4.5.7. USE OF GIS FOR THE PREPARATION OF AN ACTION PLAN FOR SEISMIC RISK MANAGEMENT IN THE CITY OF THESSALONIKI

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4.5.7.1. Introduction

The development and strengthening of capacity to prevent, reduce and mitigate disasters is a top priority area involving participation at all levels, from the local community through the national government to the regional and international level. Earthquakes are mostly considered as one of the most destructive natural hazards known to man with evident impact on urban infrastructure and human fatalities. Management of seismic risk deals with *Response – Recovery – Mitigation – Prevention – Preparedness* (Tziavos et al., 2005) (Fig.4.5.7.1.). The objective of civil preparedness is to enable the responsible authorities to swiftly and efficiently meet the resultant demands and implement short-term emergency powers and long-term relief measures.

In general, the plan of action must be characterized by simplicity, comprehensiveness, clarity and adequacy. It must contribute to the in-short-time operational response of the public sector and to the effectiveness of meters of prevention, mobilisation, action and confrontation of the devastating phenomena. It has been clear from past events that the quick response of the public authorities in emergency situations is mostly critical to reduce the magnitude of the effects.

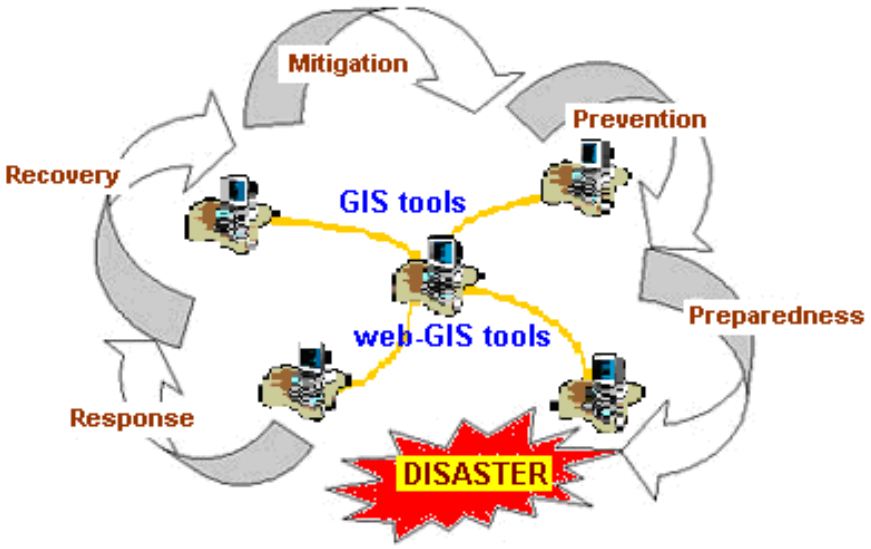

Fig. 4.5.7.1. Confronting the impact of natural disasters

It is apparent that risk assessment is a required step for the adoption of sufficient and successful disaster reduction policies and measures. The effective disaster prevention and preparedness are of primary importance in reducing the need for disaster relief. In the case of earthquakes, the civil protection authorities must develop, test and be ready to implement an effectual action plan. This plan could be developed by using information and data from different sources and disciplines. For example, scenario earthquakes could be used to identify urban areas that present an increased possibility to be damaged in each hypothetical case (Kiratzi et al., 2004). The vulnerability of buildings could also be evaluated so that the possibility of damage is assessed (Stupazzini and Zambelli 2004). Even appropriate education and training of special target groups and the whole community can be applied raising public awareness and improving the capacity of the country to mitigate the effects of earthquakes.

Furthermore, the action plan must specifically configure all aspects of response after an earthquake. A critical element of the plan is the determination of evacuation areas in the cities (for the assembly of population during the first hours after the earthquake) and areas where shelter camps or settlements must be constructed to accommodate people whose residences have collapsed or are heavily damaged (with water, sanitation, medical facilities etc.). There are certain criteria that these areas must meet in order to be used in the most effective way by the people. It is always required to episodically evaluate the adequacy of the above mentioned areas and propose improvements or alterations to the action plan.

