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Land use planning decisions using multi-criteria analysis: The case of the master plan for the western part of the coastal zone of Thessaloniki, Greece

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Abstract

Land use planning decisions involve tackling complex problems and confronting multiple interests. A variety of factors and criteria need to be considered when planning for intricate and multifaceted environments, such as physical, social, economic, environmental, institutional etc. These factors which interact with each other, either in a complementary or conflicting way, cannot always be easily integrated into the decision-making process. Quantitative approaches such as Multi-Criteria Decision Making (MCDM) techniques combined with GIS have been developed to conduct land suitability analysis and to support decision-making.

Drawing on a completed project within the IPA Cross-Border Programme 'Greece – the former Yugoslav Republic of Macedonia 2007-2013' titled "Soil degradation assessment and rehabilitation strategies for sustainable land use planning" (acronym TERRAMED), the paper presents the application of the Analytic Hierarchy Process (AHP), developed by Thomas L. Saaty in the 1970s, to produce decision maps in order to define the suitability of future land uses in the western part of the coastal zone of Thessaloniki in Greece. The analyses and scenarios produced constituted the basis for the formulation of specific strategies and actions, within the broader process of developing a master plan for this particular area.

The paper stresses the importance of MCDM methods in providing a rational framework for making consistent land use planning decisions, being able to improve the transparency of the planning processes and to contribute to consensus building on policies and actions.

Keywords: Land use planning; Multi-criteria analysis; Analytic Hierarchy Process; Coastal zone; Thessaloniki

1. Introduction

Land use planning decisions involve the consideration of a variety of factors: physical, environmental, demographic, social and regulatory. Several types of data can be identified as suitable for assisting the land use planning process (Kaiser et al., 1995), including, for example, population size and distribution, types of employment, soil, geology, topography, existing and planned future uses, all types of infrastructure, community facilities, environmental regulations and permitting system etc. (MacDaniel, 1998). The incorporation of such interrelated and often conflicting factors or criteria in the decision making process is not always an easy task. Quantitative approaches such as Multi-Criteria Decision Making (MCDM) techniques combined with GIS have been developed to conduct land suitability analysis and produce planning and management scenarios (Mosadeghi, 2013). The Analytic Hierarchy Process (AHP) is one of MCDM methods developed by Thomas L. Saaty in the 1970s. AHP helps decision-makers choose the best solution among several options when planning for complex environments in which many variables or criteria need to be considered.

The paper presents the application of the AHP method to produce decision maps in order to define the suitability of future land uses in the western part of the coastal zone of Thessaloniki in Greece. This work constitutes part of a broader process of developing a master plan for this particular area, which was carried out within the 'TERRA-MED' project, financed by the IPA Cross-Border Programme 'Greece - FYROM 2007-2013' and supervised by the Regional Development Fund of Central Macedonia, on behalf of the Region of Central Macedonia.

The paper is divided in four sections, excluding the introduction. The first one briefly describes the TERRA-MED project and the case study area, the second presents the methodology used for land use suitability analysis, while the third one shows a selection of the results. Lastly, the conclusions section highlights the value of MCDM methods for the land use planning process.

2. The TERRA-MED project and the case study area

2.1. The TERRA-MED project

The project "TERRA-MED: Soil degradation assessment and rehabilitation strategies for sustainable land use planning" is considered as an important effort to protect the environmental resources in the "Greece-the former Yugoslav Republic of Macedonia" cross-border area, through an innovative strategic approach for the systemic management of the territorial environmental problems as well as their operative factors. The interaction of the human and natural factors affecting natural environment and life quality in the cross-border area is also under examination. The project duration was 28 months, starting from January 2015 and being completed in April 2017. The project partnership consisted of the Region of Central Macedonia (Lead Partner), the Aristotle University of Thessaloniki - Department of Chemistry and the University "St. Kliment Ohridski" - Bitola, Faculty of Biotechnical Sciences.
The project activities focused on the western side of the Thessaloniki coastal zone in the Region of Central Macedonia and the area around "REK" (a mining and energy company) at Bitola in the Region of Pelagonia. The main common characteristics of the two areas are the soil contamination and the air pollution, as well as the degradation of the ecosystem and the aquifer, due to the intense industrial activity (for more details, see http://www.terra-med.eu/).

The project's overall goal was the development of an operational model for the recording and rehabilitation of the downgraded urban and peri-urban areas. The specific actions of the project include:

- Recording and monitoring of the existing land uses through a customized spatial database, considering at the same time the current planning provisions.
- Development of a digital management and multi-parametric analysis system for spatial data points aiming to record the soil quality and the capacity of land to support different uses, emphasizing on the spatial mapping of soil contamination.
- Examination of the carrying capacity of soil and development of proposals to increase its mechanical characteristics, in order for the proposed infrastructure to be implemented in a safe manner.
- Development of protocols for the recording of environmental pressures and soil degradation, as well as for the environmental rehabilitation methods.
- Development of a Master Plan that will practically be the basis for the future development of the study area (applied only on the Greek part of the project, i.e. the western side of the Thessaloniki coastal zone).
- Design and organization of targeted promotion and publicity actions, as well as actions for informing the wider public.

The aim of the Master Plan for the western part of the coastal zone of Thessaloniki (Action 4.4 of the TERRA-MED project, TERRA-MED, 2016a) was to formulate a spatial vision and a specific strategy for the area, considering the legal framework, the already existing policies and strategies, and the existing land uses and institutional restrictions. It was also in accordance with the knowledge gained in previous actions of the TERRA-MED project, as listed previously, and further analyzed in Section 3. One of the master plan's objectives was the systematic approach of the relation and the interaction between the human and the natural environment. The end-result of the master plan was an action plan proposing priority actions and projects, accompanied with possible funding sources.

2.2. The project area

The project area (6,615 Ha) is situated on the west side of the Urban Agglomeration of Thessaloniki and includes parts of three municipalities: Thessaloniki, Ampelokipoi-Menemeni and Delta (Fig. 1). It constitutes a rather complex environment, combining strong environmental requirements and limitations on use on the one hand and significant 'urban' characteristics, with the presence of various activities of the secondary and the tertiary sector, on the other. Since this development was raised without any official planning and, thus, the area is lacking adequate infrastructure networks, the environmental pressures are heavy.

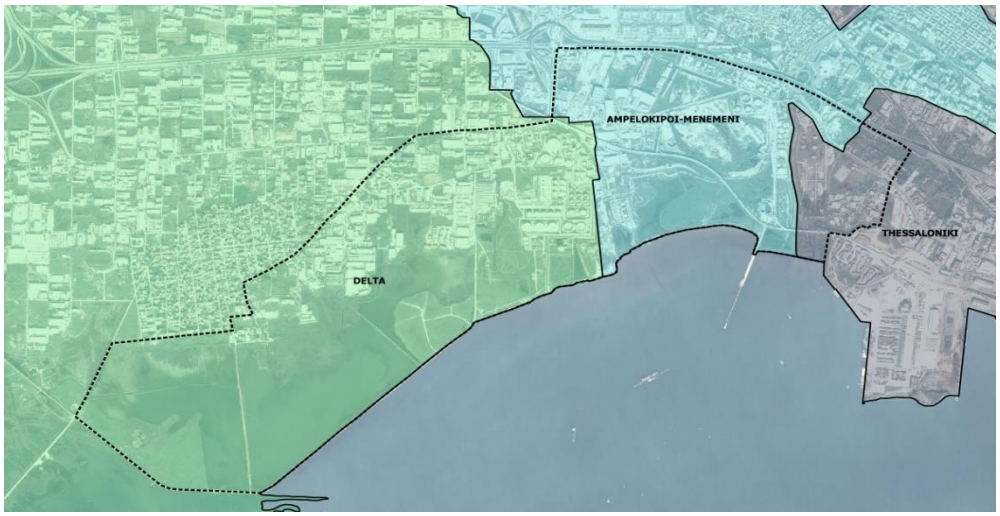


Fig.1. The study area (Source: google earth/TERRA-MED, 2016a)

The dynamic relationship between the water element and the soil characterizes the study area, whose level is in large parts lower than the sea level. The result is periods of large flooded areas (Fig. 2). A significant part of the area, in particular at the west-southwest, is included in the Natura 2000 network of protected sites, the largest part of which also belongs to the National Park of Delta Axios – Loudias – Aliakmonas. Two additional 'Areas of Special Protection' have been designated via the General Urban Plan of Menemeni. The Kalohori Lagoon constitutes a distinctive feature, situated within the National Park (Fig. 3). The eastern part of the study area is part of the metropolitan area of Thessaloniki with major dependencies from it. Apart from the short distance from the central city district, the proximity to major transport networks constitutes a key propulsive element for the area's development (Fig. 4).

