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Supporting Locational Decision Making:

Regionalization of Service Delivery Systems

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In this paper we describe a case study of our attempt to provide decision support to a public agency, the Greek Ministry of Education, that is currently reorganizing the geographical configuration of its system. We treat the problem of determining the optimal number of catchment areas, the school locations and the allocations of school children, as an interactive location-allocation problem. In our approach and during the problem-solving procedure, we deal with a set of predefined future scenarios, emphasizing on the uncertainty principles emerging from the notion of a population being subject to elements of change. The scenarios are generated from an initial dataset, through the implementation of certain demographic assumptions, concerning fertility, mortality and migration rates. By linking demographic and locational models, and using the graphic capabilities of mapping software, we provide the basis for an integrated locational planning support system and thus a more pragmatic planning process. Furthermore, we assist the decision making process through the utilization of two solution - performance criteria. Namely, the expected loss and the minimax loss criterion of the optimal solution of each future scenario configuration which is generated during the problem - solving procedure.

Keywords: *Locational planing, Planning Support Systems, Educational Planning.*

1. INTRODUCTION

One of the most important issues in locational planning is to resolve spatial problems, taking into account a set of possible alternatives and their attributes. For the majority of locational planning decisions, and schools in particular, demographic reality and thus population projections are considered very crucial. On the basis that public policy planning requires accommodation to future population changes, geographers and regional planners are frequently faced with the problem of decision making under the condition of uncertainty. Moreover, the possible future increase or decrease of school children populations for the different educational levels, being the most important factor in educational planning, clearly affects the formulation and the coordination of the national policy of education. This ambiguity requires the search for such locational schemes whose efficiency and effectiveness should be viable for longer time periods. Furthermore, it requires the generation and formulation of different future scenarios and thus the evaluation of alternative solution strategies through the integration of locational and demographic models in a prototype locational planning support system.

This paper aims to show, that through a scenario-based decision making approach to locational planning, improved problem analysis and hence more robust and sophisticated problem solving procedures can be obtained, since the uncertainty and thus the limited information inherent in a non-static problem environment can cause unpredictable mistakes along any choice procedure of sufficient complexity (de Palma and Papageorgiou 1991). Consequently, given that in locational planning the locational choices made are generally judged by the 'quality' of the decision-making process which generated those choices (Densham and Rushton 1987), improved problem analysis will lead to better locational choices and thus better locational patterns.

More specifically, we suggest the following planning process: During the problem solving procedure the decision maker defines a set of future scenarios through the implementation of certain demographic hypotheses. Beginning with some initial data he derives the possible scenarios for the future, trying to visualize all feasible states of the system in order to improve the quality of his choice. He then examines the performance of every scenario's optimal solution on the basis that if one is adopted, another might be achieved. Finally, he proceeds with his choice with the help of two solution-performance criteria. The expected loss and the minimax loss criterion.

Our paper consists of the following sections. Section two describes the concepts of locational and educational planning. Section three introduces the idea of a system being in a state of change and analyses the scenario-based decision making approach. Section four deals with an illustrative example, consistent with our framework, based on a case study, the location of new high schools in Thasos Island, Greece. It is focused on how the generation of alternative future scenarios affects the definition of viable strategies for action by the decision makers. We end this paper with a few brief comments related to some methodological aspects.

2. EDUCATIONAL PLANNING

During the 1950s and 1960s, while geographers and regional planners were focusing on the pragmatic nature of the planning process, along with the information needs of planning itself, the necessity became evident for the development of an integrated information system which by linking different types of theory and models would support the decision making process in planning. In this respect, and in the case of spatial organization of service delivery systems, it is imperative to develop such locational planning support systems, incorporating methods and techniques that can find optimal locational patterns which meet predefined criteria, through the evaluation of alternative location arrangements while dealing with demand uncertainty in terms of population trends and changes (Densham 1990; Armstrong 1991). In the case of Educational Planning, demand uncertainty refers to school populations which obviously affect to a greater extend the spatial organization of educational activities.

The spatial organisation of Educational services, however, requires the location of schools and the allocation of the school populations to them, according to specific constraints. In principle, we can put constraints into two major categories: The first one, which is termed distance-oriented, deals with the maximum time-distance that any pupil has to travel to get to his school. The second, which is termed demand-oriented, refers to the minimum and maximum number of school children which while justifying the existence of a certain school does not suggest that there is need for a redistribution of school populations. It is very common in locational planning for the above two constraints to come into conflict.

