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Decision Support System Based on Artificial Intelligence, GIS and Remote Sensing for Sustainable Public and Judicial Management

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Abstract
The reformation of public and judicial management has become an important challenge nowadays with the development of the Information and Communication Technologies and also with the rapid development of the geospatial and remote sensing technologies. This paper presents a decision support system that was developed based on Artificial Intelligence, Geographic Information Systems and Remote Sensing for implementing Sustainable decision-making strategies. Several indicators were defined in order to build a decision-making system that will help the authorities to apply the adequate public management strategies. Geographic Information Systems were used in order to process and visualize spatial data that are important in public decision making, such as environmental data, infrastructure data and crime data. Remote sensing was used regarding the manipulation of satellite images that would facilitate public decision making. Artificial intelligence was used to build neural network models important in the decision making. The developed system provides a more holistic view of the factors that affect public and judicial management and aims at improving the framework of public decision making and spatial planning and also at supporting the application of the most adequate public management policies.

Keywords: Artificial intelligence; Decision Support System; Environmental information; Geographic information systems; Public management; Remote sensing; Sustainable development.

1. Introduction

The rapid increase of public decision-making information has raised the need for adopting new information management technologies and techniques. The development of the Information and Communication Technologies (ICT) has rapidly affected the classical decision-making framework that has been implemented in public management aiming at adopting sustainable management strategies.
The application of Decision Support Systems (DSS) in public management has been studied by several researchers (McGowan & Lombardo, 1986; Wallace & De Balogh 1985; Wang, 2005). Wallace & De Balogh (1985) studied the use of decision support systems in public administration for disaster management. Wang (2005), developed a knowledge based decision support system (DSS) to be used as a tool for the governmental authorities in order to deal with decision-making problems about governmental real estate investments.
The incorporation of Geographic Information Systems in Information and Communication Technologies for developing GIS-based information systems for public administration was investigated by several researchers (Coutinho-Rodrigues, Simão & Antunes, 2011; Kouziokas, 2016a, 2016b, 2016c, 2017). Coutinho-Rodrigues, Simão &

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Antunes (2011) designed a spatial decision support system by implementing geographic information systems in combination with social, economic, and environmental cost criteria in order to implement decision aid methods in urban infrastructure planning. Kouziokas (2016c), developed a geospatial decision support information system aiming at sustainable public management and planning in the urban environment by using geographic information systems and information technology and also several kinds of information in order to build a sustainable managerial framework. Kouziokas (2016d), proposed a decision support system relying on a technology – based decision-making framework by using GIS and a relational database which includes multiple factors that affect the decision-making process including geospatial data, environmental data, human resources information and economic data.

Several application frameworks have been proposed by researchers for incorporating geospatial systems and in the decision-making process for sustainable management (Bennett (1997; Coenen, Benneworth & Truffer, 2012; Covell, 2016; Graymore, Wallis & Richards, 2009; Niu, Lu & Khan, 1993). Niu, Lu & Khan (1993) proposed a framework for integrating spatial systems in sustainable development. In the proposed framework, several indicators are proposed in order to evaluate and measure the sustainability. The proposed conceptual framework can provide useful information to decision makers in public management at various fields. Bennett (1997), developed a framework in order to integrate geospatial information systems in a model base environment. The developed information system can support the development of geographical simulation models for sustainable decision making. Graymore et al. (2009), proposed a sustainable framework by incorporating GIS in a decision support system for promoting regional sustainability. They have integrated GIS in a multi criteria based methodology in order to produce an effective decision-making tool for promoting sustainability.

This paper proposes a Decision Support Systems (DSS) in public and judicial management and a conceptual framework that can facilitate and support sustainable decision-making strategies by taking into consideration multiple factors so as to apply the most adequate management policies.

2. Materials and Methods

2.1 Designing the decision support information system

The main scope of designing the Decision Support Information System (DSIS) is to take into consideration multiple factors so as to support decisions of multiple natures. The proposed system can be used to manage and monitor data regarding the following crucial categories in public and judicial management: environmental indicators, crime data, economic data, urban data, remotely sensed data and also GIS data.