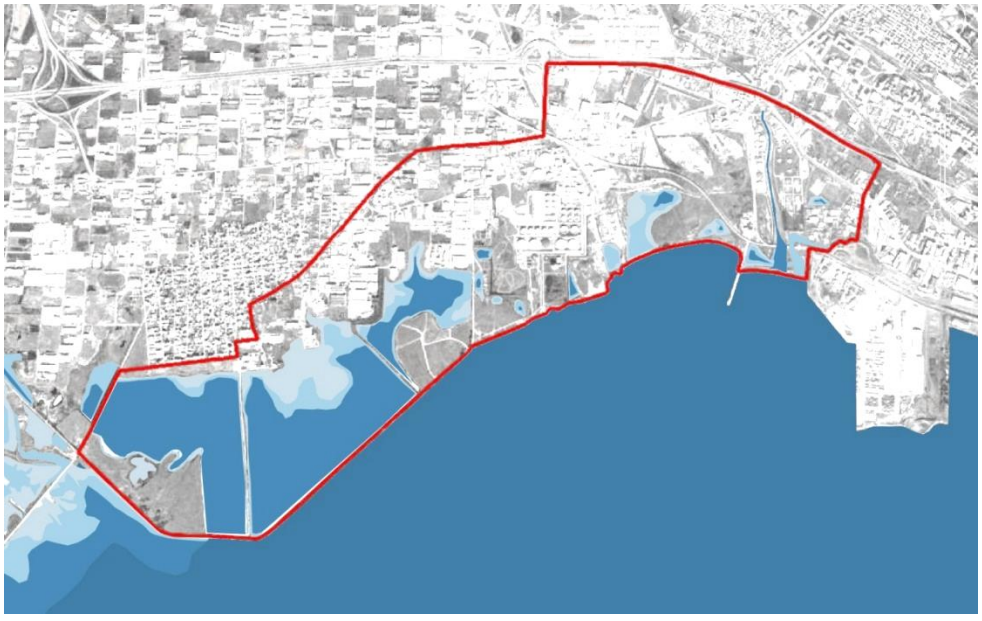


Fig. 2. Gradation of the water element within the study area, 17-07-2011 (Source: google earth/TERRA-MED, 2016a)

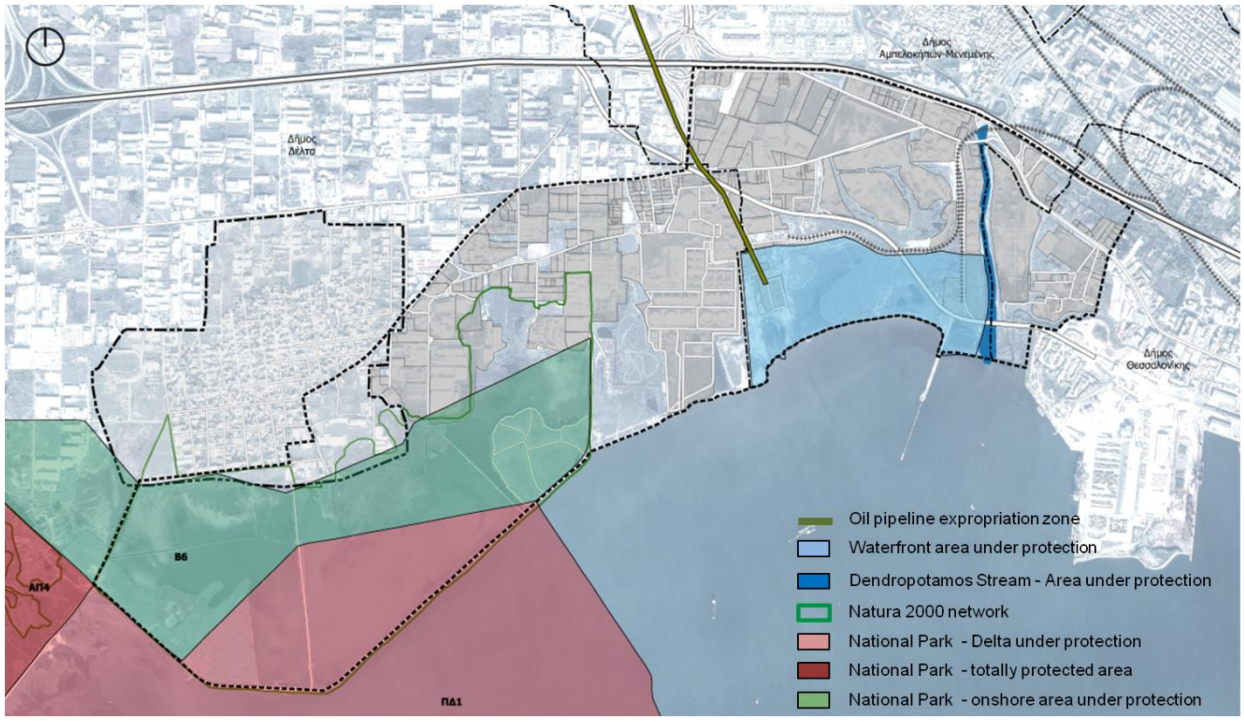


Fig. 3. Nature protection areas (Source: TERRA-MED, 2016a)

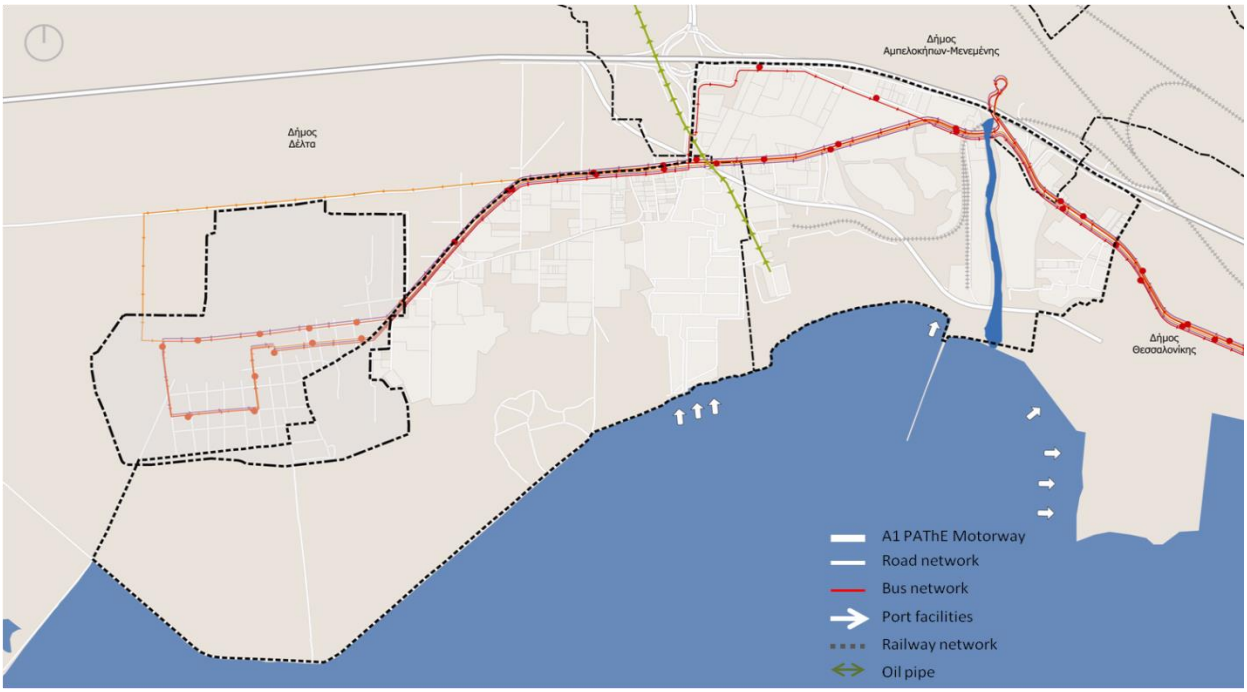


Fig. 4. Proximity to major transport networks (Source: TERRA-MED, 2016a)