In this respect, these often conflicting constrains which must be satisfied in any proposed solution, together with the uncertainty in terms of educational demand forecasting, contribute to the complexity of the problem. Eventually, there is a need for an integrated approach, which in order to generate viable alternative solutions, will adopt such capabilities as demand forecasting, through alternative population projections, according to existing statistical data or current events, during any strategic planning process. Moreover, in educational planning the following key elements must be taken into account, in order to facilitate such an integrated approach:

- *a maximum and a minimum enrolment*
- *a maximum distance*
- *solutions with long-term stability, so that the whole process would not have to be repeated, in response to likely declines or increases of school children populations.*

2.1 Demand definition dilemmas

The demand for public services in strategic planning problems, is largely determined by the size and composition of the population served. Hence, one of the most obvious and frequent uses of population projections is for planning purposes. In this respect, there is no doubt as to what every planner would ideally like: exact trends and tendencies and accurate predictions about the future. Locational planners, in particular, need to have a more detailed idea of the likely future changes in the composition, the distribution and mainly the size of the population in the problem area. In this sense, population change should be regarded as a phenomenon which has to be considered and which can itself affect public policy and locational decision making. Consequently, the implementation of policies distributing educational services more evenly, actually enhances their quality, in terms of efficiency and equity, improves access to school facilities and influences the progress of school children. In this respect, these policies may bring about such changes in the social status that also characterizes them as a major source of additional population growth.

In short, locational planning and more specifically educational planning is undertaken to determine whether immediate expenditures to provide facilities and services will be justified by population demand in the future. However, the same principles that in general require planners to look beyond the period of immediate commitments require school planners to do the same in relation to school population. Consequently, the likely errors in estimating the future size, characteristics and distribution of demand can give faulty signals to decision-makers which, in most cases, lead to costly misallocations of resources.

2.2 Locational decision making under demographic assumptions

A major consideration of locational decision making is the avoidance of unintended consequences, while pursuing intended goals (Harris and Batty 1992). In order to assess these consequences, we need methodologies that will assist the decision making process through the generation of conditional strategies based on alternative hypothetical scenarios. In this sense, and in order to deal with the dynamic nature of service systems, the integration of already available models in a computer based information system, might lead to the recognition of unforseen alternative strategies and thus to a more substantive planning process.

In such a framework, reference will be made to the initial demand population, via the assumptions about its mortality, fertility and net migration rates. As long as fertility, mortality and migration rates are known, demographic models can usually produce projections on the basis of statistical observations concerning current levels and trends in the basic demographic determinants of population change. To some extent, the main contribution of demographic models has been to prepare current estimates of demographic conditions. These projections are usually described as "*if, then*" projections: "*If these assumptions about fertility, mortality and migration hold, then the future population will have these characteristics*". Planners then, involved in the decision making process, can proceed with their problem analysis through the formulation and comparison of alternative proposals which meet predetermined objectives and criteria.

During the process of educational decision-making the main aim is to improve the geographical accessibility of school populations, given resource and policy constraints. In this context, before any attempt for organization or reorganization schemes a set of basic questions has to be answered:

- *Which is the information base decision makers use in the decision making process in order to select school locations in practice?*
- *How do the uncertainty principles in terms of population demand forecasting affect the effectiveness, the efficiency and the long term viability of proposed optimal solutions by location - allocation models?*
- *Which are, in this case, the criteria that characterise a locational decision as optimal?*

In the following sections, we will try to enlighten these questions first, by analysing the scenario-based decision making approach and second by dealing with the case study of the Greek Government's decision to locate new high schools in Thasos Island.

3. THE SCENARIO-BASED DECISION-MAKING APPROACH

Although demographic models tend normally to consider countries as a whole, forecasts for planning purposes nearly always require a sub-national breakdown (Newell 1988). In essence, there are two basic approaches. Either separate assumptions or projections can be made for each region or district, or a national projection can be made and then disaggregated. The latter approach is more frequently used because it requires fewer assumptions. One can simply disaggregate by making an assumption that, within each category into which the population is subdivided, each sub-national population remains in the same proportion as in the national population. This technique is known as the 'Ratio Method' of projection (Shorter, Pasta and Sendek 1990).

Our approach can accommodate both population projection methods. That is the basic assumption of the scenario-based decision making approach, is that every local population might or might not share the fertility, mortality and international migration of the national population. Ratios of the smaller to the larger population are allowed to change in projections. Thus, the local population can be subject to elements of change that are the same as those affecting the national population and has, in this respect, a stable proportional relationship to the national population. On the other hand, it can also be subject to unique elements of change in fertility, mortality and migration that cause the relationship of the age and sex structure of the local population to the national population to change over time.

