SPATIAL CONFLICT MANAGEMENT IN URBAN PLANNING

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Abstract

Results are reported of an effort to develop a spatial decision-making methodology to support collective decisions on integrated urban planning. The focus is on managing the spatial conflicts -interest, use and value related- which are unavoidably created by land use change planning options so that cooperative final decisions can be reached supportive of sustainable development. The area of application is the urban coastal region of Perama in Athens, Greece.

The proposed methodology, referred to as Spatial-AGORA integrates elements of the participatory conflict management algorithm AGORA (Assessment of Group Options with Reasonable Accord), GIS (Geographic Information Systems) and CA (Cellular Automata). The former utilizes Multi-Criteria Evaluation Methods, Core theory and Game theory. The GIS is used to gather, analyze and manage all necessary data from the study area as a whole as well as from predetermined sub-areas serving as decision units. Cellular Automata serve as the logic of the applied land use change (LUC) simulation model. Stakeholders from the decision units are the main participants in the application of the LUC model.

Conflict and cooperation dynamics regarding the study area revealed by the application of the proposed socio-spatial methodology are also reported.

Keywords: urban land-use change modeling, Spatial-AGORA, participatory game theory, justice

1. Introduction

This study presents an effort to develop a spatial, process-oriented decision-making methodology to support collective decisions regarding integrated urban planning. A land-use change simulation model has been developed within a participatory spatial conflict management context that enables an investigation of potential socio-spatial effects of the assumed decision behaviour. The conflicts at hand refer to different preferences -interest and/or value related- which are unavoidably created by land use planning alternatives, while their management entails the exploration of potential cooperative final land use decisions, supportive of sustainable, participatory urban planning. The case study is the urban coastal zone of Perama (Athens, Greece) located in the southwest border of Attica basin.

The coastal zone of Perama constitutes an industrial landscape, comprising shipbuilding facilities (NEZ land uses), land owned and used by the commercial port of Piraeus (OLP land uses), petrol and gas storage-transportation facilities integrated into the residential network (OILS land uses), non-open access areas of the Navy territory (Army land uses) and Psitalia's biological sewage plant, located on a small island only 0.5 miles off the Perama coast. Public, open-access spaces occupy a very small percentage of the coastal territory. The port of Perama serving the ferryboat line Perama – Salamina Island, is located at the west end of the case study area (Ferry land uses). Perama, geographically isolated from the capital of Athens, demonstrates a highly degraded coastal landscape because of a multitude of reasons such as: pollution and contamination of marine and atmospheric environment, induced mainly by shipbuilding/petrol facilities and Psitalia's sewage plant; high unemployment; ineffective implementation of the existing coastal zone management policies, as well as insufficiency of current legislation framework regarding urban land use planning and, inequalities deriving from the absence or the limited participation of the local community in decision-making processes.

2. Methodology Development & Application

The proposed methodology, referred to as Spatial-AGORA integrates elements of GIS, the participatory conflict management algorithm AGORA (Assessment of Group Options with Reasonable Accord) and CA (Cellular Automata). Future land use changes are simulated under the form of scenarios through the implementation of transition potential rules that direct the temporal evolution of the selected spatial evaluation units (i.e. sub-areas being examined for land use changes). Using these scenarios techniques of conflict assessment and management are applied, while final product of the land use change (LUC) model is the spatial representation of all possible compromise alternatives (*core alternatives*) indicating a maximum cooperation potential among stakeholders. Based on the detailed flow diagram of Spatial-AGORA that is presented in Figure 1, its inputs, implementation steps and major outputs are analyzed. It is stressed that up to now, the implementation of AGORA methodology concerns only non-spatial examples, mainly focused on integrated coastal zone management (e.g. Davos et al. 2007, Davos et al. 1997).