The city of Thessaloniki has suffered a lot of fatalities and damage to the built environment from the 1978 earthquake. A lot of scientific work has been undertaken and many prevention measures have been organized since then. The design and development of a response action plan is the responsibility of each municipality of those composing the Metropolitan Thessaloniki area, while the responsibility for the implementation of the plan belongs to the Prefecture of Thessaloniki.

In the present paper, an investigation is being carried out for the evaluation of the existing emergency response plans for seismic risk management in the city of Thessaloniki. The final objective of this research is the development of an efficient and complete action plan for seismic risk management exploiting GIS tools.

4.5.7.2. The use of GIS for seismic management

Different GIS techniques and systems have been used for the management of seismic risk and recording the structural damage information on buildings. The most effective tools have been designed as network applications (Savvaidis et al., 2005). The WWW and associated browser technologies have been recognized as the most effective way of allowing large numbers of users to interact with GIS information. In fact, the rapid development of the Internet has forced the world of Information Technologies in the creation of specialized software for such an environment, as well as new technologies in hardware. GIS-based damage assessment tools can provide a rich amount of quantitative data post-event that may enhance response and recovery efforts.

With the exploitation of GIS tools, all important information can be recorded and analysed in geographical space, thus assisting the improvement of procedures and decision making. By giving civil protection authorities the tools for integrating data from many sources and analyzing how an event will affect an area, GIS has revolutionized the way governments and other agencies manage emergencies. The

development of wireless technologies and Web-based GIS applications have also enhanced the coordination of response efforts.

As stated above, GIS has been adopted for all phases of emergency management: planning, mitigation, preparedness, and recovery. These phases are interrelated and output from one phase is often input for another. Planning involves identifying the hazards, risks, and possible consequences of an emergency. Only after the potential damage of an event is evaluated, can mitigation and preparedness activities start. GIS helps for the evaluation of the response action plans, as well. Finally, short and long term recovery can be better organized through GIS technology limiting the loss of life and property.

4.5.7.3. Action plan for seismic risk management in the city of Thessaloniki

The evaluation of the existing action plan for seismic risk management in the city of Thessaloniki is based on the general action plan of the civil protection authority for management of disasters, the emergency plans developed by the municipalities of Thessaloniki under the supervision of the Prefecture of Thessaloniki (available as maps, tables and operational instructions), demographic data, the digital map of Thessaloniki, and many more geographically distributed data concerning infrastructure, lifelines and critical facilities, medical installations, first aid units etc.

The data were organized as different shape (shp) files and were input to ArcGIS program, widely used GIS software. These shape files include the estimation of the location of each component and a table with descriptive data connected to the graphics element. The main shape files used are: The geographical borders of the municipalities of Metropolitan Thessaloniki (Fig. 4.5.7.2.), the borders of smaller sectors used for emergency management in each municipality (Fig. 4.5.7.3.), city blocks with population distribution (General Secretariat of National Statistical Service of Greece, 2001), street names, location of monuments, hospitals, administration units, police stations, fire stations, schools of all levels, accessible evacuation areas and existing location of shelter settlements (Figs. 4.5.7.4. and 4.5.7.5.) etc.

