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A Model of Automatic Block Reallocation in the Land Consolidation Projects Using Artificial Bee Colony Algorithm

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Abstract:Equitably reallocating of blocks among land owners has been one of the most important tasks in Land Consolidation studies. This task has to be fairly solved among landholdings for a land. This complicated problem is difficult to solve using linear methods. Therefore, a method is needed to solve this non-linear problem among land owners impartially. There are many applications employing optimization algorithms for solving the complicated and non-linear problems in literature. When we examine the literature, it is seen that Genetic Algorithm has been only used to overcome the block reallocation problem. Artificial Bee Colony (ABC) algorithm is one of the optimization algorithms that have been used to solve the non-linear and complicated problems in literature. Furthermore, this method has better performance when it is compared with the other optimization algorithms. In this study, we have aimed to fairly reallocate the landholding areas to blocks in a land by developing an algorithm using Artificial Bee Colony optimization method. When we develop the steps of the algorithm, we give priority to landholdings preferences and places of fixed installations. Data tables have been arranged by taking land consolidation data of DOT Village in Adiyaman, Turkey that into consideration. DOT Village land consolidation project includes 143 blocks and 225 landholders. Consequently, we have introduced the steps of an algorithm solving the block reallocation problem automatically using ABC for a sample land. Also, we have observed the applicability of the proposed method for automatic block reallocation problem in this study. This study is a preliminary study helping us to develop software providing to automatically solve complicated block reallocation problem in real time land consolidation process

Keywords:*Artificial Bee Colony Algorithm, Land Consolidation, Automatic Block Reallocation, Landholding, Optimization*

1. Introduction

Land consolidation (LC) is an important component of determining the country farmland rational development utilizing and improving the sustainable use of land resources. Traditionally, LC is the most favourable land management approach for solving land fragmentation and it has been applied in many countries around the World [1]. Land consolidation aims to change land ownership by redistribution providing fewer, more compact, contiguous and larger land parcels for individual owners [2,3]. Land consolidation (LC) is a highly complex for spatial planning process because it involves many tasks, actors (landowners, rural engineers, local and regional administrations, consultants) [4]. Lands of landholdings in Turkey are jointly owned, fragmented, away from each other and in irregular geometric shapes. As a consequence of that, because of non-monolithic parcels, increasing in workforce demand, a great loss of time and un-cultivated areas, agricultural landholdings can't use modern farming methods. Therefore, agricultural productivity decreases constantly. Besides, agricultural parcels continue to be fragmented because of inheritance provisions, sale, newly opened roads and irrigation channels. This situation makes LC projects necessary on agricultural areas [5]. One of the important objectives of studies in agricultural LC is to increase agricultural cultivation and to eliminate the problems in the agricultural structure. Land reallocation is the most important stage of LC studies and a tool to rearrange proprietary rights. In reallocation of parcels and their emplacement on lands, there are some technical obligations such as farmer's wishes, fixed installations, roads and irrigation network and the most suitable dimension, geometry, size and direction of parcels. These obligations can be easily overcame in the LC projects by using new computer technologies employing mathematical models [6].

LC projects consist of various steps. Within these steps, land reallocation is the most important and a time-consuming stage since high number of criteria are considered. Land reallocation 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 [7]. Many different solutions have been suggested for the land reallocation process. These are based on many mathematical models; model based on block priority [8–10], special-purpose interface program to perform land reallocation [11,12], a new model approach in reallocation [13], application of fuzzy logic in land reallocation [7], using the analytic hierarchy process in land consolidation [14], using the planning and decision support system in land consolidation [1], theoretical framework and application of the land-redistribution modules [15], using genetic algorithm to land reallocation of land consolidation [16], a spatial genetic algorithm for automating land partitioning [17], a preliminary study for design of automatic block reallocation algorithm with genetic algorithm method [5], comparison of

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designed different land reallocation models [6].

Although Artificial Bee Colony (ABC) algorithm has been recently improved, there are lots of studies using ABC in literature. Karaboga and Basturk compared the Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Particle Swarm Inspired Evolutionary Algorithm (PS-EA) and Artificial Bee Colony Algorithm (ABC) in the optimization of some numerical functions and they reported that ABC was better [18]. Aydin et al. were modified the ABC algorithm and they developed the Incremental ABC algorithm in which population size was grown over time and local search was applied [19].