The development has occurred almost entirely as a result of market forces, covering the area in the periphery of the settlements and thus forming an informal concentration of industrial and other business activities, without street-lay-out plans and adequate infrastructure networks. Around 200 companies (transport companies, commercial activities, offices, warehouses, industries / crafts workshops / engineering workshops, etc.) are located in the area, while its 'landmark' are the oil companies and refineries covering 26.4% of the total built-up area. Another 16% is occupied by buildings which are currently with no use or even abandoned, 13.6% by manufacturing activities, 8.2% by transport companies and 5% by commercial uses (Fig. 5). It should be noted that eight (8) firms/locations in the area have been incorporated in the SEVESO II Directive. Based on the on-site survey, the majority of firms (76.2%) are 'microenterprises' (less than 10 employees), 18.8% are 'small enterprises' (11-50 employees) and 5% are 'medium-sized enterprises'. The building stock in most cases is in 'good' or 'relatively' good condition. 70.8% of the enterprises were located in the area before the economic crisis that began in 2008, while the remaining 29.2%, which is considered quite remarkable, were located during the current crisis. According to the entrepreneurs (face-to-face interviews), since the beginning of the crisis 80% of the enterprises performed losses in their turnovers that range between 11% and 90%, while approximately 1 out of 10 enterprises (10.6%) showed a significant increase in their performance.

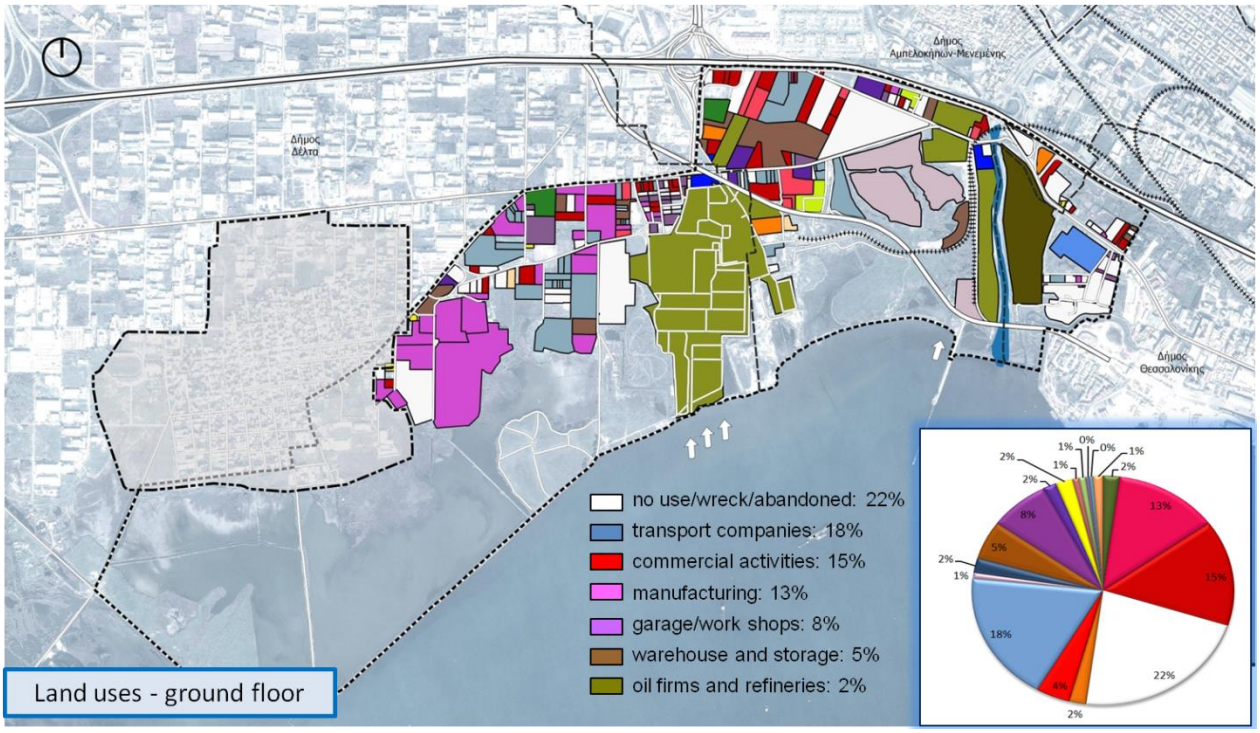


Fig. 5. Proximity to major transport networks (Source: TERRA-MED, 2016a)

The area is experiencing heavy environmental pressures because not only of the existing industrial activity but also because of the existence of facilities which are currently out of service but used to be significant pollutants in the past (i.e. the area of the old tanneries on the east side). Additional pressure is caused by the stream of Dendropotamos (also on the east side), which is the main collector of stormwater for almost the entire western area of Thessaloniki. Both the heavy metals and the 'fats and oils' are soil pollutants causing damage to the soil biota and impede the performance of key soil functions, such as the development of healthy plants and the

support of food chain (TERRA-MED, 2016b). As regards the soil formations in the area, they have low strength and high deformability, which combined with the high level of the groundwater have led to serious geotechnical problems in structures and in soil liquefaction during earthquakes (TERRA-MED, 2016c).

3. Methodology

The process of developing the master plan consists of four (4) activities: i) Analysis and evaluation of the current situation, ii) Sustainability of land uses - multi-criteria analysis, iii) Formulation of goals / strategic development and alternatives and iv) Identification of implementation strategies and action plan. The remainder of the paper focuses on the methodology for land use suitability analysis, using multi-criteria analysis.

Multi-criteria analysis is primarily concerned with how to combine information from several criteria to form a single index of evaluation. Criteria can be based on human or physical geography factors and are categorized as either factors that enhance or detract from the suitability of a land use alternative or constraints that limit the alternatives. For the case of the TERRA-MED project, the method chosen to produce the decision/suitability maps is the Analytical Hierarchy Process (AHP). This process is a structured technique for organizing and analyzing complex decisions and is based on comparisons between the factors that determine a decision. Comparisons are made with a common base, the fundamental scale Saaty (see for example Saaty, 1998; 2008). The AHP generates a weight for each evaluation criterion according to the decision maker's pairwise comparisons of the criteria. Among the relevant criteria one considers some as more important and some as less important; this is equivalent to assigning weights to the criterion according to their relative importance. The higher the weight, the more important the corresponding criterion.

The following formula presents the procedure for which every criterion is first multiplied by the corresponding weight and after that all criteria are summed in order to provide the final result.

$$\sum_{\iota}^{n} = 1 w_i \, x_i \; = \; w_1 \, x_1 + w_2 \, x_2 + \; \ldots + w_n \, x_n \qquad (1)$$

x_i = criteria, w_i=weights

The application of the AHP and consequently the development of the master plan for the western part of the coastal zone of Thessaloniki took the results of preceding actions of the TERRA-MED project dealing with the recording of a) environmental pressures and soil degradation, b) soil mechanics and c) geospatial and socioeconomic parameters into account. Three main criteria were used: 1. COST, 2. SOIL POLLUTION and 3. EXCLUSION ZONES. The criterion of COST was derived from the soil-mechanics research. The results of this research have been translated into cost, as additional constructions are needed to solve soil problems. The criterion of SOIL POLLUTION was derived from the analysis of the soil-chemical research. Lastly, EXCLUSION ZONES criterion resulted from the recording of land uses and socio-economic data, based on which certain limitations or complete building ban exist with respect to different uses (these uses constitute the 'hypotheses' for the analysis). The combination of the main criteria which were involved in each hypothesis led to the production of the final suitability maps (Fig. 6).