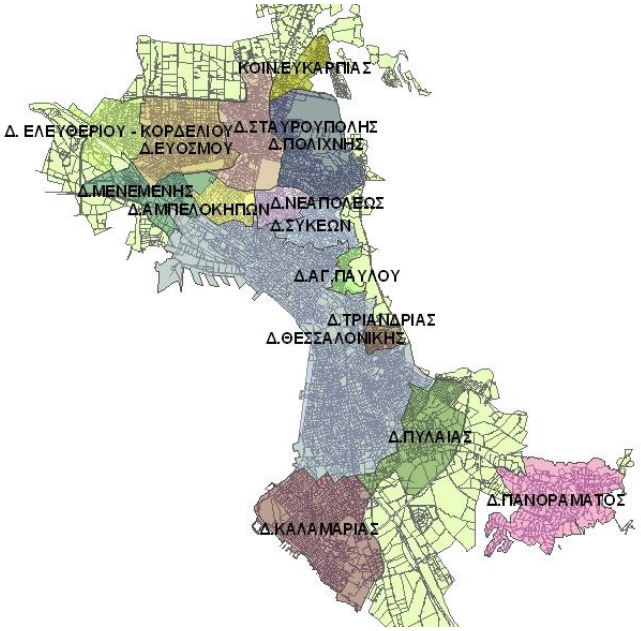

Fig. 4.5.7.2. Municipalities of Metropolitan Thessaloniki

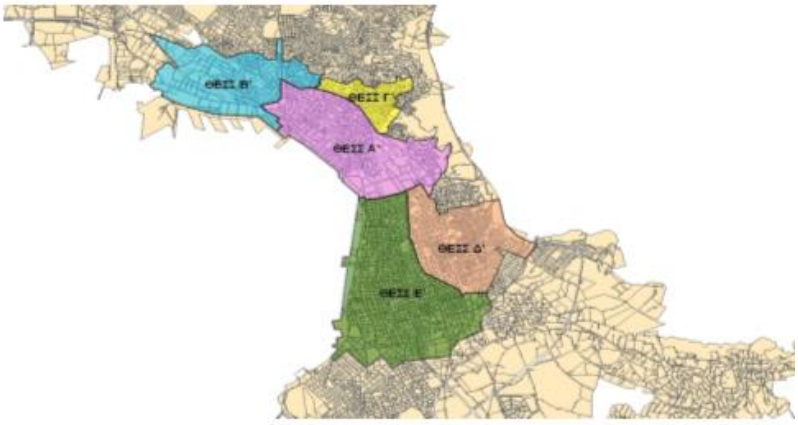

Fig. 4.5.7.3. Borders of smaller sectors used for emergency management in the municipality of Thessaloniki

For each municipality all necessary data for seismic risk management, response and relief procedures were obtained and input in the GIS system. This descriptive information is composed of more than 70 fields (Fig. 4.5.7.6.) and includes:

1. **Geometric data about border polygons and city blocks (area, perimeter etc.).**
2. **Demographic data (number of families, total population etc.).**
3. **Information about responsible authorities.**
4. **Information about evacuation and shelter areas (number, total area, facilities, number of persons etc.).**
5. **Information about facility management, technical staff and equipment.**
6. **Information and location of hospitals and medical centers, police stations, fire stations etc.**

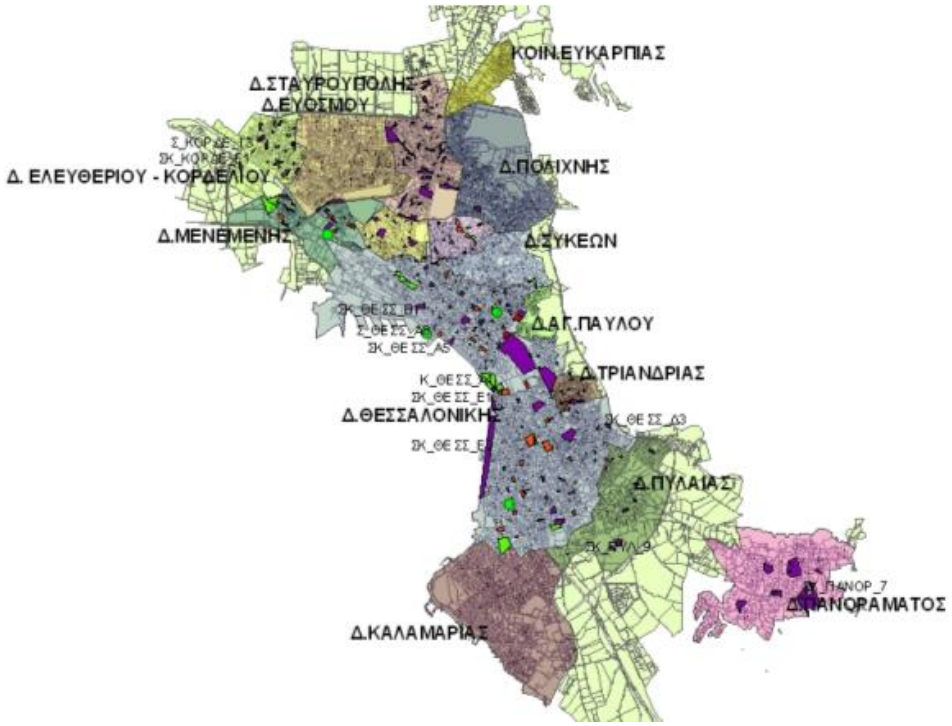

Fig. 4.5.7.4. Evacuation areas and areas for shelter settlements in Metropolitan Thessaloniki (data for the municipality of Kalamaria not used)

