Dynamic Effects of Sustainable Development Activities in the Air Quality for Selected Countries

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Abstract:

Purpose: The assessment of the linear trend coefficient plays a key role because it indicates how much the studied phenomenon has changed on average over a unit of time, i.e., five years in this study. On the basis of this coefficient, an analysis of the dynamics of individual parameters determining the degree of air pollution in the examined countries was conducted.
Approach/Methodology/Design: For the purpose of the analysis of the dynamics of the effects of sustainable development measures in the area of air quality for selected countries of Central and Eastern Europe, the assessment was made using a linear trend model. The analysis of the dynamics of downward trend of individual indicators was carried out on the basis of the values of parameters b and the graphs of the linear trend models.
Findings: The analysis showed that given the level of air pollution by greenhouse gases, it is clear that the worst situation is in the Czech Republic, as shown by the highest chart of the linear trend model with a time series. The smallest air pollution from greenhouse gases is in Hungary. PM 2.5 pollution is highest in Poland and lowest in Slovakia. The same situation occurs in the case of PM 10 dust pollution.
Practical Implications: Identify the places where there is the highest level of air pollution in order to propose studies to reduce it.
Originality/Value: Originality indicates the use of non-implemented analysis results to precisely identify the most polluting countries and the least polluting ones.

Keywords: Analysis, dynamics, sustainable development, air quality.

JEL classification: Q01, Q53, L93, R13.

Paper Type: Research study.

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1. Introduction

The current standard of living of mankind is possible thanks to the exploitation of natural capital on an unprecedented scale. Meeting the needs of the 7 billion inhabitants of the Earth is associated with increasing interference in its condition. Human activity is currently one of the most important factors influencing the global carbon and nitrogen cycles. This increases uncertainty about the future of our planet. In addition, some decisions at regional level concerning the management of natural resources lead to disasters, such as: exploitation of lowlands, degradation of agricultural areas. All this shows that we are not able to predict future developments and control the effects of our actions (Jones, 1999).

The concept of sustainable development appeared over two decades ago as an attempt to create a framework for development management. It was understood that the mistakes of the past were caused by too limited visions and goals. Development aimed at maximizing economic and political profits led to environmental, social and even economic crises. In response, societies are seeking solutions to alleviate the immediate symptoms of problems, focusing only on economic recovery (Beirlant *et al.,* 2007). In this way, they fall into the trap, as measures aimed at short-term effects rarely succeed in the long term. Sustainability allows to bypass these traps by integrating three areas: economy, society and environment. Although this concept sounds convincing, there are difficulties in disseminating and implementing it. Much more often solutions are chosen that ensure rapid economic or political returns and lead to immediate results.

An additional challenge in implementing sustainable development is to change our habits related to existing social, psychological and physical structures. Sustainable development requires a change in perceptions in order to use innovative tools and methods. It turns out that both in business and in local governments, actions for sustainable development should be based on a transparent management structure, defining programmes and indicators of their implementation. In business, such a system may refer, inter alia, to the direct and indirect aspects described above, related to the environmental impact of the product. In local governments, it is linked to other areas of planning, which for environmental and social reasons should take into account higher density and use of specific resources. It is important to cooperate in the implementation of tasks in the field of sustainable development, alongside the cooperation of business and local governments with the local community and individual people from the business world (Karjust, Pohlak and Majak, 2010).

2. Selected Aspects of Sustainable Development

Sustainability means a way of governance where the needs of the present generation are met without compromising the chances of future generations to meet their needs. Sustainable development is based on the natural environment, the economy is a tool, and the welfare of society is its goal (Albareda *et al.*, 2006). In accordance with UN

standards and documents "Sustainable Earth development is development that meets the basic needs of all people and protects, protects and restores the health and integrity of the Earth's ecosystem, without compromising the ability of future generations to meet their own needs and without exceeding the long-term capacity limits of the Earth's ecosystem" (Bourdrel *et al.*, 2017).

