# A Preliminary Study for Design of Automatic Block Reallocation Algorithm with Genetic Algorithm Method in the Land Consolidation Projects

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*Abstract*—Land reallocation is one of the most important steps in land consolidation projects. Many different models were proposed for land reallocation in the literature such as Fuzzy Logic, block priority based land reallocation and Spatial Decision Support Systems. A model including four parts is considered for automatic block reallocation with genetic algorithm method in land consolidation projects. These stages are preparing data tables for a project land, determining conditions and constraints of land reallocation, designing command steps and logical flow chart of reallocation algorithm and finally writing program codes of Genetic Algorithm respectively. In this study, we designed the first three steps of the considered model comprising four steps.

*Keywords*—Genetic algorithm, land consolidation, landholding, land reallocation.

## I. INTRODUCTION

PARCELS of landholdings in the agricultural areas are jointly owned, fragmented, away from each other and in irregular geometric shapes. As a consequence of that, agricultural landholdings can't use modern farming methods. Because parcels of landholdings are not monolithic, work force demand increases, a great loss of time and areas that can't be cultivated occur. Therefore, agricultural productivity drops constantly. Besides, agricultural parcels continue to be fragmented through inheritance provisions, sale, newly opened roads and irrigation channels. This situation entails land consolidation on agricultural areas.

One of the most important aims of land consolidation project applied in order to reform agricultural areas is to increase the agricultural productivity. However, this activity is carried out on the land that is fundamental for life and it is to be used sustainably to meet the needs of future generations [1].

Land consolidation is a necessary project to modernize rural area, to make it economically livable place and to ease environmental management [2]. This process can be performed by thinking of economic, environmental and social factors sophisticatedly [3]-[5].

The most complicated and the hardest step of land

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regulation projects is land reallocation. In constitution of new parcels and their placement on lands, there are some technical obligations such as farmer's wishes, fixed installations, roads and irrigation network, the most suitable parcel dimension, parcel geometry, parcel size and parcel direction [6]. At the same time relationship of adversary and relative, difficulty in leaving the lands that inherit from fathers and grandfathers are to be taken into consideration [7]. Land owners do not want their lands to change place not only because of economical, but also emotional reasons [8].

The developments in computer technology have enabled to analyze complex and economical relationships and unclear events, and to apply techniques to submit analyses as decision-making help for users. These methods, which provide to detect mathematical models of the systems and them to be optimized to an applicable status for planning, have been the subject of numerous studies in the purpose of eliminating the gap at this stage and reallocation to be the most economical [9].

In the literature, several methods have been developed for block (land) reallocation. Some of these are; Model Based on Block Priority, [10]-[12] Special-purpose interface program to perform land reallocation, [13], [14] Algorithm development for land consolidation software, [15]; Use of transportation models, a special case of linear programming in block reallocation, [16] A new model approach in reallocation, [17] Application of fuzzy logic in reallocation, [15], [18] Application techniques of spatial decision support systems in block reallocation, [19], [20].

Because it is not possible to use mathematical operations for a problem that cannot be solved with the help of continuous mathematical functions, development of methods that function numerically has overly been seen recently. The most actual of these is the modern optimization method, named as genetic algorithm [21].

In this study, required preliminary studies were done for being able to apply land reallocation with genetic algorithm in the land consolidation projects. In this design, the first three steps before stage of writing codes with genetic algorithm for land reallocation were completed. Data tables were prepared for a project land and reallocation conditions and constraints were identified for an example landholding, and then instruction steps and flow chart of block reallocation algorithm were prepared.

## II. DEFINITION OF BLOCK REALLOCATION PROBLEM

In the area for land consolidation, Fig. 1 (a), roads and

irrigation channels are firstly passed according to land's topography. Blocks are properly polygonal areas, which roads and irrigation channels surround, Fig. 1 (b).

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 can be defined as an 'optimization' process. Because the optimization is to investigate the perfect solution in a direction that is approaching the goal by considering the additional information that can be obtained using information and data emerging after determining the goal. At the same time, the optimization is coexisting of multiple solutions of a problem that are not equivalent but slightly near [21].

In this situation, genetic algorithm, which is one of the optimization methods, can be used in block reallocation. Because genetic algorithms offer different solutions based on natural probabilities [22].

### A. Design of Automatic Block Reallocation Algorithm with Genetic Algorithm Method

A design of genetic algorithm for developing block reallocation may consist of four steps: (1) preparing data tables for a project land, 2) determining the conditions and constraints in block reallocation, (3) designing command steps and logical flow chart of reallocation algorithm; (4) developing the program codes of genetic algorithm according to this flow chart. In this study, first three steps were completed.

