

Atlas of sustainable development in the Arctic

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INTRODUCTION

The end of 20th century and the beginning of 21st was marked by active economic development of the Arctic region in many circumpolar states, among which Russia was one of the leaders as far as territorial dimensions and radical environmental changes are concerned. A short period of enthusiasm passed and it became obvious that modern human activities in the Arctic region are related to many ecological, social and economic problems, the majority of which are common for all circumpolar states. A year earlier than the famous Rio-conference, the *Arctic Environment Protection Strategy* (AEPS) was adopted in Rovaniemi, Finland. In 1996 the Arctic Council was established for co-ordination of international strategies for economic development, environmental protection, sustainable development and natural and cultural heritage preservation, within the frames of AEPS. International cooperation resulted in many arctic programs – AMAP, CAFF, SDU etc. – dealing with different topics of sustainable development in the Arctic. In 1998 the Reykjavik Declaration outlining the action plan for sustainable development in the Arctic was adopted.

The common goal of sustainable development promoted the process of many forms of integration for coordination of economic activities in the Arctic. The Council of Northern Cities appeared, as well as many organizations of indigenous populations and other organizations. Nowadays international, bilateral and Arctic state activities have enabled the

accumulation of valuable data relevant to sustainable development. In spite of this, spatial representation of these data is disintegrated. Joint efforts for the sake of sustainable development demand the integration of accumulated knowledge.

The so-called “northern regions” of Russia occupy more than 60% of the territory. There are regions corresponding to this category also in Canada and USA, Finland, Sweden and Norway. These circumpolar regions of the Earth have many common natural features and problems of economic and social development:

- they are rich in mineral and biological (timber, game, fish etc.) resources,
- the territories are remote from central parts of the country,
- their climatic conditions hamper fast economic development and are unfavorable for human life,
- the density of population is low compared to other parts of the country,
- indigenous populations live in these regions and are engaged in traditional economic activities
- they play an important role in global fluxes of energy and matter.

We put forward an idea of international cooperation of the Arctic states for further development of regional models of sustainable development, an important element of which is the elaboration of spatial data infrastructure and creation of an *Atlas of Sustainable Development in the Arctic*.

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Nowadays it is evident that the problem of sustainable development is a very complicated one. Still, the three main aspects accepted by everybody may be presented: sustainable economic development, sustainable ecological development and sustainable social development. Sometimes the topic of “management” is added. Numerous links exist between these aspects, making separate actions toward sustainable development addressing only one of the aspects almost useless. It is evident at the same time that a model of sustainable development applicable for practical use can be formulated only at the regional basis. To formulate it one needs various data which must be processed in a certain way to obtain comparable results for the three main “blocks” of the sustainable development system: economic, ecological and social. It must be emphasized that the information needed must not be only quantitative; it must be spatial as well. One of the best forms of presentation of such information is cartographic, i.e. the compiling of map series or thematic atlases.

WHAT WE HAVE NOW

Accumulated data and experience in the creation of atlases of sustainable development and relevant thematic atlases including northern territories form the necessary background for planned atlas. Among these works are the *Khanty-Mansi Autonomous Okrug Sustainable Development Atlas*; *Ecological Atlas of the Murmansk Region*; GIS for territories with traditional economy of indigenous populations in the Sakha Republic; a map series for background and pollution monitoring in the Arctic region of Russia; a recreation potential assessment of the Arctic region; and environmental impact (“hot spots”) in the Arctic part of Russia. Some of the authors of these maps are advisors to the Parliament of Russia and other governmental organizations on

“northern problems”. It is necessary to mention that quite many of them are from northern regions (the Chukchi Autonomous Okrug (Region), the Kamchatka, Magadan, and Murmansk regions, The Sakha Republic and others). Cooperation with RAIPON (Russian Association of Indigenous Peoples of the North) will promote good local contacts necessary for data base creation.