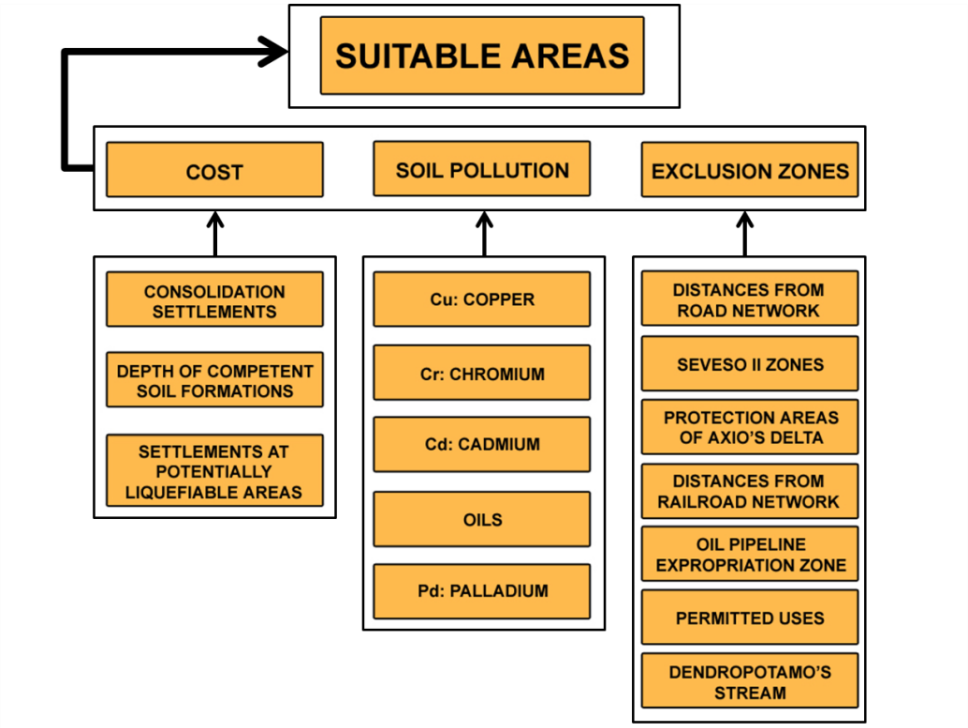


Fig. 6. Criteria and sub-criteria chosen for the land-use suitability analysis

The soil formations in the region have low strength and high deformability, which combined with the high level of the water related to the inlands, have led to serious problems in geotechnical structures and soil liquefaction during earthquakes. Following the soil mechanics research (conducted by the Civil Engineering Department / Aristotle University of Thessaloniki, TERRA-MED, 2016c), the collected geotechnical data were evaluated and were used to develop maps which illustrate the geotechnical characteristics of the area. It becomes evident that because of the poor geotechnical profile of the study area, the foundation design for medium to large buildings and other structures is challenging. Consolidation settlements, the depth of the competent ground formations and the liquefaction potential of the surface in the case of a seismic event were examined and mapped based on various scenarios. Some examples of the produced maps are shown in Fig. 7.

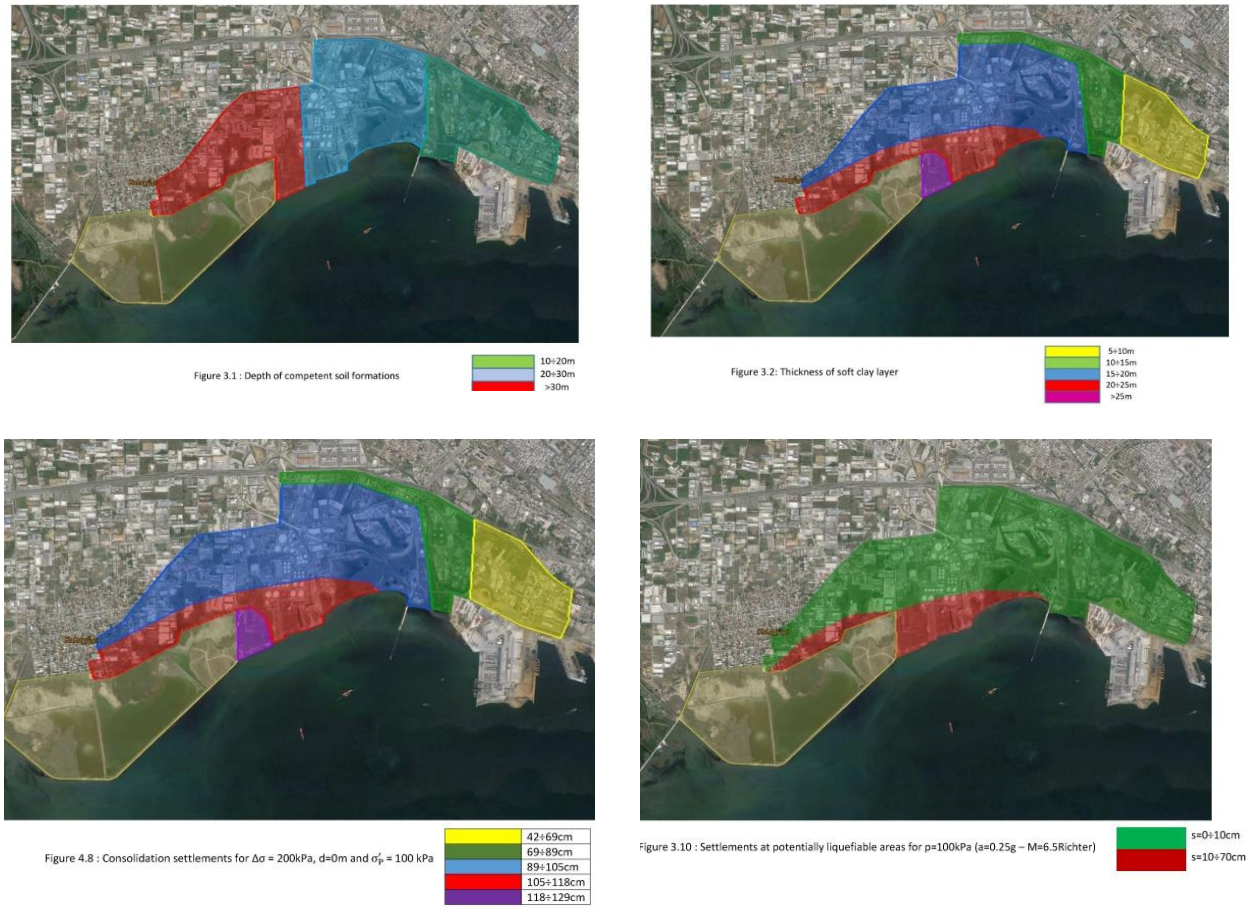


Fig. 7. Results of the soil mechanics research. (a) Depth of competent soil formations; (b) Thickness of soft clay layer; (c) Consolidation settlements for Δς=200kPa, d=0m and σ'$_{ρ}$=100kPa; (d) Settlements at potentially liquefiable areas for p=100kPa (a=0.25g – M=6.5Richter) (Source: TERRA-MED, 2016c)

The results of this research have been combined and then translated into cost, as soil problems can be solved by additional structures (i.e. the difference compared with conventional structures is the extra cost). This criterion combines 3 sub-criteria and with the implementation of the AHP gives the main criterion of COST. Fig. 8 shows the evaluation of land according to the cost needed in order to found buildings (the red area is the most costly).