### B. Preparation of Data Tables

Two data tables were prepared. The first table consists of landholdings' first degree areas, their fixed installations, landholdings' remaining areas from fixed installations and preferences of landholdings, Fig. 2 (a). The second table has been created from the first degree areas of blocks, in which the landholding areas will be placed, Fig. 2 (b).

In Fig. 2 (a), three preferences for landholdings have been made. For the areas of landholdings that have fixed installations, one preference has been made; for the remaining areas, three preferences have been made. In Fig. 2 (b); block areas are shown, in which landholding areas are placed.
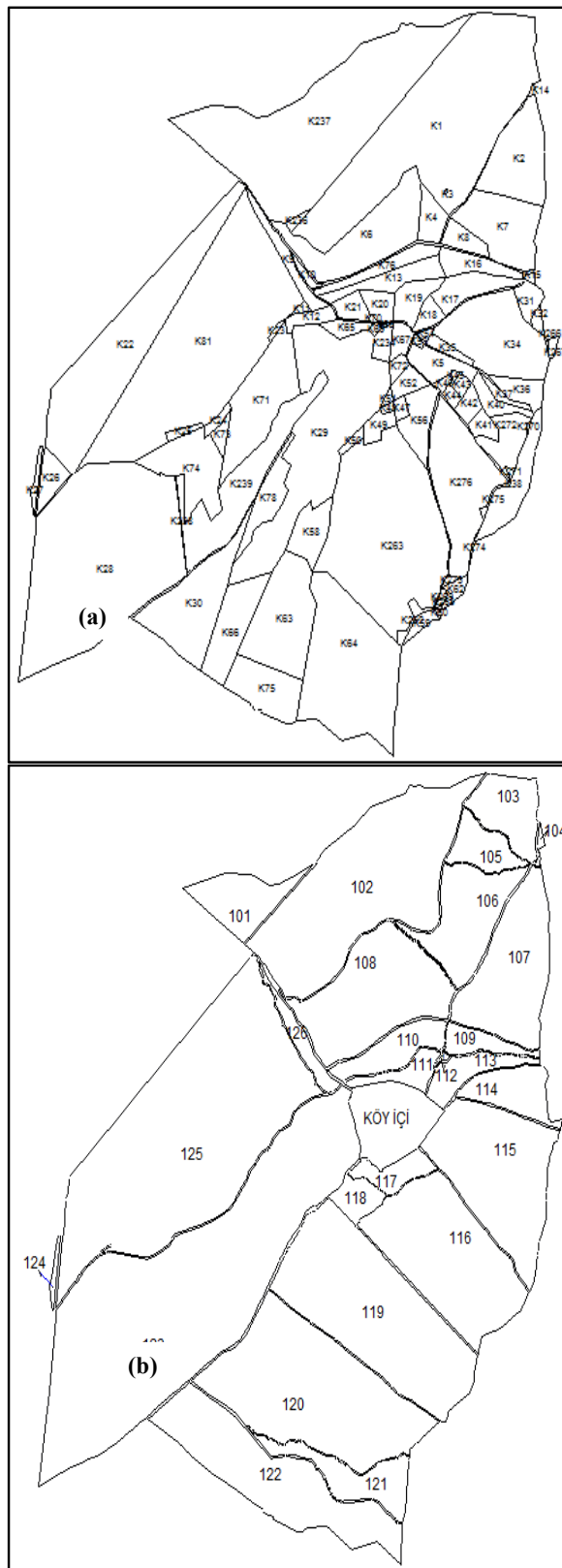


