HOW CAN GIS AND RS SUPPORT THE DECISION MAKING FOR RURAL DEVELOPMENT PROGRAMS IN EGYPT

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ABSTRACT

While all huge sounds laudable to spread the using of geographic information systems GIS and remote sensing RS in many fields of development practices, there still are some issues need to be teased out. This paper endeavors to cast some light on a critical question has arisen in the context of spatial decision analysis: that is how and to which extent can GIS and RS techniques provide the support required at each of the three stages of decision-making for rural development in Egypt. To accomplish this task, the concept of decision-making has been investigated through five main stages represent the components of integrated rural development program currently implemented in Egypt. This paper reports that GIS and RS may play a vital role at the stages of exploration and analysis of local resources, planning, and evaluation. These three stages reflect intelligence and choice phase in the context of decision-making. Meanwhile, the study does also argue that the exploiting of GIS and RS technology is extremely limited in the stage of stimulating the society as well as stage of implementation of developmental plan, which reflect the design stage of decision-making model. However, a specific influence of RS appears explicit in recognition of natural resources, which can be extremely utilized for rural development programs in Egypt instead of following traditional means currently used to report such resources. In addition, RS introduces a clear vision of changes of land-use/cover occurred during the period 1986-2000. Moreover, a lot of thematic maps can be introduced by GIS providing a comprehensive picture of the situation in each village of Assiut province, thereby facilitating the setting of priorities for rationalization of the use of resources and effective rural development planning especially at long run.

INTRODUCTION

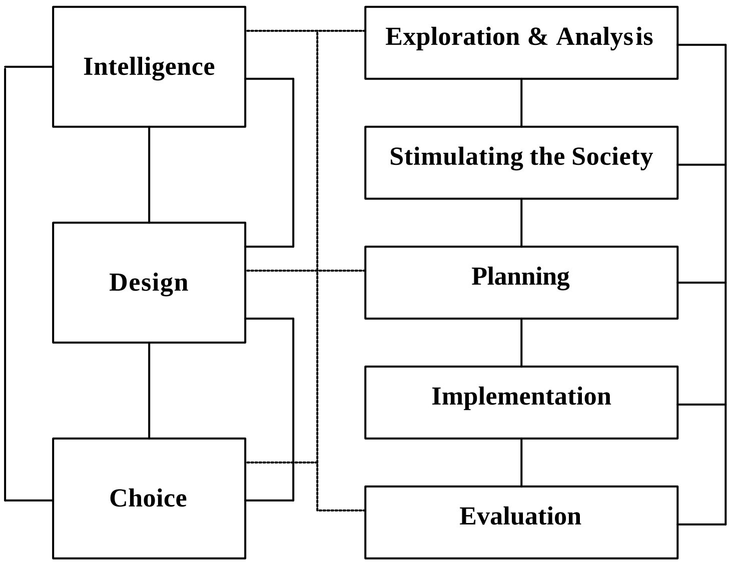
Whereas the political, socio-economic, and institutional aspects may often be of dominant importance for rural development in Egypt, there still is a considerable demand for timely and relevant technical and scientific information. Planners and decision makers, and increasingly the general public, need and demand information as a basic for informed decision. This includes benchmarks information to put the problem in the context, from monitoring to applicable standards. It does also include information on the available alternatives, feasibility of courses of actions and constraints, and finally an assessment of the likely consequences of any or no action. Such information need to be provided in a format that is directly understandable, and useful. Time is always important, and information is needed immediately, when decision is to be taken.

Despite GIS is gaining importance and widespread acceptance as a tool for decision support in land resources, environmental management, and urban and regional planning, it is still in the infant phase in Egypt. In this sense, this study may be considered the first one to explore the potentials of GIS in integrated rural development programs in Egypt. It is argued that an ultimate goal of GIS and its relevant technologies like RS is to provide support for making spatial decisions by integration of spatially referenced data in a problem solving environment.