Heuristic methods like swarm intelligence have been employed in complicated problems that are difficult to solve. These methods simulate the social behaviours of animals like bird flocking or fish schooling. Artificial bee colony (ABC) and genetic algorithm (GA) are examples of the heuristic methods. Solutions of automatic block reallocation problems in land consolidation studies are difficult and this problem has been solved by traditional methods such block priority based. However, as artificial intelligent systems like the heuristic methods develop, the solution of such complicated problems is getting easier. Genetic algorithm (GA) is one of optimization algorithms. This optimization method was firstly demonstrated for solving the automatic block reallocation problem in land consolidation projects in some studies [5,20]. Moreover, it was concluded that the optimization methods was more successful than traditional one to reallocate the blocks in a land consolidation project [20]. Artificial bee colony algorithm (ABC) is an optimization algorithm which can solve non-linear and complicated problems. This method was firstly proposed in 2005 by DervişKaraboga [18,21]. When ABC is compared with the other optimization algorithms, it is seen to produce good results for complicated problems described in literature. [22]. In this study, we propose an algorithmic model that can automatically solve the block reallocation problem in consolidation of a land using ABC. The steps of this model are described in results.

In this paper, we described the steps of an algorithm to solve the block reallocation problem among landholders for the land found in DOT village, Adiyaman-Turkey using ABC. ABC algorithm is preferred because it is swarm intelligence and said to be better than the other optimization algorithms. In Sect. 2, the proposed ABC algorithm and some materials are described; in Sect. 3 results and discussion are presented; in Sect. 4 conclusion is given.

2. Materials and Methods

2.1. Block Reallocation in Land Consolidation

The problem encountered in LC projects can be defined as reallocating “n” number of cadastral parcels to “m” number of blocks. To this end, optimization studies have been conducted for land reallocation process [7]. The remaining amount after deducting the share from the total land amounts of each landholding in land consolidation area is placed in blocks, if possible, in a single piece and as parcels in proper geometrical shapes. In this location process; preferences of farmers, fixed installations and provisions of related legislation must be taken into account. As for this situation, new parcels can be placed in blocks in many different ways. Therefore, multiple options and solutions emerge in this process. The aim is to find the most appropriate solution for our goals. For this reason, block reallocation problem can be defined as an ‘optimization’ process [5].

2.2. Application Area

The study area, Dot Village is located in the east of Adıyaman Province (Figure 1). It is situated 12 km along from Kahta district and 35 km along from Adıyaman city centre. Its altitude is 660 m. Settlement area is on the hill and Atatürk Dam Lake coast. Çataltepe east of the village, west Sarısu village, north Arılı and Zeytin villages, on the south west Beşaltı hamlet is located in the south Büyükbey village. Settlement area is between 38.170 East longitude and 37.450 North latitudes. Dot village LC project area is 1605.84 hectares. There are 225 landholding and 143 blocks in the LC project area. There are 352 cadastre parcels and 688 numbers of shares in the LC project area. Preference of 3 different blocks is made for each share.

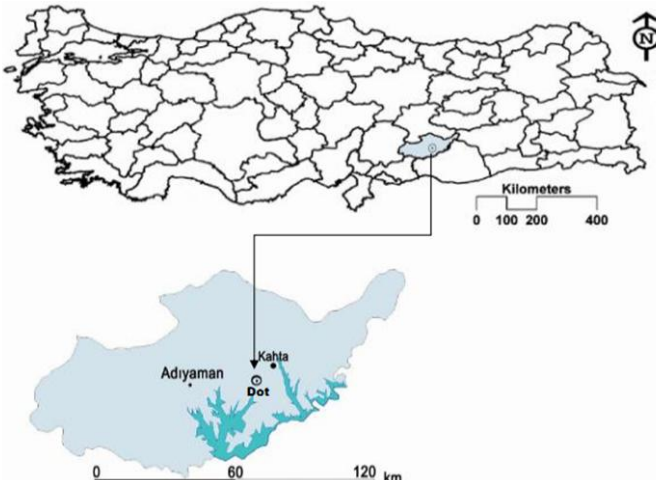

Figure 1. Study Area

2.3. Data Tables and Constraints

Two data has been prepared for block reallocation. The first data include areas of cadastral parcels, the first degree fields of cadastral parcels prepared according to the index map and farmer preferences. According to the data; there are 225 landholdings, 352 cadastral parcels and 688 numbers of shares in the LC project area. Total of the first degree areas in cadastral parcels is 9,528,608.84 m2 in the LC project area.

The second data include block areas and the first degree block fields. According to the data; there are 143 blocks in the LC project area. Total of the first degree areas of blocks is 9,528,608.84 m2 in the LC project area. Cadastral parcels and block plan of DOT village are displayed in Figure 2 and Figure 3 respectively.

The constraints of block reallocation process are in the following:

1- The first degree areas of the parcels.
2- Three preferences for parcel shares of landholdings.
3- Fixed installations.
4- Defendant parcels and grasslands located in multiple blocks.

