The Projection of Country Universally Sustainable Development Applying the Integral Cluster of Knowledge, Innovation and Technologies

Aleksandras Vytautas RUTKAUSKAS
Faculty of Social Education, Lithuanian University of Educational Sciences
Vilnius, Lithuania

ABSTRACT

The paper presents the rudiment of universally sustainable development project for a small country that lacks exceptionally valuable or unique natural resources. This is a result of rather long experience of the author while studying the perspectives of small country development under conditions of intense globalization and conflict because of world territorial division among the different development ideologies or simply different interests. Along with that, the beginning of primary interests and possibilities for a self-sufficient development organization is analysed, as well as the formation problems of development resources and implementation technologies orienting towards the clusters of scientific knowledge, innovation and technologies. Such cluster is being treated as the key inexhaustible resource for a medium-sized country. The development of integral KNIT cluster for the implementation of different functions of country development is being performed. Finally, the selection of a model of universally sustainable development as a complex of instruments for development will be reasoned. The experimental assessment is performed on the example of the Republic of Lithuania case.

Keywords: Universal Sustainability, Sustainable Development, Quantitative Measure of Development Sustainability, Complex System, the Cluster of Knowledge, Innovation and Technologies.

1. INTRODUCTION

Sustainability can be defined as an ability of a subject to retain certain functions. The concept of sustainability and especially sustainable development dominates in the literature among the most ambitious and controversial concepts [1-4]. The knowledge and researches of evolution or development become not only the original means of generation of socio-economic science knowledge, but also an alternative in analyzing especially sophisticated development problems – such as survival, effective changes, avoidance of huge losses, etc. Finding the ways of such knowledge conversion into the field of science is complex, but there is no alternative. Researches of development have already become mass, and thus the objects of cognition should be structured, possibilities should be consolidated and the efficiency of the use of resources must be elevated [5].

The paper analyses the following problem – how to select an optimal structure of investment resources in order to retain and ensure the development sustainability for a small country that does not possess abundant natural resources and, as a result, can use mainly intellectual resources while nurturing its own development.

2. THE ANALYSIS OF THE STRUCTURE OF SUSTAINABLE DEVELOPMENT SYSTEM

The strategies of retention or development of sustainable system of Lithuania as an independent country constitute the particular object of the conducted research, where these strategies are grounded by the historically formed need for the retention of country self-sufficiency and ability to generate and implement the intelligent development strategies. The guarantee and motto of survival of Lithuania as a self-sufficient country is the historically formed intelligence of self-sufficiency retention and development. Immediate assumption of country self-sufficiency survival and successful implementation of development strategies is the intelligent use of natural, as well as human-possessed and created resources. The main guarantee context of country development effectiveness and success is a universally sustainable development. Here in order to touch more thoroughly all the peculiarities of development, as well as to use all the created powers, the following subsystems of country sustainable development are distinguished: religious, political, social-demohraphic, economic, ecological, educational-professional, creative and cultural, innovative-technological, integrative, marketing, financial and investment.

In Fig. 1 the conception of interaction among subsystems' and the whole of instruments for decision formulation and search is presented: the information systems of knowledge, decisions management, uncertainty evaluation, as well as stochastic models of quantitative decisions and expert evaluation. However, the evaluation of separate problems should be recognized here as the exceptional moment, when with the help of the gathered and generated information a search for the compatibility of different aspects of development is performed.