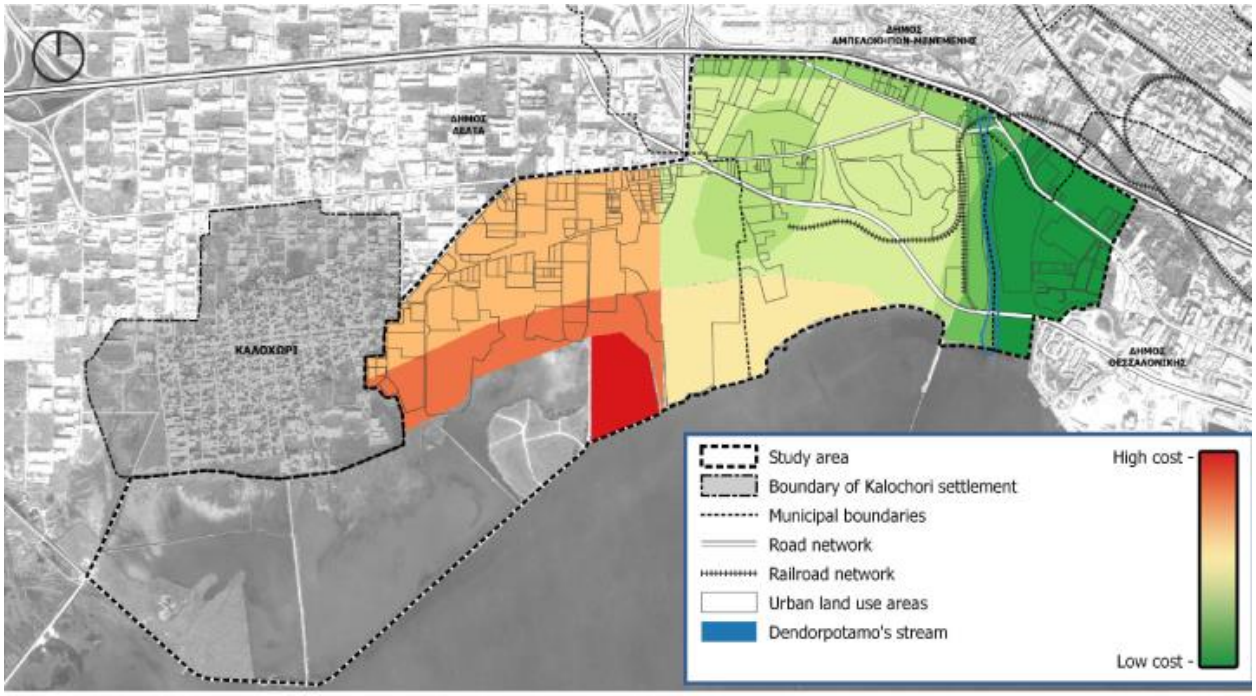


Fig. 8. Overall assessment of soil mechanics characteristics (Source: TERRA-MED, 2016a)

The criterion of SOIL POLLUTION derived from the analysis of the soil-chemical research (conducted by the Department of Chemistry / Aristotle University of Thessaloniki, TERRA-MED, 2016b) and describes the soil pollution. Same as for cost's criterion, it combines 5 sub-criteria. The main results are shown in Fig. 9.

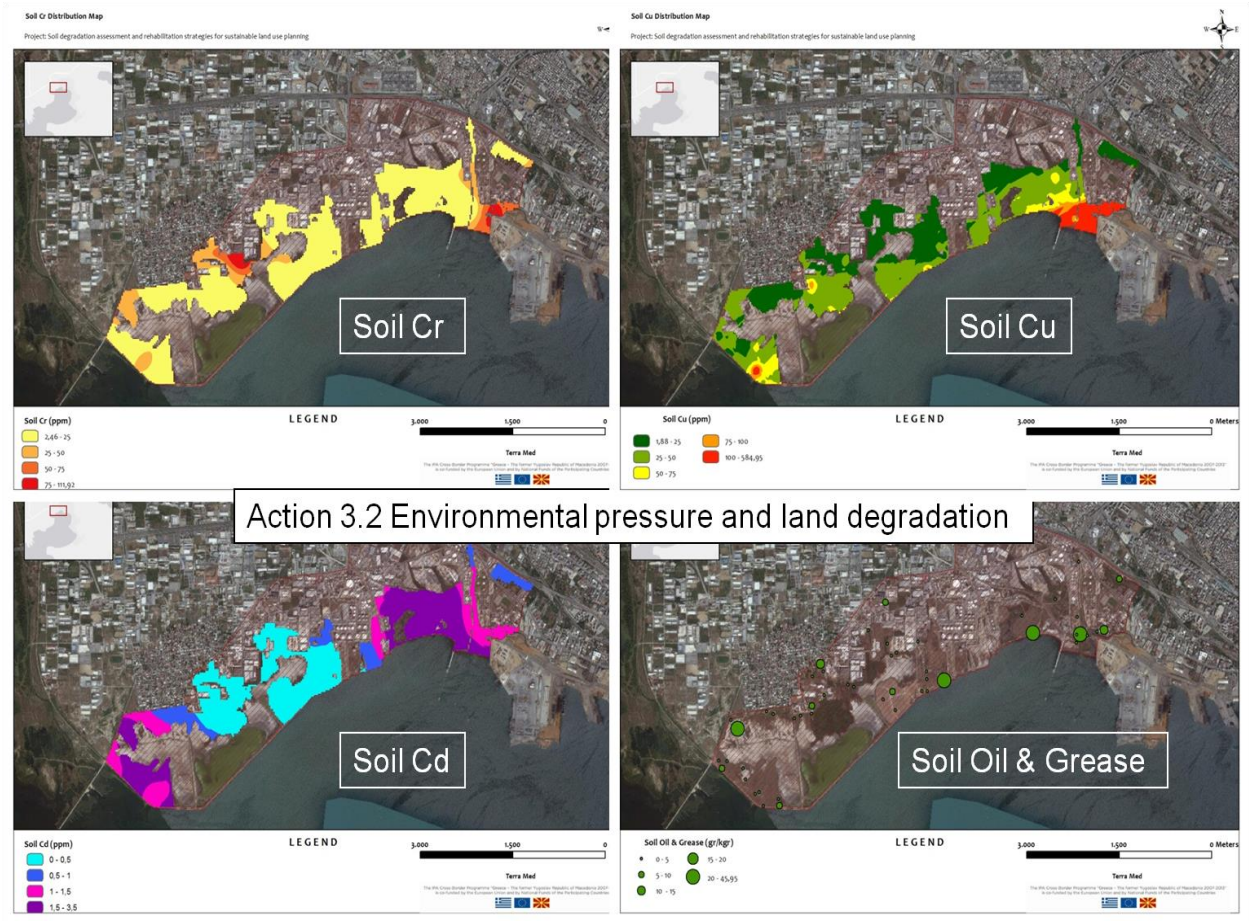


Fig. 9. Results of the soil-chemical research (Source: TERRA-MED, 2016b)

The environmental pressures and the land degradation of the study area were combined and mapped in order to present the whole “image” of the area (Fig. 10).

