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THE PRINCIPLES OF SUSTAINABILITY

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ZASADY TRWAŁOŚCI GOSPODAROWANIA

STRESZCZENIE: Celem artykułu jest przedstawienie i zinterpretowanie, a następnie rozwinięcie zasad trwałości gospodarowania, których autorem jest angielski ekonomista David Pearce. W artykule skupiono uwagę na następujących czterech zasadach: słabej, wrażliwej, silnej i restrykcyjnej trwałości gospodarowania; będących zarazem swoistymi zasadami trwałego rozwoju. Na publikacje Pearce'a i wspomniane zasady powołuje się wielu naukowców, również w Polsce, jednak dołączane komentarze często niefortunnie odbiegają od oryginalnej wersji zasadniczych wskazówek Pearce'a, które zostały wyprowadzone wprost z teoretycznych założeń ekonomii środowiska i zasobów naturalnych.

SŁOWA KLUCZOWE: trwały rozwój, trwałość kapitału

Introduction

The correct translation of the term sustainable development, from English into Polish, must take into account the obvious fact that this concept of development, from the very beginning, has been focused on continuation, vitality and adaptation. And above all, this concept is associated with the existence which is successfully sustained over the passage of time. The best Polish translation would be "trwały rozwój", without making any reference to weighting or balancing. Of course, because sustainable development is a kind of genuine development it must have a complex structure. Therefore, sustainable development is centered not only on environmental sustainability but also and simultaneously on sustainability of economic development and on sustainability of social structures. In the papers written by David Pearce original nomenclature was applied in a form of four principles dealing with: weak sustainability, sensitive sustainability, strong sustainability and restrictive sustainability. All these categories of sustainability are closely linked with the problem of constant capital, with the issue of substitution between different types of capital, and also with the characteristics of exhaustible resources that are rightly divided into renewable resources and non-renewable resources[1].

The right understanding of the principles of sustainable management indicates, on the one hand, the necessity of substituting irreversibly declining non-renewable resources, and on the other hand, emphasizes the opportunity (as shown by C.W. Clark this chance can be rejected for economic reason[2]) for rational and sustainable management of renewable resources[3]. Of key importance in the long run is the rate at which a process of replacing non-renewable resources by renewable resources may be effectively exercised. Another and particularly difficult problem is how to define boundaries and rules for the safe replacement of natural capital by a man-made capital.

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1 D.W. Pearce, R.K. Turner, *Economics of Natural Resources and the Environment*, Hemel Hempstead 1990.

2 For arithmetic comparison C.W. Clark linked the net present value of the infinite sum of annual sustainable revenues to the value of the amount proceeded from invested total liquidation of the resource when the biomass gives its greatest growth. The conclusion was rather sad: sustainable benefits from a resource that renews very slowly may be less profitable than its one-time liquidation, if there is g<r (where "g" is the rate of natural growth of the resource and "r" stays for the prevailing discount rate).

3 C.W. Clark, *Mathematical Bioeconomics: The Optimal Management of Renewable Resources*, New York 1976.

The emergence of new ideas related to sustainability management is the response to the negative changes that have occurred in the human life conditions from the crucial moment when the industrial revolution has started the overexploitation of environmental goods and natural resources. This process has ultimately led after only two centuries to the scarcity of natural resources while reducing simultaneously their quality. Environmental degradation in economic terms was a result of human activities, which did not protect the life-supporting ecological infrastructure and the entire biosphere. In particular, the exploitation of the most useful natural resources was guided by the criterion of short-term profit maximization and did not take into account sustainability of natural capital. This neglect justifies the present need for meaningful and urgent interest in the principles of working and effective sustainable management.

Sustainable resource management

The sustainable management should be understood as maintaining of the available capital, thus, not reducing the managed capital in subsequent periods of use. Let the starting point for further discussion in this paper be a simple equation showing that the total capital, which we have (K), is the sum of the capital produced by man (KH), human and social capital (KS) and natural capital (KN): K = KH + KS + KN. In this article the relationship that combines the resources forming KH and KN is a major concern.

The natural capital definition used to be as follows: the whole natural environment as a source of goods and universal means of production, which are not produced by man. Natural capital is composed of very diversified resources useful for all human beings. Natural capital are all biotic and non-biotic components of the Earth: all that is on its surface or in its interior (including soil, air, water). These resources provide people with the stream of useful goods and services. Some of them are taken directly from the nature and some of them are consumed indirectly. This stream can be renewable or non-renewable, depending on the characteristics of the resource contributing to the natural capital.