The concept of sustainable development originates from forestry, where it originally meant managing the forest in such a way that it will never be eradicated, i.e. cutting down only such a number of trees that will allow it to be renewed in the future. We can see that as many as 193 United Nations member states have reached agreement on the final document of a new sustainable development agenda entitled Transforming our world: Agenda for Sustainable Development - 2030, which contains 17 goals and 169 tasks to which they belong (Burke and Stephens, 2018):

- ➢ eradicate poverty in all its forms worldwide;
- ➢ combat hunger and achieve food security and better nutrition and promote sustainable agriculture;
- ➢ ensuring a healthy life for all people of all ages and promoting prosperity;
- ➢ providing quality education and promoting lifelong learning;
- ➢ to achieve gender equality and empower women and girls;
- ➢ to ensure access to water and sanitation for all people through sustainable water management;
- ➢ ensure access for all to stable, sustainable and modern energy at an affordable price;
- ➢ promote stable, sustainable and inclusive growth, full and productive employment and decent work for all people;
- ➢ build stable infrastructure, promote sustainable industrialisation and support innovation;
- ➢ reduce inequalities within and between countries;
- ➢ make cities and human settlements secure, stable, sustainable and inclusive;
- ➢ ensure sustainable consumption and production patterns;
- ➢ take urgent action to combat climate change and its effects;
- ➢ protect and use the oceans, seas and marine resources in a sustainable manner;
- ➢ protect, restore and promote the sustainable use of terrestrial ecosystems, sustainable forest management, combat desertification, halt and reverse soil degradation and halt biodiversity loss;
- ➢ promoting peaceful and inclusive societies, ensuring access to justice for all and creating effective and accountable institutions of an inclusive nature at all levels;
- ➢ strengthen implementation measures and revitalise the global partnership for sustainable development (Girardon, 2019).

With regard to a given development, the implementation phase of sustainable development can be revised where a country or region is located using a specific methodology. For this purpose, sustainable development indicators are used.

They shall be ordered. Management must be coherent. The integrity of management shall be achieved through sustainable protection of the environment, social and human capital and anthropogenic man-made capital, in particular cultural and economic capital. Table 1 below shows national sustainable development indicators by commodity: (Dörre, Gerstl and Seiffert, 1999; Park, Meng and Baloch, 2018).

Table 1. *National sustainable development indicators by commodity*

National sustainable development indicators by commodity	
Social order	**Economic governance**
Demographic change	Economic development
Public health	Employment
Social inclusion	Innovation
Education	Transport
Access to the labour market	Sustainable production models
Public safety	
Sustainable consumption patterns	
Environmental charitable activities	**The institutional and political order**
Climate change	Global partnership
Energy	Cohesion and efficiency policy
Air protection	Openness and participation
Marine ecosystems	Active citizenship
Fresh water resources	
Land use	
Biodiversity	
Waste management	

Source: *Own study.*

Sustainable development is enshrined in the Constitution of the Republic of Poland, its Article 5 reads: "The Republic of Poland shall protect the independence and inviolability of its territory, ensure the freedoms and rights of humans and citizens and the security of its citizens, protect its national heritage and ensure the protection of the natural environment, guided by the principle of sustainable development". The factors indicating the need for sustainable development are indicated in Table 2 (Wojtaszek and Miciuła., 2019; Reis *et al.*, 2018). Factors indicative of sustainable development are as follows:

➢ limiting the use of renewable resources to the limits set by their recovery capacity;
➢ to limit the use of non-renewable resources on a scale allowing for their gradual replacement by appropriate substitutes;
➢ to phase out hazardous and toxic substances from economic processes;
➢ to keep pollutant emissions within the limits set by their capacity to assimilate the environment;
➢ to restore and permanently protect biodiversity at landscape, ecosystem, species and gene levels;
➢ to socialise decision-making on the local environment;

> ➤ to strive to provide citizens with a sense of security and well-being, as understood as creating conditions favourable to their physical, mental and social health.