Fig. 1 (a) Land Consolidation Project Area and (b) Block Plan

| Landholding No | fixed installation No | Definition of fixed installations | 1.Degree Area (m²) | Remaining Area (m²) | Preference Block No | | |
|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 |
| 5 | | | 422086.88 | | | | |
| | 5-1 | Share Consolidation | 14232 | | 108 | | |
| | 5-3 | Share Consolidation | 6000 | | 113 | | |
| | 5-4 | Share Consolidation | 9610 | | 114 | | |
| | 5-5 | Share Consolidation | 59386 | | 115 | | |
| | 5-6 | Share Consolidation | 52754.1 | | 121 | | |
| | 5-7 | Share Consolidation | 9796.14 | | 120 | | |
| | 5-8 | Share Consolidation | 25845.47 | | 126 | | |
| | 5-g | | | 244463.17 | 119 | 122 | 123 |
| 6 | | | 465942.64 | | | | |
| | 6-1 | Cemetery | 8150.88 | | 113 | | |
| | 6-2 | Tomb | 79833.32 | | 123 | | |
| | 6-3 | Tomb | 377958.44 | | 125 | | |
| | 6-g | | | 0 | | | |
| 7 | | | 202870.18 | | | | |
| | 7-1 | Meadow | 21531.52 | | 118 | | |
| | 7-2 | Meadow | 131640.48 | | 119 | | |
| | 7-3 | Meadow | 49698.18 | | 123 | | |
| | 7-g | | | 0 | | | |
| 10 | | | 774919.74 | | | | |
| | 10-1 | Garden | 154241.11 | | 102 | | |
| | 10-2 | Garden | 42746.07 | | 106 | | |
| | 10-2 | Garden | 90841 | | 107 | | |
| | 10-3 | Vineyard | 178700.93 | | 108 | | |
| | 10-4 | Vineyard | 22002.51 | | 116 | | |
| | 10-g | | | 286388.09 | 115 | 122 | 123 |

| Block No | 1.Degree Area Of Block (m²) |
|---|---|
| 101 | 72247.51 |
| 102 | 377895.85 |
| 103 | 65518.06 |
| 104 | 2080.68 |
| 105 | 41603.40 |
| 106 | 122135.45 |
| 107 | 175443.74 |
| 108 | 192932.93 |
| 109 | 27564.46 |
| 110 | 55021.16 |
| 111 | 27829.63 |
| 112 | 1270.94 |
| 113 | 40869.87 |
| 114 | 58240.98 |
| 115 | 184330.76 |
| 116 | 109693.16 |
| 117 | 31444.13 |
| 118 | 21531.52 |
| 119 | 318917.75 |
| 120 | 353287.26 |
| 121 | 52754.10 |
| 122 | 198264.72 |
| 123 | 736463.90 |
| 124 | 5129.41 |
| 125 | 614285.50 |
| 126 | 25845.47 |
| Total | 3912602.35 |

(a)          (b)

Fig. 2 (a) Table view of Landholdings' 1.Degree area, fixed installations and preferences (b) Table view of Landholdings' 1.Degree areas

### C. Reallocation Conditions and Constrains

In order to apply genetic algorithm in block reallocation, conditions and constraints in block reallocation are needed to be determined at the first step. If these conditions and constrains are determined for block reallocation of a landholding, they can also be used for that of other landholding areas. The conditions and constrains identified for modeling are preferences of landholdings and fixed installations. At the second step, two genetic algorithm data tables have been prepared.

If reallocation conditions and constrains for one landholding are determined, they will also apply to other landholdings. These are shown as follows;

A = Landholding Areas.

F = Block Areas.

A5g = Remaining land out of the landholding's fixed installation lands.

The fixed installations areas of landholdings will be placed at the first step. Because fixed installations areas are determined on land or orthophoto maps given in Fig. 3, area at the first preference will not be bigger than its own value and will locate. Otherwise, the program should give an error message, because it means that there is an entry error.

At the second step; the remaining areas from fixed installations of landholdings will be placed in three preferences that are specified at the first table. Because places of landholding areas are fixed at the first step, genetic algorithm will be applied for the remaining areas of

landholdings at the second stage. In Fig. 2 (a), landholding no. 5 has been chosen as sample.
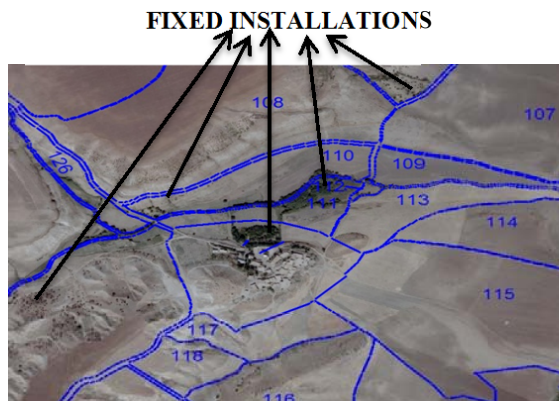


Fig. 3 Condition of Blocks and Fixed Installations on Orthophoto Map

The reallocation conditions and constrains for this landholding have been created according to fixed installation and preferences:

