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A MODULE IN THE ENVIRONMENT OF A SPATIAL DECISION SUPPORT SYSTEM FOR THE ASSESSMENT OF THE SOCIAL SERVICE COMING FROM A PUBLIC GOOD

VOUTSA D.
Aristotle University of Thessaloniki, THESSALONIKI, GREECE

ABSTRACT

A Spatial Decision Support System (SDSS) under the name of Public Facility Location Tool (PFLT) was designed and implemented in Greece in order to support the decision-making process in complicated spatial problems, through a friendly and efficient Graphical User Interface. This tool is aimed at the Local Authorities of a Municipality, that have undertake the task to seek for the optimal site for the location of a Public Facility in the area of their competence and/or to evaluate such a site. In this paper, the abilities of PFLT to solve the complex spatial problem of the assessment of the social service coming from a Public Good's location are utilized. A new PFLT module has been created, guiding the user to assess the social service. This module implements all the assessment procedures, suggested in this work and more specifically, proposes that the assessment is accomplished through the following ways: a) finding the number of the serviced citizens by utilizing the potentials of the network analysis and/or b) examining whether the position of the Public Good is safe for the citizens or not, by utilizing the abilities of the classical spatial analysis in a GIS. The new module, like the surrounding PFLT, is implemented in ArcGIS 9.3, using Visual Studio and ArcObjects. Its dialogue boxes are simple and easy to use, in order to guide the user through a step-by-step completion of the assessment process. The user draws conclusions either by looking at result maps, or reading the module's messages.

1. INTRODUCTION

Aiming at the social development and the welfare of its citizens, a Municipal Authority is often required to solve complex spatial problems, reflecting the existing spatial status. This process should take many factors and criteria into account, as they lead the Municipal Authority to documented ascertainment. It is therefore clear that the decision makers in order to address quickly and efficiently all these problems must have an easy-to-use and functional tool at their disposal. Spatial Decision Support Systems are such tools (Armstrong and Densham, 1990; Densham, 1991; Birkin et al, 1996; Keenan, 2003; Castle and Longley, 2005; Chakhar and Mousseau, 2008). The SDSS are intended to provide the user with an environment through which the analysis of geographic information can be operated in a dynamic and flexible way.

In Greece, in recent years, a multicriteria SDSS under the name of Public Facility Location Tool (PFLT) was developed (Voutsa et al, 2006; Voutsa et al, 2009;Voutsa, 2009). This tool offers an easy to use Graphical User Interface (GUI) (Voutsa et al, 2009) through which GIS functions are implemented (Fig.1.1). The PFLT aims at the Local Authorities of a Municipality who are involved in the decision making process for the location and establishment of cultural centres, nurseries, schools and homes for the elderly. The potential PFLT users are the Surveying and Civil Engineers who work in the Technical Departments of the Greek Municipalities. The tool enables the user to find solution to problems such as choosing the optimum site for the location of new facilities or relocating the existing ones, the survey of a facility location taking into consideration the construction and expropriation cost, the assessment of the social service coming from a facility etc. As the tool focuses on urban areas the descriptive and spatial data used are at scales 1:1000, 1:2000 and 1:5000. The layers included in the tool's Data Base are: city blocks and their population, buildings, road and railroad network, land uses, hydrographic network, contours, geological and seismological information, cadastral and topographic infrastructure of the Municipality, location of high voltage pillars and gas stations, land values and ownership, building codes and road congestion. The PFLT was designed in ArcGIS 9.3 (Esri, 1994; FIG, 2009), and developed in the environment of Visual Studio (Microsoft, 2003) and ArcObjects (Zeiler, 2001; Burke, 2003; Chang, 2005).

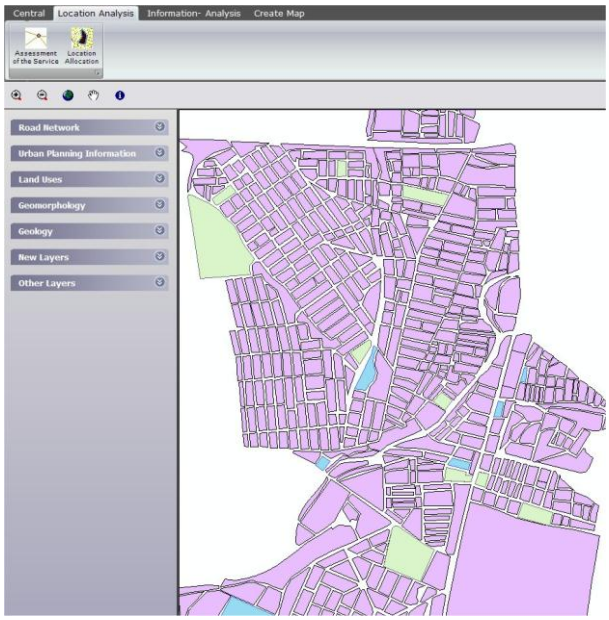


Figure1.1.PFLT's Graphical User Interface. The horizontal section includes all the commands for all the SDSS's processes and the vertical menu manages the spatial information. The spatial information is organized into groups in drop down menus.