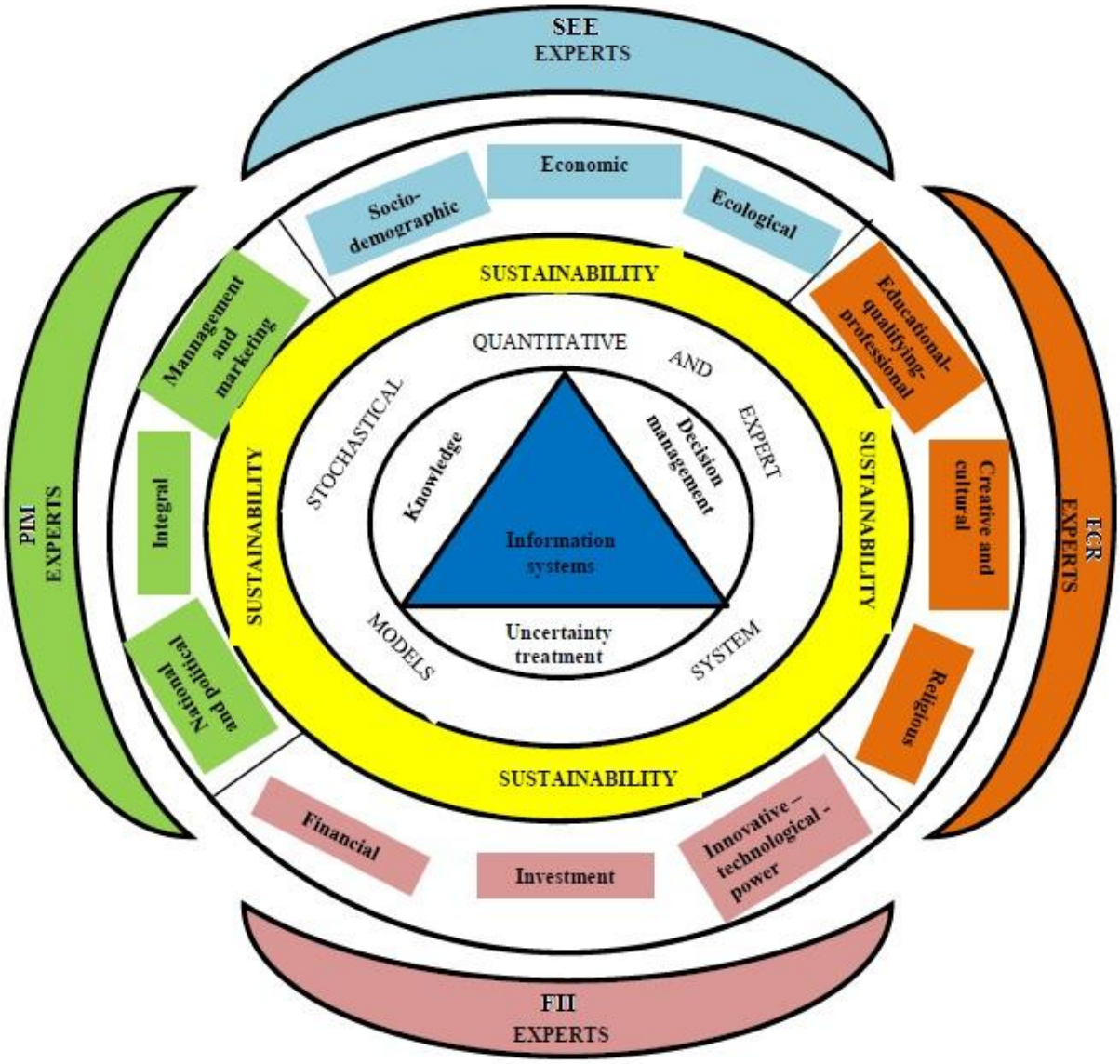


Fig. 1. Formation of components delivering the development sustainability and preparation of the means of knowledge and expert valuations pursuing the possibilities of development sustainability management and the idea of the round table [6]

As a separate challenge while analysing the sustainable development problems in the context of systems' methodology a question arises on the unification of measuring dimensions of separate subsystems and the effectiveness of the whole system. First of all, let us remind that sustainability measurement is related with two-dimensional measures – effectiveness and reliability. Reliability has an undimensional way of measurement, but while measuring the effectiveness one cannot get along without the indicators expressing the content of existence of subsystems or the whole system, such as created product, grown harvest, etc.

Also, in complex systems it is accepted that in the reality serving as the object of their cognition the possibilities exist that the state of one subsystem can be a factor of the other subsystem's state, that ultimate indicator of the state of the whole system or its generated effect can be a complex function of separate subsystems'

indicators. But the most difficult problems arise when it is necessary to solve the key economic problem – how to allocate rationally the possessed scarce resources with the objective to orient the system's movement to the optimal state or trajectory.

3. INTELLIGENCE OF THE SUSTAINABLE DEVELOPMENT SYSTEM

Thus we approach the perception of intelligence. Intelligence uses the definition of knowledge as a system to form a vision of potential development ways and methods that help to select the unique manner of work. In order to know or accept this contradictory situation, we should admit the dialectics of scientific knowledge and engineering, as cognition methodology: the science reveals the possibilities of what can be, while engineering focuses on what and how to do it. Treating knowledge, innovation and technology set as an integrated system, it is necessary to understand the diversity of situations, trying to make their integration be directed towards achieving the strategies.

