GIS MODELLING FOR THE STRATEGIC URBAN DEVELOPMENT PLANNING REGARDING THE REPUBLIC OF MACEDONIA

Sashko Martinovski, MSc
Petre Prlickov 42, Veles
Faculty of Technical and Technological Sciences, Veles
sasko.martinovski@uklo.edu.mk

Gjorgji Mancheski, PhD
Gjorce Petrov, bb, Prilep
Faculty of Economics, Prilep
gjorgji.manceski@uklo.edu.mk

ABSTRACT

The Geographic Information System (GIS) is an important component in the information technology, and it has come to be a very important component in many different areas as well. It is commonly used in the areas of state interest in the managing, analysis and planning sectors. The purpose of this paper is to develop a conceptual design of strategic urban development planning in the Republic of Macedonia in order to improve the manner of planning and help competent authorities to make quick, accurate, efficient and exact decisions. This paper shows cases of a concept of strategic urban development planning for the Republic of Macedonia by using GIS Modelling. This concept can also be applied to business models, and it has been implemented and tested on a business model regarding the influence of the socio-economic standing on the healthy nutrition of the population in the Republic of Macedonia. As a result to this concept, the way of planning is improved and the basic perception of it as planning changes into one of an applied science.

Key words: Geographic Information System, GIS, GIS_MSUDP, GIS Modelling, business models.

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INTRODUCTION

The Geographic Information System (hereafter referred to as GIS), is one of the most prospective information technologies and it represents a complex computer technology based on data processing with a few simple components: data input, data management, data retrieval, data manipulation and analysis and output data. GIS integrates spatial and other types of information into a single system and thus provides a permanent framework for analyzing spatial data. In this context, GIS can be understood as a hardware, software and procedures system, organized to support the input, manipulation, procedures and analysis of data, as well as the modelling and output of spatial reference data.

Application of GIS in the urban and spatial planning in the local and national government is default, and its application in the economy has always been useful and helpful when making business models, but some might find it strange to say that GIS can be applied even in the field of medicine. Some examples of this are using GIS to analyze the human body, using it in the public-health research in epidemiology- from identifying risk factors to the making of plans and scenarios for the spreading and prevention of diseases. The latest use of GIS is its application in analyzing and planning habits for healthy nutrition of the population by region. A new GIS model is being prepared by a team of researchers from our University on the impact of the socio-economic status of healthy nutrition of the population in Macedonia. These examples are sufficient to understand the role and application of GIS as an information technology.

Nowadays, we use various systems to support urban development planning such as the Planning Support System (PSS) and the Spatial Decision Support System (SDSS), including GIS. These systems are constantly being developed, and one can find similar SDSS and PSS, when reading on the subject, whose key common goal is planning support. They are used in several European countries and many other countries throughout the world.

ANALYSIS OF THE USE OF GIS IN THE REPUBLIC OF MACEDONIA

The analysis of the importance and use of GIS in Macedonian municipalities was done over a period starting from 2006 till today. In the period until 2006, USAID and EAR donated some GIS software for some municipalities in Macedonia (ArcMap and ArcView from ESRI) as an incentive for development. In order for it to be used properly, staff trainings
were held in the urban planning departments in each municipality, where such projects were being conducted. In 2006, out of all the municipalities in Macedonia, only 8% of used GIS software, and when asked how important was the introduction of GIS in their municipality, they responded as follows: 51% believe it is very important, 42% find it very useful, 5% find it moderately useful, and 2% find it unnecessary. When asked where they use GIS the most, regarding municipality activities, the answers ranged from: 35% on urban planning, 20% in utilities, 14% on landscaping and use of urban land, 10% in traffic 9% in environmentalism, 5% in social activities, 4% on tourism, 2% for energy facilities and 1% for other activities.

During this research, a number of discussions were held regarding the ways of strategic urban development planning, with the competent experts (urban planning experts, analysts, planners), in the municipalities in the Republic of Macedonia in major urban areas such as Skopje, as well as in smaller municipalities. The research conducted in the municipalities considered their municipality development planning strategy, the spatial and analytical data used, the reviewing of the data, the need for digitization of the same and the importance of GIS.

At present the general state of GIS is quite different. In the majority of municipalities in Macedonia, especially in the larger ones, it is already introduced or is being introduced presently (GIS hardware, GIS software, GIS training, digitalizing of spatial data). The state of GIS usage in Macedonia for spatial data analysis and planning, is as follows: at the moment, about 10% of urban planners and other municipality competent experts (especially in smaller municipalities) are using classical methods of planning, and another percentage, about 35 to 40%, use computers and software, as well as digitized data for the analysis and planning of spatial and analytical data, not a different system. The third and largest part of them, about 50 to 55%, are already using or implementing GIS, as a system of hardware, software and procedures, but haven’t built a good concept for strategic urban development planning and the application of GIS is only in urban planning. The lack of easily accessible, accurate and complete data in the process of policy making and strategic planning, has led the national governments of the Member States of the European Union to take measures to overcome this problem. The 2007 Directive of the European Parliament and the Council aims to establish an Infrastructure for Spatial Information in the European Community (INSPIRE). The National Spatial Data Infrastructure of the Republic of Macedonia in accordance with INSPIRE.
PHASES OF GIS MODELLING FOR STRATEGIC URBAN DEVELOPMENT PLANNING IN MACEDONIA (GIS_MSUDP)