1) If there is a fixed installation, if A5-1 is less than or equal to F108, place it at the first preference. If not, give an "entry error" message.
2) Continue with this operation, until the parcels that have fixed installation areas are over.
3) Take the next step.
4) If landholding has a remaining area, if A5g is less than or equal to the 1.preference area (F119), if there are fixed installation parcels choosing the same block (F119) at the 1.preference, determine the number of them. Divide the areas preferred for this block into the parcel number preferring the same block. For A5g, place in the 1.preference as much as the emerging area. If not (if there are no other fixed installation parcels choosing the same block (F119) at the first preference), place A5g in its 1.preference. If A5g is greater than the 1.preference area (F119), if there are fixed installation parcels choosing the same block (F119) at the first preference, determine the number of them. Divide the areas preferred for this block into the parcel number preferring the same block. For A5g, place in the 1.preference as much as the emerging area. If not (if there are no other fixed installation parcels choosing the same block (F119) at the first preference), place from A5g as much as F119 area in the 1.preference (F119).
5) Calculate the remaining area of A5g. If the remaining area of A5g is less than or equal to the 2.preference area (122), if there are fixed installation parcels choosing the same block (F122) at the 2.preference, determine the number of them. Divide the areas preferred for this block into the parcel number preferring the same block. For the remaining area of A5g, place as much as emerging area in the second preference. If not (if there are no other fixed installation parcels choosing the same block (F122) at the

second preference), place the remaining area of A5g in the second preference. If the remaining area of A5g is greater than the 2.preference area (F122), if there are other fixed installation parcels choosing the same block (F122) at the second preference, determine the number of them. Divide the areas preferred for this block into the parcel number preferring the same block. For the remaining area of A5g, place in the second preference as much as the emerging area. If not (if there are no other fixed installation parcels choosing the same block (F122) at the second preference), place from the remaining area of A5g as much as F122 area in the second preference.

6) Calculate the rest of the A5g area.

7) If the rest of the A5g area is less than or equal to the 3.preference area (F123), if there are fixed installation parcels choosing the same block (F123) at the 3.preference, determine the number of them. Divide the areas preferred for this block into the parcel number preferring the same block. For the rest of A5g area, place in the third preference as much as the emerging area. If not (if there are no other fixed installation parcels choosing the same block (F123) at the third preference), place the rest of the A5g area in its 3.preference. If the rest of the A5g area is greater than the 3.peference area (F123), if there are other fixed installation parcels choosing the same block (F123) at the 3.preference, determine the number of them. Divide the areas preferred for this block into the parcel number preferring the same block. For the rest of A5g area, place in the third preference as much as the emerging area. If not (if there are no other fixed installation parcels choosing the same block (F123) at the third preference), place from the rest of the A5g area in its 3.preference.

8) Calculate the area of A5g, which can't be placed in it preferences. Compare this area with block areas that have free space (from F101 to F126) and place them in any block, provided that they are less or equal to the 'block area'.

9) If the area of A5g, which can't be placed in it preferences, is greater than block area (from F101 to F126), place as much as the free space in the blocks.

10) If there are no fixed installations, carry out the operations from 4 to 9.

11) Print the placement table.

*D. Command Steps of Block Reallocation Algorithm*

The command steps of block placement algorithm have been created according to the reallocation conditions and constrains determined for the landholding no.5 as follows:

1) Read the following block number.

2) Calculate the total amount of area per block by basing on the fixed installation table.

3) Compare the block area information with calculated total area information.

4) Update the area information in placement table and the remaining area information in block table, if area

information in the block sequence number is less or equal to the parcel value to be placed.

5) If nor, program should give error massage (HALT).

6) Is block number over? If so, take the next step; if not, return to the first step.

7) Sum the remaining area information at the table of preferences.

8) Is the remaining area information zero? If not, take the next step.

9) Gets the value of the column information of the following preference area.

10) Is the information of the following preference area zero? If not, find out whether there is any landholding in the preference list making the same choice.

11) Find out the remaining area information of landholdings making the same choice and the remaining area information in block, and compare them.

12) If the information of the remaining area is less than that of in block, place the areas of landholdings making their choices and update the placement table. If not, divide the remaining area information in the block number of this preference into landholding number preferring the same row, and write the emerging area information in the placement table for landholding showing them in their preferences. Update the remaining area information in preference table and placed preference information.

13) If the preference list is over, go on the next step; if not, continue from 14.step.

14) Is the remaining area information zero? If not, go on to the next step.

15) Get the remaining area information of the following landholding that has also remaining area.

