

COMPLEX ENVIRONMENTAL GIS FOR MUNICIPAL MANAGEMENT AND MULTIDISCIPLINARY URBAN STUDIES: WORKING GUIDELINES FOR BELARUSIAN MUNICIPALITIES

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Abstract

Efficient environmental/sustainable policy-making in the cities is possible only if based upon comprehensive, permanently updated data on urban environment. Complex environmental municipal GIS is a very tool to achieve these purposes. Therefore, our goals are to offer working variant of this GIS, as well as a guidelines for such a GIS that would be feasible to make in Belarusian academic and municipal routine, and helpful when taking decisions concerning environmental management, city-planning, public health, routing public transportation. We are also aiming at suggesting the updating procedure that is relevant to Belarusian municipal policy-making routine. The study is funded by SNSF and based upon environmental municipal GIS, which are being created for the cities of Mahiliou (main project) and Minsk (supplementary case) in Belarus. In addition to basic topographic data, the GIS comprise layers and databases describing relief (genesis and morphology), geology, hydrography, soil, vegetation, natural-territorial complexes/NTC, sources and consequences of chemical contamination, monitoring networks, planning and architectural features, extraction of mineral resources, recreational areas, industrial productions, municipal infrastructure, public transportation, socially relevant objects, public health statistic, social secure. Local environmental actors in Mahiliou, who reported provisional version of environmental GIS as a very helpful, have approved the credit of GIS-guidelines.

Introduction

Over the recent decades cities have been increasingly becoming the sources of environmental threat not only of local and regional, but also national and even global relevance. At the same time, urbanized areas host majority of global population, therefore development of cities is recognized as one of the most important and difficult challenges on the way to global sustainability (World Commission, 1987). The problem of efficient management of urban environment faces policy-makers, urging social and environmental scientists, urban planners, economists and geographers to tackle the problem. Scholars from the variety of fields recognize GIS-based environmental expert system as efficient state-of-art tools, successfully working in any methodological frameworks, and applicable to various settings (Forcht, 2000). Such a system can be designed for the providing all the municipal agencies with map-based databases describing the city from different perspectives, improving coordination between the agencies through the data exchange, helping to work out sustainable sound concepts for municipal planning and management, and providing for action plans for natural/human-caused disasters.

Though there is number of papers and reports comprehensively describing GIS and GIS-based models successfully applied to the various tasks related to municipal environmental management (for instance, Gipps, et al, 2001; Bullen, et al, 1996; Parker & Campbell, 1998), the overwhelming majority of them has been approved only in Western-European/North-American settings. It means that these projects can be developed only if set in the certain conditions, such as, say, adequate scientific and public support, well-secured funding, and easy application to policy/decision-making routine. This is not available in many Central- and Eastern-European municipalities suffering from the economic crisis or its consequences, though they have crucial need for the efficient managing tools.

The paper explores problems of the developing environmental GIS in Belarusian municipalities, given that all the range of possible in Eastern Europe decision-making, financial and many other problems can happen there. It identifies environmental stakeholders supposedly interested in environmental GIS, describes their requirements to the GIS and relevant solutions, and the way they can contribute

to such a project. Thereby, the relevant policy-making and technical/scientific frameworks are outlined.

Background information

It is very common for Belarusian municipalities that nobody is particularly interested in GIS applications. Furthermore, computers are rarely used for any purposes but report writing and paper work. For the most cases observed, environmental, social, and city-building data are not stored in electronic form. In many cases the information is not even properly sorted out, and just kept as it is sufficient to use in official reporting. With few notable exceptions, municipal environmental, medical, and urban-planning officers and civil engineers usually regard GIS as a luxury, if they are aware of such helpful a tool.

In fact, quite a deal of research, planning and administrating institutions in Belarus has all the potentialities to make a GIS-based workbench. Nevertheless, there are many legal constraints. For instance, it is prescribed to obtain a license from a special board, and another license if the GIS is designed as a cadastre to be used officially. These make GIS projects much more expensive, as it takes a lot of time and money to apply for such licenses. Besides, large-scale topographic maps and remote sensing imageries are secret in Belarus and strictly forbidden for public use. They can be available only if a GIS-making institute, or any other user, has specially equipped and officially certified store with a staff member assigned to control circulation of map materials. This multiplies costs, or otherwise causes bad quality of GIS products due to the use of the publicly allowed maps, quite often very inaccurate.