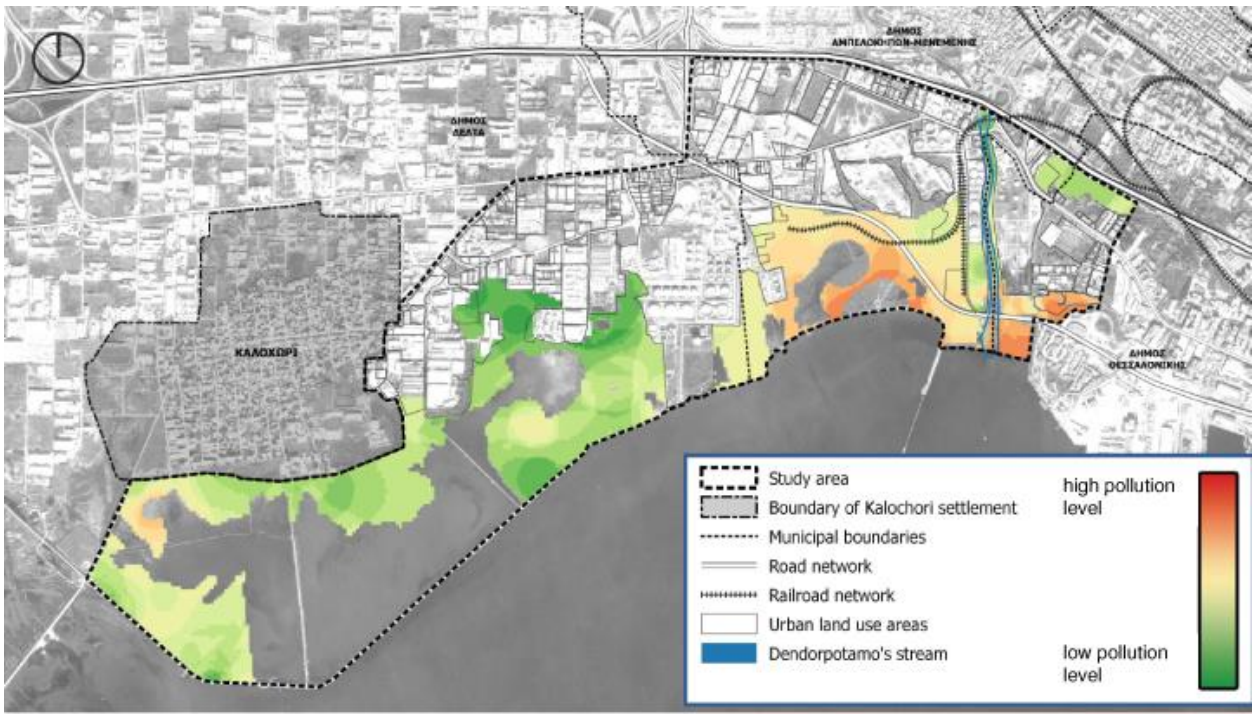


Fig. 10. Overall assessment of the soil-chemical characteristics (Source: TERRA-MED, 2016a)

The EXCLUSION ZONES criterion resulted from restrictions on uses or constraints in structuring/founding or building (TERRA-MED, 2016a). Different exclusion zones have been used for each use hypothesis. The exclusion zones list consist of: a) Allowed distances from road networks, b) SEVESO II Zones, c) Protection areas of Axios' river Delta, d) Allowed distances from railroad network, e) Oil pipeline expropriation zone, f) Allowed uses based on official regulatory plans, g) Dendropotamo's stream. Fig. 11 shows, indicatively, the risk zones I, II & location of SEVESO installations.

Fig. 11. Risk zones I, II & location of SEVESO installations (Source: TERRA-MED, 2016a based on National Technical University of Athens / School of Chemical Engineering, 2008)

The AHP was applied in order to produce land use suitability maps for seven (7) types of land use (these constitute the 'hypotheses' of the analysis), which are either dominant in the area or desirable by the local stakeholders:

For the industrial use:

- Small industrial areas of low disturbance (<100 users & < 3 floors)
- Industrial areas of low disturbance (>100 users & ≥ 3 floors)
- Small industrial areas of low & medium disturbance (<100 users & < 3 floors) and
- Industrial areas of low & medium disturbance (>100 users & ≥ 3 floors)

For the use of leisure:

- Outdoor public areas (<100 users at the same time)

For the general public use (trade, transport, restaurants etc.):

- Indoor areas of general public use (max 250 m^2) and
- Indoor areas of general public use (250 - 5000 m^2)

One suitability map was produced for each hypothesis, i.e. seven suitability maps in total, combining several sub-criteria from all three main criteria (cost, soil pollution, exclusion zones). To address the problem of incompatible values among the criteria, calibration in compatible quantities was required. Calibration was done in 4 classes, with

1 being the minimum suitability and 4 the maximum. For example (Fig. 12), for Copper values between 0-30, value 4 was assigned and so on. The higher the pollution value, the smaller the suitability.

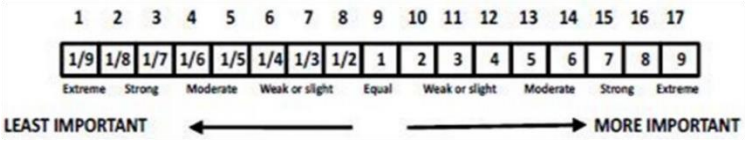
4	MAXIMUM SUITABILITY
1	MINIMUM SUITABILITY

Calibration example:

SOIL POLLUTION				
Sub-CRITERION	**VALUE 4**	**VALUE 3**	**VALUE 2**	**VALUE 1**
Cu COPPER	0-30	30-60	60-180	180-584,95
Cr CHROMIUM	0-8	8-15	15-50	50-111,92
Cd CADMIUM	0-1	1-1,5	1,5-2,5	2,5-3,5
OILS	0-4	4-9	9-15	15-20,67
Pd PALLADIUM	0-40	40-70	70-100	100-167,25

Fig. 12. Criteria and sub-criteria calibration (Source: TERRA-MED, 2016a)

The comparisons between the factors that determine every decision were made with the use of the fundamental Saaty's scale that represents the importance of every factor compared to another (Fig. 13). This comparison is always pairwise.



The Fundamental Scale for Pairwise Comparisons		
Intensity of Importance	**Definition**	**Explanation**
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment moderately favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6, and 8 can be used to express intermediate values. Intensities of 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance.		

Fig. 13. Saaty's nine-point rating scale (Source: Diaz, 2000 in Aguilar et al., 2012 & https://commons.wikimedia.org/wiki/File:AHPFundamentalScale.png)

With values of all data compatible and having calculated the weights of the criteria, the final pixel values were calculated. This was done automatically by the reclassification tool of QGIS 2.8.6 – WIEN. The flowchart below (Fig. 14) shows the steps followed to extract the final maps of suitable areas for each chosen 'hypothesis' of land use.