This paper aims at casting some light on the capabilities of GIS and RS for supporting spatial decisions from the context of decision-making process. Simon (1960) suggests in his model that decision-making process can be structured into three major phases: intelligence (is there a problem or an opportunity for change), design (what are the available alternatives), and choice (which is the line of action that will return the most perceived benefits). During the intelligence phase information is gathered to understand the problem for which a decision is required, and the various assumptions that have to be made are made explicit. Hence, during the design phase various alternatives are explored. Finally in the choice phase, a best or satisfactory decision is sought and selected, and some verification is undertaken.

To convert the theoretical objective of this paper to operational one, it typically joins on one hand the stages of integrated rural development program currently implemented in Egypt with the model of decision-making process, and with the capabilities of GIS as a supported tool on the other hand. Figure 1, shows the interchangeable relationship between the stages of rural development program and phases of decision-making process as Simon has suggested.

Figure 1. Interchangeable Relations between Model of Rural Development Program and Simon's Model of Decision- Making



STUDY APPROACH

Database of Study

The database of this study is constructed of three types of data. Firstly, remotely sensed imageries of Landsat TM5 and ETM+ dated in 1986 and 2000 respectively were imported and processed in IDRISI for windows environment to provide valuable information about the spatial patterns and differences in the natural and physical environment of local communities, which may influence the decisions of rural development. Secondly, census data of Assiut province in 1996 were converted from paper form to .dbf form to produce the tabular database. Thirdly, topographic sheets of Egyptian general survey authority at scale 1:100,000 were scanned and digitized to formulate digital base map of study.

Geographic Field of Study

The geographic field of this study is 52 villages represent all rural areas of Assiut province (one of 26 provinces of Egypt). It is located at 375km at the south of Cairo. Assiut province is consisted of 11 districts, 10 cities, and 52 villages. It is known as a rural province. Total population number of Assiut is about 2.8 million inhabitants according to 1996 population census. Rural development is of prime importance for this province because near to three fourth (73%) of population are living in rural areas.

Analytical Techniques

I. To perform multi attribute decision analysis, the following steps were carried out:

Step 1. Four indicators of fertility rate, illiteracy ratio, unemployment ratio, and access to safe-water were defined as an evaluation criteria (map layers) to represent demographic, social, economic, and environmental indicators respectively to determine which villages have to be firstly involved in rural development programs. Simple Additive Weighting (SAW) method was introduced as a decision rule to evaluate each alternative, A_i, using the following formula:

$$A_i = \sum_j w_j x_{ij} \qquad (1)$$

where x_{ij} is the score of the i th alternative with respect to the j th attribute, and the weight w_j is a normalized weight, so that $\sum w_j = 1$.

Step 2. Each criterion map layer was standardized using score range procedure as one of linear scale transformation methods to produce standardized scores range from 0 to 1. The following formula was applied:

$$x'_{ij} = \frac{x_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}} \qquad (2)$$

where x'_{ij} is the standardized score for the i th alternative and the j th attribute, x_{ij} is the raw score, x_j^{max} is the maximum score of the j th attribute, x_j^{min} is the minimum score for the j th attribute, and $x_j^{max} - x_j^{min}$ is the range of a given criterion.

Step 3. To define normalized weight of each criterion, multiple linear regression was introduced to define the straight rank of each criterion, then the resulted ranks were involved in the formula of rank sum that is:

$$w_j = \frac{n - rj + 1}{\sum (n - r_k + 1)} \quad (3)$$

where w_j is the normalized weight for the j th criterion, n is the number of criteria under consideration $(k = 1,2,...,n)$, and rj is the rank position of the criterion.

Step 4. Weighted normalized map layers were constructed by multiplying standardized map layers by the corresponding weights.

Step 5. Composite map of criteria mentioned above was generated.

Step 6. Finally, database query by attribute was performed to determine villages that should be firstly involved in rural development programs.

II. Unsupervised classification was performed to define major land-use/cover items, therefore, explore the changes may occurred of land-use/cover within the period 1986 – 2000.

