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EDITORIAL

SUSTAINABILITY MODELS AND INDICATORS

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Abstract. Achieving goals of sustainable development requires new models and indicators of gathering, sharing, and analyzing information, coordinating work, educating and training professionals, policymakers, and the public. Because of the complexity and the enormous amount of relevant data, the decision makers need effective support for their decisions. The use of a knowledge-based approach is a solution for reducing this complexity. Nowadays the strategic and operational decisions are facing challenges of economic competition on a global perspective and realization of sustainable development that are the result of a new thinking and recognition of a competitive positioning, ecological and social consequences. Sustainable development is increasingly being seen as a major challenge in global terms. New information and communication systems build the bridge to on-line and just-in-time decision-making within supply chains and production and logistics networks. Operational Research has yet to be fully utilised in this area. To date, where it has been mostly used, it tends to deal with the relationships between environmental management and product supply chain and also focuses on the social dimension. This article surveys the recent work on sustainability models and indicators to be implemented in sustainability policies and decisions.

Keywords: sustainable development, indicators, multicriterial decisions, energy planning, information and communication technologies.

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1. Introduction

The reports commissioned by the Rome Club in seventies of the last century explored a number of scenarios and stressed the choices open to society to reconcile sustainable progress within environmental constraints (Meadows *et al.* 1972). The reports offered a new and original approach applying the systems-thinking on the long-term consequences of growing global

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interdependence. The new thinking paradigm spread widely and gained a background for implementation of knowledge-based technologies and operations research in sustainable development policies and decisions (Haasis *et al.* 2001; White and Lee 2009; Kurlavičius 2009; Tamosaitiene *et al.* 2010, etc.).

Nowadays, the problems such as rising global inequality, the consequences of climate change and the overuse of natural resources have proved that the Club of Rome's fundamental views are broadly correct and confirmed that unlimited consumption and growth with limited resources cannot go on forever and is indeed dangerous (Turner 2008; Jackson 2009; Stiglitz *et al.* 2009, etc.). The future of human being lies in the sustainable development and in the creation of the knowledge based society and knowledge based economy. There is a demand for planning and decision strategies in this complex area. It requires a stronger focus on the processes itself rather than centring attention on its' components, states, outcomes or aspirations. This is not to say that all of the above are unimportant, they are useful guiding tools but the nature of the sustainability puzzle at the moment lies in the processes that will generate a different way for humanity to relate to its planet and fully embrace its stewardship role. Sustainable development goals follow the principle of making such management decisions, that the needs of future generations are not restricted by satisfying the needs of today's generation.

Because of the complexity and the enormous amount of relevant data, the decision makers need effective support for their decisions. The use of a knowledge-based approach is a solution for reducing this complexity. Achieving goals of sustainable development requires new models and indicators of gathering, sharing, and analyzing information, coordinating work, educating and training professionals, policymakers, and the public. This article surveys the recent work on knowledge-based approach for models and indicators aimed to be implemented in sustainable development policies and decisions.

2. Modeling Sustainability

Nowadays the strategic and operational decisions are facing challenges of economic competition on a global perspective and realization of sustainable development. Of course, these challenges are the result of a new thinking on and recognition of a competitive positioning, ecological and social consequences. Sustainable development is increasingly being seen as a major challenge in global terms. New information and communication systems build the bridge to on-line and just-in-time decision-making within supply chains and production and logistics networks. Operational Research has yet to be fully utilised in this area. To date, where it has been mostly used, it tends to deal with the relationships between environmental management and product supply chain and also focuses on the social dimension.

Energy is essential to economic and social development and improved quality of life. The energy sector needs to be environmentally sustainable while as being economically sustainable. Energy utilities need to earn an adequate return and satisfy shareholders, whilst understanding their corporate responsibilities and a wider social impact of their business. Adequate energy planning is a crucial task to contribute to sustainable development, enabling to match future energy supply with future energy demand. Urban energy planning presents

