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The scientific discourse on the concept of sustainable development

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Abstract

The paper focuses on key questions relating to the concepts of development, sustainability and sustainable development, and also presents the Sustainable Development Goals (SDGs) and the associated discussions regarding its complementarities and benefits. It took more than 40 years for the SD concept to take shape and turn into a global agenda. On the other hand, there is still no formalized description of a sustainable or monitoring system, of the requirements necessary for the development criteria and measures. The aim of this article is to contribute by providing concise data about its SD concept evolution, principles and their implications for the global, national and individual actions aimed to achieve SD. From the angle of a future view on sustainability, the paper reinterprets the information field, significance of the ecological economics concept (monographic method) and further elaborates on the spatial-temporal energy flows (power) approach for monitoring the socio-economic system development.

Keywords: Sustainable Development Goals (SDGs), sustainability, ecological economics, regional economic, flows of energy

Introduction

According to a United Nations recommendation in 1987, "most countries in the world adopted the Guiding Principle for Sustainable Development according to which civil society and the state have a responsibility to ensure comprehensive security and the ability to meet both current and future needs of generations.

Ensuring security in the transition to a sustainable and innovative development path is based on effective design and management through new, more advanced and effective ideas, projects and technologies, the general category of which is the

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concept of "innovation" (Schumpeter, 1982). The concept of sustainable development (SD) has attracted widespread attention and remained in the comprehensive development trend for a long period. However, despite its popularity and growing interest in the concept, people continue to ask questions related to its definition and to what it implies.

In an attempt to go beyond sustainability disputes and implement a more meaningful sustainable development agenda, it is necessary to precisely define this concept and clearly explain its main dimensions.

While it is undeniable that there is a wealth of literature on SD, some questions about the definition, history, pillars, principles, and their implications for human development are still unclear to many people. Thus, it is important to clarify the uncertainties about SD, as "decision-makers need the best data and information on the links between SD principles and pillars, but also for the better understanding of such links and their impact on the performance of human development" (Hylton, 2019).

The aim of this article is to systematize data and promote the concept of SD by providing concise information on its meaning, development, related key concepts, measurements, relationships between dimensions, principles and their impact on the global, national and individual activities in search of SD. From the angle of a future view on sustainability, the paper reinterprets the information field, significance of the ecological economics concept (monographic method) and further elaborates on the spatial-temporal energy flows (power) approach for monitoring the socio-economic system development.

The first part of the paper focuses on key questions concerning the concepts of development, sustainability and sustainable development and analysis of the 'Sustainable Development' definition. The second part focuses on the description of sustainable development pillars and some alternative development. The third part presents the models of economic, social, environmental and cultural sustainability and alternative directions. The fourth, fifth and sixth parts of the paper present the Sustainable Development Goals (SDGs) and the associated positive and critical discussions regarding the complementarities, benefits, and what can be done to achieve the SD. The seventh part formulates the main principles of ecological economics, the systematic concept of the "nature - society - human" and spatial-flows approach. In accordance with the provisions mentioned above, and the concept of ecological economics and to formalize the sustainable development tasks, in the eighth part, we consider the methodology of managing sustainable development by using the concept of flows of full and useful power in open, non-equilibrium stable systems and the spatial-power approach. The ninth part presents the main conclusions of the paper.

1. The concept of sustainable development

1.1. The concept of growth

What is growth? As a first approximation, this is a simple increase in the amount of something, in the number of someone or something. Economic growth is a quantitative change - an increase in the production and consumption of the same goods and services over time. In economics, there are two main directions of theories of economic growth: the neo-Keynesian and the neoclassical ones and, accordingly, two types of models that characterize it. The neo-Keynesian direction arose based on the ideas of J.M. Keynes about the relative instability of the capitalist economy and macroeconomic equilibrium. The neoclassical direction is rooted in Adam Smith's views on the self-regulation of the market economy, the factor theory of J.-B. Say (Spithoven, 1996) and John Bates Clark's theory of marginal productivity (McCain, R., 2013) of economic factors.

For the Keynesian theory, the central problem of macroeconomics relates to the factors that determine the level and dynamics of national income, as well as its distribution to consumption and savings. It is with this that Keynes linked the volume and dynamics of national income, the problem of its implementation and the achievement of full employment. The more investments, the smaller the consumption today and the more significant the conditions and preconditions for its increase in the future.

Among the neo-Keynesian models in economics, the most famous are those of economic growth created by the English economist R. Harrod and the American economist of Russian origin Y. Domar (Sato, 1964), which explains the connection between today's savings and tomorrow's investments and growth provided that the marginal productivity of capital and the saving rate are constant in the long run.

At the center of the neoclassical direction is the idea of equilibrium based on an optimal market system, considered as a perfect self-regulating mechanism. In the real economic life of society, this balance is violated.

A significant contribution to the development of the theory of economic growth was made by the American Nobel Prize laureate, R. Solow, who modified the production function of Cobb-Douglas by introducing another factor - the level of technology development (Solow, 1994).

Currently, the concept of "economic development without growth" or "zero economic growth" has become widespread. In addition, the supporters of this concept believe that economic growth leads to disruption of the biosphere of human life and is limited due to the planet's lack of raw materials and fuel resources.