The sustainable management should support sustainable development and this means the adoption of such a course of action by which it is possible to receive revenues/benefits from the environment for a long time. It is worth recalling that the income is defined as sustainable as it was formulated by Hicks[4]. The income is the stream of payments, which does not erode its base (the capital is not consumed) and is not merely a change in the form of assets. Thus, the benefit that comes with the loss of environmental capital should not

[4] J.R. Hicks, *Value and Capital*, Oxford 1946.

be considered as income. Consumption of natural capital without its reproduction should be interpreted as liquidation, and thus as the opposite effect to accumulation.

There is a quite substantial economic bibliography on the analysis of sustainable management of natural resources. The solution to the problem appears in these works which indicate conditions that must be met to make the long-term economic development possible which inevitably depends on natural resources[5]. However, the neoclassical Hotelling rule in its basic version is inadequate for sustainable management, because it only supports the strategy to maximize the net benefit from non-renewable resources. It indicates the optimal path of economic resource exploitation program at a given discount rate and the known benefits and costs of obtaining this resource. Sustainable management paradigm is not represented here at all and, thus, the total depletion of any resource is just one possible option among the other scenarios of its exploitation.

The seminal economic research has been actually undertaken on the desired optimum size of investment in the acquisition of new resources, which should take into account the costs arising from the increasing scarcity of resources being under exploitation[6]. Neoclassical analysis has led to the description of some important relationship between the rate of consumption of non-renewable resources and increasing ability of the economy to perform sustainable exploitation based on renewable resources. Hartwick formulated his model which showed that the condition for long-term economic growth is to invest rents from the used non-renewable resources in their substitutes what should guarantee a permanent reproduction of consumed capital. Conclusion derived implicitly from the Hartwick model could be extremely optimistic: the appropriate level of substitution of non-renewable resources by renewable resources would guarantee to maintain the current level of prosperity or even increase it, and all this in an infinite time horizon!

Economists, however, have a tendency to a rather instrumental adaptation of the diversity and specificity of the natural conditions, on which the economy depends, into their analyses. Natural capital should not be limited to the already exploited and production-oriented resources, but also have to take into consideration the overall biological conditions that ensure the proper functioning of

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5 R.M. Solow, *The Economics of Resources or the resources of Economics*, "American Economic Review" 1974 no. 64, p. 1–14; J.M. Hartwick, *Intergenerational Equity and the Investing of Rents from Exhaustible Resources*, "American Economic Review" 1977 no. 67, p. 972–974; J.M. Hartwick, *Substitution among Exhaustible Resources and Intergenerational Equity*, Working Papers 294, Kingston, Ont. Canada, 1978; Solow R.M., *On the Intertemporal Allocation of Natural Resources*, "Scandinavian Journal of Economics" 1986 no. 88, p. 141–149.

6 M. Common, C. Perrings, *Towards an Ecological Economics of Sustainability*, "Ecological Economics" 1992 no. 6, p. 7–34.

the biosphere. Therefore, an important addition to economic models are theoretical considerations on stability and resilience of ecosystems and the entire biosphere. Ecological economics seeks to recognize this problem and proposed, for instance, the theory of adaptive management of natural resources[7].

It is perfectly right that natural capital should be clearly distinguished from other forms of capital, and above all from capital produced by man[8]. The difference between them is fundamental, because only natural capital was the indispensable condition for the appearance, duration and evolutionary development of life on Earth, and now natural capital determines the duration, development and survival of human civilization. The benefits derived from natural capital for the most part of them do not exist on the market. This is why ecological services were overlooked by academic economics for a long time. As a result, imperfect policy led in the past and still leads to the overuse of natural resources and their increasingly reduced availability. In just two centuries natural capital became a limiting factor for the economic development to a greater extent than the capital produced by man. At the same time natural environment of high-quality advanced to the basket of goods sought after and desired by consumers with a sufficiently high level of income.

Principles of sustainability by Pearce

The concept of constant capital assets can be analyzed and capital durability can be graded theoretically. Such an approach implies the acceptance of distinctive typology of sustainability principles. There are more or less strict rules for capital preservation exemplified in Pearce's writings[9]. Typology proposed by Pearce used to be reduced in the literature to a very simple dualism: the principle of weak sustainability versus the principle of strong sustainability. Such a contrast opposition impoverishes interpretation and is the cause of many misunderstandings. Next in this paper four principles proposed by Pearce will be discussed in detail[10].