3.1 Anatomy of the scenario generation process

In our model we use the following notation: We consider a network **F** of **i** demand points, with which we associate a demand weight $\mathbf{w_i}$, which is a measure of the importance assigned to the point and we select a list of **j** ($j \leq i$) potential sites to establish an activity. The above network with its set of characteristics that interact within a context of demand and supply we call it **a system** and $\mathbf{D^t}$ is the complete data set associated with it. In the given network, the locations of the **j** facilities and the allocations of the demand points to them can be accomplished through the application of the appropriate location-allocation model (Rushton 1979; Ghosh and McLafferty 1987; Love, Morris and Wesolowski 1988; Koutsopoulos 1989).

In every case, when within the limits of a given system, demand is covered by a set of facilities; the **location** of those centers is the compromise between the need for **effectiveness** and **equity** (Koutsopoulos 1989). The modification of the values of these criteria after a time period calls for adjustments by the decision makers, which tend to raise the system's decreasing attractiveness. In terms of retaining a competitive position, planners and decision makers must deal with the uncertainties inherent in the problem environment. This requires first, the generation of a set of S ($\sigma \in S$) alternative possible future scenarios, where $\mathbf{D^{t+\Delta t}}$ **is** the complete network data set for time t+Δt and second, the design of strategies that are viable in the long run considering both the system's current status and future trends. Through the identification of the critical elements that give rise to uncertainty, the next step is to formulate the alternative future scenarios by considering the different possible states these elements may attain.

3.2 Solution evaluation criteria

Let us denote $\mathbf{L_\sigma}$ the optimal solution for the configuration of scenario **σ,** and **z(b,σ)** the value of the objective function if solution $\mathbf{L_b}$ is imposed and scenario **σ** is realized ($b,\sigma \in S$). When **S** contains more than one scenario, the planner can solve his problem for the **s** alternative network configurations and then examine the performance first, of each optimal solution $\mathbf{L^{+\Delta t}}$ and second, the performance of each configuration if the optimal solution of scenario **b** is imposed but scenario **σ** is achieved ($b,\sigma \in S$).

Ignoring exogenous factors, we consider the system at time **t** which might move to another state at time **t+Δt**. Unable to predict the behaviour of the system with perfect certainty, we treat the alteration of the system's characteristics as a random phenomenon and use probabilities to describe the alteration propensities. Let P_σ denote the scenario probability, which is the probability that the system moves towards scenario **σ** by the end of the change interval [t,t+Δt].

At the end of the problem solving procedure for every $b,\sigma \in S$, we can construct a "decision matrix" $[DZ_{b\sigma}]$ whose elements will be $\mathbf{dz_{b\sigma}}$, representing the loss in the solution performance of scenario **σ** if the optimal solution of scenario **b** is adopted. Consequently, if the realization probabilities of each alternative scenario are known in advance, then the planner may proceed with his choice through two different approaches. In the first one, he calculates the expected loss of each scenario $\mathbf{E_b}$ which is the summation of the losses dz[b,σ] in the objective function if the solution of scenario **b** is implemented but scenario **σ** is realized, times $\mathbf{P_\sigma}$ which is the adoption probability of σ, for every $b,\sigma \in S$:

$$E_b = \sum P_\sigma dz(b,\sigma) \quad \forall\, b,\sigma \in S \qquad (3.1)$$

and

$$\overline{E} = \min \{E_b\}. \quad \forall b \in S \qquad (3.2)$$

In the second approach, the planner searches for the solution $\mathbf{L_b}$ which minimizes the maximum loss in the objective function of every other alternative scenario **σ**, when **b** is imposed but σ is finally achieved. In this regard

$$\tilde{E}_b = \min\{\max[dz(b,\sigma)]\} \qquad (3.3)$$

4. LOCATING HIGH SCHOOLS IN THASOS ISLAND

In the last twenty years, Greece has witnessed very sharp population changes which were primarily due to the experienced very rapid differentiation in fertility, mortality and migration rates, which eventually have resulted in an aging population and an increased urbanisation (Tziafetas 1990). With respect to educational services, these trends imply that the expected population changes for the years to come, might cause a substantial alteration in the school populations which could necessitate a reorganization of the educational service system.