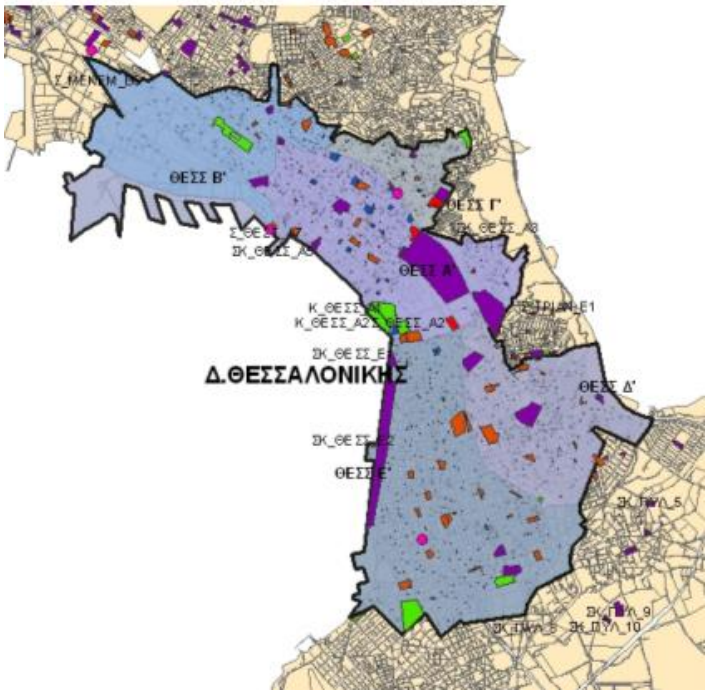

Fig. 4.5.7.5. Evacuation areas and areas for shelter settlements in Metropolitan Thessaloniki

One of the most important factors affecting the efficiency of a response action plan is the location, organization and accessibility of the evacuation areas and shelter camps. In Thessaloniki, there are areas that are expected to be used only as evacuation and concetration areas, other areas where camps are planned to be constructed for the population and areas that can be used in both ways. These areas have been included in the GIS system as polygons (Fig. 4.5.7.7.).

Attributes of DHMOI

FID	Shape*	Id	AREA	PERIMETER	Tomeis	blocks	HOUSES91	HHOLDS91	MEMBERS9	POP91	POP01	MEMBERS0	WOMEN	ME
0	Polygon	0	6772089,57512	16557,06268	0	0	31262	25595	76911	78270	84863	87963	0	
1	Polygon	0	17931722,82399	37700,08452	5	0	169667	136110	352182	359878	348576	328525	0	
2	Polygon	0	576495,92428	3610,99271	5	0	5200	4536	12803	13007	11201	10753	0	
3	Polygon	0	4031412,19013	11309,67276	0	0	5719	4959	15829	16101	18698	18334	0	
4	Polygon	0	1278334,10126	5263,82466	8	0	12436	15013	37380	37896	39694	37713	0	
5	Polygon	0	5410194,40817	19011,34348	0	0	2681	2199	7448	8017	25981	26059	0	
6	Polygon	0	1087086,74395	4623,65032	17	0	12727	10295	30031	30587	31145	29620	0	
7	Polygon	0	3643437,8845	10740,08482	5	0	14442	11376	36142	36587	41356	39234	0	
8	Polygon	0	2599854,45294	11481,26211	2	0	4726	3944	12846	12987	14804	14344	0	
9	Polygon	0	2316040,90702	8459,62201	6	0	6657	4974	16578	16773	21930	21216	0	
10	Polygon	0	4257001,04012	9598,85741	0	0	11486	8440	26781	27096	56003	53748	0	
11	Polygon	0	546964,77691	4977,56784	0	0	3142	2579	7067	7212	8042	7807	0	
12	Polygon	0	1829685,81887	7906,62917	0	0	13554	10923	32839	33362	40041	39026	0	
13	Polygon	0	4826397,29474	9386,90624	0	0	9761	7687	24810	25113	0	0	0	
14	Polygon	0	1148471,46316	5855,67491	0	0	936	826	2919	2991	3257	3238	0	