16) Read the following block information that has remaining area.

17) If the area information of the following free block is less or equal to the remaining area of the following landholding, assign this area to that block. Update the placement table and the remaining area information in the list of preferences. If the block list is not over, return to 16.step.

18) Is the remaining area list over? If so, go on from the next step. If not, return to 15.step.

19) Is the remaining area information zero? If not, go on to the next step. If it is zero, end the program.

20) Get the remaining area information of the following landholding that has also remaining area.

21) If the area information of the following free block is greater than the rest of the landholding area, assign as much as free area in block area from the rest of the following area to block. Update the placement table and the remaining area information in the list of preferences. Then return to 19.step.

*E. The Flow Chart of Automatic Block Reallocation Algorithm*

The flow chart has been created according to the command steps of block reallocation algorithm given in Fig. 4.
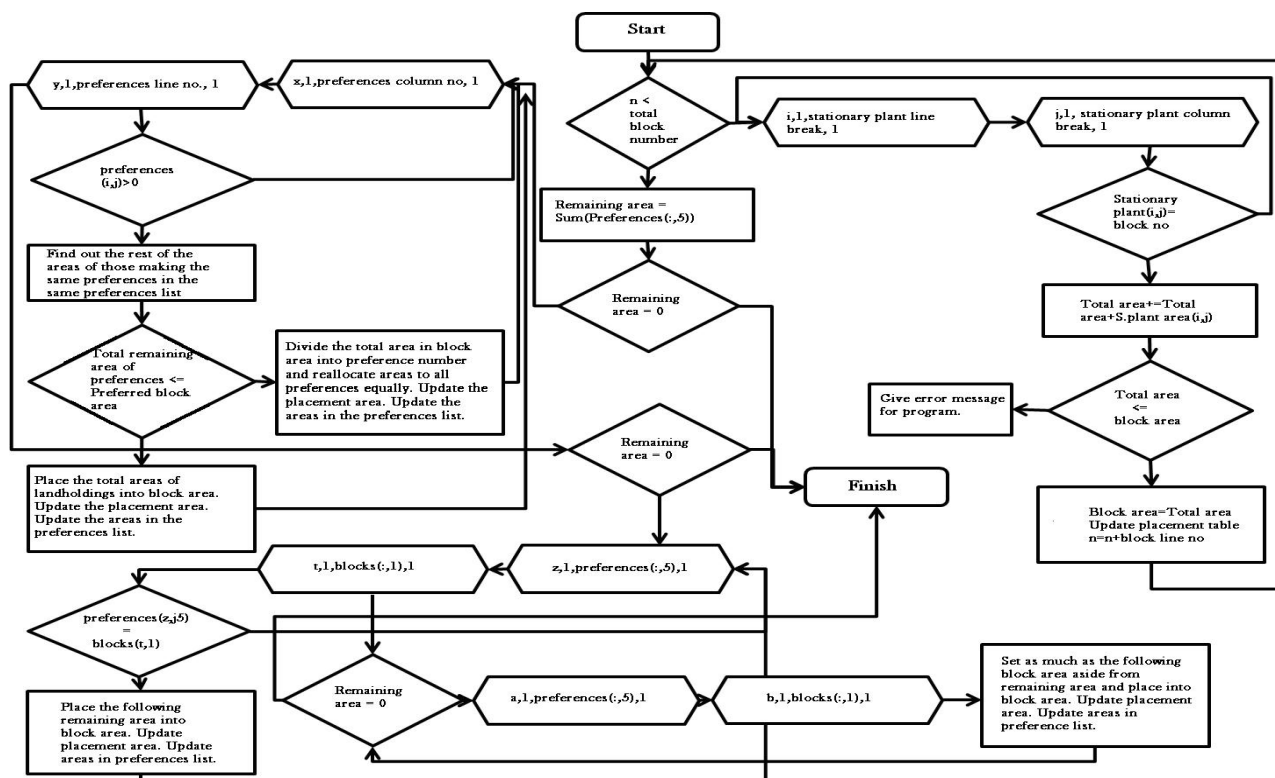
Fig. 4 Flow Chart of Block Reallocation Algorithm

### III. CONCLUSION

In this study, required preliminary studies were done for being able to apply land reallocation with genetic algorithm in the land consolidation projects. In this design, the first three steps before stage of writing codes with genetic algorithm for land reallocation were completed. Data tables were prepared for a project land and reallocation conditions and constraints were identified for an example landholding and then instruction steps and flow chart of block reallocation algorithm were prepared. In the following study, the genetic algorithm codes will be written according to command steps of block reallocation algorithm.

