Land Use Policy 70 (2018) 463–470

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Reallocation model for land consolidation based on landowners' requests

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ARTICLE INFO

Keywords:
Land consolidation
Reallocation
Priority factor
Distribution function
Balance the blocks

ABSTRACT

In a land consolidation project, preparation of the reallocation plan is a crucial and challenging stage with many factors playing a role. It is quite difficult to identify these factors and their contributions. The most important element in the allocation stage is the opinions of the landowners regarding the new location of their parcels. Projects are more successful when landowners' opinions are evaluated and considered. Current technological developments may facilitate the inclusion of the landowners' requests in the project. The land consolidation and reallocation phase is time-consuming and complex and forms the basis of the project. The biggest problem at that stage is block balancing. Therefore, in this study, we evaluated the performance of a reallocation model to perform block distribution by evaluating landowners' requests. The model was tested in four villages (Baharlar, Calikoy, Hirka, and Sofular) of the Denizli province, Tavas district (Turkey) where land consolidation work had been done before. Using the model, the excess distribution rates in the blocks were reduced to between 0.03% and 2.09%. In addition, the fulfillment ratio of first requests was 80–90% using the model; while, it was only 66–83% when the work was done without the model. The most powerful part of the model is to process the data within minutes compared with weeks or months for the project engineer. Thus, the model should save time and improve results for future land consolidation projects.

1. Introduction

Land consolidation is the primary and most effective land management instrument to address land fragmentation problems and has been applied in many countries around the world (Crecente et al., 2002; Derlich, 2002; Magel, 2003; Van Dijk, 2003; Thomas, 2004; Van Dijk, 2007; Sklenicka, 2006; Thomas, 2006; Yaslioglu et al., 2008, 2008, 2009; Arici and Akkaya Aslan, 2014). The objectives and methodology of land consolidation are influenced by the specific conditions in different countries and regions, by their historical and more recent political and social developments, and also by natural conditions (Eichenauer and Joeris,1994; Bonfanti et al., 1997; Borec, 2000; Crecente et al., 2002; Gorton and White, 2003). Land consolidation is not just reallocation of fragmented parcels, it is an important instrument of rural development in many countries (Van Huylenbroeck et al., 1996; Van den Brink, 2004; Borec, 2000; Semlali, 2001; Crecente et al., 2002; González et al., 2004, 2007; ; Akkaya Aslan et al., 2007; Pasakarnis and Maliene, 2010). Land reallocation is inherently a spatial planning process and is the most critical, technical, and complex stage of land consolidation (Yomralioglu, 1993; Sonnenberg, 2002; Essadiki et al., 2003; Cay et al., 2010; Cay and Iscan, 2011; Ayranci, 2007; Thomas, 2006; Demetriou, 2014).

Many factors are involved in the reallocation phase, including the parcel, the landowner, and the legislative/authority, as well as economic, social, environmental, and local conditions. These criteria may vary from country to country, project to project, and planner to planner, depending on the approach used for land reallocation (Demetriou et al., 2012). The basis of the reallocation phase is the negotiations with the landowners. During these interviews, lots of information is obtained about the factors mentioned above and the landowners' preferences for their parcels are discussed. The biggest problem with reallocation is to produce optimum results that place m number of parcels, owned by n number of managements, into k number (generally constant) of blocks (Cay and Iscan, 2011).

Multidisciplinary approaches and models (Van Huylenbroeck et al., 1996; Coelho et al., 2001; Yaldir and Rehman, 2002; Hoobler et al., 2003) can be useful for the reallocation in land consolidation, and many optimization studies have been conducted using mathematical models (Avci, 1999; Ayranci, 2007, 2009; Buker et al., 1990; Girgin and Kik, 1989; Kusek, 1995). However, model results are not applicable unless the views of the landowners are considered. Models have been developed that take into account the requests of the farmers in the reallocation (Stützer, 1989; Cay et al., 2010; Cay and Uyan, 2013). In a study conducted by Stützer (1989), CARE software was developed to

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https://doi.org/10.1016/j.landusepol.2017.11.028
Received 5 January 2017; Received in revised form 13 November 2017; Accepted 13 November 2017
Available online 21 November 2017

devise a reallocation model completely based on landowners' requests and the assessment criteria of the project engineer. Cay et al. (2010) evaluated block priority and interview-based models for landholding activities in Turkey. The block priority-based model was more successful in terms of the number of parcels, parcel size, duration of the land reallocation process, project costs, and farmer satisfaction. In a 2013 study, Cay and Uyan used the Analytic Hierarchy Process method. According to this method, they defined "the largest parcel", "fixed installation", "parcel density", and "high degree" as criteria, which the farmers scored from 1 to 7 (1 = "equally important", 3 = "moderately important", 5 = "important", and 7 = "very important"). The biggest drawback with this method is the time and attentiveness required for the farmers to score each of their parcels according to four criteria in seven categories.

