relation to sustainable practice, researchers such as Alemayehu et al. (2009d); Alemayehu et al. (2014) found significant positive relationships between education level and ecological environmental practice. Thus there is a positive link between practitioners and management age in relation to Greening their enterprise, as their age increases their association in sustainable activities such as in the reuse, recycle, refurbish, reduces, also increases. Alemayehu et al. (2014) Mohammad and Azizah (2014) reported that there is a significant correlation between age and Green ITIS practicing, and they found that young practitioners and management members are more towards practicing Green ITIS. Based on the gender of practitioners and management, it is reported by Alemayehu et al. (2009d) that gender is not forecasting the attitude towards the en-

vironment. Further, it has reported that there is no difference between males and females concerning sustainable practice in enterprise (Alemayehu et al., 2014; Mohammad and Azizah, 2014). The correlation among Green practice adoption and implementation in relation to the educational level of IT practitioners and management members has been researched by Alemayehu et al. (2009d); Alemayehu et al. (2014); Mohammad and Azizah (2014). The results regarding the influence of education level on Green practice adoption and implementation is mixed which some scholars such as Alemayehu et al. (2014) reported the significant influence of educational level while others argue the insignificant impact of educational level on Green practice adoption and implementation. Based on the preceding arguments the following propositions are made:

*Proposition 9a (P9a). The age of IT practitioners and IT governance management member moderates the Adoption and Implementation of Green IT/IS in enterprise.*

*Proposition 9b (P9b). The gender of IT practitioners and IT governance management member moderates the Adoption and Implementation of Green IT/IS in enterprise.*

*Proposition 9c (P9c). The educational level of IT practitioners and IT governance management member moderates the Adoption and Implementation of Green IT/IS in enterprise.*

### **Dependent Variables (DV)**

The dependent variable (DV) is the output or the effect of something in IT based organizations implementing and adopting Green practices. The dependent variable (DV) is based on the independent variables and the control variables (Siti and Ruziah, 2012), thus DV depends on IV, while IV influences DV. Therefore the dependent variable is *Green Adoption and Implementation*. This is the dependent variable as previously stated; this variable depends on other variables. This research aims to provide a decision making support model for adoption and implementation of Green ITIS practices in IT based organization. According to Hart (1997); Watson et al. (2008); Tracy et al. (2011); Adela et al. (2011) IT based organizations pursue sustainability based on the three phases of Sustainability practices namely; pollution prevention, product stewardship and clean technology.

### **Pollution prevention practice**

Mostly concerns the control and mitigation of contaminating emissions wastes during and after development procedures. In IT based organizations pollution prevention practice involves innovative use of IS to lessening pollution produced by enterprise processes. In mitigating pollution, practitioners use IS technology such as innovative carbon energy assess-

ment and control application or telematics systems to reduce enterprise's carbon footprint (Hart, 1997; Watson, 2010; Tracy et al. 2011, Adela et al., 2011).

### **Service steward practice**

This phase requires environmental effects to be considered all through IT based organizations processes. This phase is generally based on the ethics of the practitioners and management. In IT based organization, service stewardship practice includes advance use of system such as innovative digital platforms, conference and collaboration system that improve the eco-friendly of product and service Adoption and Implementation. Service steward practice also involves the utilization of diagnostic applications such as the life cycle control program in the product and service policy that can assist practitioners attain product and service ethics strategy (Hart, 1997; Watson, 2008; Tracy et al. 2011, Adela et al., 2011).

### **Clean technology practice**

Clean technology or sustainable development practice includes the use of modern application or systems to change enterprise processes by implementing and adopting practices that improve and preserve resources, low waste, non-polluting, and energy efficient strategies. Clean technology practice in IT based organizations involves usage of sustainable data and learning controlling systems that change enterprise operations. This phase also involves usage of compliance application software that is used by practitioners in product and service development for supporting enterprise decision making and creation of knowledge for ecological sustainability. This can be seen as a Green clean technology or sustainable development practice (Hart, 1997; Watson, 2008; Tracy et al. 2011, Adela et al., 2011).

### **Techniques for Green ITIS practices in IT based organizations (GT)**

Software agents and case based reasoning is used as techniques to facilitate Green ITIS Adoption and Implementation of practitioners carrying out Green process in IT based organization. Case Based Reasoning (CBR) is one of the evolving paradigms for developing intelligent systems. It shows important potential for enhancing the efficiency of unstructured and complex decision making. It resolves new issues by adopting previously successful solutions to similar problems.

In CBR technique a set of Green cases stored in the case base is used as main source of knowledge. CBR support practitioners to use experience from past and chooses the most similar case to the current problem, based on the concept that similar problems would have similar solutions (Jack and Lucky, 2015). This

research will contribute to Green ITIS research in the domain of IT based organizations by utilizing case based reasoning approach to support practitioners in decision making on how to implement and diffuse Green practices in IT based organizations process. Thus caring for the environment and reducing climatic changes. Data from the case-base library can support practitioners in decreasing energy cost and lessen CO<sub>2</sub> emission.

Software agents can assist practitioners and management in making Green decisions to support sustainability in IT based organization. Multi software agents are software that performs specific task on behalf of practitioner, independently or with little control. These agents are useful in automating monotonous tasks, discovering and explicatory information (Mazlina and Tutut, 2013).

The characteristic of the multi agents in the model includes; autonomy in which multi software agents are aware of their environment operating without human interference to some extent in order to assist in decision making. With autonomous behavior, software agents can take control over Green activities and work without practitioners' interference. The reactivity of multi software agents can observe their environment and respond to specific Green activities changes. Software agents identify the context in which Green practices are carried out and react to it appropriately. Pro-activeness of multi-software agents makes agents initiate Green practice suggestions.

Whereas the persistence of multi-software agents are not implemented on demand but run continuously and decide for themselves when it should assist in Green implementation. Interactivity is the ability of an agent to maintain communication between different Green processes. Multi-software agents establish dialogue and share Green resources and services spanning across different practitioners. Due to the mentioned features of software agents and case based reasoning, we decided to utilize software agents assisted by case based reasoning to facilitate the Green process carried out in IT based organization.

## Discussion

The role of energy in IT based organizations is being transformed. It is moving from being an item towards becoming a service. As such, Green ITIS can assist manage energy usage efficiently and effectively, it is predicted that there will be almost 100 % rise in the ICT division's footprint by 2020, but approximates that the operational use of ITIS within IT based organizations could cut CO<sub>2</sub> emissions by up to 5 times this quantity. IT based organizations are progressively realizing the significance of sustainability, and many are attempting to design or redesign their enterprise processes so that their activities are more ecologically friendly.

Even though IS literature has studied how IS can support several enterprise processes and improve the effectiveness and efficiency in enterprise, few studies have focused on how Green ITIS strategies and initiatives can improve and support practitioners decision making in relation to adopting and implementing sustainable practices.

Sustainability is a multi-dimensional objective that requires action from practitioners, societies and enterprise. This study focuses on supporting decision making of practitioners and management in adopting and implementing Green sustainable practices in IT based organizations domain. However, variables and process can also come into play and affect enterprise Green decision making. Presently more enterprise embraces Green initiatives. In order to stay competitive, IT based organizations needs to be prepared for strategic Green decision making. This research explores the roles of ITIS in developing ecological sustainability in IT based organization.

Based on sustainability research, we proposed a model and propositions to be further investigated through empirical research. The proposed model shows that implementing Green practices in enterprise is carried out based on the Green process, from creation, distribution, sourcing, usage and end of life is useful in implementing and adopting sustainable knowledge to practitioners in attaining environmental goals.

Green ITIS has recently gained increasing prevalent consideration in IT based organization. Besides concentrating on economic gains of enterprise activities, management and practitioners also need to consider the environmental and social impacts of their enterprise activities (Elkington, 2004). Green ITIS can actually support enterprise increase profitability, reduce cost, sustain their corporate sales, competitive gain among other firms, and become sustainable contributors to the humanity and enterprise business process in the long term.

Additionally, this research states the importance of sustainability research and practice in IT based organizations and consider all three factors of sustainability profit, planet, people, concurrently, if practitioners considers each of the independent variables and implement each of the model process assisted by case based reasoning and software agents they can contribute towards making profit for their enterprise. Practitioners can also care for the planet by reducing CO<sub>2</sub> emission, thus contributing to a cleaner environment for people and future generations to come.

## Research implication and limitation

### Theoretical implication

The proposed Green ITIS model represents an original contribution to the information systems literature. The models' variables and process together with case based reasoning and software agents will be useful in Green IT and Green IS research. How-

ever the theoretical implication of this research is based on the fact that the research is basically related to IT based organizations only. Green practices in IT based organization, institutions, companies and universities are implemented and diffused to ensure that IT infrastructures (hardware, software and network communications) are utilized and disposed-off properly. The research concern IT practitioners among Malaysian institution, similar to research done by (Matti, Bukaza and Joy, 2009; Maryam, Mahmood, Neginsadat and Mohammad, 2012; Carolyn and Jean-Paul, 2014; Ibrahim and Alok, 2014; Alemayehu et al., 2014; Nana, Amevi and Nii, 2016) where their research was carried out in institutions and Malaysian enterprise similar to research done by (Watson et al. 2008; Alemayehu, 2008; Jason, 2010; Edward et al., 2011; Robert et al., 2012; Tom, 2011; Bokolo and Noraini, 2015; Grant and Sam, 2012; Sulaiman et al, 2015) where the research was carried out in IT based organization.

Thus the scope of research considers only Green practices in university institution and enterprise. Also this research considers only IT practitioners in IT based organizations only. There are other Green ITIS model and frameworks that were searched and reviewed from the literatures developed by other researchers that was not considered in this paper because the researcher did not outline their variables or/and process in their proposed approaches. Other research works was not considered because the research is not related to IT based organizations domain.

### Practical implication

This proposed model comprising of Green process, variables and techniques which are software agents and case based reasoning (CBR). The model shows how Green ITIS can be implemented and diffused in IT based organization. Practitioners can use the identified process and variables as a guideline in making decision for attaining sustainability in their enterprise. The model also supports practitioners to implement Green initiatives not only from the human and managerial perspectives but also the IT technical infrastructure.

In addition, the model, rather than viewing Green ITIS from one domain of IT strategies, is based on Green process comprising of creation, distribution, sourcing, usage and end of life and variables. The proposed model can also offers a common platform for practitioners to make decision to benchmark and assess their current Green IT initiatives and strategies only.

### Limitation

We recognize the following limitations of the study. First, the field of Green ITIS and the enterprise abilities to transform toward Green ITIS practices are

evolving. We utilized both academic and practitioner literature using desk based research to identify the model variables, process and suitable techniques to develop the model. However, we haven't conducted an in-depth case studies based on interviews to confirm and pool additional variables and process if any. Although the approach suggested is suitable to ensure content validity, there is need for further improvement, especially one that is based on in depth case studies to derive any potential variable or process that are missed from the present model.

### Conclusion and future works

The adverse side effects of IT combined with the higher dependency on IT have elevated the importance of practitioners going Green. This has resulted to IT based organizations utilizing IS to achieve sustainability in the enterprise business process. Practitioners' adoption and implementation of Green practice is essential to limit the negative effects of the fast universal growth of domestic energy demand. Therefore, understanding the variables influencing Green ITIS adoption and process involved in implementing Green ITIS is both an enterprise asset and a social benefit to the environment.

But presently practitioners find it hard to make decisions on how to implement and adopt Green sustainable practices in IT based organizations. Thus this research study proposes a Green ITIS model that assists practitioners in adopting and implementation of Green initiatives in IT based organization. The significant impact of decision making support on Green practice adoption has already been reported in the literature and findings of this study outline the proposed model variables, process and techniques that are based on previous scholar works.

The proposed models' independent, moderating, control and dependent variables supports the findings from previous studies shown in Table 2 of this research paper. The model process is similar to previous works by (Alemayehu, 2009b; Alemayehu, 2009a; Alemayehu et al., 2009a; Alemayehu and Vanessa, 2009).

This study provides practitioners with guidance regarding the adopting and implementation of Green initiatives and strategies in their enterprise. IT based organizations can use the proposed model's comprehensive set of variables and process to measure their current enterprise process. The study offers a basis for benchmarking current enterprise process against the models'. The model processes are critical drivers to generate sustainability value in IT based organization. The models' process and variables represent both tangible and intangible assets and infrastructures in the enterprise.

Thus the process serve as strong performance measure components for strategic initiatives and provide practitioners and management with a means to reflect on Green actions taken through the enterprise

sustainability development procedures. Researchers investigating the variables and process involved in making decision on how IT based organizations can fully go Green can refer to the proposed model as a support oriented model. The model can be used by other researchers to institute a cause and effect relationship. It can also be used by practitioners as a Green decision support model to assess how Green their enterprise process is based on the Green process. Thus the proposed model enriches the Green ITIS body of knowledge.

Future work/Ongoing work involves the adoption of a mixed research methodology (qualitative and quantitative approach) will be adopted, similar to Nicky, Henning and Lutz (2014) research. Presently interview and questionnaire instrument are being developed based on previous measurement items from relevant literatures.

The model process and variables will be verified using case study by interview carried out in different Malaysian based enterprises similar to work carried out by (Alemayehu and Vanessa, 2009; Schmidt and Kolbe, 2011; Stefan et al., 2010; Stan et al., 2010; Savita et al., 2014; Nicky et al., 2014; Decio et al., 2015). The case study data will be analyzed using descriptive and narrative analyses. After which Green sustainable documents will be collected to verify the model also.

Data will be collected using online survey (questionnaire) among various ITIS practitioners in enterprise which is in line with research implemented by (Alemayehu, 2009b; Alemayehu, 2009a; Alemayehu et al., 2009a) who used surveys to validate their developed model. Structural Equation Modelling (SEM) will be used to analyses the data to refine and validate the model relationships similar to work carried out by (Sulaiman et al., 2015; Alemayehu et al., 2009b; Alemayehu, 2009a; Adela et al., 2011; Jens et al., 2011; Alemayehu et al., 2014; Sulaiman et al., 2015).

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# Responsible Development and Durable Development

## Rozwój odpowiedzialny i rozwój trwały

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### Abstract

In this article, it analyzes two contemporary models of social and economic development – responsible development and sustainable development. Reflections on responsibility in the present social and economic context precede reflections about the essence of the model of the responsible development. For various reasons irresponsibility increasingly prevails over responsibility, and responsibility becomes anonymous and fictitious. Thus, the tendency to behave and to act with impunity grows. One of the forms of responsible development is the so-called smart growth. Above all, people appropriately educated and wise should realize it. Unfortunately, the number of stupid people in the world constantly increases. The model of sustainable development raises doubts from the beginning. Almost all people criticize this model or refer to it in disbelief. Only optimists see it as the only chance for the survival of humanity. The choice between responsible and sustainable development is difficult, because each one is faulty. It would be good to create one model from these two models in a form of their synthesis. Certainly, that is a difficult challenge, but doable.

**Keywords:** responsible development, durable development, sustainable development, responsibility, durability, balance, asymmetry.

### Streszczenie

W artykule analizuje się dwa współczesne modele rozwoju społecznego i gospodarczego – rozwoju odpowiedzialnego i rozwoju trwałego. Rozważania o istocie modelu rozwoju odpowiedzialnego poprzedzone są refleksjami nad odpowiedzialnością w teraźniejszym kontekście społecznym i ekonomicznym. Z różnych przyczyn subiektywnych i obiektywnych nieodpowiedzialność coraz bardziej przeważa nad odpowiedzialnością, a odpowiedzialność staje się anonimowa i fikcyjna. Dlatego rośnie tendencja do zachowania się i działania bezkarnego. Jedną z form rozwoju odpowiedzialnego jest tzw. wzrost inteligentny. Przede wszystkim powinni go realizować ludzie odpowiednio wykształceni i mądrzy. Niestety, w świecie jest coraz więcej głupich. Model rozwoju trwałego budzi wątpliwości od początku. Prawie wszyscy krytykują go lub odnoszą się do niego z niedowierzaniem. Tylko optymiści widzą w nim jedyną szansę na przetrwanie ludzkości. Wybór między rozwojem odpowiedzialnym a trwałym jest trudny, ponieważ każdy z nich jest wadliwy. Być może, dobrze byłoby z tych dwóch modeli stworzyć jeden w postaci ich syntezy. Z pewnością jest to wyzwanie trudne, ale wykonalne.

**Słowa kluczowe:** rozwój odpowiedzialny, rozwój trwały, rozwój zrównoważony, odpowiedzialność, trwałość, równowaga, asymetria

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### 1. Responsible development

#### 1.1. The matter of responsibility

Responsibility comes from the willingness to bear the consequences for what we do, especially for all harmful decisions, actions and negligence. The consciousness of the prohibitions and orders that rule in

a concrete place and time determines the sense of responsibility. Responsibility closely links to the dutifulness that is a prerequisite for it. In principle, irresponsibility, like non-fulfilling the obligation, entails moral, legal, political or other unpleasantness. However, most often the responsibility has a moral or legal dimension. The consequences of violation of

the legal norms, ethical standards, and religious orders ruling in the given society are penalties, remorse, penance, condemnation, ostracism, and loss of trust. Violation of law or regulation entails a mandate, a court order or an admonition. Unfortunately, more and more people are irresponsible despite the awareness of painful consequences. There are subjective causes for the increase in the number of irresponsible people. Firstly, because responsibility limits their freedom. Secondly, they live in liberal systems that guarantee the greatest freedom to individuals. However, in fact, this freedom is strongly limited; so, it is rather freedom declared than true. There are also objective reasons, inherent to the nature of neo-liberal democracy.

Until recently, people have been responsible for what has already happened to their fault, i.e. for actual and real effects. Now, they are more and more responsible for what may happen, i.e. for possible or hypothetical effects. Thus, beside the real responsibility, it is yet a potential responsibility. For some reasons it is good when people are responsible for what can happen with their fault in the distant future. However, such *forward-looking* responsibility makes sense only when it is possible to predict effects with a high degree of probability in the available time horizon. Nevertheless, in today's world where statistical laws, chaos, cases and bifurcations play an increasingly greater role, an accurate forecasting is impossible, even for the immediate future. Where it is highly developed democracy and cooperation, more and more people are involved in specific activities and in decision-making processes. As a result, the effects of people decisions and their activity are increasingly due by collective work and their authors are unknown. Therefore, the individual and concrete responsibility disappears progressively. Together with this, collective and anonymous responsibility increases. The more people make decisions, the more abstract and indirect responsibility replaces the concrete and immediate responsibility. And when it is unknown who specifically and really is responsible for something – so it is in the case of a *collective offender*, i.e. a collective, anonymous and abstract entity – then it is spreading irresponsibility and even impunity. The more people are co-responsible for something, the more their responsibility becomes fictitious and empty. Finally, this leads to the fact that no one is responsible for nothing, because everyone is responsible for everything. More and more often, people want to be free from their responsibility, guilt and punishment. They transfer their own guilt and responsibility to different things. Therefore, the subjective, i.e. human and personal responsibility transforms progressively in the objective responsibility. Things, of course, are not guilty and cannot bear any consequences. For example, it is said that the bad state of the protective devices (flood embankments, dams etc.) is responsible for the flood. However, in fact, they are the people,

who have wrongly built them and have not supervised them. Or another example: roadside trees are responsible for traffic accidents, and not the drivers which are badly trained or mindless. This is why one cuts out them massively, although it does not affect the number of accidents.

In our day, concrete responsibility transforms in abstract, individual in collective, real in illusory, and direct in indirect. Thus, responsibility transforms even in the impunity and the concept of responsibility progressively loses its meaning.

Together with this, irresponsibility becomes more and more a mass phenomenon. People are already used to it and they relate indifferent to it and generally, tolerate irresponsibility. They do not tolerate only irresponsibility at representatives of power, protected by various immunities that allow them to make decisions that harm society and to experiment on living organisms – institutions, organizations and people, which damage them. The higher is a position by someone in the hierarchy of power or management, the more his responsibility is anonymous, empty and unpunished (Sztumski 2012).

Awareness of impunity among people at high levels of society management allows them to make thoughtless and irresponsible decisions that often harm the common good and are risky. The rulers do not want to be responsible towards people. They prefer to be responsible towards the *God and History*, claiming that this is a higher degree of responsibility. Indeed, it is illusory responsibility and a fiction of responsibility, because it refers towards a fictional or abstract being. However, this aims at calming the conscience of rulers or to ordinarily cheating people. Only an individual acting in his own strictly local environment is personally, explicitly, directly and concrete responsible. However, such personal and limited in time and space responsibility is of no importance to the functioning of society as a whole, and especially – in the border case – of the world society.

### 1.2. The essence of responsible development

Responsible development means working to meet the growing needs of people, taking into account environmental, social, economic, health and safety factors when making decisions. Responsible development:

- Is consistent with the overall goals of the community.
- Satisfies economic, cultural and educational needs.
- Sets priorities for the development of services and products that are not currently available, and not for existing ones.
- Provides employment for as many people as possible and provides them with decent pay, which allows the worker and his family to meet essential living needs.
- Saves as much as possible fossil fuels, energy and water.

One of the forms of responsible development is the *smart growth*. For now, it applies in some areas of social life, for example in urban development and economy. In the first case, it is about such urban planning so as to give city residents the best possible conditions of recreation, transport, logistics of the administrative and service centers, health and so on. In the second case it is about economic development realized through progress of innovation and knowledge. In place of the former sentence *Money makes the world go round* now appeared another – *Knowledge makes the world go round* (Freund, 2017). Knowledge is the only natural resource, which not diminish, when it is consumed, but it grows. Probably, *smart growth* will soon spread rapidly to other spheres. Maybe, one day it will be fashionable such a sentence: *Wisdom makes the world go round*. Unfortunately, there is little hope for this, because it rapidly progresses the stupidity of the masses. C. M. Cippola (1987) stated based on research that in every community there are as many stupid people – on average 80%. Now, it is ca 5,6 billion stupid people in the world, an only ca 2,0 billion wise people. However, with the civilization progress, the proportion of stupid people to wise people will yet increase (Connor, 2012).

The necessary, but insufficient condition for the responsible development and *smart growth* is the maximal rationalization of economics and management. Therefore, since some time, the economics is mathematized rapidly. This make possible determining the parameters which describe the state of the economic systems, the creating mathematical models of the economy, the controlling economic processes, and the minimizing production costs through more accurate calculation of profits and losses.

Rationalization of the economy contributes to its improvement. It means the use of methods, techniques and means that provide the most favorable economic results (among other things, the biggest gains) through the minimal use of capital, work time, energy and raw materials. Rationalization of the economy has led to some paradox: it rationalizes the economy for maximizing profit, and simultaneously it irrationalizes intentionally the attitudes and behaviors of consumers. This paradox reflects one of many characteristic contradictions of nowadays economics. It is also a paradox typical by forming a knowledge society. Unfortunately, despite the increasing enrollment and the number of people with higher education, irrationalism still prevails over rationalism, and stupidity prevails over wisdom. (This is another example of social asymmetry). However, let us imagine that someday the tendency towards rationalization will prevail over the tendency to irrationalization, and that the economy as well as other spheres of life will fully rationalized. This could happen because of widespread robotization and of the maximal use of artificial intelligence. Many people, like Stanislaw Lem, Stephen Hawking, Bill Gates,

John McCarthy and Elon Musk warn of the potential risks connected with artificial intelligence. They claim, it is not only about reduction the demand for human labor (robots will work instead of people) and associated negative social effects; this is even a threat to human civilization and to the existence of the human species. Firstly, this can happen when, the artificial intelligence will be so developed that it will replace all functions of the human brain. For now, the problem is the expansion of artificial memory (it must match the memory of the natural brain) and miniaturization of the artificial brain (Rózanowski, 2007).

Secondly, when artificial intelligence will become a *Superintelligence*, much superior to human intelligence (Bostrom, 2014). This seems unlikely today, and if, so in the very distant future and – as the optimists say – we do not worry about it. However, this can happen in a shorter time, because on the one hand, the development of artificial intelligence occurs rapidly, and on the other hand, intelligence of the human population is decreases rapidly, perhaps, proportionally to the development of artificial intelligence. However, this can happen in a shorter time, because on the one hand, the development of artificial intelligence occurs rapidly, and on the other hand, intelligence of the human population is decreases rapidly, perhaps, proportionally to the development of artificial intelligence. However, already nowadays, artificial intelligence can turn out to be dangerous if it gets in the hands of cybercriminals, irresponsible people or madmen. The greatest threat to people is the progressive cyborgization that tends to the emergence *people 2.0*, when artificial intelligence will reach the level of the natural intelligence, and to the *people 3.0*, when in the age of the *Internet of Things* the human will become superfluous at all (Kurzweil, 2014).

Cyborgization progresses gradually, but noticeable, and it aims to decerebration of people, to the disappearing their creativity and critical sense, as well as to reduction their sensitivity and emotional sphere (Sowa, 2015). In this way, there will be less man in man. As it results from the foregoing considerations, full rationalization is not at all as good as it might seem.

## 2. Durable development

### 2.1. Remarks on durability

For a long time people are interested in durability, but not so as from the early seventies of the last century. Then the issue of durability became important from the point of view of ecological balance and it engages people on a mass scale. The word *durable* contains long-term action, many years' effects, stabilization, longevity, balance, and ability to create conditions favorable to something. Thanks to environmentalists, durability refers to social development (economic, civilization etc.) and it means balancing,

harmony as well as self-sustaining. Often, one uses the word *durable* as a substitute for *sustainable development*. Some authors state that this word functions in social communication like the German *Gummwort*, i.e. an *elastic word* with innumerable meanings (Wullenweber, 2000). Since 2009, *sustainable* also means what *satisfies grandchildren*, e.i. what the Germans call *enkelgerecht*<sup>1</sup>. The word *sustainable* has become a fashionable instrument for evaluating human activities in many areas of social life. Now, if someone does something, he ought to do this having in mind the chance of survival not only the present generation but also many future generations, and so he should act with thought about balance, harmony and long-term consequences. The object of concern of people, and above all specialists in various fields, is sustaining social systems, processes, and phenomena in equilibrium, i.e. in stable states. It adds the words *equilibrium* and *balanced* to the names of many existing social phenomena, and one wants to balance all new phenomena, often in a forced way and senselessly. Now, everything has to be balanced: transport, gardening, eating, clothing, leisure, teaching, studying, fun and so on.

Social systems differ from physical ones, but they have much common features. Therefore, in deliberations about the balance of social systems one uses increasing the knowledge about equilibrium in physics. Physicists distinguish two types of equilibrium – static and dynamic. Static equilibrium is when the resultant of all forces acting on the body equals zero. Then – according to the first principle of dynamics – the body remains at rest or it moves monotone in a straight line, and equilibrium means a physical state of the body. Dynamic equilibrium is when the body deviates from its initial position, oscillates around it, and then returns to it after some time. Then, equilibrium means a physical process.

Sustainable development is about maintaining social system in a state of durable and dynamic equilibrium, understood as a social process. It became widespread belief, that balance and harmony are beneficial for human life and social development. Unfortunately, this is another myth that functions in social masses. Another myth is the view that total elimination of stress from human life is something best for him, or that the creation of a classless society (as in communism) or homogeneous (as a result of globalization) by the elimination of contradictions and social inequalities ensures happiness to people and is the most favorable for the development of humanity. It does not take into account that the equilibrium of a social system can be good or bad, useful or harmful. That depends on the social, historical and spatial context, on the aims and interests of the people, and on the choice of the criterion of good, which is usually arbitrary and relative. For example, the balance

between good and evil is bad, because good should always prevail over evil.

Social pressure to maintain equilibrium, which appeared recently in Western civilization, has its source in the European cultural heritage. Initially, in the antiquity, in beliefs and philosophies of Greece and Rome. Later in Christian culture as well as in the classical natural sciences. Up to the twentieth century, Aristotle's thought dominated European philosophy, Christian theology, classical (bivalent) logic and Newtonian classical mechanics, even relativistic. It is characteristic for thinking derived from European tradition the supposition that opposites should be in balance. Therefore it postulates that it ought to exist some *golden mean* between them in the form of equilibrium. (This is contained in the dialectical principle of *unity of opposites* formulated by Hegel and Marx.) From here, it comes the desire, to balance social systems, human activity and psyche as well as to search a *golden mean* treated as some panacea.

Since centuries, people were convinced about the equilibrium and durability of natural and social systems. This myth has been preserved in the memory of many successive generations thanks to cultural heritage. Today it is difficult to fight with it, despite the fact that modern science, philosophy and life experience confirm its anachronism and groundlessness. Similarly, over the centuries, people believed in the symmetry in the world, also anachronistic and false from the point of view of present knowledge. Despite this, the principle of symmetry governs still for example in physics, where different important principles, such as the conservation of energy, of momentum, of angular momentum and so on, result from it. The principle of symmetry is a useful tool for idealizing the sensory world. With this principle, one can describe physical phenomena in a simple and easy way by the mathematical equations, especially in macroscopic physics (Asymmetric phenomena one described by inequalities. At least in the mass opinion, algebraic operations on inequalities are more complex and difficult than on equations). It is difficult to decide whether these two suppositions about balance and of symmetry, functioning as stereotypes in the thinking about the world and in descriptions, came from aesthetic preference, or the criterion of aesthetics comes from the knowledge of the world. For example, symmetry and balance, which are signs of beauty, are still criteria of value of physical formulas. About their correctness, testify among other things the appearance and the simplicity.

Now, we form a new image of our world. This world has changed firstly, because of natural and social evolution and secondly, because we have continuously a new knowledge and life experience. The

<sup>1</sup> See: *Nachhaltige Landwirtschaft: Staatssekretär Rabius sieht Schleswig Holstein auf Gutem Weg*, in:

'Hallo Hollstein', *Nachrichten und Themen von der Ostseeküste*, 29. Oktober 2010.

world changes radically since about fifty years very fast, one can said suddenly, if one compare this period with the age of our planet, estimated at about 4.55 billion years (Pieńkowski, 1998). These changes are at most because of human activities, which is more spontaneous and thoughtless than purposeful and reasonable. Mainly, due to human interference in homeostatic mechanisms that allow nature and social systems to return to equilibrium and to ensure durability. The spoiling of these mechanisms in consequence of irresponsible and thoughtless manipulation produces imbalance, resulting in numerous perturbations, particularly the destruction of order, instability and disorder of symmetry. I treat the destruction of the tendency to equilibrium in the natural and social systems on a wide scale as the turning point in the history of the world and humanity. Above all, asymmetry and imbalance reign in today's world. Previously they were perceived badly. Currently, one rates them positively and even especially exposes them. In connection with this, the aesthetic criterion has changed. Since some time, it promotes what is unsymmetrical and unbalanced as something beautiful. Asymmetry and instability define the style in fashion, art and architecture of our time. Probably, also in the future they will determine the good taste. However, the stereotype of balance functions still as if in spite of this and one maintains it in many spheres of social life. Especially, when people use it to the principle of justice. For example, in law, there is a question of the balance between guilt and punishment. Punishment should be strictly adequate to guilt, that is, it should balance the guilt. If this is not the case, then one judges such sentence as unjust. In economics, this applies to various balances, in particular between labor and wages, supply and demand, incomes and expenses, etc. The balance, i.e. some form of the equilibrium, is the most important problem in economic evaluations. However, the balance in economy is ideal states, not real. Wage must be less than the work of employee, because this guarantees a profit to employers. In a normal economy, supply must be greater than demand, because this contributes to the prosperity. In fact, the balance can be applicable only in accounting. It does not apply to the sensory world, but only to its mathematical description. In the real world nothing is in balance, as if that should result from the third principle of dynamics, which in a very simplified popular version states: *Action equals reaction*. In pedagogy, the students' assessment has to reflect accurately their knowledge, i.e. the amount of information, which they have. However, such a fair evaluation almost never exists, because it is not guarantee, even when one uses objective tests, because of the subjective factors. About such understood justice, one can dream at most. The reality is quite different: everywhere they are various degrees of injustice, inequality and unbalance.

Durability is important in our everyday life. On the one hand, we demand it, because we want to ensure our long-time existence in the memory of posterity. We live so long, until other people remember us. So, the worst curse of the Jews is, *Let no one remember you!* For this reason, one builds stable gravestones, *eternal* tombs, bronze monuments and pyramids. On the other hand, for austerity reasons, we want that our everyday items are durable as possible, that they do not spoil as long as possible. That is why we build durable buildings and create *indestructible* materials.

On the ground of our negative life experience, we fear changes, because they are often *changes for the worse*. Therefore, we want to preserve *status quo* of our life conditions and life milieu. Thus, we are conservatives to some degree. Conservatism and durability lie in human nature. However, one can ask whether our concern for durability, balance and symmetry are justified and meaningful. There are different opinions on this subject and different answers. Due to our ego, survival in various forms of memory is justified, reasonable and meaningful. It gives us a sense of satisfaction from our own life and ourselves. In addition, it contributes to the common good, because it promotes good deeds and enriches the cultural heritage. On the other hand, it raises doubts for other reasons. For example, it has not sense from the point of view of economic development, as it does not accelerate the economy. The driving force of economic progress is the rotation of products (goods) and money. The faster circulate goods and money in the markets, the higher is the profit. Moreover, profit motivates people for rational management, better economic activity, innovation, higher productivity, saving, etc. However, it does not have to affect the prosperity of individuals and their well-being. On the contrary, the effect economic growth is the progressive impoverishment of social masses and the growing disproportion between the masses of the poor and the castes of the rich. This evokes frustration and revolutionary sentiments that are negative social phenomena. But in economics, especially macroscopic and global, people do not count, at least for as long as they do not organize themselves in a political power that could change political system and the course of history. From the standpoint of the social masses, the economic growth, no matter how it is (slow, durable, balanced, sustainable or accelerated), is senseless, because in fact, it does not turn good for them. Symmetry in the economy, expressed in the form of balance, is also not useful, because it means stagnation. The saturation of the market with durable products, which can work in *infinitely long* time, is only apparently beneficial to people. Really, it causes a decline in production or at best its stagnation with all the negative consequences: liquidation of factories, increase of unemployment, slower trade dynamics, decreases the number of transactions and finally – economic crisis.

So, durability or slowdown of the dynamics of the economy are not conducive to economic and social development. Control of economic growth in consequence of its slowdown and its restriction to ecological and rationally justified needs (which are increasing anyway), while at the same time providing people with good economic conditions resembles the squiring of the circle. This is practically an unsolvable task, at least on ground of contemporary theory and philosophy of economics. Durable development limits creativity and innovation, because it allows them to develop only to such an extent that they do not disturb stability, that is, the stable balance. What is durable must be stable.

## 2.2. The question of durable development

It is impossible to define *durable development* in a simple way because there is no fully and accurately definition. One defines it by the sum of numerous partial definitions, which take into account various elements and aspects. Some of these elements and aspects repeat themselves and therefore one can consider them as particularly characteristic of sustainable development. In this way, it created such definition: *Durable development is such, which vouches for this, that future generations will satisfy their needs no worse, than generation that lives now* (Hauff, 1987). Hence, durable development is oriented both to the present and to the future. Herman Daly (former economist at the Department of the Environment at the World Bank) studied the most important elements of sustainable development and came to the following conclusions:

- The rate of degradation of renewable resources cannot exceed the rate of their regeneration.
- The emission level cannot be higher than the assimilation capacity.
- Consumption of non-renewable resources has to be compensated by the appropriate increase in stocks of renewable raw materials (Hardtke, Prehn, 2001).

There are different definitions of durable development depending on what aspect of this development is the subject of research of some scientific discipline. For example, according to the economic definition, *durable development means such development, which does not generate profits that flow then to the environmental and social projects, but such development, which manages profits that are already accepted for social and environmental reasons* (Pufé, 2014). In general, the system develops durably, if it is able to survive and to exist in a long time (Carnau, 2011). The expression *durable development* is synonymous with the terms *sustainable development*, *eco-development*, *sustainability* and

self-sustaining development. The purpose of this development is to maintain the quality of human life milieu, i.e. geobiosphere and anthroposphere, in an unchanging state despite significant human intervention. This pious goal is practically unattainable, because people live always at the cost of their environment and therefore, in spite of best wishes, they exploit and degrade them and deplete resources. Otherwise it cannot be. Really, the issue is that the interference of people in the environment should deteriorate its quality in less and less extent. This allows asymptotically target this end goal. The essence of the concept of durable development is that current generation should exploit its life milieu to such an extent that this will not deprive the possibility of survive future generations, even in the distant horizon of time. An illusion is the assurance to the next generations the same living conditions and opportunities for further development, which has present generation. It is impossible in the sensory world. Each successive generation lives in other conditions, rather worse than previous ones, and it must deal as it can. The will of survival forces each generation to make discoveries and inventions, innovations and advances in knowledge and technology, to adapt to other living conditions in the new environment.

The idea of durable development and of its realization has already own history. For a long time, many specialists have been dealing with this and there are many publications on this subject. Some authors present the pessimistic position. They treat the idea of sustainable development as something fantastic because one cannot realize them in the modern world, that is full of contradictory interests, diverse ideologies, and religions, and where is insufficiently developed concern for the common good in the historical and future dimensions. The others are the optimists. They see in the durable development the only way to survive the human race and they hope on its realization. Yet others present positions between pessimism and optimism and they refer really and critically to the concept of sustainable development.<sup>2</sup> They treat it as one possible escape from the ecological impasse of our time, perhaps not the best, or they treat it as some mythology generated by neo-liberalism or as a manifestation of opposition to consumerism (Sztumski, 2009). In durable development, it is important firstly, to not to live on credit taken at the expense of children, grandchildren and future generations, and secondly, to limit excessive consumption and not to consume the future already *now and here*. This is the biggest trouble for any current generation. In durable development, it ought to care for the natural environment, for economically managing its vital components such as water, energy, fossil row

<sup>2</sup> For example, Antony Path, a professor of climatology at the Swiss Federal Institute of Technology, Zurich, argues that from the beginning one negates the sense of the idea

of such a development on the ground of neoclassical and evolutionary economics (see: Patt, 2013).

materials, etc., and to avoid pollution of air and water by soil toxins and radiation. All attention should focus on the protection the natural environment against thoughtless destruction and wasteful exploitation. Because the ideology of consumerism has transformed a frugal man (accustomed for centuries to saving) into a waste man, who is not able to consume what he buys and throws this into trash (Sztumski, 2013, 2015). It ignores or marginalizes the protection of the social environment that is equally important to people as natural environment. The social environment also degrades more and faster than the natural environment. The present generation still lives to a large extent on the cost of resources in both environments. It lives at the expense of future generations, because it takes loans under the pledge of future production growth. However, it is unknown whether next generations will be more productive than the present. That is uncertain because it is impossible to foresee precisely technical progress and economic prosperity. Public debt in the modern world grows continuously and rapidly. Today, each country is indebted. Even countries called *highly-developed* are indebted to their ears. For example, the United States public debt at the beginning of 2016 exceeded \$ 19 trillion, German debt it estimates at \$ 4.713 trillion, and Poland debt is \$ 286 trillion.<sup>3</sup> It is difficult to calculate how many generations will have to pay these debts. The indebteding in the world grows rapidly and no one is worried because it is always possible to print empty money or debentures without real coverage. Nobody knows what could be effect of such spiral of indebteding. Probably, this leads to nothing good – either to the next World War or to a global revolution that will change the current socio-economic system, which is already widely criticized.

Durable development should guarantee a balance between generations. It should assure a balance between ideas, thoughts, ethical values, moral norms and social orders recognized by older generations and those, which create new generations. This ensures the continuity of cultural tradition. Nevertheless, this balance is violated. Current generations live at the cost of the next generations. This cost has not only financial dimension but also a social dimension. One form of the social costs is the credit of trust between the generations. On the one hand, every future generation trusts a passing generation. For example, a child trusts parents because he is convinced that they will provide care, they will allow him to survive, and they will create the best conditions for survival and provide him the appropriate means, tools and skills. Currently, however, this credit for the passing generation is seriously

undermined. The young generation is becoming increasingly aware of the bad state of life milieu and life conditions that he inherited from the older generation. This is not about the ecological degradation but also about social and cultural degradation in broad sense. This credit is without coverage. On the other hand, the passing generation trusts the coming generation, that it will continue the old traditions, teachings, ideas, customs, ethical values, religions, etc. Durable development should preserve not only genetic but also the functional identity of social systems in the history of humankind. It manifests in this some conservatism. Older generations shape the world based on their system of values and their criterion of goodness. They are convinced that this new world will appeal to the new generation, which will also find it good. Now, nevertheless, new generations change the values, their hierarchy and the criteria of the goodness and even completely ethical systems much faster and more radical than before. This causes the reduction of the credit of trust to coming generation, of the trust in the preservation of tradition.

The question of maintaining a balance between continuity and discontinuity of social development is important because its violation leads to the collapse of the social order in general, and especially in the aspect of social ecology.

There is no continuity of the image or the model of human. Instead of people, which interact with nature, as before, there are exploiters of nature. Instead of people collaborating with others for survival and for the common good, there are individuals and exploiters of other people. Instead of empathetic people, there are egoists, which care above all for their own benefits and interests. It changes also the image of the society. Instead of elimination of social inequalities, there are growing social differentiations. Instead of striving for common global goals, in particular to the survival of humankind, there is the divergence of individual, local, corporate, etc goals. Instead of gradually eliminating national and state identities, what is natural consequence of globalization, one strengthens them. Instead of eliminating the borders between the states, one puts fences, walls and barbed wires. Instead of system of values, there is the system of anti-values. Instead of culture, there is anti-culture. Therefore, various kinds of asymmetries arise and they accumulate in the modern world and thus, the imbalance and impermanence grow. Development becomes unstable, if proportionally to the progress of capitalism the asymmetrical relations between people and nature and between humans in the social systems (in families, groups, workplaces, organizations, nations etc.) increase. With the increase of

<sup>3</sup> According to the Ministry of Finance, the indebteding of Poland at the end of December 2015 was \$ 301.62 trillion

(that is ca \$ 8.1 thousand per capita) and it grew at a pace of about \$ 810 per second.

asymmetric interpersonal relations, the social contradictions appear, intensify and exacerbate. Asymmetry and contradiction form a positive feedback system: the increase of asymmetry implies the deepening of the contradiction and vice versa.

### Conclusion

In today's world, two concepts of social and economic development – responsible development and durable development – and two corresponding development models compete. Everyone has some advantages and disadvantages. It is difficult to evaluate which one is more useful if one applies different criteria. The implementation of just one of these models does not bode good effects. Therefore, it would be best to combine them into one model that would not be their sum but a synthesis. It is easy to think, but much more difficult to achieve. This does not mean, however, that this is a challenge that is impossible to realize. Its implementation requires only the greater efforts of theoreticians and practitioners in various fields and good will of the ruling elites.

When one creates a model of development, it is best not to be guided by rationality, ideology, and politics or some specialist knowledge, but by common sense and general knowledge. Moreover, generally speaking, in shaping future development models, it should count above all as far as possible with the welfare of individuals, local communities and all humanity, and with the interests of present and future generations.

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## An e-Environment System for Socio-economic Sustainability and National Security

### System e-środowiska dla zrównowżenia społeczno-ekonomicznego i bezpieczeństwa narodowego

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#### **Abstract**

Though there are adequate institutional frameworks and legal instruments for the protection of the Sub-Saharan African environment, their impact on the development and conservation (protection) of the environment leaves much to be desired. This assertion is substantiated by the reality that in spite of these regulatory frameworks, the environment is largely degraded with negative ramifications for the twin goals of attaining sustainable socio-economic advancement and realization of environmental rights. Both national and regional state of environment (SoE) reports show that degradation is apparent. It is worthy of mention that almost all African countries have ratified and domesticated the various regional and subregional environmental agreements. Efforts to solve the puzzle have revealed that corruption and environmental degradation in Sub-Saharan Africa are closely linked. Financial impropriety in ecological funds management, poorly equipped environmental protection institutions, and inadequate citizens' environmental management awareness campaigns are outcomes of corruption in the public sector. Since corruption thrives in the absence of transparency and accountability, this study proposes a cutting-edge technology-based solution that promotes participatory environmental accountability using an e-Environment system. The web-based multi-tier e-Environment system will empower both citizens and government officials to deliberate online real-time on environmental policies, programmes and projects to be embarked upon. Both parties will equally put forward proposals on the use of tax payers' money in the environment sector while monitoring discrepancies between amount budgeted, amount released and actual amount spent. We applied design and software engineering skills to actualize the proposed solution. Using Nigeria as case study, our research methodology comprised literature review, requirements gathering, design of proposed solution using universal modelling language (UML) and development/implementation on the Microsoft SharePoint platform. In view of our determination to evolve a zero-defect software, we applied Cleanroom Software Engineering techniques. The outcome obtained so far has proved that the model supports our expectations. The system is not only practical, but ecologically sound. It is anticipated that the full-scale implementation of such an enterprise e-Environment system will decrease the current tide of corruption in the environment sector, mitigate environmental degradation and by extension, reduce social-economic tensions and guarantee national security.