Pestel and Mesarovic (Pestel,1989) believe that it is necessary to change the growth trends, introduce restrictions on the use of natural resources, and environmental pollution. With the help of modern technology, it is possible to mitigate the tension between growing needs and limited resources.

Along with Paul M. Romer (1990), Robert E. Lucas (1988) is the founder of a new theory of economic growth known as the Lucas-Romer model. According to this model, the main factor of economic growth is the growth of investment in R&D and in human capital. One of the implications of the Romer and Lucas models is that an economy with human capital resources and advanced science has a better chance of growth in the long run than an economy without these advantages.

Krugman and Fujita (2004) introduces the achievements of New Trade and New Growth Theory into the traditional location theory, and puts forward a new location theory, which is called New Economic Geography. Krugman defined the New Economic Geography as the location theory of production, which is proposed to explain the mechanism of formation and evolution of the economic spatial structure. Krugman's new Economic Geography is based on the main idea that there is a multiple equilibrium state in the development of economic spatial structure.

1.2. The concepts of development

Development is defined as the process of evolution in which human capacity increases as new structures are created, coping with challenges, adapting to constant change, and purposefully and creatively pursuing new goals (Du Pisani, 2006). Economic development is a positive qualitative change, innovation in production, products, services, management, the economy as a whole - that is 'innovation' (Schumpeter, 1982).

Several theories have explained the concept of development. These include theories of modernization, dependency, the world system, and globalization. The modernization theory (Huntington, 2017) aims to improve the living standards of traditional societies through economic growth achieved by introducing modern technologies.

The theory of dependence (Ballance *et al.*, 2003), based on the Marxist ideology, refutes the modernization theory principles and argues that, in developed countries, industrialization tends to subject poor countries to underdevelopment due to the economic surplus of poor countries used by developed countries. However, the theory fails to determine the dependence of the least developed countries on the metropolis. The theory of global systems argues that the specialization of international trade and the shift of resources from the periphery (least developed countries) to the main areas (developed countries) stifle development at the periphery, forcing them to rely on major countries (Petras *et al*., 2017). The theory of world systems (Wallerstein, 2011) perceives the world economy as a hierarchy of international inequalities. This contrasts with the classical Marxist theory, which suggests that the surplus arises from the relationship between capital and labour which exists in 'production' itself. The theory of the world system has been criticized for placing too much emphasis on the world market while neglecting the forces and relations of production. (Petras *et al*. 2017). Similar to the theory of the world system, the theory of globalization (Held, *et*

al., 1997) arises from global mechanisms that promote deeper integration of national economic transactions (Portes and Vickstrom 2012). Therefore, open and convenient communication between countries has created the basis for cultural homogenization, thus creating a unified global society (Waks, 2006). According to Mensah (2019), globalization is supported by political, economic, technological and socio-cultural factors and trends. Although development theories have weaknesses, they have paved the way for current concepts and paradigms of global development, namely 'sustainability' and 'sustainable development' (SD).

1.3. Sustainability

In general, sustainability means the ability to sustain an entity, outcome, or process over time (Basiago, 1998). However, most academics, researchers and practitioners (Tjarve and Zemite, 2016) use this concept to refer to the development and maintenance of an economic, ecological and social system for human development. Dodds *et al.* (2016) defines sustainability as the efficient distribution of resources between generations through the operation of socio-economic activities within a limited ecosystem. Ben-Eli (2018), on the other hand, sees sustainability as a dynamic balance in the process of interaction between the population and the capacity of the environment, so that the population develops to express its full potential without adverse effects on the capacity of the environment. From this perspective, Tjarve and Zemite (2016) continue to argue that sustainability focuses on human activities and their ability to meet people's needs and desires without destroying the productive resources at their disposal. It, therefore, raises questions about the way people should manage their economic and social lives, using the available ecological resources for human development. Hák *et al.* (2016) argued that transforming the global society, environment, and economy into a sustainable direction is one of the highest challenges faced today, as it must be done in the context of the planet's capacity.

Continuing the argument for innovative approaches, UNSD[1] considers that the main goal of the concept of sustainability is essentially to ensure an appropriate balance between society, the economy and the environment in terms of the planet's resilience and life-supporting ecosystems. Based on the above, modern sustainability theories seek to prioritize and integrate social, environmental and economic models into solving human problems in a way that will continually benefit people.

Environmental models focus on the biodiversity and ecological integrity. Social models seek to improve, inter alia, the political, cultural, religious, health and education systems in order to continuously ensure human dignity, well-being (Acemoglu *et al.*, 2019) and sustainable development in this regard. According to

[1] United Nations Statistics Division (UNSD) (2018), https://unstatsundesa.opendata.arcgis.com. Access: 15.11.2015.

Bolshakov *et al.* (2019), sustainability is what is maintained in a system regardless of the changes that take place in it. The rule of sustainability is the law of conservation. In this sense, sustainability is an invariant of the system.