In the performed study the particular objects are sustainable strategies of system maintenance and development for Lithuania as an independent country. These strategies are based on historically developed national self-maintenance needs and the ability to generate and implement intelligent development strategies. The guarantees and motto of survival for Lithuania as an independent country is historically formed intelligence of self-maintenance and development. Immediate premise of country independent survival and successful implementation of its development strategies is intelligent use of natural and human, available and emerging resources. The main context of country development efficiency and guarantee of success is universally sustainable development [7]. For a more detailed analysis of all development accents and application of developed powers, the four sustainable development subsystems of a country are distinguished: PIM, SEE, ECR and FII (Fig. 1), and their primary detailed description is presented in the article of [8] that is intended to explain the concept of universally sustainable development. Further, each subsystem will be shortly described, highlighting the role of intelligence:

PIM. This group is described through the possibilities to guarantee the representation of public interests in international institutions. The intelligent integration of a country into the local, regional or global organizations of national or economic security that guarantee safety under acceptable costs for a country is projected. Also, using the principles of marketing, the sustainable flow of import-export should be ensured along with the development of the utility provided by the results of general social and economic programs.

SEE. This group describes the ability to match the interests of different social groups relying on scientifically proved consistent patterns. Also, it is aimed to use rationally the internal and external resources in order to reach the desired value, in the same time maintaining diversity and efficiency of country's biological systems.

ECR. This group is described through the ability to combine learning and creativity while training business analytics and knowledge economics and striving for the balance of supply and demand in the labour market, as well as through the recognition of spiritual values of humanity. The ability to create something new and valuable using intelligence is trained.

FII. This group describes the ability to ensure the use of modern technologies based on the most efficient innovations. The power of financial system is attained, which allows for a public sector to ensure the required financial resources to implement the international liabilities.

Thus considering the nurturance of country universal sustainability it is necessary to pay attention to the ability to integrate intelligence, knowledge, innovation and technology management while solving the issues of small country development.

4. THE ASSUMPTIONS OF OPTIMIZATION EXPERIMENT ON RESOURCE ALLOCATION

Based on the assumption that sustainability of national development, sustainability [9-10] can be examined using a model of a complex system, we have to admit that the corpus of elements existing in reality would have the following characteristic features:

- a very complex system;
- high sensitivity to even the smallest changes in dependencies between components;
- its identification and verification is difficult even with the knowledge of its design or function, or both;
- it is characterised by abundant interactions between different components;
- with time, it may reveal new features or states [11].

There is no doubt that all of these characteristics are particular to the phenomenon of national sustainable development. However, if it needs to remain an open and self-regulating system, the functioning of which required resources, which may not only lead to changes in internal dependencies but also in the effect created by individual subsystems or even the entire system whilst turned into input elements, then, there should be an agreement that the system, the content of which is comprised of above-mentioned features, requires the design of adequate possibilities for its understanding and management [12].

The study conception of interaction between the subsystems, formulation of solutions and the set of instruments for solution search: the systems of information knowledge, management solutions, uncertainty assessment and the models of stochastic quantitative solutions and expert evaluation, is presented in the previous author's articles [8, 13]. But at exceptional moment here we have to recognise the assessment of separate problems, when on the basis of

collected and generated information is searched interoperability between different aspects of the development. And the fact that here invoked so-called stochastic informative examination methods for expert evaluation.

Examining sustainable development problems in the context of methodology for complex systems, a question emerges regarding the alignment of performance measurement dimensions used for separate subsystems and the entire system. It should be reminded that sustainability measurement is two-dimensional, namely, aimed at efficiency and reliability. Reliability has a dimensionless measurement method; however, the measurement of efficiency is impossible without indicators that represent subsystems or the content of the entire system [11].

However, the most difficult problem arises when dealing with the fundamental economic problem of rational allocation of scarce resources aiming to direct the system toward the optimal state or trajectory.

5. ILLUSTRATION OF EXPERIMENTAL SITUATION SOLUTION

Further temporarily simplifying the situation let us suppose that the state of every subsystem can be measured with undimensional indicator and that using the stochastically informed expert valuation one can determine the effectiveness of marginal investment unit, if it is used for the training of i^{-th} subsystem functioning. Then we can form a task – how one should search for the optimal allocation of resources among the subsystems under the conditions of uncertainty.

To solve the mentioned problems the logics and technique of adequate portfolio will be used, that is created, described and further developed by Rutkauskas [14-15]. The adequate portfolio can be treated as natural extension of the modern or Markowitz portfolio [16], because instead of the mean value of the effect of possibilities all the possibilities are used and the parameter of reliability is introduced [13].