During the last years, many planning support systems have been developed and are available to urban planners to assist them in their work. Many of them focus on the design and evaluation of possible solutions to spatial planning problems. The first advocate of the use of PPS systems was Harris (1989), later on Harris and Batty (1993), who believed in using these systems to provide tools, models and information which can be used for planning, with the help of information technologies (such as GIS). With the advances in GIS, PSS became an even more important component (Brail and Klosterman, 2001; Geertman and Stillwell, 2003; Yehetal, 2006). Similar to the PSS, the SDSS developed planning through scenarios (MacDonald 1996). Other SDSS and PSS were developed and introduced the STEPP, a strategic means for integrating environmental aspects into the planning process (Carsjens, Lihtenberg, 2007). Some of them included a multi-agent modelling system.

GIS can be used in many areas of the business environment, for the most part with examples such as: a model for the effective planning and management of taxes; a model for promoting/encouraging investments; a land use planning and natural resources management model; an energy recovery planning model; a healthy nutrition of the population planning model and many others.

Based on all the research, a concept for GIS_MSUDP has been developed. Thus, new GIS products (GIS models) are created and can be used for strategic urban development planning. The following phases are a part of the process of GIS modelling: Application Domain, Spatial Reasoning, Logical Model and Physical Model. Similarly, GIS_MSUDP is divided into five phases, as presented in Figure 1. The important feature of this concept is that all stages are represented by entities. The existence of connections between the phases and science and scientific disciplines is certainly requisite for modelling, but we could say that typically this block diagram is dynamic and it depends on the created field patterns. For example, a healthy nutrition of a healthy population planning model requires the involvement of the science that deals with healthy nutrition, such as Nutrition and food technology and biotechnology.

The suggested GIS_MSUDP concept uses entities and relations for each stage, just like the E-R models in data organisation, enables good organisation and can be applied for planning in the Republic of Macedonia.

GIS models that can be applied to GIS_MSUDP are:
- Binary models: Logical model - expressions; Map overlay; Sitting analysis; spatial query.
- Index models: allocation and standardization of the values of spatial elements of each layer.
- Regression models: are used to calculate/estimate. These models can be divided into two types: Linear regression, when all the variables are numerical and logical, and Logistic regression, where all the variables are binary.
- Process models: integrate existing knowledge about the processes occurring in the environment (real world) presented in a set of relations and equations for the quantification of processes.

**PHASE 1 - DETERMINING THE GOALS –INTERESTS**

Every business model is the lifeblood of society and its true meaning comes through a particular goal and interest (Figure 2).

Determining the goals is in a direct relation to the business model and is presented as an entity with two fields: **Goal (Model, Goal)**

![Figure 1: Phases of GIS modelling and its correlation with science](image-url)
From a business perspective, the basic national interest are tax incomes, but practical areas such as arable land, mineral rights, forests, etc. concessionary, are also of great interest. A parcel is a cadastral unit, which is the spatial extent of past, present and future rights and interests in real estate. (FGDC, 1999).

Figure 2: Goals and interests of a business model

The interest in relation to the goal and is represented as an entity with two fields: Interest (Interest, Goal)

PHASE 2 – SPATIAL REASONING

It is necessary for GIS_MSUDP to go through the stage of spatial reasoning, after the goal and interests have been determined. That is the reality, the number of phenomena we see, that really exist in all parts of their complexity, the defining of relationships, observation by making decision trees, legislation, it all depending on the business model. The better the real world is presented in a formal system, the better the spatial reasoning will be (Figure 3). In order to understand spatial reasoning and spatial phenomena we can use the help of the geo-information science and GIS.

Spatial reasoning is in conjunction with the goal and can be presented as an entity with two fields: Visualization (Visualization, Goal)

Figure 3: Spatial reasoning
**PHASE 3 – CONCEPTUAL MODEL**

The conceptual GIS_MSUDP model is enlists defining all the necessary items in the following order:

1. Defining the output data
2. Defining the input data
3. Defining modelling strategies
   - Methods and techniques
   - Data queries
   - Cartographic processing
   - Map algebra
   - Mathematics and statistics

**1. Defining Output Data**

What sets this phase apart is that it starts by defining the output data. It is best to define the output as a planning result in the beginning. It is in conjunction with the goal of the business model and is represented as an entity with two fields: **Output (Output, Goal)**.