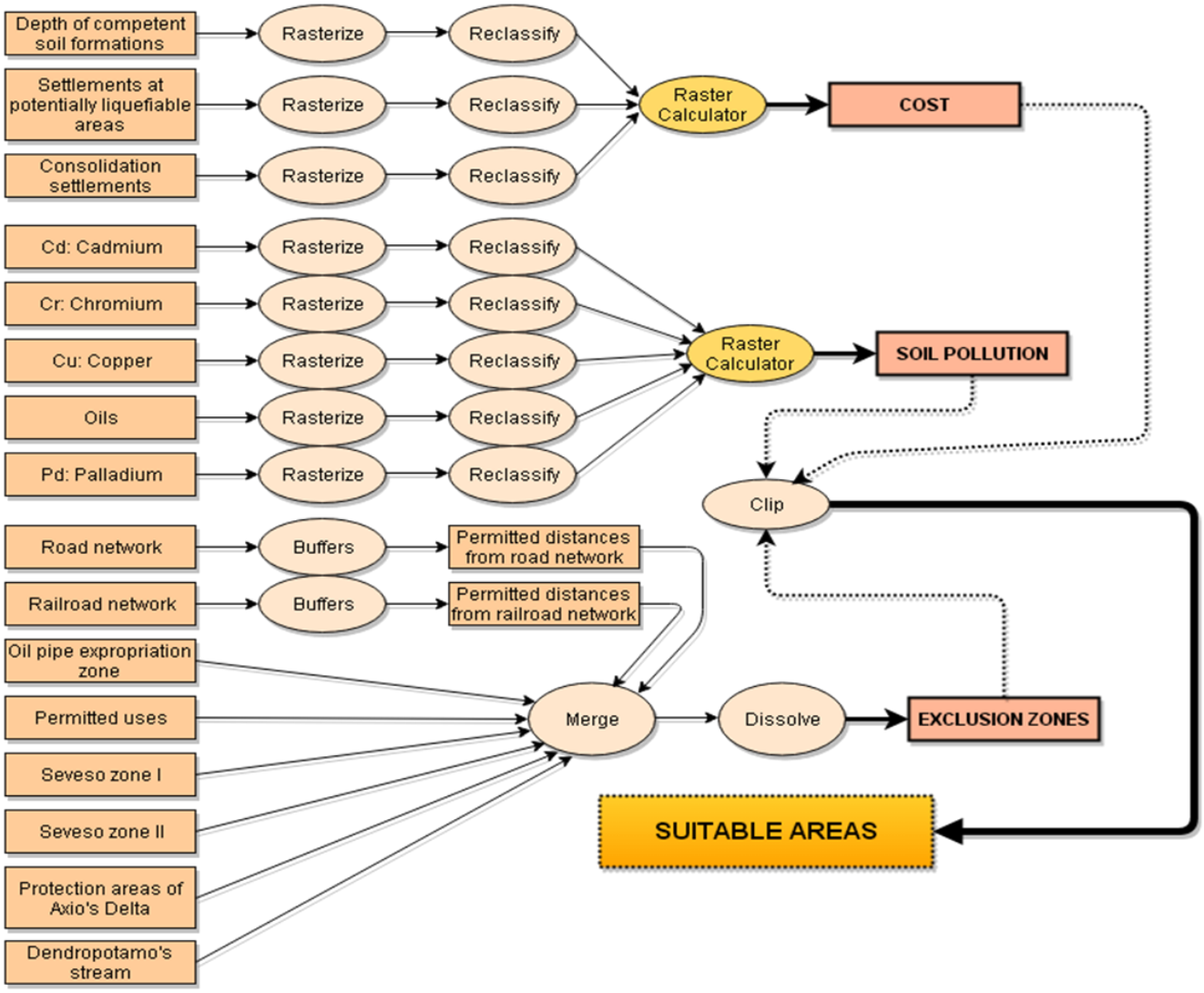


Fig. 14. Flowchart of the multi-criteria model (Source: TERRA-MED, 2016a)

4. Results

The land use suitability maps were produced for each one of the seven land use 'hypotheses', combining the appropriate sub-criteria from the three main criteria. For example, for "industrial areas of low disturbance (>100 users & ≥ 3 floors)" criteria 'cost' and 'exclusion zones' were used, for "outdoor public areas (mild leisure, max 100

users)" criteria 'soil pollution' and 'exclusion zones' were used, and so on and so forth. Indicatively, Figures 15 and 16 show the suitability maps produced for these two 'hypotheses'.

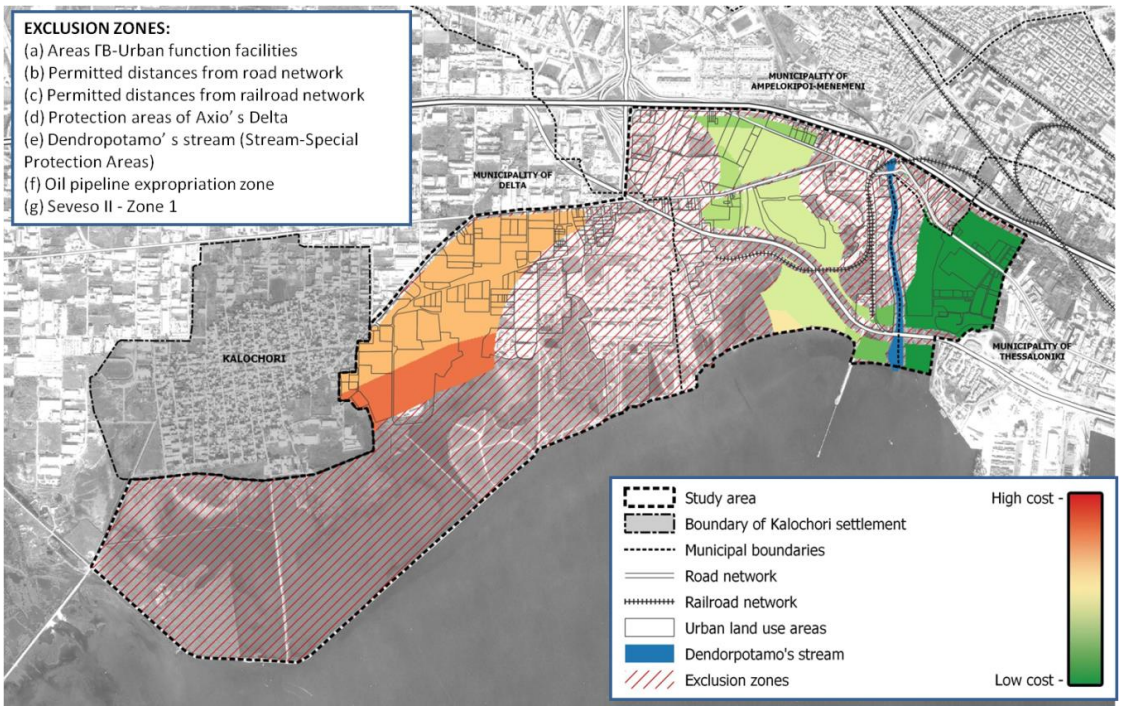


Fig. 15. Land suitability assessment for "industrial areas of low disturbance (>100 users & ≥ 3 floors)" (Source: TERRA-MED, 2016a)

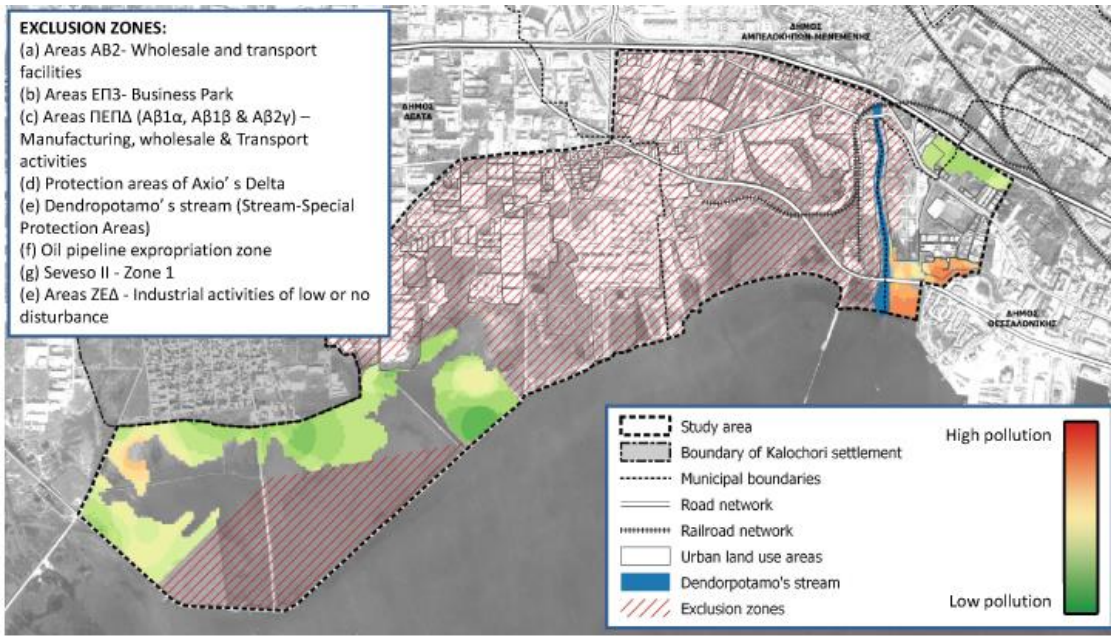
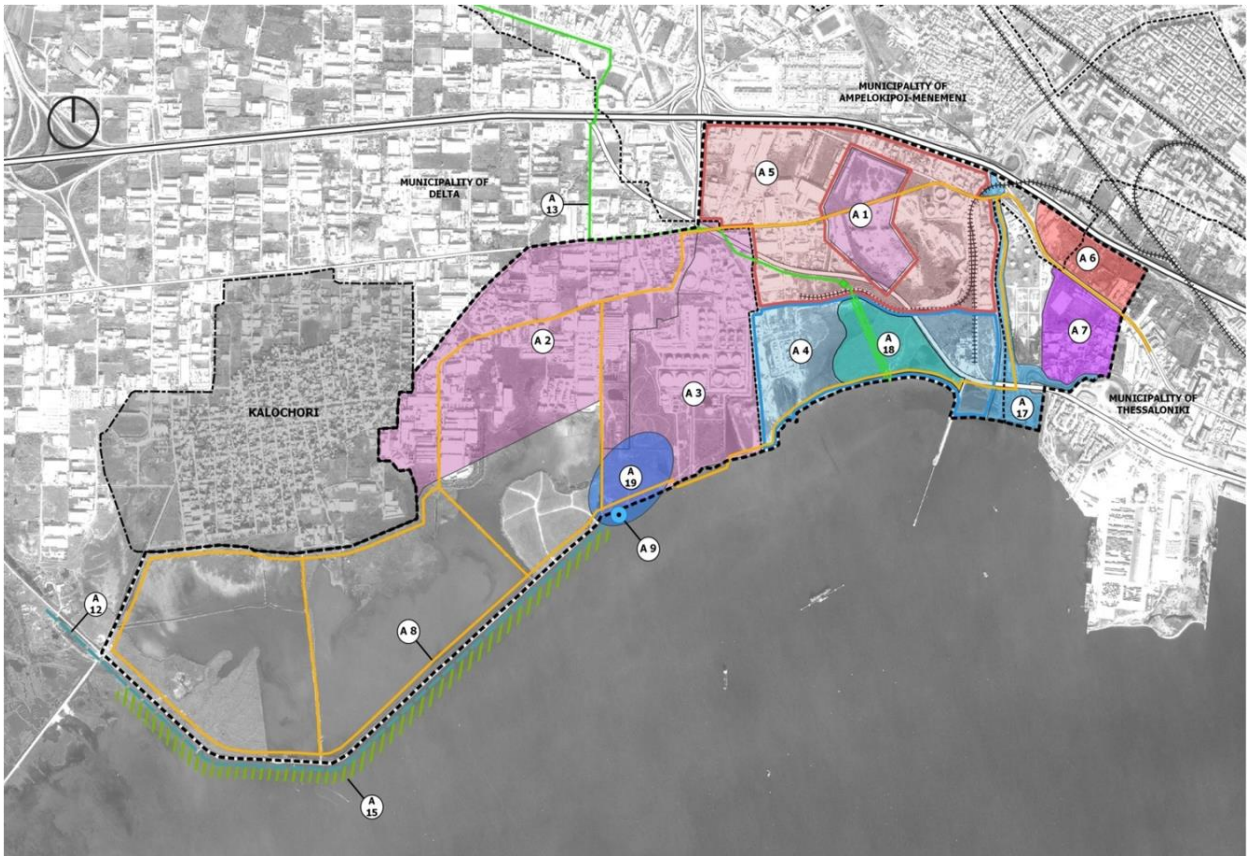