### ACKNOWLEDGMENT

### REFERENCES

[1] H. Erkan, "Relations of Consolidation and Land Management," in *Symposium of Land Consolidation in Turkey*, 2005.
[2] R. Crecente, C. Alvarez, and U. Fra, "Economic, social and environmental impact of land consolidation in Galicia," *Land use policy*, vol. 19, pp. 135–147, 2002.
[3] J. C. Coelho, J. Portela, and P. A. Pinto, "A social approach to land consolidation schemes: A Portuguese case study - The Valença Project," *Land use policy*, vol. 13, no. 2, pp. 129–147, 1996.
[4] J. Castro Coelho, P. Aguiar Pinto, and L. Mira Da Silva, "A systems approach for the estimation of the effects of land consolidation projects (LCPs): A model and its application," *Agric. Syst.*, vol. 68, pp. 179–195, 2001.
[5] X. P. Gonzalez, C. J. Alvarez, and R. Crecente, "Evaluation of land distributions with joint regard to plot size and shape," *Agricultural Systems*, vol. 82. pp. 31–43, 2004.
[6] K. Temizel, "The Importance of Orientation of The Block And Parcel in Land Consolidation," *Anadolu Journal Of Agricultural Sciences*, vol. 27, no. 1. pp. 1–5, 2012.
[7] T. Cay and Y. Inceyol, "Analysis of the Different Land Reallocation Results in Land Consolidation," in *International Conference of Ecosystems (ICE)*, 2013, pp. 416–425.
[8] L. J. M. Jansen, M. Karataş, G. Küsek, C. Lemmen, and R. Wouters, "The Computerised Land Re-Allotment Process in Turkey and the Netherlands in Multi-Purpose Land Consolidation Projects," *Facing Challenges – Build. Capacit.*, no. April, pp. 11–16, 2010.
[9] Z. Demirel, "Computer Aided Studies in Land Consolidation Process.," in *Prof. Burhan Tansuğ Photogrammetry and Geodesy Symposium*, 1987.
[10] M. Avci, "A new approach oriented to new reallotment model based on block priority method in land consolidation," *Turkish J. Agric. For.*, vol. 23, pp. 451–457, 1999.
[11] T. Cay, T. Ayten, and F. Iscan, "An Investigation of Reallocation Model Based in Interview in Land Consolidation," in *Shaping the Change, XXIII FIG Congress, October 8-13, 2006*, 2006, pp. 1–13.
[12] T. Cay, T. Ayten, and F. Iscan, "Effects of different land reallocation models on the success of land consolidation projects: Social and economic approaches," *Land use policy*, vol. 27, pp. 262–269, 2010.
[13] E. Kovács, "Results and Experiences of Tama, A Land Consolidation Project in Hungary," in *International Conference on Spatial Information for Sustainable Development*, 2001, no. October, pp. 1–10.
[14] E. H. Semlali, "A Gis Solution To Land Consolidation Technical Problems In Morocco," in *Proceedings of the FIG Working Week*, 2001, pp. 1–13.
[15] F. İşcan, "Algorithm Developing For Land Consolidation Software," Selcuk University, 2003.
[16] G. Banger and A. Şişman, "Implementation of Operation Research Techniques in Rural Area Regulations," *Bull. Chamb. Surv. Cadastre Eng. Turkey*, no. 87, pp. 82–98, 2001.
[17] Y. Ayranci, "Re-allocation aspects in land consolidation: A new model and its application," *J. Agron.*, vol. 6, pp. 270–277, 2007.

[18] F. İşcan, "Application of Fuzzy Logic In Land Consoludation Activities," Selcuk University, 2009.

[19] M. Uyan, "Arazi Düzenlemesi Çalışmalarında Mekansal Karar Destek Sistemleri Kurulumu ve Uygulaması," Selcuk University, 2011.

[20] D. Demetriou, J. Stillwell, and L. See, "Land consolidation in Cyprus: Why is an Integrated Planning and Decision Support System required?," *Land use policy*, vol. 29, no. 1, pp. 131–142, 2012.

[21] Z. Şen, *Genetik Algoritmalar ve En İyileme Yöntemleri*. İstanbul: Su Vakfı Yayınları, 2004.

[22] D. E. Goldberg, *Genetic Algorithms in Search, Optimization, and Machine Learning*. 1989.