a lot of typical problems solving of which offers an experience to be useful for other energy shareholders. Urban energy planning may be characterized as the decision making process of selecting the local energy infrastructures to invest in, the energy efficiency initiatives to promote, as well as all policies with impact on energy consumption patterns. The planning of an integrated urban energy system (comprising several energy carriers and energy distribution networks) is a complex process, with many stakeholders involved, influenced by many factors, among which the most important are the availability of energy resources and the competition between different energy carriers in satisfying energy demand. This process inherently involves a broad range of issues, multiple and conflicting evaluation criteria (economic, technical, political, environmental and social), several stakeholders and their values. However, decision problems arising in the realm of urban energy planning can be efficiently tackled using Soft Systems Methodology (SSM) as a tool for problem structuring to provide decision support based on Multi-Criteria Decision Analysis (MCDA) (Diakoulaki *et al.* 2006; Coelho *et al.* 2010). The aim of MCDA is to improve the quality of decisions by providing a rational basis for the comparison of competing solutions, since a prominent alternative does not exist whenever multiple conflicting criteria are at stake. The appraisal of possible courses of action for urban energy planning will be made in the framework of a sorting problem, that is, they will be classified into pre-defined ordered categories according to their absolute performances. For this purpose the ELECTRE TRI method has been selected, which allows for the use of different (qualitative or quantitative) scales for different criteria. This enables to evaluate the potential courses of action on an "as they come" basis and accounts for the uncertainty associated with their performances in some criteria (Stasiškienė and Šliogerienė 2009; Coelho *et al.* 2010).

Uncertainty of the power market should be taken into account when planning the power system (Beraldi *et al.* 2008; Fleten and Kristoffersen 2008). Although the problem of rational power generation under uncertainty has been extensively studied, traditional planning methods do not offer good solutions to this purpose, especially in a competitive electricity market environment where many factors are uncertain. Thus, within the framework of two-stage linear stochastic programming, a method for power planning has been developed, under the presumption that the generation outputs and load demands can be modelled as following to specified continuous probability distributions (Sakalauskas and Žilinskas 2010). The approach developed enables us to find the power plant allocation in the region which minimizes the sum of the investment and the expected operating costs over the long-term planning horizon, taking into account the environmental impact. The structure of the considered task corresponds to a power investment planning problem that often arises in the developing regions. The method is developed for solving the stochastic optimization problem by the sequence of Monte-Carlo sampling estimators. The procedures developed make it possible to solve stochastic problems with an admissible accuracy by means of an acceptable amount of computations. As follows from numerical experiments the approach presented enables us to decrease the total expected costs of power planning versus deterministic planning solution.

Our society, as well as nature, exists and develops in space and time. Location of territories and different spatial relationships are among the most important factors that influence the ecological, economical and social parameters. Development plans should in some way take

into account the spatio-temporal distribution and spatial correlation of these parameters. Thus, geospatial analysis plays a very important role in the decision making. Therefore it is very important to include geographic/cartographic dimension into regional and national sustainable development strategies, so that spatial structures, diversities, similarities and geographic determination are always taken into account. To facilitate the process of geographic decision making, a uniform model of description of geographic information is developed that could be used online and provide suggestions on which of the known methods could be efficiently applied (Beconytė and Kryžanauskas 2010). The model developed is a step towards facilitation of use of geographic methods for decision making in different spheres of life. As implemented, such model can be used by everyone moderately familiar with main principles of geography, and, on the other hand, integrate expert knowledge on various methods and their applications, thus providing a roadmap for geographically literate decision making. Due to simplicity of interface and flexibility the model could be used and also developed by planners, researchers, analysts, computer scientists and programmers.

In today's knowledge-based societies the evolution of Information and Communication Technologies (ICTs) have long been argued as a catalyst for development and change as it reinforces new forms of social and business interactions and use of services (Verdegem and Verhoest 2009). The analysis of the risk of transportation processes shows that transportation of hazardous materials is complex process and causes a risk quite a different than that of a fixed facility. Sustainability of surroundings depends on a safe transportation, especially on the safe transportation of dangerous goods by different auto transport kinds. Thus, development of the architecture of decision support system with integrated embedded components for monitoring and evaluation of transportation processes of dangerous goods using uniform models of geographic information. An appropriate interface modeling structure (components, scenarios) for service control, and integrate data-mining, knowledge-based techniques for recognizing a concrete situation of the moving object are developed (Dzemydienė and Dzindzalieta 2010). Some wireless protocols are used in establishing the object's geographical coordinates, monitoring and fixing the state behavior of the moving dangerous transportation objects. A dynamic environment has significant dynamic components that should be evaluated in accordance with correct well working Decision Support Systems. On-line working sensors help in the recognition of abnormal situations of transport means, by using mobile technologies. An approach for developing the interaction architecture of mobile devices and remote server systems with additional functionalities for contextual information transmission is proposed, too. The proposed context modeling mechanism assures an always up-to-date context model that contains information on the transport device and location. Mobile internet services to extend the users interaction with architecture are offered. The main advantage is the extensible architecture so that you can get the data to a mobile devises through web services.