This paper is focused on the utilization of PFLT's abilities concerning the assessment of the social service coming from a Public Good's location. With the previous form of the PFLT, the user had simply the necessary information for the assessment at his disposal. This, however, meant that the user should know from the beginning how to define the assessment as well as which part of the offered information to use. In order for the tool to become more helpful, the creation of a new module was decided. The module would 'come in' to direct the user through a step-by-step assessment procedure.

Initially, assessment logic was necessary to be indicated so that the module's design would follow it. Despite the thorough bibliographic search, a systematic way to the assessment's accomplishment was not found. Thus, in the beginning, a logic and the corresponding proper procedures as well as the required spatial and descriptive information were defined (§2). Then, the module was compiled in such a way that it's forms are simple and easy to understand. By activating the dialogue boxes, the user draws conclusions either by looking at result maps, or reading the module's messages (§3).

2. ASSESSMENT PROCEDURES

The assessment logic and procedures described in this paragraph are formed according to the authors' experience with regard to the way the Greek Municipalities function. Thereafter, it is suggested that the assessment is accomplished through the following ways:

A) The location of the facility is assessed to be of good service if a satisfactory number of citizens are served. The term "satisfactory number" is obviously vague. Since in Greece no relevant standards are legislated, it's up to the Municipality Authorities to clarify the term according to their policy, by defining a certain population number. Apparently, each Public Good is destined to a different age group. Therefore a proper target groupfor the assessment of each facility is considered (see §3).

In order to find the number of the served citizens, an allocation (Goodchild and Kemp, 1992; ESRI, 1994; Papadopoulou, 1997; Korte, 2001; Longley, 2005; Grinderud, 2009) procedure is utilized, considering that all the served citizens, walk to and from the Public Good, through the shortest paths that the road network provides.

The process aims at the creation of a service zone around the facility's location. The service zone is based on the traveling cost, in meters or minutes, between the citizen's residence and the Public Good. The Authorities again decide the optimum cost value, depending on the circumstances. In Greece, only the service zone around schools has a legally defined cost value, that of 800 m.

The number of the citizens that live inside the service area determines the level of the service, provided by the Public Good.

Using the allocation process with various traveling costs and creating different service zones, the Authorities, except for the optimum service, can also have an idea of the number of citizens that are moderately served or not at all.

B) The location of the facility is assessed to be of good service if it is safe for the citizens to use it. In this case, the decision maker takes into account the facility's distance from areas that are considered dangerous for the citizens. According to Greek Legislation these places are: high voltage pillars, gas stations, rivers and streams, roads with congestion and railways. Voutsa 2009, suggests that the decision maker should also take the known seismic faults of the study area together with accompanying geological data into account, since Greece is a land of high seismicity. Yet, Greek Legislation still seems to ignore the significance of such information. In order for the facility to be assessed as safe, it must be located away from dangerous sites and outside a zone that is created as a buffer around them. Some of the corresponding distances that create the critical buffers are prescribed by the Greek Legislation, like for example the distances from pillars and gas stations. However, all other distances are not specified and it is up to the Municipality Authorities to determine values.

The decision maker can follow either one of the above mentioned ways or both of them, in order to decide about the effectiveness of a facility position.

3.THE ASSESSMENT MODULE

In this module the GIS functions of spatial analysis and network analysis are integrated. The GUI is developed by using Visual Basic programming language and ArcObjects, the development platform for ArcGIS Desktop applications. The module uses network analysis commands that the ArcInfo Workstation 7.0 provides, using the Arc, ArcEdit and ArcPlot modules, as ActiveX controls.

In order to avoid obscure points while using the tool, the development of the GUI was based on the interaction between the GUI developers and Engineers, familiar with GIS procedures, from the Technical Departments of four Greek Municipalities.

The dialogue windows of the module are activated through the Location Analysis menu of the PFLT and with the choice of the "Assessment of the Service" button. When the assessment form appears, the user can either select the "Serviced Population" or the "Location Safety" button (Fig. 3.1).