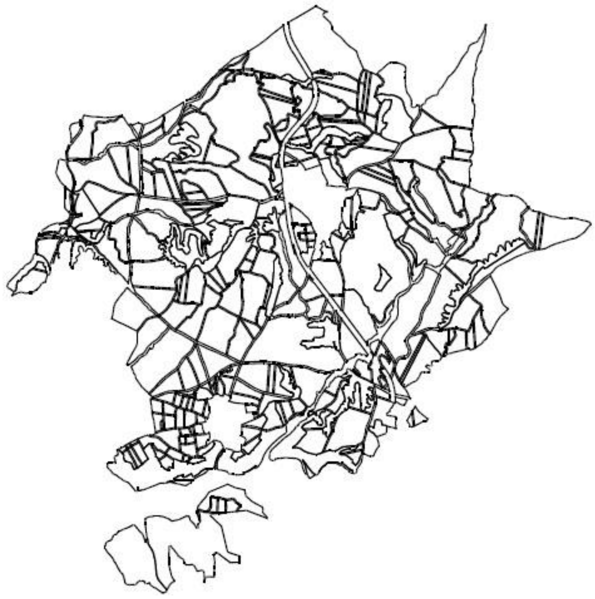

Figure 2. Cadastral Parcels of DOT Village

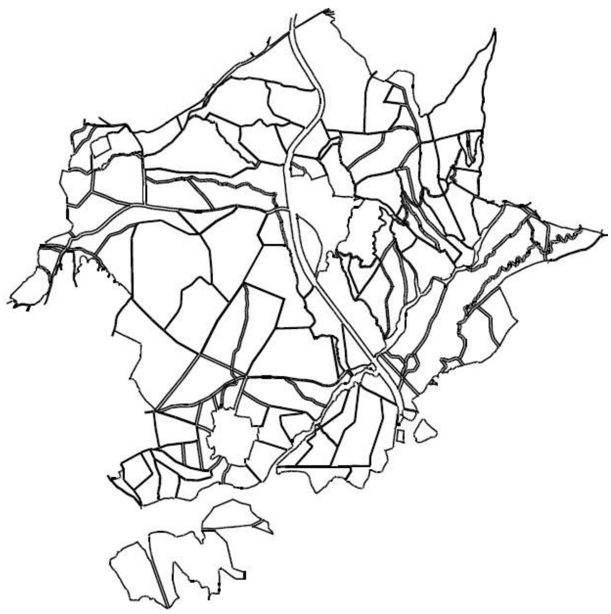

Figure 3. Block Plan of DOT Village

2.4. Artificial Bee Colony Algorithm

Artificial Bee Colony algorithm was firstly proposed as an optimization algorithm by Karaboga in 2005 [18,21]. Karaboga artificially simulated the intelligent behaviours of bees in a real bee colony to solve multidimensional optimization problems. There are three groups of bees which are employed, onlookers and scouts bees in the artificial bee colony model. Initially, colony is divided two parts. The first part of the colony includes the employed bees and second part consist the onlookers. In the artificial bee colony the numbers of food sources are equal to the number of employed bees in the artificial colony. The employed bee becomes the scout after the related food source is exhausted by the bees. The pseudo-code of ABC algorithm is given in the following Figure 4 [18,21].

- INITIALIZE.
- REPEAT.
  - (Step-1)Place the employed bees on the food sources in the memory;
  - (Step-2)Place the onlooker bees on the food sources in the memory;
  - (Step-3)Send the scouts to the search area for discovering new food sources.
- UNTIL (requirements are met).

Figure 4. The main steps of ABC algorithm

2.5. Application of Algorithm

Our model includes three external functions. These three functions generate population according to the constraints expressed in section 2.C (function 1), calculate the fitness of population (function 2) and select best population (function 3) respectively. A population in our model includes 100 rows (ensembles) and columns as the number of landholder. Each column stores block numbers in which one landholder area is located. Each landholder areas are randomly distributed to the blocks except fixed installations in each ensemble. Our model proposes to select the best ensemble in the population.

In the algorithm process, we set the initial values such that colony size (number of employed bees + number of onlooker bees) was 100; maximum cycle number in order to terminate the algorithm was 2000; number of parameters of the objective function was 225; control parameter in order to abandon the food source was 100 and number of the runs was three.

Generating of population worked as an external function in the model. This function was designed such as; areas of landholders having installations were fixed to their blocks for each ensemble in the population because the fixed installations found in the block areas couldn't be changed. So this situation was a limitation in the block reallocation process. Areas of landholders having no fixed installations were reallocated to remaining blocks in the model. Areas of landholders having no fixed installations were fixed to first preferences and second preferences in the first and second ensembles of populations respectively. Third ensembles of population were generated such as; areas of landholders having second preferences but third preferences and having three preferences were jointly fixed to their preferred blocks in third ensembles. The rest of the ensembles of the population were composed such that the blocks were randomly reallocated for landholders regardless of their preferences.

Fitness function worked as an external function in our model too. When one ensemble in the population was tested with the fitness function in our model, we calculated the settled areas and assessed the remaining areas information in m2 for each block. And, we calculated settlements status to the first, second and third preferences for each landholder. Lastly, arithmetic means of these outputs assessed the fitness status for each ensembles of population.