3. Indicators of Sustainable Development in Terms of Air Quality

European Environment Agency (EEA), together with EIONET, continuously monitors the state of the environment in Europe and provides policy makers and the public with up-to-date information. In a recently published document "Knowledge for a sustainable Europe" The Agency prepared a short summary describing the current status of the selected indicators. It shows, inter alia, the pace of change and the extent to which they correspond to the objectives and commitments made by European countries for sustainable development (Guerreiro, Foltescu and de Leeuw, 2014). In a brief overview EEA draws attention to the following issues relating to sustainable development:

- Climate change - Progress in adapting to and mitigating climate change,
- Environment - Biodiversity and water use,
- environmental pollution and health,
- resource efficiency and the food system,
- Opportunities for change: promoting innovation, costs of change,

Sustainable development objectives as a policy framework for action are good quality of life given the limitations of our planet:

- protecting, preserving and improving the quality of the Union's natural capital;
- to transform the Union into a resource-efficient, green and competitive low-carbon economy;
- to protect Union citizens from environmental pressures and threats to health and quality of life.

The EEA used 29 indicators to analyse progress towards these 3 priority objectives. This is the third edition of the annual report on environmental indicators of the European Environment Agency (EEA) - to support the monitoring of the Seventh Environmental Action Programme of the European Union.

The 7th Environmental Action Programme 2014-2020 is the overarching strategic framework for planning and implementing EU environmental policy. It contains nine priority objectives, of which three thematic priority objectives are considered key. They have the following objectives:

1. to preserve, protect and enhance the Union's natural capital;
2. to transform the Union into a resource-efficient, green and competitive low-carbon economy;
3. to protect Union citizens from environmental pressures and threats to health and

well-being.

As with the first two editions, this report examines, using 29 indicators, whether the EU is on track to achieve the three thematic priority objectives (Burke and Stephens, 2018; Park, Meng and Baloch, 2018). Table 4 shows the EU priority objectives.

Table 4. *Priority objectives in the EU*

Priority objective 1	Priority objective 2	Priority objective 3
The EU's natural capital is not yet protected, maintained and strengthened in line with ambitions. The outlook for 2020 remains generally bleak for the chosen set of objectives related to this priority objective.	The outlook for 2020 shows mixed progress. The EU is on track to meet its climate and renewable energy targets, although it is uncertain whether the energy efficiency target will be met. Resource efficiency has improved. However, waste generation has recently increased and the environmental impact of production and consumption is uncertain for the housing sector and unlikely to decrease for the food sector and mobility.	The prospects for this target for 2020 are also mixed. Emissions to air and water have fallen significantly in recent decades. However, there are still major concerns about air quality and noise pollution in urban areas and chronic exposure of the population to mixtures of chemicals.

Source: *Own study.*

The overall progress with regard to the priority objective remains thematically similar to that shown in the scoreboards in the previous two editions of this report: positive and negative trends and prospects for all, and bleak prospects for priority objective 1. Nevertheless, the prospects for achieving some of the selected objectives under the priority objectives have deteriorated from year to year. Developments in these two perspectives for 2020 They have been maintained in this year's Scoreboard. The latest data show that ammonia emissions come mainly from agricultural production and continue to grow (Beirlant *et al.*, 2007).

Firstly, primary energy consumption (used here to measure progress in energy efficiency) increased both in 2015 and 2016. Initial estimates indicate that it also increased in 2017, reaching a level higher than the linear pathway necessary to reach the energy efficiency target by 2020. The prospects for achieving the 2020 energy efficiency target have therefore been changed from likely to uncertain.

Household energy consumption (used as an indicator to track progress in reducing the overall environmental impact of production and consumption in the residential sector) increased both in 2015 and 2016. Improvements in energy efficiency in the housing sector during these years were not sufficient to outweigh the increase in energy consumption. This makes the prospects for reducing household energy consumption during this period more promising. The prospects for the EAPs are uncertain. Therefore, this edition has changed the prospect of achieving this target, from being uncertain by 2020.