Let us say that expert valuation evidences that the possibilities of the use of marginal investment unit under the certain investment proportions among the distinguished subsystems, as well as inside the formed subsystems, to change the index of every subsystem's state (which is a priori treated as one) can increase along the following stochastic multipliers:

$$D_1(a_1, S_1),\ D_2(a_2, S_2),\ D_3(a_3, S_3),\ D_4(a_4, S_4),$$

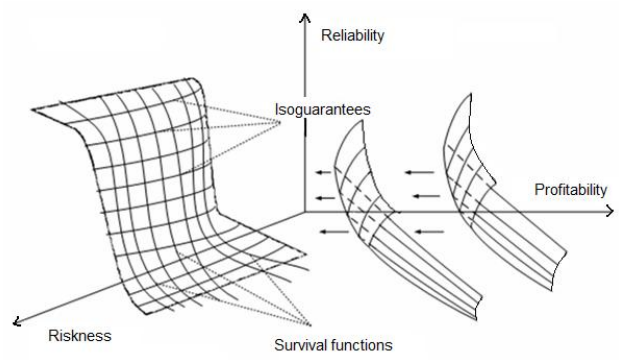
where a_i, S_i are the mean values and standard deviations of the random variables.

Let us try to determine by what proportions we should divide the marginal investment among the distinguished subsystems if the indicator I of the whole system's state is being formed as a weighted average of subsystems' indicators I_i:

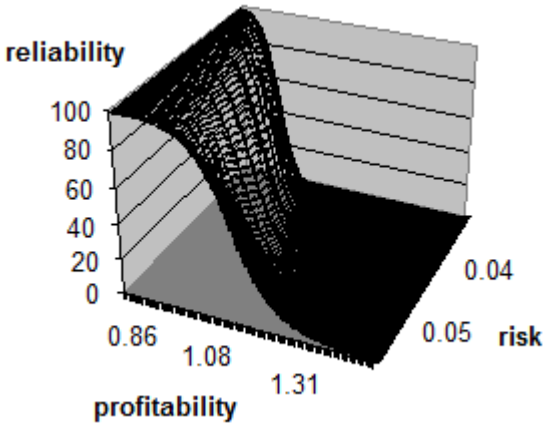
$$I = w_1I_1 + w_2I_2 + w_3I_3 + w_4I_4.$$

Let us analyse the following case:

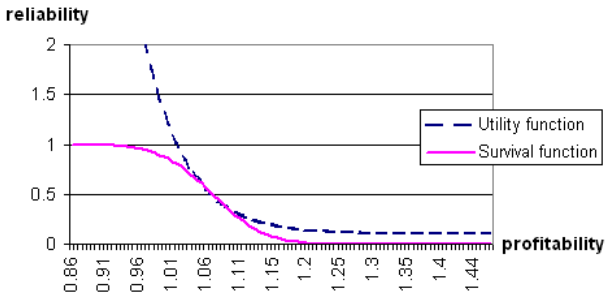
1. When the situation is complex and the mentioned variables achieve specific forms that are typical for these subsystems: D_1 becomes Gumbel, D_2 – LaPlace, D_3 – stays as Normal and D_4 as Lognormal probability distribution.



a) The general scheme of decision search



b) The surface of possibilities



c) Finding the solution

PIM subsystem	SEE subsystem	ECR subsystem	FII subsystem
Gumbel probability distribution	La Place probability distribution	Normal probability distribution	Lognormal probability distribution
0.26	0.32	0.2	0.22
Parameters: e_x – 1,151202 p_x – 0,57 r_x – 0,029649			

d) The structure and parameters of the solution point

Fig. 2. Optimal allocation of resources among the four subsystems

2. The selected probability distributions are described by the following mean values and standard deviations:

$a_1 = 0,94$; $s_1 = 0,03$;
$a_2 = 1,22$; $s_2 = 0,06$;
$a_3 = 0,99$; $s_3 = 0,05$;
$a_4 = 0,90$; $s_4 = 0,02$.

The results of finding the optimal investment portfolio are presented in Fig. 2.

The section a shows the general scheme of solution, when indifference curves approach the surface of efficient possibilities. The surface of possibilities itself is presented in section b. Section c shows the point of optimal solution in the two-dimensional plane. And section d presents the parameters of solution. The values of the four subsystems show the structure of allocation of investment unit among the development subsystems. In the analysed case the biggest part of the investment is given to the second (SEE) subsystem – 0.32. Further the parameters of solution are presented: e – efficiency (profitability), p – reliability and r – riskiness.