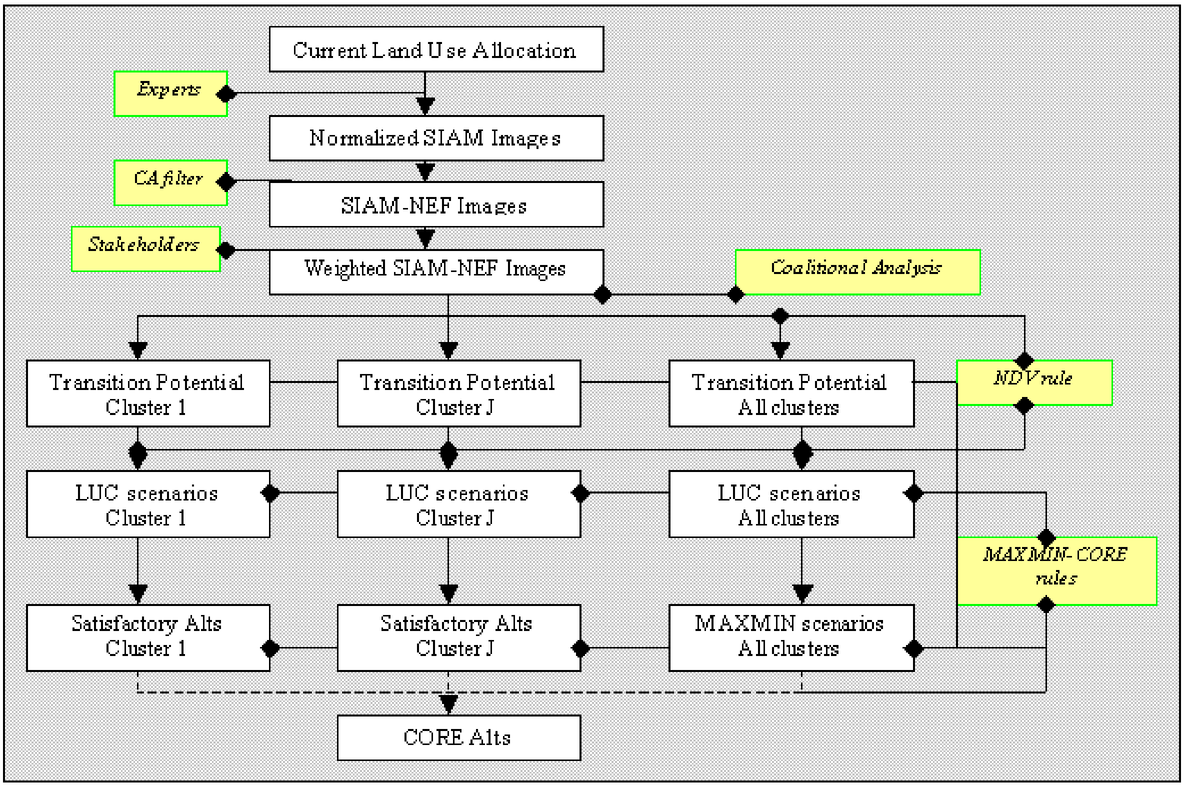
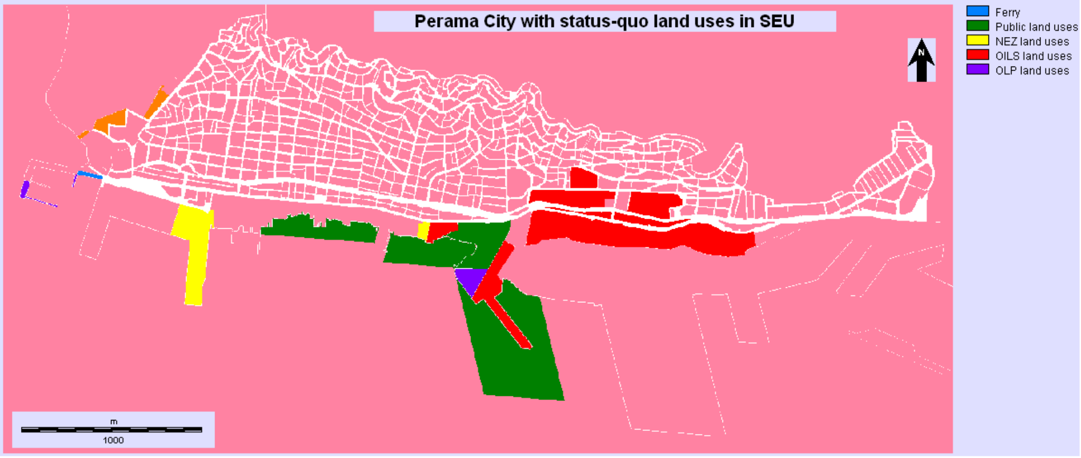


Figure 1: Flow diagram of the Spatial-AGORA methodology.