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7 C.S. Holling, *Resilience and Stability of Ecological Systems*, "Annual Review of Ecology and Systematics" 1973 no. 4, p. 1–23; C.S. Holling, *The Resilience of Terrestrial Ecosystems: Local Surprise and Global Change*, in: C.W. Clark, R.E. Munn (eds), *Sustainable Development of the Biosphere*, Cambridge 1986, p. 292–317.

8 N.O. Martins, *Ecosystems, strong and the classical circular economy*, "Ecological Economics" 2016 no. 129, p. 32–39; J. Śleszyński, *Ekonomia a nieodwracalne zmiany w środowisku naturalnym*, "Prace Ekonomiczne Uniwersytety Ekonomicznego we Wrocławiu" 2016, Wrocław, in print.

9 D. Pearce (ed.), *Blueprint 3: Measuring Sustainable Development*, London 1993.

10 J. Śleszyński, *Ekonomiczne problemy ochrony środowiska*, Warszawa 2000.

The principle of weak sustainability requires the constant size of the total capital (K) regardless of its structure. Because the total capital consists of natural capital, capital produced by man, social and human capital, it is assumed that different types of capital are perfect substitutes. At least within the limits of the current level of knowledge, activity and available resources at any given time. This assumption implies that losses in natural capital can be easily compensated, for example, using new technology and manufactured goods. This is perfectly in line with the neoclassical modeling and with its orthodox assumption about perfect substitution. However, while the lack of wood to a large extent can be mitigated by the production of plastic, it would be difficult to believe in ensuring adequate "surrogates" for the ecosystem role of certain species that went extinct through men's fault or for the hard-working insects pollinating flowering plants.

The principle of sensitive sustainability states that, in addition to maintaining the total volume of capital (K) constant, the relationship between certain resources within the total capital cannot be violated. In particular, the volume of certain resources belonging to natural capital should never be reduced. This is the result of ecological observation that the man-made capital and natural capital can be substituted, but only in very specific and rather narrow limits. For example, the proper functioning of the biosphere and numerous ecosystems creates an objective requirement that certain components of natural capital (KN_k k=1,..,K; $KN=KN_1+KN_2+...+KN_K$) should be always present in the biosphere, moreover, that they should occur in proper proportions. Sensitive ecosystem may indeed require that some of its components are always in place in a particular abundance and/or have a defined share in the biotope or in the biomass. Because we do not know enough about the ecological boundaries and critical values of the natural capital, the most practical behaviour would be a careful management of natural resources just to avoid overexploitation and above all to avoid unwanted irreversible losses[11].

The principle of strong sustainability requires keeping the total amount of capital (K) constant, accompanied by keeping the amounts of the different types of capital constant, each one separately: KH, KS, KP. This is the result of the assumption that natural capital and capital produced by man are not substitutable for each other, but only complementary. This implies a practical conclusion that the loss of some kind of capital should be offset by growth in the same type of capital, provided that it can be another resource but belonging to the same type of capital. Such a phenomenon has long been observed in the case of tools and equipment manufactured by man. Nobody is reproducing consumed man-made capital without economic reflection. Technological innovations make it possible that productive capital Anno Domini

11 J. Śleszyński, *Ekonomia a nieodwracalne…*, op. cit.

2016 is clearly different from the components of productive capital from the interwar period. To some extent, this phenomenon also applies to natural capital and energy resources. Energy carriers are changing and only the twentieth century saw the dominance of oil, which took up a position occupied so far by other fossil fuels. It should be emphasized that the strong sustainability poses a significant limitation: used portion of natural capital cannot be replaced by any investment in capital produced by man.

The principle of restrictive sustainability demands maintaining constant the total amount of capital (K) and calls for the prohibition of any depletion of the highlighted resources (KH_i k=1, ..., I; KS_j k=1, ..., J; KN_k k=1, ..., K) included in the three distinguished types of capital: KH, KS, KP. In accordance with this principle the non-renewable resources, belonging to natural capital (KN), could not be exploited at all, because the method of their reconstruction does not exist. However, in the case of a specific renewable resource, in accordance with the principle of restrictive sustainability consumption, it is acceptable. Still, only this part that in the future can be counterbalanced by the resource growth and, therefore, will not reduce the resource belonging to the natural capital, should be consumed. In other words, consumption cannot affect the ability of the resource to renew in subsequent periods, and thus to provide the opportunity of similar benefits (sustainable yield) in the future.