6. KNIT CLUSTER AS A SELF-ORGANIZING COMPLEX SYSTEM IN THE PROJECTION OF SUSTAINABLE DEVELOPMENT

Although the trio of categories - knowledge, innovation and technologies (KNIT) - are particularly often used together when examining the general characteristics of this cluster or examining the interaction of knowledge, innovation and technologies as subsystems, when the objects of their influence are the same phenomena or systems of reality, but in scientific literature there is insufficient attention to their structural analysis.

Indeed the interaction of KNIT cluster subsystems is particularly difficult, equivalent in complexity to the interaction of biological systems and lacking a sufficiently adequate understanding of adequate cluster structure there remains only a very uncertain possibility of influence when seeking a sustainable development of cluster as well as use of its power. There is no doubt that the structure of a KNIT cluster depends on the object, whose understanding and management requires information generated using KNIT. Such an object will be called a KNIT object.

In any case, the structure of a KNIT cluster can be expressed only with the example of an undetermined set (Fig. 3). It is clear that without the assumption of which object is in the centre of focus of the cluster, it is difficult to talk about Fig. 3, because it is a collection of unrelated (not linked by the needs of the mentioned object) knowledge, innovation and technology digests.

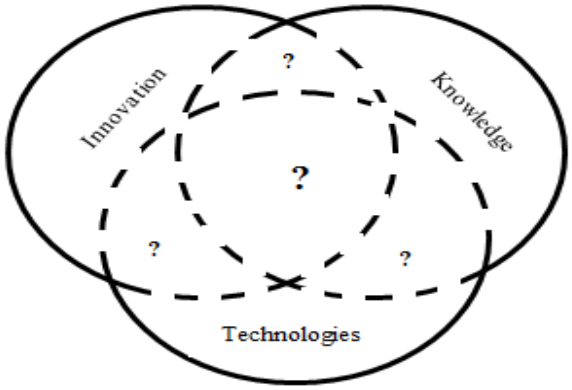


Fig. 3. Initial stage of formation of integral KNIT cluster [6]

There is no doubt that with the change of KNIT object, the content of cluster components and the structure of the cluster also changes.

What should a scheme or algorithm be that would standardize both the physical understanding of cluster components and their interaction anatomy, and, most importantly, allow one to understand how to change the cluster structure in order to make a particular change in the condition of cluster object, or what should be the value structure of the cluster that would allow it to optimally (i.e. most efficiently) use the investment resources to carry out its functions. In turn, it is important to understand, which of the components of the cluster becomes a carrier (potentially the most important to achieve the goals).

Integral hierarchy of KNIT cluster subsystems at this moment can be defined, in a simplified way, as follows:

- In cases where the problem is closely related to topics such as knowledge economy, knowledge society and so on, the leading subsystem is that of knowledge;
- In cases where the problem is linked to the analysis of innovation function system, the leading subsystem is that of innovation;
- In cases where the technological change or technology transmission are at the center, the leading subsystem is that of [17].

Of course, the fact that the cluster of linked knowledge is often already an innovation, the integrated knowledge and innovation cluster are a new technology and the integral KNIT cluster is a technology causes confusion when creating a scheme or algorithm to standardize the understanding of KNIT subsystem interaction.

6.1. Integral KNIT cluster as a main source of universally sustainable development factors pertaining to a country

Considering the development projects of many countries, especially if they do not possess abundant natural resources, the idea is being unambiguously revealed that the main and inexhaustible resource for their development becomes an integral cluster of scientific knowledge, innovation and technologies. The concept "inexhaustible" in the last sentence requires special attention. Since this factor is both naturally evolving and purposefully improved, there is probably no need to talk about its inexhaustibility. However, on the other hand, recognizing that future problems become more sophisticated, and negative processes in many areas of human existence obtain catastrophic speed, we need to understand that even if the resource remains everlasting, for many subjects, including individual countries, it may become unattainable.

There is no doubt that the integral KNIT cluster efficiency evaluation problem should become the object of exclusive attention of national and global science. Unfortunately, little work aims to propose a pragmatic solution for the latter problem. What should be the structure of the integral KNIT cluster, recognizing that the categories of knowledge, innovation and technologies mean the implementation of different functions, and the need for financial resources is also formed in different ways?