2.1. Spatial-AGORA Inputs

A map in AutoCAD format (scale 1:5000) was provided by the Municipality of Perama representing current land use allocation patterns, as well as the next decade landfill plans of the marine coastal zone, as they are proposed by the OLP commercial port sector. After the finalization of all necessary data manipulations, a first map was produced in IDRISI Kilimanjaro software as the basic data input of the model representing the 17 spatial evaluation units (SEU's) selected. The wider area Perama is represented by means of a lattice of 1214 (rows) by 2575 (columns) cells, each covering an area of 2 by 2m. The case study covers a total area of 2.428.000 sq. meters. The status quo land uses in all spatial evaluation units are represented in Map 1.



Map 1: Perama city with the status-quo land uses in the 17 spatial evaluation units.

The decision alternatives are expressed as alternative future land use plans per SEU. Spatially, the alternatives are defined as the feasible alternative states in which a cell can be converted, in a forecast time horizon of 10 years. Four general categories of alternatives have been identified as land use changes in favor of: (a) shipbuilding activities (NEZ land uses); (b) Piraeus commercial port facilities (OLP land uses); (c) public land use spaces and as (d) status quo preservation.

The evaluation criteria express the factors affecting land use transition dynamics in the case study area. Specifically, five general criteria are specified: (a) *Environmental Protection*: the degree to which the land use contributes to the preservation, protection or/and improvement of the physical environment; (b) *Economic Development*: the degree to which the land use contributes to the economic growth of Perama; (c) *Social Development and Quality of Life*: the degree to which the land use contributes to the social renewal of Perama, protects the public health and improves the quality of human environment; (d) *Implementability*: the degree to which a decision over land use change or its preservation can be implemented as it has been planned and, (e) *Equity*: the degree to which all the positive or negative impacts connected to land use, are equally distributed among all stakeholders.

Spatial Impact Assessment Matrix (SIAM) is a fundamental input of Spatial-AGORA methodology indicating the performance of each alternative per evaluation criterion. The construction of SIAM was possible through the use of specially designed questionnaires distributed to 2 experts, who were asked to evaluate alternative future directions of coastal land use change per spatial evaluation unit using a scale ranging from 0 (no performance) to 255 (very high performance).

Concerning the set of participating stakeholders, an effort has been made to develop the most comprehensive stakeholder registry possible. It is noted that the 51 selected stakeholders were asked to participate as representatives of only one specific interest group. Specifically designed questionnaires were used in order to extract criteria weights according to the direct ratio approach (Davos 1987). It was observed that the “Environmental Protection” criterion holds the highest priority (0,32) according to all participants. The “Social Development and Quality of Life” (0,24) and “Economic Development” (0,22) criteria are also ranked highly, while the lowest-ranked criteria are: “Implementability” (0,13) and “Equity” (0,09).

Taking as inputs the individual normalized priority values, the identification of three clusters (*potential coalitions*) expressing statistically similar priorities for evaluation criteria (*coalitional priorities*) was possible through k-means Cluster Analysis in SPSS software. The classification of stakeholders into groups of statistically similar priorities that can be viewed as potential coalitions is followed by the logical assumption that these coalitions could cooperate to support the alternatives that best satisfy their values.

The coalitional analysis yielded three major potential clusters. As it can be concluded from the descriptive ANOVA sub-table attached on Table 1, the clusters are distinguished by the priorities they assign to all the evaluation criteria. The affiliation of the members of these coalitions with the defined general interest categories is presented in Table 2. The 1st cluster could be characterized as a *coalition with environmental concerns* as it gives its highest priority to the “Environmental Protection” criterion (0,714). Accordingly, the 2nd cluster could be characterized as a *coalition of multi-criteria interest* as it expresses high priorities for all the evaluation criteria. Finally, the 3rd cluster could be a *coalition of economic interest* assigning its highest priority to “Economic Development” (0,499).

