Computers and Electronics in Agriculture 98 (2013) 8–16

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

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

A Spatial Decision Support System design for land reallocation: A case study in Turkey

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ARTICLE INFO

Article history:
Received 25 March 2013
Received in revised form 11 July 2013
Accepted 17 July 2013

Keywords:
Land consolidation
Land reallocation
Landowner
Spatial Decision Support System
SDSS-based land reallocation model

ABSTRACT

Reallocation of regular size parcels is accepted as the core of land consolidation. For fast and efficient progress in projects, usage of computer technology has been essential.

In this case study, a Spatial Decision Support System (SDSS)-based land reallocation model was developed to provide reallocating newly created regular size parcels to landowners in land consolidation projects. Reallocation results of the SDSS-based land reallocation model and conventional land reallocation models are compared. Surveys were conducted with the landowners in order to obtain their opinions of the land reallocation results. The purpose of the survey study was to determine which of the two land reallocation models they preferred. 66.1% (39 people) of the interviewed landowners stated that they were pleased with their land reallocation on the basis of the conventional land reallocation model. This compares with 89.9% (53 people) of the landowners who expressed that they were pleased with the outcome of the SDSS-based model. According to the results, the SDSS-based land reallocation model was more preferred by landowners.

1. Introduction

Although the agriculture sector maintains its importance in development processes, it encounters a lot of structural and institutional problems. As in most parts of the world, in Turkey the problems of rapid population growth appear as a result of provision in inheritance law, shared and divided sales, irrigation, track work and public investments in agricultural lands, which cause the split of agriculture land leaving dispersed, small and irregularly shaped parcels.

Land fragmentation is the biggest obstacle to sustainable agriculture. To prevent the aforementioned problems, legal and juridical arrangements are made in order to prevent more fragmentation and alteration, and also to heal already existing decrements, fragmentation and disorder. A project which rearranges agricultural lands is called land consolidation (LC). Governments and international establishments such as the United Nations, the Food and Agriculture Organisation (FAO) and the World Bank highly encourage and support LC policies.

LC is an inevitable application for increasing land processing efficiency (Blaikie and Sadeque, 2000; Niroula and Thapa, 2007) and is a device for supporting rural development (Sklenicka, 2006). It is related to social and economical reforms in a wider sense. Accordingly, LC in rural areas does not aim only to compound dispersed areas, but also to obtain the most efficiency from a unit and make necessary amendments to all aspects of agriculture to increase labour efficiency. It also takes all technical, social and cultural precautions to increase landowners' living standards. Additionally, LC is an effective device for nature conversation and coping with environmental problems (Uhling, 1989), establishing a ground for urban development (Gonzalez et al., 2004), combatting soil erosion in rural areas (Mihara, 1996), and developing rural areas and managing other social and economical problems (Quadflieg, 1997).

LC projects basically go through the following technical phases;

- Providence of property information of all farms and landowners.
- Creation of maps rating farms.
- Preparation of new block plans which match with road, irrigation and drainage networks.
- Asking landowners their opinions.
- New parcelation planning – in other words land reallocation.
- Creation of new registries for finalised new plans by cadastre.

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0168-1699/$ - see front matter
http://dx.doi.org/10.1016/j.compag.2013.07.010

The Turkish Statistical Institute (TUIK) performs a general agricultural census in Turkey decennially. According to the general agricultural census in 2001, the average parcel number per landholding, although different from region to region, is 4.08. There are 12.3 million piece of farm land in Turkey. Percentage distributions of average parcel number per landowner are the following:

- 19.46% one parcel,
- 57.40% two–five parcels,
- 16.06% six–nine parcels,
- 7.08% ten or more parcels (TUIK, 2001).

On the contrary to applications in Turkey, when investigating LC projects in Western European countries', it is seen that businesses start with private laws which are developed in a short time depending on experience (Sonnenberg, 1996; Thomas, 2005, 2006). Some LC data in Turkey are given in Table 1.

Reallocation of regular size parcels, which are created and given to landowners, is accepted as the core of LC. This process reorganises property rights. Reallocation or dissatisfaction is among the main reasons for objections. Basically, landowners' desires are assessed at the beginning of the project, where their desires should be assessed punctually. LC projects consist of various steps. Within these steps, reallocation of created parcels is a process which makes it necessary to perform some criteria with consideration of some conditions. The problems encountered in LC projects can be defined as reallocating "n" number of cadastral parcels to "m" number of blocks (Cay and Iscan, 2011). Computer support for the reallocation process is not frequently considered. There is a set of mathematical models in the open literature which is developed for solving reallocation problems (Ayranci, 2007, 2009; Cay and Iscan, 2011; Semlali, 2001). These models cannot give acceptable results because the reallocation process interests a lot of landowners, and it is nearly impossible to satisfy every one to the same level.