At present, all prefectures in Greece have adopted a uniform system of general education known as nine-plus three-plus five, which consists of nine years of mandatory schooling, three years of pro-university studies, and five years of university studies. Moreover, given that constant need for the educational spatial reorganization, the Greek government has defined a number of constraints that must be met in order to establish a high school at a particular place (Greek Ministry of Education 1991). These constraints, which were taken into consideration in our application, are shown in table 1 and are related to:

- *A maximum distance that every student must travel in order to get to his school*
- *A minimum number of enrolment for every school and*
- *A maximum number of students for every school.*

4.1 The study area

The study area, Thasos island, is located in the Northern Aegean, 25 km southwest of Kavala a major city of Northern Greece and capital of the synonymous prefecture, where it belongs administratively. For our problem formulation 26 demand nodes were indicated as candidates for the location of a high school, while the number of schools was limited to three, since this was the number finally provided by the Greek Ministry of Education. Total student enrolment for those 26 nodes and for the year 1991 was obtained from the Ministry of Education and was used as the measure of demand.

Table 1. Problem constraints for each educational level

	Demand		Distance
	Lower	Upper	(Km)
Preschool	7	60	15
First Grade	10	360	15
Second Grade	20	420	25
Third Grade	30	420	25

On the basis of the model developed in section three and in terms of scenario definition, we generated three alternative scenarios S = {1,2,3}, for which the associated demand matrices for high school populations were calculated for the year 2001 and are shown in table 2.

The proper way to deal with the alternative sets of assumptions linking them closely to current population tendencies in Greece, and in Thasos island in particular, it would be the in-depth analysis of statistical data, which unfortunately, has not been possible in this case study. Therefore, the projections here are, as already mentioned, primarily illustrative of the approach, rather than precise predictions of what will happen if one set of hypotheses rather than another is followed. According to our approach, we formulated three alternative scenarios through the implementation of different sets of assumptions for fertility, mortality and migration rates to each node. The population projections were performed by the software package **FIVFIV-SINSIN** (The Population Council 1991) and the results were reformatted by a utility programme in order to be compatible with the data file format that the location-allocation software (Densham 1990) requires.

4.2 The location-allocation model

In this example and in order to establish **p** high schools in **p** potential locations and supply each node from a subset of the established facilities, we consider a heuristic algorithm which solves the p-median problem (Densham 1989). By definition, the p-median is a prototype formulation that reflects many realistic locational decision problems. The p-median problem minimizes total distance of demand from the closest of the **p** centers in the system. It can be formulated in the following way:

$$\text{minimize } z = \sum_i \sum_j x_{ij}\, c_{ij}, \qquad (4.1)$$

where x_{ij} = 1 if the demand node i is allocated to facility j, 0 otherwise; and c_{ij} is a metric of interaction that can take various forms including distance, transportation cost, or travel time.

Table 2. Demand populations for time t and t+Δt.

Area	Current	Scenario #1	#2	#3
THASOS	110	120	110	110
SKALA RACHONIOU	1	15	5	5
AGIOS GEORGIOS	5	15	5	5
RACHONI	27	37	27	25
SKALA PRINOU	2	15	6	4
PRINOS	43	53	44	43
SKALA SOTIRA	5	15	6	5
SOTIRAS	4	14	5	1
SKALA KALLIRACHIS	3	24	1	1
SKALA MARION	34	55	32	30
MARIES	2	9	6	4
KALIVIA	21	22	19	17
LIMENARIA	4	6	5	1
PEFKARI	95	96	103	91
POTOS	5	6	13	1
THEOLOGOS	12	13	20	3
ASTRIS	33	34	41	24
ALIKI	3	6	13	4
KINIRA	2	7	13	4
CHRISI AKTI	4	7	14	4
KATASKINOSIS	2	7	7	3
POTAMIA	3	7	7	25
PANAGIA	42	44	44	12
CHRISI AMMOUDIA	31	33	33	76
MAKRIAMOS	1	7	7	50
KALLIRACHI	8	7	7	50

In our case, where travel distance minimization is the objective (as imposed by the Ministry of Education):

$$c_{ij} = w_i\, d_{ij} \qquad (4.2)$$

where w_i is the demand weight of node i, that is the total demand to be served at the ith location and d_{ij} is the adjusted distance from the ith to the jth location.

Shortest-path procedures (Dijkstra 1959) generated a modified data set containing the minimum weighted distances between demand nodes and candidate locations (table 4). These distances then were imported in the location-allocation software, which optimizes objective functions and is based on a heuristic vertex substitution algorithm (Teitz and Bart 1968) solving the p-median problem.

Through another utility programme we were able to obtain output files containing all the information needed to proceed with our approach. In this respect, every scenario solution output file contains the optimal solution, the value of the objective function for the specific network configuration and the values of the objective functions if this optimal solution is adopted but a different scenario is finally achieved.