Table 1: Potential coalitions, their priorities for the evaluation criteria and ANOVA table

EVALUATION CRITERIA	**Cluster 1**	**Cluster 2**	**cluster 3**	F	Sig.
Environmental Protection	**0,714**	0,218	0,206	79,605	0,000
Economic Development	0,078	0,174	**0,499**	44,954	0,000
Social Development and Quality of Life	0,138	**0,268**	0,168	39,456	0,000
Implementability	0,031	0,216	0,062	7,518	0,000
Equity	0,039	0,125	0,066	7,774	0,000

Table 2: Interest affiliation of potential coalition members with similar priorities for the evaluation criteria

STAKEHOLDER CATEGORIES	**Cluster1**	**Cluster2**	**Cluster3**	**Total**
Public Authorities	2	8	2	**12**
Economic Sector	4	7	6	**17**
Environmental Sector	1	1	1	**3**
Social Sector	5	7	2	**14**
Education Sector	1	1	1	**3**
Total	**13**	**24**	**12**	**49**

2.2. Spatial-AGORA implementation steps & major outputs

Taking as inputs the SIAM provided by the experts, SIAM-maps were constructed choosing a normalization scale ranging from 0 to 255, because of the maximum possible visual output obtained in IDRISI Kilimanjaro. The incorporation of the neighborhood effect in SIAM maps (SIAM-NEF maps) was possible by applying a 5x5 user-defined *contiguity filter* to SIAM maps. The form and the neighborhood extent of this particular filter enabled the investigation of conflict occurrence at land use boundaries, thus allowing for the exploration of the ways these boundaries are influenced by neighbouring interests pressures.

NDV decision rule belongs to concordance evaluation methods and it was used as the basis for the cellular automata transition rule definition, leading to future LUC scenarios. Two preference indexes for each alternative were produced: one for each cluster and one for a theoretical grand coalition, comprising all stakeholders. All NDV algorithms were computed by the help of spatial data handling capabilities of map algebra (Hatzopoulos 2006, Hatzopoulos 2008), via usage of several IDRISI Kilimanjaro modules (for a detailed description of all computation processes see Santorineou, 2007). One technical advantage of this approach concerns its suitability in environmental evaluation problems where there is no value matrix available. The construction of the spatial NDV transition rule includes three successive implementation steps that are technically specialized as follows.

Firstly, the *comparative advantage of each alternative per evaluation criterion* (k_{mn}) was computed. For the k_{mn} calculations and the acquisition of the corresponding maps (k_{mn} Maps), SIAM-NEF raster images were used as inputs by applying the algorithm [1]:

$$k_{mn} = (w_{mn} - l_{mn}) \qquad [1]$$

w_{mn}: the number of alternatives that satisfy less *n* criterion, in comparison to *m* alternative
l_{mn}: the number of alternatives that satisfy more *n* criterion, in comparison to *m* alternative.

Secondly, the priorities given to evaluation criteria by potential coalitions were adapted in order to reflect the comparative advantage of the alternatives. This process of "performance variability enhancement" (Davos et al. 1993) is mathematically expressed by the algorithm [2] applied in IDRISI Kilimanjaro with the help of 4 sub-models in Macro-Modeler module.

$$w_{*jn} = w_{jn} * [max\ (q_{mn})* - min\ (q_{mn})*] \qquad [2]$$

w^{*}_{jn}: performance variability enhancement of the criterion priorities per cluster
w_{jn}: mean coalitional priority weight for each evaluation criterion
$max\ (q_{mn})*$: maximum performance value of each alternative (m_i) per evaluation criterion (n_i) in SIAM-NEF
$min\ (q_{mn})*$: minimum performance value of each alternative (m_i) per evaluation criterion (n_i) in SIAM-NEF