In the studies of land consolidation in Turkey, reallocation has taken into account the face-to-face interviews with the landowners. The landowners negotiate how many pieces of land they want and where they wish for their parcel to be. When possible, the farmers provide up to three preferences. The reallocation plan is then announced to the farmers and submitted for their approval. After the evaluation of the objections, the recreated plan is submitted again for the farmers' approval. The project is then approved by the farmers and project administration and implemented. The reallocation method applied in Turkey demonstrated that the satisfaction of landowner is important. Other researchers have also shown that the success of land consolidation is largely based on the farmers' satisfaction and acceptance (Akkaya Aslan et al., 2007; Yaslioglu et al., 2009; Kupidura et al., 2014; Lisec et al., 2014; Lou and Timothy, 2017).

This study was concerned with reducing the over-allocation of blocks in reallocation, one of the most important, time-intensive, and critical stages of land consolidation. To do this, a model was developed that considers the landowners' preferences, the spatial distribution of the land, the blocks, and the priorities. The preferences of landowners are evaluated according to the position of their property on the blocks. The model consists of two stages. In the first stage, the requests of the landowners are entered. In the second stage, the blocks are distributed on the basis of the landowners' requests and priorities. Block balancing is achieved by providing small area changes between the parcels of the landowners who have properties allocated on multiple blocks.

The model was tested in four villages (Baharlar, Calıkoy, Hirka, and Sofular) of Denizli province, Tavas district (Turkey), which were previous sites of land consolidation. The model resulted in low rates of over-allocation: 0.03% in Baharlar, 2.090% in Calikoy, 0.48% in Hirka, and 1.28% in Sofular. The landowners' requests that were used in the distribution were evaluated, and these results were compared with data from the implemented project. The percentage of 1st requests met was higher in the model than in the implemented project. The most important strength of the model is that the process was completed within minutes vs. weeks/months for the project engineer. Following the introduction, Section 2 describes in detail the model's methodology and then Section 3 focuses on the test results of the model. The discussion of the results are reported in Section 4 and the conclusions are presented in the final section.

2. Methodology

The reallocation model developed was based on the interview stage, which involves one-on-one interviews with the landowners conducted during land consolidation. Even though the main goal is to identify the n landowners with m parcels in the project site and identify how these landowners would like their new parcels to be arranged, the interview stage also involves communication and compromise. The project engineer informs the landowner about the technical aspects of the project, environmental conditions that affect these aspects, the agricultural efficiency and other agricultural aspects, and keeps the interview in line with project expectations. The project engineer engages in compromise to align farmers' preferences with project expectations. To this end, the project engineer tries to get the landowner to state multiple preferences. The landowner is informed that if their 1st preference cannot be met, their 2nd or even 3rd preferences could be implemented and the landowner acknowledges this by signing the interview form. Landowners' requests are used as model parameters in the distribution model. The next sections provide detailed information on how the Request Entry Module and the Allocation Module work.

2.1. Request entry module

The steps specified by Stützer (1989), Gundogdu (1993), Arici and Gundogdu (1992, 1997) and Gundogdu et al. (1995) were considered during the interview stage. The model aims to develop a solution for land allocation during land consolidation. Therefore, some of the data for the project need to be ready before this stage. For the model to work, the system should have been planned while considering irrigation, drainage, road networks, agricultural enterprises, and the agriculture and environmental conditions at the project site. Blocks are enclosed areas, in which parcels are placed and their planning depends on the roads, irrigation system, land topography, soil, and climate. The model was designed to include no more than three requests from a landowner. While the entry of a single request is possible, from a landowner whose single parcel or all parcels are located in a single block, two or three requests from the landowners will enhance the performance of the model. During the interview, a landowner has the chance to combine with other family members' parcels, or to be separate from them. Furthermore, requests to be adjacent to another landowner or to be further apart from any landowner can be taken into account during the interview. When receiving requests, it is necessary to obtain information from the landowner about which block and which parcel in that block is preferred. Parcel location maps should first be created for each block to incorporate this information into the model. The value of these priorities needs to be calculated, so that the three requests received from landowners during the interviews can be assessed in the model and by the project engineer.

2.1.1. Determination of the priority factor

During the interviews, the landowners' requests are used to determine the prospective location of the new parcels. The consistency of each landowner's request is assessed, taking into account the location of the existing parcels. In the model, this is defined as the *priority factor (PF)*. As shown in Table 1, the *PF* is expressed using numbers 1 through 4 (PF1, PF2, PF3, PF4). The model assigns the *PF* using the landowner's requests from interviews. For a landowner to be able to express a preference for a block, they have to have a parcel in that block. To identify how many of the parcels are in this block, coefficients a, b, and c are calculated. Coefficient a is the ratio of the area of the parcels owned by the landowner within the block preferred by the landowner to the sum of the areas of all parcels owned by the landowner overlapping the same block. Coefficient b is the ratio of the sum of the areas of the landowner's parcels overlapping the preferred block to the sum of the areas of all parcels owned by the landowner in the project area (Fig. 1).

Coefficient c is calculated by taking the average of coefficients a and b, which represents the ratio of the parcels owned by the landowner in the preferred block.

Table 1
Priority factor values.

PF	*c*	Definition
1	$c \leq 25$	Parcel/landowner to be removed from the block first
2	$25 < c \leq 50$	Parcel/landowner to be removed from the block if required
3	$50 < c \leq 80$	Parcel/landowner to be removed from the block if absolutely necessary
4	$c > 80$	Parcel/landowner to be mandatorily retained in the block.