1.4. Sustainable development

The most frequently mentioned definitions of SD are given in Table 1. The first was proposed by the Brundtland Commission report (Brundtland, 1987) as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. Structurally, the concept of SD can be seen as a phrase consisting of the words 'sustainable' and 'development', on the one hand, and 'necessity' and 'opportunities', on the other. Just as each of these words, which come together to form the concept of SD, is defined differently from different perspectives, so the concept of SD is viewed from different angles, leading to a plethora of definitions of the concept (see Table 1).

Table 1. Analysis of the definition 'Sustainable Development'

Author	Cita-tion	Definition	Key words
Brundtland, 1987	120	Sustainable development is development that meets the needs of the present without danger for the ability of future generations to meet their own needs.	The ability to meet the needs. Generations
Basiago, 1998	180	Sustainable development is regarded as tantamount to a new philosophy, in which principles of futurity, equity, global environmentalism and biodiversity must guide decision-making. 'Sustainability' has emerged as a universal methodology for evaluating whether human options will yield social and environmental vitality. Sustainability means a capacity to maintain some entity, outcome or process over time.	Economic Environmental Social system
Schaefer *et al.*, 2005	158	SD is development that meets the needs of the present generation without compromising the ability of next generations to meets their own needs in the future.	The ability to meet the needs. Generations
Ropke, 2004	1794	The social-economic research strategy understands that the three pillars of sustainable development are ecological, economic and social sustainability. This means that environmental problems require much wider institutional responses than	Institutional responses

		establishing private property rights and getting the prices right.	
Cerin *et al.*, 2008	54	SD is a core concept within the global development policy and agenda. It provides a mechanism through which society can interact with the environment while not risking damaging resources for the future.	Environment
Scholtens *et al.*, 2008	54	SD as a core concept that provides a mechanism through which society can interact with the environment without risking damaging resources for the future.	Environment Resources Future
Gray, 2010	473	Sustainability is a state, SD is the process for achieving achievement this state.	Development
Scerri *et al.*, 2013	91	A traditional conceptual framework of sustainable development with the triple-bottom-line dimensions has been expanded by the fourth pillar: culture, thus including the ever-growing importance of cultural sustainability as a key element for a new strategy for sustainable economic growth.	Economic Environmental Social system Cultural system
Rockstrom *et al.*, 2016	40281	The Sustainable Development (SD) Trajectory addresses the planetary boundaries in a new way: not by an open struggle for resources, nor by contraction of high-income levels, nor by kicking away the ladder. The world should live within the planetary boundaries through the deployment of new sustainable technologies and new global rules of the game. An orderly and cooperative process will lead to dramatically improved outcomes for all parts of the world.	Sustainable technologies Boundaries
Hák *et al.*, 2016	294	The SD concept is connected with the global concerns about the judicious use of the available resources so that it will be possible to satisfy the needs of the presented future generations. SD is a call to create a balance between economic growth, environmental preserve and social prosperity.	The ability to meet the needs. Economic growth Environmental integrity Social well-being
Daly, 2019	4245	H. Daly's Three SD Rules: -Sustainable use of renewable resources means that the pace should not be faster than the rate at which they regenerate. -Sustainable use of non-renewable resources means that the pace should not be faster than the rate at which their renewable substitutes can be put in place.	Sustainable development

		-Sustainable rate of emissions for pollution and wastes mean that it should not be faster than the pace at which natural systems can absorb them, recycle them, or render them harmless.	
Kolk, 2017	38	Sustainable development is decision-making processes through the integration of economic, environmental, and social concerns.	Economic Environmental Social concerns
Bossel, 2002	692	It can be argued that the concept of SD rests, fundamentally, on three conceptual pillars. These pillars are 'economic sustainability' as a support system, 'human social sustainability', and 'environmental sustainability'. The sustainable system is a system of systems or nested systems.	Environment system Human system Support system
Zhai and Chang, 2018	9	The concept is connected with the organizing principle for meeting human development goals while sustaining the ability of natural systems to provide the natural resources and ecosystem services upon which the economy and society depend. SD aims at achieving social progress, environmental equilibrium and economic growth.	Ecosystems Social progress Environmental equilibrium Economic growth
Browning *et a*l., 2019	30	Thus, it is a development paradigm as well as a concept that calls for improving living standards without jeopardizing the earth's ecosystems or causing environmental challenges such as deforestation and water and air pollution that can result in problems such as climate change and extinction of species.	Ecosystems Climate change
Bolshakov *et al.*, 2019	9	Sustainable development is the continuous process of increasing the ability to meet the constantly existing needs of the system, expressed in units of power. Goals are achieved by improving the quality of planning and implementation of innovations that provide a non-decreasing rate of growth in the efficiency of resource use, and greater income without increasing the rate of their consumption, and reducing losses in conditions of negative external and internal influences.	The ability to meet the needs. Generation Indefinitely Power of system

Source: Author's representation based on literature review

As a result of the work of the Club of Rome, an interpretation of sustainable development has arisen, which is often called the "triune concept of sustainable development", highlighting the interdependence of the three pillars of sustainable development: environmental, social and economic. Sustainable development becomes achievable only when the stability of each of the three listed components is formed. This definition, as seen in the table, was developed in many works. At first, this formulation had a positive impact on the development of the sustainable development concept and made it possible to formalize the goals. Later, this concept slowed down the systemic view of sustainable development.