In our experiment the object of integral KNIT cluster is the projection of universally sustainable development pertaining to a country (Fig. 4). The concept of universally sustainable development is quite extensively presented for the scientific community (see examples in [8, 18]), so there is no need to talk about its content and constructivism. It is only worth to mention the structure of each of the four subsystems of country development sustainability:

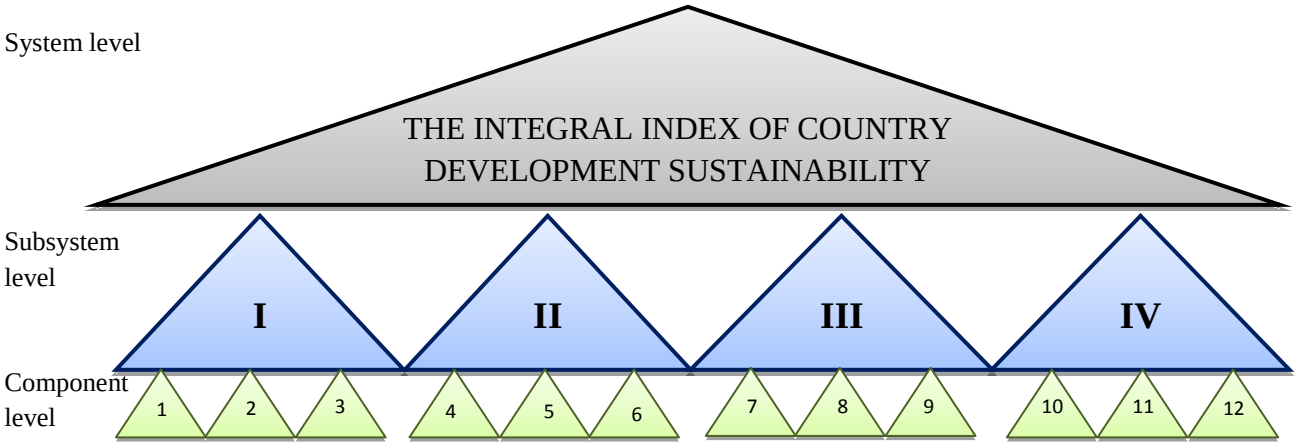


Fig. 4. The hierarchical formation of components for sustainability development

- 1st subsystem PIM, composed of political (1), integration (2) and managerial (3) components;
- 2nd subsystem SEE, composed of social (4), economic (5) and ecological (6) components;
- 3rd subsystem ECR, composed of educational (7), cultural (8) and religious (9) components;
- 4th subsystem FII, composed of financial (10), investment (11) and innovation (12) components.

The schemes, positions and contents of the components are also extensively described in [5, 19-20].

The title of this section appeals to the fact that the integral KNIT cluster should be a key source of the universally sustainable development factors. Fig. 4 illustrates the fact that all components of universal development sustainability require the help of KNIT for generation of required knowledge, innovation and technologies. It is evident that the cluster has to be adapted to meet the needs of a specific object – the projection of universally sustainable development pertaining to a country.

The title of Fig. 4, the idea of a round table, highlights the fact that in the selection of final solution the interests of all development sustainability components or just the experts representing those interests should participate, otherwise there should be adequately formulated criteria. The idea of the round table helps to express a provision that there should be a possibility to quantify and coordinate these interests.

6.2. Integral KNIT cluster as the technology of an adaptive complex system

Understanding of technologies is, on the one hand, increasingly approaching the definition of its unique features: nuclear technologies, nanotechnologies, Internet technologies. On the other hand it reflects more and more the whole of actions and processes, principles, methods and criteria which express the possibility of transforming

the original resource, for example knowledge and innovation, into a valuable product such as management system, monitoring and development strategy [21].

These are apparently the natural changes of thinking logic, because in the case of even a not particularly sophisticated supply of production or service, a network of technologies of the organization and manufacturing of production, supplying, market formation, marketing, finance and so on is formed, the perception of which itself becomes a problem. Therefore it is worth considering whether it is not better to sometimes just choose the ideology of complex network or system organization and management, without doubting that the formally identified object of understanding of the complex system and research instrumentation remained adequate to systems emergent in reality and the interaction of its subsystems and components.

An outlook forms that technologies, innovation or even technological discoveries can come from the side of managerial effort. It sends a positive signal for multiple service providers because stereotypically they usually stayed beside technologies.

