New Method for Land Reallocation by Using a Geographic Information System

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Key words: Land Consolidation, Land Reallocation, Data Base, PC ArcInfo, GIS.

ABSTRACT

Land consolidation plays a significant role in the countryside of Morocco. It has offered farmers the opportunity for higher income and improved working conditions. It has proved to be an appropriate solution to problems of small plots which are sometimes irregularly shaped and distant from homestead, and where there are problems of water management and access to land. However, land consolidation projects and, more specifically, land reallocation, are time consuming and less accurate when using traditional methods, which has a negative impact on the purpose and the initially proposed objectives of Land Consolidation.

The main objective of this study is the optimization of the technical steps of a land consolidation project using a Geographic Information System (GIS). The methodology developed for this purpose consists of three main steps: 1) establishment of a conceptual model for different phases of land consolidation project; 2) development of the landowner lists to be reallocated inside a block; 3) development of a specific GIS prototype for the purpose of solving the issues of land consolidation in general, and land reallocation in particular.

A new method for “Temporary Land Reallocation” was developed to determine the landowners list to be reallocated inside a block, by giving a weight to each land consolidation qualitative and quantitative parameter. The developed interface with SML language based on PC Arc/Info, allows for the data gathering, processing, querying, analysis, and archiving functions of the data base.

RESUME

Le remembrement est une opération dynamique et plurielle, qui joue un rôle primordial et très significatif dans le développement de l’agriculture du Maroc en général, et dans le développement du monde rural, en particulier. Le remembrement rural est un outil d'aménagement de l'espace rural qui tend à constituer des parcelles continues, régulières, aussi rapprochées que possible du siège de l'exploitation, jouissant d'accès indépendants, de l'écoulement des eaux et de travaux d'amélioration foncière. Cependant, son élaboration avec les méthodes conventionnelles exige un processus de longue durée, et en particulier au niveau du recasement; ce qui a un impact négatif sur la région à remembrer et sur les objectifs du remembrement initialement fixés.

Cette étude a comme objectif principal, l'optimisation des différentes étapes techniques d'un projet de remembrement en se basant sur un SIG. La méthodologie développée a cet effet comporte trois étapes fondamentales : 1) établissement d'un schéma conceptuel des données d'un projet de remembrement ; et 2) développement d'une nouvelle procédure de détermination de la liste des propriétaires à recaser à l'intérieur d'un bloc; et 3) développement d'un prototype de SIG dans le but de résoudre le problème d'un projet de remembrement en général, et celui du recasement parcellaire en particulier.

Une nouvelle procédure a été développée pour le "Recasement Provisoire" dans le but de déterminer la liste des propriétaires à recaser à l'intérieur d'un bloc, en tenant compte des différentes contraintes du remembrement, qu'elles s'agissent de données quantitatives ou qualitatives, et ceci en affectant des poids à chacune d'elles. Le prototype, développé en langage de programmation SML en se basant sur le logiciel Arc/Info sur PC, permet de faire la saisie, le traitement, l'analyse, le stockage et la mise à jour des données, et offre la possibilité d'interroger la base de données d'un projet de remembrement.

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1. INTRODUCTION

Rural land consolidation, or "Remembrement" in French, has been defined as an operation which has as its aim the improvement of land cultivation by replacing the existing scattered division of the land into many parcels, with a new division characterized by smaller number of parcels, larger in size, easily accessible and suitable for cultivation by machinery.

This rural land consolidation or land regrouping is composed of technical, legal and administrative operations. It plays a significant role in the rural areas of Morocco, particularly for irrigated perimeters with high investments. Land consolidation offers the farmers opportunities for higher income and improved working conditions. It has proved to be a particularly appropriate solution to problems of small parcels, sometimes irregularly shaped and distant from the homestead, to problems of water management as well as those of access to the fields (Bensouda, 1998; Seyfried, 1997).

Land consolidation operation necessitates the mobilization of a large number of specialists (e.g. lawyers, agronomists, surveyors..) and requires many years of study and decision making, before actually being implemented. Indeed, research done on this subject indicates that the realization of a land consolidation project is very slow and time consuming. This by itself will have a negative impact on the results hoped for by the land consolidation.