Sustainable development combines ecological, social, and economic concerns, and offers opportunities to improve the lives of people (Grundey 2008). Market attributes that can serve the purpose of sustainability – such as freedom of choice, competition, and innovation – should be more fully engaged in such concerns, because markets also provide the poor with more opportunities and can better reflect the values of environmental goods and services crucial to our quality of life. The emphasis is laid on the concept of market capacity which is

comprehended as market potential (the other term occasionally referred to is, potential capital') and which is also the highest possible, from a theoretical viewpoint, amount of product/service sales that could be reached within a certain period of time by all the companies in the market. The focuses is done on the actually complete market (actually covered market) and on market niche (the uncovered part of markets). The capacity of market is defined by the possibility of transactions, their volume and value. Possible scenarios of partly closed market formation have been studied (Knyvienė *et al.* 2010). Studies show that from the viewpoint of logistic analysis, markets can be divided according to their closure. Results show that with the intensification of market closure, the economic system is essentially changing its behaviour. From the perspective of logistic analysis, closed markets are more important. Capital growth in such markets can be modelled by means of logistic models. Logistic analysis shows that with the increasing closeness of the market, the behaviour of producers and consumers also changes thus increasing the possibility of the occurrence of economic paradoxes.

Considering the role of information and communication technologies (ICT) as means for knowledge management processes within knowledge management systems, the bound between knowledge-based economy and sustainable development, the analyze of the use of information and communication technologies in different countries, over time and through comparison with the high human developed group, is very up-to date. To explore the extent to which novel investment evaluation tools can combined and used in collaboration with the innovation theory and the expected consequences for agricultural extension are of the great interest. The selected approach uses discounted cash flow techniques in combination with Monte Carlo simulation (Michailidis *et al.* 2010). At a theoretical level, the unambiguous result that evaluation under uncertainty causes significant changes in investment decision is obtained. Application of novel investment tools into agricultural extension issues and how the theoretical findings can be translated into empirical actions, working as a catalyst of decision's change, through the employment of a real options model have been shown at an empirical or practical level. However, as a first systematic attempt to adapt an engineering economics model in the agricultural extension issues, the employed model was limited to an *ex-ante* examination and to a rather small number of estimated uncertainty elements. Further, it is advisable to concurrently investigate differing rural areas, including, for example, areas close to urban centres or related to more 'elitist' activities such as agro-tourism which may be more familiar to technologies and thus have different ICTs diffusion patterns.

3. Sustainability indicators and sustainability surveys

To understand the widespread change of environmental indicators and to find ways to improve the conditions is a challenge for the human community. The development and application of sustainability indicators is an area of active research and practice that has received a lot of attention. It has produced a variety of lists and descriptions such as the 2006 United Nations list of Indicators of Sustainable Development which includes a total of 96 indicators (<http://www.un.org/esa/dsd/dsd_aofw_ind/ind_index.shtml>) or sets applicable at community, corporate, national, state or local government level. They can also cover particular activities, such as sustainable consumption or production. There have also been attempts to develop a

holistic or aggregate indicator to measure sustainability (OECD 2001), such as the genuine savings indicator, gross national happiness (Brooks 2008) or ecological footprint (Rees 1992). The aim for the majority of indicators is to somehow assign a value or a number against that describes the complexity between social, environmental and ecological health (Mofatt *et al.* 2001; Ledoux *et al.* 2005; Lin 2010). Nowadays such areas as sustainable development, knowledge economy and information society are among the most important issues discussed in strategies. Strategies of sustainable development are analysed in-depth by (Hass 2002). Implementation of every strategy is based on certain implementation policy. Statistical indicators identifying respective social, economic or environmental processes enable to perform policy evaluation and preparation functions. Thus, appropriate usage of statistical indicators is of high importance when preparing effective regional policy.

According to the Lisbon strategy (2000), the European Union (EU) should become the most competitive region in the World. Goals, defined in the strategy, and instruments for seeking them are identified by structural indicators as well as their systems. Main structural indicators identifying implementation of Lisbon Strategy goals and by using them evaluate Lithuania's position in the European Union are given by (Baležentis *et al.* 2010), where structural indicators are described and classified, main methods of quantitative analysis based on use of structural indicators are surveyed, position of Lithuania in the European Union is evaluated. Thus, Lithuania is among leaders in the European Union by employment level, youth education attainment level, comparative price levels and greenhouse gas emissions. Thus Lithuania does not have serious environmental problems and can successfully compete in international market because of relatively low production costs. The Baltic region is quite homogenous in innovation and research as well as in economic reform areas, thus it can become attractive for investors. GDP per capita, labour productivity and employment level of older people are relatively low in Lithuania. In addition intensity of energy consumption should be lowered by encouraging modern energetic technologies. Therefore technological backwardness is characteristic to Lithuanian economy due to low labour productivity on the one hand and high energy consumption intensity on the other. This backwardness can be eradicated by promoting innovations and R&D activities.