Now among the titles of technologies very often are those which appeal to the business organizational side or the features of possible solutions. So, next to information technologies, the technologies of complex systems, which are oriented to the object, their mutual relations, the processes of changes and the abundance of criteria and especially the complexity, are attempting to win their place in system [22-23].

Considering the complexity of system management practices an opinion forms [24] that it is apparently useful to choose an already professionally prepared model of the complex systems that has the ability to cover and reveal all the functions typical of a very broad class of complex systems, find the analyzed system among the whole of model's functions and identify it as the particular case. There is no doubt that it will always be the case that the particular system chosen has its peculiar characteristics and that this necessitates the development of the general model. However, it is necessary to always remember that the creation of adequate model for a wide class of complex systems is a long and costly work.

The circumstances presented above apparently form a basis to not overly generalize the understanding of technology as knowledge and skills of using the mechanical tools and applied science results [25-27] or that the technology is the totality of manufacturing process performance methods and tools [10, 28].

6.3. Integral KNIT cluster as a complex system

Projecting KNIT as a self-organizing system which could be the resource of a country's sustainability development factors and the backing force of sustainability, it is important to adequately perceive the possibilities of knowledge, innovation and technology cluster. Naturally, the formation of the cluster leads to distinction of the mission and core functions of each component, which in turn could be the base for expert evaluation of financial resource requirements. On the other hand, special attention must be given to the understanding of the role of each of the components in order to achieve the strategic objectives of a country's sustainable development [8] and which can be divided into four groups and that are presented in sufficient detail in Fig. 4. These are:

- political, integration and managerial;
- social, economic and ecological;
- educational, cultural and religious;
- financial, investment and innovation.

In turn, there is no doubt that most of the components of the country's universally sustainable development project (Fig. 4) are potential objects of an adaptively changing integral KNIT cluster, whose objectives can be achieved by means of a complex adaptive system technology or simply by means of technological support of KNIT cluster.

But at the same time it must be remembered what growth is expected of the requirements of an integral KNIT cluster so that it can adequately adapt moving from one object to another, or in our experimental case, from one project of universally sustainable development to another. But it is important to know how to choose the typical scheme or algorithm of adaptation to preserve the efficiency of the proposed methodology.

Yet the supreme requirement exists for the KNIT cluster itself, namely that by becoming an agent of social development it should not only not lose status of inexhaustible source of expansion factors, but also remain cost-effective. In the next section, by means of stochastically informative expertise the importance of KNIT contribution at each of the aggregated components of universally sustainable development is evaluated, and the optimal KNIT structure when the object of KNIT remains the same project of universally sustainable development is found.

7. FURTHER TRENDS OF RESEARCH OF UNIVERSAL DEVELOPMENT SUSTAINABILITY

The universal sustainability is an ability of a state, process or system to retain a certain collection of functions which guarantees the existence of a system and the accessibility of a structure. In the previous section the solution to the problem of optimal allocation of resources is presented, when the marginal investment unit is divided among the four sustainability subsystems responsible for separate areas of activity. This is an innovative and adequate instrument for efficient use of investment resources.