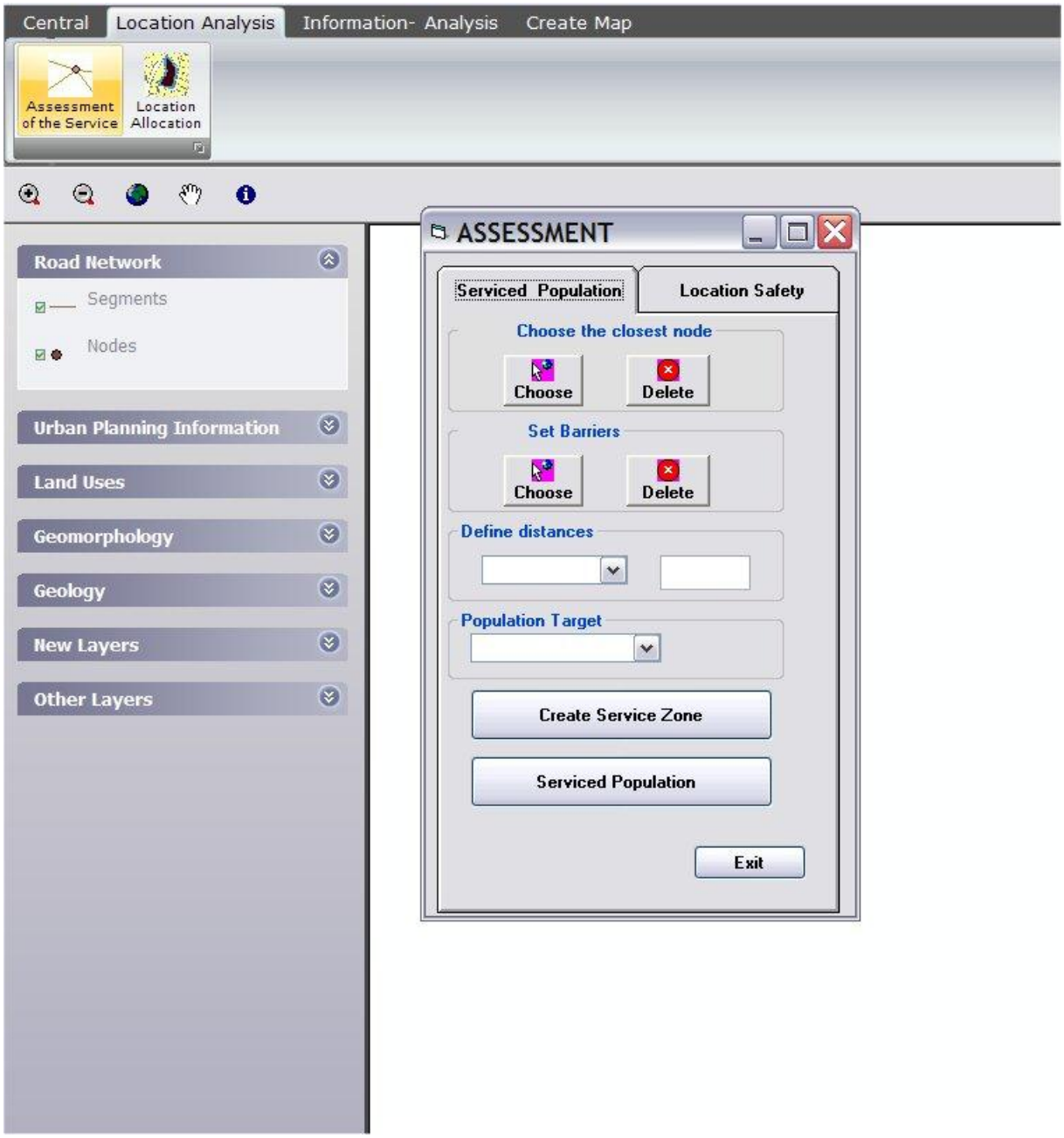
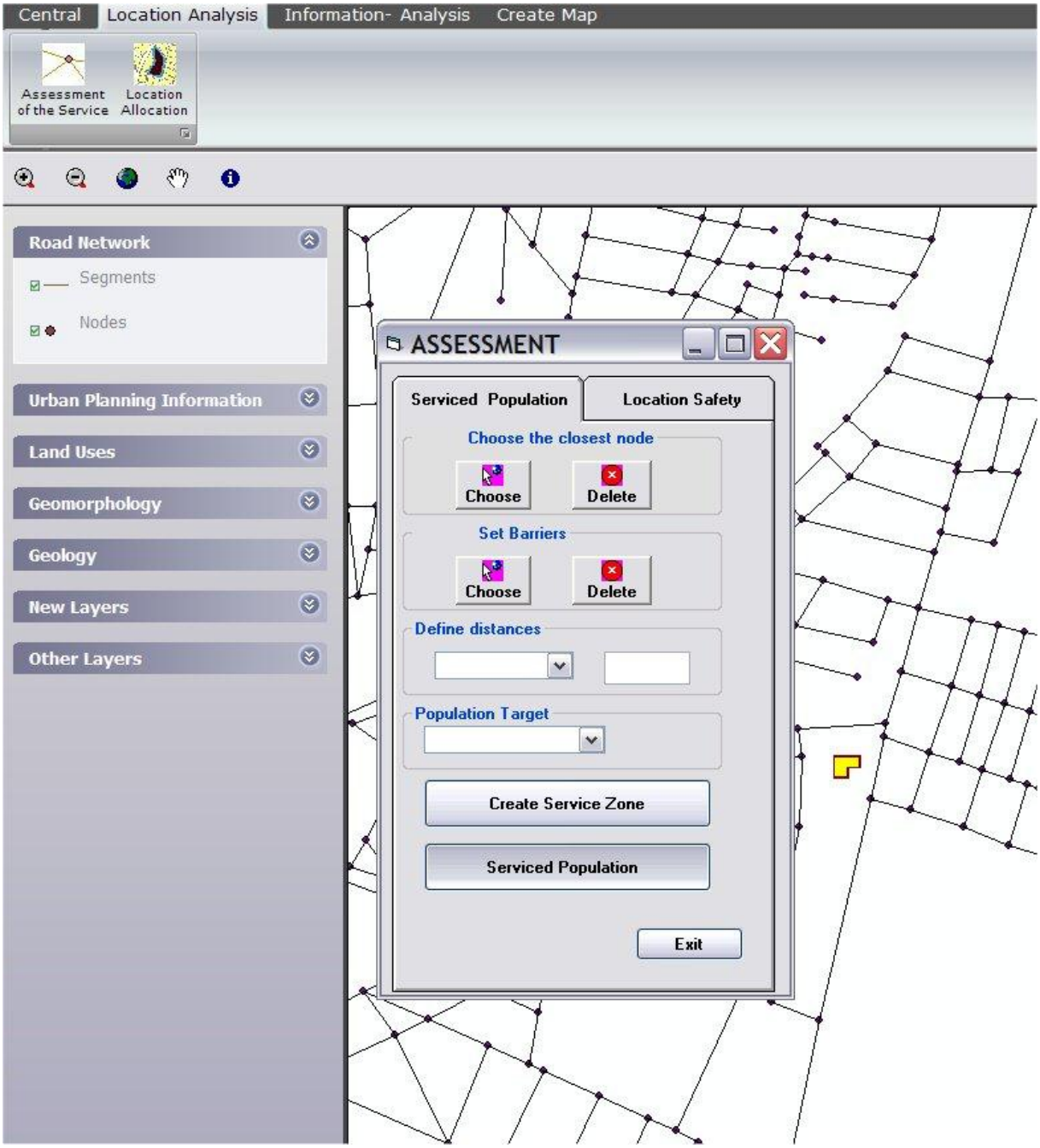