The atlas “Sustainable development of Russia” may be used a model for the new atlas structure (table 1). The major part of the atlas for the Federal level is almost ready. In brief, this atlas includes the following:

- A combination of the maps presents the complexity of the ecological and social-economic situation in Russia, enabling a monitoring of modern changes and give a forecast of modern technogenic environmental impacts.
- Cartographic, remote sensing materials in combination with text are presented as a hypermedia information system which may include graphics, hypertext, slide series, and a short sound movie. This will enable a grasp of the full complex information for a region compared to other parts of the country, and to monitor the character of modern changes and elaborate its strategy of sustainable development.
- This system may be used as a base for the future design of a permanently operating monitoring system compatible with the Internet. The maps are planned to be used for the elaboration of suggestions for innovative activities in the region and its separate parts.
- Multimedia means will give new opportunities for the presentation and use of information. It will be possible to demonstrate not only static cartographic images but dynamic (animation forms) as well. Cartographic animation is a form of consequent presentation of changing im-

Table 1 The atlas *Sustainable Development of Russia* (thematic structure)

Part 1. Potential stability of environments to human impact. Maps for Russia (scale 1: 20 000 000)	2.3.5 Fisheries and hunting
1.1 <i>Natural resource potential of Russia</i>	2.3.6 Industrial and municipal wastes
1.1.1 Renewable resources (land, water, forest resources)	2.4 <i>Efficiency of labour use</i>
1.1.2 Nonrenewable resources	2.5 <i>Ecological adaptation of economic development</i>
1.1.3 Climate comfortableness potential	2.5.1 Industry
1.1.4 Ecological assimilation potential	2.5.2 Agriculture
1.2 <i>Natural stability of environment</i>	2.5.3 Transport
1.2.1 Ecosystems stability	2.5.4 Urban sustainable development
1.2.2 Self-purification potential of soils	2.6 <i>Nature conservation</i>
1.2.3 Conditions for self-purification of surface waters	2.6.1 Nature reserves
1.2.4 Conditions for natural forest restoration	2.6.2 Capital investments in nature conservation
1.2.5 Stability of natural pastures	2.6.3 Ecological information and education
1.2.6 Stability of biodiversity	2.7 <i>Risk of economic defaults</i>
1.3 <i>Contemporary ecological situation</i>	2.8 <i>Integrated assessment of economic sustainability</i>
1.3.1 Atmosphere	Part 3. Social-demographic sustainability
1.3.2 Surface waters quality	3.1 <i>Contemporary demographic potential and its dynamics</i>
1.3.3 Soil pollution and degradation	3.1.1 Population density and patterns of settlement
1.3.4 Ecological situation of forests	3.1.2 Urbanization
1.3.5 Reduction of biodiversity	3.1.3 Population reproduction, sex ratio
1.3.6 Radioactive pollution	3.1.4 Migration activity
1.4 <i>Integrated assessment of environmental stability to human impact</i>	3.2 <i>Population health and health dynamics</i>
Part 2. Stability of economic development in Russia	3.2.2 Life expectancy at birth and longevity
2.1 <i>Retrospective maps of human environmental impact (18th to 20th C)</i>	3.2.3 Population morbidity
2.1.1 Population	3.2.4 Children and youth morbidity
2.1.2 Land resources	3.2.5 Population with disabilities and their causes
2.1.3 Industry and transport	3.2.6 Losses in life potential
2.1.4 Forests	3.3 <i>Social welfare of populations and their dynamics</i>
2.2 <i>Contemporary economic potential</i>	3.3.1 Incomes of population
2.2.1 The agroindustrial complex	3.3.2 Education status
2.2.2 The forest industry complex	3.3.3 Adequacy of nutrition
2.2.3 The power-energy complex	3.3.4 Occupation and unemployment rate
2.2.4 The metallurgical complex	3.3.5 Criminal situation
2.2.5 The chemical industry complex	3.3.6 Human rights realisation
2.3 <i>Economic efficiency of natural resource use</i>	3.3.7 Integrated assessment of social welfare
2.3.1 Energy consumption	3.4 <i>Political behaviour of population</i>
2.3.2 Water consumption	3.4.1 Structure of population political polarisation
2.3.3 Forest resources consumption	3.5 <i>Risk of emergency social-demographic situations</i>
2.3.4 Natural fuel and mineral resources extraction	3.6 <i>Integrated assessment of social-demographic stability</i>