**Key words:** Cleanroom Software Engineering, corruption, e-Environment, environmental degradation, socio-economic, sustainability, national security

## Streszczenie

Chociaż w Afryce Subsaharyjskiej istnieją odpowiednie ramy instytucjonalne i instrumenty prawne dla ochrony środowiska, ich wpływ na zachowanie (ochronę) środowiska naturalnego pozostawia wiele do życzenia. Pomimo istniejących ram regulacyjnych, środowisko jest tu w dużej mierze zdegradowane, co negatywnie wpływa na możliwość osiągnięcia podwójnego celu: osiągnięcia zrównoważonego rozwoju społeczno-gospodarczego i ochrony środowiska. Zarówno krajowe, jak i regionalne raporty o stanie środowiska (SoE) pokazują, że degradacja ma miejsce. Warto wspomnieć, że prawie wszystkie kraje afrykańskie ratyfikowały i wprowadziły różne regionalne i subregionalne porozumienia dotyczące ochrony środowiska. Próby zmierzające do uporządkowania sytuacji pokazały, że korupcja i degradacja środowiska w Afryce Subsaharyjskiej są ze sobą ściśle powiązane. Niepewność finansowa odnosząca się do zarządzania funduszami ekologicznymi, słabo wyposażone instytucje ochrony środowiska oraz nieodpowiednie kampanie informacyjne na temat zarządzania środowiskiem w zakresie ochrony środowiska są wynikiem korupcji w sektorze publicznym. Ponieważ z braku przejrzystości i odpowiedzialności korupcja kwitnie, niniejsze badanie proponuje nowoczesne rozwiązanie, które promuje partycypacyjną odpowiedzialność za środowisko z wykorzystaniem e-Środowiska. Wielowarstwowy system e-Środowiska, oparty na Internecie, umożliwi zarówno obywatelom, jak i urzędnikom państwowym, dyskusję w czasie rzeczywistym odnoszącą się do polityki dotyczącej ochrony środowiska, a także wszelkich przygotowywanych programów i projektów. Obie strony będą również wysuwać propozycje dotyczące wykorzystania pieniędzy podatników w sektorze środowiskowym, przy jednoczesnym monitorowaniu rozbieżności między kwotą przewidzianą w budżecie, a faktyczną wydaną. Zastosowaliśmy umiejętności projektowe i programistyczne, aby zaktualizować proponowane rozwiązanie. Wykorzystując studium przypadku w Nigerii, nasza metodologia badań obejmowała przegląd literatury, określenie wymagań, projektowanie proponowanego rozwiązania z wykorzystaniem uniwersalnego języka modelowania (UML) oraz opracowanie / wdrożenie realizowane na platformie Microsoft SharePoint. W związku z naszą determinacją odnoszącą się do opracowania w pełni funkcjonalnego oprogramowania, zastosowaliśmy techniki Cleanroom Software Engineering. Uzyskane wyniki dowiodły, że model ten spełnia nasze oczekiwania. System jest nie tylko praktyczny, ale także ekologiczny. Przewiduje się, że pełne wdrożenie takiego systemu e-Środowiska w przedsiębiorstwie doprowadzi do zmniejszenia obecnej fali korupcji w sektorze środowiskowym, zmniejszy degradację środowiska, a poprzez to zmniejszy napięcia społeczno-gospodarcze i zapewni bezpieczeństwo narodowe.

**Słowa kluczowe:** Cleanroom Software Engineering, korupcja, E-środowisko, degradacja środowiska, społeczeństwo, ekonomia, zrównoważoność, bezpieczeństwo narodowe

## 1. Introduction

Amid concerns that climate change is the defining threat of the century, measures are being put in place globally to mitigate its effect. In Africa, humanitarian crisis linked to environmental challenges such as flash flood, desert encroachment, coastal erosion, oil spillage and gully erosion continues to be a threat to national security (Ewharieme, Cocodia, 2011; Akokpari 2007). The reason not far-fetched: economic livelihoods are threatened by ecological distortions. The environment is of strategic imperative to Africa's sustainable development drive. The Environmental Initiative of NEPAD (New Partnership for Africa's Development) has acknowledged that a productive and healthy environment is a sine qua non in that it is critical to the creation of the ecological and social base as a veritable platform for the partnership to thrive. Before the inception of NEPAD, African leaders had acknowledged that the environment and its resources are relevant to the continent's development and therefore put measures in place for its conservation and protection as confirmed at the *Algiers Convention* which adopted the *African Convention on the Conservation of Nature and Natural Re-*

*sources* in 1968 (Amechi, 2009). Since then, other regional and subregional environmental agreements have come into the fray such as the *Nairobi Convention for the Protection, Management and Development of Marine and Coastal Environment of the Eastern Africa Region*, *Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region*, and *Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa*.

Equally at the national level, there has been actions – many environmental initiatives have been adopted to facilitate socio-economic development and protect the environment. Moreover, many human rights initiatives in Africa have sufficiently made provision for environment right that ensures positive contribution to the promotion of socioeconomic development in the region. Specifically, people have the right to satisfactory environment that supports their development as enshrined in article 24 of the *African Charter on Human and Peoples' Rights*.

It is worthy of mention that almost all African countries have ratified and domesticated these charters.

For instance, the *South African Constitution* in section 24 provides that the health or wellbeing of everyone shall be protected by the right to a non-harmful environment. In like manner, for the benefit of present and future generations, the environment has to be protected via well thought-out and secured ecologically sustainable development. Another means is through the efficient deployment of natural resources even as social and economic development is promoted.

Despite the presence of many legal instruments/ institutional frameworks for environmental protection, expectations on their impact on the conservation or protection of the Sub-Saharan African environment have been cut short. Hence, the environment remains largely degraded with negative aftermaths for the realization of the right to environment and attainment of sustainable development. State of Environment (SoE) reports at national and regional levels such as the 2006 South African SoE and 2003 Kenyan SoE provide ample proofs of monumental degradation. Since it has been established that the environmental devastation problem and associated non-realization of right to environment on the continent is not as a result of absence of regulatory frameworks, we therefore beamed our searchlight somewhere else. As alluded to in the literature by some authors, corruption exists in Africa (Okewu and Okewu, 2015) and it has continued to aggravate environmental degradation on the continent (Ewharieme, Cocodia, 2011). Mismanagement of ecological funds, poorly equipped environmental protection institutions, inadequate citizens' environmental management awareness campaigns are some of the fallouts of corruption in the public sector. Bribes and illicit deals don't only fleece away resources from the public coffers, they impede economic advancement and ecological justice, providing fertile grounds for social tension and national insecurity. Using expert opinions across the world, Transparency International, the global coalition against corruption, gauged the perceived levels of public sector corruption globally in its *2014 Corruption Perceptions Index*. The index produced a disturbing picture of African countries. Globally, above two-thirds of countries scored below 50. Also, not a single country got a perfect score. With a scale of 0 (highly corrupt) to 100 (very clean), the fact that 92% of African countries scored below 50 is a pointer to the phenomenal corruption in the region (Transparency International..., 2014). As concerning as corruption is to all countries, a poor score indicates widespread bribery, inadequate sanction for corruption and non-functional public institutions that are unable to respond to citizens' needs. Countries at the bottom of the index have to take stringent anti-corruption measures to impact positively on the lives of their people just as countries at the top should oblige not to export corrupt practices to developing countries (Transparency International..., 2014).

This paper proffers a technology-based approach to handle the challenge of corruption-induced environmental devastation in a bid to enhance environmental sustainability and national security in Sub-Saharan African countries. Our strategy is to provide participatory environmental accountability forum through an online real-time e-Environment system that is web-based. This is against the background that corruption thrives in the absence of transparency and accountability (Okewu and Okewu, 2015). The solution empowers the citizenry and government to engage in constructive discussions on how public finance for the environment sector is utilized. It is a confluence for all environment stakeholders to cross-fertilize ideas on appropriate policies, programmes and services that would best serve the ecological governance of their country. With e-Environment, financial prudence in the public sector is promoted, fiscal discipline entrenched, corruption levels are checked and resources freed up to cater adequately for protecting the environment and realizing the right to it.

Typically, African countries share a lot in common in context of environmental practices, operations and structure even though they have their peculiarities. Therefore, modelling and developing software using a reuse-based approach that is relevant to many countries with minimal errors will be of significant benefits. Cleanroom software engineering (CSE) is a virtual error-free paradigm of developing software where environments and processes are meticulously examined, monitored and controlled for any errors (Head, 1994; Mills et al., 1987). In the event a defect is found, it is classified to ascertain failed process and measures taken to avert such failure subsequently. The faulty process is amended and rerun while the original product is discarded. In CSE, unit testing is not required (Pressman, 2009) and this implies reusable components from tested and trusted vendor products that engenders users and developers confidence are of strategic imperative (Sommerville, 2011; Okewu, Daramola, 2014).

In this paper, we present a report of a study of the use of CSE for designing and developing an e-Environment system for Africa with Nigeria as test bed. It practically investigates the nexus between corruption, environmental sustainability and national security that have been alluded to in the literature by some authors (Akokpari, 2007; Amechi, 2009; Kakonge, 2006). Nonetheless, few reports on practical application of CSE in the industry exist in the literature. Kaur (2011) and Selby et al. (1987) argue that more empirical evidence of the application of CSE is required by the cleanroom software engineering research community. Moreover, the fact remains that renowned international conferences in the field of environmental science and technology such as the *International Conference on Environmental Science and Technology* and *European Industrial Symposium on Cleanroom Software Engineering* are cont-

inuously advocating for more case studies in their calls for papers. As a contribution, we seek to enrich the body of knowledge in environmental science and technology by an empirical evidence of CSE application in Nigeria. This is of particular significance in that it is rare to come across empirical evidence of an e-Environment system with origin in Africa.

The remaining segment of this article is composed as follows: in Section 2, the focus is on related work and background of study; the methodology and selected case study are presented in Section 3; section 4 discusses results; and we conclude the paper in section 5.

## 2. Background and framework

### A. Climate change in Africa

Climate change in Africa is of growing concern to stakeholders within and outside the continent. Schneider et al. (2007) stressed that Africa is probably the most vulnerable to climate change amidst all the continents. The same sentiment was shared by Boko et al. (2007) who forecasted that in many African countries and regions, there is likelihood that food security, water availability and agricultural production would be gravely hampered by the vagaries of climate change.

In East Africa, the worst drought in many years was experienced in 2011 owing to interrupted seasonal rains for two seasons in a row. Overtime, the precipitation rate of many areas within the region during the rainy season has dwindled considerably with less than 30% of the average rainfall for the time period 1995-2010. Researchers in 2012 uncovered a connect between changes in the sea surface temperature of the tropical Pacific Ocean and the region's low rainfall. They explained that the disruption of long rains was as a result of this relationship. This unique discovery is already aiding emergency preparedness and improved forecasts.

Sahel region has its fare share – it is yoking under climate change vulnerabilities and environmental risks. It has been pointed out that between 1970 and 2010, a temperature rise in excess of 1°C was experienced by 15 per cent of the population of Sahel region. Equally, flooding has increased in severity and frequency just as it is experiencing below average mean seasonal rainfall. For instance, in the 17 Sahel region countries, about five floods have impacted on 54% of the population since 1985. Furthermore, in 2012, there were severe drought conditions. So far, regional governments have responded with strategies to deescalate the environmental challenge.

### B. Sustainable development and national security

Incidences of terrorism, kidnapping, youth restiveness, militancy, among others are recurring decimals in developing economies (Okewu et al., 2017). Reason being that there are limited options for survival; hence massive unemployment and underemploy-

ment which translate into low purchasing power. The dearth of critical infrastructure such as power, transportation system, water, etc means real sectors of the economy such as agriculture, education, manufacturing and others like construction, extractive and service sectors are underdeveloped for the engagement of productive minds. Consequently, overall national productivity is low resulting in downward looking economic indicators such as GDP, interest rate, inflation rate, unemployment rate, and exchange rate. Caught in the web of poverty and misery, citizens begin to agitate which finds expression in social vices such as ethno-religious crisis, terrorism, kidnapping, militancy, among others. All these agitations pose serious national security threats and in extreme case, humanitarian crisis erupts. There is strong evidence that environmental degradation and devastation can destroy people's livelihoods and inflict insecurity in a nation. For example, some developing economies such as Nigeria that have not been able to manage their oil and gas resources very well have had to deal with oil spillage over the years with attendant destruction of the ecosystem of communities where oil exploration is taken place. Oil spillage does not only destroy the fertility of the land but also destroys aquatic lives upon which the people depend for their sustainability. Gas flaring also releases harmful gases into the atmosphere, occasioning global warming. In frustration, citizens device negative strategies for survival, exploring options such as oil bunkering, illegal refining, outright pipeline vandalism, embracing piracy and kidnapping and in extreme cases, taking up arms as militants. The Niger Delta region of Nigeria that has been embroiled in crises over the years is a case in point. Conversely, in developed countries where such resources have been optimally harnessed, sustained growth and development is the outcome as there is positive multiplier effects on all sectors of the economy. There is therefore need for both multinational corporations and governments to pay special attention to ecological justice as a way of ensuring sustainable development and guaranteeing national peace and security. Despite efforts made in the past to protect and preserve the environment, brazen public and private sectors corruption has made proper ecological funds management a mirage (Ewharieme, Cocodia, 2011).

### C. Corruption incidence and measurement in Africa

As observed by Okewu and Okewu (2015), in order to manage corruption successfully in Africa, there is need to understand its depth and breadth. The menace is real and of monumental threat to the socio-economic and political advancement of the continent. Against the background that measuring corruption will enable us to manage it more effectively and efficiently in the context of environmental justice, we examined corruption incidence in Africa for a period of 3 years (2012-2014) relying on data from the global corruption perception index by the global cor-

ruption watchdog, Transparency International. Our findings indicate that Africa is the poster child for corruption and poor governance. Of the 175 countries measured for the 3-year period, data clearly indicated that vast majority of African countries were at the bottom of the table, a segment classified as highly corrupt. Table 1 is a summary of the corruption perceptions index 2014 by region measured on a scale of 0 (highly corrupt) to 100 (very clean).

Table 1. Corruption Perception Index 2014, results by region, source: Transparency International Corruption Perception Index 2014

Region	Average score	Top (Cleanest Country)	Bottom (most corrupt country)	% of countries that scored below 50
Americas	45	Canada (83)	Haiti, Venezuela (19)	68%
EU and Western Europe	66	Denmark (92)	Greece, Italy, Romania (43)	16%
Sub-Saharan Africa	33	Botswana (63)	Somalia (8)	92%
Eastern Europe and Central Asia	33	Georgia (52)	Turkmenistan (17)	95%
Middle East and North Africa	38	United Arab Emirates (70)	Sudan (11)	84%
Asia Pacific	43	New Zealand (91)	North Korea (8)	64%

As shown above (Table 1), there is ample statistical evidence that Sub-Saharan Africa is among the most corrupt regions in the world, having tied with the Eastern Europe and Central Asia region on average score of 33 with 92% of its countries scoring below 50. Even then, one of the most corrupt nations, Somalia, is in Sub-Saharan Africa tying with only North Korea at a corruption score of 8. Of the 175 countries gauged in 2014, Denmark emerged the cleanest with score of 92.

To corroborate these statistics and global perspective with ground-level perspective, virtually all institutions in Africa ranging from legislature to judiciary are under the yoke of corruption and mismanagement of public resources (Okewu and Okewu, 2015). A case in point: despite the pervasive poverty in African countries like Nigeria and Kenya, the cost of governance is high. In a comparative study, Tom and Attai (2014) provided statistical evidence as shown in Table 2, comparing the emoluments of legislators and their minimum wages in six countries, Nigeria and Kenya inclusive.

Going by the above statistics, it is concerning that politicians in Africa (Nigeria and Kenya) compared

to their counterparts in developed societies, are taking advantage of the already impoverished masses. For instance, it is breathtaking that while only 0.47% and 0.13% (0.18%) of legislators' pay constitute minimum wage in Kenya and Nigeria respectively, the figures are 8.6%, 21.68% and 26.73% in US, UK and France respectively. Juxtaposing these statistics with those of Transparency International in 2014 corruption index, we observed that Nigeria and Kenya respectively occupy distant 136 and 145 out of the 175 countries measured. Since, these legislature pay structures don't reflect the economic realities of these African countries, it is safe to say that politics in Africa favours political officials to the detriment of the masses. Little wonder then that would-be political office holders would do anything, including corrupt practices, to secure position at all cost. And once there, they explore and exploit public sector finance, including ecological funds, for personal aggrandizements. An inclusive dialogue platform such as the e-Environment system that empowers the masses to air their concerns on environmental budgets, policies, programmes and services will certainly checkmate these fiscal excesses.

To substantiate the sentiment in some quarters that corruption has assumed the status of a culture in Africa, both the highly and lowly placed citizens engage in the practice with impunity. Overtime, the weakening of institutions has made things worse as prosecution of offenders is now a mirage. Nonetheless, the judicial system, home and abroad, has been instrumental in bringing to book some high profile corruption cases in Africa. This situation calls for additional and complimentary urgent measures to get Africa out of the woods. One of such measures we proposed in this study is the technology approach (e-Environment) which provides a technique of enhancing participatory environmental accountability in ecological governance.

#### D. Cleanroom Software Engineering

One doctrine of cleanroom software engineering (CSE) is ensure virtual error-free software by eliminating unit testing as much as possible (Head, 1994; Linger, 1993; Linger, Tramell, 1996). Hence, six-sigma (highly quality) software could be achieved by focusing on design and coding. One practical way to achieve this is to use tested and trusted components from established vendors (Sommerville, 2011) such as embedded in Microsoft SharePoint (Okewu, Dar-amola, 2014). CSE is a metaphor derived from integrated circuit manufacturing. In this domain, conscious and concerted efforts are made to ensure the environment for large-scale integrated circuits manufacturing is free from amoebas, dust, flecks of skin, and the likes. The environment and processes are meticulously controlled just as the results are monitored constantly. Any defect that occurs is not seen as defect in the product but rather defect in the process. To confirm the process failure that produced

Table 2. Comparison of legislators' pay in six countries

Country	Legislators' pay monthly	Legislators' pay annually	Minimum wage monthly	Minimum wage annually	% of legislators' pay that is minimum wage
Nigeria	Senate N15.2m Reps N10.6m (\$69,533)	Senate N182m Reps N127m (\$834,402)	N18,000 (\$118.15)	N234,000 (\$1,536) inclusive of 13th month salary	0.13% 0.18%
India	N305,058 (\$1,999)	N3.7m (\$23,988)	Varies from state to state, sector to sector	-	-
US	N2.2m (\$14,500)	N26.5m (\$174,000)	N191,667 (\$1,257)	N2.3m (\$15,080)	8.6%
UK	N1.3m (\$8,686)	N15.9m (\$104,228)	N283,333 (\$1,883)	N3.4m (\$22,597)	21.68%
Sweden	N1.2m	N14.1m	Set by annual collec- tive bargaining deal	-	-
France	N1.02m (\$6,754)	N12.3m (\$81,951)	N275,433 (\$1,805)	N3.3m (\$21,664)	26.73%
Kenya	N2.2m (\$14,543)	N26.7m (\$175,000)	N10,534 (\$6,917)	N126,413 (\$830)	0.4%

the defects, they (defects) are subsequently characterized, debugged and rerun. This leads to a regenerated product just as the original defective product is discarded (Mills et al., 1987; Linger, 1993).

The philosophy of CSE is similar to the cleanroom process of integrated circuit manufacturing. Environments and processes are scrupulously monitored and controlled for defect. The presence of defects means a single or multiple processes contain such defects. The defects could exist in the inspection techniques, specification process, or the design methodology used. The code module or source file typically does not harbour defects. To determine the failed process, each defect is categorized. The classification also help in preventing failure. After correcting the failing process, it is rerun and the original product discarded. The original product is then discarded. As a result, the traditional life cycle is different from the life cycle of a cleanroom project. It is widely acknowledged that the traditional 40-20-40 post investigation life cycle is composed of 40 per cent design, 20 percent code, and 40 percent unit testing (Pressman, 2009). Thereafter, the product undergoes integration testing. On the other hand, cleanroom patronizes an 80-20 life cycle which entails designing is 80% while coding takes 20% of the life cycle. Thereafter, the integration testing is presented with the untested and unexecuted product amid expectation that it will work. Should it fail, ways of improving the process are determined by examining the defects. The improved process is then used to regenerate the defective and discarded product. This way, unit testing is conspicuously absent in cleanroom software engineering (Sommerville, 2011).

E. Innovative System and Inclusive Environmental Protection and Development Sustainable protection and development of the African ecosystem should be collective responsibility of government and the citizenry alike. In this light, a major consideration is a platform that drives real-time dialogue between lead-

ers and the led such that public expenditure on proposals and implementations of environmental initiatives should be well scrutinized for fiscal discipline in the environment sector. Our proposal of a web-based online real-time e-Environment system is part of efforts to deploy innovative system for inclusive environmental protection and development. It is anticipated that e-Environment will empower government ministries, departments and agencies (MDAs) on one hand and the citizenry on the other hand to have fruitful deliberations on how environmental budgets such as ecological funds should be spent. Besides the conversation, it will provide a monitoring and compliance scheme such that citizens are able to monitor discrepancies between amount budgeted, amount released and actual amount spent on environmental management programmes. This way, endemic corruption in the sector can be mitigated if not eliminated.

#### F. Related work

Previous efforts in the literature that are related to corruption and environmental management in Africa are as follows.

Ewharieme and Cocodia (2011) x-rayed urban development in Nigeria vis-a-vis ecological governance with particular focus on the Niger Delta region reputed for its environmental degradation struggles. The authors noted that owing to the cardinal role of oil in Nigeria's Niger Delta political economy over the years, public discourse has centered on issues of oil-related environmental degradation. But they observed that besides oil, corruption has aggravated the situation, wrecking havoc on the environment and making the oil-induced environmental assaults worse. The paper also examined how issues such as ecological menaces are treated and the impact of corruption in leaving them unattended to. Despite providing linkages between corruption and worsening environmental degradation in Nigeria, the study fell short of suggesting how ICT could be used to

tackle environmental challenges in a bid to guarantee national security. This is the chief motivation for our study.

Vuuren (2014) studied corruption in South Africa in the context of its nature and degree. Though laws and institutions have been developed in South Africa that provide measured response at the national level to cases of corruption, the researcher observed that the law is applied inconsistently giving leeway to corruption to escalate levels of economic inequality. The author stressed that the solutions to South Africa's problems should embrace institutions, open society and destruction of corrupt elite networks. Else, inequality will deepen and anti-democratic forces will hold sway. It is worth mentioning that our proposal for an e-Environment solution is to drive open and online real-time conversations between citizens and government officials on how public finance is utilized with particular reference to the environment sector.

Kakonge (2006) focused on the challenges confronting the internalization and institutionalization of Environmental Impact Assessment (EIA) process. Amid concerns that environmental planning is yet to gain ground in Sub-Saharan Africa, the author stressed that countries can adapt and benefit from the process of Environmental Impact Assessment (EIA). A number of issues that have impeded the full utilization of the EIA process were outlined as scanty public participation, unreliable and inadequate data, dearth of experience and national expertise in EIA, weak enforcement, defective environmental legislation, and limited impact coverage. Measures to correct the situation were highlighted as complying with international agreements, broadening ownership of EIA, supporting public sensitization to simplify the EIA process, scaling up funding of EIA studies for government funded-projects, facilitating good governance and mitigating corruption. In conclusion, the researcher advised that more resources and intensified efforts would be needed at all levels of the development planning process to integrate EIA for the realization of full benefits. Though the study did not highlight the role of ICT in environmental planning, the author agreed that corruption impacts on environmental impact assessment.

Amechi (2009) approached the subject from a legal point of view, emphasizing the nexus between sustainable development and the environment. The article proffered a comprehensive approach to handling the challenge of environmental devastation as part of efforts to actualize the right to environment and attain sustainable development in Africa. Contributory factors to environmental degradation on the continent were outlined. Recommendations on how the international community could help African countries to protect their environment and facilitate the realization of the right to environment were made. The author was concerned that in spite of Af-

rica's many institutional frameworks and legal instruments for environmental protection, much still needs to be done on its conservation. Although the study did not suggest a technological solution for dealing with environmental challenge, it drew a link between ecological governance, economic sustainability and national security.

Akokpali (2007) opined that human insecurity has reached unprecedented levels in Africa, especially Sub-Saharan Africa. Apart from having large portion of its population living below poverty line, the continent is bedevilled with conflict and instability. In addition, Africa has high disease burden even as food and nutritional inadequacies have assumed phenomenal proportions. He cautioned that the continent remains vulnerable to drought, even as environmental degradation is on the increase; typified by deforestation, desertification, soil erosion, oil spillage, pollution, and depleting fish and game stocks. The paper added that ecological problems in Africa are made worse by inability of African governments to establish credible environmental regimes coupled with their willingness to trade the environment for scarce foreign exchange. The combination of all these factors presents Sub-Saharan Africa as an indisputable region for human insecurity. The study sufficiently drew a connect between environmental injustice and national (human) security even though it was silent of role of ICT in entrenching ecological governance.

Head (1994) shared practical experience from the application of cleanroom software engineering (CSE) at Hewlett-Packard (HP). The paper confirmed that CSE has demonstrated capability of producing non-defective software and remarkable results were achieved when applied in a typical HP environment. The author emphasized that CSE is possibly the easiest methodology and most repeatable technique of all software development methodologies used for producing six-sigma (high quality) software system. In the early 1980s, CSE emerged, originating from IBM Corporation's Federal Systems Division. Although the only application areas of six-sigma were initially manufacturing processes and hardware reliability, it has been realized it could be applicable to software quality. The six-sigma value is put at 3.4 parts per million (3.4 ppm) defective and the philosophy is that long-term reliability requires more refined design that guarantees the ruggedness of the emergent product in terms of enduring stress without failing. Despite sharing industrial experience of using CSE, it was not applied in an African context to tackle the problem of ecological degradation, socio-economic sustainability and national security.

In a nutshell, none of the reviewed literature focused on applying CSE to resolving corruption-driven environmental degradation for socio-economic sustainability and national security. We therefore instituted a study in this regard.

### III. Methodology – Cleanroom Software Engineering for the e-Environment

The study used Nigeria as a test bed since environmental degradation is an existential threat in the country – the Niger Delta region in particular (Ewharieme, Cocodia, 2011). In addition, its nature and scale are a microcosm of Africa's ecological challenges. It is on record that Nigeria was the first country in Africa to have an environmental protection agency with the inauguration of the Federal Environmental Protection Agency (FEPA) in 1988. Prior to the 1987 toxic waste dumping at Koko village in Delta State, Nigeria could not manage demanding environmental crisis. This is because environmental laws and regulations could not be enforced for protecting the mother earth owing to the dearth of institutional templates.

Following the Koko toxic waste scandal, the Federal Government came up with the 1988 Harmful Waste Decree 42. This expedited the setting up of the Federal Environmental Protection Agency (FEPA) based on Decree 58 of 1988 and the amended Decree 59 of 1992.

The onus of environmental management and protection then rested on FEPA. However, FEPA has metamorphosed into a parastatal in the Federal Ministry of Environment called National Environmental Standards and Regulations Enforcement Agency (NESREA).

With the understanding that Nigeria's environmental experience represents in microcosm the African ecological experience, we used the country as case study and for industrial experience. We developed the e-Environment system and tested it. The proof of technology was done using Microsoft SharePoint while the underlying theoretical framework was cleanroom software engineering (CSE) with real-life environmental data from Nigeria to enhance confidence in our work (Pressman, 2000; Sommerville, 2011). Guided by the CSE life cycle activities (specification, development and certification), the study progressed. We reviewed literature, gathered requirements, designed the proposed solution using unified modelling language (Martin, 1998), developed and implemented it on the Microsoft SharePoint platform. We then verified and validated the solution and discussed our findings.

#### A. Specification

Requirements were gathered, analyzed and system modeled using unified modelling language (UML). The researchers, using gathered requirements, summarized the cross-cutting functional requirements of the proposed solution in Table 3.

Deployment diagram was also used to model the proposed e-Environment solution. It comprised personal computer (PC), third party tool such as phone, online payment device, among others. Users can

view outcome on PC and as well on phone. It is anticipated that even with intensity of environmental awareness campaign and government regulation and enforcement systems, some citizens may default and would be sanctioned by way of paying fines. We therefore included an online payment component. This way, defaulters can make payment online real-time directly to appropriate and authorized accounts operated by environmental agencies like NESREA.

Table 3. Cross-cutting functional requirements

Req. ID	Requirement	Brief Description
R01	Add environmental information	The system shall allow authorized users to add environmental information to the database depending on assigned rights and privileges.
R02	Access environmental information	The system shall allow authorized users to access environmental information from the database in accordance with assigned rights and privileges.
R03	Edit environmental information	The system shall allow authorized users to edit environmental information on the database in line with assigned rights and privileges.
R04	Delete environmental information	The system shall allow authorized users to delete environmental information from the database contingent upon rights and privileges assigned.

#### B. Development

Microsoft SharePoint was used as the development platform. This is against the backdrop that reusable components from an established vendor's (like Microsoft) product that is well tested and trusted promotes confidence of users and developers (Sommerville, 2011; Okewu, Daramola, 2014) that the proposed solution would be virtually error-free in tandem with the ideology of cleanroom software engineering (Kaur, 2011; Linger, 1993). Fault eradication apart, integrating reusable components in the development effort fast-tracks software development. Also, the web-based multi-tier clustered architecture of Microsoft SharePoint supports quality requirements and emergent properties of the e-Environment system – usability, availability, reliability, fault tolerance, maintainability, among others (Pressman, 2009).

Ahead of development and implementation on the web-based n-tier Microsoft SharePoint development platform, we evolved an algorithm for the proposed system.

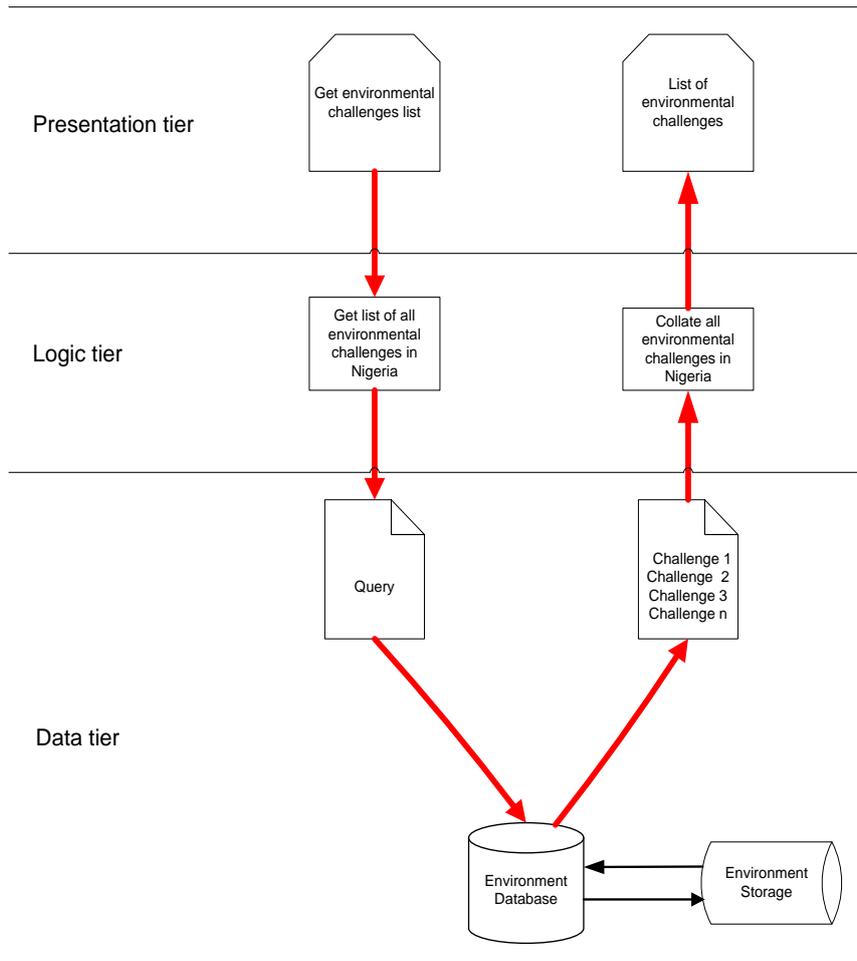


Figure 1. Visual overview of the 3-tiered e-Environment architecture

The e-Environment software architecture pattern is presented as n-tier architecture and the visual overview is shown in Fig. 1.

In consonance with the requirements of six-sigma and CSE for refined design such that product can withstand stress during usage without failing (Head, 1994), the e-Environment architecture is a clustered architecture with clustered application servers and clustered database servers. In this instance, they are three layers, hence  $n = 3$  and we have a 3-tier architecture as explained in the Table 4.

### C. Certification

To verify and validate the e-Environment architecture, a prototype was developed using Community Site component of Microsoft SharePoint. The web-based solution was then tested using real-life interactive sessions between stakeholders. As the name implies, the Community Site component facilitated online real-time conversations among environment stakeholders. Test scenarios were presented where service users (requesters) sought for information from the service providers housed in the service registry. To underscore the dynamic collaboration philosophy of the e-Environment system which en-

Table 4. e-Environment architecture explained

SN	Tier	Explanation
1.	Presentation tier	The user interface is the top-most layer of the application. Its primary function is to convert results and tasks into meaningful facts that are comprehensible by environment stakeholders.
2.	Logic tier	This tier is responsible for processing commands, articulating application, evaluating and taking logical decisions, and performing calculations. Additionally, data between the other two surrounding layers are moved and processed by the logic layer.
3.	Data tier	At this layer, the environment database or file system is used to store and retrieve information. The fetched information is transferred to the logic layer for processing prior to returning same to the user.

courages real-time exchange between information users and providers, the prototype ensured that information was provided on real-time basis. This confirmed that e-Environment is a not only web-based, but also service-oriented. Put in another fashion, service users were able to access service providers warehoused in the service registry of the e-Environment system (Okewu, 2015).

#### IV. Results and discussion

Concerned about the impact an innovative system such as e-Environment could make on environmental management initiatives within the broader context of entrenching fiscal discipline in public expenditure, we conducted a test run and assessed the outcomes. The researchers evaluated possible threats to results obtained.

##### A. Results of software experiment

The e-Environment system was built as a community site on Microsoft SharePoint enterprise development platform using cleanroom software engineering techniques. True to its name, the web-based multi-tier enterprise application allows members of the environmental management community – comprising citizens and government officials – to deliberate on topical environment protection and development issues. Underling this software engineering is the environmental message that in the absence of participatory social accountability and transparency in the application of environmental funds, corruption will thrive and the already dilapidated environment would be worse for it (Okewu and Okewu, 2015). We set up an experimental design in University of Lagos, Nigeria precisely at the Centre for Information Technology and Systems and test-run the system from near (Lagos environs) and remote location (from Nigeria's capital, Abuja. Online postings and responses were made from both Lagos and Abuja in real-time.

Going by the reliability standards of cleanroom software engineering approach for design and development, real-life operational data on environmental issues in Nigeria were used (Kaur, 2011; Selby et al., 1987). The experiment confirmed that ICTs could bridge the gap between stakeholders in the environment sector and more importantly entrench transparency and accountability in environmental protection and development. The participants in the experiment agreed that the outcome of the experimental study was seamless and robust online real-time communication among environment stakeholders on topical public policies, programmes, projects and services that are result-oriented. Ultimately, the e-Environment dialogue ignited a sense of transparency procedure capable of promoting participatory environmental accountability for sustainable environment, and by extension national security. Though we experienced platform-dependent and hardware-depend-

ent challenges at the initial stage testing from remote location (Abuja), this suggests that more robust infrastructure is needed for wide-scale implementation in the future.

##### 4.2 Evaluation threats

It is possible that a broader evaluation of the different components of the e-Environment system could throw up new perspective of things. Nonetheless, those who participated in the test run have the required experiential knowledge of the challenges confronting environmental governance in Nigerian – corruption, weak ecological infrastructure, oil spillage in Niger Delta, coastal erosion in South-West region, gully erosion in South East, desert encroachment in Northern Nigeria, among others. They also had adequate hands-on experience with the e-Environment system. This provided them ample platform to make objective assessment of the impact of proposed solution on environmental justice by ensuring judicious utilization of public funds meant for ecological renewal, improved livelihood and national security. Thus, their views can be taken seriously (Host et al., 2000; Runeson, 2003; Sauro, Kindlund, 2005; Svahnberg et al., 25).

Also of note is the small number of participants engaged in the evaluation which potentially could constrain the statistical relevance of the result (Nielsen, Landauer, 1993; Turner et al., 2006). Nevertheless, the outcome of the experiment shows that every aspect of possible stakeholder interactions within the ecological space was adequately covered and robust online real-time conversation ensued. In our view, this is a good result in that at this juncture, the aim is to have a sense of how the e-Environment system could inject transparency and accountability into environmental governance. Hence, regardless of the constraint of few evaluators used, there is adequate grounds to conclude there is a favourable disposition to the e-Environment software system as a tool for enhancing participatory environmental accountability for sustained economic livelihood and national security. It means optimal utilization of state resources such as ecological funds as a consequence of transparency will translate into wellbeing of the citizenry, mitigating social tension and insecurity. We can thus generalize that the CSE-developed e-Environment system is effective for enhancing environmental sustainability, economic stability and national security.

#### V. Conclusion

So far, we have addressed the problem of environmental injustice perpetuated by financial impropriety in the environment sector. Though a number of measures have been advanced before now to stem the tide of corruption militating against environmental protection and development efforts, we unveiled an innovative system approach. The ICT solution, e-

Environment system, empowers environment stakeholders to put forward proposals as well as monitor how budgets on environmental management are spent. This way, excesses of government officials reputed for diverting ecological funds are checked. With state resources judiciously utilized, environmental degradation is checked, socio-economic livelihood improved and national security guaranteed. Apart from solving a problem using cleanroom software engineering approach, the study presents a case study and an industrial experience from the African context as addition the cleanroom software engineering body of knowledge. Finally, the e-Environment system is practical and ecologically sound.

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# Sustainable Water Management in Cities under Climate Changes

## Zrównoważone zarządzanie wodą w miastach w warunkach zmian klimatycznych

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### Abstract

Increasing global change pressures like urbanisation, climate change, deterioration of urban water infrastructure, cities have difficulties in efficiently managing water resources. To manage these challenges cities have to improve the efficiency of urban water systems by rethinking old paradigms and developing more sustainable solutions.. Between 1.8 and 2.5 % of the annual global GDP is needed for implementation of water-related sustainable development goals. Currently the main challenge is to ensure public health and satisfy water needs while protecting the quality and quantity of water resources for future generations by efficient production and use of water, energy and materials. The paper presents principles to develop water-sensitive cities that ensure access to safe water and sanitation and also to increase resiliency to floods and droughts.

**Key words:** climate change, population growth, sustainable development, water management, water resources

### Streszczenie

Zarządzanie zasobami wodnymi w obszarach miejskich jest coraz bardziej problematyczne z uwagi na intensywną urbanizację, zmiany klimatu oraz starzenie się miejskiej infrastruktury wodnej. Aby sprostać tym wyzwaniom, miasta muszą poprawić efektywność miejskich systemów wodnych poprzez odejście od dotychczasowych paradigmatów i opracowanie bardziej zrównoważonych rozwiązań. Obecnie około 1,8 ÷ 2,5% rocznego światowego PKB potrzebne jest do realizacji celów w zakresie zrównoważonego rozwoju gospodarki wodnej. Głównym wyzwaniem jest zapewnienie zdrowia publicznego i zaspokojenie potrzeb w zakresie dystrybucji wody, przy jednoczesnej ochronie jakości i ilości zasobów wodnych dla przyszłych pokoleń dzięki wydajnej produkcji i wykorzystaniu wody, energii i surowców. W artykule przedstawiono główne wytyczne dla rozwoju miast zapewniających bezpieczne źródła i systemy dystrybucji wody, odprowadzenie i oczyszczenie ścieków, a także zwiększenie odporności miast na występowanie zjawisk powodziowych oraz okresów suszy.

**Słowa kluczowe:** zmiany klimatyczne, wzrost zaludnienia, zrównoważony rozwój, gospodarka wodna, zasoby wodne

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### Introduction

With increasing numbers of people living in metropolitan areas, water, energy and materials need to be used carefully, reused and renewed. By 2030, over 6 billion people are expected to live in cities. More populated, denser cities will be required to provide more efficient services. Water is essential for the

well-being of citizens, their safety and social inclusion in cities (IWA, 2016). Historical development pathways are often not appropriate to plan future water systems. Two uncertain factors are forcing the changes in water, wastewater and stormwater management: climate changes and population growth. The Intergovernmental Panel on Climate Change (IPCC) coordinates the activities of scientists and

other researchers around the world to prepare projections of future climate changes and associated impacts. Climate change projections presented in assessment report are based on the outputs of computer simulations that project how the climate might evolve given different assumptions about greenhouse gas concentrations in the atmosphere. The observed historical record and future simulations indicate that it is certain that temperatures have increased and are likely to continue increasing – even the most optimistic scenario assumes a temperature increase to average value 4°C (fig.1). Increased atmospheric moisture storage is likely to lead to increased precipitation and more frequent and intense precipitation events, although it is less certain that this outcome has already been observed in the historical record (Paludan et al., 2016).

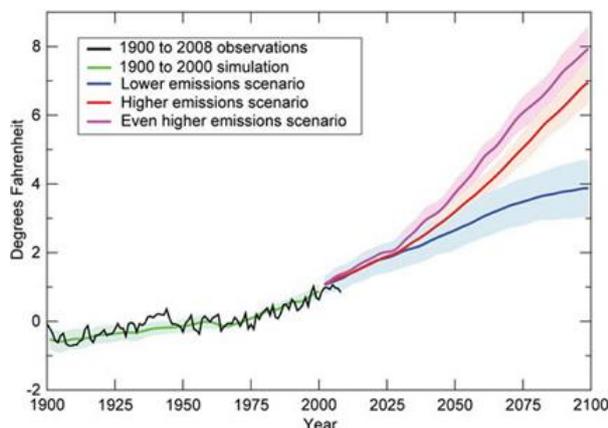


Figure 1. Prediction of world's average temperature growth by 2100 year (IPCC, 2014).

Climate changes may lead increase of the intensity, frequency, and duration of extreme rainfall events, with impacts on urban drainage systems. It is also possible that climate change will affect average sea levels and extreme sea level rise events. Because of computational limitations, global climate models use a grid size that is too large to simulate physical processes that are important for rainfall and other variables at local scales. Therefore, regional climate models are required to project changes in the characteristics of local weather.

In 2013 European Commission published *The European Union strategy on adaptation to climate change*. Urbanized areas were defined as special category in the structure of geographical space, characterized by a high density of the human population, and thus are very sensitive due to the negative impact of anthropopression. Cities are directly threatened by three phenomena:

- intensification of urban heat island,
- intensive rainfalls causing floodings,
- drought periods (water deficit in cities).

The abovementioned phenomena must be disturbing if we take into account the prediction of population growth. In its most recent forecast, the United Nations predicted that the world's population would

keep rising throughout this century, reaching 10.9 billion people by 2100. The urban population in 2014 accounted for 54% of the total global population, up from 34% in 1960, and continues to grow. The urban population growth, in absolute numbers, is concentrated in the less developed regions of the world. It is estimated that by 2017, even in less developed countries, a majority of people will be living in urban areas. The global urban population is expected to grow approximately 1.84% per year between 2015 and 2020, 1.5 % per year between 2020 and 2030. According to United Nation's predictions, the world population is expected to be 67 % urban in 2050. It should be noted that there are major differences in the rate of population growth and urbanization in different parts of the world. Thus, urban areas of the world are expected to absorb all the population growth over the next decades. Deterioration of the water management is expected to be worse, while already in many cities this is a serious problem.