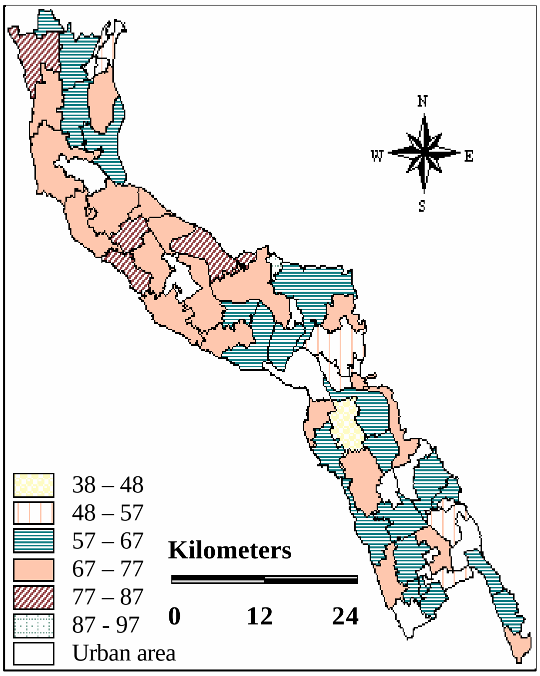
RESULTS AND DISCUSSION

Some results of study included in this paper will be presented along with the stages of integrated rural development program currently implemented in Egypt.

I. Exploration and Analysis Stage:

As intelligence phase of decision making model, exploration and analysis stage involves searching or scanning the decision environment for conditions calling for decisions. During this stage raw data are obtained, processed, and testified for clues that may identify opportunities or problems. In this sense, GIS is capable of introducing a lot of thematic maps as the most standard output format to report characteristics of human resources, economic resources, infrastructure, NGOs, and so on. Such data have a vital role for integrated rural development programs. They do not only describe the current state of physical and human resources, but they also serve, along with indicators of rural development and other data, as benchmarks against which future changes and improvements can be measured and reported.

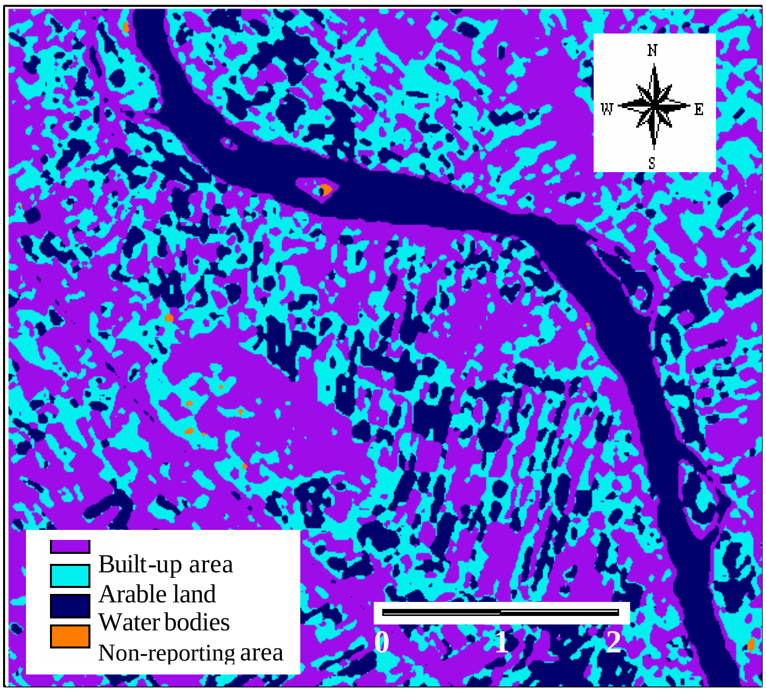
Figure 2. % Pop with blue-collar occupations



A sampling includes the following thematic map shown in figure 2 reveals that blue-collar occupations like farmers, production worker, and labourers are more dominant than professionals, technical, administrative and managerial workers, and other relevant white-collar occupations at villages of Assiut province in general. Blue-collar occupations of the study area are varied from 43% up to 89% of total occupied population. One can obviously notice from the figure that most of villages having a higher level of blue-collar occupation are located far from urban areas. In other words, villages that have lower level of blue-collar occupations are found more closed to urban areas. This may indicate to the positive spatial correlation between urbanization and white-collar occupations. This result is logic, but it has a strong side effect on the rural areas. It leads to increase the phenomenon called Rural-Brain Drain. Such process, however, leads to exploiting of highly qualified human resources of rural areas to participate in development of urban areas rather than development their rural areas. This result is oriented to decision makers to adopt new policy by maximizing the chances of white-collar occupations in rural areas so that rural development can be undertaken by such effective forces of white-collar occupations otherwise the developmental gap between urban and rural will be increased more and more.