2. Pillars of sustainable development

According to Bossel (2002) and other authors (Table 2), it can be argued that the concept of SD is based on three conceptual pillars. These pillars are 'economic sustainability', 'social sustainability' and 'environmental sustainability'. The traditional conceptual framework for sustainable development has been extended to the fourth pillar: culture (Scerri *et al.*, 2013), thus incorporating the growing importance of cultural sustainability as a key element of the new strategy for a sustainable economy growth. Bolshakov *et al.* (2019) considered that development in nature-society-humanity is a creative process meant to maintain a non-diminishing increase in the efficiency of the use of opportunities. A special role is given to the human system - a source of creativity and innovation. The further development of the concept of sustainable development followed the path of combining three main points of view: economic, social and environmental (see Table 2).

Table 2. Description of Sustainable Development pillars

Systems/ Pillars	**Basiago, 1998**	**Scerri, 2013**	**Bossel, 2002**	**Rockstrom, 2016**	**Bolshakov, 2019**
Environmental system	Environmental system	Environmental system	Environmental system	Environmental system	Environmental system
Social system	Social system	Social system	x	Social system	x
Human system	x	x	Human system Social system Government	x	Human system
Culture system	x	Culture system	x	x	x
Economic system	Economic system	Economic system	Support system: Economic Infrastructure	Economic system	Social system Economic system

Source: author's representation based on literature review

Reconciling these different perspectives and translating them into concrete interventions as a means of achieving sustainable development is a daunting task since all three elements of sustainable development must be considered in a balanced way. The 180 degree-turn of the famous 'temple' of sustainable development could be a decision.

Thus, the foundation of the 'temple' of sustainable development has been transformed into a base for a systematic analysis of the pillars of sustainable development - economy, society and nature. The pinnacle of this temple is the goal of sustainable development of the system - the quality of life (Trusina and Jermolajeva, 2021).

3. Economic, social, environmental and cultural sustainability

The Economic sustainability implies a production system that meets current consumption levels without compromising future needs. Economists have traditionally assumed that the supply of natural resources is unlimited, placing too much emphasis on the market's ability to allocate resources efficiently. They also believed that 'the economic progress to replenish natural resources destroyed in the production process' would accompany economic growth (Cooper and Vargas, 2004). Allen *et al.* (2020) echo that 'human life on earth is supported and sustained through the use of the finite natural resources found on earth'. 'Economic sustainability requires decisions to be made in the most equitable and financially possible way, while considering the other aspects of sustainability' (Zhai and Chang, 2018). As the Porter Hypothesis states (Porter and Linde, 1995) properly designed environmental policies that make use of market incentives can encourage the introduction of new technologies and reduce production waste. Market-based environmental tools are generally perceived as more "business friendly" than traditional command and control policies (Cooper and Vargas, 2004).

The Social sustainability encompasses notions of fairness, empowerment, accessibility, participation, cultural identity and organizational stability (Daly and Umana, 2019). The concept implies that people are important because development is about people. However, in a more fundamental sense, social sustainability is concerned with the link between social conditions, such as poverty and environmental destruction (Farazmand, 2012). In this respect, the social sustainability theory also suggests that the alleviation of poverty should not involve undue environmental destruction. It should seek to alleviate poverty within the society's existing environmental and economic resource base (Scopelliti *et al.*, 2018). Seven (2006) believes that, at a social level, sustainability means the development of people, communities and cultures and that one of its aims is to help achieve a meaningful life, gender equality education, and stability worldwide.

Unlike the environmental and economic systems in which flows and cycles are easily observed, 'the dynamics in the social system are intangible and cannot be

easily modeled' (Saner at al., 2020). According to Kolk *et al.* (2017), 'social sustainability is not about making sure that everyone's needs are met, but about providing conditions for everyone to have the ability to fulfill their needs if they so wish. Anything that hinders this ability is seen as a barrier.

The concept of *environmental sustainability* is concerned with the natural environment and how it remains productive and resilient to support human life. Environmental sustainability is about ecosystem integrity and capacity of the natural environment (Brodhag, 2010). The implication is that natural resources must be harvested no faster than they can be regenerated while waste must be discharged no faster than the environment can assimilate (Daly and Umana, 2019). This is because the earth's systems have limits or boundaries in maintaining equilibrium. However, the search for unobstructed growth places even greater demands on the earth's system as well as more and more stress on these limits because technological progress may fail to support exponential growth. Climate change refers to the significant and long-lasting changes in the climate system caused by the natural variability of the climate or by human activities (Coomer, 1979). What is clearly a good idea, according to Paavola and Ropke (2015), is that, for sustainability, all societies must adapt to the emerging realities of ecosystem management and to the natural limits to growth.

The theoretical and conceptual understanding of *cultural sustainability* within the general frames of Sustainable Development remains vague. And consequently, the role of culture is poorly implemented in the environmental, as well as in the political and social policy. The impact of Cultural Sustainability is found by investigating the concept of culture in the context of Sustainable development, through multidisciplinary approaches and analyses. This means examining the best practices for bringing culture into political and social policy as well as into practical domains, and developing means and indicators for assessing the impacts of culture on Sustainable Development (Scerri *et al.*,2013).