3. Results and Discussion

In this study, we proposed to prepare the data tables of a land founding DOT village, Adıyaman Turkey. Moreover, a model was secondly developed to apply automatic block reallocation in the land consolidation project. This model aimed to use ABC algorithm. When we determined to use ABC for block reallocation in land consolidation projects, the previous studies in literature were examined and this algorithm was observed to be more feasible than the other optimization algorithms. As a result of the study, we developed the pseudo codes of the model and the flow chart of the algorithm applying automatic block reallocation

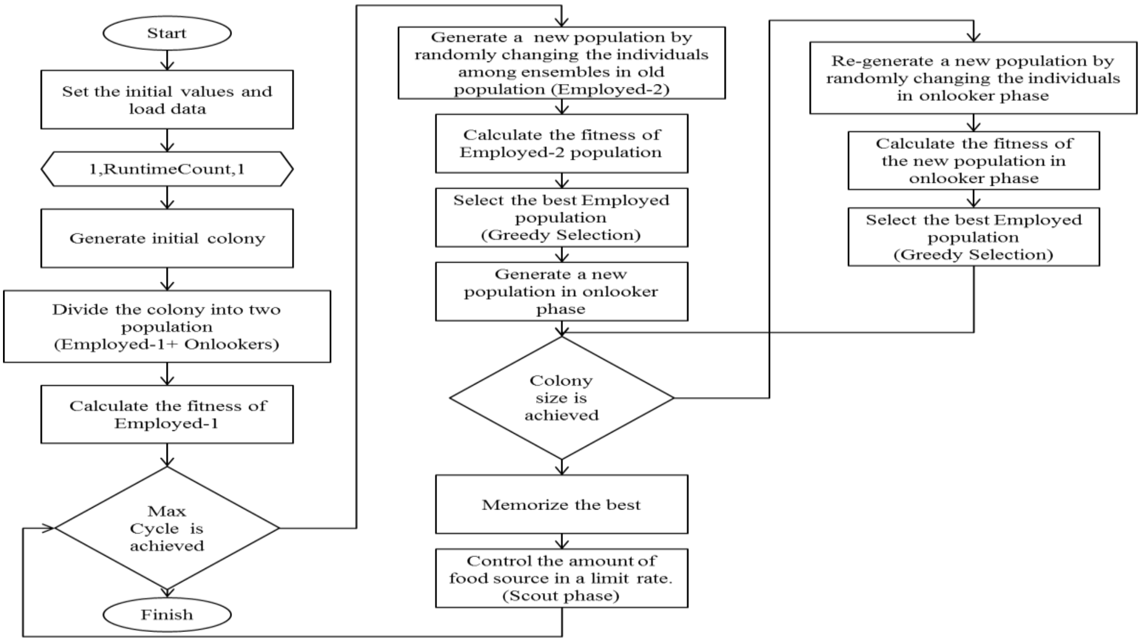

Figure 5. Flow chart of the proposed algorithm

process. The flow chart (in Figure 5) and the general pseudo code of the study are given in the following;

Step 1. Set the initial values (Colony Size, Max Cycles, Run Time, Number of Parameters of objective function)

Step 2. Load data belonging to the all areas and blocks

Step 3. Set the global minimum (The amount of empty area in blocks must be min).

Step 4. If runtime number is achieved, finish the loop else go to next step.

Step 5. Generate the initial colony

Step 6. Divide the colony in two parts for employed and onlookers bees phases.

Step 7. Calculate the fitness of the employed colony

Step 8. If max cycle is achieved, finish the loop else go to next step.

Step 9. Change the individuals among ensembles as much as employed population size and derive the new population.

Step 10. Calculate the fitness of the new generated employed colony.

Step 11. Greedy selection between the old and new employed colony.

Step 12. Normalize the preferred colony.

Step 13. If the population size of onlookers is achieved finish this loop else go to next step.

Step 14. Change the individuals among ensembles as much as onlookers' population size and derive the new population.

Step 15. Calculate the fitness of the new generated onlookers' population.

Step 16. Greedy selection between the old and new onlookers population

Step 17. Go to step 13.

Step 18. Memorize best.

Step 19. Control the amount of food source in a limit rate. (Scout phase)

Step 20. Go to step 8.

Step 21. Go to step 4.

4. Conclusion

In this study, required model to apply the land reallocation using artificial bee colony algorithm in the land consolidation projects were designed. In this design, the first three steps before stage of writing codes with artificial bee colony algorithm for land reallocation were completed. Namely, data tables were prepared for a project land and reallocation conditions, constraints were identified for an example landholding and pseudo code and flow chart of block reallocation algorithm were prepared. In the future study, the codes of the block reallocation algorithm will be written according to developed these three steps.

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