The key environmental indicators according OECD (e.g. air quality, waste generation, SO2, NO2, emissions) (OECD Environmental Directorate, 2008) are used as systematic methods for measuring and reporting about the environmental performance (Hammond, & World Resources Institute, 1995) and can be utilized in environmental management and planning

The crime factors include crime data and can be used in adopting crime prevention and management strategies. Furthermore, crime data can be very useful in judicial

management in managing the court cases and the court processes. The urban data include all data all factors are essential to be considered in decision making in urban management and planning (e.g. buildings, infrastructures, etc.). The remotely sensed and GIS-based factors must also be taken into consideration in spatial and environmental management and planning (Millington, Walsh, & Osborne, 2013).

2.2 Artificial Intelligence

Artificial intelligence has been applied in decision support systems in several ways (Sol, Cees, & de Vries Robbé, 2013). In this research, artificial intelligence is utilized as a sophisticated tool by developing neural network forecasting models to be used in decision making.

The Artificial Neural Networks (ANNs) are defined as intelligent computational systems that simulate the neural framework of the human brain. A neural network processes the information from the input factors. The input data traverse through the neurons and after being processed, the output results are produced (Svozil, Kvasnicka, & Pospichal, 1997).

2.3 Remote sensing and GIS

Remote sensing can be used in public management and planning in multiple ways, such as monitoring the urban growth and the land cover. An application example is the implementation of remote sensing to detect the vegetation change, which has an important role in ecosystem management and in monitoring the land cover and also the land-use (Shalaby, & Tateishi, 2007; Whitlock, Shafer, & Marlon, 2003).

The authorities can use the information derived from remotely sensed images as a decision support tool in order to manage natural resources more efficiently and to make the appropriate decisions regarding a sustainable framework of preserving the natural resources. The remotely sensed images can be stored into the system's database and also to be used as a decision tool for the related managerial issues at any time.

GIS based data can be very useful in spatial planning in public management (Wilkinson, Saarne, Peterson & Colding, 2013). For this reason, the data stored in the database have also information about their spatial coordinates. Furthermore, spatial data analyzed by GIS software can also be stored in the system's database. For example, hotspot analysis can be applied on the crime data in order to find the regions with increased concentration of crime which is very important in crime prevention and in law enforcement operations.

2.4 Implementation technologies

The Decision Support Information System was developed by using several technologies, programming languages and a Database Management System (DBMS). Microsoft SQL Server was utilized as a Database Management System (DBMS) in order to construct the relational database of the system which is considered as one of the most reliable and allows the access for multiple users. Geographic Information Systems were incorporated into the information system so as to facilitate managers and public administration to solve issues regarding the spatial management and planning. The Google maps API was utilized for retrieving, managing visualizing spatial data from the

system's database on maps. Microsoft IIS (Internet Information Server) was used as a Web Server for serving the web maps. The Microsoft .NET Framework was implemented as a development framework for building the Graphical User Interface (GUI) of the information system. Microsoft Visual C Sharp and Hyper Text Markup Language (HTML) were used as programming languages.

3. Results and Discussion

The scope of developing the proposed decision support system for the public management was to support public decision making in a holistic way by taking into consideration multiple factors that affect public and judicial management.

A prototype decision support information system was developed to facilitate public management processes. The developed information system provides a computerized way of managing information regarding several kinds of indicators and factors that are considered to be important in public management. Sustainable public management strategies can be supported by the developed system based on the management and the interpretation of the proposed urban indicators and factors in order to build decision scenarios so as to apply the most adequate practices.

Geographic Information Systems were integrated into the system as they are considered as a very significant technology that permits the visualization of spatial data and also the analysis of spatial data which is very important in spatial management and planning (Budić, 1994; Nedović-Budić & Godschalk, 1996).

Also, remote sensing capabilities were incorporated into the system by storing and managing remotely sensed images into the database. Remote sensing contributes to better public management and planning practices, since it can provide data about decision sectors such as urban growth and the land cover in a more reliable way through satellite images that cannot be performed in any other way. The role of remote sensing is very important in environmental and ecosystem management by monitoring the urban growth, the land cover, the land-use and also the vegetation change (Masser, 2001; Shalaby & Tateishi, 2007; Weng, 2001; Whitlock et al., 2003).

The proposed application framework includes the implementation of a Database Management System (DBMS) for inserting, retrieving and managing data and a Model Base Management System (MBMS) which has the role of creating and managing decision models. Figure 1 illustrates the proposed conceptual framework by using the developed decision support system.