The main factors and constraints that are liable to slow down a rural Land Consolidation project and to cause delays, are numerous and may be regrouped in two main categories:

- Legal and administrative problems
- Technical problems.

The main objective of this study is to develop a new methodology approach using a Geographic Information Systems, that considers all types of data involved in a rural land consolidation project (e.g. soil types, social and economic investigations, and spatial data). Indeed, the development of models for land consolidation based on a GIS will support decision makers and will accommodate present and future needs.

2. THE METHODOLOGY

Most often, a land consolidation project is based on legal, administrative and technical tasks. Among these technical operations, we can distinguish:

- Land-surveying tasks;
- Social and economic investigations;

- Soil studies;
- Network studies (water management and network access to fields);
- Reallocation procedures;
- Implementation.

These technical operations of land consolidation can be performed either by conventional methods or computer methods. In practice, specialized software to carry out the necessary steps does not exist.

One of the most important and decisive technical steps is land reallocation. It is the synthesis, the analyzing and the decision making step. All the land consolidation process is identified in this application. However, this step still lacks a good approach for handling large volumes of data. Given the mass of data and the diversification of documents, some of difficulties arise at various levels:

- The manipulation of diverse documents (land-surveying maps, soil types maps, and hydraulic network maps).
- The data treatment.
- The preferences (wishes) of farmers for a particular spatial location.

In other words, in a land consolidation project, one can find qualitative and quantitative data. Taking in account all of these factors and parameters, we propose to develop a new methodology approach integrating the steps of land consolidation and land reallocation in a G.I.S framework taking into account the conditions of present day Morocco. The use of a GIS provides significant advantages and allows a user to:

- Improve the evaluation of the soil, land-surveying and parcel information.
- analyze data correctly.
- Update easily geographic information.
- Make appropriate decisions concerning space.
- Model existing data.
- Create and manage data base at a local level.

The developed methodology is composed of three main steps.

1) Designing of a conceptual model for all phases of the land consolidation project.

2) Establishment of the landowners list to be reallocated inside a block or “Temporary Land Reallocation”.

3) Development of a specific GIS prototype for the purpose of solving the issues of land consolidation and land reallocation.

However, this study will focus more on the “Temporary Land Reallocation” step, which deals with both the qualitative and quantitative data.

3. CONCEPTUAL DATA MODEL FOR LAND CONSOLIDATION

Before taking a GIS as a solution for the technical problems, it's necessary to built a data base for land consolidation project in irrigated areas. The construction of the database model takes several steps.

The development of this database was based on the Merise method which is characterized by three levels: the conceptual level, the logical level and the physical level (Louvet, 1990).

The conceptual level consists of identifying and describing objects and their relationships. Once done, we established the Conceptual Data Model (CDM) , which is the transition from the real world to a model process.

At the logical level, the ArcInfo GIS software was used to build the prototype database (Essadiki, 2001).

4. LAND REALLOCATION PROCESS

Land reallocation is a very important technical stage in the land consolidation process. It is also a lengthy process. This procedure consists of four main operations (Essadiki, 2001):

- Preliminary calculations
- Temporary Land Reallocation
- Definitive Land Reallocation
- Implementation.

4.1 Preliminary calculations

Before starting land reallocation, the operator needs various documents in order to carry out a number of preliminary calculations:

- Parcels maps before land consolidation,
- Social and economic impact surveys,
- Soil types maps,
- Hydraulic network maps.

The following calculation steps should be undertaken (figure 1):

1. Calculation of the parcel areas and their values, before land consolidation, by digitizing parcel limits and their soil types.
2. Calculation of the block areas and their values by digitizing the area of all soil types within the blocks.
3. Calculation of the required public use land value (roads, hydraulic networks, etc).
4. Calculation of the reduced values of landowners.