In the city of Mahiliou chosen for the typically hazardous state of environment, bad social and medical statistic, just two municipal offices – Municipal Centre for Hygiene and Epidemiology (MCHE) and City Council's Administration for Architecture and City-Building (CCAACB) have been reported to have ongoing GIS-oriented projects. MCHE has initiated such a project because of enormous enthusiasm of some staff members and accidentally favourable funding situation. However, the implicit term of the later was also to commission the project to a Mahiliou-based research institute that unfortunately did not have proper capacity to fulfill the commission. Thereby, in spite of the longing, need, and even sufficient funding, the hygiene officers did not get the GIS as they desired. The project handed in just partly met the commissioned requirements, and has been based on the inaccurate city map, though it also featured some interesting software solutions. On top of everything, the MCHE staff could not properly examine what they have really received, since none of them was an expert GIS-user.

Besides the practical requirements, the interest of the Mahiliou's CCAACB in the GIS is also based upon the prescription of the Ministry of Architecture to find out within city communes the capacity to facilitate creation of municipal electronic cadastrals. The municipal architects managed to secure funding due to the special taxes from the city's land-users. Nevertheless, this unlikely will be resulted in a project appropriate to their needs and requirements, as they are not allowed to put into the GIS all the contents they are interested in, moreover they are obliged to use software developed by the research institutes of The Ministry of Architecture wherever it is possible. This software prescribed serves as a very convenient viewer, with functions to edit, add and remove objects. However, it does not feature tools of geographical analysis that are of particular interest for the municipal architects.

The first recorded attempt to employ a GIS-based workbench in Mahiliou was made by the officers of city's affiliation of the Regional Committee for Natural Resources and Environmental Protection (RCNREP). They have commissioned GIS-based model of an artesian water-supply area. However, in few months having reinstalled software they could not run the model. Since it was not really involved to their practice, they did not do anything to make it running.

These stories are hardly can be considered as good practices of GIS application in municipalities, however Mahiliou's MCHE, CCAACB, and city's affiliation of RCNREP have made substantial steps forward, especially compared to other municipal institutions. In many respects, our project has been based on their experience, involved the work done, and also relied on their reputation of the users of advanced managing tools.

Municipal environmental stakeholders

Any policy/decision-making framework works only if based upon reliable stakeholder dialogue. Major internal stakeholders for Mahiliou's commune are set at Table 1. In keeping with the normative interpretation of stakeholder theory, 1.) a stakeholder is defined as any group that has an interest in the company and not necessarily vice versa; and 2.) stakeholder needs are assumed to have intrinsic value (Donaldson and Preston, 1995). In spite of the assumed intrinsic value of stakeholder interests,

empirical evidence indicates that fulfilment of stakeholder needs affects project's function and success (Elias & Cavana, 2000; Halal, 2000; Kippenberger, 1996; Steadman *et al.*, 1996).