The broad field of development research (Rockstrom *et al.*, 2016) has traditionally treated the environment or economic field as ones among many systems contributing to human well-being. This way of relating humans was reflected in the Millennium Development Goals and Agenda 2030.

The transition to a new vision of the development of civilization must include understanding of the fact that the economy is a subsystem of society, in turn a subsystem of the biosphere - nature, and that the increase in the scale and spread of the human dimension and the connectivity and speed of the globalized world now shapes the biosphere and our own future in profound ways. The biophysical basis and natural capital have always been a cornerstone in ecological economics, focusing on the interplay of scale, distribution and efficiency in this context.

4. The sustainable development goals

Sustainable development is linked to the principle of achieving human development goals while preserving the ability of natural systems to provide the natural resources and ecosystem services in the context of economic and social development (Cerin *et al.*, 2008). The most recent of these challenges are the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs). The MDGs are a continuation of SDG. The MDGs marked a historic global mobilization to achieve an important set of social priorities worldwide (Breuer *et al.* 2019).

However, despite the MDGs' relative effectiveness, 15 years after their implementation (2000-2015), not all targets were met; therefore, the implementation of SDG continued with the development agenda. As part of this new development plan, the UN has endorsed the 2030 Agenda, which is a call to action to protect the planet, end poverty and guarantee human well-being.

According to the United Nations Communication Group (UNCG), the SDG is a world call to action to end poverty, protect the planet in peace and prosperity by 2030. In 2016, SDGs were adopted by 193 countries and aimed to promote economic growth, to ensure social inclusion and environmental protection. The objective of this partnership is to provide a sustainable path for the future generations (Breuer *et al.*, 2019).

Agenda 2030 includes five themes known as the Five Ps: People, Planet, Prosperity, Peace, and Partnership. The defined Ps cover 17 goals and 169 targets with 263 indicators (Hylton, 2019). They aim to tackle with poverty, covering such areas as: health, education, energy, economic growth, industry, innovation, climate change, natural resources and others. According to the SDGs, the goal of sustainable development is to achieve social progress in the context of environmental balance and economic growth.

4.1. Positive discussion about sustainable development goals

The Sustainable Development Goals (SDGs) provide a system of goals, targets and indicators for the implementation of sustainable development concept by 2030. Different approaches developed in sustainability sciences can help countries address these challenges (Metternicht *et al.*, 2018). The main feature of SDGs is that their development goals and objectives are essentially interdependent and interrelated. SDG includes complementarity or synergy. The complementarities define that addressing one goal could help to address some other goals and targets at the same time.

The complementarities imply that addressing one goal could help to address some others at the same time. For example, tackling with climate change could bring additional benefits to energy security and biodiversity (Le Blanc, 2015). The choice,

according to Mensah (2019), would have to be informed concerning the priorities of each country and the availability of resources. It is also worth noting that, due to the complementarity of many objectives and target areas, a single indicator can serve to measure the progress towards some other objectives and targets. According to Le Blanc (2015), tackling with climate change (goal 13) is a good example of a competitive interest.

Keitsch (2018) continues and states that trade-offs can raise governance issues when SDG has complex problems, when the interests of different stakeholders' conflict. Another major challenge, according to Spahn (2018), is to ensure responsibility and accountability for progress in compliance with SDGs. Kanie *et al.* (2017) believes that this requires appropriate indicators and monitoring systems to evaluate the progress of SDGs, especially at the national level. Environmentally-friendly infrastructure is an important factor to increase economic output and productivity (Waage *et al.*, 2015).

4.2. Criticisms of sustainable development goals

The dilemma between striving for a strong position on key issues and gaining broad political acceptance, as well as supporting and understanding the many dimensions of sustainability and developing its measures, criteria and principles, has been a key challenge since the first steps towards the implementation of sustainable development goals were taken (Lele, 1991).

In his analytical papers, Kenny (2015) formulated five top SDGs criticisms:

1. The objectives do not consider inequalities in the international system;
2. Goals are set from the top down and bureaucratically ignore the local context;
3. SDGs are aspirations, not goals and not related to the SMART concept;
4. Targets are not binding, which means that countries are not penalized for not meeting them. It is also not clear who will implement them;
5. Lack of data.

Pogge and Sengupta (2015) also emphasized that 'SDG is a statement of aspirations, and the formulation of objectives should provide a clear picture of the steps required to achieve the objectives, as well as provide an independent monitoring organization'. Swain (2018) assessed that ambitious SDGs are difficult to measure, implement, and monitor. The analysis showed that 'there is a potential mismatch between the SDGs, especially between socio-economic development and environmental sustainability goals. Criticism also raises questions about the measurability and monitoring of broadly formulated SDGs. The targets are not binding and each country is expected to draw up its own national or regional plans'.

Wyborn (2018) supports the definition of sustainable development as "development that meets the needs of today while maintaining the support system for life on Earth, on which the well-being of present and future generations depends". The authors recommend it as a key goal supported by the UN. Development goals

must be pursued. In addition, SDG integration is less than scientifically necessary. The effective implementation of SDGs will require governments to pay attention to trade-offs and duplication.