In addition to such capabilities of GIS in the exploration and analysis stage, the study reveals that RS serves as a very important source of data required at this stage especially in terms of natural and material resources and how it is utilized at present time. Figure 3 shows for updated distinct features of land-use/cover of Assiut province in November 2000. By calculating the area of each class, it is reported that built-up area has occupied the bigger size of Assiut province area (723 km^2), while, arable lands has come in the second rank (462 km^2), followed by water bodies (349 km^2), in addition to 14 km^2 area could not be exactly defined. Such result, however, reports land-use/cover classes more accurately than traditional means that used to be followed before.

Figure 3. Land-Use/Cover Major Classes, November 2000



II. Stimulating the Society Stage:

It is argued that communities having a say in the development of policies for their locality are much more likely to be enthusiastic about their implementation. From this point of view, this stage is taking off to focus the attention of rural community members on inefficient utilization of their resources. This paper explores that GIS and RS technologies may not take place in this stage because it generally implies activities that mainly depend on focusing and discussion groups between decision makers and community citizens. For example, it includes reminding community citizens with some developmental experiences already applied in similar local communities.

III. Planning Stage:

This stage ultimately aims at generating detailed plan including timetable, technical details, and distribution of roles among individual and organizations participating in implementation of developmental projects and activities. It implies answer of the question; “who” have to do “what”, “when” and “how”. It meets parts of both design and choice phases in the context of Simon’s decision-making model.

This paper offers an examp le the capability of GIS with support of simple additive weighting (SAW) to define villages required to be firstly involved in rural development programs. Initially this category of villages should be determined because lack of resources especially financial ones cannot allow starting development programs in all villages simultaneously. Table 1 summarizes normalized weights of four criteria involving fertility rate as a demographic criterion, illiteracy ratio as a social one, access to safe- water for environmental indicators, and unemployment ratio as an economic criterion. Those criteria are suspected to serve as benchmarks to set the

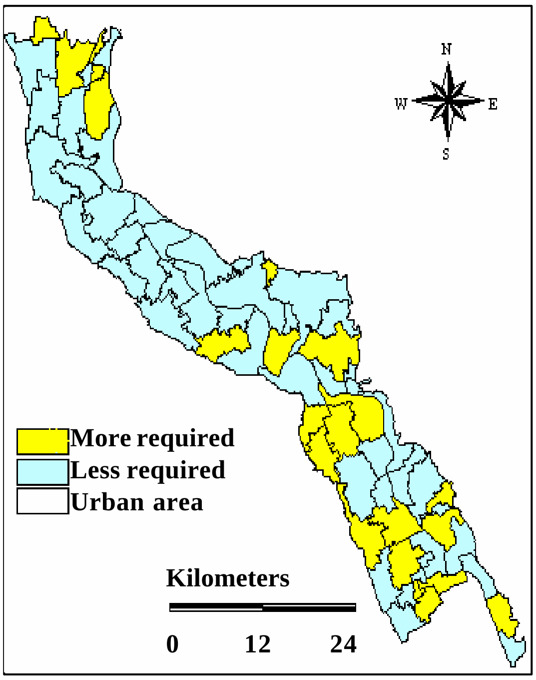
Table 1. Assessing Normalized Weight by Rank Sum Procedure