Figure 3.1. The "Assessment of the service" on PFLT's graphical user interface and the "Assessment" form with the two choices: "Serviced Population" and "Location Safety"

The PFLT software, considers that the centre providing the service is a node of the road network layer and for this reason when the form "Serviced citizens" is activated the spatial layers of road nodes and segments, from the vertical road network menu, appear on the screen (Fig. 3.2a). The first step for the user is to choose the closest to the facility node. With the choice "Set Barriers" the module gives the user the ability to set barriers on the network and exclude certain parts that are accounted as unsafe for the citizens (Fig.3.2b). The barriers can be set either on the nodes or on the segments and they are the restrictions that the user sets for an easier access to the Public Good. The PFLT user is not allowed to interfere in the content of the tool's Data Base. Thus, all the barriers choices are made on the screen, something that is actually more convenient. This form allows the user to reverse a wrong collection of the barriers and the nodes by choosing the "delete" button.


Central
Location Analysis
Information- Analysis
Create Map
Assessment of the Service
Location Allocation
Road Network
Segments
Nodes
Urban Planning Information
Land Uses
Geomorphology
Geology
New Layers
Other Layers
ASSESSMENT
Serviced Population
Location Safety
Choose the closest node
Choose
Delete
Set Barriers
Choose
Delete
Define distances
Population Target
Create Service Zone
Serviced Population
Exit