During last decades trade and capital movement liberalisation and the transition of countries to a market economy increased the possibilities for production transfer abroad. Multinational enterprises (MNEs) now face such concerns as to whether invest abroad or not, how and where to invest. The most frequently a MNE is defined as an enterprise that engages in foreign direct investments and owns (or controls) value-added activities in more than one country (Dunning and Lundan 2008). Not long ago the main form of international economic activities was trade when today global sales of foreign affiliates of (MNE) are almost double of the size of global exports (UNCTAD 2008). The boost of foreign direct investments and related sales were fuelled first of all by trade liberalization and easiness to carry out geographically spread activities. German MNEs are the major participants in the internationalisation process with huge FDI to other EU and third countries. Statistics indicate that the Czech Republic, Slovakia or Hungary had been more favourable for German investments than the Baltic States. The analysis of German MNEs to production networks in Central European and Baltic countries is given by (Miškinis and Reinbold 2010). Germany is

a large exporting country and has a big potential for international production transfer when German MNEs face a high cost level and a stagnating demand at home. Growing German investments into production abroad raise the question. The research revealed that the main motive for worldwide German foreign direct investments is a search for new demand markets as the local market in Germany demonstrates a slow development and growth prospects are limited. German investments into production units in CE and Baltic countries in contrast to worldwide investments are mainly of vertical integration to exploit the cost advantages of those countries. Horizontal investments in these countries are less prevalent as companies tend to export to the region instead of investing in production units serving local markets. The determining factors for the transfer of production units by German MNEs to a specific country in CE and Baltic countries are state policies, local labour markets and location. Czech Republic, Hungary and Slovakia and to some extend Poland provide the needed workforce together with low regulation of labour market and foreign direct investments incentives. Coupled with low wages and low tax rates they are the most attractive locations for German MNEs. In contrast the Baltic States although offering the lowest wage levels in the region do not offer necessary workforce and have stringent employment regulations. In addition, their foreign direct investment incentives are limited to low tax rates and do not offer significant cost saving prospects. A long term education development programme towards more technical related professions is also required.

Special emphasis should be given on multi-criterial decision aid (MCDA) and Multiple Objectives Optimization that looks more robust to obtain regional and international development and represents one form of decision aid, which can be very helpful in preparing the decision by revealing the decision context and the possible impacts of specific decisions. The results show that MCDA is an appropriate decision support approach, as long as the facilitators applying it, take the following prerequisites into consideration. They have to make sure that emphasis is put on the process and not only on the result, that all relevant dimensions and perspectives of the decision problem are addressed, that the characteristics of complex systems are taken into account, and that both the persons affected and the decision makers are involved in the process. If these prerequisites are given, the chance of achieving effective decision processes and arriving at satisfactory solutions for the given problems is very high. However, it has to be noted that multi-criteria decision approaches can never replace the socio-political discussion processes preceding decisions and their implementation.

The inequality between the regional incomes in a nation with a developed fiscal and para-fiscal regime including social security will be equilibrated automatically by transfer payments from the richer to the poorer regions. Moreover a system of transfer payments is not sufficient to measure the well being of a regional population. In the well-being economy, each individual would have to feel good concerning material wealth, health, education, all kind of security and concerning the environment. With other words, multiple objectives have to be fulfilled. However, these different multiple objectives are expressed in different units. The choice and importance of the objectives is also non-subjective if all stakeholders involved come to an agreement. This theory is applied on the different counties of Lithuania using multiobjective optimization by (Brauers *et al.* 2010). At that moment it is no more only a question of redistribution of income but also of a national policy of new constructions, of

tourism development, of pollution abatement and of energy renewables, after the European Commission "related to the promotion of local employment". A policy of smoothing out the differences in economic development may not result in a killing disadvantage for the richer regions. On the contrary, any project of industrialization or commercialization has to be a win-win-operation for all regions.