A perpetual refusal to integrate into the SDG would be dangerous for achieving keys goals. Therefore, a systematic approach is needed to identify gaps and links between goals and targets of the SDGs, as well as leverage points for effective intervention.

The above authors lightly criticize the adopted documents, without emphasizing or formulating the main problem. The previous sections of the article showed the accepted concept of sustainable development (Agenda 2030) and tried to anticipate the answers to two research questions: how many of the goals, targets and indicators of sustainable development (SDGs) will be achieved by 2030? What will the overall result be? The tentative response (Rockstrom *et al*, 2016) is that the world will not reach all SDGs by 2030 or 2050, and that the global margin of safety will continue to decline. The increased attention paid to the achievement of the SDGs and the more additional economic growth do not change this conclusion. A transformational change and, perhaps, even a paradigm shift are needed.

At the methodological level, the approaches and models of Bossel (2002), Rockstrom *et al.* (2016), Bolshakov *et al.* (2019) show that it is possible to combine the socio-economic model of activity with the ecological model of the resulting impact on the global system model, and use this "global system model" to predict the future achievement of the SDGs and reduce pressure on nature.

It may be necessary to return to the original ideas and formulations of sustainable development outlined in the documents Brundtland (1987) - sustainable development that meets the needs of the present and the opportunities to will meet the needs of future generations?

5. Ecological economics

Humanity has come to a point where special responsibility, rationality in decisions and actions, considering national interests and needs of the world community are required. It is necessary to get rid of the causes that give rise to conflicts, wars, hunger, poverty, disease, illiteracy, destruction of the natural environment. It is necessary to create conditions that ensure the sustainability of the development of the world on a scientific, reasonable basis. Society has entered an era when knowledge of these laws and their skillful use have become a necessity. As the power of humanity grows, its responsibility for each step taken must increase. Humanity has become a powerful global geological force. Domination over nature should consist in the ability to cognize its laws and use them for the good, to be able to use these laws as an objective criterion for collective reason and for the effectiveness of one's practical activity. A direct continuation of this classical thought is the teaching of Vernadsky (2006) about the restructuring of the biosphere

into the noosphere - a qualitatively new state, which is a historically inevitable process.

On a planetary scale, the noosphere means social and natural integrity, whose defining link is the human mind, which cognizes and correctly applies the general laws of nature in order to ensure sustainable development in the "nature - society - human" system. The main function of the noospheres' world is to ensure such a course of the world historical process that guarantees the stability of its development based on the implementation of general laws in their mutual internal connection. Due to this, the rate of the noospheres' world's formation entirely depends on scientific knowledge and ability to correctly apply general laws in social practice, and the time of its formation is determined by the period of mankind's mastery of these laws.

Ropke (2004) formulated the ecological economy as the interaction of natural and economic processes as a result of human exposure. The natural processes in the sense that they can be considered as biological, physical and chemical processes and transformations.

Therefore, economy ought to be studied not only as a natural object but economic processes should also be conceptualized in terms usually used to describe natural processes. Human activities could also be described in terms of flows of energy and matter and starting in the 1980s- '90s, some system ecologists began to focus much more on economic issues (Costanza, 1989; Georgescu-Roegen, 1986).

When economic and ecological systems are conceptualized in the same language of flows of energy and matter, it is natural to state that human economy is embedded in the geo-biosphere of the earth. This is what Herman Daly, using an expression from Schumpeter, calls the preanalytical vision of ecological economics: human economy is an open system inside the framework of a closed system in the thermodynamic sense (Daly, 1993). Human economy exchanges matter and energy with the larger system of the earth, whereas the earth does not exchange matter with the surrounding universe (except for a few meteors). The earth receives solar energy from outside and emits heat, and this energy flow maintains the processes of the system.

Based on the conversion of biomass units into energy units, Lindeman (1942) formulated a new methodology for studying ecosystems through the analysis of energy flows. These innovative contributions were synthesized by Odum in his book, Fundamentals of Ecology in 1953, - a book that became a landmark for the establishment of ecology with a systems' perspective. Contrary to other textbooks, it introduced the whole before the parts, starting with the ecosystem level and proceeding with the organisms that were parts of the system.

The research of the Odum brothers in the fifties contributed substantially to the development of new methods to study energy flows in a systems' perspective (Odum, 1968). Making use of the biophysical understanding of the links between the economy and the environment, in her recent research, Ropke noted that (Ropke and Paavola, 2015) there is also substantial scope for research.

This model can provide the basis for integrating and mobilizing concepts such as physical limits, social justice and constrained economic optimization to make better sense of issues of emerging importance, such as climate change. From this viewpoint, global atmospheric sinks, just like many other environmental resources have uncertain but clearly limited physical capacity to deliver services. Their sustainable management as global commons will call for consideration of justice in the use of these sinks, and both adherence to physical limits and attainment of justice will ultimately be a matter of crafting and enforcing a set of appropriate institutional arrangements for the purpose.

Societies have to cope with environmental crises related to climate, biodiversity, scarcity of land and water, as well as with economic and social crises, such as increasing inequality and increasingly unequal levels of development, unemployment, dysfunctional financial systems and unsustainable levels of debt.