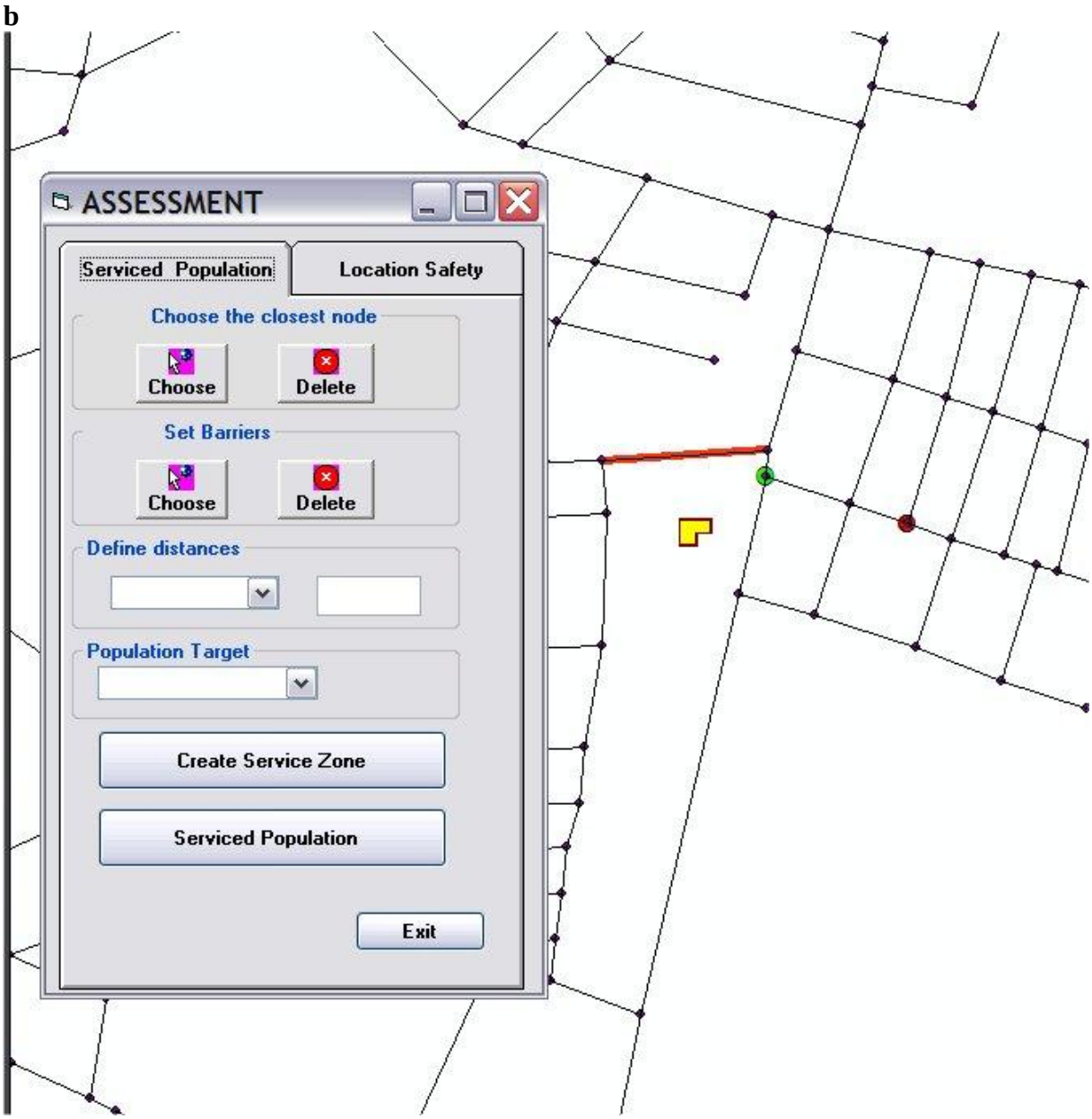


Figure 3.2 The activation of the layers "nodes" and "segments" and the selection of the closest to the Public Good (in yellow) node (a). The function of the "Set Barriers" button on the network. The user can set barriers on the nodes or on the segments of the network (in red). In green, is the closest to the facility node (b)

The next step of the assessment procedure is the definition of the distance that the citizens travel in order to approach the Public Good. As it was said in §2, the distance is either length or time (Fig. 3.3a). The definition of the distance is followed by the calculation of the serviced citizens. The serviced citizens may be either the entire population of the Municipality or specific age groups. In Fig. 3.3b, the age groups corresponding to nurseries, schools and elderly homes as well as the entire population used when the facility under survey is a cultural centre, are depicted.

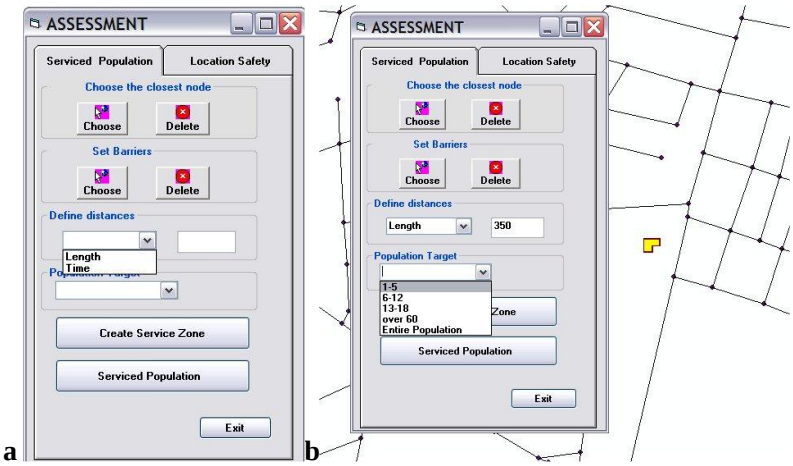


Figure 3.3. The definition of the distance from the Public Good based on the time or on the length. In the text box the user types the distance in meters or in minutes (a). The next step is the definition of the age groups for the serviced citizens (b).

Clicking on the command "Create Service Zone", the results of the procedure appear on the screen. The user may also give different service distances using the "Serviced Population" button more than once and can create zones of various services (§2) (Fig.3.4) (Voutsa and Papadopoulou, 2002; Voutsa et al, 2009).

The number of the citizens that live inside a service area results from the overlay of the service zone layer on the city blocks layer, which carries the population information (see §1). This number appears on the screen, by clicking on the "Serviced Population" button. (Fig.3.5)

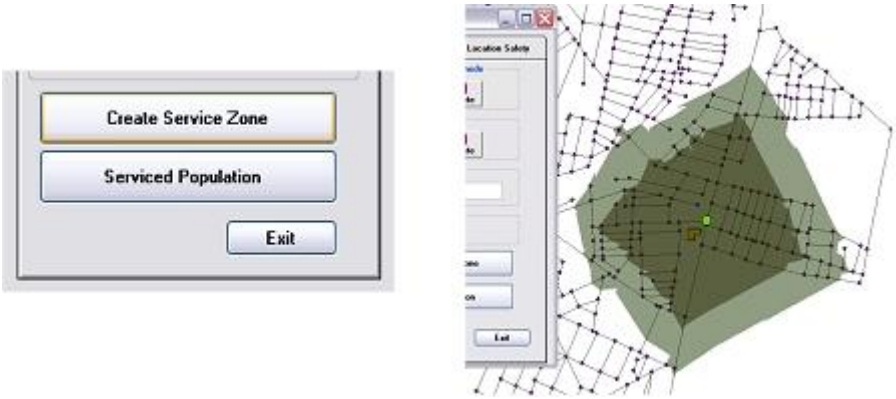


Figure 3.4. The creation of two different service zones for 350m (in brown) and 500 m (in green).