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Fig. 4.5.7.6. Table of information on seismic risk management, response and relief procedures for each municipality

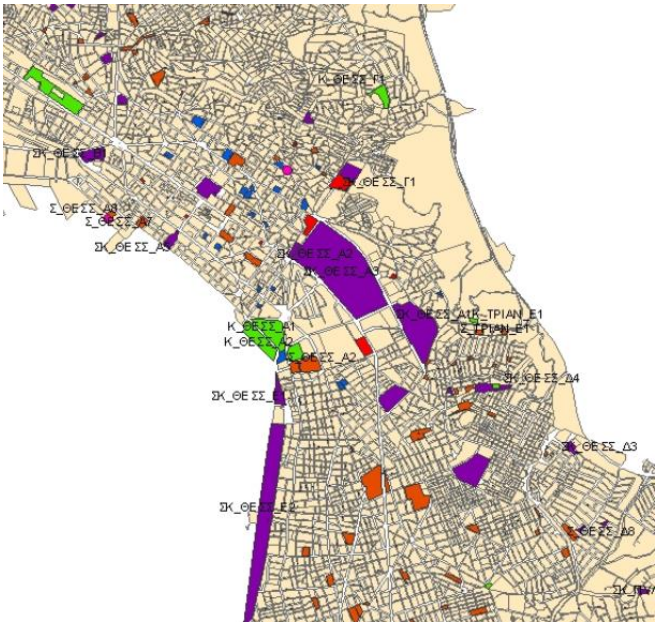

Fig. 4.5.7.7. Evacuation and concetration areas (in orange color), other areas where camps are planned to be constructed for the population (in green color) and areas that can be used in both ways (in magenta color) for the municipality of Thessaloniki

For every one of these areas, all useful data concerning vital elements for their usability were obtained and input in the GIS system. This descriptive information is composed of more than 80 fields including:

1. **Geometric data (area, perimeter etc.).Administrative and organizational information (Name of person in charge, communication data for municipality offices responsible etc.).**
2. **Demographic data (number of families, population per city block etc.).**
3. **Infrastructure of the area - planned to be operational in short term - (water, sanitation, electricity etc.).**
4. **Information about the number of people that can be using a specific area.**
5. **Security information (access and emergency exits etc.).**
6. **Information about cooking facilities and food supply.**
7. **Information about medical facilities and pharmacy.**

In this way, a table of characteristics about all areas of evacuation and concetration, and settlements has been developed. The information contained in the database was then used for a critical avaluation of the existing action planin Metropolitan Thessaloniki.

4.5.7.4. Critical evaluation of the existing action plan in the city of Thessaloniki

A first and urgent question that has to be answered concerning seismic impact management is the capacity of the evacuation areas, where people will gather in the initial time period after a strong earthquake. A survey was carried out for the municipalities of Thessaloniki based on the data of the GIS system. An "adequacy factor" was computed for each municipality as the ratio of total population and the maximum number of persons hosted in the existing evacuation areas (Fig. 4.5.7.8).