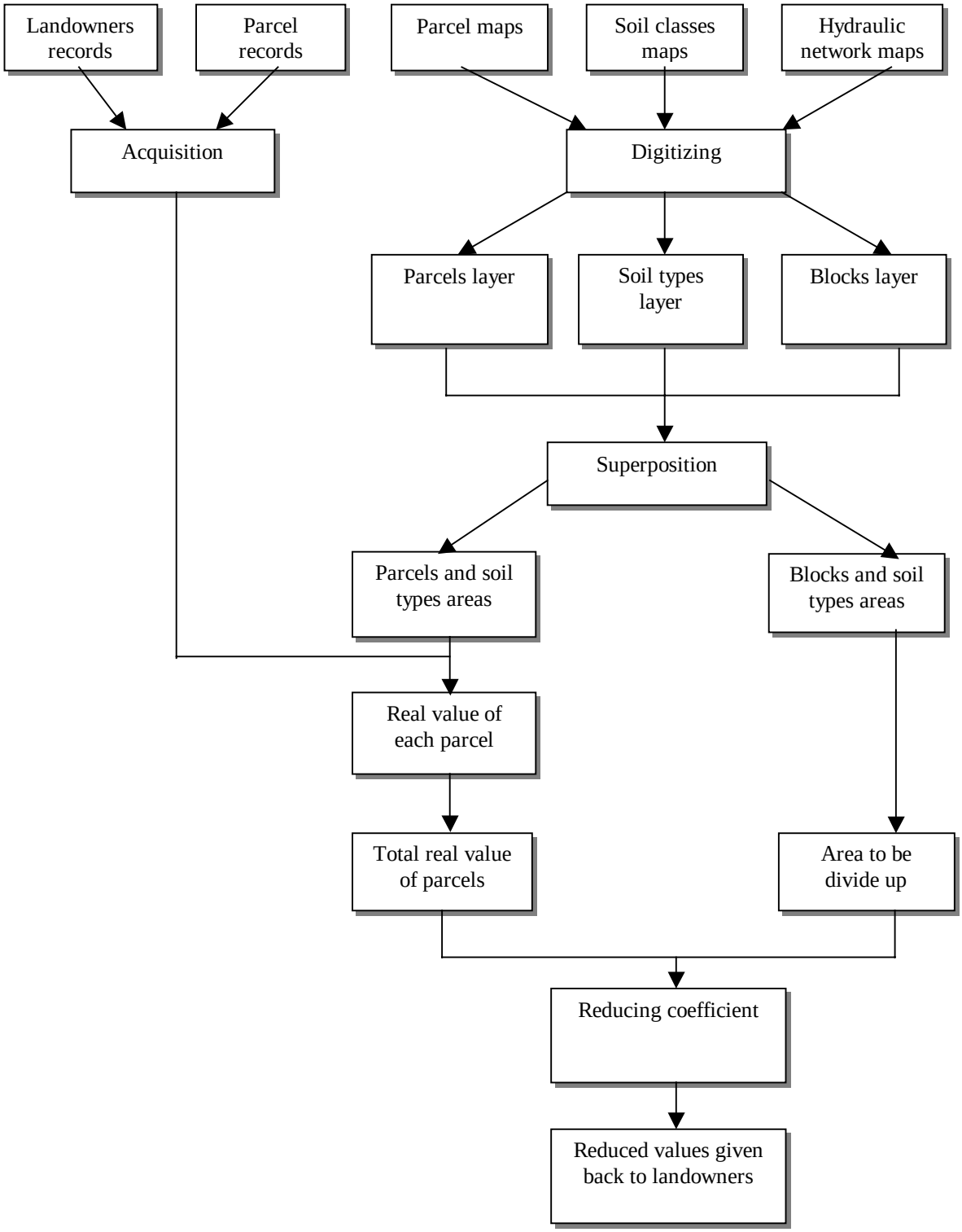

Figure 1 Calculation steps of Land Reallocation

In theory, the total land value of all the land parcels should be the same as the total value of the blocks. In practice, it's impossible to have this result, because of digitizing errors. All these calculations will be needed for the following steps of the land consolidation procedure.

4.2 Temporary Land Reallocation

The "Temporary Land Reallocation" allows for the determination of the approximate placement of landowners inside the hydraulic network frame (blocks) and the landowners list affected in each block, taking into account factors listed below:

- Existing "plus-value" e.g. building, house, well, or rock mass.
- Existing parcel within the "block".
- Landowners requirements and wishes.
- Existence of a dominant class of soil inside a "block".
- Existence of a parcel whose value is higher than the mean of all parcels of a specific area.

4.3 Definitive Land Reallocation

The "Definitive Land Reallocation" involves knowing the exact position and the "definitive" location of each landowner's parcel in a specified "block".