Thirdly, the production of raster images indicating *NDV of each alternative per cluster* (r_{jm}) was possible via the GIS computation of the algorithm [3]. Repeating the same computations by using the normalized mean priorities of clusters, raster images indicating *NDV of each alternative according to the grand coalition* (R_{jm}) were produced. All raster images were transformed into LUC scenarios (Maps 2-9), taking into account the first, as well as the second-ranked land use preferences of clusters per SEU. This kind of *scenario sensitivity analysis* takes place following the theoretical background of a Process-Orientated environmental evaluation. A Spatial Kappa Index of Agreement (SKIA) is shown for each pair of clusters, as a measure of preferences convergence regarding their land use change scenarios (the first two columns in Table 3).

$$r_{jm} = \sum k_{mn} \times w^{*} jn \quad [3]$$

The *NDV for grand coalition* (R_{jm}) is a collective ranking algorithm, functioning more as a technical rather than as a decision behaviour-related conflict management rule and uses a normalized average value as input, in order for a collective decision outcome to be derived. In practice, this makes the investigation of the decision behaviour rather difficult, as there is no possibility to explore issues such as individual/collective rationality in the framework of the analysis. In this sense, this first kind of conflict management rule supposes *neutral decision behaviour*: all participants will accept the compromise of their preferences by finding a common-accepted average outcome.

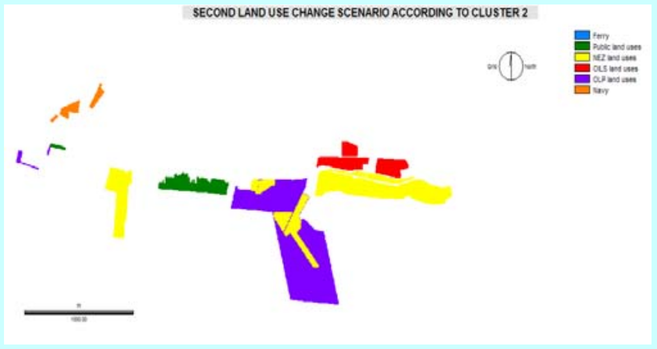
Table 3: SKIA between clusters per LUC scenario

SKIA	1st NDV	2nd NDV	1st MAXMIN	2nd MAXMIN
cl1-cl2	0,9431	0,2726		
cl1-cl3	0,9825	0,3787		
cl2-cl3	0,9605	0,8857		
cl1-all	0,9846	0,4536	0,9825	0,3787
cl2-all	0,9585	0,7791	0,9605	0,8857
cl3-all	0,998	0,8819	1	1

Map 2: First-ranked LUC scenario of 1st cluster

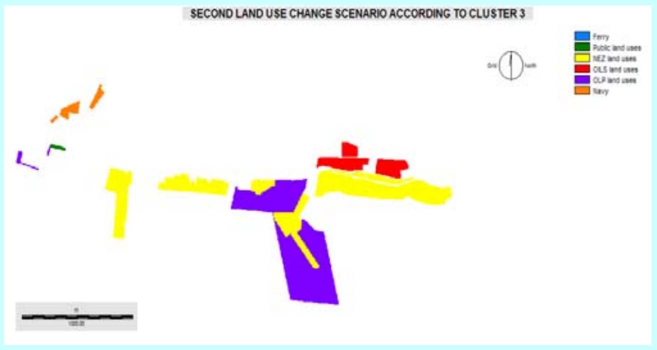
Map 3: Second-ranked LUC scenario of 1st cluster