Table 3. Shortest path distances for time t.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	~	12	16	16	16	17	21	25	23	26	32	43	37	39	41	42	53	45	32	21	13	13	10	8	12	2
2		~	5	5	5	6	10	14	12	15	21	32	26	28	30	31	42	36	43	33	25	24	22	19	24	14
3			~	2	7	9	12	16	14	17	23	35	29	30	32	33	44	38	48	37	29	29	26	24	28	18
4				~	8	9	12	16	15	18	24	35	29	31	33	34	44	39	48	37	30	29	27	24	28	19
5					~	2	5	9	8	11	17	28	22	24	26	27	37	32	46	37	29	29	26	24	28	18
6						~	3	7	5	8	14	26	20	21	24	24	35	30	44	38	31	30	28	25	29	20
7							~	4	2	5	11	23	17	18	20	21	32	27	40	42	34	33	31	28	33	23
8								~	6	9	15	27	21	22	24	25	36	31	44	46	38	37	35	32	37	27
9									~	3	9	21	15	16	18	19	30	24	38	44	36	36	33	30	35	25
10										~	12	24	18	19	21	22	33	27	41	47	39	39	36	33	38	28
11											~	12	6	7	9	10	21	15	29	40	45	45	42	39	44	34
12												~	9	11	13	14	24	19	33	43	52	56	54	51	55	46
13													~	1	4	4	15	10	24	34	43	46	45	45	49	40
14														~	2	3	14	8	22	33	41	45	44	46	51	41
15															~	1	12	6	20	31	39	43	42	44	49	43
16																~	11	5	19	30	38	42	41	43	48	44
17																	~	16	30	41	49	53	52	54	59	55
18																		~	14	24	33	37	35	38	43	46
19																			~	11	19	23	22	24	29	32
20																				~	9	12	11	14	18	22
21																					~	4	3	6	11	14
22																						~	3	5	10	14
23																							~	3	8	11
24																								~	5	8
25																									~	13
26																										~

Finally, after viewing the results of the problem solving procedure and studying the proposed locational patterns, the decision makers are able either to formulate a solution strategy or to redefine the scenarios in terms of assumptions, objectives and specific parameters for the location of high school in the study area.

4.3 Locational patterns of proposed regionalizations

Following the analysis of the three alternative scenarios, in which we held constant the number of centers, supposing that three school facility sites should be located at three candidate nodes of the problem network, we were able to construct the decision table shown in table 4.

For every proposed regionalization by the location - allocation model we computed the value of the objective function for the optimal solution and the loss in the objective function in the case we adopt the optimal solution of scenario b, but σ is achieved for all b,σ∈S. Following equations (3.1), (3.2) and (3.3) we calculated and filled the Expected Loss and Minimax Loss columns of the table. The evaluation and comparison of the examined alternatives and the results in our example show that scenario #1 has both the minimum Expected Loss and the minimum Maximum Loss for the current problem formulation.

Table 4. Solution Evaluation Table

	Realized Scenario			Loss	
Adopted Scenario	#1	#2	#3	Expect	Max
#1 (P_1=48%)	0	4538	1404	1702	4538
#2 (P_2=32%)	3554	0	5406	2841	5406
#3 (P_3=20%)	1140	5862	0	2364	5862

Furthermore, another procedure generates spider maps (Allard and Hodgson 1987) directly from the scenario solution files. Those files are then imported to the mapping software, in our case **AtlasGraphics** and **AtlasDraw** (Strategic Location Planning 1990), and overlaid with the area map which had been previously digitized. Eventually, they indicate which nodes are allocated to which school facility site, along with the total enrolments that must be served by every school and are displayed to Figures 1, 2 and 3.

Figure 1. Scenario-one: Three center locational arrangement.