The output is one of the important factors for strategic planning, and apart from analytical data it may come in the form of reports, thematic plans through spatial data in the form of GIS layers (thematic layers) and in the form of maps, satellite imagery, orthophoto images, etc.

**2. Defining Input Data**

To obtain the output data is necessary to define all the required input data. The input is in conjunction with the output and can be presented as an entity of two fields: **Input (Input, Output)**.

Digitalized input data is needed for a good analysis, such as a GIS layer with cadastral locations, satellite imagery, orthophoto, GIS infrastructure layers, maps and many others. Also included in the input are databases and legislation data (laws, regulations). When defining the input, it is required to define its source. The data source can be presented as an entity of two fields: **Data Source (Source, Input)**.

Data sources can include: the municipality, the surveying office, other state agencies and other sources. It is important to emphasize the need for digitization of spatial data.

**3. Defining Modelling Strategies**

- GIS Methods and techniques

GIS_MSUDP uses GIS methods and techniques which can be applied to get certain output data which could be used in the strategic urban
development planning. They are in conjunction with the input and can be presented as an entity of two fields: **Methods-Techniques (Method, Input)**

Methods and techniques that can be applied are: geo-referencing, vector of layers, transformation, etc.

- **Data Queries**

  To receive the output data, one can use the data queries provided by GIS. Data queries in GIS software (ESRI) are made as a SQL Query. Data queries can be presented as an entity of two fields:

  **Queries (Query, Input)**

  - **Cartographic processing**

    This is a frequently used possibility offered by GIS, which allows overlapping, buffering, etc. using multiple GIS layers to obtain a new GIS layer. Cartographic processing can be presented as an entity of two fields:

    **Cartographic processing (Processing, Input)**

    - **Map Algebra**

      This is a useful feature that allows GIS to make calculations from maps. Map algebra is in conjunction with the input and can be presented as an entity of two fields: **Map algebra (Algebra, Input)**

    - **Mathematical and statistical calculations**

      Mathematical and statistical calculations are always needed for strategic planning and can be presented as an entity of two fields:

      **Mathematics - Statistics (Calculation, Input)**

**PHASE 4 - LOGICAL MODEL**

Based on all entities of the previous phases, a logical model has been built and represented as E-R diagram (Figure 4). Three conjunctions are the most characteristic: business model/goals, output/goals and output/input. For easier application of the proposed logical model, a relational database has been created with the same structure. A separate Windows application has also been created in conjunction with this database, to serve for editing and displaying data in the logical model entities.
PHASE 5 - PHYSICAL MODEL

The physical model is created on the basis of the logical model. The next block diagram shows a physical model (Figure 5). The designing and testing of the physical model is made with the existing GIS software. This is done by using the ArcMap - GIS software by ESRI, and ModelBuilder, a graphical tool for designing models. To test the proposed GIS_MSUDP concept, a distinctive business model has been selected: the socio-economic impact on healthy nutrition in Macedonia, and new GIS model has been created through the GIS software. This business model was chosen for two reasons: to demonstrate the application of the proposed concept in economy and the healthy food technology, and the second reason is that there is a database at the Faculty of Technical and Technological Sciences in Veles, created by our own ongoing research on the socio-economic impact on healthy nutrition, dietary habits and healthy food in general. The spatial data used includes maps and satellite photos of Macedonia.
The proposed concept is built on the basis of several principles. The first principle is for the model to be as simple as possible, rather than building a complex model that offers more options. It is better to build two simple models rather than one that is more complex. The concept we propose is much simpler in comparison with other concepts such as PSS and SDSS systems that are complex and hard to manage and the possibility of a mistake is far greater. The second principle is to use easily accessible data. PSS and SDSS systems require a lot of input data, that aren’t always necessary for certain decisions and accessing them is very difficult due to great time complexity. The process of digitalisation of spatial data, necessary for input, represents a comprehensive process that on occasion requires a long time. The third principle is to avoid building an ideal model that would fully describe the real world in a formal system. This is not possible. The more one goes towards the idealization of the real world in a formal system, the more complex and bigger this system gets. The proposed concept makes visualising the real world in a formal way only in certain areas important for planning, but does not go on into idealizing.

CONCLUSION

The concept of modelling for the strategic urban development planning represented in five phases does not allow for improvisation and mistakes. This will improve the way of strategic planning and thus help the competent authorities from the municipalities, government and the citizens to quickly, efficiently and accurately make correct and timely decisions. The new GIS model obtained by GIS modelling for strategic urban development planning can affect the performance of municipalities, and generally the national government in terms of urbanism, but also in all other parts of their jurisdiction. The created GIS model for strategic urban development planning, with software support, can be applied from both a theoretical and an applicative aspect, thus making its importance even greater.
This concept has been practically applied and tested on a business model for socio-economic impact on a healthy nutrition in the Republic of Macedonia. The modelling is done with an existing software (by ESRI) thereby creating a new GIS model.

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