Map 4: First-ranked LUC scenario of 2nd cluster



Map 5: Second-ranked LUC scenario of 2nd cluster

Map 6: First-ranked LUC scenario of 3rd cluster



Map 7: Second-ranked LUC scenario of 3rd cluster

Map 8: First-ranked LUC scenario of grand coalition

Map 9: Second-ranked LUC scenario of grand coalition

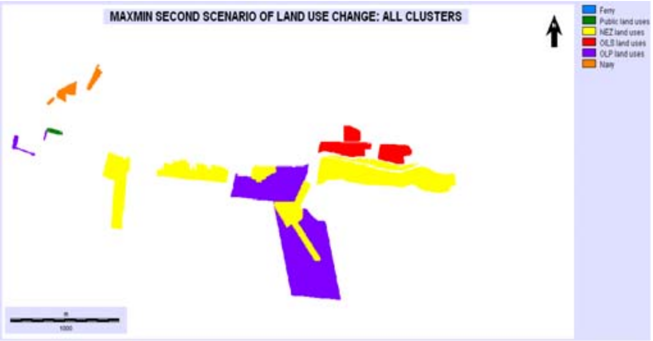
The last implementation step of spatial-AGORA involves the spatial application of cooperative games involving multiple stakeholders bargaining over which alternative to recommend per spatial evaluation unit out of a finite set of alternatives. The participatory conflict management rules applied use elements from Core Theory (Tesler 1994) and the MAXMIN theory of justice (Rawls 1971).

According to Core Theory, the stakeholders will be willing to cooperate in the implementation of a specific solution if and only if by doing so they can achieve an outcome at least as good as by acting alone. This outcome has an individual reservation value, thus introducing an element of *individual rational decision behaviour* into the evaluation process. In this regard, a distinction can be made regarding the decisions that can be achieved via a collective effort: (i) dominated (not satisfactory) decisions: possible alternatives not accepted by some coalitions as these clusters can achieve better outcomes when acting alone and, (ii) non-dominated (satisfactory) decisions: the rest of the alternatives comprising the core.

For the determination of the core, each coalition is assumed to set the following question: "*How can I know which alternative will select the other players, in order to decide if I will cooperate with them or not*?" It is proposed that an answer is possible if we assume the existence of a criterion that the others will try to best satisfy in order to make their collective decision. The criterion examined here is a justice-related one, as it was proposed by Rawls' MAXMIN theory of justice. In this situation, a *collective reasonable decision behaviour* is assumed, implying that all participants are ready to propose or to accept the necessary principles in order for the collaboration terms to be defined. The reasonable individuals are expected to honor these principles, even against their individual interests, under the prerequisite that also the others going to honor these principles accordingly. In this respect, all participants are assumed to select that alternative that best satisfies the less advantaged players.

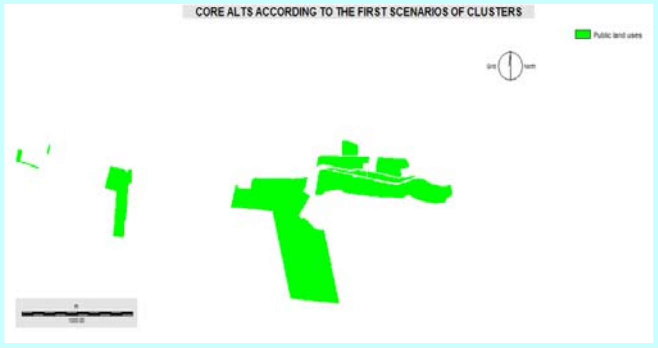
The spatial MAXMIN algorithms are applied using the NDV matrix as input (Santorineou 2007). For the identification of MAXMIN Net Dominance Values and their corresponding scenarios, a 2-step process is followed. First, for each combination of j-1 potential coalitions, a map is produced indicating minimum NDV per alternative, on a spatial evaluation unit basis. Next, by overlying these maps a raster image output representing MAXMIN NDV for each j -1 clusters is produced. The transformation of MAXMIN NDV maps into MAXMIN land use change scenarios yielded a first-ranked, as well as a second-ranked MAXMIN LUC scenario for each j-1 clusters. By repeating the previous steps without excluding any cluster from the analysis, a 1st-ranked as well a 2nd-ranked MAXMIN LUC scenario for the grand coalition is produced (Maps 10-11). Table 3 was updated by adding to it the new SKIA information obtained via the enrichment of the NDV decision rule with a justice-based criterion.