It is necessary to formulate coordinated responses to these multiple crises. These sustainability transitions are not only about changing provision systems for energy, mobility, food and so on: they are, also, fundamentally about changing distribution systems, that is, who gets access to what.

Daly formulated the concept of uneconomic growth as: uneconomic growth exists when the benefits of economic growth are less than the negative consequences of that economic expansion. Uneconomic growth may occur when growth in the economy leads to negative environmental, economic, or social consequences. It may also occur when that level of the GDP growth is not sustainable and eventually results in future problems.

6. New approach and research methodology

In accordance with the above-mentioned provisions and with the concept of ecological economics and in order to formalize the tasks of sustainable development, the methodology of managing sustainable development by using the concept of flows of full and useful power in open, non-equilibrium stable systems, the flows model of interactions in the 'man - society – nature' system, as well as the theory of a unified system of space-time measurements were considered.

It should be noted that, in accordance with the definitions of natural sciences, all living things - nature and society - are open, stable non-equilibrium systems. And therefore, it is natural to use the laws of living systems for the creation of technologies for sustainable development. There is not a single closed living system in Nature, which has no inflows and outflows of energy, with power (changes in the amount of energy or flow) equal to zero. The law of energy conservation is valid only for the systems closed in energy flows and cannot serve as an adequate measure of open, living systems.

Currently, the inconsistency or incoherence of measures of heterogeneous (social, economic, ecological, etc.) systems is the reason for the rupture of ties,

leading to social systems being controlled in isolation from the general laws of living systems, which ultimately leads to a global systemic crisis. It is possible to eliminate this gap by establishing a measure that expresses the essence of living systems. According to Bauer E.S. (2002), a characteristic of living systems is that, due to their free energy, they perform work against the expected equilibrium. Based on the stable non-equilibrium principle, the main property of energy flows circulating in living systems is their ability to perform external useful work or their working capacity and to have the useful power.

Based on the above formulated concepts, the spatial-temporal approach to the analysis of powers and energy flows of life open systems is based on three main laws (invariants):1. The law of power conservation (energy flow) (Kuznetsov, 2015), underlying the sustainable development of socio-economic systems (as a life open system). This is the statement that, in the system open for energy flows, in time (t), the total power N (t) is equal to the sum of the useful power P (t) and the power losses G (t), equations (1):

$$N(t) = P(t) + G(t) = \text{const} \quad (1)$$

The principle of development preservation (Podolinsky, 2004; Vernadsky, 2006). The development of the socio-economic system is preserved if takes place under the following conditions: if preserving the system quality in spatial-temporal dimension of power and if preserving the continuous increase in the efficiency φ (t) of using full power, equations (2):

$$\Delta\varphi(t) = \frac{d\varphi(t)}{dt} > 0, \text{ where } \varphi(t) = P(t) / N(t) \quad (2)$$

The principle of sustainable development (in units of power) (Bolshakov *et al.*, 2019). Sustainable development is the continuous process of increasing the opportunities to meet the existing constant needs of the system by increasing the efficiency of the full power of the system, reducing losses and without increasing the consumption power in conditions of negative external and internal influences. The introduction of the invariant measure 'power' in the management of sustainable development makes it possible to establish a measurable relationship between needs and opportunities, to build a system of indicators and criteria for sustainable development in accordance with the invariant of the projected class of the 'man - societies – nature' systems. The flow of energy consumed by society N (t) includes all types of energy resources for supporting life, production, technological and other processes. It is the needs or opportunities (potential) of society. Full power can be used and converted to net power P (t) with variable efficiency. This means real opportunities (real capacity of the system or the gross product produced).

Spending power P (t) (a measure of labour), after the lapse of time dt, society gets at its disposal a flow of fuel, energy and food resources, measured by the value N (t+dt) - the total power released at the time of primary consumption of energy resources. The value of N (t) is many times greater than the value of P (t). After power transformation systems have power loses G (t) - lost opportunities. The amount of capacity at the disposal of the systems is a measure of the ability of the system to affect the environment. Demand is the required capabilities (power) of the system, which are not currently available, but which you need to have in order to maintain development in the future. The problem is the difference between the required and available system capacities. Thus, a system of indicators of sustainable development with an invariant capacity is determined, which characterizes the technological, economic, environmental, social and other capabilities and needs of a complex system. From a methodological point of view, that system is an effective tool for the design of sustainable development in the "man - society - nature" system. The principle (criterion) of sustainable development is the statement that development is supported in the long term, subject to the following conditions, which can be formalized in the system of equations (3), (4), (5), (6):

$$\Delta N = N - N_0 = \frac{dN}{dt}t + \frac{d^2N}{dt^2}t^2 + \frac{d^3N}{dt^3}t^3 \leq 0, \quad \text{and} \quad \Delta N \leq 0 \ (3)$$

$$\Delta P = P - P_0 = \frac{dP}{dt}t + \frac{d^2P}{dt^2}t^2 + \frac{d^3P}{dt^3}t^3 \geq 0, \quad \text{and} \quad \Delta P \geq 0 \ (4)$$

$$\Delta G = G - G_0 = \frac{dG}{dt}t + \frac{d^2G}{dt^2}t^2 + \frac{d^3G}{dt^3}t^3 < 0, \quad \text{and} \quad \Delta G < 0 \ (5)$$

$$\Delta \varphi = \varphi - \varphi_0 = \frac{d\varphi}{dt}t + \frac{d^2\varphi}{dt^2}t^2 + \frac{d^3\varphi}{dt^3}t^3 \geq 0, \quad \text{and} \quad \Delta \varphi \geq 0 \ (6)$$