It is justified to anticipate that in the near future economic development will have to change fundamentally because of its obvious limitations associated with the use of disappearing non-renewable resources and the poor ecological conditions of renewable resources. Using the concepts introduced by Pearce someone can describe the problem and suggest that a new paradigms consistent with the paradigm of sustainable development should be based on the adoption of principles of sensitive or strong sustainability, and also, in some cases, principles of restrictive sustainability in the management of renewable resources. In the management of natural resources sometimes we are willing to substitute one type of the resource for the other, for instance this occurs in the case of fishing. However, this replacing has certain limits, because when we intensify cod fishing we still don't want to lose the population of cod completely so after a while we allow this resource to renew by intensifying the exploitation of another resource like herring. In turn, the conservation of threatened species and protected areas is a good example where the application of the principle of restrictive sustainability makes sense. For example, we will never be able to replace coral reefs in the biosphere and coral reefs are essential in the shaping of global ocean environment also the global climate.

The principle of weak sustainability and to some extent the principle of sensitive sustainability are the right way of dealing with non-renewable

resources. Non-renewable resources, by definition, irrevocably disappear following their acquisition and consumption. Scientific and technological progress allowed the transition from one type of non-renewable resource to another. This tactic was successful in the case of mineral deposits and much less in the case of fossil fuels. However, in the near future, we should expect serious problems with the application of this principle with respect to the Rare Earth Metals and Minerals (Rare Earth Metals/Minerals). Such rare resources like scandium, lanthanum, cerium or yttrium are non-renewable, while terribly needed in most electronic devices. In addition, there are only traces of them in the Earth's crust and about 90% of the raw material is now in the hands of China. The economic practice of substitution will be extremely difficult, because these are elements with unique properties and China's monopoly will additionally hamper any strategy to find substitutes among other and equally scarce elements.

The presented logical and coherent interpretation of sustainable management should eliminate from public discussion and literature such statements like, for example: a) "the principle of strong sustainability and certainly the principle of restrictive sustainability are unrealistic and can not ever be implemented in practice", b) "the principle of weak sustainability is not connected with the problem of substitution", c) "the principle of strong and weak sustainability can be used regardless of whether the analyzed resources are renewable or non-renewable", etc. These and similar statements exist in the circulation of information and at first glance seem to be intriguing and polemical. However, confronted with the precise interpretation of the typology given by Pearce, they simply turn out to be untrue.

A necessary addition to the theoretical considerations on sustainable management is mentioning of the fact that the management takes place within the limits of the ecosystems, which are not static but undergo evolutionary changes in response to changing environmental conditions. Single cells, organisms, populations, social and economic systems, the biosphere as a whole – all these objects on their level of organization of life are not eternal. They are characterized by a certain but determinable "life expectancy" which is given to them evolutionarily and that usually is sufficient to develop an appropriate response to all changes taking place in the environment. Too short lifespan, equally in the case of a body as in a socio-economic system, does not allow for finding satisfactory adaptive response. On the other hand, too long lifespan also becomes lethal because of the increasing weakening of the system which leads to a loss of its viability and critically limiting its adaptability.

Talking about sustainability in biological and economic terms should not be construed as an improvement of the definition, but as an encouragement

and an incentive to predict the future and attempt to find the best response to the challenges of the future[12]. Significant and real importance should be attached to the recognition of characteristics of the resources making the total capital. This knowledge is necessary for an appropriate application of the principles of sustainable management and providing specific answers to the questions: what is the capital we would like to keep constant and what we can effectively and meaningfully substitute, what is the time horizon preferred for such sustainability, how to supervise and monitor the process of adaptation? In addition to predicting and planning sustainability, methodology for adaptive thinking is needed to elaborate an appropriate reaction to dynamic changes in the relationship between man and its natural environment[13].

The continuation of human civilization will depend both on random and determined environmental factors, and first of all on the success of properly designed adaptive man-made processes. In this context managing the precautionary principle but also determining allowable safe limits of intervention in the environment, and avoiding irreversible and dangerous changes in the environment are increasingly important[14]. Only on a such firm foundation sustainable management of natural resources and sustainability of our socio-economic system can be safely built.

Conlusions

The close relationship of environmental conditions and the economy emphasizes three simple recommendations of sustainable development proposed in the beginning of Nineties[15]:

1. In order to reduce the scale of the use of environmental resources, reduce the material flow in the economy and increase the efficiency of used resources that are really necessary for us.

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12 R. Costanza, B.C. Patten, *Defining and predicting sustainability*, "Ecological Economics" 1995 no. 15, p. 193–196.