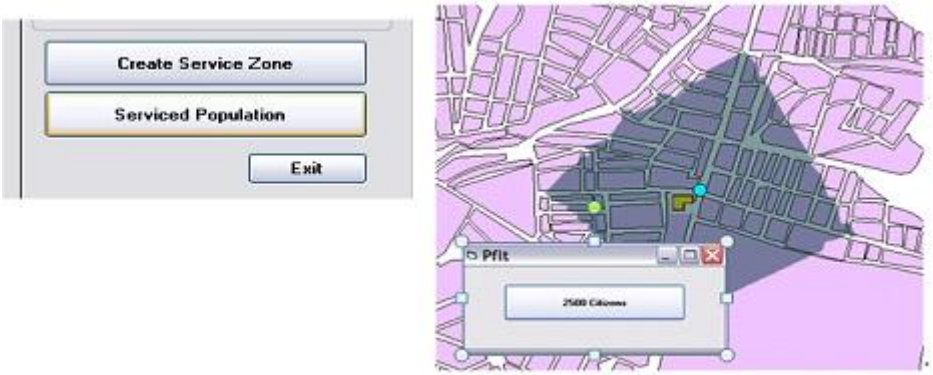


Figure 3.5. The message on the screen gives the number of the citizens.

At this point, the allocation procedure is completed and the user is able to assess the service.

With the "Location Safety" button the safety of the facility's position is checked (see §2) (Fig.3.6). This form has two choices. The "Create Buffer" and the "Geological Information" buttons.

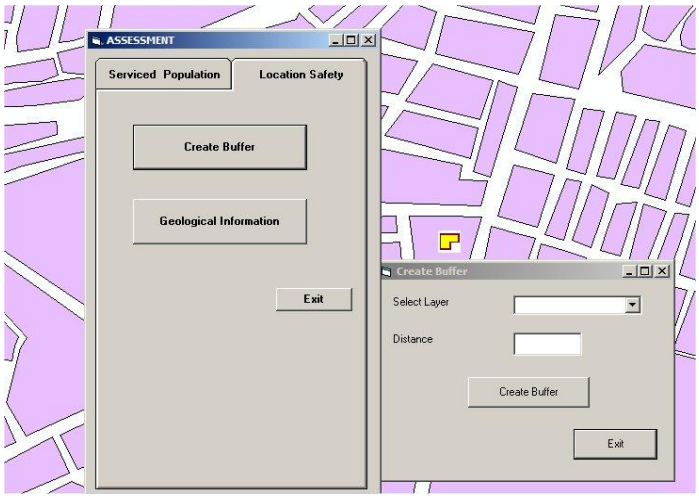


Figure 3.6 The "Location Safety" dialogue window, through which the user finds out if the location of the Public Good meets certain spatial criteria.

With the first choice the "Create Buffer" form appears and the user creates buffer polygons to a specified distance around the system's spatial layers. In the first step, the user defines the layer (Fig.3.7a) and in the second step the distance (Fig.3.7b). If the Greek Legislation prescribes the distance, it automatically appears in the text box and the module does not allow the user to change it. Otherwise, the user has to type a distance, taking into account the Municipality's will.