Fig. 16. Land suitability assessment for ""outdoor public areas (mild leisure, max 100 users)" (Source: TERRA-MED, 2016a)

The results of the land-use suitability analysis were incorporated into the final decision-making, which led to the definition of strategies and specific actions for the TERRA-MED project. The final master plan within the framework of the TERRA-MED project is shown in Fig. 17.



Action (A)	
A.1	Development of Business Park in the Municipality of Ampelokipi - Menemeni
A.2	Urban planning for the Business Zone in the Municipality of Delta
A.3	Designation of parts of the Municipality of Delta as an Area for Organized Development of Production Activities.
A.4	Special regional planning study for the ' Waterfront ' area of Ampelokipi –Menemeni.
A.5	Study for the urban regeneration for the unplanned part of the area where production and entrepreneurial activities are located.
A.6	Study for the integrated planning of the area known as "Vegetable Gardens" between 2 municipalities as an urban and central functions' pole.
A.7	Feasibility study for the development of the old tanneries as freight or commercial center.
A.8	Design and construction of walking and cycling route from the port of Thessaloniki to the Lagoon of Kalochori combined with recreation activities.
A.9	Updating of the existing study and construction of fishing port in the Municipality of Delta.
A.10	Completion of the sewage and drainage network: studies and implementation.
A.11	Study / research on assigning allowed uses in areas whith installations of SEVESO III.
A.12	Design and construction of strengthening the coastal embankment.
A.13	Construction of Flood control infrastructure.
A.14	Application of a phytoremediation system into the soil ecosystems of the region as a measure against pollution of areas that will function as recreational sites.
A.15	Integrated management system for the macroalgae.
A.16	Hydrological study for the wetlands' drainage network.
A.17	Plan for the recovery of the wetland functions of Dendropotamos stream.
A.18	Creation of a recreational marina (studies and implementation).
A.19	Recovery of wetlands - soil stabilization.
A.20	Recording of public and municipal property in order to explore the possibilities of exploitation.

Fig. 17. Master plan for the western part of the coastal zone of Thessaloniki – Actions (Source: TERRA-MED, 2016a)

5. Conclusions

The approach used for developing the master plan for the western part of the coastal zone of Thessaloniki constitutes an effort to support sustainable urban development policies and actions, by considering a variety of factors that construct the area's complexity; in this specific case, environmental, soil mechanical and socioeconomic. This effort entails the objective of transforming the area into a 'model' area where important economic activity on the one hand and a valuable natural environment co-exist in line with the sustainability principles (economic, social and environmental).

AHP was used as one of the MCDM methods which can facilitate land use planning and development, by approaching the given area as an integration of interrelations, functions and constraints. The procedure followed helped the planners and the decision-makers interpret and evaluate the territorial problems and structure choices. It contributed to the definition of potential uses that different sub-areas can support. In this respect, the different analyses and scenarios were taken into consideration when, at a later stage of the planning process, alternative strategies, priorities and specific actions were formulated. It supported and specified already existing local policies in the area. As a result, it constituted a useful tool for discussion between planners, engineers, local politicians and municipal executives, and at the end of the day it supported the master plans' public acceptance.

Given their 'rational' nature, it is argued that the incorporation of such techniques into the planning process can lead to consistent planning decisions, improved transparency, consensus building, increased trust in planning and institutions, which in the case of the Greek planning practice are extremely important aspects, given the long-standing characteristics of the planning tradition and cultures.

Finally, it is highly important to mention that the Region of Central Macedonia has already endorsed in its Regional Operational Programme for the Programming Period 2014-2020 some of the actions which are included in the TERRA-MED's Master Plan and until the end of the Programming Period these actions will be implemented either by the Region or by the Municipalities.

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References

Aguilar, N., Galindo, G., Contreras, C., Fortanelli, J., (2012) 'A methodological approach to sugar mill diversification and conversion', Ingeniería e Investigación, 32(2), http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0120-56092012000200005#fig4

Kaiser, E.J., Godschalk, D.R., Chapin, F.S., (1995) *Urban Land Use Planning*. 4th edition. Urbana and Chicago: University of Illinois Press.

MacDaniel, R.W.B., (1998) 'Land Use Suitability Analysis: An Assessment for the Rhode Island Central Landfill', Open Access Master's Theses/ University of Rhode Island, Paper 515, http://digitalcommons.uri.edu/theses/515.

Mosadeghi, R. (2013) 'A Spatial Multi-Criteria Decision Making Model for Coastal Land Use Planning', PhD Thesis. Brisbane: Griffith University.

National Technical University of Athens / School of Chemical Engineering, (2008) 'Industrial hazards and spatial planning interventions', Research Programme (Organization for the master plan of Thessaloniki – ORTHE), 1st Deliverable.

Saaty, T.L. (1980). *The analytic hierarchy process*. New York: McGraw-Hill.

Saaty ,T. L., (2008) *Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World*. Pittsburgh, Pennsylvania: RWS Publications.

TERRA-MED, (2016a) 'Developing of Master Plan', Action 4.4 of the IPA Cross-Border Programme 'Greece – the former Yugoslav Republic of Macedonia 2007-2013' "Soil degradation assessment and rehabilitation strategies for sustainable land use planning".

TERRA-MED, (2016b) Recording of environmental pressure and soil degradation Action 4.1 of the IPA Cross-Border Programme 'Greece – the former Yugoslav Republic of Macedonia 2007-2013' "Soil degradation assessment and rehabilitation strategies for sustainable land use planning".

TERRA-MED, (2016c) 'Recording of soil mechanics and geotechnical mapping', Action 4.2 of the IPA Cross-Border Programme 'Greece – the former Yugoslav Republic of Macedonia 2007-2013' "Soil degradation assessment and rehabilitation strategies for sustainable land use planning".