A certain type of tourism is desirable for the sustainable development of national parks (NP) as it can contribute to the economic development of the local community, provide funding for maintaining their environmental values, foster the environmental education of tourists, and even raise public awareness of the conservation of NP. Nevertheless, tourism is an anthropic pressure which some authors consider as the main cause of environmental impact on some NP. In fact, pressure from tourism degrades the natural values of the protected areas most valued by tourists. Therefore, tourism must be considered (and proposed) as a driving force for sustainable development, not as an aim in itself. Tourism brings sustainability to a national park if it contributes to the ecological, socio-cultural and economic objectives of the NP. It is well known that an appropriated model is difficult to obtain because of the high number of variables to take into consideration and the relationships among them, which are usually complicated to set. Finally, when the information available is biased and uncertain, as is the case in sustainable development modelling, assessment or planning, it is necessary to make estimates. To help managers making decisions about sustainable tourism strategies a new MCDA approach based on the Analytic Network Process (ANP) technique and the participation of a group of experts and stakeholders is proposed by (García-Melón *et al.* 2010).

Information on the location, condition and evolution of resources is an important step towards sustainability, but unfortunately such information can be hard to get. Earth observing satellite technology combined with geographical information management can help fill the information gap. In this objective, and because of its unique position to support the implementation of advanced interoperable geospatial technologies, the Joint Research Centre (JRC) of the European Commission (EC) is setting-up of an "*Observatory for sustainable development*" as single portal to support decision-making for development in the fields of natural resource and food security. The African Union and European Union recognise the importance of this service and are beginning to develop this capacity as part of the AU EU joint strategic partnership. The needs, and first steps taken by the JRC and by the joint partnership in harnessing space technologies to help meet Millennium Development Goals, in particular eradication of poverty, and environmental sustainability are presented by (Roggeri *et al.* 2010). The permanent dialogue with Africa, Caribbean and Pacific countries, particularly via National services, Regional Economic Communities and the ACP Secretariat, as well as the AU-EU Strategic Partnership set up the general framework of collaboration between Africa and Europe and contributes to foster the role of the AUC as continental organization with an overall responsibility of African development, poverty alleviation and general improvement towards the attainment of the MDGs. To fulfill its mandate Africa needs to develop the necessary architecture to cope with continental issues and therefore to produce relevant policies and guidelines. In parallel the EU, as world's largest donor of Official Development Assistance, needs to empower its capacity to understand situations and trends, to develop prospective and multi-thematic analysis and to prepare appropriate responses to the chal-

lenges. These crucial activities imply the definition of a long-term strategy and the set-up of appropriate observing and "knowledge-management" capacities.

4. Conclusions

The sustainability concept is evolving with a deeper comprehension that knowledge and technology created by man's intellect influence the survival processes of civilization no less than abundance of natural resources. Sustainable development requires economic, environmental and social policies to be designed and implemented in a mutually reinforcing way. This implies a need for new management thinking to improve policy coherence and increase the role of knowledge in the formulation and implementation of policies as well as improve communication with civil society and business. Sustainable development should not be considered an additional requirement but an overarching principle, which governs the development processes. Economical, social systems and ecosystems, involved in sustainability interactions consist of multiple disparate entities that generate large volumes of data related to their environmental and operational state. Implementation of every strategy is based on certain implementation policy. Statistical indicators identifying respective social, economic or environmental processes enable to perform policy evaluation and preparation functions. Thus, appropriate usage of statistical indicators is of high importance when preparing effective regional policy.

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TVARUMO MODELIAI IR INDIKATORIAI

L. Sakalauskas

Santrauka. Darnusis vystymasis tampa vis svarbesniu iššūkiu globaliu mastu. Darniojo vystymosi tikslams įgyvendinti reikia sukurti naujus informacijos kaupimo, paskirstymo ir analizės modelius bei indikatorius, skirtus profesionalams, vadybos specialistams ir visuomenei informuoti, koordinuoti bei mokyti. Dabartiniai strateginių ir operatyvinių sprendimų priėmimo metodai turi atsižvelgti į ekonominę konkurenciją globaliomis sąlygomis ir būtinumą įgyvendinti darniojo vystymosi sprendimus. Žinių technologijų naudojimas leidžia sukurti efektyvius didelių įvairialypės informacijos kiekių apdorojimo metodus. Operacijų tyrimas (OT) gali ir turi būti pritaikomas aplinkosaugos vadyboje, gamybos „žaliose" grandyse ir socialinėje sferoje. Naujos informacijos ir komunikacijų sistemos leidžia realizuoti laiku ir vietoje sprendimus, susijusius su tiekimo grandžių vadyba bei produkcijos ir logistikos tinklais. Šiame darbe apžvelgiami modeliai ir indikatoriai, naudojami darniojo vystymosi politikai bei sprendimams įgyvendinti.

Reikšminiai žodžiai: darnusis vystymasis, indikatoriai, daugiakriteriniai sprendimai, energijos planavimas, informacijos ir komunikacijų technologijos.

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