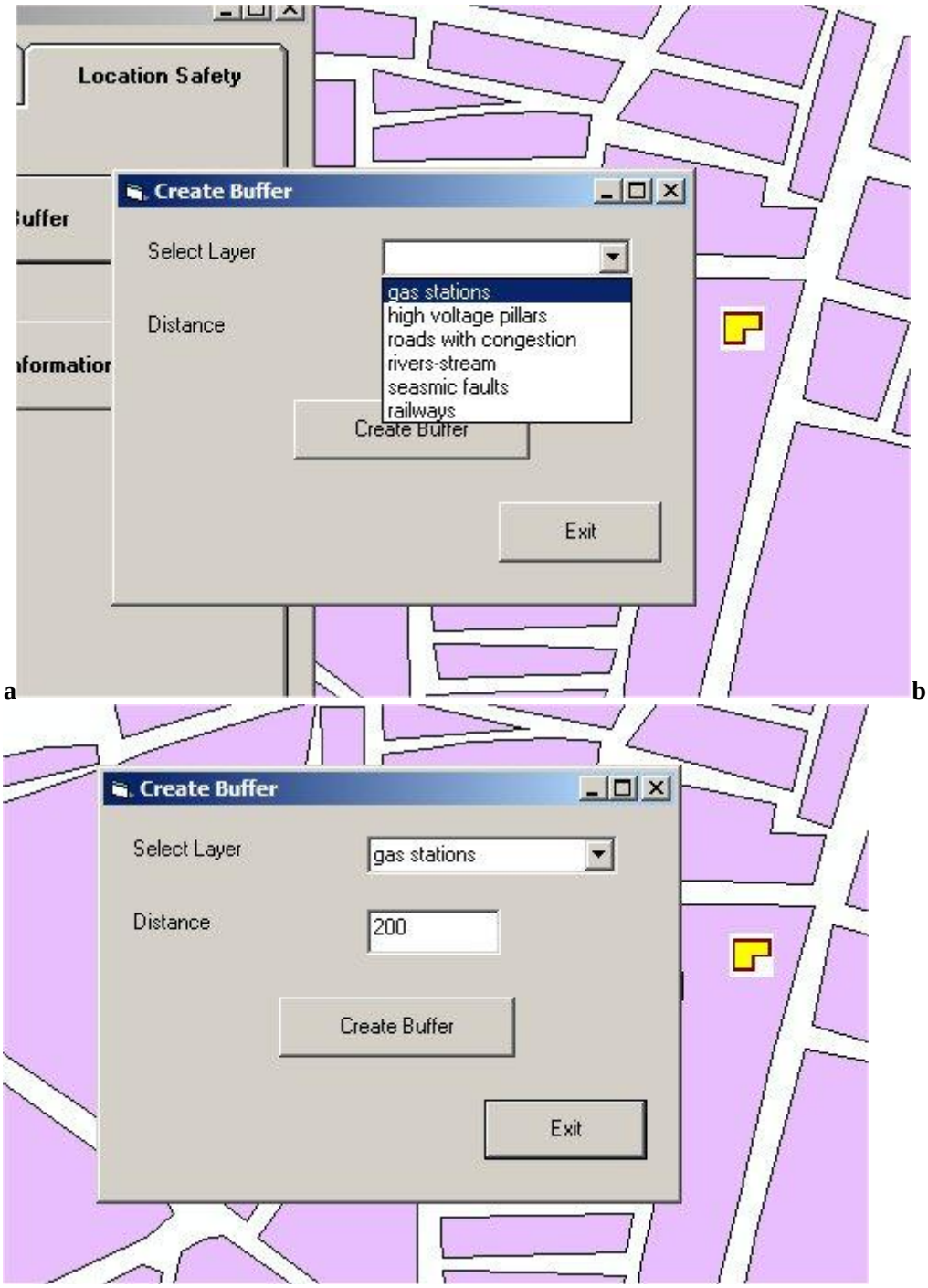


Figure 3.7. The steps to the buffer. The definition of the layer and the distance in meters (a). In this case the distance is prescribed by the Law and the text appears automatically in the text box (b).

The buffer zones appear on the screen with the 'Create Buffer' command (Fig. 3.8).

Fig 3.8. Buffers at a 500m distance from high voltage pillars (a) and 200m distance (b)from the location of gas stations. The user can see that the facility is located safely outside the restricted buffers.

The second choice that has been included in the "Location safety" dialogue window is the "Geological Information" (Fig. 3.9). The corresponding information is provided through technical reports or maps. These data concern the stability of the area where the facility is established and give information about the general behaviour of the bedrock of the facility's foundation.

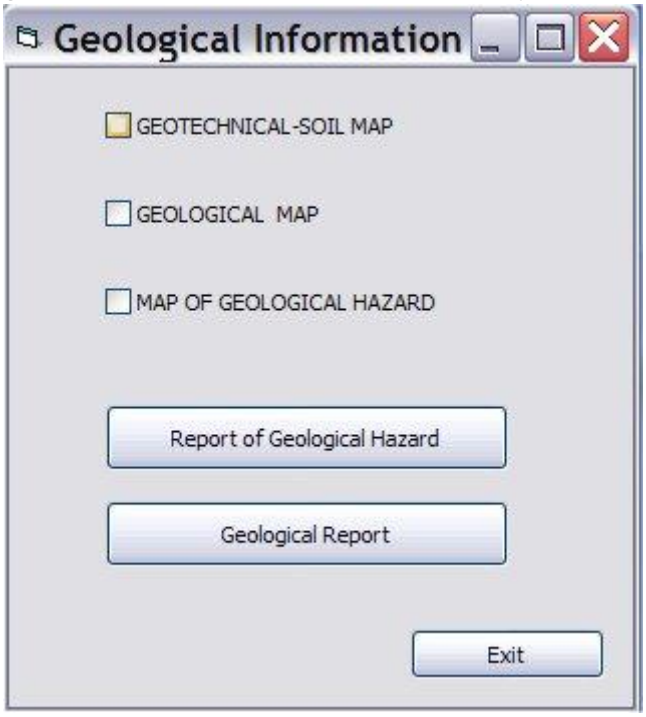


Figure 3.9.The form for the retrieval of geological information.

4. CONCLUSIONS

In this paper, ways in which Local Authorities can face the problem of whether the current position of a Public Good serves the citizens are described.

A decision maker can assess the social service using the PFLT's assessment module, which combines fundamental GIS processes. Despite the thorough search, no assessment methods were found in the bibliography and the module adopted procedures suggested by the authors, according to current operation of the Greek Municipalities. Thus, these processes vary, depending on the type of the Public Good, on the specific conditions that prevail in each region, on the rules for the citizens' safety as the Law ordains and on the Local Authority's requirements for a higher standard of living.

The module is simple, comprehensible and easy-to-use. However, behind its simplicity complicated programming procedures are hidden and many lines of code compile each dialog box.