Criterion	Straight Rank	Weight $(n - rj + 1)$	Normalized Weight
Fertility rate	1	4	0.4
Access to safe-water	2	3	0.3
Unemployment ratio	3	2	0.2
Illiteracy ratio	4	1	0.1
		10	1.0

priority of villages for development. Figure 4 shows the result of database querying of previous criteria. We assume that villages more required to firstly improve the quality of life of its people are those having (Me + 1~2Std.Dv.) of composed criteria mentioned above. One may note from the figure that most of villages having highest priority for development are located in the center and south parts of Assiut province. This result does not seem logic especially if we understood that the quality of life of northern villages is worse than in southern ones especially in terms of illiteracy, access to safe-water, unemployment ratio separately. Hence, such result may due to the followed rule of database query to combine all criteria together because the total looks to be different from the sum of parts. This output confirms the capability of database query implemented through GIS to add geographic aspect to the results rather applying database query in other statistical software.

As mentioned above GIS may play a good role in setting priorities for development, but it should be noted that the reality is more complex than setting priorities by the way mentioned above. It is possible for the straight weights of criteria to be changed times and times according to the situation or decision makers' preferences, etc. In this context, GIS may not allow decision makers the flexibility to change the importance of evaluation criteria.

Figure 4. Villages by Requirement for Development



IV. Implementation Stage:

This paper argues that GIS and RS may not play a role in this stage of development because it implies translation of the local development plan into real actions while each involved individual or organization is performing his role predetermined in the stage of planning.

V. Evaluation Stage:

This stage implies detection of changes may occur due to implementation of rural development programs. In this sense, RS is suspected to play a powerful role for updated understanding of land cover change detection. This paper analyzes the differences between two images of TM5 and ETM+ to address the changes may be occurred within the period 1986 – 2000. Findings refer to increasable growth of urbanization along that period. One can notice from table 2 that built-up area in 2000 has increased 64 km^2 than 1986.
In other words the annual increment rate of urbanization has reached about 0.7%. This indicator is very critical especially in the content of sustainable development. Meanwhile, the area of arable land has decreased about 19 km^2. Moreover, the table reveals that the area of water bodies has decreased about 16 km^2 during that period. Such result refers to which extent RS can report the change detection in natural resources more precisely.

Table 2. Changes of Land-Use/Cover classes during the period 1986-2000

Major land-use/cover class	Area (km^2)		Change in land-use (km^2)	Notes
	1986	2000		
Built-up area	659	723	64	Increase
Arable lands	481	462	-19	Decrease
Water bodies	365	349	-16	Decrease
Not-reporting area	43	14	-29	Decrease

CONCLUSION

The outcomes of study refer to effective role can be played by GIS especially in the stage of Exploration and analysis of local resources through producing thematic maps of as the most standard output format to report characteristics of human resources, economic resources, infrastructure, NGOs, and so on. This effectiveness may due to the geographic aspect that can be overlapped by GIS so that add more information and profound interpretation of statistical data. It is also very easy to update data involved in GIS database with more accuracy and reliability. There is also an important role can be played by RS in the first stage of rural development. In this study, unsupervised classification of remotely sensed data is performed and revealed that built-up area is the highest rank of land cover items of Assiut province; followed by arable land, then water bodies and other non-reported features.

By overlaying images of 1986 and 2000, it is indicated that the annual increment rate of urbanization has reached 7%; therefore, decision makers should strongly try to decrease or stop this critical problem.

On the other hand, this paper explores that GIS and RS technology seems to be useless in the stages of stimulating the society, and implementation of local developmental plan. This may due to the nature of these stages. For the stage of stimulating the society, it mainly depends on the abilities of decision makers to manage the discussion with community citizens through focusing groups. In case of implementation stage, it implies translation of local developmental plan to real actions; therefore, it depends on the human, natural, and financial resources rather utilizing GIS and RS. Finally, it should be also noted that there is a restriction for using GIS in the choice phase regarding the merging of decision makers' preferences in the decision-making process. In this sense, GIS may not permit more ranges of flexibility to change the relative weight of evaluation criteria, which may continuously happen in reality. We hope this page to be a nuclear for more studies to investigate the capabilities of GIS and RS technologies to strongly push integrated rural development programs to improve the quality of life of 57% of population living in rural areas in Egypt.

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