Table 1: Internal environmental stakeholders for Mahiliou's commune

Stakeholder	Environmental functions in the commune	Need in GIS	Possible contribution, major constraints
<i>Interested and ready to contribute into GIS</i>			
Municipal Centre for Hygiene and Epidemiology (MCHE)	Municipal agency for public health, and monitoring of drinking water and food supply, infectious diseases, indoor/outdoor/occupational environment	Developing spatial social, medical and environmental databases, analyzing current situation and possible scenarios, presenting current situation with public health and environment	Very modest financial contribution; social, medical and environmental databases. Shrinking annual budget, cutting down program on environmental monitoring, unsteady style of work, ignorant in environmental issues Chief of the Centre
City Council's Administration for Architecture and City-Building (CCAACB)	City Council's agency regulating building activities in the city, keeping building rules, and implementation of long-term development plans	Inventory of all the objects of engineer infrastructure, buildings, green objects, and land-users; optimization of building environment	Financial contribution, cadastral maps. Strong restrictions in the activities to be undertaken, missing scope of environmental issues
City's affiliation of the Regional Committee for Natural Resources and Environmental Protection (CA of RCNREP)	City Council's agency regulating use of natural resources and environmental pollution, and collecting environmental fees and penalties	Inventory of users and polluters of the environment; integrating sanitary spatial restrictions; optimization of monitoring network	Modest financial contribution, environmental monitoring databases, registry of environmental users. Casual, sometimes unprofessional staff, slightly aware of the goals and tools of environmental management/policy
Mahiliou's Planning Institute for City-Building (MPICB)	Planning institution, taking commissions for any kinds of civil planning, engineering surveys, and environmental appraisals	Inventory (see CCAACB), setting environmental restrictions and sources of environmental and engineering hazard	Modest financial contribution, raw data on city-building and engineering geology. Severe problems of organization; need for immediate profit from the money invested
<i>Interested, but unwilling/unable to contribute</i>			
Regional Committee for Natural Resources and Environmental Protection (RCNREP)	Regional Administration's board, coordinating environmental policy, imposing environmental fees and penalties, reporting on the state of environment	Inventory (see CA of RCNREP) and reporting, assessment of the environment and current management practice, optimization of environmental policy	Ignorant staff, missing integrated scope of environmental problems, missing awareness of the goals and tools of environmental management/policy
City Council's Administration for the Municipal Infrastructure (CCAMI)	City Council's agency, maintaining municipal infrastructure (pipe systems, partly public transportation), municipal accommodation, collecting and disposing solid wastes, treating sewage	Inventory (see CCAACB), monitoring, management, and optimization of the infrastructure.	Some distrust in computer-aided work in their particular field, considering GIS as an obvious luxury; strong restrictions in defining the items to be paid
Municipal Water Supply (MWS)	City Council's company, producing water, maintaining water and sewer pipe-lines	Inventory of the pipe-lines and water wells, monitoring of water supply	Unwillingness to transfer to electronic form their data, still considering as the secret
Mahiliou State University (MSU), Department of Natural Science (NS)	University department, holding B.Sc. programs and undertaking research projects on chemistry, biology and geography	Powerful tool for the studies of urban ecology and geography	Lack of the funding, weak scientific program, irregular research activities
Regional Centre for Hydrometeorology, Environmental Monitoring and Radiological Control (RCHMRC)	National Environmental Ministry's agency, maintaining environmental monitoring and hydrometeorological networks within the Mahiliou Region, including the city of Mahiliou and reporting the data of observations	Developing spatial environmental databases, presenting results in the reports, obtaining tools for revision and further redesigning of the monitoring networks, ensuring compatibility of the data reported	Extremely scarce funding, strong authority of Minsk-located Ministry of Environment, suppressing local initiatives, necessity to cover all the Mahiliou's region, not only the City
Environmental NGOs	Raising environmental awareness	Presenting and independent assessing tool	Lack of any facilities (money, highly-motivated volunteers, etc)
<i>Supposed to be interested to participate in the project, but not aware of GIS applications and their tools</i>			
Citizens	Living in the environment	Drawing comprehensive picture of what the city really looks like, getting insight the state of the environment in the city; appropriately adjusting their behavioral patterns	Lack of environmental awareness, as well as awareness of the existence of GIS and GIS-based managing/policy-making tools
Local business	Polluting the environment		
Media	Informing the population		
Other municipal institutions	Running the city		

Basic requirements to the municipal environmental GIS

Practically, the research has been designed according to the requirements of the first group (see Table 1), yet many inquiries from the second group of stakeholders also have been laid ground to the framework of the GIS to be created, given their possible participation and substantial contributions to the further steps of the project. Insofar as it is most likely that at a short- and even mid-term the third group cannot be considered as a potential contributor, and its requirements can rather be figured out than identified, we have assumed their interest in GIS to be the same as the first and second stakeholder groups' demands. Their inquiries were analyzed from environmental, geographical, project-management, legal, and technical perspectives. The most general and widely applicable of the proposed solutions along with the requests are listed in Table 2.

Table 2: Basic requests from the participating stakeholder groups and possible solutions