Due to bad economics or poor infrastructure, every year millions of people, most of them children, die from diseases associated with inadequate water supply, sanitation and hygiene. In 2013, 783 million people globally did not have access to potable water – it is nearly 10% of the world's population.

It is certainly not possible to precisely provide either population or temperature, as it depends on many factors, but both values will increase. Cities are major contributors to climate change with estimates suggesting that cities are responsible for more than 75% of global carbon emissions. To safeguard public goods and services, such as water, cities must develop and implement innovative and sustainable solutions to protect their residents.

## 2. Present situation and future challenges in water management

It is now well established that population and economic growth are placing water resources under increasing pressure. Major regions of the world will face a massive water challenge the coming decades if current trends continue – with potentially devastating consequences for human life and health, business and agriculture, international relations, and the environment if they do not adapt. Today's situation in water management in cities is varied and depends on the location and development of a given country. Globally at least 1,8 billion people use a source of drinking water that is fecally contaminated. Between 1990 and 2015, the proportion of the global population using an improved drinking water source has increased from 76 % to 91 %, but water scarcity affects more than 40 % of the global population and is projected to rise. Over 1,7 billion people are currently living in river basins where water use exceeds recharge. When assessing the situation in water supply it should be emphasized the wastewater management is even more problematic. Near 2,5 billion people



Figure 2. Population growth of the world's top fifteen cities, including metropolitan areas (millions, 2011-2025).

lack access to basic sanitation services, such as toilets or latrines. More than 80 percent of wastewater resulting from human activities is discharged into rivers or sea without any pollution removal. This threatens the quality of water supply sources. Approximately 70 % of all water uptaken from rivers and aquifers is used for irrigation. Higher temperatures and increased variability of precipitation would lead to increased irrigation water demand, even if the total precipitation during the growing season remains the same.

By 2030, under an average economic growth scenario and if no efficiency gains are assumed, global water requirements would grow from 4,500 billion  $m^3$  today to 6 900 billion  $m^3$  – this is 40 percent above current accessible, reliable supply (including return flows, and taking into account that a portion of supply should be reserved for environmental requirements (WRG, 2009).

In global scale floods and other water-related disasters account for 70 per cent of all deaths related to natural disasters. In Europe floods are the most prevalent natural hazard – it was estimated that floods cost € 4.9 billion a year on average from 2000 to 2012, a figure that could increase to 23.5 billion euros by 2050 (Jongman et al. 2014). In addition, large events such as the European floods in 2013 are likely to increase in frequency from an average of once every 16 years to a probability of every ten years by 2050 (Koop and Leeven). The impacts of floods and droughts could be tempered by appropriate infrastructure investments and by changes in water and land-use management, but the implementation of such measures will entail costs (US Global Change Research Program, 2000). Conventional drainage systems remain the most common, method to manage stormwater in cities throughout the world. This is despite a number of issues that question the sustainability of such systems in the long-term, particu-

larly their increasing inability to prevent flooding, pollution and environmental damage.

### 3. Sustainable water management

The three pillars of sustainable development - economic, environmental and social – are integral to the development agenda worldwide. The idea of *sustainable cities* is closely aligned with this understanding, according to definition: *A sustainable city enables all its citizens to meet their own needs and to enhance their well-being, without degrading the natural world or the lives of other people, now or in the future.* Climate change and urban population growth are urgent imperative to move toward sustainable cities – the foundation of sustainable development. On September 2015, countries adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda. Each goal has specific targets to be achieved until 2030 year. Water related goals call upon countries to: *Ensure access to water and sanitation for all* (goal 6), *Make cities inclusive, safe, resilient and sustainable* (goal 11) and *Take urgent action to combat climate change and its impacts* (goal 13).

Sustainable water management is a major challenge. This is probably also the reason why the World Economic Forum (2014) ranked the water crisis and water-related risks as major global risks in terms of both probability and impact. Cities need to protect their citizens against water-related disasters (e.g. droughts and floods), to guarantee water availability and high-quality groundwater, surface water and drinking water. Cities need to have adequate infrastructure in response to climate, demographic and economic trends (OECD, 2015). The cost of water and wastewater infrastructure estimated by UNEP (2013) for period 2005-2030 is about 22 trillion

USD, more than that for energy, roads, rail, air and sea ports put together.

There is a significant distinction between climate change mitigation and adaptation. Mitigation efforts aim to prevent further climate change. Adaptation involves readjusting life to the reality that a certain amount of climate change will inevitably occur. An effective climate change policy for cities however needs to include both, and they need to be approached in an integrated manner.

Adaptation will have impacts primarily on a local scale: actions are based on specific needs of the affected regions. Costs might be very high, especially in large-scale infrastructure such as flood protection works.



Figure 3. Adaptation and mitigation action.

Mitigation is a global effort requiring broad changes of behavior and technological advancements. Mitigation strategies are usually expensive in the short term, because they are capital intensive and require fundamental changes to urban systems. Over time, the cost of mitigation is generally self-financed through cost savings. Wastewater, stormwater and water supply are each managed separately without being aware and taking advantage of the numerous links that exist between them. Examples:

- stormwater can be used for non-potable water supply such as irrigation, car washing, toilet flushing etc. and also to recharge aquifers for supply purposes,
- wastewater and stormwater is linked through combined sewer overflows, releasing untreated sewage into rivers during rainfalls; combining stormwater with wastewater increases the volume and cost of wastewater treatment,
- reuse of grey water and treated wastewater is an alternative water supply source that can supplement non potable water demand needs;
- poorly treated wastewater discharges due to leakages, overflows and inadequate treatment can pollute water supply sources such as rivers and lakes.

Understanding and use of mutual connections in urban water cycles makes possible to implement integrated water management in cities. An integrated approach to urban water management makes it easier to identify and exploit these positive links while min-

imising the negative implications throughout the system.

#### 4. Water-wise cities

In 2016 the International Water Association developed principles to help city leaders ensure that everyone in their cities has access to safe water and sanitation, that their cities are resilient to floods, droughts and the challenges of growing water scarcity, and that water is integrated in city planning to provide increased livability, efficiencies, and a sense of place for urban communities (IWA, 2016). The main goal is to ensure public health and satisfy all current needs while protecting the quality and quantity of water resources for future generations by efficient production and use of water, energy and materials. Increasing demand of potable water will be difficult maintain without negative consequences for water resources, so consumption per capita of water will need to fall. Reduce water intakes to match quantities that the natural environment is able to renew, and protect the quality of water sources from wastewater and urban runoff so that it is fit for ecosystems and for use with minimal treatment requirements. To obtain these goals cities need to reduce the amount of water used and also the energy used in transporting and treating urban waters and use diverse sources of water with treatment that matches the user needs. Urban water system should be flexible and ensure there are multiple resource, treatment, storage and conveyance options for ensuring appropriate service and resilience of the systems in the face of predicted climate changes.

Water sensitive urban design seeks the integration of urban planning with the management, protection and conservation of the total urban water cycle to produce urban environments that are *sensitive* to water sustainability, resilience and live ability co-benefits. Plan and implement urban design enabling regenerative water services to reduce the water, energy and carbon footprint of housing, benefiting ecosystems and people, while also improving social and urban amenities. Urban spaces should be designed to reduce flood risks by developing urban drainage solutions, integrated with urban infrastructure design (limiting local floods and treating rainwater as a resource). Natural water bodies should be visible –and create opportunities for recreation, inclusive public space, economic development and transportation, providing shade and mitigation of heat islands phenomenon. Next important issue is selection of urban materials of roofs, walls, surfaces, roads etc. to minimize their impact on water pollution.

It is important paradigm to plan and design in the basin scale. Secure the water resource and plan for drought mitigation strategies by sharing the water resource with agriculture, industry and energy sectors, and other cities who all contribute to the basin's. This applies not only to quantitative aspects but also

to protection of the quality of the water resource together with the other basin stakeholders to ensure high quality drinking water achieved with minimal treatment and energy requirements. Prepare for extreme events, such as storms and heavy rains, by investing in flood warning system and managing flow regimes in rivers, by maintaining adequate vegetation cover in the basin to reduce flash floods phenomenon.

The implementation of the previous sets of principles requires a holistic approach and strong partnerships – people are probably the most important ingredient during implementation of sustainable concepts. Following groups can be distinguished (IWA, 2014):

- Citizens involved in the sustainable urban water vision, can drive urban planning and design with their understanding of the risks (i.e. flooding) and opportunities (i.e. resource recovery). Trust and engagement of the local community is the foundation of successful implementation of waster sensitive city concept.
- Professionals who understand the co-benefits (finance, technical, social) across urban sectors so that they may plan and implement the best solutions for inhabitants and businesses. Professionals, realising the market and non-market value of the co-benefits associated to an integrated urban agenda, will enable innovative sustainable solutions. Interdisciplinary teams should integrate all kind of waters (freshwater supply, stormwater, rivers, seas and wastewaters) in city planning. Additionally all waters are connected with other urban systems (parks, roads, energy, transport and waste) and urban planning so that efficiencies and synergies arise from a coordinated approach.
- Policy makers establish policies and financing mechanisms to drive and enable sustainable urban water; they monitor, evaluate and adjust the policies based on future needs as they change over time.

Key factor is collaborative action, underpinned by a shared vision, so that local governments, urban professionals, and individuals actively engage in addressing and finding solutions for managing all waters of the city.

## Conclusions

Climate change poses serious threats to urban infrastructure, quality of life, and entire urban systems. Not only poor countries, but also rich ones will increasingly be affected by anomalous climate events (World Bank, 2010). As rapid urbanization continues, cities will be confronted with ensuring that water resources are effectively managed (Policy summary). With more than half of humanity now living in urban agglomerations, so cities around the world

are playing a leading role in building resiliency against climate change impacts. Whereas storm events may become stronger, at the same time it is expected that dry periods will become longer, it may lead to increased water scarcity. To manage these challenges cities have to improve the efficiency of urban water systems by rethinking old paradigms and developing more sustainable solutions. City densification is both an opportunity for economic growth and a threat to liveability. By managing water sustainably, we are able to better manage the production of food and energy and contribute to economic growth.

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## Filial Churches as a Sustainable Development Constituent

### Kościół filialne jako element zrównoważonego rozwoju

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#### Abstract

The catholic social sciences have always been associated with the idea of sustainable development. This is affirmed by the numerous writings of John Paul II and nowadays, emphasised in the speeches of Pope Francis. The paper considers the environmental aspects of the filial churches functioning. It investigates whether they fit with the idea of sustainable development. Considerations are carried with particular reference to the thirteen filial churches in Zawierciański pastoral district of the Archdiocese of Częstochowa, Poland.

**Key words:** filial churches, sacral buildings, sustainable development

#### Streszczenie

W nauczaniu społecznym kościoła katolickiego zawsze można było zauważyć silne powiązania z ideą zrównoważonego rozwoju. Dowodem na to jest wiele pism Jana Pawła II, a obecnie szczególnie liczne wypowiedzi na ten temat papieża Franciszka. Biorąc za punkt wyjścia te rozważania teoretyczne autorka analizuje ekologiczne aspekty funkcjonowania kościołów filialnych, badając jak obiekty te pasują do idei zrównoważonego rozwoju. Zagadnienie zostało omówione na przykładzie trzynastu kościołów filialnych zawierciańskiego okręgu duszpasterskiego archidiecezji częstochowskiej.

**Słowa kluczowe:** kościoły filialne, budynki sakralne, zrównoważony rozwój

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#### Introduction

There are 310 parishes in the archdiocese of Częstochowa, some of which have filial churches within their boundaries. These are objects situated within the parish but which are not the main church building. The functional design of filial churches is generally poorer than that of parish churches, and the buildings are smaller. Filial churches were erected, especially in territorially large parishes, to shorten the travel time for the faithful to worship. Long distances from church cause particular difficulty for elderly parishioners, children and adolescents. The expectations of believers have changed, compared to the past, and nowadays people expect the journey to the church to be both comfortable and short.

The Archdiocese of Częstochowa is divided into four pastoral districts: Częstochowski, Radomszczański, Wieluński and Zawierciański. Across the four districts, the author has documented 74 filial churches and chapels. These studies focused on

churches built after 1945, as previously filial churches practically did not exist.

In the Częstochowski region of the Archdiocese of Częstochowa, 85 new church buildings have been erected since 1945, of which 76 are parish churches and 9 (12%) are filial churches. There are many more filial churches in the three other, less urbanized pastoral districts of the Archdiocese. The greatest number have been erected in the Wieluński region, where agricultural land predominates. Here, there are 51 new church buildings in total, including 26 parish churches and 25 (49%) filial churches.

The Radomszczański region comprises 61 church buildings erected since World War II. Of these 33 are parish churches and 28 (46%) are filial churches. The Zawierciański pastoral region has the least number of churches built since 1945 – only 37. Of these 24 are parish churches and 13 (35%) are filial churches.

The social teaching of the Catholic Church has always been tied in with the issue of sustainable

Table 1. Filial churches of Zawierciański pastoral district: data concerning the construction of the walls and roofs, source: author's own research

No.	Church	Location	Kind of external walls	Coef. $U_{c(max)}$	Roof construction	Years of construction
1.	Filial church of St. John Vianney	Mzyki (par. Gniazdów)	hollow cinder blocks 51 cm + external plaster	0.753	wooden	1989-1994
2.	Filial church of St. Francis of Assisi	Gęzyn (par. Koziegłowy)	hollow cinder blocks 51cm (part of walls) and silica brick 51 cm; No external plaster	0.753 and 1.396	reinforced concrete structure	1984-1987
3.	Filial church of Our Lady of the Rosary	Zdów (par. Góra Włodowska)	limestone 60 cm + external plaster	2,090	wooden	1987-1999
4.	Filial church of the Ascension	Pomrożyce (district of Zawiercie, par. of St. Nicholas)	hollow cinder blocks 38 cm + external plaster	0.951	wooden	1991-1993
5.	Filial church of the Immaculate Heart of Mary	Zerkowice (district of Zawiercie, par. of Holy Trinity)	ceramic bricks 51 cm, no external plaster	1.151	wooden	1987-1990
6.	Filial church of St. Stanislaus	Piasek (par. Janów)	hollow maxi bricks 60 cm + external plaster	0.826	wooden	1986-1990
7.	Filial church of St. John the Baptist	Hucisko (par. Niegowa)	hollow cinder blocks 42 cm + external plaster	0.880	wooden	1991-1993
8.	Filial church of St. Stanislaus	Mirów (par. Niegowa)	hollow cinder blocks 20 cm + gas concrete 24 cm + external plaster	0.738	wooden	1997-2007
9.	Filial church of Our Lady of Czestochowa	Trzebnów (par. Niegowa)	hollow maxi bricks 40 cm + external plaster	1.126	wooden	1981-1992
10.	Filial church of Maximilian Maria Kolbe	Gorzów Nowy (par. Złoty Potok)	limestones 40 cm + Styrofoam 5 cm + Max hollows 19 cm	0.540	wooden	1984-1986
11.	Filial church of Our Lady Mother of the Church	Pabianice (par. Złoty Potok)	hollow maxi bricks 49 cm + external plaster	0.968	wooden	1989-1994
12.	Filial church of Our Lady of Perpetual Help	Siedlec (par. Złoty Potok)	hollow maxi bricks 29 cm + sawdust concrete 10 cm + limestone 25 cm	0.726	wooden	1982-1986
13.	Filial church of the Pentecost	Czatachowa (par. Żarki)	limestones 60 cm + external plaster	2.090	wooden	1994 -1998

development. This is evidenced by the numerous writings of John Paul II (Ewertowski, 2013) and now, especially, by the speeches of Pope Francis. Against this background of theoretical considerations and the teaching of the church, this paper considers the environmental aspects of the functioning of filial churches and whether they fit with the idea of sustainable development. It has been tested how theoretical considerations fit into the reality of the smallest religious buildings – filial churches. Considerations are carried with particular reference to the churches in Zawierciański pastoral district.

### The technical characteristics of filial church buildings

Most of the filial churches were erected in the 80s and 90s, when, after many years of great difficulty, it became easier to obtain building permits for the construction of religious facilities. Many of these

objects were originally designed as catechism buildings as it was easier to obtain planning permission for such teaching facilities. During construction, a number of changes to the building plans would be introduced to have a larger space for the sacral part. As a result, the architecture of such structures is often quite random and the functional design is far from optimum. However, there are also some very interesting buildings in terms of their form and functional solutions, especially those later realisations, erected around the turn of the century. The issue of the thermal insulation of churches was investigated with particular reference to contemporary sacral objects situated in Zawierciański pastoral district of the Archdiocese of Częstochowa. Church buildings in this district have been erected from the 1970s to the present day, with the majority of them built in the 80s. Data relating to these objects is presented in Table 1. The coefficient  $U_{c(max)}$  [W/m<sup>2</sup>·K] was calculated by taking the average value of coefficient  $\lambda$  for a given type of material.

Table 1. Filial churches of Zawierciański pastoral district: data concerning the location of objects and the number of local residents.

No.	Church	Location	Number of local residents *	Distance to the parish***
1	Filial church of St. John Vianney	Mzyki (par. Gniazdów)	114	3 km
2	Filial church of St. Francis of Assisi	Gęzyn (par. Koziegłowy)	336	7 km
3	Filial church of Our Lady of the Rosary	Zdów (par. Góra Włodowska)	536	8 km
4	Filial church of the Ascension	Pomrożyce (district of Zawiercie, par. of St. Nicholas)	282**	4 km
5	Filial church of the Immaculate Heart of Mary	Żerkowice (district of Zawiercie, par. of Holy Trinity)	409**	3 km
6	Filial church of St. Stanislaus	Piasek (par. Janów)	330	3 km
7	Filial church of St. John the Baptist	Hucisko (par. Niegowa)	27	9 km
8	Filial church of St. Stanislaus	Mirów (par. Niegowa)	151	5 km
9	Filial church of Our Lady of Czestochowa	Trzebnów (par. Niegowa)	344	7 km
10	Filial church of Maximilian Maria Kolbe	Gorzków Nowy (par. Złoty Potok)	400	8 km
11	Filial church of Our Lady Mother of the Church	Pabianice (par. Złoty Potok)	233	8 km
12	Filial church of Our Lady of Perpetual Help	Siedlec (par. Złoty Potok)	506	8 km
13	Filial church of the Pentecost	Czatachowa (par. Żarki)	156	5 km

\* (Rocznik Statystyczny, 2009), \*\* (information from Zawiercie city government), \*\*\* (<http://6/kuriaczestochowa.pl>)

A typical act of worship in church generally lasts no more than one hour and the faithful stay in outdoor clothing. Thus it may be sufficient to maintain an interior temperature in the range of 8°C to 16°C.

Technically a church is a public building and for public buildings, the current requirement for the thermal insulation of the walls is considered to be met if the heat transfer coefficient  $W/(m^2K)$  for a temperature of  $8^\circ < t_i \leq 16^\circ C$   $U_{(max)} \leq 0.45$ .

Table 1 shows that the values of  $U_{c(max)}$  are in the range of 2.090 to 0.540 ( $W/m^2 \cdot K$ ). The walls of none of the churches have values  $U_{c(max)}$  which meet the current requirement.

Two filial churches located in Zawierciański pastoral district (15%) have no external plaster yet (fig.1). The remaining 11 churches have external plaster or another kind of finishing on the exterior walls.



Figure 1. Filial church of St. Francis of Assisi in Gęzyn

Almost all (92%) the examined filial churches have a wooden roof truss structure. Owing to the difficulty in accessing the structural elements of the roof, data on the thickness of the layer of roof insulation is unknown for most of the objects. However partial data, established during research, shows that the insulation layer (usually mineral wool) is not thicker than 14 cm, and often even less. Research also showed that in the churches built in the 80s, Supra with a thickness of 5 cm was often used for roof insulation. Due to a lack of exact data on all the filial churches, it is not possible to come to a definitive conclusion on the roof structure insulation. Nevertheless, it is possible to say that for the vast majority of these churches insulation is inadequate and does not meet the current heat insulation requirements.

The windows in the studied buildings are not energy efficient as they often have steel frames and no double glazing (Repelewicz, 2014).

The data obtained in the Zawierciański pastoral district is representative of filial churches across the whole Archdiocese of Czestochowa. After the difficult years of communism, the Catholic Church in the Archdiocese of Czestochowa and throughout Poland inherited a large number of filial churches buildings with very low energy efficiency. It seems that in the past this issue had been completely

ignored during the investment process. This can probably be explained in part by the centuries old tradition of not having heating in churches and consequently there being no need to take energy efficiency into consideration in the design process. It can therefore be concluded that filial churches are not ecological objects.

### Ecological aspects of the considered filial churches

The thirteen filial churches in Zawierciański pastoral district are located at distances of between 3 to 9 kilometers from the main parish church. These are journeys which if made on foot (one-way) would take an adult on average from 36 minutes to almost two hours. For the elderly and young children, these distances too long, especially as they need to made in both directions. Public transport in rural areas is poor especially on Sundays when services are infrequent. Therefore, the faithful would have little choice but to use their cars.

Sunday and Christmas Masses as well as some First Friday devotions are celebrated by the priests of the parish in all the considered filial churches. In addition, the faithful often congregate there to say the rosary and to celebrate devotions in May, when a priest is not present.

Given the number of inhabitants in the villages where filial churches are located (27 to 536), and taking into consideration the percentage of people participating in holy Mass, so-called *dominantes*, which is 40% on average in Poland (Kościół katolicki..., 1991-2011, 2014) then it follows that from 11 to over 214 church-goers would have to travel by road from their homes to their main parish church. In fact, this number is almost certainly higher, not only because rural populations are traditionally more religious when compared to urban residents, but also due to the fact that filial churches are used by the inhabitants of neighbouring villages, for whom these churches are closer than their parish church.

The overall population in the villages where the filial churches of Zawierciański pastoral district are located is 3824, and 40% of that number is 1530 people. Multiplying the number of dominantes by the distance, they would have to get the parish church, gives the result of 9450 km for one congregation. Assuming that one car delivers average 3 people to the church, about 3150 km would have to be driven every week in Zawierciański pastoral district. It gives about 163800 unnecessary driven kilometers a year. An amount of fuel needed to support this journeys is saved thanks to the existence of filial churches.

It can be concluded that due to the existence of filial churches that at least 1530 faithful have no trouble getting to church on Sundays and holy days. This results in the saving of fuel and time as well as providing great psychological comfort.

What are, in turn, the financial costs associated with

such facilities? Undoubtedly, the greatest of them is the cost of construction and fitting out the building. A study conducted by the author showed that all the considered filial churches were erected at low cost. Generally these objects are small (fig. 1,2). The building plots were commonly donated by one of the faithful or were municipal areas. Building materials were also donated or purchased with money collected from the faithful, and the construction work was done by volunteers from the local community.



Figure 2. Filial church of St. Stanislaus in Mirów

The furnishings and fittings of filial churches are usually very simple (fig. 3,4). Sometimes there is no heating. This is for both financial and practical reasons as these churches are used occasionally and for short periods of time because the main celebrations take place in parish churches.



Figure 3. Interior of the filial church of Our Lady of the Rosary in Zdów



Figure 4. Interior of the filial church of St. John the Baptist in Hucisko

These objects are relatively new and therefore do not require much in the way of repairs. However,

ongoing maintenance works are usually carried out by members of the congregation free of charge. Additionally, cleaning and decorating the church is organized on a voluntary basis. One of the few regular charges are electricity bills, but as the facilities are used for relatively short periods of time these are not high.

It follows from the above analysis that the benefits arising from the existence of filial churches in the territorially large parishes of Zawierciański pastoral district are enjoyed by many – not less than 1530 people. In the less urbanized districts of the Archdiocese, where there are 61 more filial churches, the number of beneficiaries can be estimated in the thousands.

### Survey among users of selected churches

The survey was conducted among inhabitants of selected representative villages, in which filial churches are located (Pabianice, Siedlec, Hucisko, Mirow). In total, 38 questionnaires from active filial churches parishioners were collected. The study involved 24 women and 14 men aged 29 to 79, of which 24 were over 60. The majority (20 respondents) completed basic education level, 10 reported secondary and 8 tertiary education level. The survey included 9 questions, 7 close-ended and 2 open-ended.

The majority confirmed that the presence of filial churches influenced a greater bond between the priest and the faithful (34 persons), four people did not have any opinion on this subject, no one denied. Liquidation of filial church, would not change the frequency of worship among 26 faithful, while 12 people (mostly over 70) would be less likely to congregate.

24 interviewed people affirmed that the existence of filial church affects the feeling of being in touch with the local community. 14 persons did not have any opinion on it. No one answered negatively.

The existence of filial churches situated away from the parish church, was considered to be pro-ecological and to support the sustainable development. 30 respondents emphasized that the Catholic Church encourages faithful to work for the protection of the environment. Seven people have answered *hard to say* and one *no*.

The most interesting statements came in response to open-ended questions. As the greatest benefit of the filial church existence, respondents predominately mentioned the vicinity that eliminates inconvenient commuting, saving time and money. Older women emphasized the possibility of every Sunday worship. *The church is close and I do not have to worry about getting to the parish* one of the ladies wrote.

Driving license and car possession among elderly inhabitants of rural areas is rare, therefore getting to a parish can become a challenge.

Respondents mentioned also a number of other catholic services, they can attend on weekdays: May devotions to the Blessed Virgin Mary, Lenten Lamentations, Way of the Cross, Rosary. These services are often carried out by the local rosary prayer circle.

In response to the question *How the filial church construction influenced interpersonal relations within the local community?* interesting opinions emerged. Recalling the construction time, one of the respondents wrote *It was a time of unity and collective decision-making*. Another wrote: *The work on the construction of the chapel was divided among all the inhabitants*.

As a current activities within the church, the respondents mentioned: *joint chores around the church, common altar decorating*. They also described in detail: *tidying up the chapel, subsoil scattering on the courtyard, lawn mowing, catechetical room painting*. One of the pollster emphasized: *The residents are more concerned about the church, they carry out the money collection willingly when bigger purchase or renovation are required and Residents are more focused on their filial church instead of the parish one*. The woman from Pabianice (67 years old) wrote: *My role is to collect money when the community has to buy something, perhaps to emphasize her commitment and important social function*. According to parishioners opinions, filial churches are the only regular meeting places for aging, lonely residents of villages.

72-year-old parishioner from Pabianice wrote: *On the way to church and back, I can meet my neighbors and talk*. Her 79-year-old borderer stated very similarly: *I have the opportunity to meet my friends and neighbors*. Pretty similar opinions occurred among other parishioners: *When I go to the church I meet others, we can talk and We butt with all the residents on the way to church, discussing the village affairs*. Young people are moving out, and as a result, old and lonely people stay alone in their countryside. Going out to church and meeting with other villagers, opportunity to led a conversations and sharing the service is often one of the few moments of social contact for this aging people.

It is of great importance to the villagers that *the masses are for the deceased of our village, you can pray and reminisce*. It further unites the local community.

There is also a pride of owning church, because *not all villages have their own churches*.

One of the respondents mentioned the advantage of the filial church presence for the holidaymakers coming to the village: *The summerhouses are also close to the church and we meet vacationists, we pray together*.

Great satisfaction of the filial church possession is visible in all the completed questionnaires. Respondents point out a number of measurable and impon-

derable benefits from the fact that such a facility is functioning in their village.

### Summary

Local religious buildings, also known as filial churches, are of great benefit to the people in the small villages they serve as church-goers do not have to travel as far as the parish church for religious celebrations. The usefulness of the existence of such buildings is proven in practical terms. Moreover, they also bring some other, non-material benefits. These are sometimes the only place for collective meetings in the village, and as such have great importance in establishing and maintaining a sense of local community. The faithful often organize themselves around such a centre: forming various prayer groups. In small villages, filial churches fulfill, in a manner of speaking, the function of various associations for seniors in cities: universities of the third age, day care places or recently popular senior's movement activity squares. For older, lonely people they are a place to meet and share. It is also give them a feeling of importance and relevance.

Sustainable development involves not only environmental issues but also issues on a technical and social plane (Pawłowski, 2009). So, paradoxically, the least ecological religious buildings (parish churches were built with more care) fit perfectly with the issue of sustainable development.

Among the many positions and arguments the most evident is the need to protect the environment, as it is necessary for the preservation of human life both now and in the future (anthropocentric argument). Quality of life is obviously a highly relevant factor which needs to be taken into account. It is important to recognize that human biological, psychological and social needs as well as ecological concerns are factors which should be and can be satisfied through environmental protection (Pawłowski 2009). It can be concluded that the Catholic Church's social teaching, in its ecological aspect, is practically reflected in the functioning of filial churches.

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## What Factors can Influence the Expansion of Protected Areas around the World in the Context of International Environmental and Development Goals?

Jakie czynniki mogą wpływać na poszerzanie obszarów  
chronionych na świecie w kontekście międzynarodowych  
celów środowiskowych oraz rozwojowych

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### Abstract

The protection of biodiversity is an integral part of sustainable development. All the major international environmental and development programs – Aichi Biodiversity Targets, Millennium Development Goals and Sustainable Development Goals – have committed countries to conserving valuable ecosystems by ensuring that a certain proportion of their terrestrial and marine areas are protected. While many countries have registered improvements in their coverage of protected areas, a significant number are behind in their targets. This paper attempts to shed light on the role of various factors in nature conservation which go beyond the performances of individual countries. Regression analyses were performed on variables that could influence the coverage of protected areas. The main findings point to the significance of economic development, whereas other factors remain less relevant. Although the level of economic development corresponds to the protected areas on an individual country level, it does not automatically ensure a slowdown in biodiversity loss.

**Key words:** protected area, biodiversity, environmental indicator, sustainable development, Millennium Development Goals, Sustainable Development Goals, Aichi Biodiversity Targets

### Streszczenie

Ochrona bioróżnorodności jest nieodłączną częścią zrównoważonego rozwoju. Wszystkie znaczące międzynarodowe programy ekologii i rozwoju – Cele Aichi (Aichi Biodiversity Targets), Milenijne Cele Rozwoju (Millennium Development Goals) oraz Cele Zrównoważonego Rozwoju (Sustainable Development Goals) – zobowiązały kraje do ochrony cennych ekosystemów poprzez zapewnienie, że pewne części ich lądowych oraz morskich obszarów będą podlegały ochronie. Wiele krajów zanotowało wzrost zasięgu ich obszarów chronionych, jednak wiele innych nie osiąga zamierzonych celów. Niniejszy artykuł koncentruje się na ogólnej próbie analizy różnych czynników wpływających na ochronę środowiska związanych z ochroną środowiska. Wykorzystano analizę regresji zastosowaną wobec zmiennych, które mogą wpływać na przyjmowaną powierzchnię obszarów chronionych. Przeprowadzone badania wskazują na znaczącą rolę rozwoju ekonomicznego, podczas gdy inne czynniki wydają się mniej znaczące. Chociaż stopień rozwoju ekonomicznego odpowiada wielkości chronionych obszarów na poziomie poszczególnych krajów, nie oznacza to automatycznie spowolnienie tempa ubytku bioróżnorodności.

**Słowa kluczowe:** obszar chroniony, bioróżnorodność, wskaźnik środowiskowy, Milenijne Cele Rozwoju, Cele Zrównoważonego Rozwoju, Cele Aichi

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## Introduction

This paper focuses on using the coverage of protected areas as an environmental indicator in the context of sustainable development. Biodiversity conservation is an important part of the environmental component of the concept of sustainable development (UN, 1992), and it interacts with the economic and social dimensions of sustainable development (Giddings et al., 2002). Protected areas are seen by many conservationists as a key tool in biodiversity conservation (Saout et al, 2004; Naughton-Treves et al., 2005), moreover they may help to maintain food security and water supplies, strengthen climate resilience and improve human health and well-being (IUCN, 2015). Despite this, the socio-economic benefits generated by protected areas remain controversial and under debate (Adams et al., 2004; Naughton-Treves et al., 2005, Brockington, Wilkie, 2015). Because the loss of biodiversity is recognized by the international community as one of the most serious global environmental threats (the United Nations General Assembly declared 2011-2020 the *United Nations Decade on Biodiversity* (CBD, 2010), it is not surprising that the coverage of protected areas is a widely used indicator of sustainable development (Chape et al., 2005, IUCN, 2010). Probably the most recognized definition of a protected area is provided by the International Union for the Conservation of Nature – an international organization working in the field of nature conservation and sustainable use of natural resources. According to this organization, a protected area is a *clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values* (Dudlay, 2008:8). *The Millennium Development Goals and the Sustainable Development Goals* include the coverage of protected areas indicators. *The Millennium Development Goals* contain indicator no. 7.6, *Proportion of terrestrial and marine areas protected* within Target 7.B. (UN, 2015a). The indicator focuses on changes in the proportion of protected areas – however, because it does not set any measurable goals, the rate of change is non-essential. *The Millennium Development Goals Report* is largely positive concerning the performance within the 7.6 indicator. Indeed, many regions have significantly increased their terrestrial protected areas since 1990. Globally, 15.2 per cent of terrestrial and inland water areas, and 8.4 per cent of coastal marine areas (up to 200 nautical miles from shore) were protected in 2014 (UN, 2015a). *Sustainable Development Goals* (officially known as *Transforming our World: the 2030 Agenda for Sustainable Development*) only use the *coverage of protected area* indicator for marine areas within Goal 14. Target 14.5 commits countries to, *By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international*

*law, and based on the best available scientific information* (UN, 2015b). Apart from quantitative aspects, the SDGs put more emphasis on the quality of biodiversity conservation in this target, and it is done through the standardization of rules and science-based management. While Goal 14 deals with *life below water*, Goal 15 is focused on *life on land*. The first Target, 15.1 states that countries will, *By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular, forests, wetlands, mountains and drylands, in line with their obligations under international agreements* (UN, 2015b). Therefore the target does not come with a measurable indicator for terrestrial ecosystems; instead it commits countries to fulfil their obligations under international agreements.

*The Strategic Plan for Biodiversity* is an important international agreement in relation to nature conservation and protected areas. The plan was adopted by Parties to the United Nations *Convention on Biological Diversity* (CBD) in Japan in 2010 (Pereira et al., 2013) and it contains 20 *Aichi Biodiversity Targets* organized under five strategic goals. Target 11 postulates that *By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, will be conserved. This is to be done through a number of effectively and equitably managed, ecologically representative and well connected systems in protected areas, along with other effective and area-based conservation measures, all integrated into the wider landscapes and seascapes* (CBD, 2010). Therefore Target 11 of the *Aichi Biodiversity Targets* can be used as a benchmark for the SDGs Target 15.1, which is, in itself, an important international commitment.

In order to structure and analyse indicator sets, many organizations now use the driving force-pressure-state-impact-response (DPSIR) framework (Mace, Baillie, 2007). The indicator *coverage of protected areas* can be classified, according to its place in the DPSIR framework, as a response indicator (Butchart et al., 2010), measuring the effectiveness and impact of policy and management responses (Walpole, 2009). In other words, it measures political commitment to biodiversity conservation and does not provide information on *effectiveness* in conserving biodiversity (Chape et al, 2005). Although the actual performance of and future trends regarding the indicator *coverage of protected areas* have been described (UN, 2005a; Butchart et al, 2010), there is little knowledge of the factors which influence changes (either positive or negative) in the coverage of protected areas. In the literature, more attention is paid to the factors that affect the success of biodiversity conservation in national parks and other protected areas (Bruner et al., 2001; Leverington, 2010). Knowledge concerning the actual performance of

Table 1. Frequency distributions of protected areas in 1990 and 2012 (source: own elaboration)

PA coverage (%)	Number of countries in 1990	Relative distribution in 1990 (%)	Number of countries in 2012	Relative distribution in 2012 (%)
0-1	46	23.00	23	11.39
1-5	59	29.50	41	20.30
5-10	37	18.50	29	14.36
10-15	28	14.00	27	13.37
15-20	15	7.50	29	14.36
20-30	7	3.50	33	16.34
30-40	6	3.00	12	5.94
over 40	2	1.00	8	3.94
Total	200	100.00	202	100.00

Table 2. Regional aspect of terrestrial protected areas in 1990 and 2014 (source: own elaboration)

Region	1990	2014	Difference	Growth Rate
Caucasus and Central Asia	2.70	4.60	1.90	170%
Oceania	2.00	5.00	3.00	250%
Southern Asia	5.40	6.80	1.40	126%
Northern Africa	2.70	7.70	5.00	285%
South-Eastern Asia	8.40	14.00	5.60	167%
Sub-Saharan Africa	10.60	15.30	4.70	144%
Western Asia	3.70	15.40	11.70	416%
Eastern Asia	12.00	16.80	4.80	140%
Latin America and the Caribbean	8.80	23.40	14.60	266%

Table 3. Terrestrial and marine protected areas in 2012 and achievement of SDGs and Aichi Biodiversity targets (source: own elaboration)

PA coverage (%)	Terrestrial protected areas (17 % target <sup>1</sup> )		Marine and coastal protected areas (10 % target <sup>1,2</sup> )	
	Number of countries	Cumulative distribution	Number of countries	Cumulative distribution
0-1	13	6.50	38	24.68
1-5	35	24.00	48	55.84
5-10	26	37.00	17	66.88
10-17	47	60.50	19	79.22
17-30	52	86.50	13	87.66
30-50	24	98.50	10	94.16
50-75	3	100.00	5	97.40
over 75	0	100.00	4	100.00
Total	200		154 <sup>3</sup>	

<sup>1</sup> Aichi target, <sup>2</sup> SDGs target, <sup>3</sup> There are 46 landlocked countries in the world

protected areas in biodiversity conservation at a local level is undoubtedly important, but it does not provide useful information about factors critical to the success or failure of achieving an increase the coverage of protected areas worldwide. This paper attempts to shed light on the role of various factors behind the performance of individual countries in establishing or enlarging their protected areas. To address the issue, we performed a regression analysis on variables that could influence the coverage of protected areas.

### Protected areas in the world: statistical overview

The following section provides a basic statistical overview of the performance of countries in fulfilling the three international development and environmental goals – *Millennium Development Goals*, *Sustainable Development Goals* and *Aichi Biodiversity Targets*. Starting with *Millennium Development*

*Goals*, the average value of protected area coverage in 1990 (the baseline) was 7.51%. The performance of the investigated countries had changed considerably by 2012, by which time the coverage had almost doubled to an average value of 13.92%. At the same time, differences among countries increased. The worst performers (Sao Tome and Prince Island) had a rate of protected area on their territories lower than 0.01%, four countries' protected areas were below 0.1% (Aruba, Barbados, Jordan and the Federal States of Micronesia) and twenty three countries' had less than 1%. In contrast, twenty countries achieved the threshold of 40% and the eight best performing countries (Germany, Greenland, Hong Kong, Lichtenstein, Monaco, Namibia, Slovenia and Venezuela) protected more than 50% of their territory. The detailed distribution from 1990 and 2012 is displayed in Table 1.

In rare cases, a decrease in the proportion of protected areas has been documented; the biggest drop

occurred in the case of Jordan. All other countries witnessed either stagnation or a rise in their protected area network. In 47 countries the number of protected areas increased by more than 10 percentage points. Additionally, 13 of those countries increased their protected areas by 20 percentage points and 4 (Bulgaria, Monaco, Namibia and Slovenia) increased theirs by 30 percentage points or more.

From a regional perspective, progress in the protection of terrestrial protected areas can be found in every region of the world, but some regions performed better than others. In Latin America and the Caribbean, the protected areas grew from 8.8% in 1990 to 23.4% in 2012. Similarly, Western Asia's protected areas quadrupled from 3.7% to 15.4%. The protection of marine and coastal areas increased the most in Oceania, where there were no protected areas in 1990 and by 2012 that had changed to 7.4% of marine and coastal areas being protected. The performances of various regions are listed in table 2.

In September 2015 the UN member states adopted 17 *Sustainable Development Goals* after the expiration of the MDGs. SDGs are part of a wider 2030 Agenda for Sustainable Development and form an integrated framework of linked and mutually reinforcing goals. Moreover, SDGs can also be seen as a paradigm shift (Lebeda, 2015). Although the environmental dimension to SDGs has been significantly strengthened compared to the previous MDGs agenda (Hajer et al., 2015). It sets measurable targets only for marine areas (Target 14.5 commits countries to conserve at least 10 per cent of coastal and marine areas by 2020) (UN, 2015b). This deficiency however, can be overcome by the inclusion of Aichi Biodiversity Targets, which set the tangible threshold at 17% of terrestrial and inland water, and 10% of coastal and marine areas (CBD, 2010). In 2012, some 79 countries (39.5%) achieved the Aichi target for terrestrial areas, and 51 countries (33.12%) complied with the targets for marine and coastal areas (see Table 3).

When comparing the average size of terrestrial and marine protected areas, it is not surprising that the latter (marine and coastal areas) are larger. The best performing countries protect almost all of their marine and coastal areas; Slovenia (98.42%), Bosnia and Herzegovina (99.21%) and Monaco (99.99%). However, we should recognise that their marine and coastal areas are small in absolute terms. Nevertheless, there are also examples of good performers whose marine and coastal areas are relatively large, but they are still able to provide protection to a significant part of them, i.e. the Netherlands (61.82%), Germany (64.46%) and Ecuador (75.66%).

### Regression analyses: data, variables and results

In this section we attempt to find whether economic, social, environmental or institutional factors are associated with the proportion of protected areas in the

countries of the World. Therefore we have performed two regression analyses. The cross-sectional regression analysis should explain which factors influence the proportion of protected areas in a cross-section of countries (from 2012; the most up-to-date data). The panel regression will allow us to analyze not only the variability of protected areas among countries, but also their variability over time in the period under study (i.e. 1990-2012).

#### *Data and variables*

Our dependent variable is the proportion of protected areas (terrestrial and marine combined) in the total area of countries. Since it is a proportion that varies between zero and one, we have transformed this variable through a logit transformation to take its bounded nature into account. The data for countries for the period 1990-2012 were obtained from the World Bank's database *World Development Indicators* (World Bank, 2016a).

We are interested in a possible association between various indicators of development and the proportion of protected areas. Therefore our main explanatory variables measure the level of development in different dimensions. Dietz and Adger (2003) show in their analysis that the extent of government environmental policy increases with economic development. Because nature conservation and the establishment of protected area networks are part of a state's environmental policies, we should expect the wealthier countries to have the higher share of protected areas. The level of economic development is measured by gross national income (GNI) in per capita terms (atlas method, current USD). The data were acquired from the *World Development Indicators* database (World Bank, 2016a).

The level of social development is approximated by two indicators – the mean years of education and the *Human Development Index* (HDI). HDI is a composite indicator that consists of two sub-indices of education (expected years of education and mean years of education), one sub-index of health (life expectancy at birth) and one sub-index of standard of living (gross national income per capita). Although HDI measures the level of human development, it is evident from its composition that it can also be used as an approximation of social development. Data for both indicators were obtained from the *United Nations Development Programme* (UNDP) *Human Development Report Database* (UNDP, 2016). Due to data unavailability it was not possible to include other explanatory variables that the authors were interested in, such as indicators of poverty (poverty headcounts) and income inequality (Gini coefficient).

In the development and environmental literature the quality of institutions is considered to be one of the determinants of successful biodiversity conservation processes (Smith et al., 2003). We approximate the level of institutional development by three indica-

tors. First, we used the average of six indices from the *Worldwide Governance Indicators* (WGI) that measure institutional quality in six dimensions: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and absence of corruption. Each of the six indices has values from -2.5 to 2.5, with higher values indicating better performances. Data for these indicators were acquired from the WGI World Bank's website (World Bank, 2016b). Second, we used the Index of Freedom calculated by the organization Freedom House as the average of two indicators that measure the level of civil liberties and political rights in a country. The index can have values from 1 to 7 and the lower the index, the better the quality of a country's institutions (Freedom House, 2016). Third, we used the Heritage Foundation's Index of Economic Freedom (IEF) as an approximation of institutional quality. The index can have values from 1 to 100 with higher values indicating a better quality of institutions (Heritage Foundation, 2016).