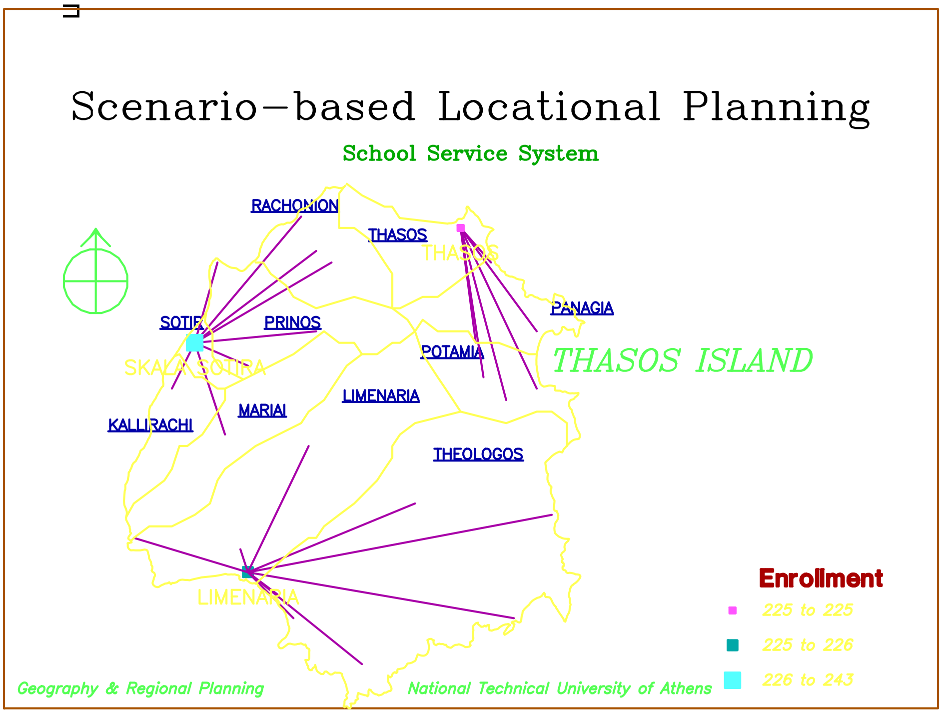


Figure 2. Scenario-two: Three center locational arrangement.

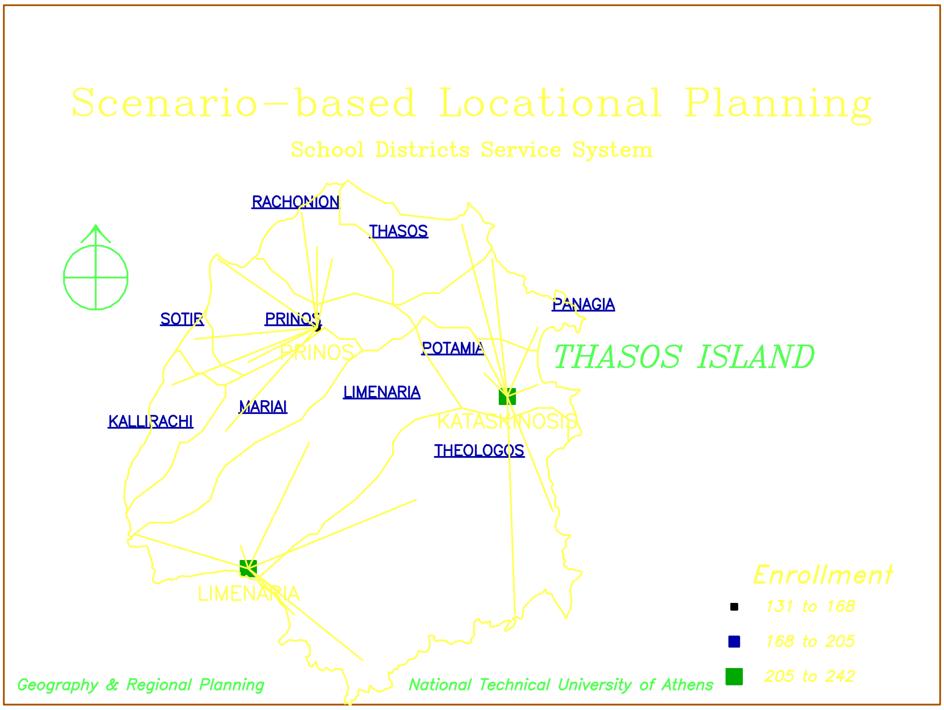
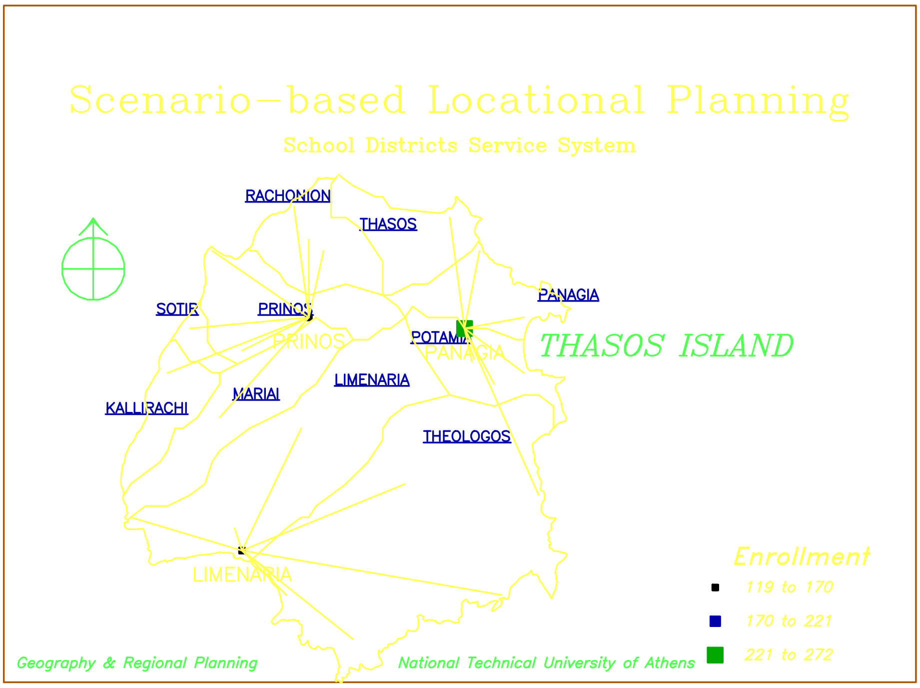