Based on the basic parameters, it is possible to formulate the different trends in the socio-economic - natural systems development (see Table 3):

1. *"Zero growth" or stagnation* - the absence of growth in the total manufactured product for a certain period, which indicates the absence of positive shifts;
2. *Growth* - an increase in the total produced product mainly due to the growth in resource consumption, and not due to an increase in the efficiency of their use;
3. *Development* - an increase in the total produced product mainly due to an increase in the efficiency of resource use, and not due to an increase in consumption;
4. *Sustainable development* - reproduction of innovative development in the long term through the implementation of advanced technologies and increase in the rate of growth of useful power in the long term.

Table 3. The trends of socio-economic-natural systems development

	State of the system	ΔN	ΔP	ΔG	Δφ
1	"Zero growth" or stagnation	> 0	= 0	> 0	= 0
2	Growth	> 0	> 0	> 0	= 0
3	Development	> 0	> 0	< 0	> 0
4	Sustainable development	the system of equations (3), (4), (5), (6)	the system of equations (3), (4), (5), (6)	the system of equations (3), (4), (5), (6)	the system of equations (3), (4), (5), (6)

Source: Author's representation based on Bolshakov *et al.* (2019)

In the context of spatial-temporal power flows approach, universal sustainable development indicators were calculated for Latvia (Trusina and Jermolajeva, 2021). The calculation of the indicators was carried out by using data from Latvian Central Statistical Bureau for the period from 2010 to 2019 (Table 4).

Table 4. Sustainable development parameters of Latvia in 2019

Sustainable development parameters	ΔN	ΔP	ΔG	Δ φ
The requirement of sustainable development, equations	≤0	≥0	<0	≥0
The sustainable development parameters for Latvia in 2019	<0	<0	<0	<0

Source: Author's representation

In accordance with the requirements of sustainable development, the system of four indicators shows that, by 2019, the system of Latvia had a trend towards degrowth ($\Delta P < 0$). A decrease in consumption ($\Delta N < 0$) indicates an extensive development, which is the result of a decrease in population, and is not associated with improving the structure of resource consumption, their efficient use and technological excellence ($\Delta\varphi < 0$).

This study takes place within the framework of the scientific activities of the Latvian University of Life Sciences and Technologies and its aim is to establish the monitoring of socio-economic systems using the spatial and temporal energy flow (capacity) approach in the concept of ecological economy.

Conclusions

The analysis of the existing state of the problem showed the followings.

On the one hand, it took more than 40 years for the SD concept to take shape and become a global agenda. On the other hand, there is still no formalized

description of a sustainable system, a monitoring system that meets the requirements of sustainable development and, above all, the requirements for the chosen measure and criterion of development, and this affects the accuracy of the results of designing sustainable development and of achieving sustainable development goals.

Even in the scientific community, there is still a lack of understanding that this is more than a combination of environmental, ethical, social and economic systems. It is a new relationship to each other and to nature. "Pillar" Systems are described in languages that are not related to the principle of sustainable development, using a large number of sets of disproportionate indicators, indices, indicators, which affects the accuracy of results.

There is no formalized description of the tasks of monitoring and evaluating the effectiveness of development consistent with the sustainable development requirements and principles. This results in erroneous decisions which contribute to the emergence of risks and unforeseen situations, affect the accuracy of determining the growth of resource use efficiency and makes it impossible to achieve sustainable development goals, lead to incorrect estimates of the possible consequences of development, giving rise to the illusion of growth, risks, conflicts and crises.

Social crisis and specific economic and political factors were crucial for the breakthrough of modern ecological economics. Ecology played a part in promoting the new social discourses on pollution, population, etc. In economics, such perspectives had a strong potential for radical critique of the rationale of economic growth, so they tended to be at odds with both the dominant political forces and the mainstream economic thought.

The modern reformulations of the sustainable development main ideas in the context of an ecological economy have gone through a period of maturation and formation. The basic idea of ecological economics is very close and harmonic to the sustainable development idea - human economy is embedded in nature and economic processes are also natural processes in the sense that they can be seen as biological, physical and chemical processes and transformations. It is important to remember that various other processes can easily influence and even conflict with environmental considerations, so strong and systematic support would be needed for the environment to become an important aspect of most areas of human life.

In accordance with the requirements of sustainable development, the four-indicator system shows that, by 2019, the system of Latvia had a trend towards non-sustainable development. A decrease in consumption ($\Delta N < 0$) indicates an extensive development and is the result of a decrease in population, and is not associated with improving the structure of resource consumption and their efficient use.

The authors have presented a new approach, which is already present in the world literature (Costanza, R, Bolshakov, B.Y., Daly, Y., Ropke, I., Rockstrom, J. *et al.*), and will continue in-depth and extensive research in this direction. The broader analysis of the methodology and results will be described in future publications.

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