The third indicator relates to greenhouse gas emissions from transport (used as an indicator to track progress in reducing the overall environmental impact of production and consumption in the mobility sector), which increased year-on-year between 2014 and 2016. Preliminary estimates indicate that emissions also increased in 2017. It is therefore unlikely that there will be an overall decrease in greenhouse gas emissions from transport over this period.

Implementation of the EAP (2014-2020). As a result, this year's Scoreboard has changed the outlook for achieving this target from uncertain to unlikely by 2020. Waste generation increased between 2010 and 2016, in particular from 2014 onwards. As with the assessments in previous years' Scoreboards, the projections for waste generation up to 2020 remain uncertain, inter alia due to several data points available for assessment. Nevertheless, the risk that the EU will not reach this target by 2020 has increased.

For several other scoreboard indicators, under the three thematic priority objectives, the analysis showed a slowdown in the implementation of the time series in recent years. These developments do not currently imply an increased risk that the prospects for achieving the 2020 targets, which correspond to these indicators, will be reduced. This is because past progress has been sufficient for the EU to move in the right direction, or it is already clear that the targets will not be met (Bird, Wüstenhagen and Aabakken, 2002). The low level of economic activity in the EU after the financial crisis in 2008 contributed to several positive trends from the past as shown in the Scoreboard. However, relatively high economic growth in the EU in recent years has contributed to the recent slowdown in progress observed for several of the indicators examined (Park, Meng and Baloch, 2018).

4. Dynamic Effects of Sustainable Development Activities in the Air Quality for Selected Countries of Central and Eastern Europe

In this section, the authors analysed the dynamics of air pollution indicators in four selected Central and Eastern European countries in the years 2000-2015. The analysis used data on the level of greenhouse gas emissions (X_1), air pollution level of dust PM2,5 (X_2), and dust PM 10 (X_3). The variables are described in detail in Table 1.

Table 1. *Variables indicating air pollution levels of selected harmful substances*

Variable designation	Variable name
X_1	greenhouse gas emissions per capita in tonnes of equivalent CO_2
X_2	exposure of the urban population to dust contaminated air PM2,5 in micrograms on m^3
X_3	exposure of the urban population to dust contaminated air PM10 in micrograms on m^3

Source: *Own study.*

For each variable in each country, data were collected in four periods 2000, 2005, 2010 and 2015. As observations on the same variables in Table 1 were collected in each of the four countries, the authors introduced additional markings for the variables. In addition to the number of each variable, in the lower right index, a letter was used for each country Poland (P), Slovakia (S), Czech Republic (C) and Hungary (H). Thus, according to this nomenclature, the second variable for Poland adopted the following designation X_{2P}.

The authors have carried out the analysis of the dynamics of air pollution indicators using the method of linear trend models as one of the time series analysis methods. A linear trend model can be presented using the following formula:

$$Y_t = \beta_0 + \beta_1 t + \xi_t,$$
(1)

where: t means a time variable, β_1 end β_0 are the structural parameters of the model respectively the linear trend coefficient and the free expression, and ξ_t is a random component. A linear trend factor β_1, plays a key role because it indicates how much, on average, the studied phenomenon has changed over a unit of time, i.e., five years in the conducted study. On the basis of this coefficient, an analysis of the dynamics of individual parameters determining the degree of air pollution in the examined countries was conducted. The parameters of the trend model in formula (1) were estimated by the method of the smallest squares by matching the estimated trend model in simple form to the course of the empirical series. The estimated form of the model is given by the formula:

$$\hat{y}_t = b_0 + b_1 t$$
(2)

where: b_0 and b_1 means parameter estimators accordingly β_1 and β_0.