At this moment in Greece, none of the Municipalities uses the PFLT to carry out assessment procedures. More over, the Municipalities own part or none of the data needed. Therefore, it is not possible the module

to be checked in real conditions and data. The module was tested by the Municipalities' Engineers using hypothetical queries. Their observations, suggestions and impressions were very helpful for the development and improvement of the module. Finally, the testers stated that this module is essential and will contribute decisively in the decision-making process specifically now that an ambitious government plan to redraw administrative boundaries takes place in Greece. The Local Authorities, with their new extended boundaries will be required, to meet the needs of more citizens, to manage large amount of data and to evaluate more alternatives.

PFLT in its entirety and consequently the newly developed module is not a static system. It has the potential for development, adaptation and continuous upgrading. The system's Data Base can be expanded to include new spatial and non-spatial data as well as new Legislation requirements. The usage of 2D5 data for the visualization of the assessment's results and the addition of other information concerning the citizens' safety, like, for example, information about the air pollution, are the module's future development objectives. This means that new assessment criteria can be embodied in the module, depending each time on what the current Legislation requires.

By this way, the decision makers are directed to safe conclusions that reflect the continuously increasing citizens' need to live in a comfortable and safe environment.

5. REFERENCES

1) Armstrong, A. P., Densham, P. J., 1990. **Database organization strategies for spatial decision support systems,** IJGIS, vol.4, no. 1, pp: 3-20.

2) Birkin, M., Clarke, G., Clarke, M., Wilson, A., 1996. **Intelligent GIS Location Decisions and Strategic Planning,** 1st ed. Cambridge, UK: Geoinformation Intelligent

3) Burke, R., 2003. **Getting to Know ArcObjects,** ESRI Press.

4) Castle, C., Longley, A., 2005. **A GIS-Based Spatial Decision Support System for Emergency Services: London's King's Cross St. Pancras Underground Station**, In: Oosterom, P., Zlatanova, S., and Fendel, E. M., (eds) Geo-information for Disaster Management, Springer, Berlin Heidelberg.

5) Chakhar, S., Mousseau, V., 2008. **Multicriteria Spatial Decision Support Systems**, In Encyclopedia of GIS, Shashi Shekhar Hui Xiong (eds.), pp:753-758, Springer, N.Y.

6) Chang K.T., 2005. **Programming ArcObjects**, CRC Press.

7) Densham, P.J., 1991. **Spatial Decision Support Systems**. In: Maguire, D.J., M.F. Goodchild, Rhind, D.W. (eds.), Geographical Information Systems: Principles and Applications, vol.1, pp: 403-412, Longman.

8) ESRI, 1994. **Network Analysis**, ESRI, ARCINFO ver. 7.0.

9) FIG, 2009. **The ESRI GIS products family**, http://www.fig.net/figfoundation/esri.htm (last accessed 12-9-2010).

10) Goodchild, M., Kemp, K., 1992. **Application Issues in GIS**, Core Curriculum, NCGIA, University of California, unit 58, pp: 3-8.

11) Grinderud. K., 2009. **GIS the geographic language of our age**, 1st ed, Tapir Academic Press, Trondheim.

12) Keenan, P. B., 2003. **Spatial Decision Support Systems**, In: Mora M., Forgionne G., and Gupta J. N. D. (eds.), **Decision Making Support Systems: Achievements and challenges for the New Decade**, pp: 28-39, Idea Group.

13) Korte, G., 2001. **The GIS Book**, Cengage Learning.

14) Longley, P. A., Goodchild, M. F., Maguire, David J., Rhind, D. W., 2005. **Geographic Information Systems and Science**, 2nd ed., J.Wiley and sons, Chichester, UK.

15) Microsoft Corp., 2005. **MSDN Library Visual Studio.N**ET, Microsoft Corp.

16) Papadopoulou, M., 1997. **An assessment of social service for elderly people in the city of Argos using GIS**, Technica Chronica, 17(3), pp: 47-55 (in Greek).

17) Voutsa, D. & Papadopoulou, M., 2002. **Using GIS for an assessment of the social service for the citizens of Stavroupoli from the City's cultural center**, Social Practices and Spatial Analysis-European and Hellenic experience in GIS, Thessaloniki, Greece, 27-28 June 2002, Dept. of Cadastre, Photogrammetry and Cartography (in Greek).

18) Voutsa, D., Sarafidis, D., Papadopoulou, M., 2006. **Development of a Public Facilities Location Tool (PFLT) in a GIS Environment**, Proceedings of 21st European Conference for ESRI Users, Athens, Greece.

19) Voutsa, D., Papadopoulou, M., Sarafidis, D., 2009, **The Development Of A Spatial Decision Support System For The Location Of Public Goods,** Proceedings of the 24th International Cartographic Conference, Santiago, Chile.

20) Voutsa, D., Papadopoulou, M., Sarafidis, D., 2009. **The Development of a Graphical User Interface for a SDSS destined to the Local Authorities,** Proceeedings of the 2nd Hellenic Conference "Planning and Regional Development", Volos, Greece (in Greek).

21) Voutsa, D., 2009. **The design and development of a Municipal Spatial Decision Support System,** Phd., Thessaloniki: Aristotle University of Thessaloniki, Greece (in Greek).

22) Zeiler, M., 2001. **Exploring ArcObjects**, 1sted, Redlands California, ESRI Press.

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