Our control variables include the total area, total population and population density of countries, the proportion of people living in urban areas and the proportion of forest areas in the total area of the countries. Data for all these variables were obtained from the World Development Indicators database (World Bank, 2015). As for the proportion of forest variable, the literature suggests (see, for instance Joppa and Pfaff, 2009; Jenkins et al., 2015) that countries tend to protect forested territories in remote areas, unsuitable for agriculture and other human activities. For instance, the USA protects very large areas of its dry, mountainous west – and very little else (Joppa, Pfaff, 2009). It is therefore reasonable to expect that countries with a higher proportion of forests will also have a higher percentage of protected areas.

Apart from the proportion of forest areas, we have decided to incorporate other variables that roughly approximate the differences in land use structure among countries. This is because some types of habitats might constitute a significant factor for biodiversity conservation (Hoekstra, Boucher, 2005). To control this influence in our regressions, we have included variables of land use acquired from the FAO GeoNetwork database (FAO, 2016). Through a series of geospatial analysis operations conducted in ArcGIS 10.3., we have determined the proportion of main land use types for each country. These types were further aggregated into the following four groups of land use/land cover (LULC), partly according to EPI categories (Yale University, 2016) and partly arbitrarily: grassland and shrubs (as those with a higher chance of being protected); wetlands (as a special type of land use); cropland and urban land (land use types directly shaped by human economic activity) and other types of land use (aggregation of sparsely vegetated areas, bare areas and open

water areas). With the latter type of land use – sparsely vegetated areas, bare areas – we can expect a similar pattern to the forests. According to Joppa and Pfaff (2009), the common phrase *rock and ice* summarizes the perception that protected area locations are biased towards marginal (arid, rocky, icy) lands. It may be financially expedient and politically pragmatic to protect such land that has a low financial value (Ando et al, 1998). After these adjustments, we have a total of five land use variables (including the proportion of forest areas). The aggregation has been done to reduce the number of variables entering the regressions.

We have also included a dummy variable to control for any form of a country's membership in IUCN (IUCN, 2010). Protected areas should benefit from their countries' IUCN membership because the organization is committed to the protection of biodiversity and supports the expansion of protected areas among its members (IUCN, 2017). We have also identified other variables that could potentially have an impact on the dependent variable (such as the GEF index for biodiversity and the IUCN Red List Index). However, the problem with these variables was the unavailability of data, therefore we decided not to include them in our regression models.

#### *Cross-sectional regression*

We transformed the dependent variable as described above and applied logarithmic transformations to some of the regressors (GNI, population and area). We included the (logged) average of GNI per capita to smooth the fluctuation of this variable in time, and to increase the number of observations available. We used the standard OLS estimation technique for cross-sectional data. It is possible to summarize the model of our interest in terms of a general equation as

$$E(\text{proportion of protected areas}) = \alpha + \beta_1(\text{economic/institutional/social development}) + \beta_2(\text{population/area/density}) + \beta_3(\text{forest area}) + \beta_4(\text{grassland and shrubs}) + \beta_5(\text{cropland and urban land}) + \beta_6(\text{wetland}) + \beta_7(\text{other land use variables}) + \beta_8(\text{IUCN membership}) + \varepsilon. \quad (1)$$

We are especially interested in coefficients that estimate the effects of economic, institutional and social development variables on the proportion of protected areas. The applied models and results are summarized in table 4.

Based on the results of the eight models presented (and also some others not presented), it is possible to conclude that when other influences are controlled (i.e. land use, total population or area and IUCN membership), the level of development plays a somewhat significant role in explaining the proportion of protected areas. However, when there are more (than one) indicators of development present in the model, they all tend to lose their statistical significance (see model 1, for example). We believe

Table 4. Cross-sectional regression models and results(source: own elaboration)

variables	dependent variable: lprotect							
	models							
	1	2	3	4	5	6	7	8
ln_avg_gni	0.038 (0.124)	0.184*** (0.057)	–	–	–	–	–	–
wgi	0.314 (0.214)	–	0.415*** (0.094)	0.416*** (0.093)	–	–	–	–
ln_popul	0.128* (0.066)	0.110 (0.067)	0.136** (0.068)	–	0.136* (0.068)	–	–	–
ln_area	–	–	–	0.171** (0.067)	–	0.134* (0.068)	0.134** (0.068)	0.139** (0.066)
forarea	0.018*** (0.006)	0.021*** (0.007)	0.020*** (0.007)	0.015** (0.007)	0.022*** (0.007)	0.018** (0.007)	0.018** (0.007)	0.017** (0.007)
grabs	0.009 (0.008)	0.012* (0.007)	0.009 (0.007)	0.004 (0.007)	0.010 (0.007)	0.006 (0.007)	0.008 (0.008)	0.008 (0.007)
antrop	0.004 (0.003)	0.005* (0.002)	0.004* (0.002)	0.005** (0.002)	0.005** (0.002)	0.007*** (0.002)	0.006*** (0.002)	0.005** (0.002)
wetland	–	–0.050 (0.052)	–0.034 (0.055)	–0.039 (0.053)	–0.049 (0.053)	–0.043 (0.053)	–0.045 (0.050)	–0.045 (0.050)
others	–0.003 (0.006)	–0.004 (0.006)	–0.004 (0.006)	–0.009 (0.006)	–0.003 (0.006)	–0.006 (0.006)	–0.008 (0.007)	–0.010 (0.006)
ief	–	–	–	–	0.023*** (0.009)	–	–	–
free	–	–	–	–	–	–0.134*** (0.045)	–	–
iucn	0.356 (0.226)	0.363 (0.231)	0.431** (0.215)	0.425** (0.214)	0.452** (0.212)	0.552** (0.222)	0.552** (0.219)	0.496*** (0.221)
school	–	–	–	–	–	–	0.059** (0.028)	–
hdi	–	–	–	–	–	–	–	1.610*** (0.558)
_cons	–5.526*** (1.720)	–6.558*** (1.410)	–5.404*** (1.214)	–4.998*** (0.830)	–6.875*** (1.472)	–4.437*** (0.857)	–5.335*** (0.888)	–5.900*** (0.959)
R <sup>2</sup>	0.253	0.249	0.313	0.326	0.275	0.293	0.276	0.292
Obs.	157	157	162	162	158	162	160	160

Note: White's robust standard errors of regression coefficients in parentheses. \*\*\*Significant at 1% significance level. \*\* Significant at 5% significance level. \* Significant at 10% significance level. One regression outlier has been identified in the regression models (Jordan). Exclusion of this observation has not changed the results significantly therefore all the presented models include Jordan.

that this occurs due to a high collinearity (correlation) among the variables, which approximates the level of economic, social and institutional development. It is also apparent that WGI (variable *wgi*) is the strongest of the development variables: it is the least statistically insignificant development variable when the others are included in the regression (see model 1), and it is the most significant when only one development variable is included (see models 3 and 4 compared to the rest of the models).

The other development variables are also significant when included in the regressions separately. This is true for the variables that approximate the level of

economic development (GNI per capita, variable *ln\_avg\_gni*), the level of social development (mean years of education, variable *school*, and HDI, variable *hdi*), and the level of institutional development (index of economic freedom, variable *ief*, and index of freedom, variable *free*). It is possible to conclude in all instances that a higher level of development (economic, social or institutional) is associated with a higher proportion of protected areas.

Total population (variable *ln\_popul*) is a positive but weak determinant of our dependent variable: countries with a larger population tend to have a higher proportion of protected areas. If we include total area

(variable *ln\_area*) as another control variable in our regression, both variables lose their significance. We believe that, once again, this is caused by a high collinearity between these two regressors. If we replace the total population variable by the total area variable, the latter is always significant, while other regression results only change slightly. The only exception is a slight decline in significance of the proportion of forest areas (variable *forarea*). Nevertheless, this always remains significant with at least a 5% significance level.

The other land use variables (*grabs* as an aggregation of grasslands and shrubs, *wetland* for wetlands, and *others* as an aggregation of sparsely vegetated areas, bare areas and open water areas), are not statistically significant, except for the variable *antrop* (an aggregation of cropland and urban land), which is significant in most of the models. Originally we would have expected a negative (if any) relationship between this variable and our dependent variable. On the other hand, the variable may also approximate the level of economic development (more developed countries will tend to use a higher proportion of land for agricultural and urban economic activities). This may be a plausible explanation because the significance of the *antrop* variable particularly increases in models where the variable does not directly measure the level of economic development (i.e. models without GNI per capita).

The IUCN dummy variable (*iucn*) is significant, with no less than a 5% significance level, except for models 1 and 2, where it is not significant at all. This is because of the presence of the economic development variable: if we control for level of economic development, the IUCN membership is not a statistically significant determinant of our dependent variable. At this point it is appropriate to concede that there may be an endogeneity issue related to the IUCN explanatory variable. The higher proportion of protected areas may be a consequence of IUCN membership and, at the same time, IUCN membership may be a consequence of a higher level of environmental protection, leading to a higher proportion of protected areas. However, due to the unavailability of time data for IUCN membership, and having performed the cross-sectional regression analysis, it is practically impossible to fully account for this kind of problem.

Moreover, it is necessary to stress that our regression models explain only a third of the total variability of the dependent variable. So some other important factors must exist that influence the proportion of protected areas. Our regression may therefore suffer from an omitted variable bias. To account for these issues, we have decided to perform a panel regression. The next sub-section deals with the panel regression approach.

### Panel regression

Similar to the cross-sectional regression, we have transformed our dependent variable (proportion of protected areas in countries' total areas) using a logit transformation to account for its bounded nature. The explanatory variables have also remained the same. Despite using the same variables, a panel data analysis may lead to better estimates as it considerably increases the number of observations available. Moreover, it enables an analysis of the variability among countries and the changes over time. On the other hand, time is a serious issue in our panel regression because many of our explanatory variables are time-invariant.

This is the case with almost all land use variables in this category, the only exception being the proportion of forest areas, the data for which were obtained from the *World Development Indicators* database (World Bank, 2016a). The other land use variables were acquired from the FAO GeoNetwork database (FAO, 2016) by means of the GIS analysis described above. The data were available only for one time period as no historical records exist (this, however, may reflect reality well because land use changes little over time). There are also other variables in our analysis that do not change over time. This is true for the IUCN dummy variable and for the total areas of countries.

This issue is a challenge for our analysis because it is not possible to estimate the impact of time-invariant variables on a dependent variable using the fixed-effects (FE) method (due to the nature of the method; it excludes all time-invariant variables from the regression). However, these impacts can be estimated using the random-effects (RE) approach. It is appropriate to use the RE method if no variables are omitted from the regression, or if the omitted variables do not depend on the variables already included in the model (i.e. if there is no correlation between the two groups of variables). If these assumptions do not hold, the application of the RE approach leads to inconsistency in the estimated regression coefficients. When omitted variables correlate with the variables already included in the model, the FE method is the correct one to use; it leads to unbiased and consistent estimates. This approach enables to control for an omitted variable bias because it assumes that the omitted variables are time-invariant, i.e. they have time-invariant values and time-invariant effects. However, the FE approach does not allow one to estimate the effects of time-invariant observable variables in the model: all time-invariant influences (whether observable or not, i.e. omitted) are estimated together as (time-invariant) individual-specific effects.

There are statistical tests available to determine whether the RE or FE method should be used. First, we performed the Breusch-Pagan test and it showed that the pooled OLS approach is not appropriate for

our data. In other words, the test confirmed that we should choose either the FE method or the RE method. Therefore, we applied both the Hausman and the Mundlak tests and they showed that the FE method is the correct one to use. However, in that case we would not have been able to estimate the effects of the time-invariant variables (they would be combined with the time-invariant individual-specific effects along with the unobserved omitted variables, also assumed to be time-invariant).

Because a significant number of our variables do not change over time we decided to use both the FE and the RE methods. However, it must be stressed that only the FE approach will lead to unbiased and consistent estimates, while the RE method will provide inconsistent estimates. Table 5 summarizes the regression models and the results. Once again, we are especially interested in coefficients that estimate the effects of economic, institutional and social development variables on the proportion of protected areas. In the first set of models (1a and 1b), we included all the development variables in the regression at the same time. When the RE method (model 1a) is used, the variable measuring economic development (*ln\_gni*) and one of the variables that approximates social development (*school*, mean years of education) are positively statistically significant, while the institutional development variables and the other social variable (*hdi*) are not. This is true no matter how the institutional development is measured: whether WGI (variable *wgi*) is replaced by the index of economic freedom (variable *ief*), or by the index of freedom (variable *free*), nothing changes substantially (it is only when *free* is included, that the *iucn* dummy variable loses its marginal statistical significance). When we use the FE method to estimate the same model (1b), but without the time-invariant variables, only the social development variable *school* remains significant; other development variables are no longer significant. Again, nothing really changes when we alternate the way we measure the level of institutional development – the model is slightly better when we use the index of economic freedom instead of the WGI.

Therefore, in the second set of models, we used *ief* to measure institutional development and we approximated the level of social development only by using *hdi*. In model 2a (when RE is used), none of these variables are statistically significant, while the economic development variable is marginally significant. The results did not change when we used *wgi* to measure institutional development. However, if we measure the level of institutional development by *free* instead of *ief*(or *wgi*), then *hdi* becomes statistically significant at a 1% significance level, while *free* is not significant and the model is slightly worse. When the FE are used (model 2b), the economic development variable loses its marginal statistical significance but other results from the RE model remained valid.

In the third set of models, we replaced the social variable *hdi* with the variable *school* and we measured the level of institutional development using *wgi*. While the institutional variable in the RE model (3a) is once again not significant, the social variable *school* is statistically significant at a 1% significance level. The economic variable is also significant (at 5% significance level). These results persist no matter how the level of institutional development is measured. The FE model (3b) shows similar results. The social variable *school* is always significant to no less than a 5% significance level, while the economic and institutional variables are not. Nothing changed when we replaced *wgi* by *ief*. But an interesting situation occurs if we substitute *wgi* for *free*: the economic variable is significant once again but the population variable is not.

In the fourth set of models we excluded the variables measuring social development in order to find whether some of the other development variables gained significance. In RE model 4a, this is true for the economic variable and its significance greatly increases, while the institutional variables remain insignificant (although *wgi* is, surprisingly, *negatively* significant at a 10% level). The same results are obtained when the FE method is applied (model 4b). When we replaced *free* with *wgi*, the *wgi* variable was once again negatively statistically significant, this time even at a 5% level. Although this is a surprising result, this model is generally very poor.

In the last (presented) set of models we did not control for the level of institutional development but we did control for social and economic development. When the RE model is used (5a) both variables (*ln\_gni* and *school*) are statistically significant. If we substitute *school* with *hdi*, the economic variable is only marginally statistically significant at a 10% level. If both social variables are included at the same time, then *hdi* loses its significance, while *school* and *ln\_gni* remain significant. When the FE model is used (5b), the significance of the economic variable declines substantially, and is only marginally statistically significant (at a 10% level). Interestingly, some of the control variables also lose their significance. This is true for the population variable and the proportion of forest areas. On the other hand, the social variable *school* is highly significant at a 1% level. Similar results are obtained when the *school* variable is replaced by *hdi*, which becomes significant at a 5% level. But if we include both social variables in the model at the same time, then once again the economic variable and the control variables (population, proportion of forest areas) regain their significance. The *school* variable is also significant at a 1% level, while *hdi* is not significant. We have also excluded all development variables other than the institutional ones from the models (not presented in table 5). The results show that it is only in this case and when the RE method is used, that the institutional variables are statistically significant.

Table 5. Panel regression models and results(source: own elaboration)

variables	dependent variable: lprotect									
	models									
	1a (RE)	1b (FE)	2a (RE)	2b (FE)	3a (RE)	3b (FE)	4a (RE)	4b (FE)	5a (RE)	5b (FE)
ln_gni	0.169** (0.077)	0.053 (0.103)	0.138* (0.073)	0.005 (0.106)	0.111** (0.044)	0.011 (0.059)	0.284*** (0.337)	0.229*** (0.043)	0.122*** (0.044)	0.119* (0.062)
Wgi	-0.142 (0.110)	-0.173 (0.158)	-	-	-0.138 (0.105)	-0.158 (0.139)	-	-	-	-
ln_popul	0.208*** (0.064)	1.077*** (0.370)	0.216*** (0.062)	1.099*** (0.415)	0.244*** (0.064)	1.062*** (0.290)	0.479*** (0.092)	1.193*** (0.269)	0.260*** (0.061)	0.389 (0.335)
forarea	0.027*** (0.007)	0.044** (0.019)	0.026*** (0.007)	0.056*** (0.020)	0.027*** (0.007)	0.039** (0.018)	0.014** (0.007)	0.021** (0.010)	0.016** (0.007)	0.007 (0.014)
Grabs	0.016** (0.007)	-	0.016** (0.007)	-	0.016** (0.008)	-	0.007 (0.009)	-	0.012 (0.008)	-
Antrop	0.003 (0.003)	-	0.003 (0.003)	-	0.002 (0.003)	-	-0.004 (0.005)	-	-0.002 (0.004)	-
wetland	-0.042 (0.050)	-	-0.060 (0.048)	-	-0.035 (0.050)	-	-0.010 (0.050)	-	-0.014 (0.055)	-
Others	-0.003 (0.005)	-	-0.002 (0.005)	-	-0.003 (0.005)	-	-0.014** (0.006)	-	-0.008 (0.006)	-
Ief	-	-	0.003 (0.006)	-0.008 (0.006)	-	-	-	-	-	-
Free	-	-	-	-	-	-	0.001 (0.023)	0.024 (0.026)	-	-
Iucn	0.373* (0.219)	-	0.320 (0.207)	-	0.338 (0.230)	-	0.015 (0.238)	-	0.232 (0.229)	-
school	0.098** (0.049)	0.176*** (0.064)	-	-	0.104*** (0.035)	0.138** (0.060)	-	-	0.141*** (0.031)	0.180*** (0.049)
Hdi	-0.403 (1.447)	-0.606 (2.100)	0.911 (0.973)	2.565 (2.160)	-	-	-	-	-	-
_cons	- 8.984*** (1.260)	- 22.36*** (5.491)	- 8.642*** (1.246)	- 23.01*** (6.281)	- 9.387*** (1.280)	- 21.85*** (4.557)	- 12.72*** (1.730)	- 23.99*** (4.279)	-9.33*** (1.171)	- 11.36*** (5.023)
R <sup>2</sup>	0.215	0.183	0.220	0.190	0.205	0.176	0.167	0.183	0.178	0.135
Obs.	753	830	719	775	1220	1339	3216	3686	1325	1456

Note: White's robust standard errors of regression coefficients in parentheses. \*\*\*Significant at 1% significance level. \*\*Significant at 5% significance level. \*Significant at 10% significance level.

This is particularly true for the *ief* variable, which is significant at a 1% level, while *free* is only marginally statistically significant and *wgi* is insignificant. When the FE method is used, none of the institutional variables are significant.

### Summary and discussion of results

The results of the cross-sectional and panel regressions point to the same conclusion. They show that there is a significant relationship between the level of development and the proportion of protected areas. Generally, we can conclude that a higher level

of development is associated with a higher proportion of protected areas, no matter how the level of development is approximated.

First, we performed cross-sectional regressions. Bearing in mind the possible limitations of this approach (as already discussed), we found statistically significant relationships between indicators that approximate levels of development and the proportion of protected areas. However, in the cross-sectional settings this is only true when the development indicators enter the regression separately. When more development variables are included in models at the same time, they all lose their statistical significance.

This may be caused by the collinearity (high correlation) between the development variables (*ceteris paribus*).

The results of the cross-sectional regression models can be summarized as follows (*ceteris paribus*):

- A higher proportion of protected areas is associated with a higher level of development (economic, social or institutional).
- Larger countries (in terms of land size) tend to have higher proportions of protected areas.
- More populated countries tend to have higher proportions of protected areas.
- A higher proportion of protected areas is associated with a higher proportion of forest areas.
- A higher proportion of protected areas is associated with a higher proportion of cropland and urban areas (combined).
- No other land use variable is significant.
- A higher proportion of protected areas is associated with IUCN membership.

Secondly, we performed panel regressions. Because a considerable number of our explanatory variables are time-invariant, we faced a difficult choice when selecting the optimal model. It is possible to estimate the impacts of the time-invariant variables when the random-effects method (RE) is used. However, these estimates may be inconsistent if our data favours the fixed-effects method (FE). That it is indeed the case, as has been shown in the results of the Hausman and Mundlak tests. Nevertheless, the application of the FE approach does not allow one to estimate the impact of the time-invariant variables. Therefore, we applied both approaches to the same models, bearing in mind that the estimates of the RE method (with the time-invariant variables included) are probably inconsistent. In contrast, the estimates of the FE method (with the time-invariant variables excluded) should be unbiased and consistent.

The RE models indicate that there are statistically significant relationships between variables which measure levels of development and the proportions of protected areas. The results of these models can be summarized as follows (*ceteris paribus*):

- The social development variable *school* is highly significant in all models where it was included, while the other social development variable, *hdi* is mostly insignificant (collinearity is a probable cause; it is a composite index of some other variables in most of the models). This means that a higher proportion of protected areas is associated with a higher level of social development (approximated by mean years of education).
- The economic development variable (*ln\_gni*) is also statistically significant (at least at a 10% level) in all models. This means that a higher proportion of protected areas is associated with a higher level of economic development.
- Institutional development variables are almost always insignificant. The only exceptions are *ief*

and *free* in models where no other development variable is included.

- More populated countries tend to have higher proportions of protected areas.
- A higher proportion of protected areas is associated with a higher proportion of forest areas.
- Most of the time-invariant land use variables are insignificant. The only exception is the variable *grabs* (the aggregation of grasslands and shrubs) in models where all development variables are included.
- The IUCN dummy variable is mostly insignificant.

However, the results of the RE models are probably inconsistent. Therefore, better evidence is provided by the FE models, which should yield consistent estimates. In accordance with the approaches used previously, the FE models also indicate statistically significant relationships between variables approximating the level of development and the proportion of protected areas.

The results of the FE models can be summarized as follows (*ceteris paribus*):

- The social development variable *school* is statistically significant (at least at a 5% level) in all models it enters, while the other social development variable *hdi* is mostly insignificant. So a higher level of social development (approximated by mean years of education) is associated with a higher proportion of protected areas.
- The economic development variable *ln\_gni* is highly significant (at a 1% level) in models where institutional development variables are included and social development variables are excluded. It is also marginally statistically significant in models where we control for social development and do not control for institutional development. Generally we may conclude that a higher level of economic development is associated with a higher proportion of protected areas.
- The institutional development variables are not significant no matter how we measure them.
- More populated countries tend to have higher proportions of protected areas, and this is proved by every model except the one where we do not control for the influence of institutions.
- A higher proportion of forest areas is associated with a higher proportion of protected areas. This is not only true for the model in which we do not control for the influence of institutions.

To conclude, it is obvious from the summaries above that a significant relationship exists between the level of development and the proportion of protected areas. All other things being equal, the more developed countries tend to have a higher proportion of protected areas. This assertion is true no matter how the level of development is approximated. However, we should take into account the findings of some studies (for instance Rees (2003), which highlight the fact that beyond a certain point, there is unavoid-

able conflict between economic development and environmental protection. The proportion of protected areas is only one of many environmental indicators (OECD, 2008; Syrovátka, Hák, 2015); therefore we cannot simply generalize that a higher level of development automatically means better protection for the environment.

The majority of development variables are significant in most of the models, the only exception being the institutional variables, which are not significant once the levels of social or economic development are controlled for. This is indicated by the cross-sectional and the panel approach and by the findings. The conclusion isn't consistent with the findings of Smith et al. (2003), who found correlation between governance scores and environmental performance (although not in terms of protected area coverage). In our analyzes, we have also found that a higher proportion of forest areas and a larger population size are associated with a higher proportion of protected areas. The relationship between the proportion of forests and protected areas was also confirmed by (Joppa, Pfaff, 2009); forests often occupied remote areas with environmental conditions less suitable for agriculture (Opršal et al., 2016; Dyrťová et al., 2016) and these can be set aside for protection. In contrast with our original expectations, the other land use variables proved to be insignificant in most cases. This may be surprising, especially in the case of bare land and sparsely vegetated areas (deserts) – in our research, the countries' proportions of protection areas were not biased towards these two categories of land cover as the literature suggests (Ando et al., 1998; Joppa, Pfaff, 2009). Also, our regression models have only explained a limited amount of the total variability of the dependent variable (approximately one third in the cross-sectional approach and one quarter in the panel regression approach), so there remains some room for further improvements in the regression models and methods.

The findings mentioned so far represent rather positive trends and important steps towards nature conservation, as well as the widely accepted role of the protected area coverage indicator, which reflects the importance of protected areas in biodiversity conservation. However, the use of the indicator naturally has certain limits. First of all, measuring the extent of protected areas provides only partial information concerning political commitment to biodiversity conservation. Therefore, measurements of extent should be combined with assessments of conservation effectiveness within protected areas. Without sound and effective management based on scientific knowledge, protected areas may fail to meet their main objective of biodiversity conservation (Leverington et al., 2010). Moreover, the mission of protected areas has expanded in recent years and encompasses not only biodiversity conservation, but also the socioeconomic development of local communities (Naughton-Treves et al., 2005). Given the fact

that further economic growth will most likely create more pressure on Earth's ecosystems, and may undermine sustainable human development (Rockström et al, 2009), the integration of biodiversity conservation and socioeconomic development goals remains a serious challenge.

Our paper focuses on various factors behind the performance of individual countries in nature conservation, in terms of the coverage of protected areas. Yet, we recognize that protection across the world is geographically very uneven, both at a national level and at the ecosystem level. Despite the expansion of global terrestrial protected area systems, many biomes still have less than 10% of their area within formally protected areas (Jenkins, Joppa, 2009). Protection area networks are biased towards places that are unlikely to face land conversion, such as higher elevations, steeper slopes and places that are a greater distance from roads and cities (Joppa, Pfaff, 2009). Taking these facts into consideration we may assume that setting conservation agendas such as the Aichi Biodiversity Targets, Millennium Development Goals and Sustainable Development Goals might raise the coverage of protected areas at a national level, but at the same time it may not adequately cover countries' unique species and ecosystems (Scott et al. 2001; Maiorano et al, 2006; Jenkins et al. 2015). The relationship between biodiversity targets and the actual needs of nature conservation remains a challenge for future research.

## Conclusion

The world's system of protected areas has grown substantially over the past 23 years, covering over 14.0% of countries' total area. Considering the magnitude of the changes that have occurred in nature conservation since 1990, an increase in the proportion of protected areas has been recorded in almost every country in the world. Nevertheless, the scale of this progress varies considerably among countries, and the disparities between best and worst performing countries are enormous. Since nature conservation and socioeconomic development represent the backbone of the *Millennium Development Goals* and the *Sustainable Development Goals*, the links between these two phenomena have been investigated. Therefore, we applied methods of regression analysis to find whether a relationship exists between the level of development and the proportion of protected areas. We have approximated the level of development using various economic, social and institutional variables. After controlling for some other influences and performing both cross-sectional and panel regressions, we have concluded that the more developed countries tend to have higher proportions of protected areas. Although the coverage of protected areas is well-established and a useful indicator of environmental performance of individual countries, it does not ensure adequate cover of a country's

valuable species and ecosystems as well as sound environmental management of existing protected areas.

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# Upcycling as a Manifestation of Consumer and Business Behavior that Expresses Sustainable Consumption and Determines the Functioning of the Communal Services Sector

## Upcycling jako przejaw zachowań konsumenckich i biznesowych wyrażających zrównoważoną konsumpcję i determinujący funkcjonowanie sektora usług komunalnych

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### Abstract

The article addresses the issue of upcycling as a new pattern of consumer behaviour, enabling the production of new goods from the previously used products, which prolongs their *life*. Such behaviour also leads to a reduction in the use of new products on a market basis and reduces the need to throw things out that have lost their former usefulness. Creativity is an important element of upcycling, which allows us to find new uses for things, which have previously been treated as useless rubbish or waste.

Increasingly, large corporations take the example from individual and undertake activities related to upcycling of their products or convert things which have so far been treated as waste into starting material for manufacturing products. The activities described earlier are strengthened by the media, which promote the ideas of upcycling as a modern form of business, art and a new pattern of sustainable consumption. The following paper attempts to address these perspectives and indicates the opportunities and threats that are brought about by this phenomenon for the functioning of the communal services sector.

**Key words:** upcycling, communal services, sustainable consumption, consumer behaviours, business

### Streszczenie

Artykuł porusza zagadnienie upcylingu jako nowego wzorca zachowań konsumenckich, umożliwiających wytworzenie z zużytych wcześniej produktów nowych dóbr co przedłuża ich *życie*. Zachowania tego typu prowadzą również do ograniczenia korzystania z nowych produktów na zasadach rynkowych oraz zmniejszają konieczność wyrzucania rzeczy, które straciły swoją dotychczasową przydatność. Ważnym elementem upcylingu jest kreatywność, pozwalająca znaleźć nowe zastosowanie dla rzeczy, które wcześniej były traktowane jako beżużyteczny śmieć czy odpad.

Coraz częściej wielkie korporacje biorą przykład z osób indywidualnych i podejmują działania związane z upcylingiem swoich produktów lub przekształcają rzeczy dotychczas traktowane jako śmieci w materiał wyjściowy do wytwarzania produktów. Działania opisane wcześniej wzmacniane są przez media, które promują idee upcylingu jako współczesnej formy biznesu, sztuki oraz nowego wzorca zrównoważonej konsumpcji. Poniższe opracowanie próbuje odnieść się do tych perspektyw oraz wskazuje szanse i zagrożenia jakie te zjawisko niesie dla funkcjonowania sektora usług komunalnych.

**Słowa kluczowe:** upcycling, usługi komunalne, zrównoważona konsumpcja, zachowania konsumencie, biznes

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### Introduction

Upcycling as a current trend of consumer and business behaviour is a part of sustainable consumption.

It is the response of consumers to global environmental and social problems. It is also identified with consumer mobilization and a demonstration of the

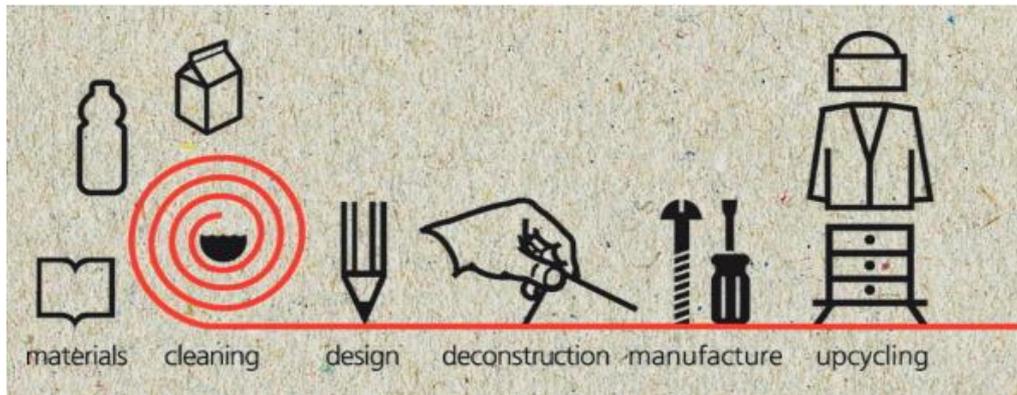


Figure 1. Upcycling process, [www.blog.inselly.com](http://www.blog.inselly.com)

active force, which is owned by the consumers over the dishonest manufacturers, who exploit their employees. This type of activities are considered a manifestation of consumerism. Consumer orientation towards ecology, justice and intergenerational responsibility is explored in many area of science – sociology, economics, law, psychology, philosophy, to name a few. Research conducted in these disciplines supports the thesis that satisfying the basic needs of people related with the physical and economic security enabled and contributed to turning people to post-material values (Inglehart, 1977).

Sustainable consumption is usually referred to as buying goods that contribute to greater balance between the three components: economy, ecology and people. Felicjan Bylok (Bylok, 2013), defining sustainable consumption, refers to three elements: social, environmental and economic, included in the definition of sustainable development. Such consumption of its essence is based on the principles of: economic rationality (economic optimization in the choice of goods); environmental rationality (selection of such goods, which are least harmful to the environment); social rationality (selection of goods, which solve social problems or at least do not contribute to their deepening). This author claims (Bylok, 2013) that sustainable consumption should also be a resignation of goods, which harm the environment and people. Upcycling takes into account the aforementioned assumptions of sustainable consumption. It is a new pattern of consumer behaviour, which enables us the creation of new goods from the previously used products, which prolongs their *life*. Such behaviour limits the need to use new products and their acquisition on the commercial principles. They reduce the amount of waste disposed, which reduces the demand for communal services.

Currently, upcycling is also a phenomenon increasingly used by the companies, which create new products from the things previously treated as waste, or enrich the goods offered so far to the consumers. So it can be said that this is also a new model of running a business or an important element of the strategy of companies. Creativity is an important element of upcycling, which allows to find new uses for things,

which were previously treated as useless trash or waste.

### Upcycling – the essence of the phenomenon

Upcycling is a process of creative recycling, which involves giving higher value to seemingly used items and materials, turning them into aesthetically pleasing, usable and fully valued products (Fankiewicz, 2016, p. 26-27). During its implementation, the waste is transformed into goods of a certain value and quality, which get the so-called *second life* (Braungart, 2002). Its undoubted advantage is that it does not require the consumption of a lot of energy, as it takes place in the manufacturing activity and it eliminates the need to produce products from newly extracted raw materials (Szaky, 2014). The potential of this type of activities is demonstrated by the fact that in the USA the market of good manufactured based on upcycling increased in 2011 by 400% compared to 2010 (Hartman, 2014, p. 42-50). The products that are created based on upcycling are: clothes, furniture, soap, fertilizers and works of art, and even buildings made of materials recovered from the rubble from the demolitions of earlier objects. (Anderson, Hemmings, 2009, p. 1-2 ). It can be said that upcycling covers quite a wide range of industries and gives unlimited possibilities, in principle, for creating useful goods (see figure 1).

It is an element of fashion and consumer trend. It owes its roots to the so-called trash art. Trashion is one of its manifestations – that is the conversion of *old, broken, unnecessary, unfashionable things (both clothes and other »garbage«) into completely new objects – fashionable, unique, inventive, that do not fit ant prevailing trend, and therefore timeless* (About..., 2016). The clothes, jewellery and small trinkets are based on this type of activities (Bramston, 2013, p. 123-133). The creators of this kind of products operate through online services, which promote and sell upcycling products. In addition, this type of business activity is supported by an educational activity, which demonstrates how to use upcycling for creating new objects at home (Emgin, 2012, p. 63-71).

The increasing consumer interest in upcycling results from their implementation of the 5 R principles in their market behaviours, i.e. reduce, reuse, redistribute, repair and recycle (Wilczak, 2016, p. 87-99). The *eco* consumer trend is the factor reinforcing the phenomenon of upcycling. It has been developing for many years as a consequence of the megatrend of *sustainable development*, covering all areas of life. The *eco* trend has been additionally strengthened by the recent recession and there is no sign of its weakening. According to it, everything should be *eco*. This trend means limiting consumption according to the 3R motto: reduce, reuse, recycle (reduce – consumption, environmental use, waste; reuse things again – recycle, repair, lend, exchange, give back; use recycling – segregate waste, collect secondary materials, use reusable packaging, resign from *disposables*, etc.). In Poland, this trend has been around for a long time. It is further strengthened through the penetration of global trends into fashion, design and lifestyles, as well as adapting the Polish legislation to the EU standards on environmental protection, carbon dioxide emissions, usage of disposable packaging, waste disposal, etc. (Trends File Report, 2012).

The pursuit of being retrospective is the second important consumer trend positively influencing the interest in upcycling. The trend of *retro-modernity* involves the enjoyment of everything that is old at the aesthetic level maintaining modernity at the functional and technological level. This trend is manifested in the references to retro in fashion, cuisine, automotive industry, as well as the popularity of handicrafts and genuinely old things. The objects – and brands – are sought, which are authentic, unique, and so valuable; brands with a tradition of good design, history, class. This trend is due to the fatigue of the mass retail offer, the desire to stand out and to be different, turning towards tradition, nostalgia, the search for roots, authenticity, safety of the lost childhood or carefree youth. Manufacturers are returning to different times – the pre-war times, the Hippies era, recently to the 90s (Raport ‘Teczka Trendów’, 2012). Upcycling gives the abilities to create products that retain the traditional looks and provide users with the functionality they desire.

### Upcycling as a model for conducting business

The changing attitude of consumers to environmental issues, and especially the interest in their ecological marketing and consumption result in changes in the activities of business companies, which try to reduce their harmful impact on the environment and try to promote such activities, thus creating their positive image (Bryła, 2015, p. 79-88). Consumers themselves are also becoming more responsible in their consumer behaviour. They take into account the impact of consumption on the state of the natural environment in them. They also require the companies

to use environmental marketing, taking into account the impact of the manufactured products on the natural environment and the promotion of consumer behaviour that has a positive effect on the state of the environment. At the marketing level, companies are striving to educate consumers, create ecologically friendly products (Skowron, Szymoniuk, 2014, p. 39-46). Upcycling can be used for this purpose as a tool for creating product innovations. From a marketing point of view, it can be used by companies to create a positive image and be an important element of the business strategy.

Actions based on upcycling are used more frequently by corporations in their activities. They use waste generated in them to design and create new, useful products for the needs related to image, promotion, education and utility (Frankiewicz, 2015). This type of activities are referred to as brand upcycling. Their first step is to analyze the possibilities of using upcycling. It analyses the waste generated in the company in terms of brand upcycling. Then, the analysis of needs is performed in terms of products from upcycling in all crucial areas of the marketing and business activity, i.e. CSR, HR, PROMOTION, MARKETING, PR, etc. The creation of a report with the possible directions for using upcycling in the business activity is the effect of this type of analyses.

The second step of brand upcycling is the creation of ideas for generating upcycling products. Its first step is to test the selected waste materials with their manufacturers and trash designers. The sketches of potential products are created this way. Another element of the discussed stage is the selection of the right idea for creative processing of the previously defined group of waste taking into account the use of this idea as a CSR or marketing strategy element, or for the purposes of educational activities. The end result of these activities is the package of ready ideas for the management of the selected waste fractions. The last step in the brand upcycling is the preparation of production of products using upcycling. Their prototypes are done as its part. Then, the valuation of the selected products and methods of their production is carried out taking into account the recycled materials for this purpose. Then, the production of the previously selected products is initiated. The implementation of the product concept into production is the effect of this upcycling stage (Frankiewicz, 2015).

For example, the H&M company as part of the Garment Collecting action encourages consumers to participate in the garment collection, which will then be reused or recycled. The rules are simple – anyone can bring clothes to the H&M store, which are no longer used. In return, they will receive a discount coupon, which can be used during the next purchase. The H&M Garment Recycling action is the first clothing recycling project on a global scale. It applies to all countries, where the H&M brand is present. The project is long-term, and one of its main

goals is to develop technology of fibre recovery from the already produced clothes, so that the need to grow natural fibres (such as cotton or wool) as well as the production of synthetic fibres can be significantly reduced.

Coca Cola is also an example of a company, which used the marketing potential of upcycling in the *2nd Lives* campaign developed by the Ogilvy & Mather agency. Sixteen special overlays for PET bottles were produced as part of the campaign carried out in Vietnam, which gave a new life to the used beverage bottles. During the campaign, the company distributed 40 000 free overlays, adding them to the purchased Coca Cola bottles. The overlays changed the ordinary PET bottles into lamps, toothbrushes, pencil sharpeners or soap dispensers.

Upcycling also offers great opportunities for combining product solutions with social actions. For example, the Adidas company partnered with the *Parley For The Oceans* environmental organisation, to jointly develop the idea of creating shoes made almost of plastic waste, nets illegally placed by poachers and fishing nets left in the sea (Frankiewicz, 2016, p. 26-27).

### Upcycling and the development of communal services industry

The municipality, performing tasks in the sphere of municipal services, can implement them through budgetary institutions, equity companies with their share, use the public-private partnership, as well as contract municipal services with private entities (Bałdyga, 2004, p. 57-76).

The payer is an important element while analysing the communal services. These are the municipality and the residents. The first group includes services related to the maintenance of greenery, removal of impurities and cleaning of public places or communal cemeteries. Often, in the case of the aforementioned services, the municipality selects the entity providing them, according to the rules, which is advantageous for it, as long as it negotiates parameters previously of the services provided by the external entities.

There is a great diversity of legal regulations, natural monopolies, quite an extensive transmission infrastructure and considerable investment needs in the second group of communal services, which implementation is paid by the inhabitants. Nevertheless, depending on the industry, the way of performing these services is varied. The sectors of communal services that belong to the second group are, among others: public transport, waste management and water and sanitation services (Szymanowicz, 2000, p. 27-28).

The more and more widespread popularization of upcycling can be an opportunity, as well as a restriction, for companies that deal with communal services in the area of collection and recycling of

waste. Dealing with the recovery of new waste fractions is a potential chance for this type of companies, which can be used for creating products produced based on upcycling. Potentially, this could lead to the creation of a new market, their activities and services related to the recovery of such raw materials could be a new source of profit for companies dealing with such communal services.

The further opportunity that is created by upcycling for the companies that offer communal services in the field of waste collection and disposal is the diversification of their activities by creating upcycling products based on the cooperation with eco-designers and their sale through online services or by developing cooperation with traditional trade networks. This type of strategy of operation of companies providing communal services would require changes of their existing business models from the ones based on the service activity into business models that combine the service, production and trade activities. Moreover, activities of this type would stimulate the use of the marketing approach, greater than before, to running own business.

Potentially, upcycling can also be a barrier to the development of companies that traditionally approach the provision of communal services in the field of waste collection and disposal. This is due to the fact that it contributes to reducing the amount of waste disposed by the companies and households, which is a starting product for companies that process it further within its activity related to the provision of communal services. This phenomenon may cause *shrinking* of the existing supply markets for this type of companies, and thus a decrease of their profits, along with the need to search for new areas of activity or it will cause acquisitions and of entities that deal with the waste collection and their segregation, leading to the consolidation of these markets.

### Conclusion

This paper has undertaken the subject of upcycling as a new pattern of consumer behaviour and conducting business. This trend fits into sustainable consumption leading to rational and economical management of natural resources. This phenomenon also has a social context, because it translates into the scope and type of goods purchased by consumers. The social dimension of upcycling also concerns the design of products created as its manifestation. Creativity is very important in this case, which gives an unlimited field of new goods from things, which were previously treated as waste or trash.

Currently, upcycling is also becoming an element of the business strategy, which increasingly utilizes the possibilities of this type of activities in its marketing activity, as well as for shaping a positive image. The philosophy of upcycling also contributes to the emergence of new businesses. This phenomenon also creates the potential opportunities and threats for the functioning of companies that provide com-

munal services. Certainly, its widespread use will necessitate the change of current business models by some of them. They will have to go from the previous service activity towards the business combining the service, production and trade activities.

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# Forced Migration in Ukraine and Reality of Sustainable Development Goals Achievement

## Wymuszona migracja na Ukrainie a realność osiągnięcia Celów Zrównoważonego Rozwoju

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### Abstract

The article examines the impact of mass internal migration in Ukraine, caused by the military conflict, on achievement of sustainable development goals in the country. Despite the fact that migration and human mobility issues are mentioned only in six goals, they actually affect the achievement of majority of them. The impact of forced mass internal migration in Ukraine on its sustainable development goals achievement is shown as complex, many-sided, unpredictable and different in strength. Forced displacement of people seem to have not only negative, but also positive impact on country's sustainable development. Moreover, the achievement of goals in its turn influenced further migration in Ukraine. Perception of forced migration as temporary influence the behaviour of internally displaced people and thus the level and possibility of achievement of sustainable development goals in the country. The analysis of the impact of migration on sustainable development allows to determine priorities and instruments for fight with negative phenomena and support the positive impact of forced migration on the development of regions in Ukraine.