Since the human brain has a limited capacity for information storage and processing, it is possible to make mistakes or errors in analysis at the decision-making stage. This situation reduces decision-making efficiency and effectiveness. Decision Support Systems (DSS) can have an enhancing effect on the cognitive performance of decision makers. As a computer's data processing capability is faster and more trustworthy than humans', the time limit effect can be reduced by using DSS (Topcu, 1999). The concept of a Spatial Decision Support System (SDSS) emerged as a leading paradigm in the solution of complex problems (Prastacos and Prinet, 2004). SDSS are computer-based systems which are designed to provide high success to a user or a group of users regarding spatial-based decision problems (Malczewski, 1999). Nowadays, these systems are applied in various areas related to spatial or regional variables (Zou et al., 2008). SDSS is a computer-based system which aims to help decision makers (Armstrong et al., 1991; Densham, 1991).

Armstrong and Densham (1990) have offered five key modules which are necessary for an SDSS. These are:

Table 1
LC datas in Turkey.

	Subject	Area (Ha)
1	Total consolidation area	14.0 million
	Irrigated farming area	8.5 million
	Dry farming area	5.5 million
2	Consolidated area (1960–2010)	1.1 million
3	Ongoing consolidation area (2011)	2.4 million
4	2010–2014 Strategical plan target	5.7 million
5	Area to be consolidated after 2014	4.7 million

- A database management system (DBMS).
- Analysis processes in a model-based management system (MBMS).
- A graphical view producer.
- A report producer.
- An interactive user interface.

Recently there have been a lot of studies about SDSS (Eldrandaly et al., 2003; Kurtural, 2005). They are also used as proper devices in studies about sustainability of SDSS land sources (Alexander, 1997; Banai, 2005; Laskar, 2003; Murphy, 2003; Wang, 2001). Cohen et al. (2012) developed a model to predict plot infestation level with V. dahliae prior to potato production, by implementing expert knowledge and a MCA mechanism, and developed a SDSS for optimising crop rotation toward reducing the risk of VW expression. Eldrandaly (2010) developed a prototype Gene Expression Programming-based Spatial Decision Support System for multisite land use allocation. Wang et al. (2010) developed an integrated land use assessment and Spatial Decision Support System (IA-SDSS) for consideration of carbon sequestration. In the literature there are not examples of the use of the SDSS method in the field of LC and reallocation.

In this case study, SDSS-based land reallocation software (AT_MKDS V 1.0) is developed for providing an overachievement for experts who take part in LC projects and in reallocation of newly created regular size parcels to landowners. This software is a system that allows cadastres and block registries, land degrees, and application borders to be processed easily for use in LC projects, supported by graphical views. It automatically reallocates new blocks to landowners according to determined criteria and provides the highest level of decision support for decision makers. In the study, the system will be called an SDSS-based land reallocation model.

2. Material and method

2.1. Study area

The main material of the research is comprised of LC project data collected from Alanozu Village, Guneysınır District of Konya Province (Fig. 1). The topographical structure of the project area is generally flat and close to flat. The area is irrigated by existing groundwater wells.

The area of the Alanozu Village land consolidation project is 153 ha (150 ha as agricultural land, 3 ha as pasture). There are 333 landowners and 683 cadastral parcels in the consolidation field. In total, 53 of these cadastral parcels are shared parcels. The average size of cadastral parcels is 0.2236 ha. The intercommunication system length is 6.587 m and the number of parcels that are directly used in the intercommunication system is 260 (21%).

Documents of cadastral parcels, grading maps, interview forms and information on the area, owners and other rights of the parcels were obtained from the Agricultural Reform Regional Directorate (TRGM). Block plans were processed on the cadastral map. Eighteen agricultural blocks were formed in block plans (Fig. 2).

2.2. Methodology

LC projects consist of various steps. Within these steps, land reallocation is the most important and a time-consuming stage of LC studies. It is crucial for social peace to conduct land reallocation studies in such way to meet the demands of landowners and also the principles of equity and justice. The problem encountered in LC projects can be defined as reallocating "n" number of cadastral parcels to "m" number of blocks. Reallocation studies rely on interviews with landowners. Initially, the preferences of the