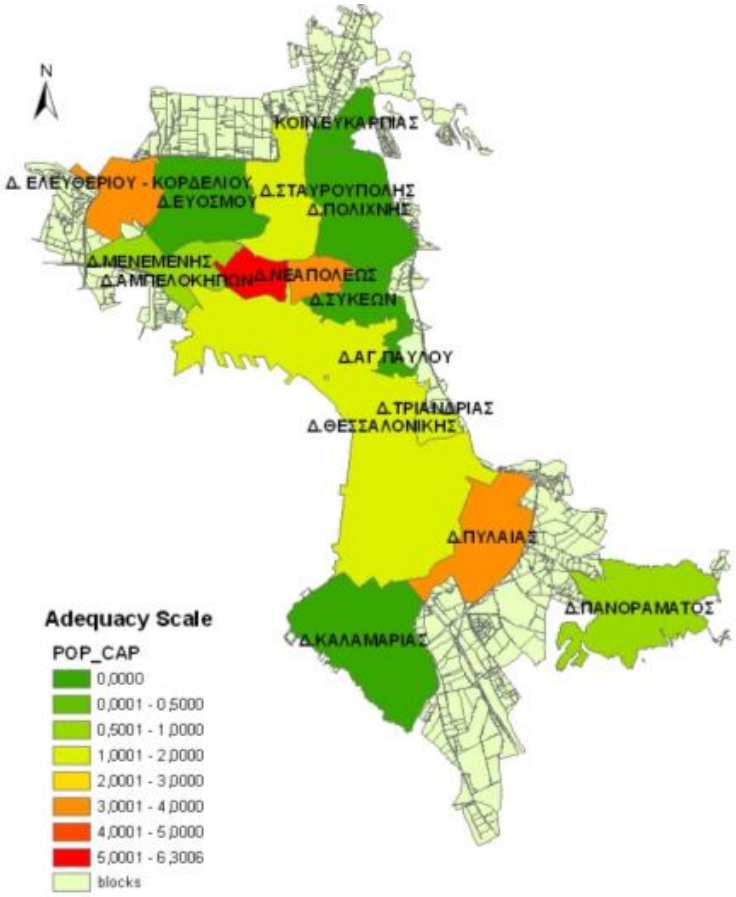

Fig. 4.5.7.8. Values of the "adequacy factor" computed for the municipalities of Metropolitan Thessaloniki

It was considered that if the value of this factor equals to 1, then the capacity of the areas is satisfactory. However, if this factor exceeds this value, then the available space in the particular municipality is not enough. As a matter of fact, as the value of the adequacy factor increases, the problem for the protection of the population becomes vital. As it can be seen from Figs. 4.5.7.8., 4.5.7.7. out of the 15 municipalities of Metropolitan Thessaloniki seem to face problems with the evacuation areas capacity. Municipality of Neapolis is in the most unfavorable situation while the municipality of Thessaloniki, with an adequacy factor of 1.6, should proceed in re-organization and improvements.

Then, an evaluation was performed of the existing plans for areas where shelter camps and settlements will be constructed to provide accommodation for people with destroyed or severely damaged houses. These areas must meet certain criteria determining their appropriateness for providing security and quality of life under the difficult circumstances of the post-earthquake era (Wisner and Adams 2003). The evaluation of these locations and facilities was done on the basis of the above mentioned criteria (mostly set by the World Health Organization) and an evaluation factor (rating 1-100; poor to excellent) was computed for each camp or settlement area (Fig. 4.5.7.9).

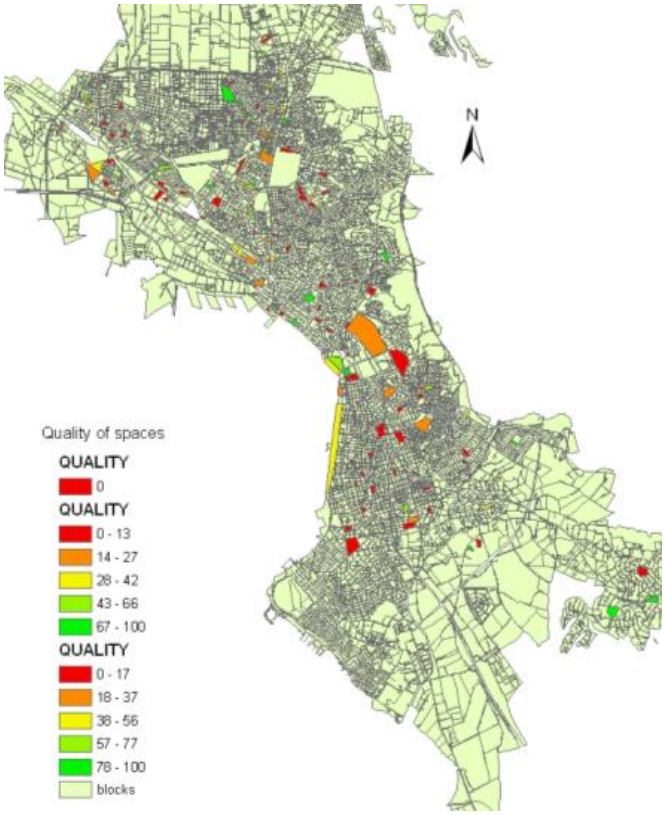

Fig. 4.5.7.9. Evaluation factor for existing shelter camps and settlement areas in Metropolitan Thessaloniki

As it can be seen from Fig. 4.5.7.9, the evaluation factor for existing shelter camps and settlement areas in Metropolitan Thessaloniki has shown that 65% of the areas do not meet the criteria mentioned and are not appropriate for hosting people for a smaller of larger period of time. Even worse, for some of the areas there is lack of information about the existing or organized infrastructure.