**Key words:** sustainable development, sustainable development goals, migration, internally displaced person, achievement, forced displacement, impact

**Key words:** 10 p.

### Streszczenie

Artykuł omawia skutki masowej migracji wewnętrznej na Ukrainie, spowodowanej przez konflikt zbrojny, na realność osiągnięcia Celów Rozwoju Zrównoważonego w tym kraju. Chociaż migracje i zagadnienie mobilności ludzi wspomniane jest tylko w 6 celach, w praktyce wpływają one na większość pozostałych. Wpływ wymuszonej masowej wewnętrznej migracji na Ukrainie na realizację Celów Zrównoważonego Rozwoju okazuje się złożony, wielowymiarowy, czasem nieprzewidywalny i osiągający różny poziom siły. Okazuje się, że wymuszane przemieszczanie się ludzi ma nie tylko negatywny, ale także pozytywny wpływ na zrównoważony rozwój kraju. Co więcej, osiąganie poszczególnych celów przyczynia się do dalszego wzrostu migracji. Percepcja wymuszonej migracji, jako tymczasowej, wpływa na zachowanie poddających się temu procesowi ludzi a poprzez to na możliwości osiągnięcia Celów Rozwoju Zrównoważonego. Analiza wpływu migracji na zrównoważony rozwój pozwala wyznaczyć priorytety i instrumenty, dzięki którym możliwe będzie pokonanie negatywnych zjawisk i wsparcie pozytywnego wpływu wymuszonej migracji na rozwój poszczególnych regionów Ukrainy.

**Słowa kluczowe:** rozwój zrównoważony, cele rozwoju zrównoważonego, migracja, osoba wewnętrznie przemieszczona, osiągnięcie, wymuszona migracja, skutek

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## Introduction

Over the last years, the concept of sustainable development has become prevalent while developing the strategies of not only individual business entities, but also entire countries. Along with the desire to maximize profits or to show the biggest economic growth, the willingness of entities and countries to help the surrounding society and to take care of the environment steps forward. All these endeavours were first laid in the *Millennium Development Goals* which gave place to *Sustainable Development Goals* (SDGs) in 2015. Almost all countries of the world, including Ukraine, strive to achieve or at least approach them. To accomplish this, countries set specific plans, develop certain indicators, and each year analyse the degree of approximation to the desired results.

Military conflict, which started in Ukraine several years ago, and situation which we perceive as occupation of the large part of the eastern regions had significant impact on the achievement of SDGs of the country. This geopolitical conflict caused 6.8% decrease of real GDP and devaluation of the Ukrainian currency hryvnya (UAH) (*Tsili rozvytku...*, 2015). As of December 31, 2015, Ukraine was at the 8<sup>th</sup> place in the world by the number of IDPs (Smal & Pozniak, 2016). Many people became forced migrants who left their homes, and today they are trying to start a new life in a new place. The Ministry of Social Policy in Ukraine counts 1,656,662 migrants from Donbas (Eastern Ukraine) and Crimea (*Oblikovano...*, 2016), who represent 3.89% of the current population of Ukraine (42,620,007 persons by November 1, 2016). The largest number of IDPs was registered in the East of Ukraine (*Naseleattia Ukrainy...*, 2016).

Displacement of considerable quantity of population inside the country is seen primarily as a negative factor for Ukraine's development. However, migration itself cannot be directly attributed to the factors, which negatively affect the achievement of SDGs. Certain researches have shown that there is correlation between migration and sustainable development of a country (Tacoli & Okali, 2001). Some scholars believe that there is positive correlation between migration and sustainable development, which is often underestimated. This positive relationship is characterized, above all, with enriching human capital, unemployment decrease, increase of enterprises' innovation activity (*The Correlation of Migration...*, n.d.). At the same time, migrants can steal jobs from local communities population, lead to conflicts between population groups, negatively affect urban planning, influence consumption structure and size (*Migration and sustainability...*, n.d.).

Migration process is a natural phenomenon related to people's search of the better life, work and salary. The reasons for migration can be search of safety for oneself and a family, internal conflicts, systematic

violations of human rights, natural disasters that have swept the world recently and others. Ukraine suffered heavy population movements within the country because of the military conflict. Some analysts believe that this conflict together with the anti-terrorist operation (ATO) challenged environmental and social situation in the country, especially in the ATO zone and places of mass migration (*Tsili rozvytku...*, 2015). It is clear that different reasons of migration have different effects on the achievement of SDGs.

### *Impact of internal migration in Ukraine on its SDGs*

In 2015 the United Nations member states adopted the new Agenda for world sustainable development, for the period between 2015 and 2030. The 2030 Agenda declared the need to empower migrants, refugees and IDPs, which make positive impact on *inclusive growth and sustainable development* (Sustainable Development Knowledge Platform, 2015). Therefore, migration and human mobility have been included to the targets of SDGs No 4, 5, 8, 10, 16, 17. Despite the fact that migration and human mobility issues are mentioned directly only in six goals, they actually can affect the achievement of any goal. The impact of internal migration in Ukraine on its SDGs achievement is examined below.

#### *1. No poverty*

Anti-terrorist operation (ATO) in the East of Ukraine negatively affected population welfare. The population of Luhansk region with average total revenue per month below poverty level almost doubled in 2014 compared to 2013. It changed from 7.2% to 14.1% of the total population (*Dyferentsiatsiia zhyttievoho...*, n.d.). According to the National Report *Millennium Development Goals. Ukraine: 2000-2015* by the criterion of actual living wage, level of poverty increased from 22.1% in 2013 to 32% in 2015 (*Tsili rozvytku...*, 2015). Many people had to leave their homes and move either to relatives or to unknown cities in search of a new place of residence and work. The impact of internal migration on the growth of poverty population is questionable. On the one hand, people have left their homes and property and, therefore, lost many resources. Women with children who thus could not work and poor people who had no savings became the most vulnerable population layer. On the other hand, people moved inside Ukraine or abroad searching for *the better life*. Perhaps the most *successful* moving or employment led to a small decline in the share of population with average total revenue per month below poverty level from 14.1% in 2014 to 12.5% in 2015 (*Dyferentsiatsiia zhyttievoho...*, n.d.).

At present, the government of Ukraine does not meet even minimal social needs of IDPs. Those, who are not able to rent housing or find a job, return back

home to the occupied territory. The monthly targeted assistance to an employed IDP in Ukraine is UAH 442 USD (about EUR 15). Such assistance for the whole family cannot exceed UAH 2400 (about EUR 80). Lack of social assistance to IDPs from the Ukrainian government is partly compensated by the increased attention of international organizations (e.g., IOM, UNDP), which provide humanitarian and financial assistance to IDPs, as well as assistance for evacuation of people from the occupied territories (which are not under Ukrainian Government control).

## 2. Zero hunger

Migration processes directly affect the achievement of goal No 2 by increasing or decreasing the needs of population of certain areas in food because of changes in the number of population. Subject to military conflict, the migration processes affect the financing opportunities of agriculture, access to land, the ability to supply food to dangerous territories (close to the demarcation line). The ATO took place in the fertile lands of Donetsk and Luhansk regions and included mine-laying in agricultural fields and transport routes, blowing up infrastructure buildings, roads and bridges. Decrease of population due to mobilization and migration took place. This has led to 21.2% decline in agricultural production in Luhansk region and 7% decline in Donetsk region in 2014 compared to 2013. These indicators were the worst in Ukraine and resulted into humanitarian catastrophe in some parts of the Eastern Ukraine. Analysis of overall food consumption in Luhansk region households shows decrease in average consumption per month per person in 2015 compared to 2013 of such food products as meat and meat products (by 33%), milk and dairy products (by 16.5%), fish and fish products (by 56.3%), fruits and nuts (by 44.4%). The consumption of other products also decreased but at a slower pace (*Spozhyvannia produktiv...*, n.d.).

## 3. Good health & wellbeing

In 2014 compared to 2013 the Ukrainian population declined by 5.5% due to military activities, worsening of living conditions, increased mortality among the elderly because of heart attacks etc. The ratio of deaths per 1,000 living people started to increase from 14.5 in 2012 to 14.9 in 2015. According to the research of the impacts of internal displacement of people, the regions which hosted the biggest quantities of IDPs improved their demographics, as there were twice as more children and 30% less elderly (aged 60 years and older) among IDPs than in local communities. The average age of IDPs is almost 10 years less than of the population of the new local community, where they moved, and is around 32-33 years. At the same time, average age for local community residents was about 42.2 years nationwide (Novikova, Amosha, & Antoniuk, 2016).

On the other hand, the increase of internal migration resulted in additional load on medical institutions on the territories with the largest concentration of IDPs and increasing outbreaks of infectious and viral diseases. *Government supply of medicine for treatment of diabetes, HIV/AIDS and tuberculosis is insufficient. Some IDPs live in remote regions and lack regular inspection by mobile medical teams and continuous treatment of chronic illnesses. There is no redistribution of health budget by regions according to the quantity of IDPs, who live there. The regions are not provided with vaccinations and immunizations* (Government Agency, 2015).

## 4. Quality education

From 2014 to 2016 28 educational establishments, including 18 higher education institutions, were displaced from the East of Ukraine and Crimea to the territory under Ukrainian Government control. The quantity of students from displaced universities and academies is more than 40 thousand people; the quantity of teaching staff is about 3.4 thousand people (*Iz zony ATO...*, n.d.). Migration of students to other regions in no way affected their studies in any particular institution. Students continue to study remotely, as many higher educational institutions have established e-learning platforms. Displaced students also had the right and attended classes in any other higher education institutions in different cities of Ukraine, if they moved to these cities. In addition, students from the ATO zone were allowed to transfer to other educational institutions of Ukraine with their scholarship and budget places, or renew the studies in the higher education institutions where they had studied provided they had a long break in their studies and were dismissed (*Lyst Ministerstva...*, 2014). Thus, the mobility of students in Ukraine increased. The Ministry of education of Ukraine created special conditions for school pupils from occupied territories for distance learning at Ukrainian schools. Such pupils were allowed to pass final examinations and external independent testing examinations in special centres when they arrive to Ukrainian territories. After the children pass exams they can receive Ukrainian high school diploma and enter Ukrainian higher education institutions (*Ia khochu vstupyty...*, n.d.). In this way the Government of Ukraine created the conditions for migration for children – school graduates from the occupied territories – to provide them with quality education and ensure attainment of SDG No 4 in the country.

## 5. Gender equality

Women and children make up two thirds of registered IDPs (*Genderna rivnist*, n.d.). Typically, women predominate in the low-income share of the population, who appeal to the government for social assistance. Special attention should be given to increasing violence against women in military conflict environment in the East of Ukraine, including sexual

violence. According to the Ministry of Social Policy of Ukraine in 2015 there were 103,101 appeals regarding domestic violence, of which 86.9% belonged to women (Ministerstvo sotsialnoi..., n.d.). The number of appeals regarding domestic abuse remains approximately the same compared to the years before the military conflict. However, there is a problem of violence against women, who remained on the occupied territory and therefore did not submit the relevant appeals to the Ukrainian authorities, as well as increased violence in families, suffered from the military conflict. Availability of information on such violence indicates that it also happens with IDPs' families.

Migration of many women, including those with young children and those who have suffered from ATO, led to increased attention of international organizations to women. Gender issues were among the priority goals of providing grant aid, and were included to the documents of strategic development of regions in Ukraine (*Stratehiia...*, 2016). After the beginning of the military conflict in Ukraine, the level of civil activity of Ukraine's population (including women) has significantly increased (*Gender Dimensions...*, 2015). Women-IDPs are actively involved in public activity and / or create women's NGOs to address their own problems, the problems of IDPs and the communities they moved to.

#### 6. *Clean water and sanitation*

Regarding the impact of migration in Ukraine on goal №6 it should be noted that in general IDPs settled in worse conditions than those they had in their native homes (*Tematychnyi zvit Vnutrishnie...*, 2016), but information on the lack of access to water is not available. However, the workload of the companies providing water services in the cities with the highest concentration of IDPs increased, and some were temporarily damaged by military actions. Because of damage of water supply systems, the incidence of hepatitis A (cirrhosis) doubled. This resulted into spread of infectious diseases to neighbouring regions (Government Agency, 2015).

#### 7. *Affordable and clean energy*

Information regarding the direct effects of migration on access to energy resources is not available. However, as with the previous goal, the only power station, which supplies energy to Ukrainian cities and to the occupied territories of Luhansk region, is overloaded. The necessity to provide the whole Luhansk region and displaced population with electricity was the main reason for beginning of energy networks restoration and new energy network creation in the region (Luhanska oblasna... n.d.).

#### 8. *Decent work and economic growth*

The main target of the Goal No 8 concerning migrants is *to protect labour rights and promote safe*

*and secure working environments for all workers, including migrant workers (Transforming our..., 2015).* Some companies and organizations relocated from the occupied territory to the territory under Ukrainian Government control and provided all their displaced employees with jobs. However, a significant number of IDPs have lost their jobs and have to look for new jobs. Addressing employment of IDPs became a priority for state and local government authorities. Adopted in 2015 the Law of Ukraine *On amendments to some laws of Ukraine to strengthen social protection of internally displaced persons* provided some compensation to employers that employ IDPs, some compensation to IDPs related to change of employment, and financing measures and activities, which promote IDPs' employment (*Law of Ukraine 'On amendments...', 2015*).

Local authorities in Luhansk region together with NGOs have implemented 300 projects with budget UAH 5 billion (approximately EUR 181 million), which were included to local target programs of districts and cities *Adaptation of IDPs in 2016 (Na Luhanshchyni...*, 2016). Similar programs are being implemented in Donetsk region (*Rehionalna prohrama intehratsii...*, 2015). These programs include IDPs' retraining and skills improvement for their further employment and promoting self-employment among IDPs, including opening social enterprises.

Public Employment Service of Ukraine also provided assistance to IDPs: unemployment payments, assistance in finding jobs, organization of vocational trainings and temporary work. The total number of IDPs who received Public Employment Service assistance from March 1, 2014 to November 30, 2016 was 75,933 people. Among them, 44,354 persons (58.4% of the total number) were receiving unemployment payments, 5,466 persons (7.2%) passed vocational training, and only 23,520 persons (31%) obtained employment. The share of women among the unemployed IDPs is 67.1% on average in Ukraine, while their share in the total number of unemployed in Ukraine is 54.6% (*Informatsiia pro nadannia...*, n.d.).

Two of the main problems facing the unemployed IDPs are a small number of jobs offered on the labour market and the mismatch of IDPs' skills with the requirements of employers. A small number of jobs is evidenced in Luhansk and Donetsk regions due to business interruptions or closures because of ATO (*Kilkist pidpriemstv Luhanskoi...*, n.d.). Many of IDPs were forced to accept other jobs with lower wages or in lower positions. Some IDPs claim they met with discrimination when applying for a job, as employers sometimes refused to hire them or offered wages or conditions worse than those that the local employees had (*Tematychnyi zvit Vnutrishnie...*, 2016). International organizations give considerable attention to reduction of unemployment

among IDPs, provide funds for retraining and job creation for IDPs.

#### 9. Industry, innovation and infrastructure

There is close connection between internal migration and development of infrastructure, industry and innovations in Ukraine. National and international strategies of integration of IDPs into local communities include separate programs for development of regions with the highest concentration of IDPs. The question is about expanding infrastructure capacity of hosting communities in accordance to the number of IDPs to avoid negative attitude of local population to displaced citizens and reduce the public infrastructure load. These programs include various State programs, Regional programs and projects of International organizations, directed to adaptation, recovery, and peace building in the Eastern regions of Ukraine (The Cabinet of Ministers of Ukraine Resolution, 2016; *Zvit pro stan...*, n.d.). The total financing needs for restoration of peace in Donbas amounted to USD 1.52 billion (Ministry of Economic Development and Trade of Ukraine, n.d.). The necessary funds are partially from the budget, partially borrowed, partially from donors.

#### 10. Reduced inequalities

Ensuring equal opportunities and rights for IDPs and local population is essential for sustainable development of Ukraine. Unfortunately, a large number of IDPs meets with discrimination and violation of rights and freedoms. One type of discrimination is employment. Another biggest violation is restrictive mobility or violation of freedom of IDPs movement and travel. The large number of checkpoints in the territory, close to the demarcation line between Ukrainian and the occupied territories, prevents the free movement on the territory of Ukraine. The crossing of the demarcation line is very problematic: there is a limited quantity of checkpoints, which can stop working without warning, long lines of people for many hours with no adequate conditions for this. There are violations which deal with the payment of pensions, which the government authorities suspended for those persons, who are not IDPs, or who are temporarily living in the occupied territories, or do not have a verification certificate of an IDP (*Tematychnyi zvit Vnutrishnie...*, 2016). Pensions to IDPs are paid only through State Savings Bank of Ukraine. This procedure makes access of IDPs to financial services more difficult. To continue receiving pensions people have to undergo regular inspections, unlike retirees from other regions of Ukraine, who continue to receive pensions uninterrupted. Restriction of political rights of IDPs is another form of discrimination: IDPs are deprived of the right to vote in local elections, despite the fact that they are already members of new local communities and take active part in public life. To ensure the rights and freedoms of IDPs the relevant Law of Ukraine was

adopted (*Law of Ukraine 'Pro zabezpechennia...*' 2015), which, unfortunately, does not assist to realization of all the rights and freedoms of IDPs.

#### 11. Sustainable cities and communities

Internal migration in Ukraine caused change to the worse in achieving goal No 11 in those cities of Ukraine, which hosted many immigrants. There is not enough housing for IDPs. Many families, who lived separately before the conflict, are living together. Some families live at campus living centres. Sometimes IDPs received accommodations in buildings, which had been initially designed for other purposes (summer camps, motels, holiday centres etc.) (*Tematychnyi zvit Vnutrishnie...*, 2016). Apartment rent has significantly increased with demand. Thus, IDPs' access to *adequate, safe and affordable housing* is often missing.

Sustainable transportation is also unsatisfactory. A large number of migrants particularly in Luhansk region needs additional means of communication with other regions and cities of Ukraine. However, destroyed transport infrastructure and infrastructure initially designed for smaller population, are unable to meet the growing needs of the population (*Stratehiia...*, 2016).

At the same time, IDPs try to preserve their cultural heritage and make the hosting cities more comfortable to stay. The large number of NGOs, which appeared recently, evidences this. The activities of these organizations often take aim at improving the living conditions of migrants (*Zareiestrovani hromadski...*, 2016).

#### 12. Responsible consumption and production

Achievement of goal No 12 indirectly affects and depends on migration. Population growth in 2014 in ATO zone, controlled by Ukrainian Government, accompanying reduction or termination of food supply to unsafe territories led to the humanitarian catastrophe. Responsible consumption of resources has become imperative associated with survival in difficult conditions. Number of cases of illegal coal mining significantly increased on territories, which are not under Ukrainian Government control (Kulytskyi, 2016), as it became merely the only source of income for the unemployed miners, who either were unable to migrate, or could not find a job in other regions of Ukraine and returned home.

#### 13. Climate action,

#### 14. Life below water

Displacement of many people inside Ukraine has not obviously affected the achievement of the goal No 13 and 14 related to climate change mitigation, conservation and rational use of marine resources.

#### 15. Life on land

Displacement of many people inside Ukraine has not obviously affected the achievement of the goal re-

lated to protection and restoration of ecosystems and sustainable forest management and land use. At the same time, land under cultivation in Luhansk and Donetsk regions decreased because of occupation of the part of these regions (State Statistics Service of Ukraine, n.d.).

#### 16. *Peace and justice, strong institutions*

The problem of obtaining justice and peace are closely connected to the internal migration in Ukraine. On the one hand, the failure of attainment of the targets of goal No 16 became one of the main reasons for people's moving, namely increasing danger to life, violence, death, crime, misappropriation of property, lack of legal protection, corruption etc. On the other hand, massive internal migration caused new conflicts, especially between IDPs and population of the hosting communities.

International organizations pay attention to systematic human rights violations in ATO zone, including the territory under Ukrainian Government control (*Tematychnyi zvit Zakhyst...*, 2015). The most serious is the threat to the life of people because of continuing military actions. The United Nation claims that *more than 9,200 people have been killed, among them are about 2,000 civilians. More than 21 thousand people have been injured, many of them have suffered disfigurements or trauma (10 rechei...*, n.d.). Today about 24 settlements suffer of shellfire. To ensure health and safety people should be relocated, which requires significant resources and cannot be instantly done. Those people, who stay on the occupied territory, often cannot move to the territory under Ukrainian Government control because of non-compliance of procedures for obtaining permission to cross the demarcation line and the inability to appeal to authorities or other organizations who can facilitate evacuation.

When crossing the demarcation line or Ukrainian state borders IDPs complained on corruption, interrogation, insults from the border-guards or soldiers (*Tematychnyi zvit Zakhyst...*, 2015). Displacement of the courts and prosecutors led to loss of many materials and proceedings cases in Luhansk and Donetsk regions, which sometimes makes peaceful resolution of disputes and claims review impossible (*Tematychnyi zvit Dostup...*, 2015). Displacement of law enforcement and justice institutions and absence of an action plan in case of such displacement caused problems with justice administration and enforcement of certain judgments.

Migration of many people to other communities also led to emergence of social tension and conflicts between IDPs and local community members. Some representatives of local population had certain stereotypes and critical attitude to IDPs, emphasizing their pro-Russian and separatist views and blaming for the situation. Competition for jobs, housing, places in schools and kindergartens, reception hours in public facilities and other resources appeared be-

tween local population and IDPs (*Stavlennia nase lennia...*, 2016). Some organizations started providing funds for projects, which deal with establishment of dialogue between the hosting communities and migrants.

It is important to understand that part of IDPs will never return home, while some of them are temporary migrants. Post-conflict rehabilitation and reconciliation will be essential for the sustainable development of the region and full settlement of the conflict in the East of Ukraine. Thus, the main obstacles for peace are the fighting in the East of Ukraine and complicated relationship of IDPs and hosting communities, and IDPs and the population remained on the occupied territory.

#### 17. *Partnerships for the goals*

Goal No 17 is being implemented due to coordinated joint actions of international organizations and public and private institutions in restoration and establishment of peace in Ukraine and integration of IDPs into local communities. Projects and programs of international aid, implemented in Ukraine (Open Aid Ukraine, n.d.), demonstrate interaction of the government and international donors. Within individual projects and programs one can see the increased attention to the establishment of dialogue platforms for having partnerships between donors and the private sector, non-governmental public organizations and other civil society groups to address the urgent problems of IDPs. These problems deal with assurance of work, housing, human rights and freedoms, creation of decent living conditions (*ES nadav...*, 2016).

### **Conclusions**

Sustainable development of Ukraine is the only way of survival and preservation of human potential in present conditions. This way is possible only based on the achievement of 17 SDGs. Each country has its own problems, which require urgent solution to save the nation and promote its further sustainable development. For Ukraine, the safety of its citizens' lives became such a problem. Military conflict in the East of Ukraine, which began in 2014 and continues to this day, caused massive internal migration, for which the country was not ready and still has not solved all the issues to ensure decent living standards for its citizens who became IDPs. The migration processes affected all areas of people's life and opportunities for further development. The effects were complex and different in strength, and influenced the majority of SDGs. The analysis of the impact of migration on sustainable development of the country allows determining priorities and instruments for fight with negative phenomena and supporting the positive impact of migration on the development of regions in Ukraine. As many migrations are temporary, this temporality and perception of migration as temporary may influence the behaviour of migrants.

That is why the level and possibility of achievement of SDGs in Ukraine as it is now may be such because of expectations of Ukrainians that their internal displacement is temporary. The time, which passes since the start of hostilities, change these expectations, which in turn can affect the sustainable development of the country. The durability of military conflict in Ukraine changes the status of IDPs to the status of new members of local communities who count on additional support and attention. The continuing military conflict requires development of not temporary, but long-term strategies and measures for sustainable development of the enlarged communities and the country as a whole.

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## The Impact of the CAP *Green* Programmes on Farm Productivity and its Social Contribution

### Wpływ zielonych programów WPR na produktywność gospodarstw rolnych i jego implikacje społeczne

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#### Abstract

Facing the opinion about the ambiguous impact of decoupled subsidies on productivity, the article aims to check whether there are some CAP programmes contributing to the *greening* trend, which have a positive impact on productivity in FADN regions. Second research question is whether the CAP schemes create social sustainability? A two-stage panel analysis was carried out in the years 2007-2012: in the first stage clusters of regions with significantly different farming were identified; in the second the impact of particular CAP mechanisms on productivity was determined. It is concluded that, depending on the sustainability of farming, there are some CAP 'green' programmes which have a positive influence on productivity.

**Key words:** CAP, green box subsidies, sustainability, agriculture, productivity

#### Streszczenie

Wobec opinii o niejednoznacznym wpływie subsydiów na produktywność, artykuł ma na celu sprawdzenie, czy istnieją programy wspólnej polityki rolnej (WPR) przyczyniające się do *zazielenienia*, które mają pozytywny wpływ na produktywność techniczną w produkcji rolnej w regionach Unii Europejskiej (według FADN). Drugim pytaniem badawczym jest, na ile subsydia WPR kreują ład społeczny? Przeprowadzono dwustopniową analizę panelową w latach 2007-2012: w pierwszej fazie zidentyfikowano klasy regionów, w których rolnictwo cechuje odmienny sposób gospodarowania; w drugim kroku określono wpływ poszczególnych mechanizmów WPR na produktywność zużycia pośredniego. Stwierdzono, że w zależności od poziomu zrównoważenia rolnictwa istnieją różne *zielone* programy WPR, które mają pozytywny wpływ na wspomnianą produktywność.

**Słowa kluczowe:** WPR, subsydia w ramach green box, zrównoważenie, rolnictwo, produktywność

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#### 1. Introduction

Agricultural economics faces the dilemma how to reduce the effectiveness of the post-industrial development model in favour of an improvement in the sustainable quality of life (Wojtyna, 2008; Zegar, 2012). Agricultural policy should therefore take into account the complementarity of the traditional and new aims of agriculture (Czyżewski, Stępień 2014; Wilkin, 2008). In the authors' view, however, the significant structural differences between regions, which have been noted by many authors (Giannakis, Bruggeman, 2015), mean that it is not possible to apply

one, universal model of agricultural support over the whole EU. One can assume that various models of farming are reflected in the structure of subsidies acquired by specific EU regions.

The question of what effect CAP subsidies have on the productivity of farms in the European Union has been studied by many authors, but it has not yet been definitively answered (Olley, Pakes, 1996; Hennessy, 1998; Ciaian, Swinnen 2009; Rizov et al., 2013; Banga, 2014). Generally subsidies, which change competition conditions and turn into the support of incomes rather than production are supposed to rather lower productivity. These studies show that

before the decoupling reform (Luxembourg, 2003) subsidies had a positive impact on production, while having a negative impact on productivity. Conclusions concerning the period since that reform remain rather ambiguous, although they tend to show that a negative effect is found less often (in terms of the influence of subsidies on the level of the total factor productivity (TFP) or average productivity) or not at all (in terms of the influence on the rate of growth of TFP) (Rizov et al., 2013). The cited paper by M. Rizov, J. Pokrivcak and P. Ciaian is the most comprehensive study in this field, and also reviews the results of other researchers. The problem, however, is that it remains inconclusive in regard to the period since the decoupling reform, and that it concerns only the EU15 countries. In the cited study, the correlation coefficients proved to be statistically insignificant for 11 of the 15 countries regarding the relationship between TFP growth and subsidies (Rizov et al., 2013). Rashmi Banga made an extensive study on the effect of *Green Box* (GB) subsidies on the technical efficiency of agriculture in various countries of the world, including the EU26, concluding that total factor productivity growth in EU agriculture is 3.7% per annum without GB subsidies, but that it increased to 8.3% per annum due to GB subsidies in 1995-2007 (Banga, 2014). We believe, however, that it is rather unjustified to ascribe this growth in productivity to pro-environmental subsidies and action taken to further sustainable development, because not all GB tools are of that nature (they include also investment support), and moreover there are large regional differences in support models, while average measures of productivity growth in the EU may be strongly affected by countries and regions with little use of GB support. Hence there is a need to continue research in this field focusing on the influence of specific programmes rather than on agricultural policy as a whole. It is worth taking into account the period since the decoupling reform and the new member countries of the EU28 in the cross-sectional regional perspective. We believe that this problem requires a slightly different approach to the evaluation of the effect of subsidies than was applied in the works cited above. Firstly, subsidies for agriculture in the EU should be considered as not so much an econometric problem but as one of political economy. Secondly, the productivity of resources in agriculture can be affected not by the amount of subsidies, but also by their structure, which differs more at regional than national level. In this view, the structure of subsidies treated holistically as the proxy for structural differences becomes a qualitative rather than a quantitative predictor.

We shall attempt to fill the aforementioned gaps by means of a two-stage study. In the first stage the goal is to identify clusters of EUFADN regions which differ significantly in terms of farming models. For this purpose the structure of acquired CAP funds was used as the proxy for structural differences. In the

second stage, panel regression models were estimated for the clusters identified, in order to find out which CAP *green programmes* have a significant impact on productivity. The spatial analysis was carried out based on data from EUFADN for the 2007-2012 financial perspective; it covered all FADN regions in the EU28, focusing on representative farms for the regions (131 units representing 4,919,580 farms in 2012), and considered average indices of productivity of intermediate consumption. This approach was also presented and discussed during the XV EAAE (European Association of Agricultural Economists) Congress (Czyzewski et al., 2017)

## 2. The problem of capturing structural differences

It is an open secret that decisions on the sizes of CAP support envelopes for the whole European Union and for individual countries are influenced by political rather than economic considerations. This is particularly visible in the case of the new EU13 member countries, where there is a majority of small, semi-subsistence family farms (Davidova et al., 2013). A basic criterion used in determination of the amount and structure of support under Pillars I and II of the CAP is the need to reach the largest possible number of farms, as these represent potential voters, regardless of the fact that they account for a relatively small total area of agricultural land and only a small percentage of total output. The microeconomic models of productivity usually do not take into account the political criteria for subsidies allocation, which in our view determines the process, and in this way they influence productivity in agriculture. The econometric methods of addressing structural differences on the microeconomic level somehow fail to fulfil those criteria for several reasons:

- 1) The assumptions of the microeconomic models are adopted implicitly, so they are not set out and discussed. This applies, for example, to the problem of how price effects are captured, which is generally encountered by researchers working with FADN data. The FADN database does not contain data on transaction prices, but only nominal values. Another problem corresponds to the assumption on which a production function is built, namely that *conditional on staying in production, the farm has to decide about its inputs, labour and materials use and investment* (Rizov, et al. 2013; Olley, Pakes, 1996) – but what about land? Semi-subsistence farms land remains in production for own needs regardless of market conditions, and the decision on purchasing or sale of land is not based on the criterion of profitability of production.
- 2) The assumptions are not tested to determine whether they correspond to reality (few remember about Popper's principles concerning the falsification of theories, which indicate the need to

test auxiliary assumptions (Gezelter, 2009; Popper 1959). For example, the condition of the sale value of the farm maximisation is unrealistic for a semi-subsistence farm, which tends to *optimise* income, i.e. to make it sufficient, while satisfying the household's own food needs. Apart from that, farm labour (own labour in the case of a small farm) is not a function of subsidies or one about which decisions are always made during the current period. Labour resources in small farms remain constant irrespective of agricultural policy or market conditions, and are determined more by demographic processes.

- 3) The efficiency of these models in terms of production results is low, since the conclusions resulting from the huge amount of research work are ambiguous and hard to implement in practice.
- 4) The models do not take into account the political criteria for subsidies allocation, which in our view determine the process and in this way they influence factor productivity in agriculture.

With reference to the last point, our approach has two stages. If it is assumed that the criterion for determination of the structure of national CAP envelopes is maximisation of the number of beneficiaries, the structure will initially be matched to the structure and dominant types of production in a given country, and more importantly – its regions. *Initially* means negotiating a given CAP financial perspective and determining the structure of Pillars I and II within the permissible limits of flexibility at national level. With regard to the period covered by this study, this refers to 2007, as the start of the 2007-2013 financial perspective. Nonetheless, the determined support structure (amounts allocated to individual programmes) secondarily shapes the agrarian structures in a given country and region, by forcing them to adapt to the criteria presented to beneficiaries of the various programmes (when subsidy applications are submitted). In this way the subsidies structure as a whole also exerts an influence on factor productivity. We still believe, however, that it is the support model treated holistically that exerts this influence, not the amounts of the subsidies, because the model of CAP Pillars I and II has been defined as a whole through a political process. Many microeconomic models treat subsidies as taxes with a reversed sign, which in this case is not a completely valid approach. The structure of CAP Pillars I and II, determined by politicians and being a derivative of the agrarian structures in a particular country, is a qualitative variable which affects factor productivity in three ways.

- 1) Indirectly, through fulfilment of the criteria of CAP programmes relating to agricultural practices and the structure of production (impact on technical and financial productivity). According to (Baumol, 1990; Alston, James, 2002) this impact is negative, because subsidies distort the production structure of recipient farms, leading to allocative inefficiency if recipients invest in

subsidy-seeking activities which are relatively less productive. Recipients may not be eager to seek cost-improving methods.

- 2) Indirectly, through subsidisation of investment and technology (impact on technical productivity). The impact can be positive due to investment-induced productivity gains, but also negative while subsidies give an incentive to change the capital-labour ratio, which can lead to over-investment.
- 3) Directly, through influence on financial productivity and incomes (positive impact). Research carried out in Poland indicates that the dominant target function of the agricultural producer is the maximisation of returns in conditions of substitutability between economic rent, having its source in efficiency of production, and political rent, whose size results from the agricultural policy applied in the region in question. An agricultural producer replaces an income source which is for him/her more costly and demanding, with a cheaper source which does not require so much input. In the light of the concept of rational and adaptive expectations, improving the efficiency of use of production factors subject to given price relations is always harder than waiting for support (Bezat-Jarzębowska, Rembisz, 2013, p. 36-39).

### 3. Research methodology

Having the above considerations in mind, we propose a relatively simple statistical procedure based on assumptions which will not give rise to doubts of the kind discussed above. In the first stage, the goal was to identify areas in the EU28 having similar agricultural support models. For this purpose an agglomerative cluster analysis was carried out (using Ward's method) covering 131 representative farms for all EUFADN regions (representing 4,919,580 farms in 2012), according to the criterion of percentage contributions to the different *boxes* of subsidies, i.e. for the following grouping variables:

X1 – value of payments for public goods belonging to the title *green box* (assumed as the sum of set-aside and agri-environmental payments, support for less favoured areas and other subsidies under rural support programmes);

X2 – value of crop and animal production subsidies (the sum of other subsidies for crop and livestock production plus the balance of subsidies and penalties for milk production, subsidies for other cattle production and subsidies for sheep and goat production);

X3 – value of single farm payments and area payments (might be classified as the component of *green box*);

X4 – value of subsidies for indirect consumption;

X5 – values of investment subsidies.

The variables X1–X5 were taken as average values across a six-year reference period (2007-2012), as well as for each year separately. The estimated cluster sets were quite similar in each year, because national structures of subsidies are mostly defined at the beginning of the programming period when the programmes of CAP Pillars I and II begin. However, we chose the clustering result from the last year of the analysis, because it reflects adjustments in agrarian structures over the entire programming period and gave the best results for disjointness tests. The disjointness of clusters is the most important criterion from the point of view of the hypothesis put forward at the outset. It was tested by evaluating the significance of the differences between the average contributions of types of subsidy to the political rent in the obtained clusters. The assumption of homogeneity of variance of variables between the groups of regions was evaluated using Levene's test and the Brown–Forsythe test. The hypothesis of homogeneity of variance in comparable groups was rejected for individual variables (X1–X4) with the exception of the variable expressing the contribution of subsidies for indirect consumption. Hence the significance of the differences between the means of samples (clusters) was evaluated using the non-parametric Mann–Withney U test (Stanisz, 2006, p. 247). It was confirmed that the clusters (isolated at a level of approximately 50% of the maximum distance) differ significantly in terms of the structure of budgetary subsidies for agriculture.

In the second stage, we computed a panel regression for each of the clusters A, B and C. A log-linear model was applied, as follows:

$$\ln TP_{it} = \gamma' SUB_{it} + \beta' X_i + u \quad (1)$$

where:  $TP_{it}$  denotes for average technical productivity excluding subsidies: total output (SE131 FADN code) / total intermediate consumption (SE275) in the region  $i$  and year  $t$ ; the vector of coefficients for the respective subsidies (the FADN codes include: SE406 SE407 SE612 SE613 SE616 SE617 SE618 SE619 SE621 SE622 SE623 SE699 SE625 SE626 SE631 SE632 SE640 SE650);  $\beta$  the vector of coefficients for years dummy variables;  $u$  random term. Next we computed ordinary least squares (OLS) base models (together with dummy variables for years). In case of rejection of the hypothesis of applicability of this approach (based on the Breusch–Pagan test) we estimated panel models with fixed (FE) and random effects (RE). In these models, we introduced the variables step by step, checking whether the model was stable and whether the addition of a further variable caused changes in the signs of the other regression coefficients. The effect of the time factor was also shown in the panel models, provided that it might be significant in capturing the impact of CAP on productivity in the years 2007-2012 in clusters B and C. The evaluation of which of these models (FE or RE) was appropriate was made on the basis of Hausman and Welch tests. The final models

were computed taking account of the Beck-Katz robust standard errors (PCSE) for cluster A and Arellano robust standard errors (HAC) for clusters B and C. In the results section we present, for each cluster, a final panel model with robust standard errors, along with the marginal effects for individual years.

#### 4. Results and discussion

The analysis identified three clusters of regions with different farming models according to the support structure. (Figure 1). In the most numerous group of regions (cluster A) a *moderately sustainable* model operated, in which support for agriculture was provided primarily through single farm and area payments (these contributed more than 59% of the subsidies). At the same time farms in those regions derived significant economic benefits from the supply of public goods – the contribution of agri-environmental payments, set-aside payments, support for less favoured areas and other subsidies under rural support programmes to the political rent of representative farms in those regions was close to 17%. In the regions in the next largest cluster (B), the contribution of single farm and area payments to the political rent was markedly higher than in the other clusters, at close to 80%. The contributions from other types of budgetary support, including payments for public goods, were relatively small. Cluster B clearly reflected to the greatest degree a model in which support for production has been almost entirely replaced by direct support for farms, and which can be described as weakly sustainable. The third, and least numerous group of regions (cluster C) contained parts of the EU28 having a model that combines different mechanisms for the support of farms. Payments for crop and animal production, as well as single farm and area payments, made contributions of no more than 30% to the political rent. Cluster C also had the highest contributions for the aforementioned payments for public goods (approx. 33%) and investment subsidies box (almost 10%) compared with the other groups of regions. It is therefore seen that over most of the area of EU in 2012 there functioned a model (A or C) in which support for agricultural production was being replaced by direct payments (area and single farm payments) and payments for public goods (Figure 1) (Czyzewski, Smędzik-Ambroży 2017).

In most regions of the old EU member countries, however, model B operates, oriented exclusively towards direct payments, which are treated as a substitute for production support and produce a relatively weak stimulus for sustainable development, whereas in the countries of Central and Eastern Europe model A applies, providing an opportunity for placing a value on public goods produced by agriculture. This is confirmed by the spatial analysis of Giannakis and Kutkowska, in which it was observed, among other things, that direct support primarily reaches farms in

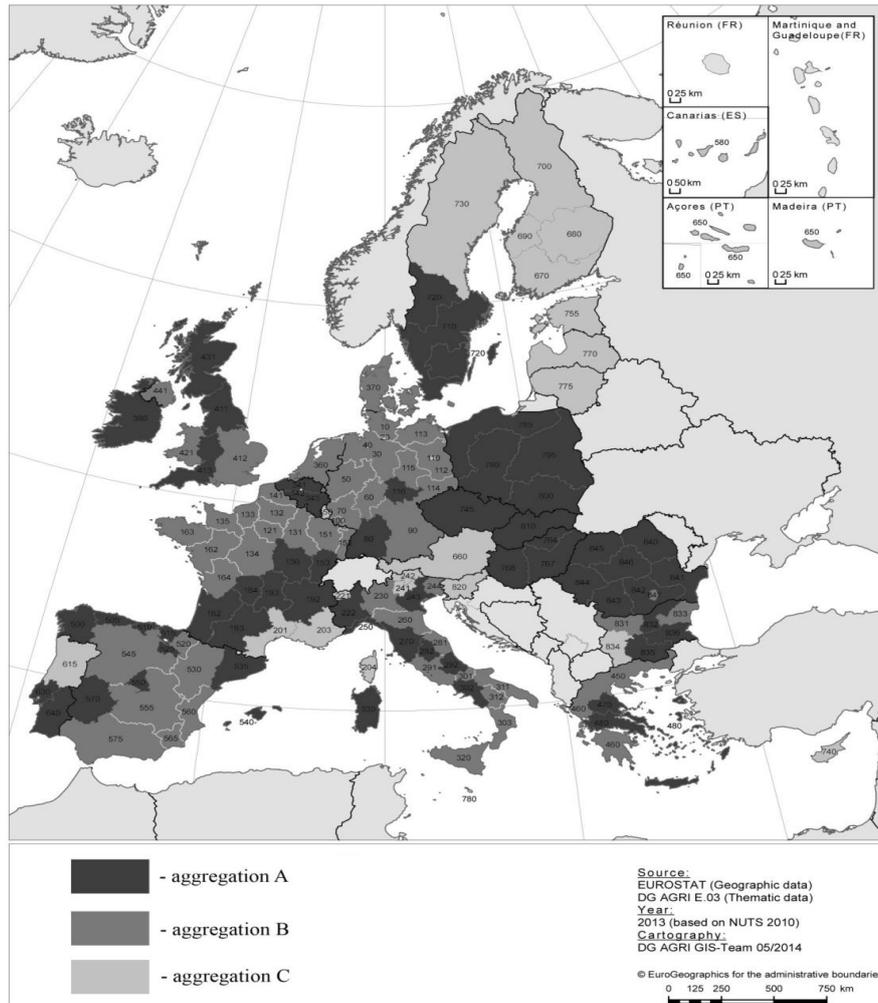


Figure 1. FADN/RICA Regions of EU28 (2013)

intensive farming areas (Giannakis, Bruggeman, 2015). It was also noted that the regression, resulting from modulation, in area payments for farms with larger areas in the new member countries will cause changes in production in favour of methods that are more friendly to the environment and assist sustainable development (Kutkowska, Berbeka, 2012, p. 266-267). This is no doubt determined by fears of a fall in factor productivity in agriculture in case of a possible change in the support structure.

In a small group of regions there was found to be a strongly sustainable support model combining various forms of assistance to farms (cluster C). Subsidisation for the supply of public goods was accompanied there by high subsidies for agricultural production and significant direct support (single farm payments). This group included most of the island regions of the EU, the northern part of Europe consisting of the Finnish regions and the Län i Norra region in Sweden, and the regions of Lithuania, Latvia and Estonia. This cluster also contained a few regions in southern and central Europe, mainly mountainous (Figure 1). In summary, it was found that the groups of EU28 regions generated by the cluster analysis differed significantly in terms of the struc-

ture of budgetary subsidies to agriculture, and that only models A and C were to a greater or lesser extent aligned with the development priorities of the European agricultural model emphasised in the new financial perspective of 2014-2020.

In the second stage of the study the aim was to assess which CAP programmes have a positive impact on productivity in regions from the different agrarian structures and to find out whether there are any green subsidies among them. In each case, the fixed effects model was found to be appropriate. All of the models fit fairly well: the LSDV R2 value ranges from 0.90 to 0.94, and within-R2 from 0.20 to 0.40. Some variables were excluded due to excessive collinearity. All variables in the three models are statistically significant (p-values do not exceed 0.1, except for Single farm payment in cluster A and B for which  $p = 0.11$  in A and 0.12 in B and two variables in cluster C for which  $p = 0.13$ ).