ages in a certain time interval. Alongside with cartographic animation, other multimedia means (movies, sound support) are planned to be used for the atlas.

- In particular, full-scale multimedia systems may become the main tool for choosing strategies for the transition to sustainable development in Russia and its regions. The thematic composition of several maps is created by means of cartographic-mathematical modelling.
- The region is characterised both as a part of a larger unit – the state – and as a separate unit capable to develop using its own resources as well. Maps belonging to the part “Patterns of transit to sustainable development in the regions of Russia”, exemplified by Murmansk Province, are compiled being a part of the atlas of sustainable development of Russia. A computer envelope with maps placed there is planned for Federal and regional levels, comprising a joint system.
- An important feature of hypermedia design is a possibility of transit from small-scale thematically and compositionally compatible cartographic products to large scales, and vice-versa.

Works on the part of the atlas as a regional-federal system presented as a hypermedia construction are entirely original and have no analogies in Russia and as far as we know not in foreign practice either. Several theoretical, methodical and practical problems of hypermedia presentation in computer media of a complex cartographic product were solved. Methods of application of this system in education, science and practical activities for decision making for the sake of sustainable development are to be elaborated.

The methodological base of the planned atlas hypermedia structure will be presented by the ecological “chain” of nature-society studies: environment > human

environmental impact > environmental response (changes) > assessment of changes (ecological situation assessment) > changed environmental impact on the human society and its economic activities > a forecast of environmental situation > activities directed to the transition of a territory to sustainable development. The system of hypermedia layers reflects the general methodology of interrelation studies in the system “geographical media–society”.

The distinguishing feature of our work is the use of a system approach to the compilation of electronic maps at different scales, treated as a complex providing heterogeneous information and efficient processing, interpretation, analysis and combination from state to regional level and with the creation of a full-scale hypermedia system at its base. Analysis of the used and suggested indicators of sustainable development in different countries demonstrated a near-absence of a common practice. The choice of characteristics for the atlas maps compiling is stipulated first of all by the following reasons:

- availability of information,
- possibility to consider the studied processes in dynamics,
- possibility to compare the characteristics of maps with similar topics for different territorial levels,
- possibility to create integral maps reflecting a degree of approach to sustainable ecological, economic and social-demographic development of different parts of the region.

Series of thematic animations reflecting the growth of human environmental impacts have been elaborated for the retrospective part of the atlas. Cartographic animation titled “Changes in forest cover in Russian regions for the last 300 years” gives a dynamic picture of this process with

the help of smooth changes of colour depending on the value of a parameter. Effect of continuity is achieved due to the chosen step dimension (3–5% of change in colour per each percent of change in forest cover and arable lands area). When certain limits are reached, the colour changes. The animation “Growth of the urban network” demonstrates the process of appearance and re-naming of Russian cities using consequent display of symbols for cities and their names. Each historical epoch has a specific colour. The animation “Development of the metallurgical industry in Russia in the 18th–20th century” is the first stage in the preparation of another complex animation, “Development of industry and transport in Russia”. Symbols representing the metallurgical industry and the gradual change in size (growth or decrease, even disappearance) of these symbols gives a clear overview of the development of the industry. All animations are shown at a speed of 10 sequences per second (each sequence corresponds to one year).

THE BARENTS ATLAS

In order to launch the project of the new atlas, we suggest to start with a pilot project for its regional part – Barents, with extension up to Greenland. The following territories will be under consideration in Russia: Murmansk and Arkhangelsk regions. In the Nordic countries, northern parts of Finland, Sweden, Norway and Iceland will be considered.