Map10: First-ranked MAXMIN LUC scenario of grand coalition

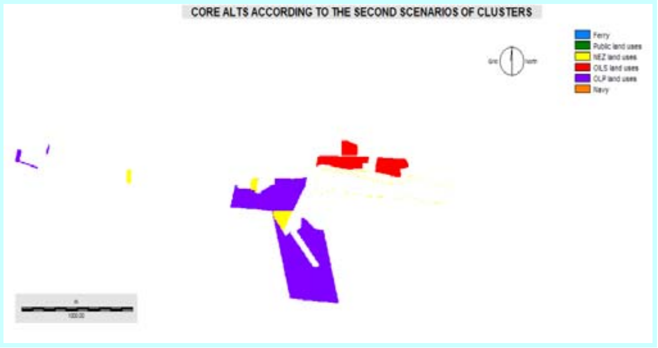


Map 11: Second-ranked MAXMIN LUC scenario of grand coalition

For the determination of core alternatives, the following process is spatially implemented, via a MAXMIN-CORE rule combination. First, MAXMIN criterion is applied in order raster images representing MAXMIN scenarios for j-1 clusters, as well for all players to be produced. Next, satisfactory alternatives for cluster 1 are identified per spatial evaluation unit via the comparison of its NDV values with the MAXMIN NDV of the rest coalitions. For a given spatial evaluation unit, if the NDV of alternative *m* (according to the 1st cluster) equals to or exceeds the MAXMIN NDV of the same alternative for the rest of the coalitions, then the *m* alternative is considered as satisfactory for the 1st cluster. The above process is repeated by using different cluster as the reference point of the analysis. Finally, all MAXMIN NDV scenarios are spatially constrained to regions that represent only the spatial evaluation units with satisfactory alternatives according to each cluster and all coalitions. Final outputs are two raster images indicating potential core alternatives of the 1st and of the 2nd ranked LUC scenarios (Maps 12-13).



Map 12: Core alternatives of the 1st ranked scenarios



Map 13: Core alternatives of 2nd ranked scenarios

3. Discussion of conflict-cooperation dynamics and major conclusions

According to the first-ranked land use change scenarios, all coalitions would assign almost the total of the case study area to public land uses. The current limited percentage of public land use spaces in combination with high priorities expressed for the “Environmental Protection” evaluation criterion, are the major factors leading into the formation of a commonly accepted scenario that proposes the conversion of almost the total study area into green and open-access spaces. If our analysis had stopped at this point, the basic conclusion would have been the inexistence of land use preference conflicts among stakeholders. Instead, we have developed a more sensitive conflict assessment and management approach where this commonly accepted “*green scenario*” is characterized as difficult to be implemented. It could be argued that, although the interested participants opt for high percentages of public land uses, certain interests of profession groups could not easily allow for the conversion of existing commercial land uses into public ones. In this sense, a scenario sensitivity analysis has been conducted allowing for a spatial investigation of the second-ranked land use preferences of clusters in any case the “green scenario” may not be realized.

Exploring the second-ranked LUC scenarios a multitude of hidden conflicts (interest and/or value related) are unfolding that were not observed in the first-ranked scenarios of clusters. Although in the 1st-ranked scenarios the conflicts between clusters concerned their land use preferences in four out of seventeen spatial evaluation units, in the 2nd-ranked scenarios the conflict sources are apparent in eight spatial evaluation units. The existence possibility of core alternatives is also depended on whether the analysis is focused on 1st or on 2nd-ranked LUC scenarios. In the first case, a total of thirteen core alternatives are observed, while in the second case the core alternatives are reduced to nine. The augmentation of preference conflicts over land uses is also confirmed via the examination of the first two columns in Table 3, where a remarkable decrease in agreement indexes is evident between all possible pairs of clusters.

The spatial-AGORA methodology offers an opportunity to explore the socio-spatial impacts of the conflict management rules applied. Their spatial impacts over the kind of grand coalition’ proposed land uses per SEU were compared and the following most important conclusions are indicated. It is noted that the focus is on the second-ranked LUC scenarios. Concerning 2 out of 9 SEU’s (referred as OILS4, OILS5) where land use preference conflicts are observed among individual clusters, the average value outcomes are different from the justice-related ones. Specifically, the “OLP” alternative is preferred taking into account the average coalitional priorities, whereas the “NEZ” alternative is chosen if MAXMIN conflict management rule is applied.