For cluster A (moderately sustainable model of agriculture support) the model explains more than 90% of the variation in productivity of intermediate consumption, taking account of individual country effects (LSDV R2 = 0.903102) which are constant over time (but vary in space). The within-group R2

Table 1. Panel regression for the cluster A (fixed-effects, using 357 observations, included 60 cross-sectional units, dependent variable: log-productivity of intermediate consumption, Beck-Katz standard errors), source: own study based on EUFADN data

	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>	
Const	0.552186	0.0511908	10.7868	<0.0001	***
Economic size	0.00115674	0.00063528	1.8208	0.0737	*
Subsidies on investments	-8.97732e-06	5.12817e-06	-1.7506	0.0852	*
Setaside premiums	-0.000848691	0.000401887	-2.1118	0.0390	**
Other crop subsidies	3.48189e-05	7.3805e-06	4.7177	<0.0001	***
Subsidies other cattle	-2.29505e-05	1.01412e-05	-2.2631	0.0273	**
Subsidies sheep&goats	9.07244e-05	3.80155e-05	2.3865	0.0202	**
Other livestock subsidies	-4.76956e-05	8.95212e-06	-5.3279	<0.0001	***
Environmental subsidies	2.49441e-05	5.42378e-06	4.5990	<0.0001	***
LFA subsidies	-3.10549e-05	1.33202e-05	-2.3314	0.0232	**
Other subsidies	-9.69108e-06	5.04416e-06	-1.9212	0.0595	*
Subsidies on intermediate consumption	-2.81006e-05	1.38462e-05	-2.0295	0.0469	**
Single Farm payment	-7.45402e-06	4.57004e-06	-1.6311	0.1082	
Single Area payment	-1.02835e-05	4.7033e-06	-2.1864	0.0328	**
Additional aid	0.00037333	0.000133433	2.7979	0.0069	***
Support_Art68	3.5304e-05	1.39287e-05	2.5346	0.0139	**
LSDV R-squared 0.903102; Within R-squared 0.201075					

Table 2. Panel regression for cluster B (Fixed-effects, using 294 observations, Included 49 cross-sectional units, dependent variable: log-productivity of intermediate consumption, Robust HAC standard errors), source: own study based on EUFADN data

	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>	
Const	0.931524	0.0839827	11.0919	<0.0001	***
Payments to dairy outgoers	0.000231715	0.000119086	1.9458	0.0575	*
Setaside premiums	-0.000676872	0.000120662	-5.6096	<0.0001	***
Other crop subsidies	-4.81729e-05	2.63026e-05	-1.8315	0.0732	*
Subsidies other cattle	-3.68319e-05	1.84421e-05	-1.9972	0.0515	*
LFA subsidies	-1.26174e-05	6.74698e-06	-1.8701	0.0676	*
Single Farm payment	-3.7522e-06	2.37638e-06	-1.5790	0.1209	
Single Area payment	4.80934e-05	1.65638e-05	2.9035	0.0056	***
Additional aid	-0.000597601	0.000204699	-2.9194	0.0053	***
dt_2 (time dummy variable ref.2007)	-0.0711015	0.014209	-5.0040	<0.0001	***
dt_3	-0.223094	0.0504853	-4.4190	<0.0001	***
dt_4	-0.194809	0.0444979	-4.3779	<0.0001	***
dt_5	-0.221163	0.0442124	-5.0023	<0.0001	***
dt_6	-0.23388	0.042717	-5.4751	<0.0001	***
LSDV R-squared 0.944601; Within R-squared 0.402253					

explains 20% of the intragroup (*within*) variation. We should recall that we are analysing a stack of time series (the years 2007–2012 for each region), hence *within-R2* attributes variation in productivity of intermediate consumption to explanatory variables which vary over time. Their variation over time is seen in cluster A to have had no statistical significance (cf. Table 1).

In cluster A, with the moderately sustainable model of agriculture support which operated in most of the EU-13 regions and the mountainous French regions, the majority of CAP subsidies had a negative effect on the dependent variable as expected. It is interesting that this model confirms the thesis present in the literature that farms from new member states spend a large part of decoupled payments on consumption

or on various unsuccessful investment projects, which is shown by the negative impact of single area payments on productivity (we recall that the productivity measure used here excludes any subsidies). A quite surprising thing is the negative impact of *subsidies on investment*. It happens that farms buy new assets without conducting a profitability analysis. Although there is evidence in the literature on over-investment in equipment (Szeptycki, 1996; Kowalski and Szeląg-Sikora, 2006; Rizov et al.; 2013; Grzelak, 2014) in new member states, we believe that the increase in productivity due to the investment needs more time. The exceptions, with a positive impact on productivity, are as follows:

- subsidies for sheep and goat production, which, apart from subsidies for breeding sheep and

goats, include subsidies for products made from goat's and sheep's milk, as well as specific support for the production of sheep and goats. This mechanism is crucial to maintain a certain level of production in mountainous regions and regions with a predominance of extensive grazing stock production. Therefore, subsidies for products made from goat's and sheep's milk may affect also the productivity of intermediate consumption in a positive way;

- other crop subsidies, covering subsidies for field crops, horticulture and perennial plantations, apart from set-aside subsidies, compensatory and decoupled payments may be understood as a residue of direct payments, but it should be noted that the coefficient is rather low – 100 EUR, other crop subsidies will cause an increase in productivity of intermediate consumption by 0.00348%;
- environmental subsidies, which is also quite a surprising finding. We assume that in mountain regions and in regions with a predominance of extensive production, especially in the new member states, the environmental criteria have already been reached, so they make it possible to acquire new funds for development without bearing additional costs. Therefore they might positively influence the productivity of intermediate consumption; Moreover, in the literature the conventional perception about environmental protection claims that it imposes additional costs on firms, which may reduce their global competitiveness with negative effects on growth and employment. But, at the same time, more stringent environmental policies can stimulate innovations that may over-compensate for the costs of complying with these policies (Porter and Van der Linde, 1995). This confirms analysis of De Santis and Lasinio (2015) which says that the gradual strategic reorientation of environmental policies in the EU in favor of economic incentives has been more effective in stimulating productivity and innovation than in setting explicit directives about pollution control levels;
- special support granted pursuant to Art. 68 of Regulation (EC) No 73/2009, within which Member States may grant specific support to farmers in respect of: specific types of farming which are important for the protection or enhancement of the environment, improving the quality of agricultural products, improving the marketing of agricultural products, specific agricultural activities entailing additional agri-environment benefits; and in areas subject to restructuring or the development of programmes in order to prevent the abandonment of land or addressed to specific disadvantages for farmers in those areas. This may be granted in the form of contributions to crop insurance, animals and

plants, and by mutual funds for animal and plant diseases and environmental incidents in accordance with the conditions set out in Article. 71. This support is intended to cover the additional costs that were actually incurred and income foregone in order to achieve a particular purpose, and as regards improving the marketing of agricultural products, it meets the criteria set out in Article. 2-5 of Council Regulation (EC) No 3/2008 of 17 December 2007 on information and promotional actions for agricultural products in the internal market and in third countries. Therefore, the mechanism had a positive impact on both – reducing costs and increasing revenues;

- additional aid, which is an additional amount of aid resulting from the modulation of direct payments. As it was mentioned before, production support, apart from having a positive impact on production, did have a negative impact on productivity before the decoupling reform, so it might be concluded that the modulation led to a change in this phenomenon.

As for cluster A, also for cluster B (weakly sustainable model of agriculture support) the appropriate model was that with fixed effects (cf. Table 2). The model explains more than 94% of the variation in productivity of intermediate consumption, taking account of individual country effects (LSDV  $R^2 = 0.944601$ ). The within-group  $R^2$  explains 40% of the intragroup (*within*) variation (twofold more than in cluster A). The variation of the dependent variable over time has in this case strong statistical significance. The impact of time was negative in the whole period (referring to 2006) (cf. Table 2).

As in cluster A, also in this case of weakly sustainable support, the negative impact of CAP subsidies on productivity dominated. The model confirmed the observations of the negative impact of the Single Farm payment which is likely to act as a destimulant for improving productivity, preserving the historical support model. Only two variables had a positive impact on the productivity of intermediate consumption, and these were:

- payments to dairy outgoers, which can be explained as an improvement in productivity by reducing costs of production by turning from cost intensive animal production to less cost absorbing crop production. According to the model, 1,000 EUR spent on payments to dairy outgoers led to an improvement in productivity by 0,23%;
- single area payments, which presumably are used in the regions of new member states in this cluster (cf. figure 1) as investment funds improving competitiveness of production. The positive impact of decoupling on productivity is mentioned in the literature by some authors due to the following mechanisms (Serra et al., 2006; Weber and Key, 2012). Firstly, they change the

Table 3. Regression results for cluster C (Fixed-effects, using 138 observations, included 23 cross-sectional units, time-series length = 6, dependent variable: log\_productivity of intermediate consumption, Robust (HAC) standard errors), source: own study based on EUFADN data

	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>	
Const	0.438462	0.0783623	5.5953	<0.0001	***
Subsidies on investments	-3.20247e-05	1.12936e-05	-2.8357	0.0096	***
Set-aside premiums	-0.00414695	0.00195916	-2.1167	0.0458	**
Environmental subsidies	-5.42784e-05	3.44221e-05	-1.5768	0.1291	
LFA subsidies	8.90297e-05	5.13534e-05	1.7337	0.0970	*
Single Area payment	4.25656e-05	1.96353e-05	2.1678	0.0413	**
Additional aid	-0.000327124	0.000208785	-1.5668	0.1314	
dt_2 (time dummy variable ref. 2007)	-0.0734276	0.0340674	-2.1554	0.0423	**
dt_3	-0.14195	0.0438113	-3.2400	0.0038	***
dt_4	-0.123363	0.0440283	-2.8019	0.0104	**
dt_5	-0.151302	0.0512326	-2.9532	0.0073	***
dt_6	-0.16012	0.0448902	-3.5669	0.0017	***
LSDV R-squared 0.944276; Within R-squared 0.398523					

risk preferences of farmers leading them to make more productive investment decisions (Hennessy, 1998), secondly, direct payments might increase access to borrowed capital for credit constrained farmers by increasing land values and available collateral (Goodwin et al., 2003; Roberts et al., 2003), thirdly, decoupled payments may lead farmers to reallocate labor from off-farm employment to on-farm activities due to the nonpecuniary benefits that they derive from the latter (Ahern et al., 2005; Key and Roberts, 2009). This may lead to higher levels of agricultural output and productivity (Kazukauskas et al., 2014).

The model for cluster C (strongly sustainable model of agriculture support) also explains more than 94% of the variation in productivity of intermediate consumption, taking into account individual country effects (LSDV  $R^2 = 0.944276$ ). The within-group  $R^2$  explains almost 40% of the intragroup (*within*) variation. As it was in cluster B, the time factor plays a significant role: the impact of respective years was negative over the whole period (referring to 2006), and a negative tendency can be observed there (cf. Table 3).

In cluster C, covering regions with a strongly sustainable (green) model of agricultural support, only six variables proved to be statistically significant (two of them were on the threshold of significance with a p-value of 0.13). Four programmes negatively affected productivity, as expected. However LFA subsidies and Single Area payments surprisingly had a positive impact on productivity in this cluster. Single area payments seem to improve competitiveness, as stated above. The LFA is commonly the largest programme financed within the CAP and it is perceived as a not very effective one in Central-Eastern European countries. (Gorton et al., 2009). Many studies suggest that the LFA scheme appears more effective in reducing land abandonment or in promoting continued land use in intermediate rural and predominantly agricultural regions (where the share

of population living in rural areas is between 15-50% and more than 50% of the rural population works in agriculture) (Zawalińska et al., 2013) which is to some extent in line with our findings (cf. Figure 1).

## 5. CAP subsidies and social sustainability

Although there is evidence for a negative general impact of CAP subsidies on productivity, it should be stated that the role of subsidies (especially green box subsidies) for social sustainability, which is related to social capital, social inclusion, social exclusion and social cohesion in rural economies, cannot be forgotten. Nikolov et. al. (2012) point out that there is limited literature that focuses on social sustainability to the extent that a comprehensive study of this concept is still missing. A study by the OECD (2001) on sustainable development points out that social sustainability is dealt with in connection with the social implication of environmental politics rather than as an equally constitutive component of sustainable development. Due to this fact according to authors, there have been very few attempts to define social sustainability as an independent dimension of sustainable development. Each author or policy maker derives own definition according to specific subjective criteria, making a generalised definition difficult to achieve. For instance, from a sociological point of view (Littig and Griesler, 2005) define social sustainability as *a quality of societies. It signifies the nature-society relationships, mediated by work, as well as relationships within the society. Social sustainability is given, if work within a society and the related institutional arrangements satisfy an extended set of human needs [and] are shaped in a way that nature and its reproductive capabilities are preserved over a long period of time and the normative claims of social justice, human dignity and participation are fulfilled*. In recent years, social sustainability has become an important component of the mainstream political discourse of European governments. A report by the European Panel on Sustainable Development

(EPSD, 2004) points out that the Lisbon European Council in 2000 for the first time launched the idea of a social dimension as an integral part of the sustainable development paradigm. An entire section of the Lisbon conclusions covered four main features of social sustainability, which included:

- a commitment to enhance education, especially in relation to the new skills required for the *knowledge-intensive* economy
- revamping employment policy so as to create *more and better jobs*
- modernising social protection to accommodate the many challenges faced by welfare states, to *make work pay* and to promote equality;
- and the development of a strategy to counter poverty and social exclusion by *promoting social inclusion* (EPSD, 2004, p. 18).

Omann and Spangenberg (2002) contend that social sustainability focuses on the personal assets like education, skills, experience, consumption, income and employment and comprises every citizen's right to actively participate in his/her society as an essential element. Thus, in their analysis, access to societal resources is a key element of social sustainability also in rural areas. In this way environmental subsidies while enhancing valued landscapes and habitats, improve the public enjoyment of the countryside and according to Research for AGRI Committee – The role of the EU's Common Agricultural Policy in creating rural jobs (2016) might have a positive impact on promoting agro tourism and therefore creating new jobs opportunities in agricultural areas (Dobbs and Pretty, 2008). The reform of the CAP and decoupling has had a negative impact overall on employment within the agricultural sector. The evidence suggests that overall Pillar I is preventing out-migration of small and family farms from the sector, and is at best maintaining jobs in the agricultural sector but not creating new jobs. Further, Pillar I initiates more intensive and higher productivity thus gradually reduces the size of the agricultural workforce (Manos et al., 2011). On the other hand Pillar II might be successful in creating new jobs in other areas such as tourism, food processing and associated sectors but implementation is highly dependent on Member State and regional implementation approaches.

Pawłowska-Tyszko (2014) claims that environmental payments bring positive effects in the social dimension, because as a basis of remuneration for green services, they play also a profit-making role, which is of particular importance in small, extensive holdings being main beneficiaries of these programmes. However, S. Chabe-Ferret and J. Subervie (2012) noted that *as a result of support for agri-environmental activities, two effects emerged: 'additional' – value added generated by the implementation of an obligation and 'windfall' – extraordinary,*

*unexpected income. Therefore, farmers should actually receive remuneration from the budget for achieving the 'additional' effect only. Meanwhile, after receiving the subsidy, the producer's marginal private costs decrease and its benefits increase. Thus, subsidies are cost-ineffective and hence producers do not incur full social costs of their activities.*

## 5. Conclusion

In the article, we evaluated both the structural effect and the individual influence of the respective CAP schemes on the average productivity of intermediate consumption. Three clusters of regions in the EU28 countries were identified, differing significantly in terms of the structure of CAP schemes. In the most numerous group, of the EU28 regions, the moderately sustainable model A operated, primarily combining direct support with payments for public goods. The second most numerous represented was the weakly sustainable model B, in which support consisted chiefly of single farm and area payments. The smallest group of regions featured a highly sustainable model, combining various forms of support for farms at similar levels (both through direct and production subsidies, and through payments for the supply of public goods and to a lesser degree the subsidisation of investment). The analysis confirmed that an agricultural support model which reflects structural farming differences is a significant factor in determining the productivity of intermediate consumption over the whole of the studied period. The direction of the influence of studied schemes depends on the sustainability level of farming in the respective regions. Hence, for example, the Single payments might have a positive influence on productivity only in the old member countries included in the most sustainable model, while the Environmental subsidies positively contributed to productivity only in cluster A (and negatively in cluster C. Although there is evidence for a negative general impact of CAP subsidies on productivity, in each cluster we can observe CAP programmes which positively affected the productivity of intermediate consumption. Cluster A (moderately sustainable model of farming), which encompasses the majority of new member states, was characterised by the highest number of such schemes.

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# Urban Shrinkage and the Identification of China's Shrinking Cities. A study Based on Semi-Industrialized Semi-urbanized Structure

## Kurczenie się miast i ich identyfikacja w Chinach. Badanie oparte na strukturze częściowo-uprzemysłowionej i częściowo-zurbanizowanej

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### Abstract

Urban shrinkage has been a remarkable phenomenon in city development, both domestic and foreign, which cannot be convincingly explained by growth theory. This paper studies the theoretical foundation and connotation of urban shrinkage, as well as its internal dynamic mechanism and external spatial mechanism. Thereby reaches the conclusion that both shrinkage and expansion is a natural historical process of the urban development. Compared to the urban shrinkage in highly industrialized countries which features generalizability and regularity, the case in China is quite different due to the under-development of urbanization and industrialization. Therefore we referred to the regularity, and further used internal dynamic mechanism and external spatial mechanism to identify and classify China's shrinking cities, then discussed several patterns and drives, and finally proposed some policy suggestion and urban planning thoughts for sustainable development regarding various types of urban shrinkage.

**Key words:** Urban shrinkage, spatial structure, dynamics, urban planning, sustainable development

### Streszczenie

Kurczenie się miast jest niezwykłym zjawiskiem w historii rozwoju miast na całym świecie, którego nie da się przekonująco wytłumaczyć teorią wzrostu. Niniejszy artykuł analizuje teoretyczne podstawy i konotacje kurczenia się miast, a także mechanizmy ich wewnętrznej dynamiki i zewnętrznej przestrzeni. Na tej podstawie można postawić tezę, że zarówno kurczenie się, jak i rozszerzanie miast to naturalny proces historyczny rozwoju miast. Porównując kurczenie się miast w krajach silnie uprzemysłowionych, charakteryzujące się pewną regularnością, przypadek Chin jest odmienny, z uwagi na słabszy poziom urbanizacji i uprzemysłowienia. Dlatego też odnieśliśmy się do regularności i następnie zastosowaliśmy mechanizmy wewnętrznej dynamiki i zewnętrznej przestrzeni. W ten sposób zidentyfikowaliśmy i sklasyfikowaliśmy chińskie kurczące się miasta, aby następnie poddać dyskusji kilka wzorców. Przeprowadzona dyskusja pozwala na zaproponowanie sugestii politycznych i wskazówek dla urbanistyki w kontekście rozwoju zrównoważonego, uwzględniając różne typy kurczących się miast.

**Słowa kluczowe:** kurczenie się miast, struktura przestrzenna, dynamika, urbanistyka, zrównoważony rozwój

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### 1. Introduction

Urbanization in China is based on growth theory, increasing urbanization leads to great city expansion which has become a key drive of economic growth.

However, problems of urbanization emerge while China cities amass wealth and boost economy. One particular problem is polarization. Mega cities keep expanding but face increasing aging problems, small cities in contrast have less attractiveness suffer from

population loss and dire prospects. Although urbanization in China never stops its paces, issues like oversupply of real estates and shortage of land will lead to larger scale of urban shrinkage without proper intervention. In the present and foreseeable future, urban shrinkage will become a critical political subject. It is pivotal to consider whether urban shrinkage is long-term or short-term, which cities shrink in what mechanism, why does it happen, and how to cope with it, and so on.

## 2. Literature review

Cities are the core of modern society and economy, a city is a manmade vessel of social planning, economic development, technology innovation and cultural exchange. Both the shrinkage and expansion of a city is natural and inevitable, but it is curious that they fate distinctively in mainstream economic theories. Expansion is usually the direct or indirect consequences of urban planning, but shrinkage is not, it is a result beyond city planning. We will discuss the increasingly prominent urban shrinkage in terms of urban spatial structure and urban development theory, and then conclude a few patterns of shrinkage.

### (1) Urban spatial structure

Studies on urban spatial structure have evolved from the idealized one-centered concentric zone theory to sector theory embedded with actual social economic distribution (Burgess, 1925) as urbanization and industrialization advances. However, both theories are limited to single center and urban circles management, until Harris & Ullman (1945) pioneered the multi-nuclei theory of urban spatial structure transition. This theory holds that urban space will transit from one-centered economic gathering to multi-pole development. Given the social economic factors such as differential rentals, public facilities and geographic locations, by gathering more and more resources, these new centers could threaten and even take the old centers' places. Dickinson R.E (1947) and Shinzo Kiuchi (195) studied European and Japanese urban structures respectively, and developed concentric zone theory and three zones theory, suggesting that urban circles are composed of the central zone, the middle zone and the outer zone, which follows a cascade development pattern. Mann (1965) studied the structures of old industrial cities of UK, and further developed the theories above to concentric – sector theory.

In the peak times of quantitative modelling research on geography, Friedman (1966) proposed the theory of regional spatial structure evolution. This theory starts with industrial spatial dynamic mechanisms, and through utilizing the innovative theory (Schumpeter, 1911), constructing an inconsistent spatial polarization process where outer regions, only those with advantages, obtain development opportunities. Such unbalanced development evoked some deep

thoughts on factor relationship in regional development, thereby core-periphery theory was proposed. Regional urban structure theory (Russum, 1973) and Desakota (1991) pattern theory is based on the observation on underdeveloped Asian countries and developed western countries, they comprehensively studied the intertwined effects and development patterns of urban and rural regions.

The rise of humanism along with information networking compelled scholars to pay attention not only to products and services in urban structure function, but also to culture and interaction (Mumford, 1961). With the networking urban structure gradually came into being, information nodes became centers of regional flow. Enlightened by spatial expansion, Goldblatt & Muller (1981) further developed urban function, and formed a metropolitan pattern consisting of the urban fringe, the outer suburbs, the inner suburbs and the central city. Urban and regional structures are also influenced by global networking, resulting in reorganization and adjustment, thus forming a new urban structure built up of declining city center and small peripheral distinctive cities.

### (2) Theory of urban development

Marx concluded four reasons of city development. First is that a city is a fair or market for rural residents to trade their original products for industrial products, Second is industry development. The significant characteristics of capitalist industries are that *it builds modern large industrial cities (they grow like lightning quickly) instead of the cities that grew up from nature.* Third is foreign trade. *The real city is only in place where it is particularly suitable for foreign trade* Forth is military and political demand. Community militarization and residential concentration induced by war is an objective factor of city establishment. To enhance their power, rulers always set up state apparatus and set up a regime in a place, where cities were born. *The walls of the new fortified city are not invincible: their trenches are deep into the tombs of the clan system, and their towers are towering into the civilized era.*

Subsequently, Marx discussed the expansion of urban development theory, from the dialectical materialism critical point of view, stating that capitalist pattern of production and industrialization of urban development brings destruction to ecosystems and social systems: *capitalist production makes the population of the central city increasingly dominant, so that it gathers the historical power of society and, on the other hand, destroys the material transformation between man and land, that is, the natural part of land consumed in the forms of food and clothing cannot return to the land, thus undermining the natural conditions of the land's long-term fertility.* The destruction of natural ecological system in urban fringe area is accompanied by the uneven relationships between urban and rural areas and the unbalanced development of the dual structure. *Manchester and its*

*suburbs of 350,000 workers almost all live in the harsh, damp and dirty little house, and the streets holding these small house are mostly extremely bad and unclean, the construction did not take into account air circulation, but only the huge profits of the owners.* As city centers became crowded and messy, development problems like consumption and pollution became sharp. Marx's theory advocates sustainable development of social systems and economic systems, and the development of appropriate laws and regulations to guide and regulate people's behavior to optimize urban development.

The theory of urban decentralization begins with E.Howard's theory of pastoral city (1891), which advocates an idealized urban-rural coexistence structure so as to exert the advantages of the both and form the social structure of *urban-rural integration*. Taylor's satellite city theory (1966) is of great significance to the urban development of western countries, and also profoundly affects the urban development planning of developing countries nowadays. Satellite cities have their own urban facilities and core industries, but also social and economic complementarity with central cities, despite that they are geographically distant from main cities. Wide-scale city theory looks forward to the construction of a semi-farmland community, and fully rejects the collective development pattern of cities. Theory of organic evacuation expects to evacuate industries, population and infrastructure from the center to the outside and then form an organic integer, in regard with the fact that the city center is crowded enough to bring about serious problems such as *urban disease*. With the evolution of global informatization, the development of technology and the demand of urban functions, theories of modern urban development, such as information city, knowledge city, intelligent city and eco city, came into being. Urban development is extending to a much wider and deeper content.

### 3. Urban shrinkage patterns

The external spatial mechanism of urban shrinkage is characterized by the diversification of urban development, and economic factors, social factors, cultural factors and urban layout together shape different shrinking processes. On a global scale, we summarize the different types of shrinkage and arrive at the following urban shrinkage patterns.

#### (1) Concentric circles

This pattern is represented by London and northeastern American industrial cities. The internal mechanism of urban suburbanization influences urban shrinkage in such way: in the mid-20th century, *city hollow* emerged in some developed cities in Europe and US and spread outward in *circle effect*. With central function decline, environmental deteriora-

tion, and large migration of enterprises and population to suburbs, taxation and economy in city centers dropped, which further led to unattended facilities, high crime rate and low quality of life. High-income groups have fled city centers into suburbs for work and life. The phenomenon so called *white flight* and *eight miles and Wyoming wall* in US cities is the embodiment of such situation. The directional multi-axis guidance shrinkage of Copenhagen and radiation corridor combination shrinkage of Washington which is to improve urban structure is also based on concentric circle theory and organic evacuation theory.

#### (2) Anti-concentric circles

This pattern is the *post-suburbanization* sign of developed countries, Paris is a typical example. Urban shrinkage first occurs in the *suburban first ring* where manufacturing sectors and working-class residence concentrate. With deindustrialization and declining employment of manufacturing sectors, high living cost and inferior environmental conditions drive workers to even further outskirts, and suburban first ring begins to shrink, but the city center remains as central commercial and cultural area. This is the non-circle pattern that city center keeps thriving while the first ring around city declines.

#### (3) Anti-magnetic center

This pattern is a derivative from satellite city theory, sample cities are San Jose – San Francisco, Bridgeport – New York City, Keelung – Melbourne and so on. Anti-magnetic centers can effectively alleviate urban problems like population density, environmental pollution and traffic pressure caused by the lack of core spatial structure. They can also share some of the city functions, improve urban communication efficiency, and reduce living and development cost. The worldwide development of anti-magnetic satellite cities has proven the shrinkage of main cities. An anti-magnetic center can set a good example, as a satellite city it can individually spread to the surrounding areas. It is not only bound to the central city in close economic and social networks, but also through highways to other satellite cities in a cluster formation. Each satellite city has unique functions, appropriate scale and modern communication networks.

#### (4) Scatter

This pattern is represented by Detroit of US and Utashinai and Yubari of Japan. As mines went depleted in mining cities of Japan, unemployment soared, industrial structure totally collapsed, only aged and low-income groups stayed in scattered communities surrounded by large area of empty land and idle properties. Such area features low density and sporadic space, similar to suburbs.

#### (5) Perforation

This pattern is best illustrated by the transforming cities in socialism countries after the collapse of Soviet Union. During the planned economy, Ivanovo's urbanization and industrialization were developed, but then the heavy industry and manufacturing industry, which were scattered, were disintegrated with the decline of factories. The original population was automatically drained and the environmental damage was increasing. Some enterprises were in line with the needs of policy and industrial transition, and received full support from the government, resulting in an intertwined distribution of new thriving enterprises and old declining industrial areas, and finally a *petal* type of spatial structure of the city.

### 4. Connotation of urban shrinkage

The word *shrinkage* usually refers to the change that a matter gets smaller, shorter, or less. Most scholars understand *urban shrinkage* as all kinds of reduction under all sorts of reasons, such as permanent loss of population, decline of economic activities, and oblivion of society and culture, some even define shrinking cities as vertical cities. Qualitative analysis cannot determine the exact distribution of urban shrinkage, therefore we attempted to measure shrinkage by using average population density, which is relatively accepted internationally, as a quantitative indicator. Even so, the understanding from quantitative analysis can still be limited, thus we need to dig deep into the characteristics of urban shrinkage and fully understand the reasons and evolution paths that lie behind.

#### (1) *Urban shrinkage is relatively chronologically stable*

A city may switch from the initial expansion to the present shrinking, such as the cities on the *rust belt* of US which are all based on the economic prosperity, population growth, and urban expansion brought about by the first and second industrial revolution, like Detroit. However, due to the impact of suburbanization, Detroit urban population dropped more than 50% in nearly half a century. The development of a city, including expansion and shrinkage, has its characteristic stages, including budding, developing, maturity and decline. Also, urban shrinkage has time characteristics, cities will not shrink permanently, those drained of vitality will die, shrinkage will naturally end with their annihilation; some continued to shrink on different levels, of which extreme cases we call abandoned cities or dying cities; and some cities shrunk while some local areas revived due to new industries or new planning. Nevertheless, shrinkage is not a sudden change and usually occurs in a few decades or even several centuries of time. Urban shrinkage is relatively stable in a certain time range.

#### (2) *Urban shrinkage coexists with urban expansion*

In the process of modern urban development, the idea of growth has dominated, thus industrial goals were given to cities, but when the process of industrialization and urbanization reached its peak, urban shrinkage began. Therefore, urban expansion and growth is not immutable, shrinkage is born right in the cities based on growth theory, and rooted in the expansion expectation of modern society, and reflected in the economically and socially polarized geographical space. However, a city may also shrink while its regional economy develops. For example, the old industrial city of North England demonstrated some new vitality when they continued to shrink at the same time, part of them continued to decline, and the others achieved continuous improvement of employment rate and growth of urban vitality through structural adjustment and implementation of new industrial plans. Urban expansion and shrinkage can exist in the same time and the same place, which is the internal link between them. For example, there are two very different patterns of the development of US cities: one is a strong rapid suburbanization and urban spread, and the other is *re-urbanization* within the shrinking cities to revitalize them.

#### (3) *Urban shrinkage means not full atrophy of society and economy*

Urban shrinkage is not necessarily a path of contraction and decline, not simply a reduction in population of an area or a weakening of economic activities, although population reduction is an acknowledged sign of urban shrinkage. Shrinkage refers to the reduction in the use of urban space, meaning more idle or abandoned buildings and real estate, while the city is still spreading to periphery and scattering economic activities to more marginal areas. It is not a one-way contraction of space, but accompanied with the expansion and growth of mobile space. Urban shrinkage is actually a reorganization of urban spatial structure, which is to reshape the internal connection and intensity of all funds, technology, talent and information (Brenner, Neil, 1999a). Urban shrinkage includes not only the changes in the objective environment, but also the subtle changes of city functions and space that finally lead to fundamental changes. This can explain the unique paradox that population reduction and spatial expansion coexists in some regions of China. Urban shrinkage is not a displacement of a city as a center of economic activities and link to regional and global economics (Short, 2000), but relocation of space, economy, society, urban hierarchy and functions.

#### (3) *Internal dynamic mechanisms of urban shrinkage*

During the process of globalization, with accelerated communication frequency and efficiency, the system

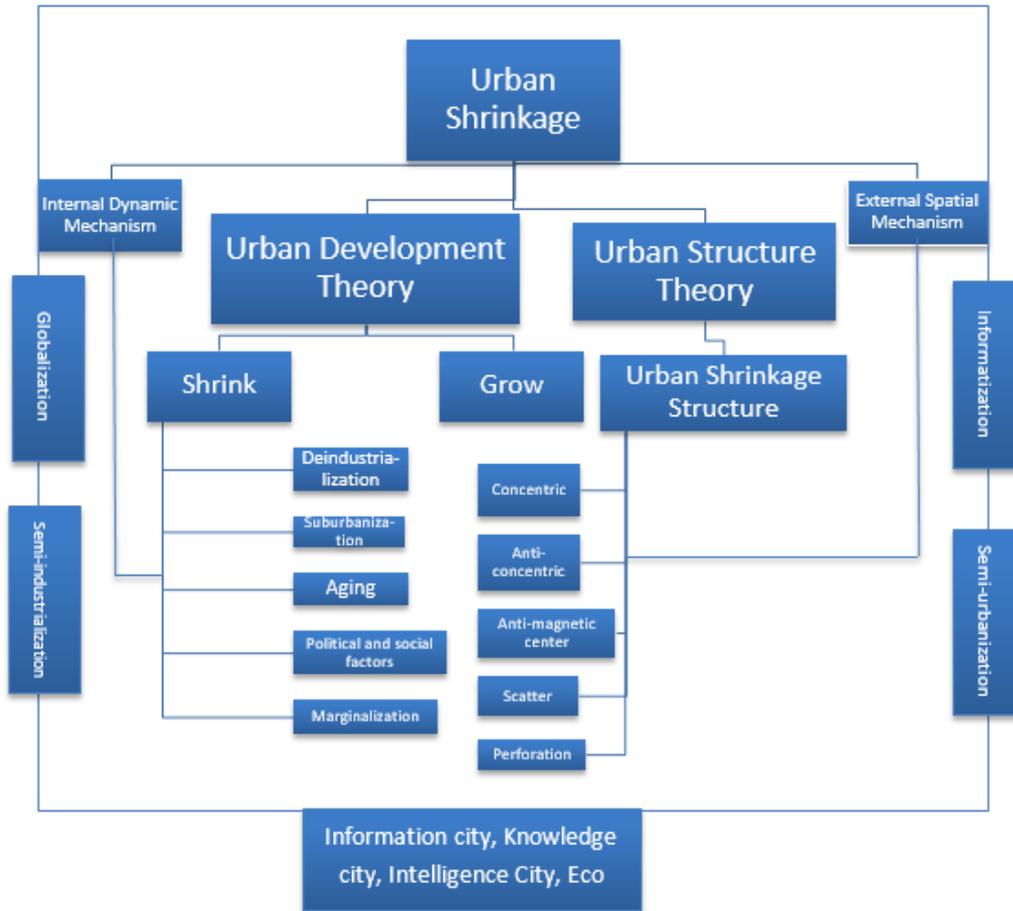


Figure 1. Relation chart of urban shrinkage system

function of time and space in administrative divisions is strengthened, and the advantages of city centers are narrowing comparing to marginal areas, so population and industry are naturally relocated to cheaper and wider land. The geographical distribution of economic activities on the periphery of cities is not limited to the *central-periphery* regional division, which brings about the reshaping and resetting of social spatial order, and ultimately resulting in *shrinking cities*, exactly as that discussed in new economic geography. The process of urban shrinkage not only changes urban space and population density, but also reconstructs the geographical distribution of authority in commercial areas, and essentially forms a new force that counterbalances old growth-driven cities and regionally supplements and replaces urbanization. Throughout the history of capitalist industrialization, the inherent dynamics of urban shrinkage can be summarized as follows: deindustrialization, marginalization, suburbanization, population aging, and political and social instability. The external spatial mechanism of urban shrinkage includes concentric circles pattern (Wallis), anti-concentric circles pattern, anti-magnetic center pattern, scatter pattern, and perforation pattern.

## 5. China's urban shrinkage analysis

Over the last few decades China's economy has boomed, urbanization and industrialization kept rising, the number of cities has increased from 190 in 1978 to 661 at the present time, the rate of urbanization surged from 17.92% to 56.1%, and the urban population has reached 749.16 million (National Bureau of statistics information network). According to the statistics in September 2016, China currently has 293 prefecture-level cities in total (China Statistics Database). The urbanization of China is similar to that of the cities of Germany, UK and US in early stage, which are all driven by industrialization and urbanization. However, China's urban shrinkage has its particularity, because it starts with incomplete industrialization, which also means incomplete urbanization. Such shrinkage carries the characteristics of the dual structure (urban and rural) and the economic system transformation. Despite the rapid economic development, urban problems like imperfect urbanization structure, shortage of resources, regional poverty and other urban shrinkage problems have emerged in the accelerated phase of China's urbanization, which has aroused our attention and thinking.

We used the demographic data from China’s 1994-2014 statistical yearbooks, and name resident population change rate as  $POP_p$ , household population change rate as  $POP_r$ , employed population change rate as  $POP_e$ , to measure the change of population density in city areas. In the following,  $t$  is time by year,  $P_0$  is the base population:

$$POP_p = \frac{P_{p0}}{P_{pt}}$$

$$POP_r = \frac{P_{r0}}{P_{rt}}$$

$$POP_e = \frac{P_{e0}}{P_{et}}$$

The ratio between resident population change rate and household population change rate is  $POP_{pr}$ , the ratio between employed population change rate and household population change rate is  $POP_{er}$ :

$$POP_{pr} = \frac{POP_p}{POP_r}$$

$$POP_{er} = \frac{POP_e}{POP_r}$$

If these indexes are all above 1, then urban population expansion is proven, if all below 1, then for shrinkage. By referring to urban population density index, we can determine population shrinkage of China cities, results are shown in appendix 1.

(1) Marginalized peripheral cities

Rapid urbanization has induced metropolitanization, in the Yangtze River Delta, the Pearl River Delta and Beijing-Tianjin-Hebei metropolitan city group, large urban population gathers. Regional difference due to unbalanced regional development policy and differential socio-economic system magnifies the economic and demographic attraction of metropolitans immensely. The progress of urbanization is based on expected growth rate, but not all cities in the region are growing. Of Beijing-Tianjin-Hebei metropolitan city group, only Beijing and Tianjin maintained a stable rise by a small margin in 2009 and 2014, the rest of the cities have seen fluctuated decrease and gradual dilution of population density, which in good chance will continue. The inter-provincial and inner-provincial population migration of China is mainly due to the unbalanced development of regional economy, which further leads to urban shrinkage of partial areas (Social Blue Book, 2014). We can see that cities in the Beijing-Tianjin-Hebei metropolitan area, other than Beijing and Tianjin, are all facing the lack of development momentum, the stagnant industrial productivity, and the decrease of population density. The difference of city sizes in several metropolitan areas of China keeps enlarging due to these reasons, thereby forming marginalized peripheral cities in concentric circles mode.

Some of the small and medium OEM cities in the Pearl River Delta region shrink because of the upgrade of global industry and the rise of labor prices in China. Some of the backward and labor-intensive

industries have been transferred to lower-priced Southeast Asian and inland China by international enterprise. Except for Shenzhen and some other large cities which have strong foundation and powerful resource concentration for industrial restructuring, industrial areas in smaller cities which rely on the *Three-plus-one* trading-mix (custom manufacturing with materials, designs or samples supplied and compensation trade) began to shrink. All prefecture-level cities shrunk in the Yangtze River Delta region, urban shrinkage also appeared in half of the cities of Anhui Province and Zhejiang Province.

Population, resources and wealth are not only concentrated in cities, but also relatively concentrated in greater urban area in a region. As shown in Fig. 2, the total annual population and land use of the four municipalities, the capital cities of all provinces and other prefecture-level cities, has changed a lot, but the rate of change varies among different types and levels of cities. The growth rate of land use and population density ranks in such order as municipalities, provincial capital cities and other prefecture-level cities. The Beijing-Tianjin-Hebei metropolitan area has a *double-center, polarized* geo-spatial structure, and very distinctive social development level of each city. Industries in the three cities are poorly related, factors of production flow in single way, so central cities keep enlarging while peripheral cities shrink.

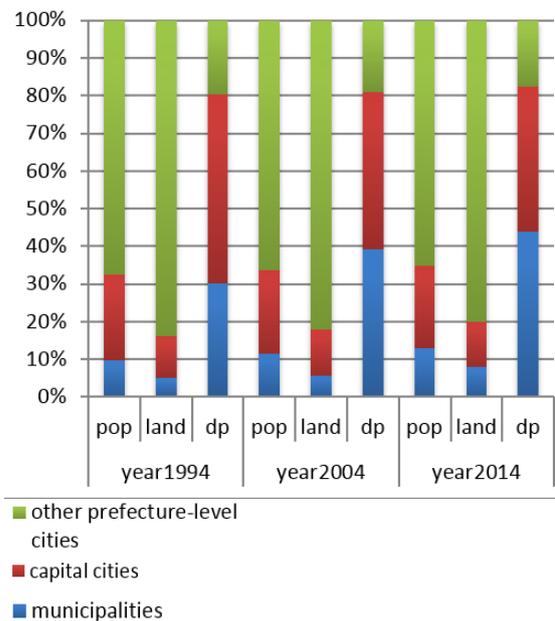


Figure 2. Changes in Population Structure of Prefecture – level Cities, Capital Cities and Municipalities in 1994 – 2014

(2) Deindustrialization of traditional industrial base

There are two types pf deindustrialization in China: first is industrial upgrading, second is industrial transformation. Northeast China used to be the most important manufacturing base in the planned economy period. It had a complete industrial system mainly composed of steel, machinery, petroleum and

chemical industry. However, since the market economy reform in the 1990s, the northeast base was devoured by the wave of globalization and informatization, causing stagnant development, weak growth, slow technological growth, low labor productivity and poor product competitiveness of local industries. Nevertheless, as a result of the revitalization of old industrial bases, new industries emerged in the old industrial layout of northeast China, thus a perforation pattern of staggered distribution of old and new industries appeared, just similar to that of Soviet Union and East Germany. The shrinkage of old industrial bases is essentially the structural and cyclical recession of their leading industries. The northeast must understand their own characteristics, and learn from shrinking cities with traditional industries worldwide, so as to successfully cope with deindustrialization and transform and optimize their industrial structures.

Cities like Liupanshui and Tongren of Guizhou Province, and most cities of Shanxi Province are resource-dependent and less urbanized. Therefore, these cities have not shown obvious shrinkage. However, it cannot be ignored that if they continue to adhere to the extensive production mode, they will suffer the same fate as the cities in northeastern region like Yichun, Daqing, Baishan, Liaoyuan, and Panjin which used to rely heavily on resources in their initial development stage. The shrinkage of resource-dependent cities is due to their single industrial structure, lack of adequate social security, and serious damage to the ecological environment. Finally, these cities declined with the resources depleted.

### (3) 'City village' and pseudo-urbanization phenomenon

Historical problems have caused the geographical division of urban and rural areas, and the expansion of urbanization have made lands more and more valuable. High land price raised the compensation of land acquisition, which has become an important source of income for rural residents or relocated households. Particularly, rural residents around large cities usually demand very high compensation which the government and developers cannot afford, so they are not willing to sell their land and finally surrounded by new high-rise buildings, thus forming a typical *city village*. Although this is a form of urban shrinkage, it is not a traditional shrinkage that happens in economic recession, neither the process of proactive population flow to suburbs, it is a unique reverse-urbanization of China, known as *pseudo-urbanization*. Additionally, some of the urban population, such as migrant workers or low-income groups and new immigrants with low labor skills, cannot be integrated into urban life. The result is that citizenization lags behind urbanization and the segregation of urban housing, causing restrictions on the development of surrounding areas, and leading to shrinkage of some city areas. Besides, flow of labor force

and other factors of production across regions are not sufficient in China, due to the economic and historical reasons labors cannot return to their original rural or underdeveloped areas, causing urban shrinkage in perforation pattern.

### (4) Population aging in backward areas

China's industrialization lagged behind the population aging, *aging before wealthy* has become a normal social problem. Compared to Europe and the US, China holds a huge population but a small number of legitimate immigrants. China has become an aging country since 1999 according to international standards, with a large number and rapid growth of elderly population. The population over 60 years of age will reach the double of the current number 20 years later, and in 40 years will account for one third of the whole population. Issues like disability and semi-disability, lack of companionship and attendance, and loss of only child, have become serious social problems. The allowance for elderly support rose rapidly, policies like *retirement insurance* and *delayed retirement policy* triggered fierce discussion. Based on the data of the population density of the prefecture-level cities in each province, the proportion of shrinking cities has reached about half of the whole nation. Among them, there are provincial cities such as Shijiazhuang and Urumqi, and more than 100 prefecture-level cities. Due to China's unbalanced regional economic development, talent drain and population loss in central and western China has become very normal, residents in these regions face severe aging problems, and also single-structured industries, bad ecological environment, and lack of vitality. Urban shrinkage in such regions is usually in scatter pattern.

In central China, cities in Hubei Province, Hunan Province and Henan Province shrink particularly fast. Similar situation happens to small and medium cities in southwest mountain regions and southeast coastal areas. Unbalanced regional economic development has accelerated the population loss in backward areas.

### (5) Macro-intervention by the government

Compared to the political factors causing urban shrinkage in other countries, China's influencing political factors are mainly from regional policy planning. Since the reforming and opening, the directional regional preferential policies have made the industrialization of China develop rapidly, but the regional gap has also been enlarged in the same way. In recent years, the rapid development of urbanization has made land price substantially higher, the price of real estate in a few developed areas becomes astronomical. Uneven distribution of land price and land value gains among regions, urban and rural areas, and social classes has become a critical reason of urban shrinkage. On one hand, urban and rural household registration system slows down the rate of

labor exchange, restricting the quantity and frequency of rural labor force flowing to cities. On the other hand, the rural land resources are difficult to trade and transfer, scale operation of agriculture is hard to achieve, which leads to the reality that urbanization fails to narrow the urban-rural income gap. In the marginal areas of Guangxi Province, Yunnan Province and Guizhou Province, the population density growth of some municipal districts is mainly brought about by border trade and national support for minority ethnic groups, but the provincial capital cities in these areas are shrinking due to the lack of mainstay industries and economic potential, and policy preference from the central government.