13 L.H. Gunderson, C.S. Holling, S.S. Light (eds), *Barriers and bridges to the renewal of ecosystems and institutions*, Columbia University Press, New York 1995; D. Reed (ed.), *Structural Adjustment, the Environment, and Sustainable Development*, Earthscan, London 1996.

14 C.W. Clark, F.H. Clarke, G.R. Munro, The Optimal Exploitation of Renewable Resource Stocks: Problems of Irreversible Investment, "Econometrica" 1979 vol. 47, pp. 25–47; J. Śleszyński, *Ekonomia a nieodwracalne…,* op. cit.

15 H.E. Daly, *Sustainable Development: From Concept and Theory to Operational Principles*, "Population and Development Review" 1990 no. 16, Supplement: Resources, Environment, and Population: Present Knowledge, Future Options, p. 25–43.

2. Renewable resources should be used in accordance with the principle of sustainable revenue. It means that in the case of living organisms operation should be limited to their growth and do not exceed the limit guaranteeing their restoration. In the case of pollutants released into the environment their quantity should not exceed the capacity of natural ecosystems to assimilate these pollutants.
3. Non-renewable resources should be used in such a way that the available natural capital would not undergo reduction, which means that in the long-term the present consumption of non-renewable resources should be gradually replaced by their renewable substitutes.

Truly, the concept of sustainable development is anthropocentric, since it is aimed at improving the living conditions of the human population. However, it also contains a conservative component, because it takes into account the need to ensure appropriate conditions for the functioning of nature and, in particular, for the continued supply of resources and services aimed at sustaining life. Seen from this perspective, sustainable development must be understood as a consensual strategy to improve the quality of life within the limits set by the resistance to human pressure of the most important ecosystems forming the biosphere and within the barriers to the development set by the availability of natural resources[16].

The principles of sustainability are only a typology of management methods that take into account the possibilities and limitations of the substitution process. Substitution, which in this scheme is a specification that relates primarily to natural capital and man-made capital. In that context, the lack of substitution between resources belonging to different types of capital is considered. Alternatively, the substitution of all resources regardless of which type of capital they are is allowed. Certainly, the inclusion of considerations on human and social capital would make whole theoretical reasoning more difficult and unclear. Therefore, it should be noted that the principles discussed here facilitate the description of reality, but it is neither comprehensive nor perfect.

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16 This way of understanding and interpreting sustainable development is also present in the Polish economic literature. At this point it is worth mentioning, just for example, several works that relate to the general concept of sustainable development or relate to the system of indicators to measure sustainability: T. Borys, *Indicators for Sustainable Development – Polish Experiences*, Warszawa-Białystok 2005; A. Graczyk (ed.), *Teoria i praktyka zrównoważonego rozwoju*, Białystok-Wrocław 2007; T. Żylicz, *Sustainability Indicators: An Economists's View*, in: T. Hak, B. Moldan, A.L. Dahl (eds), *Sustainability Indicators. A Scientific Assessment*, Washington D.C. 2007, p. 97–105; B. Fiedor, *Trwały rozwój a koncepcja społecznej gospodarki rynkowej*, "Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu", in: *Kształtowanie zrównoważonego rozwoju w reakcji na kryzys globalny*, no. 225, Wrocław 2011, p. 13–29; J. Śleszyński, *Synthetic sustainable development indicators: Past experience and guidelines*, "Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu" 2013 no. 308, p. 144–164.

Nevertheless, in-depth study of the theory and practice of sustainable development and management can only benefit from principles of sustainability but cannot be limited to them. Certainly, ecological economics needs a strong and effective rejection of too optimistic neoclassical assumption of perfect substitution. Moreover, a soft return to certain themes of classical economics talking about the circular economy would be justified and expected[17].

It seems that the fundamental value of the discussed typology of the principles of sustainable management is their focus on two issues. Firstly, they clearly indicate the problem of major defects in the assumption of perfect substitution between factors of production. Continuation of such an assumption in relation to the decisive part of all natural resources is not only wrong but also dangerous. Secondly, the principles help to consider and highlight the differences between non-renewable resources and renewable resources. What's more, the principles can become a stimulus for reflection and research related to discovery of the real limits of substitution with respect to the key components of natural capital. In particular, the principle of sensitive sustainability demands application of specific and empirically developed limits of intervention in the environment. Such limits should concern the sustainability of the important and often essential components of the biosphere.

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[17] D.W. Pearce, R.K. Turner, op. cit.; N.O. Martins, op. cit.

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