This atlas may be regarded as the first step towards an atlas of sustainable development of the whole circumpolar space, laying out the general structure and providing valuable experiences in methods for original data processing and presentation, based on the latest GIS technologies. Tight links with the regional background, a systems approach to data accumulation, and user-friendly presentation will make such an edition

a valuable “encyclopedia” for regional authorities in the process of territorial administration and elaboration of suggestions for innovation activities, as well as for businesspeople and scientists working in the Subpolar regions and tourists visiting them for leisure.

Cartographic and remote sensing materials in combination with text are presented as a hypermedia information system, which may demonstrate graphics, hypertext, slide series, and may be a short movie clip. This will enable a grasp of the full complex information about a region that is necessary to monitor the character of modern changes and formulate a regional pattern of a strategy for sustainable development. This system may be used as a base for the future elaboration of a permanently operating monitoring system compatible with the Internet.

The main content of the atlas is directed at the detection of ecological, economic and social limits of sustainable development and the presentation of sustainable development practices already existing in the region. The methodological base of the hypermedia structure will consist of a systems analysis of nature–society links, following a similar pattern as that described above for the atlas *Sustainable Development of Russia*. Thus the system consists of hypermedia layers presenting data about numerous characteristics necessary for a regional model of sustainable development. Cooperation of at least three countries within the atlas project will enable the suggestion of some regional sustainable development indicators for Northern neighboring territories of Russia and Scandinavia. The planned atlas will contain small-scale maps for the whole region and medium- and perhaps large-scale maps for its separate parts. The atlas design will provide compatibility of maps included in it which is very important for future users.

The traditional practice of presenting data (including maps) in the context of sustainable development has almost no history of integrated processing of heterogeneous ecological, economic and social information. Maps which show the results of data processing are planned in the suggested atlas. The thematic composition of these maps will be achieved by means of cartographic-mathematical modelling.

A specific feature of the suggested project is an attempt to include the presentation of traditional knowledges of sustainable development patterns of indigenous populations in the atlas, as well as their traditional economies, as they are an important part of sustainable development in the Arctic. This part of the project was approved by RAIPON, which expressed a desire to participate in this work.

We are going to use the following methods in our investigations:

- systems analysis of sustainable development patterns for the Arctic region,
- GIS methodology and multi-media information systems,
- special and cartographic modelling,
- comparative economic and social geographical analysis,
- comparative ecological / social analysis,
- comparative economic and ecological analysis,
- comparative analysis of regional culture.

Although it is too early to outline the content of the envisaged atlas at this stage, several basic maps may be prepared even now, based on the already existing knowledge of the co-investigators. Some of these are the following:

- Natural resources of the region
- Present economic development

- Population size, national composition, density
- Population welfare
- Ecological situation
- Nature conservation
- Traditional economy and demography of indigenous populations
- Risk of emergency situations of different origins
- Integrated assessment of regional sustainable development patterns
- Involvement of the region in different international programs relevant to sustainable development
- The Arctic region as a crossroad of energy and matter fluxes

CONCLUSION

Sustainable development of the Arctic states in the 21 century demands new forms of data presentation for the management of economic development. The *Atlas of Sustainable Development in the Arctic*, based on modern GIS technologies, offers a new form of spatial data presentation for decision makers. This atlas will promote better knowledge of the sustainable development experiences and problems of neighbouring states for the sake of common goals. The *Barents Atlas*, being a part of the work, may be regarded as a pilot project. It is very important to note that for the first time indigenous populations of the North will be analysed from the standpoint of sustainable development of the whole region. The planned atlas may turn out to be a good example for the further preparation of regional atlases about sustainable development. It should show decision makers the benefit of co-operation in the utilisation of natural resources in Arctic, instead of each state struggling for its own ends.