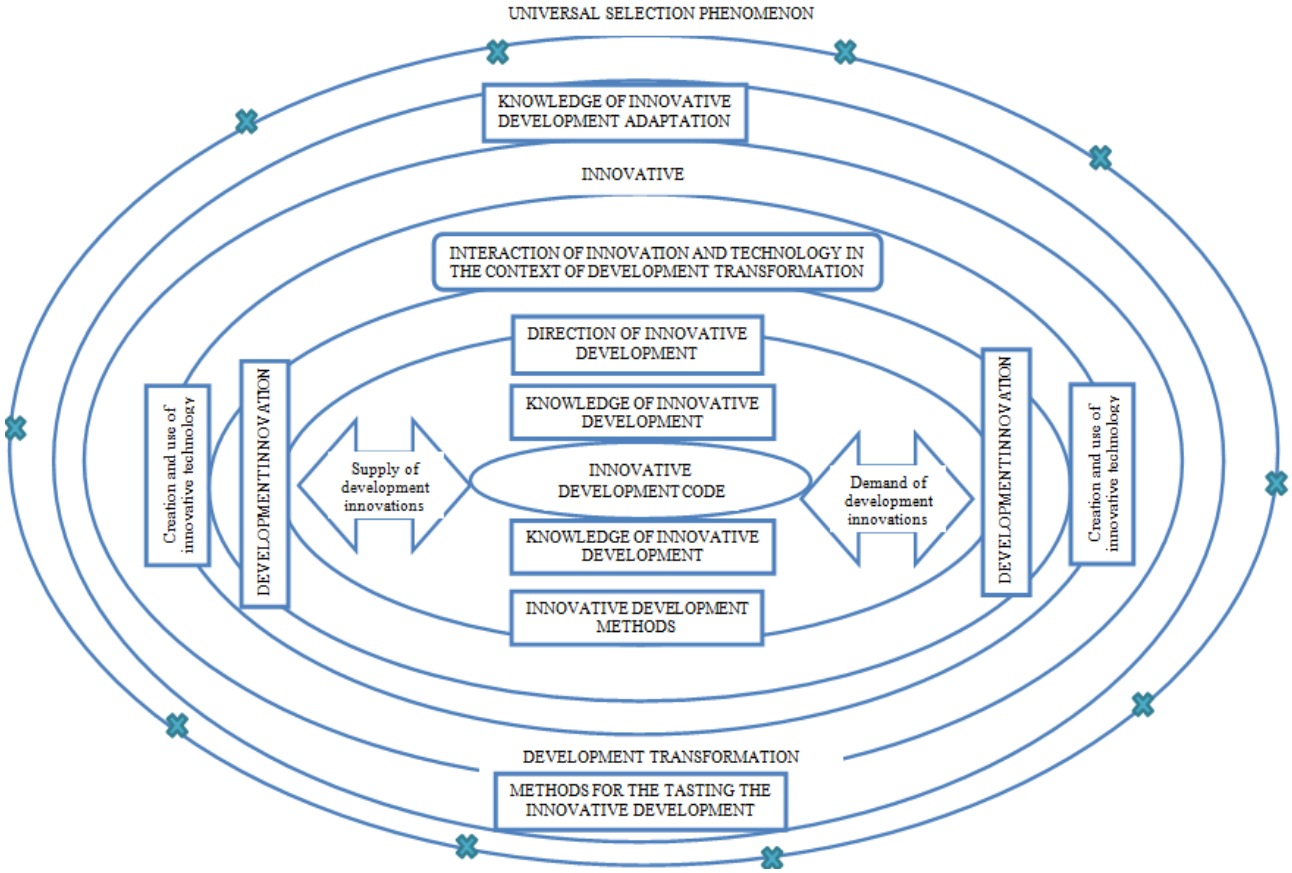


Fig. 5. Shifting development code

By its essence the sustainability is not a status quo; while situation is changing, its effect can also grow or diminish. However, the system whose sustainability is being analysed in the paper should possess a shifting development code (Fig. 5). Otherwise it is a matter of time before the system disappears or degenerates. The integral KNIT (knowledge, innovation and technologies) cluster [6, 11, 17] with its object being the country development becomes a generator of the key scientific knowledge, describing what development strategies, with regard to the changing conditions, would allow to keep the shifting development. In such a situation the innovation and technological subsystem of the cluster will guarantee the implementation of the selected development strategies. Thus it is advisable to elaborate the researches of KNIT cluster as a shifting development code in the context of retention of sustainability state.

8. CONCLUSIONS AND SUGGESTIONS

Immediate premise of country independent survival and successful implementation of its development strategies is intelligent use of natural and human, available and emerging resources. And the main context of country development efficiency and guarantee of success is universally sustainable development

Sustainability should be analysed as a complex model of systems that possesses respective characteristics. However, such a system remains an open and self-regulating system, where resources are used in the form of inputs and they can change the internal interdependencies inside the system.

The paper presents the solution to the problem: how to optimally allocate investment resources among the four sustainability subsystems (PIM, SEE, ECR and FII) under conditions of uncertainty. The solution to this problem is an innovative and adequate means to reach the universal sustainability of a country.

Proper development of KNIT cluster using investment resources would help to reach the universal sustainability of a country, which, in turn, is expressed through the four fields of expertise: SEE (social, economic and ecological), ECR (educational cultural and religious), FII (financial, investment and innovation) and PIM (political, integration and managerial).

The application of the integral KNIT cluster as an adaptive complex system model for the cognition and projection of universal sustainable development has revealed and dictated the real problems of cluster cognition and analysis of its development.

The shifting development code, the background of which is the KNIT cluster (knowledge, innovation and technologies), is a deep trend of further researches that can be undertaken while analysing the assumptions and means of ensuring the sustainability of a small country.

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