Finally, the location and distribution of the evacuation and settlement areas in the city was studied and related to the location of health facilities, hospitals, fire and police stations etc. (Fig. 4.5.7.10). In this way, it is possible to study and propose a better organization of emergency areas according to their distribution and proximity to other health and security units.

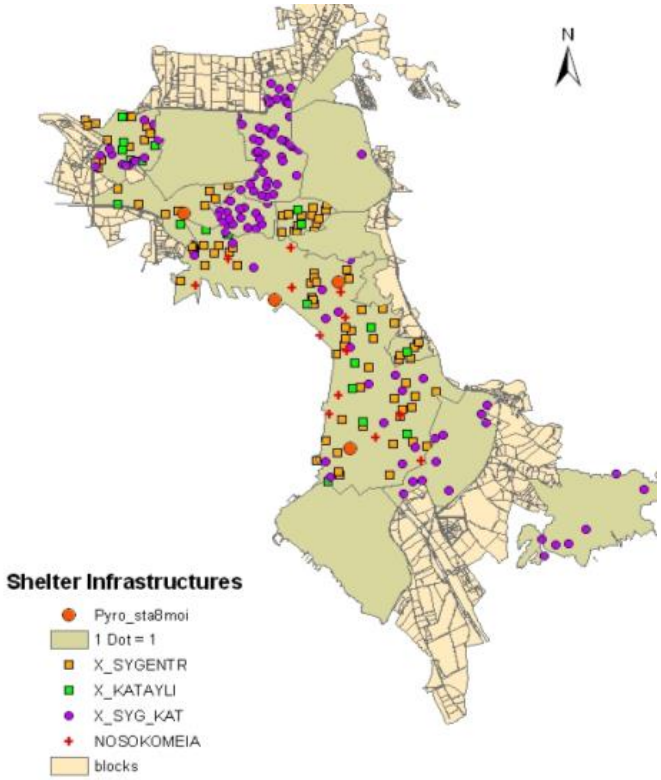

Fig. 4.5.7.10. Distribution of the evacuation and settlement areas in Metropolitan Thessaloniki (data for the municipalities of Kalamaria and Evosmos not used)

As it can be seen from Fig. 4.5.7.10., there are extended regions of the municipalities of Thessaloniki with limited or inexistent free space allocated to the concentration of the population, such as the NW part of the municipality of Thessaloniki. There are also cases where the emergency areas are well distributed but their capacity is not enough. All the above mentioned issues can be spotted, studied and re-organized with the help of the GIS system.

4.5.7.5. Conclusions

A lot of information with geographical reference can be input into the GIS system concerning data capable to help authorities estimate the seismic risk and vulnerability, along with data related to the observed damage to the buildings. The emergency response meters just after an earthquake can be better organized bringing immediate relief to the population.

The use of a GIS system for the evaluation of the existing procedures for seismic risk management in Metropolitan Thessaloniki and the preparation of an effective action plan has resulted into many interesting observations about the preparedness of the state authorities and the resultfulness of the response procedures. Through this survey, it was shown that there are many unsolved problems with the existing evacuation areas that host the population just after an earthquake and the shelter settlements that accommodate houseless people for a considerable period of time after the earthquake. These problems include lack of free space for evacuation areas and settlements, improper distribution of emergency areas, complete lack of information of these areas, inability to host large number of people safely, insufficient infrastructure in settlement areas, poor and low quality inhabitation services and more.

This research will be continued making an accurate recording of existing conditions, evaluating the situation with the GIS tools and proposing certain interventions to the Prefecture of Thessaloniki and the technical departments of the municipalities.

4.5.7.6. References

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