Table 2 lists the values of the estimators of parameters β_1 and β_0 in the second and third columns respectively. The fourth column contains the forms of the estimated linear trend models for individual variables in the four countries studied. The last column contains parameter b_1^*, which is one fifth of the estimator b_1 value. Since the value of the estimator b_1 determines the average change of the examined variable over a period of five years, the value of parameter b_1^* indicates how much the average value of this indicator has changed every year. Additionally, for the purpose of dynamic analysis of the examined indicators reflecting air quality in the examined countries, the time series of variables X_1 - X_3 are presented in Figures 1 - 3 together with the model of linear trends.

In interpreting the results obtained, it should be emphasised at the outset that for all air pollution indicators undertaken in each country the value of the β_1 parameter estimator has a negative value. This means that in all the countries studied there is a downward trend in the values of selected indicators reflecting the degree of air

pollution in the analysed period. On this basis, it can be concluded that the examined countries meet the objectives of sustainable development in the area of air quality. The results obtained will be analyzed in detail at the beginning of the assessment of the dynamics of the downward trend of individual indicators.

Table 2. *Parameters of trend models for individual variables*

| Variable	b_0	b_1	Model	b_1*
X_{1P}	11,25	-0,21	$\hat{y}_t = 11,25 - 0,21t$	-0,042
X_{2P}	30,15	-1,97	$\hat{y}_t = 30,15 - 1,97t$	-0,394
X_{3P}	42,85	-2,06	$\hat{y}_t = 42,85 - 2,06t$	-0,412
X_{1S}	10	-0,51	$\hat{y}_t = 10 - 0,51t$	-0,102
X_{2S}	23,35	-1,34	$\hat{y}_t = 23,35 - 1,34t$	-0,268
X_{3S}	34,05	-1,98	$\hat{y}_t = 34,05 - 1,98t$	-0,396
X_{1C}	15,85	-0,83	$\hat{y}_t = 15,85 - 0,83t$	**-0,166**
X_{2C}	28,3	-2,85	$\hat{y}_t = 28,3 - 2,85t$	**-0,57**
X_{3C}	35,5	-2,27	$\hat{y}_t = 35,5 - 2,27t$	-0,454
X_{1H}	7,9	-0,4	$\hat{y}_t = 7,9 - 0,4t$	-0,08
X_{2H}	22,6	-0,4	$\hat{y}_t = 22,6 - 0,4t$	-0,08
X_{3H}	41,4	-4,19	$\hat{y}_t = 41,4 - 4,19t$	**-0,838**