It's more than a geometric problem, because the operator has to take in account more than one constraint:

- The value of the new parcel.
- The value of the block.
- The soil types.
- The "plus value", which could be a house, well, or other variable.
- The types of irrigation networks ("trames" in french).

Once achieved, the implementation of land reallocation could be carried out. However, one of the main problems with land consolidation in general, and land reallocation in particular, is the manipulation and combination of qualitative and quantitative data. To overcome this challenge, a new approach has been developed for "Temporary Land Reallocation".

5. NEW APPROACH TO LAND REALLOCATION

The determination of landowners list is a time consuming when using conventional methods. To resolve this problem, the request model for land reallocation becomes an absolute necessity and a sine qua none condition for good data management and consequently a successful land consolidation project. Before the elaboration of the request model to determine the landowners list inside the blocks, a questionnaire was created and sent to the people involved in the land consolidation project (local authorities, private companies, governmental offices, etc).

5.1 Results of the Survey

From the results, a model was developed by assigning weights for each block, taking into account prioritized criterions and various constraints.

Given the fact that weights are different from one region to another, it was decided to attribute numerical value to each criterion by two methods:

- Closed method (by default), and
- Open method (by choice of the user).

In the first method, weights are fixed and the user is not allowed to change them. The assignment of these weights is based on the synthesis of the survey results.

The second method allows the user to enter the weights, according to each criterion that is considered important or has priority for land reallocation. The development of this option affords the users the opportunity to work according to the specificity of every region.

5.2 Determination of Owners Weights

As previously stated, the determination of landowners weights inside a block was based on criterions and constraints of land reallocation, and also on the questions survey. Consequently, every criterion is attributed with a value according to its quality and its importance.

In order to emphasize the importance of the ”PLUS VALUE”, it was decided to give this criterion the highest weight. In this way, it’s assured that the farmer or the landowner who has a ”plus value” will be served first, i.e. selected and reallocated into the appropriate block. The weights were applied to the closed method only, as follows:

Criterions and constraints	Weight
“Plus values”	50
Possession a parcel inside a block	20
Landowner wishes	15
Dominant soil type	10
Existence of a parcel whose value is higher than the mean of all parcels of a specific area	7
Existence of a parcel whose value is lower than the mean of all parcels of a specific area	4
Closeness to the village	3

5.3 Landowner Reallocation Algorithm

The applied methodology for determining the landowner lists to be reallocated within a block is based on the following algorithm:

- Calculate the numerical value for each landowner, on the basis of criterion priorities inside of each block.

- Calculate the sum of numerical values of the landowners in each block.

- Classify blocks in ascending order according to the sum of numerical values.

- Determine the landowners to reallocate, starting with the block which has the maximum points of landowners.

- Reallocate the landowners possessing the ”plus value” in the specified block.

- Determine the landowner lists to be reallocated by priority order, and by comparing the sum of reduced value landowners with the value of the block.

- Proceed in the same way for other blocks, each time eliminating the reallocated landowner.

With this method, the landowners possessing the maximum of points will be the first selected inside a specified block. The operation is repeated by iteration until the land consolidation operator is satisfied.

The adjustment of the block value with the total value of landowners will be achieved interactively, if it is deemed necessary. Determination of the landowners list to be reallocated in a ”block” is realized by different possible combinations of the sum of the landowners reduced value, which should be equal to the ”block” value, with a tolerance not exceeding 1%.

Once the approximate position of new parcels and the landowner lists are established, the determination of the exact position of parcels inside the blocks consists of the follow steps. The figure 2 summarizes all these different steps.

6. DEVELOPMENT OF THE PROTOTYPE

Due to the complexity of land consolidation process, the use of data analysis tool is very important to accomplish the distinct technical steps of a project. In this case, a prototype was developed with Simple Macro Language (SML) based on PC Arc/Info. This prototype is used to deal with complex tasks in the information gathering, processing, querying, analyzing, displaying, and archiving the data base which are spatially referenced.