Almost in all cases where one or more clusters disagree over the kind of future land uses, the inexistence of a core alternative per SEU is evident, implying the persistence of individual rational decision behaviour. Nevertheless, this is not the case when OILS1 & OILS2 areas are examined. Here, the implementation of the integrated MAXMIN-CORE conflict management rule leads into a compromise decision outcome (i.e. NEZ alternative) regarding the kind of land-uses at the outer boundaries of these sub-regions. The social impact of this spatial information, observed because of the CA integration into our analysis, is the existence possibility of one core alternative in spite of the differences among the individual scenarios. This core alternative could promote a higher level of cooperation among stakeholders, since the individual rational behaviour does not exclude a collective reasonable one that directs stakeholders to propose justice-based decision outcomes.

The social impacts of the conflict management rules were further investigated focusing on their relative potential ability to induce the cooperation potential among stakeholders. Taking inference by the SKIA information presented in Table 3, it was observed that although by the implementation of NDV rule the SKIA value between 2nd -ranked LUC scenarios of 2nd cluster and the grand coalition was 0.78, this value was increased to 0,89 when MAXMIN rule was applied. Likewise, the SKIA value between second-ranked scenarios of 3rd cluster and the grand coalition is 0,88 when NDV rule is applied, while this value is increased to 1 (i.e. absolute agreement) via the MAXMIN rule application. Therefore, it can be concluded that the 2nd as well as the 3rd cluster are more willing to unify their forces in a grand coalition that supports land use alternatives best satisfying a justice-based outcome, rather than an average satisfaction outcome for all participants. It seems that a participatory conflict management approach based on the implementation of a justice-related criterion, could enhance the cooperation potential between these two clusters and accordingly the effective implementation of the final planning decision outcomes.

In contrast to the above observations, the examination of conflict-cooperation dynamics showed that the 1st cluster is the only one for which the willingness of cooperation with the grand coalition is decreased when MAXMIN conflict management rule is applied. This cluster is highly differentiated from the rest of the clusters and, as it can be confirmed by the results, it is responsible for the inexistence of a core solution in 5 out of 7 spatial evaluation units. It can be argued that the land use conflicts between 1st cluster' and rest coalitions' scenarios are value-related since the 1st cluster has an almost exclusive interest in environmental issues, being the only one assigning such a high priority value (0,714) to only one evaluation criterion.

The willingness of cooperation between the first cluster and the rest of coalitions could be induced if conflict management agenda focuses on their potential points of agreement in order for the "optimism about the level of optimism" to be enhanced (i.e. the stakeholder optimism about the level of cooperativeness of all other stakeholders to be increased). Apart from their absolute consensus points, the examination of LUC scenarios leads to the identification of potential bargaining strategies, one of which is discussed as a demonstration example. It is stressed that the focus is put again on the second-ranked LUC scenarios. If the agenda focuses on land use decision-making over OLP2 and OLP6 spatial evaluation units, then clusters 1 and 3 could join their forces and cooperate in order to better support their common land use preferences (i.e. NEZ). This kind of cooperation could facilitate the development of collaboration principles between these two clusters. Moreover, there are several reasons that could lead cluster 2 to accept a NEZ solution. Firstly, it is the most preferred solution for these spatial evaluation units according to its first-ranked LUC scenario. Secondly, it is the alternative that best satisfy the justice criterion according to all stakeholders. Thirdly, it is the most preferred option for cluster 3, with which cluster 2 has an increased cooperation potential.

It is argued that the tight-coupling integration of land-use change models with participatory conflict management techniques can be very helpful in bringing the domains of land-use planning and modeling closer together. The ability of integrated land-use models to simulate several effects of predicted decision behaviour could encourage the exploration of potentially different socio-spatial impacts accompanying alternative rationality hypotheses, attached on urban planning theories. Finally, the usefulness of this kind of integrated land-use models could be further explored in a future research study, by evaluating the role they can play in scenario-writing, visioning and good story-telling that Helen Couclelis (2005) proposes, in order for the future-oriented, strategic function of spatial planning to be enhanced.

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