## 6. Reasons of urban shrinkage in China

### (1) Squeeze effect of central cities

The economic concentration power is still playing a leading role in China, with the development of the tertiary industry, not only the expansion of mega cities is unstoppable, large regional cities' role as a sub-centers is also strengthened. Central cities concentrate development momentum which is self-strengthening and produces locking effect. Large cities have mastered a lot of economic resources, and achieved scale effect under such unnatural factors as sharing, matching, and learning.

The expansion of large cities may be accompanied by the shrinkage of small cities around, because of the centrifugal force on urban shrinkage, namely the crowding effect. The excessive expansion of large cities has trenched on the opportunities of surrounding regional cities. Large, competitive cities will seize scarce resources and development space from smaller cities. In addition, with close adjacency, due to the significantly better infrastructure in large cities, industrial enterprises will choose to be placed in large cities rather than smaller ones, consumers will also choose to shop in large cities, all cultural activities, communication, and business will be carried out in large cities because they are anyway close.

### (2) Land finance

China's land finance began with the *Land Management Law* 1988 amendment, and was triggered by the 1994 tax system reform, which resulted in financial constraints of local governments and their fanatic behavior of land trade later. Farmers' land was then seriously encroached by governments and real estate developers driven by economic interests. Illegal use and acquisition of land remain incessant after repeated prohibition. But there is more than that, the urban housing prices rose irrationally fast, and income inequality increased along with it. The core position of large and mega cities has been fixed and consolidated by the development of land finance, which has further aggravated the social problems such as poverty and marginalization of marginal areas, as well as regional differences and dualization

of urban and rural areas. Real estate has already been preferably developed, but due to the lack of investment opportunities, local governments may even further favor real estate, draining capitals from industries to high-return real estate, finally causing inflation and twisted industrial structure which can severely undermine national economy.

Urban real estate price and land rent is the direct channel of land finance affecting national economy. On one hand, the rapid expansion of the real estate bubble exaggerated the real estate market value, and will increase the cost of real economy and living. On the other hand, since land finance has become the main source of revenue for local governments, and steadily tied to local finance, local governments continued to expand the scale of the cities for more land revenue, and ignored the corresponding inputs of infrastructure and public services, creating a large amount of urban operating costs and an increase of factor price. This has caused large debt for the governments, so they will have to sell more land to pay for the debt, and get caught in a vicious circle. Because if a city expands too fast, its expenditures on infrastructure and public service must increase continuously to meet the demand of the city function and its carrying capacity, but when a city expands without sufficient development of industrial enterprises, it is impossible to carry on. The unregulated flourish of land finance in some regions with weak industries and less development momentum has become a serious problem. The land finance is unsustainable, with its potential drained, the real estate goes into downturn, more and more empty cities and ghost towns have emerged to prove this. Such shrinkage is the retraction after blind urban expansion, but the environment becomes unrepairable after the shrinkage.

### (3) Industrial upgrade and transformation

The change of the global factor division has put forward new requirements to industries in China. A key point of changing China's position in international trade is industrial transformation and upgrade. Developed coastal areas have successfully completed the first stage of integration into the global factor division, the second stage is to keep traditional comparative advantages, and at the same time work better on existing technology and industrial added value. Industrial upgrade is a new round of competition and elimination among international and domestic enterprises, some cities of the coastal areas will certainly face recession in this process. As part of the enterprises and capitals move to inland, west China market will show scale advantages and cost advantages, but part of the coastal cities will experience population loss and temporary recession.

Currently, China's resource-dependent cities and single-structured industrial cities have been forced to undergo transformation because they have no ability to solve existing problems and contradictions through industrial upgrade which costs less than full

transformation. The reason of this kind of shrinkage is the depletion of resources that leads to business collapse and unemployment.

#### (4) *Dual economic structure*

There are a series of institutional and policy factors, such as household registration system, land system and other factors leading to the obstruction in the flow of factors of production. Unbalanced regional policies lead to the increase of non-productive consumption, which hinders the process of urbanization and the development of urban labor division. Because the labor force cannot flow freely and the land system is imperfect, the arable land resources are difficult to circulate, and the scale operation of agriculture is very difficult to realize, so a large number of rural surplus labor force continues to stay in the countryside. Besides, some peasants who have entered a city receive less income and public service than urban residents. There are a large number of non-local residents among city residents in China, the proportion of which keeps rising as urbanization expands. For a long time, the gap between urban and rural areas has resulted in a disparity between city residents and rural population, namely the gap of income and public service between household and non-household population, thus forming a new *dual* society which is a segregation of the relations among urban population. This kind of segregation is like a barrier that will lead to the weakening of a city's centripetal force, and the intensification of social contradictions.

Dual economic structure makes the population statistics of the urban shrinkage in China more complex and peculiar, leads to economic imbalance and constraints a city's development momentum and concentration power, ultimately causing negative economic growth and population outflow in certain areas perennially.

### 7. Conclusion and policy suggestion

The reasons of urban shrinkage are complex, some factors may be dominant in a given period, but most urban shrinkage is the result of a combination of factors in all aspects. The dynamics of shrinkage have evolved over time, but it is certain that urban shrinkage and expansion is both an inevitable trend in urban development. Shrinking cities require us to rethink on the traditional planning ideas and operation methods. Urban expansion does not last forever, lack of human resources, housing vacancies, and public service in some areas and cities is natural. We have to recognize that industrialization and urbanization can indeed improve living standards and promote modernization, but also in some way destructs living quality and future development. Therefore, in the future, we must not only actively deal with the process of urban shrinkage and take measures to promote sustainable urban development, but also understand

the characteristics of semi-industrialization and semi-urbanization in China to identify different types of shrinking cities, and to distinguish their dynamic mechanism and development patterns. Further work is to study the scientific shrinkage plan.

Mega urban group area needs to promote urban integration, balance public facilities and services, enhance supporting infrastructures, improve regional industrial chain relations, change backward traffic, and establish regional communication networks.

For resource-exhausted cities, the government needs to change the long-existed idea of disorderly urban expansion and plan for city transformation, adjust the nature and function of the city. Besides, the government needs to introduce all kinds of funds to restore urban ecosystem, clean up industrial pollution, build green network, and construct suitable commercial and residential density, so to increase environmental attraction and land value. The government needs to take into account the local consumption and ecology to build a diversified information network for industrial investment to upgrade the industry. Also land management and valuation must be considered, as well as the establishment of land banks. The government must gradually shrink the traditional backward production sector, at the same time of the transformation of traditional industrial technology, pay close attention to the introduction and cultivation of modern high-tech industries, then improve the industrial structure of old industrial bases and balance the light and heavy industries. Furthermore, the government must fundamentally improve the efficiency of resource use, gradually reduce the primary production scale of raw materials, adjust industrial layout, and guide enterprises to transfer outward.

For shrinking cities under the overall situation of large-scale urbanization, the government needs to develop a diversified economy, to take in potential small and medium enterprises from the eastern part of China to enhance the city's anti-risk ability. The government needs to do appropriate streamlining and transformation for the urban infrastructure with low utilization rate, and by considering the uncertainty of future development and taking into account the actual needs of local residents, to encourage the division of communities into several core areas, and achieve orderly distribution of economic activities and social life.

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Appendix 1 Population Trends of Municipal Districts in 1994 – 2014

Districts	Province	prefecture-level cities with population shrinkage	prefecture-level cities with population growth
North China	Hebei (11)	Shijiazhuang, Tangshan, Qinhuangdao, Handan, Xingtai, Baoding, Zhangjiakou, Chengde, Cangzhou, Langfang, Hengshui (11)	
	Shanxi (11)		Taiyuan, Datong, Yangquan, Changzhi, Jincheng, Shuozhou, Jinzhong, Yuncheng, Xinzhou, Linfen, Luliang (11)
	Inner Mongolia (9)	Baotou, Chifeng, Tongliao, Hulunbeier, Bayannaoer, Wulanchabu City (6)	Hohhot, Wuhai, Erdos City (3)
Northeast China	Liaoning (14)	Dalian, Anshan, Fushun, Benxi, Dandong, Jinzhou, Fuxin, Liaoyang, Tieling, Chaoyang, Huludao City (11)	Shenyang, Yingkou, Panjin City (3)
	Jilin (8)	Changchun, Jilin, Siping, Liaoyuan, Tonghua, Baishan, Songyuan, Baicheng City (8)	
	Heilongjiang (12)	Harbin, Qiqihar, Jixi, Hegang, Shuangyashan, Daqing, Yichun, Jiamusi, Qitaihe, Mudanjiang, Suihua City (11)	Heihe (1)
East China	Jiangsu (13)	Nanjing, Wuxi, Xuzhou, Changzhou, Suzhou, Nantong, Lianyungang, Huai'an, Yancheng, Yangzhou, Zhenjiang, Taizhou, Suqian City (13)	
	Zhejiang (11)	Hangzhou, Ningbo, Shaoxing, Jinhua, Quzhou City (5)	Wenzhou, Jiaying, Huzhou, Zhoushan, Taizhou, Lishui City (6)
	Anhui (16)	Hefei, Wuhu, Huainan, Ma On Shan, Huaibei, Tongling, Anqing, Chuzhou, Suzhou,	Bengbu, Huangshan, Fuyang, Lu'an, Xuancheng City (5)

		Bozhou, Chizhou City (11)	
	Fujian (9)	Fuzhou, Putian, Quanzhou, Longyan City (4)	Xiamen, Sanming, Zhangzhou, Nanping, Ningde City (5)
	Jiangxi (11)	Nanchang, Ganzhou, Ji'an, Shangrao City (4)	Jingdezhen, Pingxiang, Jiujiang, Xinyu, Yingtan, Yichun, Fuzhou City (7)
	Shandong (17)	Jinan, Qingdao, Dongying, Weifang, Jining, Weihai, Rizhao, Linyi, Dezhou, Liaocheng, Binzhou City (11)	Zibo, Zaozhuang, Yantai, Taian, Laiwu, Heze City (6)
Middle China	Henan (17)	Kaifeng, Luoyang, Xinyang, Jiaozuo, Xuchang, Luohe, Nanyang, Shangqiu, Zhoukou, Xinyang, Zhumadian City (12)	Zhengzhou, Pingdingshan, Hebi, Puyang, Sanmenxia City (5)
	Hubei (12)	Shiyan, Yichang, Xiangyang, Jingzhou, Jingmen, Ezhou, Xiaogan, Huanggang, Xianning, Suizhou City (10)	Wuhan, Huangshi City (2)
	Hunan (13)	Changsha, Zhuzhou, Xiangtan, Hengyang, Yueyang, Changde, Yongzhou, Huaihua City (8)	Shaoyang, Zhangjiajie, Yiyang, Chenzhou, Loudi City (5)
South China	Guangdong (21)	Guangzhou, Shao-guan, Zhuhai, Shantou, Foshan, Zhanjiang, Maoming, Huizhou, Meizhou, Shanwei, Heyuan, Yangjiang, Qingyuan, Dongguan, Chaozhou, Jieyang City (17)	Shenzhen, Zhaoqing, Zhongshan, Yunfu City (4)
	Guangxi (14)	Nanning, Liuzhou, Wuzhou, Beihai, Chongzuo City (5)	Guilin, Fangchenggang, Qinzhou, Guigang, Yulin, Baise, Hezhou, Hechi, Laibin City (9)

	Hainan (4)	Haikou (1)	Sanya (1)
Southwest China	Sichuan (18)	Zigong, Panzhihua, Luzhou, Yibin, Dazhou, Bazhong City (6)	Chengdu, Deyang, Mianyang, Guangyuan, Suining, Neijiang, Leshan, Nanchong, Meishan, Guang'an, Ya'an, Ziyang City (12)
	Guizhou (6)	Guiyang, Zunyi City (2)	Liupanshui, Anshun, Bijie, Tongren City (4)
	Yunnan (8)	Kunming, Yuxi, Lijiang, Pu'er City (4)	Qujing, Baoshan, Zhaotong, Lincang City (4)
Northwest China	Shanxi (10)	Xi'an, Tongchuan, Baoji, Weinan, Yan'an City (5)	Xianyang, Hanzhong, Yulin, Ankang, Shangluo City (5)
	Gansu (12)	Jinchang, Baiyin, Tianshui, Wuwei, Zhangye, Pingliang, Longnan City (7)	Lanzhou, Jiayuguan, Jiuquan, Qingyang, Dingxi City (5)
	Qinghai (2)	Xining (1)	
	Ningxia (5)	Shizuishan, Guyuan, Zhongwei City (3)	Yinchuan, Wuzhong City (2)
	Xinjiang (4)	Urumqi (1)	Karamay City (1)



## Antibiotics in the Environment as one of the Barriers to Sustainable Development

### Antybiotyki w środowisku jako jedna z barier dla zrównoważonego rozwoju

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#### Abstract

The paper has analyzed the presence of antibiotics in crude (hospital, medicine production and municipal) waste water, treated waste water, surface water and drinking water across the world. The concentrations of antibiotics in medicine production waste water reached a level of up to  $900 \mu\text{g}/\text{dm}^3$ ; in hospital waste water, up to  $124 \mu\text{g}/\text{dm}^3$ ; and in municipal waste water, up to  $64 \mu\text{g}/\text{dm}^3$ . Antibiotic concentrations in treated waste water approached  $260 \text{ ng}/\text{dm}^3$ . The presence of antibiotics in surface water has also been covered. The most often identified medicines were: Ciprofloxacin, Erythromycin, Norfloxacin, Sulfamethoxazole and Trimethoprim. The maximum antibiotic concentrations in surface water are as high as up to  $2 \mu\text{g}/\text{dm}^3$ . In the majority of cases, identified antibiotics occurred in concentrations from several to several dozen  $\text{ng}/\text{dm}^3$ , and less often in several hundred  $\text{ng}/\text{dm}^3$ . The presence of antibiotics in drinking water, similarly as for waste water, was identified worldwide, e.g. in China, USA, Germany, Canada, France. Very high antibiotic concentrations were noted in Guangzhou, China, which reached a level of up to  $679.7 \text{ ng}/\text{dm}^3$  (Ciprofloxacin), but also in the USA (Triclosan) –  $734 \text{ ng}/\text{dm}^3$ . In the majority of instances, antibiotics are present in water in much lower concentrations. The consequence of environmental contamination with antibiotics is the drug resistance of many bacterial strains with the resultant deaths of 25 000 people in the European Union and 700 000 people across the globe. The other effects of the presence of antibiotics in the natural environment are not fully understood yet. For example, carcinogenic, teratogenic or mutagenic effects are attributed to these contaminants.

**Key words:** antibiotics, water pollution, drug resistance

#### Streszczenie

W pracy przeanalizowano obecność antybiotyków w ściekach surowych (szpitalnych, z produkcji leków, komunalnych), oczyszczonych, wodach powierzchniowych i wodzie pitnej na świecie. Stężenia antybiotyków analizowane w ściekach z produkcji leków dochodziły do  $900 \mu\text{g}/\text{dm}^3$ , w ściekach szpitalnych do  $124 \mu\text{g}/\text{dm}^3$  i komunalnych do  $64 \mu\text{g}/\text{dm}^3$ . Stężenia antybiotyków w ściekach oczyszczonych dochodziły do  $260 \text{ ng}/\text{dm}^3$ . Przedstawiono również obecność antybiotyków w wodach powierzchniowych. Najczęściej identyfikowanymi lekami były: ciprofloksacyn, erytromycyna, norfloksacyn, sulfametoksazol i trimetoprim. Maksymalne stężenia antybiotyków w wodach powierzchniowych dochodzą nawet do  $2 \mu\text{g}/\text{dm}^3$ . W większości przypadków identyfikowane antybiotyki występowały w ilości od kilku do kilkudziesięciu  $\text{ng}/\text{dm}^3$ , rzadziej w ilości kilkuset  $\text{ng}/\text{dm}^3$ . Obecność antybiotyków w wodzie pitnej jest identyfikowana, podobnie jak w przypadku ścieków na całym świecie np. w Chinach, USA, Niemczech, Kanadzie, Francji. Odnotowano bardzo wysokie stężenia antybiotyków Chinach w Guangzhou dochodzące do  $679,7 \text{ ng}/\text{dm}^3$  (ciprofloksacyn), ale również w USA (triclosan –  $734 \text{ ng}/\text{dm}^3$ ). W większości przypadków antybiotyki w wodach są w znacznie niższych stężeniach. Konsekwencją zanieczyszczenia środowiska antybiotykami jest lekooporność wielu szczepów bakterii i w konsekwencji coroczna śmierć 25 000 osób w Unii

Europejskiej i około 700000 na całej kuli ziemskiej. Nie do końca poznane są inne skutki obecności antybiotyków w środowisku. Przypisuje się temu zanieczyszczeniu właściwości rakotwórcze, teratogenne lub mutagenne.

**Słowa kluczowe:** antybiotyki, zanieczyszczenie wody, lekooporność

## Introduction

One of the problems of sustainable development is the rapid increase in the resistance of many bacterial strains to antibiotics used in health care. The significance of this issue can be indicated by the fact that, in the USA, as many as 70% of bacteria involved in hospital infections are resistant to at least one antibiotic, which was previously effective in the treatment of a specific bacterium (Bruton et al., 2007). It is estimated that about 25 000 people in Europe die each year due to infections caused by bacterial strains resistant to all antibiotics possible to be used in a given therapeutic recommendation. A constantly increasing percentage of bacteria resistant to many antibiotics simultaneously is being observed, for both Gram-negative and Gram-positive bacteria (Żabicka et al., 2012). The invention of penicillin by Alexander Fleming in 1928 gave hope for the effective treatment of many diseases and significantly extended the life expectancy of people. This invention won him the Nobel Prize in 1945. It seemed a breakthrough invention that would solve the problem of bacterial diseases. As it is still considered one of the greatest inventions of the 20th century. At present, in spite of synthesizing ever newer antibiotics, we are increasingly often helpless in combating antibiotic-resistant bacterial strains. So, the main principle of sustainable development, which is to use the environment in such a manner that does not reduce the potential of future generations for development, has not been met for antibiotics. The antibiotic-resistance problem was highlighted, e.g., by the establishment of the European Antibiotic Awareness Day in 2008 by the European Commission upon a motion by the European Centre for Disease Prevention and Control. The aim of this action has been to provide information on antibiotics, their effect and risks that may arise from their improper use. One of the major threats is the constantly aggravating phenomenon of the antibiotic resistance of microorganisms (WHO, 2014). Also the presence of antibiotics in various elements of the environment and food arises concern due to its not fully understood consequences.

One of the problems of concern is the presence of antibiotics in the aquatic environment, because water is among the factors that determine the existence of life. The protection of this element of the natural environment is a prerequisite for eco-development. Antibiotics present in the water environment are toxic to many aquatic organisms, including animals (Wollenberger et al., 2000; Yu et al. 2016). They may reduce the human immunity and exhibit

carcinogenic, teratogenic or mutagenic effects. Acting as hormones, part of antibiotics may disrupt human physiological functions (Jones et al., 2005). An inevitable consequence of the presence of antibiotics in the environment, including water, is the emergence of super-bacteria resistant to all antibiotics (Martínez, 2009).

An important issue is to identify the sources of antibiotics in water and to assess their concentrations in surface, ground and potable waters. The presence of antibiotics in surface and ground waters, and even in drinking water, is identified worldwide, e.g. in the UK (Mompelat et al., 2009), Italy (Grenni et al., 2017), China (Zhao et al. 2016), Australia (Watkinson et al. 2009), and the USA (Loraine and Pettigrove, 2006).

The purpose of the study is to analyze the problem of environmental contamination with antibiotics and to assess the effectiveness of their removal in conventional waste treatment plants based on the literature review.

## The sources of antibiotics in water

The identification of drugs in the environment is a relatively new problem. It was not until 1998 that Thomas Ternesa carried out the first trials to analyze drugs in the environment (Thomas, 1998). As a result monitoring the state of rivers, streams and waste waters in the area of Germany, the presence of analgesic, anti-inflammatory, psychotropic and antiepileptic drugs, beta-blockers, hormones and the regulators of fats and their simpler structures, so-called metabolites, was found. Further, extended examinations found antibiotics present in treated waste water and surface water in Germany (Thomas, 2001).

Antibiotics are used in the treatment of people and animals, in agriculture as growth promoters, in aquaculture and in animal husbandry (poultry and pig farming). The quantity of antibiotics used by people is large. In 2012, in 26 UE countries and in Iceland and Norway, approx. 3400 tons of antibiotics were sold to treat people and 7982 tons in slaughter animal farming (per active substances). Per biomass, the antibiotic dose averaged out at 116.4 mg/kg for people and 144.0 mg/kg for slaughter animals (ECDC/EFSA/EMA, 2015; Osek and Wiczorek, 2015). Part of the antibiotics, either in the unchanged form or as metabolites, find their way to the environment. This leads also to the contamination of meat with antibiotics. For example, the presence of tetracyclines in the amount of up to 100 mg/kg in the muscles, 300 mg/kg in the liver, 600 mg/kg in the kidneys, and streptomycin in the amount of 500

mg/kg in the meat, fat and the liver, and as much as 1000 mg/kg in the kidneys was found (Stec, 2015). Especially controversial is administering antibiotics to animals to accelerate their growth and increase their meat mass, or dosing them onto the fields with the aim of increasing the crop, thus reducing the costs (Liewska et al., 2006). In animal husbandry, antibiotics are used for both therapeutic and metaphylactic purposes (the treatment of the whole herd when isolated animals fall ill). Due to significant side effects, among which antibiotic resistance was predominant, using antibiotics prophylactically with feed was banned in the entire European Union in 2006 (Biernasiak et al., 2010). Veterinary antibiotics and their metabolites may be leached from the farmland replenished with animal fertilizers to water reservoirs, or get there as a result of the direct application of medicinal products, e.g. in pisciculture (Stec, 2015).

So, other drug sources in the environment can include waste water from medicine production and veterinary clinics, natural fertilizers, and surface run-offs (Kemper, 2008; Li, 2014). In the case of antibiotics used therapeutically by humans, a substantial load of these contaminants occurs in waste water. They are excreted from the body either in the unchanged form or as metabolites. Also, part of pharmaceuticals past their sell-by date, in spite of organizing their collection in pharmacies, find their way to the sewerage or onto landfill sites. Even in the case of a well operating conventional waste treatment plant, the effectiveness of removal of many pharmaceuticals, including antibiotics, is low (Golovko et al., 2014; Wu et al., 2016). So, antibiotics get to the water environment with treated waste water, which are directly discharged to surface water or used, e.g., for the irrigation of fields or the replenishment of ground water, or even underground water (MED-EUWI, 2007). Depending on their structure and properties, part of hard decomposable pharmaceuticals and their metabolites are retained in sewage sludge which, in turn, may be used for land reclamation or for soil fertilization in agriculture. As indicated by literature data, antibiotics from the groups of tetracyclines, macrolides and fluoroquinolones are most often identified in sewage sludges (Kümmerer, 2009). Another source of antibiotics can be landfills, liquid manure reservoirs, sewage sludge lagoons, or domestic no-outflow sewage tanks.

A large load of antibiotics and their metabolites is discharged to the environment together with hospital waste water. In Hanoi (Vietnam), waste waters originating from the six biggest hospitals in that region were examined for their content of the most commonly used antibiotics of the fluoroquinolone group. The presence of ciprofloxacin in a concentration ranging from 1.1 do 44 µg/l and norfloxacin from 0.9 to 17 µg/l was found. The concentrations were comparable to the results of

studies carried out, e.g., in Germany, Switzerland and Sweden (Bielińska and Nałęcz-Jawecki, 2009; Duong et al., 2008).

There is a very high contamination of soils and ground water with veterinary antibiotics. It is estimated that the load of antibiotics introduced to the soil with fertilizers reaches a level of several kilograms per hectare. The concentrations of assayed antibiotics often exceed 500 mg/kg of soil, with tetracycline-group antibiotics and sulphonamides, which are commonly used in pig and poultry farming, making up the largest share (Kemper, 2008).

### Waste water as the main source of antibiotics in water

Domestic sewage, hospital and antibiotic production waste waters constitute a major source of antibiotics in the water environment. In spite of the fact that waste treatment plants receive the majority of waste waters (treated waste water makes up 95% (GUS 2016), they are not prepared to remove such peculiar contaminants, as antibiotics. In conventional waste treatment plants, antibiotics may either undergo either total or partial mineralization as a result of biodegradation, or be retained on the sewage sludge (Fig. 1) (Adamek et al., 2015). Nevertheless, the effectiveness of removal of these contaminants is often low (Golovko et al., 2014; Wu et al., 2016). Conventional waste treatment technologies rely most often on degradation processes (either aerobic or anaerobic), that is they utilize microorganisms. These are fairly cheap and relatively simple technologies, which are characterized by a high effectiveness of organic matter decomposition. The presence of antibiotics in waste water may adversely affect the operation of the biological section of a waste treatment plant (Michael et al., 2013; Guerra et al., 2014).

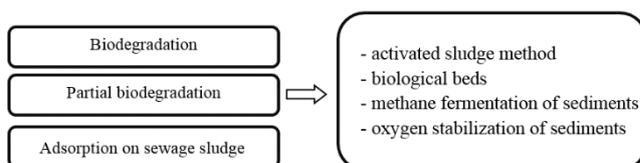


Figure 1. Municipal sewage treatment processes influencing the antibiotic concentrations

Particularly high antibiotic concentrations occur in hospital and antibiotic production waste waters (Table 1). In hospital waste water, e.g., Ciprofloxacin concentrations approached a level of up to 124.5 µg/dm<sup>3</sup>, and Ofloxacin concentrations, up to 39.1 µg/dm<sup>3</sup> (Ahmad et al., 2012). Even higher concentrations were noted in drug production waste water (Table 2). In this case, the examined concentrations approached the following levels, respectively: for Enrofloxacin – 900 µg/dm<sup>3</sup>; for Norfloxacin – 420 µg/dm<sup>3</sup>, for Ofloxacin – 160; for

Table 1. Antibiotic concentrations in hospital waste water and antibiotic production waste water

Antibiotic	Wastewater $\mu\text{g}/\text{dm}^3$	Country	Reference
Ciprofloxacin	3-87	USA/hospital wastewater	Carmosini and Lee, 2009
	15-26	Italy/ hospital wastewater	Verlicchi et al., 2012
	28-31	India/ drug production facilities	Larsson et al., 2007
	0.7-124.5	Germany/ hospital wastewater	Ahmad et al., 2012
	3,6-101	Sweden/ hospital wastewater	Lindberg et al., 2004
	3-87	Switzerland/ hospital wastewater	Ashfaq et al., 2016
	2,5-15	Australia/ hospital wastewater	Watkinson et al., 2009
Enoxacin	150–300	India/ drug production facilities	Larsson et al., 2007
Enrofloxacin	780–900	India/ drug production facilities	Larsson et al., 2007
Lomefloxacin	150–300	India/ drug production facilities	Larsson et al., 2007
Norfloxacin	390–420	India/ drug Production facilities	Larsson et al. 2007
Ofloxacin	150–160	India/ drug production facilities	Larsson et al., 2007
	7.9-39.1	Pakistan/ hospital wastewater	Ahmad et al., 2012
	1,66-4,2	China/ hospital wastewater	Chang et al., 2010
	3.7-31	Italy/ hospital wastewater	Verlicchi et al., 2012

Lomefloxacin and Enoxacin – 300  $\mu\text{g}/\text{dm}^3$  and for Ciprofloxacin – 31  $\mu\text{g}/\text{dm}^3$  (Larsson et al., 2007). Lower antibiotic concentrations were observed in municipal sewage. These occur in nanogram concentrations. The concentrations of the following antibiotics were found in waste water in concentrations of up to, respectively: Ciprofloxacin 860  $\text{ng}/\text{dm}^3$  – Czech Republic (Golovko et al., 2014); Cephalexin 175  $\text{ng}/\text{dm}^3$  – China (Wu et al., 2016); Norfloxacin 1330  $\text{ng}/\text{dm}^3$  – Czech Republic (Golovko et al., 2014); Moxifloxacin 180  $\text{ng}/\text{dm}^3$ -Spain (Gracia-Lor et al., 2012); Trimethoprim 4300  $\text{ng}/\text{dm}^3$  – Australia (Watkinson et al., 2009). Nevertheless, even such concentrations are often too high and are not completely removed in the waste water treatment processes (Table 2). In the majority of waste treatment plants, a partial removal of antibiotics took place. The efficiency of those processes was varying, being dependent both on the waste water treatment method and conditions and on the antibiotic being removed.

Table 2. Concentrations of selected antibiotics in crude and treated waste waters, respectively

Antibiotic	Wastewater before treatment $\mu\text{g}/\text{dm}^3$	Wastewater cleaned $\mu\text{g}/\text{dm}^3$	Country	Reference
Ciprofloxacin	0.278	0.120	WWTP of Lede, Belgium	Vergynst et al., 2015
	0.86	0.19	WWTP, Czech Republic	Golovko et al., 2014
	1.1	-	WWTP Australia Queensland	Watkinson et al., 2009
Cephalexin	0.175	0.064	WWTP Shanghai, China	Wu et al., 2016
	64	0.26	WWTP Australia Queensland	Watkinson et al., 2009
Enrofloxacin	23.93 3.67	2.47 2.35	WWTP Shanghai, China	Wu et al. 2016
	0.04	0.002	WWTP Australia Queensland	Watkinson et al., 2009
Erythromycin	28.6 22.4	11.7 20.8	WWTP Shanghai, China	Wu et al., 2016
	0.3	0.35	WWTP, Czech Republic	Golovko et al., 2014
Moxifloxacin	0.149	0.062	WWTP of Lede, Belgium	Vergynst et al., 2015
	0.072	-	WWTP China	Jia et al., 2012
	0.18	-	WWTP Spain	Gracia-Lor et al., 2012
Sparfloxacin	0.004	-	WWTP China	Jia et al., 2012
	0.022	-	WWTP India	Ashfaq et al., 2016
Oxyteracycline	0.126 0.012	nd 0.011	WWTP Shanghai, China	Wu et al., 2016
	0.35	0.07	WWTP Australia Queensland	Watkinson et al., 2009
Penicillin V	13.8	2	WWTP Australia Queensland	Watkinson et al., 2009
Roxithromycin	0.077 0.028	0.023 0.012	WWTP Shanghai, China	Wu et al., 2016
	0.5	0.5	WWTP Australia Queensland	Watkinson et al., 2009
Sulfamethoxazole	245	133	WWTP of Lede, Belgium	Vergynst et al. 2015
	55.6 138.5	39.5 70.6	WWTP Shanghai, China	Wu et al., 2016
	3	0.2	WWTP Australia Queensland	Watkinson et al., 2009
	0.49	0.26	WWTP, Czech Republic	Golovko et al., 2014

Antibiotic	Wastewater before treatment $\mu\text{g}/\text{dm}^3$	Wastewater cleaned $\mu\text{g}/\text{dm}^3$	Country	Reference
Sulfadiazine	0.544 0.009	0.010 nd	WWTP Shanghai, China	Wu et al., 2016
Sulfamethazine	0.010	0.006	WWTP Shanghai, China	Wu et al., 2016
Trimethoprim	0.158	-	WWTP of Ledo, Belgium	Vergynst et al., 2015
	4.3	0.25	WWTP Australia Queensland	Watkinson et al., 2009
	0.53	0.44	WWTP, Czech Republic	Golovko et al., 2014
	0.04	0.05	WWTP Australia Queensland	Watkinson et al., 2009
	0.22	0.25	WWTP Australia Queensland	Watkinson et al., 2009
	1.33	0.25	WWTP, Czech Republic	Golovko et al., 2014
Ofloxacin	2.937	0.196	WWTP Shanghai, China	Wu et al., 2016

WWTP – Wastewater treatment plant

The majority of antibiotics are removed in 50-70% by means of biodegradation, hydrolysis of photolysis. Another mechanism is adsorption on the active sludge, which eliminates Erythromycin in 25%, Clarithromycin in 54%, Trimethoprim even in 69%, and Sulphamethoxazole in a maximum of 55% (Kasprzyk-Hordern, 2009; Sukul and Spittler, 2006; Monteiro and Boxall, 2010). The antibiotic removal efficiencies given by the authors are much higher than those in operating waste treatment plants, e.g. in China (Wu et al., 2016). It should be emphasized that it is low antibiotic concentrations that favour the formation of immunity mechanisms and resultant drug-resistance.

### The occurrence of antibiotics in surface water

In surface water, almost all antibiotics used in medicine and veterinary are identified. The occurrence of antibiotics in the natural environment is closely related to their structure. In terms of their chemical structure, antibiotics can be divided into:  $\beta$ -lactam antibiotics, peptide and glycopeptide antibiotics, aminoglycosides, tetracyclines, macrolides, lincosamides, amphenicols, fusidic acid, rifamycines, ketolides, fluoroquinolones, streptogramins and chemotherapeutics of a different chemical structure (Janiec et al., 2010).

The assayed concentrations of these substances often come to values of up to  $2 \mu\text{g}/\text{dm}^3$  and are detected in surface water, ground water and even underground water (Table 3) (Wu et al., 2016; Grenni et al., 2017; Lucia et al., 2010; Kümmerer, 2009). They are

present in waters in all continents and in different countries, both very high developed (the USA, Germany, the UK, Australia), as well as much poorer ones (India or Vietnam). Especially often assayed are: Ciprofloxacin (a maximum concentration of  $1300 \text{ ng}/\text{dm}^3$  – Australia), Erythromycin (max.  $450 \text{ ng}/\text{dm}^3$  – South Korea), Norfloxacin (max.  $1150 \text{ ng}/\text{dm}^3$  – Australia), Sulfamethoxazole (max.  $1900 \text{ ng}/\text{dm}^3$  – USA) and Trimethoprim ( $150 \text{ ng}/\text{dm}^3$  – Australia). In the majority of cases, identified antibiotics occurred in concentrations from several to several dozen  $\text{ng}/\text{dm}^3$ , and less often in several hundred  $\text{ng}/\text{dm}^3$ .

Antibiotics contained in a water environment are subject to the action of both biotic and abiotic factors (sorption, desorption, photodegradation, biodegradation) (Fig. 2). The stability of antibiotics and their metabolites in a water environment depends on many factors, including the concentration of inorganic ions, the presence of organic suspended matter and the intensity of solar radiation (Skól, 2013).

The ability of antibiotics to adsorb on other matter particles depend largely on their diverse chemical constitution, containing groupings both acid and basic in character. For this reason, the distribution of these substances in the water environment largely depends on the pH value. The reaction of the water environment will also determine their solubility, hydrophobicity or sorption coefficient (Reemtsma and Jekel, 2006). One of the elements promoting the degradation of antibiotics in the water environment is photodegradation by UV radiation. Among many groups of antibiotics, quinolones, tetracyclines and sulphonamides are substance sensitive to solar radiation. Photodegradation has a significant importance in the process of surface water self-purification. The effectiveness of photodegradation depends on many factors, including temperature, irradiation intensity and the volumetric flow rate of water (Skól, 2013; Reemtsma and Jekel, 2006; Heberer, 2002).

Responsible for degradation processes in surface and ground waters are chiefly bacteria and fungi contained in them (Ternes, 2001). The biodegradation of antibiotics and their metabolites may lead to their total mineralization or biotransformation, that is the simultaneous formation of intermediate decomposition products that may exhibit much higher stability and higher toxicity compared to the parent substances. Based on the most recent studies it can be stated that antibiotics are substances relatively resistant to degradation processes and, in the majority of instances, undergo transformations resulting in the formation of new, previously unidentified compounds. Residues of antibiotics and their metabolites, together with the treated waste water, are discharged from the waste treatment plant to surface water, or, together with the sludge, migrate

into the soil and ground water that is the main source of drinking water (Halling-Sorensen et al., 1998; Watkinson et al., 2007).

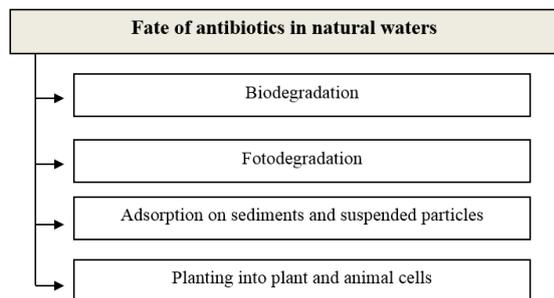


Figure 2. Transformations of antibiotics in natural water

The presence of antibiotics and their metabolites in the water environment has an adverse impact on organisms living in it. The toxicity of these substances to aquatic organisms is high, as they are exposed to them on a continuous basis and through many generations (Fent et al., 2006).

### Antibiotics in water intended for drinking

Literature reports on the presence of antibiotic residues in drinking water are scarce. One of the main reasons behind this situation are analytical difficulties due to the determination limits of measuring apparatus used. The progress in analytical chemistry is oriented to the development of methods and the improvement of measuring apparatus to enable the detection of compounds occurring in micro-traces and the determination of new substances (Kümmerer, 2009).

It has been found that the presence of antibiotics in drinking water may have an adverse impact on humans. They may exhibit carcinogenic, teratogenic or mutagenic effects, affect the hormonal regulation and impair the immunity (Jones et al., 2005). An inevitable consequence of the presence of antibiotics in the environment, including water, is the emergence of super-bacteria resistant to all antibiotics (Martínez, 2009). Particularly dangerous is the occurrence of antibiotics in low concentrations, which are non-toxic to bacteria.

A major problem is the identification of antibiotic sources and the assessment of their concentrations in potable water. The presence of antibiotics in drinking water is being identified throughout the world, e.g. in China, USA, Germany, Canada, France (Table 5). Very high antibiotic concentrations were noted in Guangzhou, China ((Lomefloxacin – 197 ng/dm<sup>3</sup>, Ciprofloxacin – 679.7 ng/dm<sup>3</sup>, Norfloxacin – 82.7 ng/dm<sup>3</sup>), but also in the USA (Triclosan – 734 ng/dm<sup>3</sup>) (Yiruhan et al., 2010; Loraine and Pettigrove, 2006).). In the majority of cases, antibiotics are present in water in much lower concentrations (Table 4). Due to the analytical difficulties in the identification of those antibiotics,

whose concentrations are at a level of ng/dm<sup>3</sup>, they are very rarely assayed in drinking water. It is hard

Table 3. Pharmaceuticals most often detected in surface water

Antibiotic	Country/ River	Max. concentration ng/dm <sup>3</sup>	Reference
Amoxicillin	UK/ R. Taff	240	Mompelat et al., 2009
	China/ Huangpu R.	53.9	Wu et al., 2016
	Italy/ R. Lambro	16.7	Grenni et al., 2017
	Australia/South-East Queensland	200	Watkinson et al., 2009
Ciprofloxacin	France/ R. Seine	20	Tamtam et al., 2008
	Italy/ R. Lambro	14.4	Zuccato et al., 2006
	Finland/R. Vanta	40	Mompelat et al., 2009
	Streams USA	30	Kolpinet et al., 2002
	China/ Yellow R. Delta	70.3	Wu et. al 2016
	Italy/ R. Po	124	Grenni et al. 2017
	Italy/R. Tiber	19	Grenni et al. 2017
Chlorotetracycline	Australia/South-East Queensland	1300	Watkinson et al. 2009
	Streams USA	670	Kolpin et al., 2002
Erythromycin	Australia/South-East Queensland	600	Watkinson et al., 2009
	China/R. Pearl	423	Zheng et al., 2012
	Vietnam/ R. Mekong	11	Zheng et al., 2012
	Japan/ R. Tamagawa	448	Zheng et al., 2012
	South Korea/R. Youngsan	450	Zheng et al., 2012
	UK/R. Taff	21	Kasprzyk-Hordern et al., 2009
	Italy/ R. Po	15.9	Zuccato et al., 2006
	Italy/R. Lambro	20	Mompelat et al., 2009
Enoxacin	China/ Yellow R. Delta	23.3	Zhao et al., 2016
	France/r. Seine	15	Mompelat et al., 2009
Enrofloxacin	China/ Yellow R. Delta	20.9	Zhao et al., 2016
	China/ Huangpu R.	5.4	Wu et al., 2016
	Australia/South-East Queensland	300	Watkinson et al., 2009
Clarithromycin	Italy/R. Po	4.6	Calza et al., 2013
		128	Grenni et al., 2017
	Italy /R. Lambro	8.3	Zuccato et al., 2006
		149	Grenni et al., 2017
	Japan/R. Tamagawa	1.1	Murata et al., 2011

Antibiotic	Country/ River	Max. concentration ng/dm <sup>3</sup>	Reference
Lincomycin	Italy/ R. Po	20	Calza et al., 2013 Grenni et al., 2017 Zuccato et al., 2006 Grenni et al., 2017 Watkinson et al., 2009
		248.9	
	Italy/R. Lambro	24.4	
		24.4	
	Australia/South–East Queensland	50	
Norfloxacin	France/R. Seine	40	Tamtam et al., 2008 Locatelli et al., 2011 Kolpin et al., 2002 Mompelat et al., 2009 Brown et al., 2006 Watkinson et al., 2009
	Brazil/R. Atibaia	50	
	USA streams	150	
	Finland/R. Vantaa	140	
	Bresil/Rio Grandr Australia/South–East Queensland	300 1150	
Ofloxacin	France/R. Seine	70	Vieno et al., 2006 Wu et al., 2016
	China/ Huangpu R.	16.4	
	China/Yellow R. Delta	23.4	Zhao et al., 2016 Grenni et al., 2017 Grenni et al., 2017
	Italy/R. Po	33.1	
	Italy/R. Lambro	306.1	
Oxytetracycline	USA streams	320	Kolpin et al., 2002 Zhao et al., 2016 Grenni et al., 2017 Grenni et al., 2017
	China/Yellow R. Delta	83.5	
	Italy/ R. Po	8.0	
	Italy/R. Lambro	14.4	
Roxithromycin	USA streams	210	Kolpin et al., 2002 Zhao et al., 2016 Wu et al., 2016 Watkinson et al., 2009
	China/Yellow R. Delta	14.1	
	China/Huangpu R. Australia/South–East Queensland	2.01 350	
Spiramycin	Italy/R. Lambro	80	Lucia et al., 2010 Grenni et al., 2017 Grenni et al., 2017
		74.2	
	Italy/R. Po	26.8	
Sulfamethazine	Vietnam/Makong R.	60	Managaki et al., 2007 Kolpin et al., 2002 Wu et al., 2016
	USA streams	260	
	China/Huangpu R.	10.8	
Sulfamethoxazole	China/R. Pearl	165	Zheng et al., 2012 Zheng et al., 2012 Zheng et al., 2012 Tamtam et al., 2008 Madureira et al., 2010
	Japan/R. Tamagawa	23	
	South Korea /R. Youngsan	110	
	France/R. Seine	75	
	Portugal/R. Douro	53.3	

	UK/R. Taff	8	Kasprzyk-Hordern et al., 2009 Nödler et al., 2011 Loos et al., 2007 Managaki et al., 2007 Kasprzyk-Hordern et al., 2009 Kolpin et al., 2002 Wu et al., 2016 Grenni et al., 2017 Grenni et al., 2017 Watkinson et al., 2009
	Germany/R. Leine	63	
	Italy/Lake Maggiore	10	
	Vietnam/R. Mekong	190	
	Poland/R. Varta	40	
	USA streams	1900	
	China/ Huangpu R.	25.9	
	Italy/ R. Po	2.39	
	Italy/ R. Tiber	68	
	Australia/South–East Queensland	2000	
Tetracycline	USA streams	130	Kolpin et al., 2002 Zhao et al., 2016 Watkinson et al., 2009
	China/ Yellow R. Delta Australia/South–East Queensland	64.8 80	
Trimethoprim	Vietnam/ R. Mekong	20	Zheng et al., 2012 Zheng et al., 2012 Zheng et al., 2012 Tamtam et al., 2008 Madureira et al., 2010 Kasprzyk-Hordern et al., 2009 Kolpin et al., 2002 Watkinson et al., 2009
	Japan/R. Tamagawa	100	
	South Korea/R. Youngsan	20	
	France/R. Seine	20	
	Portugal/R. Douro	15.7	
	UK/ R. Taff	120	
	USA streams	70	
	Australia/South–East Queensland	150	

to assess the actual exposure of humans to this type of antibiotics.