Feature of GIS project	Requirements	Solution
Scale of topographic map to be used as basis	Sufficient to recognize separate buildings, serving as basic units for many social and medical databases, however not too small to miss overall picture	Scale 1:10,000 – it provides for clear recognition of small objects, and still small enough to see at normal screen a large part of the city
	Not too detail, given high costs for digitizing, collecting and updating of information for layers and databases	
	Detail enough to give comprehensive picture of the state of all components of urban environment	
	Sufficient to recognize and set with acceptable resolution the objects of municipal and industrial infrastructure: pipe-lines, water supplies, chimneys, etc.	
Form and accuracy of topographic data	To include only allowed data (details, topographic contour lines), since some sharers do not have special facilities to store and use officially restricted data, and GIS should be available for wider public	Excluding restricted topographic data from the GIS to be used; setting only results of geographical analysis: computed models of relief, slopes, aspects, etc
	To support operations, requiring detail hypsometric data (hydrological and meteorological modeling, setting objects, etc)	
Units of the databases storage	To make possible comparisons and statistical correlations of the data from various themes, given frequent changes of statistical units in different sectors (municipal boundaries, zones of medical service and statistics), i.e. to store data in basic units transferable from/to any other statistical units	To store data in clusters; in Mahiliou's settings the sufficient size of a cluster is 50x50 m
Software to be employed	To feature variety of tools for spatial analysis and modeling	GIS ArcView-ArcGIS
	To be worldwide acceptable and easy-to-transfer to other formats	

To serve as an efficient decision/policy-making tool, an environmental GIS besides the required parameters also should be actual, objective, and topologic. The former is achievable only if set in adequate policy-making framework, facilitating permanent updating of the databases and maps. Though objectivity is set to the system already at the very first steps of the project design, the system remains objective only if regularly receiving actualization, i.e. it also depends on the adequacy of the set stakeholder-based mechanism.

Content of the GIS

Insofar as the environmental GIS for the city of Mahiliou has been primarily designed as a scientific externally funded project, it includes many themes that cannot be considered as directly needed for municipal decision/policy-making yet vigorously employed in various environmental, geographical, and social urban studies. However, this also helped us to identify the themes to be employed in municipal management and various aspects of environmental policy-making. The basic requirements to the GIS contents from the participating stakeholders are as follows:

- To be of interest for as big number of potential participants as possible.
- To contain easy to update databases, corresponding to ongoing activities of the participants.
- To be feasible to create and update in the current very tough funding situation.
- To have potential to serve as a platform for fundamental research projects, as it implies external funding to be invested to the GIS development.

Summing up, the GIS should contain the maximum possible number of highly relevant maps and databases for the minimum possible costs. The themes to be included into the GIS adopted for Mahiliou municipality are:

- *Topography*: basic topographic information excluding elevations, and geographical coordinates;
- *Relief*: models of the relief – surface, slope, hillshade, aspect, erosion networks;
- *Geology*: underlain sediments – composition, origin, geologic age, engineering conditions;
- *Hydrology*: water bodies, runoff measurements (for small rivers), hydroecological data, surface runoff, distances to water courses, watersheds;

- *Vegetation, soils, and landscapes*: green spaces, soils, natural-territorial complexes (NTC) and their environmental assessment information, geochemistry;
- *Land-use and urban planning*: land-use pattern (ccode), history of land-use and planning development, characteristics of blocks;
- *Environmental pollution*: air pollution, water pollution, soil pollution, outlets of water- and airborne pollutants, including outlets of storm sewers, highways and railways most contributing to air pollution, noise pollution, electromagnetic pollution, other sources of environmental hazard;
- *Environmental monitoring networks and environmental restrictions*: sampling points of the monitoring agencies (MCHE, CA of RCNREP, RCHEMRC), past and current allocations of emission rights, sanitary zones of industrial facilities/allocations, water bodies, and groundwater supplies;
- *Public health*: various morbidity indexes, death and birth rates;
- *Municipal services and engineering infrastructure*: public transportation, central heating plants and pipe-lines, sewer pipe-lines, storm drains, water supply lines, phone cables and outlets;
- *Economic activity*: major commercial firms;
- *Social infrastructure and quality of life*: quality of physical environment, quality and availability of basic services – housing, primary and secondary education, health care, entertainments and recreation, public transportation, retail trade, means of communication.

As it was proved, besides municipal decision-making purposes, the GIS can also be employed in quite complicated policy-making tasks. Thus, outcomes of GIS analysis has been already integrated in the Environmental Section of Mahiliou's Long-Term Development Plan, and setting sanitary zones. Thereby, the project done can be reported as successfully approved in Belarusian municipal settings, and proposed framework can be recommended for the wider use at a municipal level.

Acknowledgement

The activities laying ground to the presented results were carried out in the framework of the programme SCOPES 2000 – 2003 (Scientific co-operation between Eastern Europe and Switzerland) of the Swiss National Science Foundation and financed by the Federal Department of Foreign Affairs.

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