Source: *Own study.*

Figure 1. *Graphs of time series with matching linear trend models for variable X_1.*
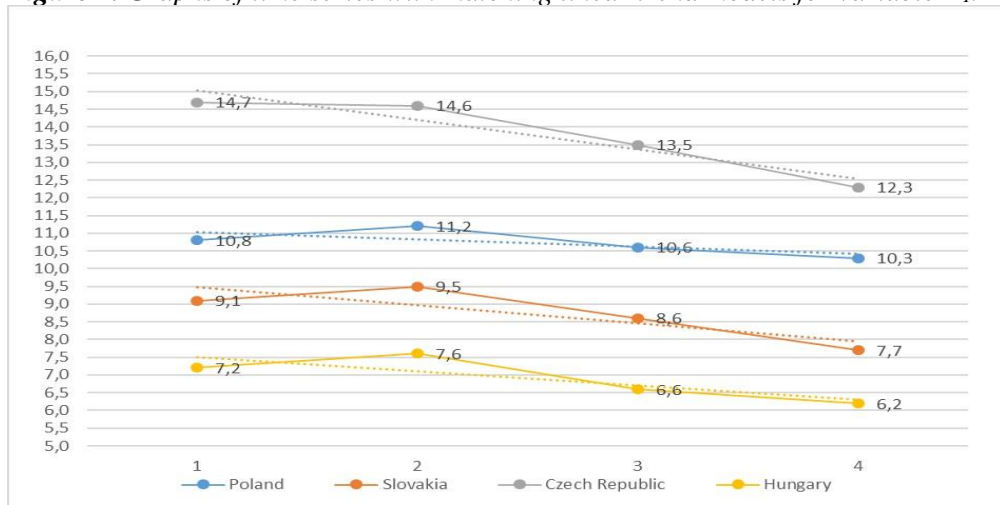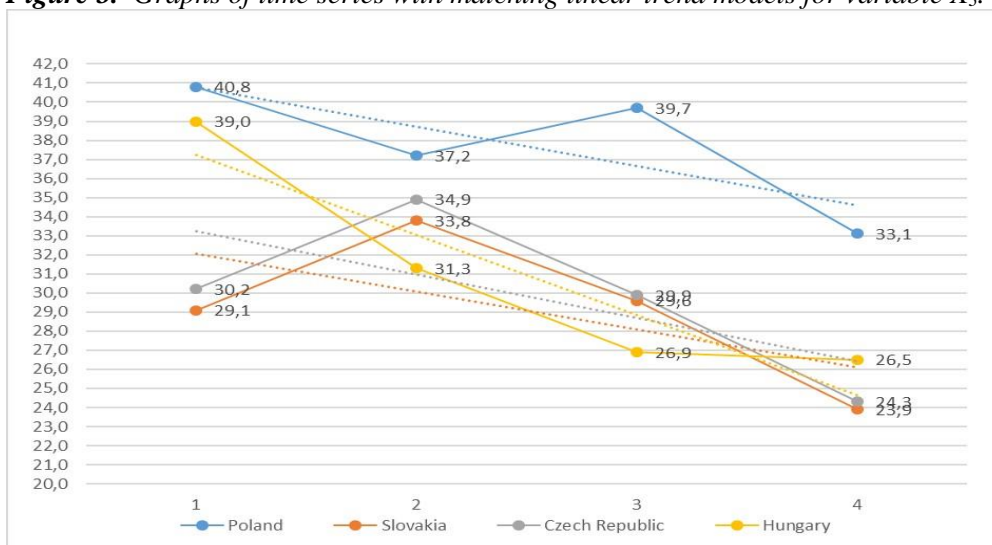

Source: *Own study.*

Figure 2. *Graphs of time series with matching linear trend models for variable X_2.*
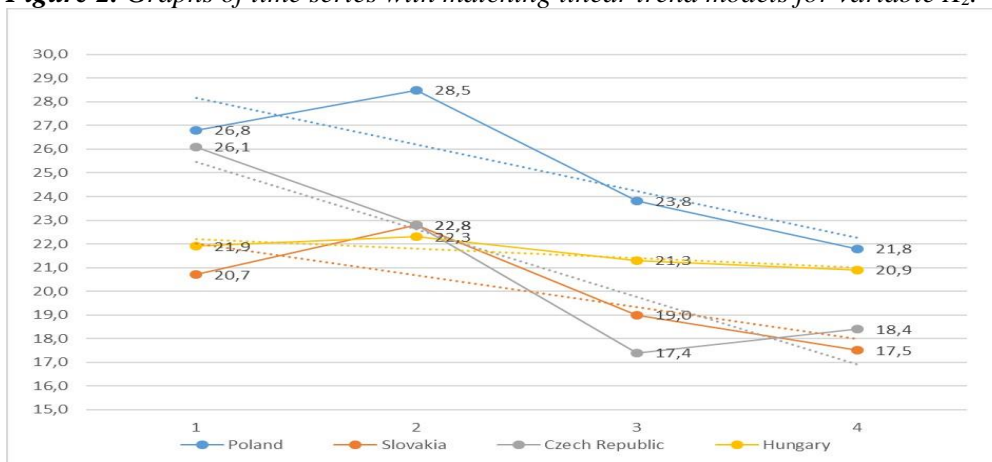
Source: *Own elaboration.*

Figure 3. *Graphs of time series with matching linear trend models for variable X_3.*

Source: *Own elaboration.*

The analysis of the dynamics of the downward trend of individual indicators was carried out on the basis of the values of parameters b_1* and charts of the viested linear trend models. The greatest downward dynamics of the index reflecting the level of greenhouse gas emissions (X_1) is observed in the Czech Republic. In the analysed period, on average, annual greenhouse gas emissions decreased by 0.166 tonnes CO_2 per capita. As regards air pollution by PM 2,5 (X_2) the greatest dynamics were also observed in the Czech Republic. On average, annually in this country, the level of PM 2.5 dust pollution decreases by micrograms per 0.57 m^3. The quickest fall in air pollution from dust PM 10 (X_3) was recorded in Hungary.