### Antibiotic resistance

At the beginning of 2015, three European institutions, namely the European Centre for Disease Prevention and Control (ECDC), the European Food Safety Authority (EFSA) and the European Medicines Agency (EMA), published for the first time a common report concerning the relationship between the consumption of antibiotics and the occurrence of resistance to antibacterial drugs. This problem applies to bacteria causing diseases both in humans and in animals. A consequence of the abuse and misuse of antibiotics both in humans and in animals and the presence of antibiotics in the environment is the rapid increase in the quantity of bacteria and parasites resistant to those antibiotics (Adamek et al., 2015; Bbosa et al., 2014; Barbusiński and Nalewajek, 2011).

Resistance to antibiotics is a genetic adaptive feature that enable bacteria to survive and develop in the

Table 4. Antibiotics in drinking water

Antibiotic	Country	Max. concentration, ng/dm <sup>3</sup>	Reference
Ciprofloxacin	China (Macao)	8.2	Yiruhan et al., 2010
	China (Guangzhou)	679,7	Yiruhan et al., 2010
Clarithomycin	China	0.2	Padhye et al. 2014
Erythromycin	Germany	20	Verlicchi et al., 2012
	Canada	12	Kleywegt et al., 2010
	USA	0.3	Bull et al., 2011
	USA	1.3	Deo and Halden, 2013
	Portugal	5	Gaffney et al., 2014
Enrofloxacin	China(Macao)	5.2	Yiruhan et al., 2010
	China (Guangzhou)	8.3	
Lomefloxacin	China(Macao)	37.1	Yiruhan et al., 2010
	China (Guangzhou)	197.0	
Norfloxacin	China(Macao)	17.1	Yiruhan et al., 2010
	China (Guangzhou)	82.7	
Sulfonamides	Portugal	1.9	Gaffney et al., 2014
Sulfamet-hoxazole	France	0.8	Bull et al., 2011
	USA	6	Verlicchi et al., 2012
	USA	20	Deo and Halden, 2013
	USA	13.7	Wang et al., 2011
	China	12.7	Padhye et al., 2014
Sulfathiazole	USA	3.4	Ye et al., 2007
	USA	10	Deo and Halden, 2013
Trimethoprim	France	1.0	Bull et al., 2011
	Germany	2	Verlicchi et al., 2012
	USA	1.7	Wang et al., 2011
	China	19.8	Padhye et al., 2014
Triclosan	USA	734	Lorraine and Pettigrove, 2006

One example of antibiotic-resistant bacteria is *Staphylococcus aureus* (mortality without the use of antibiotics is > 80%). At present, only 20% strains

are susceptible to Penicillin, Meticillin, Vancomycin and aminoglycosides. Other antibiotic-resistant presence of the drug that is supposed to destroy them. A major problem is multidrug resistance. Some pathogenic bacteria exhibit resistance to many antibiotics, and there are even such strains (super-bacteria) that no longer respond to any antibiotics (Davies and Davies, 2010). The antibiotic-resistance problem was foreseen already by Fleming (in his lecture delivered after winning the Nobel Prize in 1946). Nevertheless, it was not until the 21st century that this phenomenon became a global problem. A return to the pre-antibiotic era, when many infectious diseases were incurable, is even expected (Gross, 2013).

infections may cause an increased death risk (up to 2-3 times) (OECD, 2015). The resistance mechanisms have been described for all antibiotics being currently in use in human and veterinarian medicine. It is estimated that the number of deaths cause by antibiotic-resistant bacteria is already large, but the greatest concern is caused by the increasing trend (French, 2010). According to recent estimates, 23 000 people in the USA, 25 000 in the European Union and about 700 000 across the globe die each year due to bacterial antibiotic resistance (Carvalho and Santos, 2016). This problem may become the cause of an annual death rate of 10 million people by around 2050 (O'Neill, 2014). Another adverse side effect is the increased health care cost resulting from the prolonged stay in hospital and the use of many antibiotics, including new-generation and more expensive ones.

## Summary

The investigations have confirmed the presence of antibiotics in surface water, ground water and even drinking water. The sources of those contaminants are diverse: human and veterinary medicine, agriculture (animal husbandry, plant growing, aquaculture). Among the most important sources are municipal sewage and hospital, agricultural and industrial (drug production) waste waters. Very high antibiotic concentrations were assayed in drug production waste water (up to 900 µg/dm<sup>3</sup>), hospital waste water (up to 124 µg/dm<sup>3</sup>) and municipal sewage (up to 64 µg/dm<sup>3</sup>). In the majority of cases, the concentrations of various antibiotics in crude waste water are lower. A concern is caused by the presence of antibiotics also in treated waste water (up to 260 ng/dm<sup>3</sup>). As a consequence of their penetration into ground water and even underground water, antibiotics are also detected in drinking water. In the majority of instances, the assayed antibiotic concentration in drinking water ranged from several to several dozen ng/l. However, there were cases (China, USA), where these concentrations attained a level of several hundred ng/dm<sup>3</sup>. A consequence of the abuse of antibiotics is their presence in the

environment. The consequences of the constant exposure of organisms to antibiotics, e.g. in water, are not fully understood yet. Nevertheless, a proven, extremely dangerous phenomenon is the resistance of many bacterial strains to these drugs. It is estimated that this causes the deaths of about 700 000 people in the world, of which 25 000 in Europe. However, a very fast increase in the number of strains resistant to known antibiotics is foreseen. The drug resistance, which may lead to the incurability of many infectious diseases, is the consequence of upsetting the sustainable development conditions. The excessive, often mindless use of antibiotics with the aim of increasing profits, e.g. in agriculture, is contrary to the eco-development principles. Less understood are the carcinogenic, teratogenic or mutagenic effects of environmental contamination with antibiotics. In many cases, though, such adverse effects are confirmed.

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## Development of Road Infrastructure in Environmentally Valuable Areas – Sustainable Designing

### Rozwój infrastruktury drogowej na obszarach cennych przyrodniczo – zrównoważone projektowanie

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#### Abstract

The paper contains analysis of the problems of sustainable development in terms of road infrastructure development in environmentally valuable areas. We have seen a dynamic development of roads and related engineering objects in the last several years. The aim of the paper is to discuss the issues of sustainable development (and inaccuracies in terms of environmental conditions) influencing on the solution of engineering objects of road infrastructure, including bridges, carried out in the areas of National Parks and Natura 2000 areas. The article presents problems associated with a number of road investments designed and implemented in North-Eastern Poland, for which the authors developed Reports on the environmental impact. They also referred to the road building on protected areas from other countries. Problems arising from the lack of understanding of the preconditions for sustainable development, and on the other hand, construction and building conditions, have been presented. Differences between the approaches of road construction engineers and the requirements deriving from environmental regulations in these areas, have been also elucidated. Solutions making possible to reconcile designers with environmentalists have been pointed out. Analysis of these investments gave the plane to formulate questions and key comments for the solution of problems at the stage of road designing in protected areas. A proper understanding of these issues provides an opportunity to design the environmentally friendly, and at the same time, functional and safe road facilities.

**Key words:** road infrastructure, sustainable development, environment, environmentally valuable areas

#### Streszczenie

W artykule przeprowadzono analizę problematyki zrównoważonego rozwoju w kontekście budowy infrastruktury drogowej na obszarach cennych przyrodniczo. W ciągu ostatnich kilku lat obserwujemy dynamiczny rozwój dróg i związanych z nimi obiektów inżynierskich. Celem pracy jest dyskusja, jak perspektywa rozwoju zrównoważonego wpływa na przyjmowane rozwiązania odnoszące się do obiektów inżynierskich infrastruktury drogowej, z uwzględnieniem mostów, na obszarach parków narodowych i obszarów Natura 2000. Przedstawiono problemy dostrzeżone przy wielu inwestycjach drogowych zaprojektowanych i realizowanych w pñ.-wsch. Polsce, dla których autorzy przygotowali Raporty o wpływie na środowisko. Omówiono także podobne przypadki z innych krajów. Zwrócono uwagę na problemy wynikające z niezrozumienia uwarunkowań rozwoju zrównoważonego, a także konstrukcji i warunków budowlanych. Ukazano różne podejścia do inżynierii budowy dróg i wymagania wynikające z regulacji ochrony przyrody. Analiza tych inwestycji umożliwiła sformułowanie pytań i kluczowych wyjaśnień odnoszących się właściwego rozwiązywania problemów na poziomie projektowania dróg na obszarach chronionych. Właściwe zrozumienie tych spraw daje szansę na projektowanie prośrodowiskowych, a zarazem funkcjonalnych i bezpiecznych dróg.

**Słowa kluczowe:** infrastruktura drogowa, rozwój zrównoważony, środowisko, obszary cenne przyrodniczo

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## Introduction

Construction investments are inextricably linked to the economic development of each country. Expansion of towns and settlements, construction of industrial, commercial, recreational and communication network is necessary and results from regional development strategies. In order to make their implementation possible, it is necessary to prepare the land earmarked for development. In many regions of our country, lands under construction are increasingly limited, and furthermore the investors often care of an attractive investment location. For this reason, more and more construction projects dangerously close to areas of high natural values and protected, and often enter these areas. To minimize the negative impact of the investment on the environment, several variants are developed and then assessing their positive and negative effects, some alternative that is the best and the least disturbs the environment, is selected (Szafranko, 2017).

Nowadays, Poland is the largest road construction site in Europe. One of the main reasons for this situation are many years of neglect and abandonment in the construction and expansion of Polish roads. The dynamic growth in the number of vehicles on Polish roads, including vehicles with large masses in transit, has led to a critical situation, in which a need for well-prepared development of the road network is the order of the day. On one hand, the road network in Poland to be closer to European standards, which would contribute not only to increase the safety and traffic flow, but also to improve the living and working conditions of people living in the vicinity of roads. On the other hand, the road infrastructure with traffic generate various factors, which are not only a threat to human health, but also to the environment. There is no doubt that the social considerations require removal of transit traffic to the correct distance beyond the regions inhabited by man. However, this leads very often to conflicts of interests between local community and the environment. This is particularly apparent when we consider the Polish regions, where a large number of valuable nature sites (mostly Natura 2000 areas) have little room for maneuver during the expansion and reconstruction of existing roads (Kobryń, 2007).

Rapid implementation of road investments cannot, however, be carried out to the detriment of the environment. Can universal globalization be reconciled with the protection of nature? (Drogi przyjazne środowisku... 2017, Pawłowski, 2009). Road construction is undoubtedly a branch of the engineering industry contributing heavily to the degradation of natural resources. Starting from the stage of natural resources extraction, through the technology of building materials production, to planning and designing of routes, as well as implementation and operation of the routes, a harmful or destructive inter-

ference with ecosystems takes place. It has consequences in a form of fragmented habitats, disturbance of hydrological relations, or disturbance in the landscape harmony. These phenomena are accompanied by majority of road projects (Leniak-Tomczyk and Łagoda, 2007).

With reference to the above development of the road infrastructure on environmentally valuable areas in Europe and in the world a multidimensional-ness of the sustainable development and his following aspects are putting their name down:

- the ethical dimension (the issue of humanity's responsibility for nature),
- the ecological dimension (nature conservation, protection of the environment created by humankind, spatial planning),
- the social dimension (since the social environment – and not merely the natural one – may experience degradation),
- the economic dimension (taxes, grants and other economic instruments),
- the technical and technological dimension (new technologies, being economical with raw materials),
- the legal dimension (environmental law),
- the political dimension (formulation, implementation and enforcement of sustainable development strategies) (Pawłowski, 2009).

It is therefore necessary to develop appropriate mechanisms to assist in making the optimum decisions in the field of the road infrastructure development taking into account the negative impact both on the environment, but also on the health of users and people living in the immediate vicinity of roads.

## Range of problems of the sustainable development

Investments, that are most commonly the cause of a collision with valuable nature areas, and consequently also the subject of environmental conflicts, cover a wide range of projects. However, one can identify the objects that are most likely the cause of such a situation. Basic groups of these facilities primarily include linear investments, especially of great length, whose course is difficult to determine with complete excluding areas with high natural values. In the group of linear investments, the road projects are included within the most conflict-collision making ones (in particular, motorways and expressways, city ring roads, and other roads with heavy traffic). In the last few years, it can be seen an increase in the intensity of social conflicts related to the implementation of projects that may cause significant negative changes in the resources and natural beauty of environmentally valuable areas. The term *conflict* is often confused with the notion *human impact on the environment* or *environmental degradation*. However, not every negative impact of human activities

on nature creates conflict. The occurrence of environmental degradation (which can also be referred to as collisions with the environment) is not always associated with the creation of the conflict, since a social subject (person, group) must be found, which reveals the emergence of this degradation and finds that it is in contrary to its interests or views. In addition, conflicts can arise even when environmental degradation has not occurred yet, and only guess that it may occur in the future. Locating the investment in environmentally valuable areas is a growing problem not only when environmental conflicts arise, but always when it results in irreversible losses or changes in the environment. Genesis of the growth in the number of investments located in environmentally valuable areas and emerging as a result of environmental conflicts recorded in recent years, is relatively complex. Among the root causes, Kistowski (2008) lists:

- rapid and often chaotic privatization of large areas, carried out mainly in the 90s of the twentieth century, in areas of the former state farms, part of post-military, municipal and forestry areas, during which, the interests of the state and part of the citizens to have the right to use and control of natural areas has not been taken care;
- Polish accession to the European Union, which on the one hand resulted in the influx of huge funds, most of which has already been allocated for investments, e.g. roads, and on the other hand, which leads to the necessity of compliance with EU law, for example The Habitat Directive (92/43/EEC), which is the basis for creation of Natura 2000 areas;
- lack of a stable legal system, in particular in the field of nature conservation as well as planning and land use;
- investment pressure due to the increased dynamics of socio-economic development during the last few years, combined with declarations of a compliance with the constitutional principles of environmental protection and sustainable development;
- changes in behavior and preferences of Polish society; on the one hand increasing the environmental awareness and associated rights to live in the natural environment with good quality, on the other hand, increasing public demand for material goods and the use of comforts of life often invested in environmentally valuable areas or in their vicinity is considered a factor enhancing the attractiveness and thus the economic value of these objects.

It is possible however to notice, it is reasonable to suggest that we possess the technology to allow protected areas to be maintained in a state that does indeed allow future generations undiminished possibilities for making use of them. The problem here is that, thanks to the high costs involved – and (in part in consequence of that) a perceptible lack of will to

act, there is ongoing degradation of protected areas – so ongoing in fact that an *irreversible* state of degradation may be being approached in certain areas. Thus, while humankind may be in possession of the appropriate technical and technological power allowing for environmental sustainability to be achieved, this aim is not being pursued in many areas on account of an absence of the will to target the necessary material resources at the problem (Pałowski, 2009).

### **Problems of the road infrastructure development within the protected areas**

Poland is one of the few countries in Europe where relatively a lot of valuable natural areas have been maintained and where populations of rare species of animals, such as bison, moose, bears, lynx and wolves, have been survived. These biocoenoses are our contribution to the natural resources of united Europe, and because of the particular geographic location of Poland, they appoint us as an important link in the process of Western Europe colonization by species eradicated there in previous centuries (Leniak-Tomczyk and Łagoda, 2007).

The north-eastern territory of Poland, including Podlasie, is located in an area of outstanding individual features in comparison with other regions of the country. A significant individuality of the region is at the same time accompanied by a multitude of natural objects and perfect state of their preservation. These are the areas of highest worldwide virtues, for instance Białowieża Forest (included in the global system of Biosphere Reserves), or Biebrza River Valley (the largest natural complex of bogs in Central Europe). In particular, the presence of large and poorly fragmented forests, a large area of meadows and bogs, and the abundance of lakes in the area of young glacial landscape in the north of the region, represent an enormous attractiveness of the area. Białystok, which is the capital of the region, occupies a central position relative to most major complexes. Within several kilometers, there are: Knyszyn Forest, Biebrza River Basin with the National Park, Narew River Valley with the National Park. Within a radius of several tens of kilometers, there are: Augustów Forest, Białowieża Forest, Borecka Forest, Romińska Forest, Suwałki National Park, Wigry National Park, and Bug River Valley. Almost all of these objects entered in whole or in part, within Podlasie province, in the ecological network Natura 2000 (Kwiatkowski and Doroszkiewicz, 2007).

Against the background of the country, this region stands out above average natural values. A large natural values of the province are determined by a large proportion of forests (29.2%), grasslands (19.8%), wetlands (3%), and waters (3%). Forests are preserved in the form of large complexes. They are: Białowieża Forest, Knyszyn Forest, and Augustów Forest. The province is intersected with broad river

valleys: Narew, Biebrza, and Bug. The post-lake landscape represents the area north of Suwalki. Ecosystems, natural habitats, specimens of species and their habitats, forms of nature and landscapes, deserving special protection, are covered by different forms of nature protection. In Podlasie province, there are 12 special birds protection areas and 24 areas for Community Importance (designed special areas for habitat protection), representing over 31% of Podlasie province territory. Location of special bird protection areas is related to the concentration of a birdlife in the valleys of following rivers: Biebrza, Narew, and Bug, and forests areas: Białowieża, Knyszyn, and Augustów. Special habitat protection areas are associated with wetlands, especially river valleys, bogs, water reservoirs, forests, as well as extensively performed grasslands (Natura 2000, 2017). In the face of this rich set of *natural objects*, it becomes clear that the road network in the region repeatedly crosses the areas covered by different forms of protection. Of particular importance here is the role of bridges (Karaś and Bohatkiewicz, 2015). Consequently, development of road infrastructure in Podlasie region more and more often raises environmental and social conflicts. It is applied to a long process of investment planning and overcoming a series of procedures aimed at reducing the negative impact on the environment. New legal grounds and establishing the Natura 2000 areas significantly changed the mode of road implementation in Podlasie province and often made even impossible the continuation of investments having been already underway. Desire to leave the region with possible the largest protected areas is almost always in collision with infrastructure development in the region, enabling the financial advancement of Podlasie society and improving the standards of people living in villages around the routes (Górnjak and Wiater, 2007). Similar issues are regarding the development of a system specially protected natural areas (SPNAs) in the context of the concept of sustainable development in Russia. The authors suggest ways of finding a balance of economic, environmental and social interests in SPNAs, which will not lead to a decrease in their number or area, however, prevent a number of economic and social problems. The change in approaches to the management of the system of SPNAs including in terms of their creation, modification of their boundaries or termination of their operation will allow including SPNAs in the system of social economic relations of regions and certain countries, provide an opportunity to withdraw from the current one-sided bias solely in favor of environmental factors. This will ensure the necessary balance of the interests of the local population, business and protection of nature (Anisimov, Lidzheeva and Ryzhenkov, 2017).

Economic and the economy importance of environmental impact assessments for the development of Irish road projects was underlined among others in

the Foundation report for the Economics of Sustainability FEASTA (Douthwaite, 2007).

In Lithuania an intense influence of the development of the road infrastructure and meaning of the sustainable development were also emphasized to natural environment and environmentally valuable areas. Transport infrastructure, its components, relations with other objects, even participants play a great role in the formation of an attractive living environment. The influence of transport infrastructure on the living environment can be described by the number of indicators which are determined and systemized while preparing development projects. The social-economic assessment is usually used for transport investment providing a comprehensive evaluation of projects profitability and cost-effectiveness. The results are used in the process of decision making seeking to determine whether it is appropriate to implement separate development projects and to form priority options for investment. However, even the social-economic assessment often faces uncertainty (Griškevičiūtė-Gečienė and Griškevičienė, 2016).

In Latin America within protected areas to read about problems of the development of the road infrastructure we can among others in the Natural Capital report & Roads. This document illustrates how incorporating ecosystem services into road project design and development can lead to more sustainable, cost-effective roads while maintaining or enhancing the additional benefits nature provides to the region's citizens, from clean water and air, to food and timber (Lisa Mandle and Rob Griffin, 2014).

The Twenty-First Century will see an unprecedented expansion of roads, with at least 25 million kilometers of new roads anticipated by 2050 (Laurance et al. 2014). Nine-tenths of these new roads will be in developing nations, which sustain many of the planet's most biologically rich and environmentally important ecosystems (Laurance et al. 2015). While roads are critical for economic development, these ecosystems and the services they provide are vital for sustaining life. Roads are key drivers of land use change and deforestation, threatening biodiversity. In Latin America and the Caribbean, commercial agriculture facilitated by transportation networks is a leading driver of deforestation (Watkins, 2014).

The challenge is for road development to proceed without having detrimental effects on the environment and local communities (Quintero, 2012).

### **Environmentally friendly roads**

In the last several years, the authors worked on reports on the environmental impact of several road projects designed and implemented in North-Eastern Poland, for which environmental decisions were achieved.

During development of those reports, a series of criteria and factors for variants of road projects, were set out. It included the following main criteria for

further review of different options of investments (Abu Dabous and Alkass 2008, Dytczak 2010, Szafranko, 2017):

1. Functional criterion (length of the route of the analyzed variant, accessibility for transport (number of nodes), bandwidth of the route and the level of movement freedom, etc.);
2. Technical criterion (number and area of engineering objects, technical solutions, engineering-geological conditions, collisions with the technical infrastructure, etc.);
3. Movement criterion (travel time, traffic safety, etc.);
4. Economic criterion (value of the project, rate of benefits, value of land designated for redemption, price of the current annual road maintenance, etc.);
5. Environmental protection criterion (crossing with watercourses, length of the intersection with valuable natural areas, areas of natural habitats, which can be destroyed, intersection of animal migration routes, amount of dangerous substances emissions, number of trees to be cut, etc.);
6. Social environment protection criterion (possibility of social conflicts, compatibility of the project with provisions of the local spatial development plans, number of households covered by the negative impact zone, number of houses provided to address in connection with planned investment, etc.).

Today, when building or upgrading each route, several variants of the route are created. Each of them is subjected to a thorough analysis by the team of experts to assess whether the investment is threatening the natural environment. Among others, the impact of the construction on the status of the groundwater, plant or animal habitats, is examined. On this basis, solution that is the least detrimental to the environment, is chosen then. In a situation that the route runs through the area extremely valuable – particularly the area included in the Natura 2000 network – and it is impossible to avoid the loss in nature, the road builders are obliged to compensate the damage. Thus, they plant trees in place of the cut ones, include the positions of endangered plant and animal species with a special care, build shelters for the birds or take compensation measures. To reduce the interference of a new investment towards nature, designers and investors should use environmentally friendly technologies. At highway construction sites, non-toxic materials, harmless to the environment and safe for future road users, should be used, while ensuring the sustainability of infrastructure. Engineers in a responsible manner should also apply raw materials not depriving their natural resources. New and upgraded roads must also be environmentally friendly during their use. Therefore, they are equipped with modern infrastructure to protect soil and water from pollutants emitted from vehicles and

from a layer of bituminous pavement. Natural and artificial barriers separating the noisy route from human and animal communities are also built on the roadside. Safe passages to migrate between habitats are constructed for mammals, reptiles and amphibians. Built roads, viaducts and bridges should not violate the natural landscape, but be aesthetically composed to it. Poland is one of the few countries with such a large diversity of terrain; one can meet up with mountains of alpine character, lowlands and highlands, vast lands of lakes, as well as sand dunes and cliffs. This places high demands to architects, but also to greenery designers planning belts of trees and shrubs along the roads. In this regard, Scandinavian engineers are the role models (Drogi przyjazne..., 2017) .

### Key issues to solve

The above problems and conditions allow the isolation of a number of key issues, whose solution and proper understanding gives the chance to design environmentally friendly and at the same time functional and safe road facilities.

One of the key issues to solve are in general the legal aspects. We can on the one hand talk about the faulty national legislation, and their too often changes. As regards, for example to the law on spatial planning and development (e.g. insufficient rank of the condition study in a municipality or no obligation to produce or eco-physiographic development or a prediction of the impact on the environment at some levels of planning), turning off the localization of part of the project from the provisions relating to spatial planning. In addition, over the past several years, major changes in regulations took place repeatedly affecting the way to take into account natural conditions at the stage of investment location, and in particular the manner of developing an environmental impact assessment. Only part of these changes can be regarded as conditioned by objective factors, e.g. Polish accession to the European Union. This resulted in the situation that subsequent phases of the investment process took place against various provisions in force. Often during this process, e.g. an obligation to prepare environmental impact assessment appeared, which previously did not exist, or widened (or *narrowed*) the range needed to draw up the assessments. These changes generally complicate and prolong the investment process. On the other hand, we still can talk about inconsistency of part of Polish legislation with the EU law; there are still shortcomings in the implementation of EU law into national law. Of course, deficiencies in national law also arise in part from inconsistencies in EU law. In three the most important directives governing these issues: on the assessment of the effects of certain plans and programs on the environment (Dyrektywa, 2001), on the assessment of the effects of certain public and private projects on the environment (Dyrektywa, 1985),

and on the conservation of natural habitats and wild fauna and flora, there are considerable differences in the approach to take into account the natural circumstances in the course of the investment location, especially the obligation to carry out an environmental impact assessment. These provisions in a different way have the approach to the issue of obligation to produce a number of alternative solutions of a given investment, which does not facilitate the formulation and evaluation of alternatives during the process of planning and localization (Twardowska, 2007).

Another important issue affecting the sustainable designing of road infrastructure is insufficient public participation in planning procedures, and within them, in the environmental impact assessment at this stage. In the last decade, the level of social interest in those processes in an early stage of planning has increased. The desire to participate is reported mainly by social organizations (usually ecological), and not by local residents. Residents – to a small extent – are interested in the impact of the investment on nature mainly when it has already to be formed and may directly threaten their economic interests or their quality of life.

An important cause of various conflicts is still often poor quality of the projects of spatial plans, design of projects, and reports and forecasts of the environmental impact. Unfortunately, it often stems from the weak skills of their contractors. While in the case of urban planners and architects, there is a system of authorizations and professional associations of these bodies (SARP, TUP), which may use disciplining instruments, the preparation of environmental impact assessments does not currently require any certificate, experience and education (in practice, everybody can make them). Errors made in these assessments may have far-reaching negative consequences for the environment. On the other hand, not only people conducting the assessment should be blamed, because they have a limited impact on the final form of the project design or policy, strategy or plan, for which they prepared the report or EIA forecast.

An important issue, although fortunately occurring in ever smaller scale, is so-called investor's arrogance. As a rule, they *push* only one variant of the project guided mainly by economic criteria and they do not allow the possibility of significant changes in their concepts and projects. Still it comes to attempts of forcing the administration favorable decisions or determination of not always environmentally friendly solutions to the designers, making financially-dependent contractors. Because investors bear the costs of preparing the reports on the impact on the environment, they often demand favorable opinion in relation to the authors of those studies.

The above issue is related to still frequent insufficient commitment of administration. Because of low wages, labor shortages and cases of lack of competence, the local administration at various levels often does not sufficiently affect the implementation of en-

vironmental issues to the localization process. One can distinguish too passive and too active attitude in the administration. The former consist e.g. in a lack of sufficient control over the investment process or level of planning, design and document assessing the impact on the environment studies. Too active attitudes involve promoting or obstructing the investors *at any cost* (Kistowski, 2008).

Still, we can also speak in many cases, about the lack of adequate and current information on nature. Often the knowledge about resources and natural beauty is insufficient. Wider knowledge of the resources and values of nature exists only for protected areas (nature reserves, national and landscape parks, Natura 2000 areas). This often causes the need to carry out costly and long-term natural inventory in areas of planned road investments at the expense of investor.

### Summary

Among the great diversity of engineering facilities needed for economic development, the linear objects deserve special attention (Szafranko, 2013). Their implementation is related to a number of problems, mainly due to the fact of their great length, often tens of kilometers, which often come into conflict with the surrounding natural environment. Therefore, measures to reduce the possible harmful effects of these investments on the environment should be carried out at the stage of investment planning (Siuta, 2016). The most important group of actions is the right location and plotting the route in the initial stage. Solutions that as little as possible disturb ecosystems and natural areas are analyzed at the planning stage. At the designing stage, decisions are made on the construction details, technology solutions, and materials, and for the protection of animals and plants. Designed solutions also affect the inconvenience during the works as well as during the entire period of operation (Green Building..., 2010, Broniewicz et al., 2009). From the presented analyzes and considerations it follows that the main cause of the collision and environmental conflicts in the process of road investment location is defective way of spatial planning, especially disregarding the natural conditions to the sufficient degree. Reliable process of environmental impact assessment is the most important instrument for solving the problems. The most important factors that can help to alleviate the above described problems, collisions and conflicts, include first of all the increase of the legal importance of study on conditions and directions of spatial management of a municipality as well as legislative strengthening of the rank of eco-physiographic studies for the concept of spatial development of the country, including preparation of local development plans. Moreover, the EIA procedures should not be carried out by the same institutions or offices that performed the project or plan. It is also very important the liquidation of financial depend-

ency of the EIA report contractor and sometimes the EIA forecasts from the investor, which significantly affects the reliability and quality of the EIA documents. These studies should be financed by funds from the investor (representing e.g. a specific percentage of the investment project), collected, for instance, on sub-accounts of institutions reconciling the evaluated projects; and also these institutions, not investors, should choose the contractors for assessment (Kistowski, 2008). It seems reasonable to restore permissions, or the requirement of a proper experience and education in relation to contractors of EIA studies, in order to make them by persons with the appropriate preparation, for which disciplinary instruments could be used. It seems also important to increase the importance and rank of the opinion formulated by the National and Provincial Committees on Environmental Impact Assessment in relation to the location of major investments (e.g. large industrial plants, major transmission networks, motorways and express roads, water reservoirs, especially in the case of locations threatening Natura 2000 areas). Currently, members of these committees perform their functions, in principle, socially.

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# Buddhist Attitude towards Sustainable Development

## Postawa buddyjska a zrównoważony rozwój

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### Abstract

*Religion* plays a significant role in *Human Action*. *Buddhism* is one of the most important religions of India. There is an argument that, Buddha places emphasis upon a logical understanding of the cause of human suffering. He explains ignorance as the root link in the causal chain and, thus, shows the way towards Nirvana. Human suffering is not due to the devaluation of nature. It is due to the pain that is associated with the cycle of birth and rebirth. Hence, Buddhist philosophy is dysteleological in its nature. That's why it is hard to discuss *sustainable development* within the framework of Buddhist philosophy. In this paper, I have argued that Buddhist philosophy places a substantial emphasis upon sentient as well as non-sentient beings. Essentially, as per the Buddhist concept of Buddha-nature, I have argued that Buddha-nature is present in all sentient and non-sentient beings.

**Key Words:** Buddhist Philosophy, Sustainable development, Buddha-nature, Rebirth.

### Streszczenie

*Religia* odgrywa znaczącą rolę w kierowaniu *ludzka aktywnością*. *Buddyzm* jest jedną z najważniejszych religii w Indiach. Budda kładzie nacisk na logiczne zrozumienie przyczyny ludzkiego cierpienia. Wskazuje na ignorancję jako źródło w łańcuchu przyczynowym, a tym samym wskazuje na drogę do Nirwany. Ludzie cierpienia nie wynika z dewaluacji natury. Jest spowodowane bólem związanym z cyklem narodzin i odrodzenia. Stąd filozofia buddyjska ma charakter dysteleologiczny. Dlatego trudno dyskutować o zrównoważonym rozwoju w ramach filozofii buddyjskiej. W tym artykule przedstawiam argumenty za tym, że filozofia buddyjska kładzie istotny nacisk tak na bytu czujące, jak i nie-czujące. Zasadniczo, zgodnie z buddyjską koncepcją natury Buddy, Budda-natura jest obecny we wszystkich bytach czujących i nie-czujących.

**Słowa kluczowe:** filozofia buddyjska, rozwój zrównoważony, Budda – natura, odrodzenia

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### Introduction

People started using the word *Sustainable Development* when the International Union for the Conservation of Nature and Natural resources presented the *World Conservation Strategy* (Baker, 2006, p. 18) in 1980. The aim of the strategy was to give importance to sustainable development through the conservation of existing resources. The World Commission on Environment and Development published its report entitled *Our Common Future*, which is also known as Brundtland Report, in 1987. This report links sustainable development to social, economic and ecological dimensions (Baker, 2006, p.19). It lays stress

upon Human Good-will for the well-being of both the present and future generations.

Religion plays a very significant role, in varied ways, in sustainable development. It influences human behaviour or gives support to the belief system. It encourages the progress of human condition for a better world. *Human behaviour towards nature is deeply conditioned by religion* (White, 1967, p. 1205). When religion argues that God has created everything in the world or when religion says that God is omnipresent, the followers tend to respect all sentient and non-sentient beings. However, when religion is more human centric then it contributes towards the devaluation of nature. Lynn White Jr. ar-

gued that the western religion, which is anthropocentric in form, was the root cause of the ecological crisis (White, 1967, p. 1205; Edelglass, 2009, p. 428). This is the prime reason of the degradation of relationship between the human and natural world. Religion influences human action and belief system significantly. Therefore, religious teachings, to a great extent, can affect the harmony between the human and natural world. Sustainable development focuses upon human belief system and behaviour towards the natural resources. There are two different perspectives for understanding this development. *First*, there is the standpoint of anthropocentrism which accords more importance to human life. The theory says that human life has a greater significance than all other living and non-living entities. Therefore, human beings can use other living and non-living entities for their own development. *Second*, there is egocentrism which gives equal importance to all living and non-living beings. For the purposes of this paper, both perspectives are significant. In the first part of the paper, there is an elucidation upon the viewpoints of a few scholars. These intellectuals argue that Buddhist thought places emphasis only upon human problems and their solution. Therefore, Buddhist philosophy is dysteleological in nature (Harris, 1995). In the second part of the paper, I have argued that there are possibilities to bring the notion of sustainable development within the Buddhist framework.

### Buddhism and Ecology

Buddhism started as an ethico-religious system and placed more emphasis upon the moral fact of suffering and the painful nature of life. It explained that suffering is necessarily associated with a causal factor. Otherwise, there would be no way out. So, there is a need to search for its genesis. Buddha explained that suffering is due to craving, which is itself due to ignorance. Ignorance exists as regards the real nature of things. Buddha had a practical (also spiritual) goal, namely, *Nirvana*. The main objective of Buddhist philosophy is to get rid of the sufferings and sorrows of life, which are caused by desires and attachment. In order to get rid of the root cause of suffering, namely, desires and attachment, Buddhism puts forth the need to give up the belief in the body-soul dualism. It, therefore, provide us with an extensive analysis of mind. Buddha maintained silence with regard to the questions of the existence of soul. He did not want to make a commitment to the ontological position of the eternality of an enduring soul. He, instead, presented an analysis of human person *per se*, as an existential being. His main concern was to pave way for *Nirvana*, the cessation of suffering, without making a metaphysical commitment in the reality of the self or soul. We will, further, elucidate upon the Buddhist notion of rebirth in next section. The important point, here, is that Buddhist teachings

focus upon human suffering and emphasize upon the total extinction of suffering. Buddha gave the four noble truths as his basic philosophy. Four Noble truths are all about suffering and its extinction. For Buddhism, the attainment of Nirvana is the prime purpose of life. Buddhist response on the question of reality of external world is that the external world exists due to our ignorance. The philosophy of the wheel of existence brilliantly explains the cycle of birth and rebirth without any reference to an eternal self. Here, Buddha shows that, ignorance is the root cause of all suffering. Scholars argue that Buddhist philosophy provides immense motivation for the extinction of ignorance and attainment of the state of liberation. Notwithstanding, it barely provides any encouragement for right action, as an attempt to save the natural world or for sustainable development. Lambert Schmithausen in his paper, entitled *The Early Buddhist Tradition and Ecological Ethics*, writes that Early Buddhist theory does not motivate us for preserving natural or sustainable development. It propels us only towards the desire and endeavour to liberate oneself from sorrow (Schmithausen, 1997, p. 11). Let us try to understand the argument through a diagram.

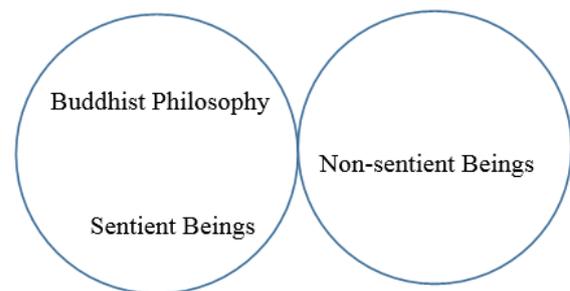


Figure 1. Early Buddhist Philosophy and Sentinent Beings versus Non-sentinent Beings

The above figure clearly shows that Buddhist teaching is intended purely for the sentient beings. Schmithausen writes that the idea of mutual dependence or inter-connectedness or interrelatedness of all things is not mentioned in the early Buddhist texts (Schmithausen, 1997, p. 13). Ian Harris has also argued that Buddhist philosophy follows the anthropocentric tradition, which is solely devoted to the liberation of human beings from suffering (Harris, 1995). He points that, Ian Harris has argued that, dysteleology is deeply rooted in Buddhist thought. Therefore, one cannot talk about environmental ethics within the Buddhist framework. He believes that it is very hard to decipher the Buddhist approach towards the natural world. We find it quite difficult to discuss the problem of global warming or decrease in the diversity of species from the Buddhist point of view (Harris, 1994, p. 53). In the next section of this paper, we will elucidate upon the notion of Buddhature and argue that Buddhism is a fertile resource

for the philosopher, who is seeking a theoretical background for sustainable development.

### The Notion of Buddha-nature

*Tathagatagarbha* tradition holds that *Tathagatagarbha* is one's true self. It means the womb or embryo of the *Tathagata* (Gethin, 1998, p. 251; Harvey 2013, p. 139). The *Lankavatara Sutra* notably and influentially asserts that *Tathagatagarbha* must be understood as Buddha-essence or Buddha nature with the substratum as consciousness (*alaya-vijnana*). *Mahaparinirvana Sutra* teaches that there exists a real permanent element in the sentient beings and this element enables sentient beings to become Buddha. According to Buddhism, pure Buddha nature (*tathagatagarbha*) is present in all beings and, therefore, all are potential Buddhas. In other words, *Tathagatagarbha* must be understood as the Buddha essence, which is present in all sentient beings (Harvey, 2013, p. 139). It means that Buddhist thought sees Buddha essence as the seed-potency, in every sentient being, which can be cultivated by following a proper path. Here, it is very significant to note that, the word *Buddha* means a person who has awakened from the sleep of ignorance and has gained perfect knowledge. To further clarify, when we talk about Buddha nature it means that all sentient beings have the Buddha essence or all sentient beings have the capability to achieve the state of Buddha by following the right path. Some Buddhist scholars have also argued that Buddha-nature is also present in the non-sentient beings. William Edelglass in his work, entitled *The Ecological Self*, writes that, for some of the Buddhist traditions, Buddha essence is not only present in the sentient being but also in the non-sentient nature (Edelglass, 2009, p. 429). Ruben L. F. Habito, in his work entitled *Environment of earth sangha: Buddhist perspectives on our global ecological well-being*, has mentioned how the Japanese Buddhist thinker, Annen, in the tenth century, and his followers, in the Tendai tradition, have given significance to even grass and tree. Tendai tradition argues that grasses and trees can also attain Buddhahood (Habito, 2007, p. 143). Thus, we can argue that the Buddhist tradition gives equal importance to nature and also raises our spirit for sustainable development. Here, it is significant to note that, the Mahayana Buddhist thought argues not only for the liberation of the self but also for the liberation of others. The concept of Bodhisattva, which essentially includes compassionate love, becomes significant here. Bodhisattva helps others achieve the state of Buddhahood. The vows of Bodhisattva consist in helping others get rid of their suffering. A person who aims at attaining full Buddhahood is called Bodhisattva (William, 2009, p.55). In other words, one who has apprehended the problem of suffering or the four noble truths of Buddha, and wants to attain the state of Buddhahood is called Bodhisattva. We need

to understand that this is not a simple desire. One needs to take a vow, to be reborn, in order to attain the state of Perfect Buddhahood (William, 2009, p. 55). Bodhisattvas generate infinite compassion not only for all the sentient beings in the present time, but also future generations. Therefore, a person who is seeking ultimate happiness, or Nirvana or wants to attain the state of Buddhahood, has to essentially remain concerned about the natural resources of the future generations. The idea of rebirth is, also, a strong argument in the favour of Buddhist thought giving due significance to sustainable development.

Buddhism does not believe in an eternal self. Buddha argues that a changeless self is not a substantial entity and elucidates upon the notion of mind and body. He argues that mind is not self, but just a word that represents all the activities of the body. Buddhism also says that, in order to achieve Nirvana, one has to exhaust all inclinations. For this, one life is not enough. As mentioned above, in order to attain Nirvana, one needs to go through the cycle of birth and rebirth until the attainment of Buddhahood. While explaining dependent origination, Buddha brilliantly expounds upon the problem of birth-rebirth without any reference to an eternal soul. He explains that ignorance is the root cause of suffering. Buddhism inspires us to understand the problem of suffering and walk towards the state of Nirvana. Dependent origination shows ignorance as the root cause of the cycle of the birth and rebirth. Buddhist notion of rebirth gives us ample reason to think about sustainable development. If man is not involved with creating awareness for self as also others, about the problem of devaluation of nature, then mankind will, soon, have nothing to save for the future generations. We, therefore, need to be concerned about the resources that are essential for the well-being of future generations. Dalai Lama argues that the idea of rebirth gives us one reason to have a direct concern with the future generations (Gyatso, 2007). He writes that one should not exploit nature. Swearer writes that Buddha-nature provides a basis for unifying all existent entities in a common sacred universe (Swearer, 2001, p. 230). Buddhist environmentalists also argue that Buddha has given importance to nature because Buddha was born, attained enlightenment as also died under the trees (Swearer, 2001, p. 232). Therefore, the existence of tree and nature is pertinently linked to salvation. We, thus, have enough evidence to believe that the notion of sustainable development can be discussed within the Buddhist framework.

Buddha's profound belief in promoting common good and interest, mutual welfare and wellbeing, nobility of life and its perfection justifies his great compassion for humanity. Out of these sublime truths, Buddha evolved a genuine code of ethics and morality, the practical side of his philosophy, in the form of a simple yet practical system of human life. These are the five noble precepts known as *Pancasila*, which are considered as the basic teaching of Bud-

dha and are accepted by all schools of Buddhism. They are:

- (1) not to kill,
- (2) not to steal,
- (3) not to tell lies,
- (4) not to live immoral life and
- (5) not to consume intoxicants.

Among the five noble precepts, the first holds great significance for the purposes of this paper. It is non-violence or not-killing which is known as *ahimsa*. It is the prominent and common concept in all Indian religions. It includes positive love in the form of compassion and friendship towards all beings in thought, word and deed. Buddhism prohibits killing in any form. Life is dear to all creatures. All living beings, irrespective of age, sex, size – from the time of their conception in their mother's womb, are included within this precept's fold. The precept wards off any scope for, recent ethical issues of concern like the, devaluation of nature. In this connection, His Holiness Dalia Lama writes that although we do not believe that tress or flowers have minds, we treat them also with respect (Gyatso, 2007; Habito, 2007, p. 136). Therefore, one should not exploit nature gratuitously (Gyatso, 2007).

### Conclusion

Religion always plays an important role in the progress of social well-being. Buddhist philosophy is a fertile source for the theoretical support of sustainable development. The Buddhist notion of rebirth is essentially linked with the concern about the future generations and the resources for their well-being. Therefore, Buddhist thought not only talks about the liberation of all sentient beings but also warns against unethical human action towards the natural world. Buddhist spiritual beliefs and practices contribute towards, or in the least encourage, right action for sustainable development.

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Annually two issues are published.

*Problemy Ekorozwoju/Problems of Sustainable Development* represents social sciences. Every paper should refer to the basic paradigms of sustainable development. We also prefer international comparisons than local studies.

Scope of the journal:

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The magazine publishes original papers not longer than 20 pages (40 000 characters) as well as reviews and letters no longer than 5 pages (10 000 characters).

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