Figure 3. Scenario-three: Three center locational arrangement.



Reports for every proposed regionalization are produced by a report generator program and in this context the decision makers are allowed to explore their problem both by visual inspection and comparison of two or more maps, or by examination of the performance of each proposed solution for the varying constraints and criteria that can be applied throughout the decision making process, elevating or depressing the overall total score of the alternative locational arrangements (Table 5).

Table 5. Accessibility to facilities:

Region center	Enrolment	Average Enrolee	Maxm Enrolee	Average Node	Maxm Node
SCENARIO #1					
THASOS	225	4.35	13.20	19.73	38.70
SKALA SOTIRA	243	5.85	12.30	16.27	27.70
LIMENARIA	226	6.19	32.70	19.33	30.10
Totals	649	5.48	32.70	18.44	38.70
SCENARIO #2					
PRINOS	131	5.08	9.20	22.97	38.70
LIMENARIA	221	4.59	13.80	19.50	27.70
KATASKINOSIS	242	9.79	22.70	22.57	30.10
Totals	594	6.82	22.70	21.68	38.70
SCENARIO #3					
PRINOS	119	5.02	9.20	21.20	38.70
LIMENARIA	133	3.23	22.20	17.73	27.70
PANAGIA	272	4.97	13.50	20.80	30.10
Totals	524	4.54	22.20	19.91	38.70

5. CONCLUDING REMARKS

Uncertainty is inherent in most locational planning situations, due to the dynamic nature of the problem environment and the inability of the planners to predict with accuracy the exact future system configuration and network specification. Nevertheless, it is the exception rather than the rule that such considerations are studied in locational decision problems. In this paper we presented a scenario-based locational planning framework. We deal with a set of alternative future scenarios defined by the decision maker, concerning the course of demographic indices of the population under consideration. Furthermore, we assist the decision making process through the utilization of two solution performance criteria. In this respect, and according to the nature of locational planning and the problems faced within the context of location analysis, we argue that through the implementation of our approach, we can determine a more reasonable decision making process. Undoubtedly, there are many possible types of change in the problem environment and consequently a plethora of ways of translating them to decision criteria and incorporating them in the problem framework. In the empirical case study of Thasos island, Greece, we applied an operational version of our framework throughout our attempt to provide decision support to a public agency, the Greek Ministry of Education, that is currently reorganizing the geographical configuration of its system. In this sense, the overall objective of this paper is to provide insights about integrated methodologies which, being in a decision support system's framework, can greatly contribute to the solution of locational decision problems in practice, where we believe that there is a strong need for further refinements of the decision making process.