On average, the PM 10 dust pollution decreases annually in the analysed period by 0,838 micrograms on m^3. The conclusions described above are also confirmed by the graphs of the linear trend models shown (rys. 1-3). The slope of the linear trend model is the highest in the countries where the indicator shows the highest downward dynamics in the analysed period. It can also be said that in the Czech Republic, in the years 2000 - 2015, measures to improve air quality with respect to pollution by greenhouse gases and PM 2.5 dusts were the most effective in comparison to the other countries participating in the study. The most effective activities related to the reduction of air pollution with PM 10 are carried out in Hungary.

In the second step, the level of air pollution of particular substances in the analysed countries will be analysed. The analysis will be carried out on the basis of time series diagrams together with the model of rope trends (Fig. 1-3) and the values of parameter estimators β_0. Given the degree of air pollution by greenhouse gases it is clear that the worst situation is in the Czech Republic, as shown by the highest graph of the linear trend model with a time series (Figure 1). The smallest air pollution by greenhouse gases is in Hungary. PM 2.5 pollution is highest in Poland and lowest in Slovakia (Figure 2). The same situation occurs in the case of PM 10 dust pollution (Figure 3).

5. Conclusion

The analysis shows that everyone knows that sustainable land development is development that meets the basic needs of all people and preserves, protects and restores the health and integrity of the Earth's ecosystem, without compromising the ability of future generations to meet their own needs and without exceeding the long-term limits of the Earth's ecosystem.

However, more and more companies are taking action in the field of sustainable development, recognising its benefits, and not only in response to pressure from external stakeholders. One of the most obvious is the reduction of costs associated with saving energy and resources - leading to eco-efficiency. Eco-efficiency can apply to production as well as to buildings erected and used by businesses.

According to the authors, as long as there is no uniform introduction of hard sustainability rules for all companies, there will always be companies that are better for customers in terms of price, because they will save on the introduction of sustainable development. Analysing sustainability reports in Europe, we can see that less developed countries are trying to catch up with the best, which further increases the pressure on the environment. According to forecasts, these cumulative effects will lead to even greater environmental degradation and at the same time have a negative impact on human health and life. It is therefore important that further economic development is at least environmentally neutral. Overall progress towards the priority objective remains a topic.

In today's world, the effects of sustainable development activities are very important. Ensuring the highest air quality is important worldwide. There have been some undisputable situations around the world indicating global carbon and nitrogen cycles that lead to air quality pollution.

Primary energy consumption and household energy consumption have increased, as well as greenhouse gas emissions, which have a significant impact on air quality. For the purpose of assessing the dynamics of the effects of sustainable development measures in the area of air quality for selected countries of Central and Eastern Europe, an assessment was made using a linear trend model.

The assessment of the linear trend coefficient from the point of view of the authors of the studies plays a key role because it informs about how much, on average, the examined phenomenon changed over a unit of time, i.e. five years in the conducted studies. On the basis of this coefficient, an analysis of the dynamics of individual parameters determining the degree of air pollution in the examined countries was conducted. The analysis of the dynamics of downward trend of individual indicators was carried out on the basis of the values of parameters b1* and graphs of the selected linear trend models.

The analysis showed that, taking into account the degree of air pollution by greenhouse gases, it is clearly visible that the worst situation is in the Czech Republic, which is illustrated by the highest graph of a linear trend model with a time series. The smallest air pollution by greenhouse gases is in Hungary. PM 2.5 pollution is highest in Poland and lowest in Slovakia.

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