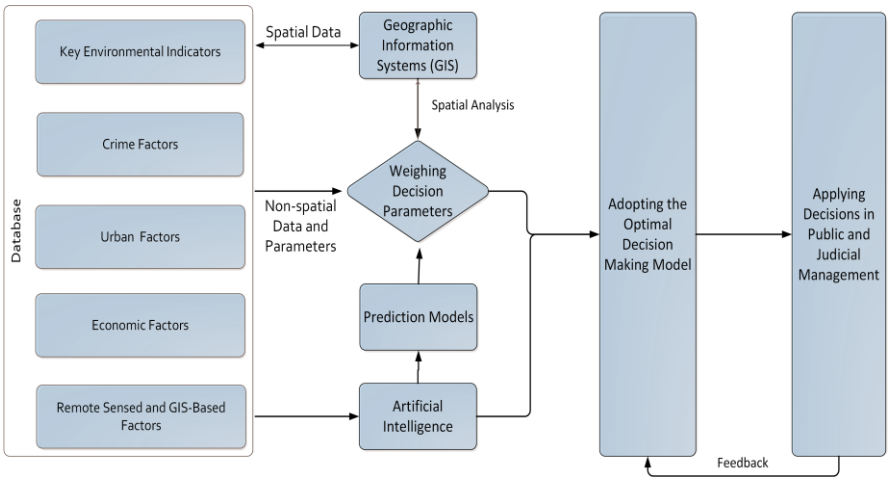

Figure 1. The proposed framework for supporting decision making in public and judicial management.

The collected spatial and non-spatial data regarding the key environmental indicators, the crime, economic, urban data, remotely sensed and GIS-based factors are inserted into the database. The results are used in the parameters weighing stage in order to assess the decision-making alternatives.

Artificial intelligence has been used in decision support systems in multiple ways (Sol, Cees, & de Vries Robbé, 2013). In this research, artificial intelligence is implemented as a sophisticated tool by using the collected data so as to feed the neural network forecasting models. For example, artificial neural networks can be used in crime forecasting by using historical data as input factors (Kouziokas, 2016b; Kouziokas et al., 2016a). Also, the neural networks can be used in environmental data forecasting in public management (Kouziokas et al., 2016b).

The advantage of the developed Decision Support System (DSS) in public management, compared to other researches on decision support systems (Coenen, Benneworth & Truffer, 2012; Coutinho-Rodrigues, Simão & Antunes, 2011; Wang (2005), is that public managers can take into consideration multiple factors in order to achieve the best solution regarding the managerial issues or problems.

Another advantage, is that the developed system adopts a combination of technologies such as remote sensing which can provide documents about environmental issues regarding land cover that cannot be provided in any other way (e.g. About the vegetation change spatially). Furthermore, Geographic Information Systems are incorporated into the system for managing and visualizing spatial information in public decision making and planning and also for promoting spatially enabled societies (Roche, 2014; Williamson, Rajabifard & Holland, 2010). Moreover, the developed system can manipulate large datasets compared to the traditional decision-making applications.

4. Conclusions

The rapid increase of information related to public management issues in many sectors has led to the development of new computerized systems in order to be used as

decision support systems in public administration.
In this research, a new decision-making framework in public and judicial management is proposed by implementing various technologies in order to develop a decision support system for applying sustainable management strategies. Pubic management practices should adapt new technologies and systems like the one proposed in this paper, so as to provide an improved support in decision making strategies and also in order to promote sustainable management and planning.
Geographic Information Systems were incorporated into the system as they are considered as very important in implementing public management strategies (Budić, 1994; Nedović-Budić & Godschalk, 1996). Furthermore, remote sensing capabilities were integrated into the system, since the role of remote sensing is very significant in environmental and ecosystem management and planning, according to the literature (Masser, 2001; Shalaby & Tateishi, 2007; Weng, 2001).
A prediction-based decision making methodology is proposed in this research so as to support decisions in public and judicial management by using Artificial Intelligence (AI) in order to build forecasting models regarding several managerial issues which include factors that affect public and judicial decision making (Norton, 2003; Sol et al., 2013).
Furthermore, the interpretation of the collected and the predicted data can help stakeholders to build an improved administrative framework and also to adopt the optimal management strategies in public and judicial management in the direction of sustainable management and planning.

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