At this stage, and according to current trends, there is an increasing interest in the ability to operationalize the handling of more complex criteria than we have shown in our example, which can be treated as a bicriteria model (that is, incorporating only two criteria), particularly as it regards decisions concerning the location of public facilities. However, despite the abundance of the existing algorithms, we believe, that the need for a more sophisticated approach of locational decision making should lead to more interactive and thus much more pragmatic planning procedures. More specifically, we refer to a different planning tool whereby location - allocation, demographic and other models will be integrated into an information system to support the decision making process, and allow for interaction among the decision maker, the planner and a computer. This, we believe, will lead to 'better' strategic decisions, which certainly are more vital than a stand-alone 'realistic' location - allocation model. As Krarup and Pruzan stated (1990):

> *There is no doubt that locational decision problems focus upon strategic rather than tactical matters, for example where to place schools rather than how to route school buses. That is, the emphasis is placed upon planning and design problems rather than on operational problems. It should be noted however that in practice a locational decision problem can seldom be considered in isolation from other strategic decisions.*

Although we deal with a rather simplified case, our approach can be considered as an attempt to provide answers to a limited number of 'what if' questions and furthermore, yields insights into two basic aspects. On the one hand, scenario-based locational planning is emphasizing on the definition of possible future states of the system, through the visualization and the definition of alternative hypothetical scenarios. On the other, is focusing on the urgent need for the development of an integrated locational planning support system. Undoubtedly locational and demographic models are well developed in planning. However, we believe that by transferring input and output data between demographic and locational models and using the graphic and representational capabilities of mapping software, planners and decision makers will be assisted both in the analysis of spatially distributed service systems and the evaluation of the consequences of the proposed alternative solution strategies.

Since location decisions require long-term future investments that can be changed only at considerable costs, and given the importance and possible impact of the systematic evaluation of future uncertainties, we believe that considerable effort should be placed on the development of methodologies that will assess the expected performance of alternative system configurations which, finally, will lead to more sophisticated analyses of locational planning problems and thus more efficient locational patterns.

REFERENCES

Allard, l. and M.J. Hodgson. 1987. Interactive graphics for mapping location - allocation solutions. ***The American Cartographer*** **14**, 49-60.

Armstrong, M.P., G. Rushton, R. Honey, B. Dalziel and P. Lolonis. 1991. Decision support for regionalization: A spatial decision support system for regionalizing service delivery systems. ***Computers Environment and Urban Systems*** **15**: 37-53.

De Palma, A. and Y. Papageorgiou. 1991. A model of rational choice behaviour under imperfect ability to choose. Forthcoming.

Densham, P.J. and G. Rushton. 1987. Decision Support systems for Locational Planning. In R.G. Golledge and H.Timmermans, eds. ***Behavioural Modelling in Geography***. (New York: Croom Helm).

Densham, P.J. 1989. Computer Interactive Techniques for Settlement Reorganization, ***Ph.D. Dissertation***. Department of Geography, The University of Iowa.

Dijkstra, E.W. 1959. A note on two problems in connexion with graphs. ***Numerisc Mathematik***.

Fisher, H.B. and G. Rushton. 1979. Spatial efficiency of service locations and the regional development process. ***Papers of the Regional Science Association*** **42**: 83-97.

Ghosh, A. and S.L. Mc Lafferty. 1987. ***Location strategies for retail and service firms***. (Toronto: Lexington books).
Ghosh, A. and G. Rushton. 1987. ***Spatial Analysis and Location - Allocation Models***. (New York: Van Norstrand Reinhold Company).
Greek ministry of Education. 1991. ***High School Locational Planning: Tasks and Regula-tions.*** (Athens).
Harris, B. and M. Batty. 1992. ***Locational Models, Geographic Information and Planning support systems***. Technical Paper 12-1, NCGIA.
Koutsopoulos, K. 1989. ***Geography and Spatial Analysis***. (Athens: Papadamis).
Krarup, J. and P.M. Pruzan. 1990. Ingredients of Location Analysis. In P.B. Mirchandani and R.L. Francis, eds. ***Discrete Location Theory*** (New York: Wiley).
Love, R.F., J.G. Morris and G.O. Wesolowski. 1988. ***Facilities location: Models and methods.*** (New York: North Holland).
Newell, C. 1988. ***Methods and Models in Demography*** (New York: The Guilford Press)
Rushton, G. 1979. ***Optimal location of facilities***. (Wenworth: COMPress, N.H.)
Shorter, E., D. Pastra and R.Sendek. 1990. ***Computational methods for population pro--jections: with particular reference to development planning.*** (New York: The Population Council).
Teitz, M.B. and P. Bart. 1968. Heuristic methods for estimating the generalized vertex median of a weighted graph. ***Operations Research* 19**: 955-961.
Tewari, V.K. and S. Jena. 1987. High school decision making in rural India and location - allocation models. In A. Ghosh, and G. Rushton, eds. ***Spatial Analysis and Location - Allocation Models.*** (New York: Van Norstrand Reinhold Company).
Tziafetas, G. 1990. ***Population Analysis.*** (Athens: EL.KE.PA)