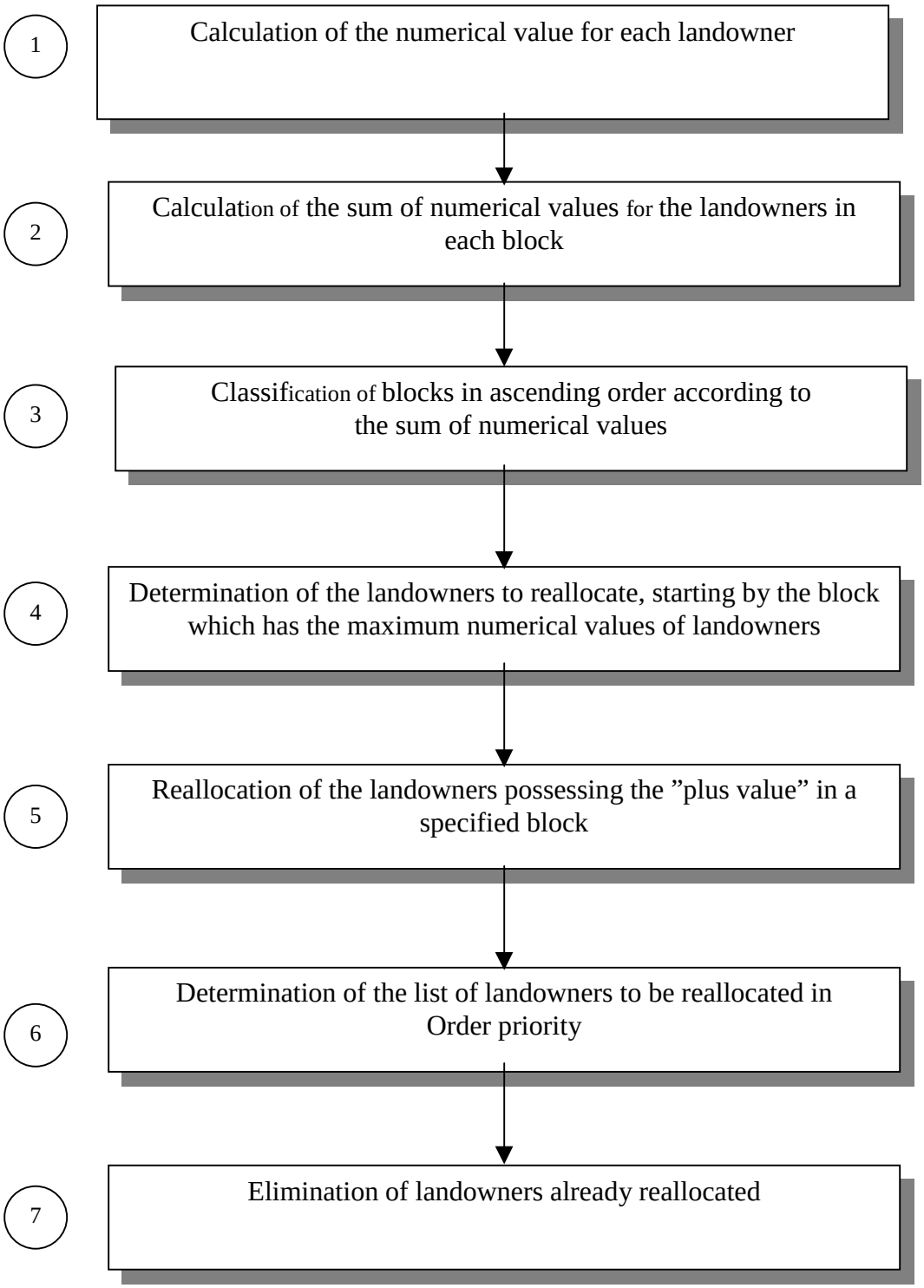

Figure 2 Post-destination algorithm for landowners

7. CONCLUSION

This study on land consolidation has had positive impact on rural land development, which is undergoing much serious discussion at many levels (in governmental agencies, in Moroccan society and in scientific research).

The new method of the "Temporary Land Reallocation" was developed by quantifying all qualitative data and thereby facilitating the use of the ArcInfo GIS software. When an actual project was tested using this application the results were achieved in only a few days instead of the weeks required originally.

Hence, the utilization of GIS is essential for the success of such projects, especially when dealing with multi-criteria data analysis.

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BIOGRAPHICAL NOTES

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