Hybrid Method Application in Land Consolidation Studies

Ela ERTUNÇ and Tayfun ÇAY, Turkey

Key words: Land consolidation, land reallocation, interview based reallocaiton model, block priority based reallocation model, hybrid method, cadastre

SUMMARY

Land Consolidation (AT) is one of the most effective land management approaches used to improve the agricultural sector, protect natural resources, and contribute to the development of rural areas all over the world and in our country. The block reallocation phase in land consolidation studies is a project step that directly impacts the success of land consolidation projects and is the most time consuming part of land consolidation projects. Scientific studies for block reallocation, which prioritize the requests of enterprise owners and enable the block reallocation to be done in a shorter time, are increasing day by day. In this study, a new hybrid algorithm-based algorithm (AT-FGA) was developed using genetic algorithm and fuzzy logic algorithms that provide block reallocation in land consolidation projects by using the datas of Land consolidation project belonging to the Acıöz Neighborhooh (Şereflikoçhisar-Ankara-Turkey). Block reallocation is done automatically with this developed model. In addition, interview priority and block priority reallocation models were applied for AT belonging to the Acıöz Neighborhooh and the results obtained were compared between these, three models according to the number of parcels, average parcel size, number of parcels per enterprise, number of shared parcels, width / length ratios of parcels and distance of parcels to village center.

According to the results obtained, the consolidation rate in the interview-based reallocation model is 27% while the hybrid model is 38%, After the AT, in the interview-based model the jointly owned parcel is 25 and the hybrid model is 8. According to the number of parcels per enterprise, the hybrid model is also more successful than the interview-based method.

The results obtained from the application area show that the FGA block reallocation model can be accepted by farmers. According to these results AT-FGA block reallocation model developed for block reallocation in land arrangment works can be proposed.

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1. INTRODUCTION

The basic economic activity necessary for the survival of human life is agriculture. In spite of this precaution that agriculture can carry on the existence of human beings, in the face of ever-increasing world population, the soil is staying the same, even decreasing. Since the areas where agriculture can be done can not be increased in parallel with the population increase, the solution is to find ways to get more yield from the limited existing agricultural land. Despite the increase in population in country, do not increase the same rate of arable land is gradually increasing population pressure on land. Mainly the principles of inheritance law in Turkish Civilization numbered 4721, irrigation and drainage channels and roads continue to be fragmented. (Dinçbilek, 2012). For this reason, the amount of land owned by the enterprises is getting smaller and the business land consist of a large number of distant, irregular parts. (Boztoprak et al., 2015). In order to increase agricultural productivity, firstly legal measures should be taken to prevent further fragmentation of agricultural land, after the existing fragmented structure should be reassembled and regulated according to the principles of modern agriculture management. An important aim of the land regeneration work for the rearrangement of the agricultural area is to increase the agricultural yield. However, this activity is based on the land that is the basis for life, and the land must be used in a sustainable way to meet the needs of future generations (İşcan, 2009).

Land consolidation, which is implemented in rural areas by plot and land regulation, is one of the important means of increasing productivity in agricultural production. In order to increase agricultural production, unfavorable forms of land divided into in small parcels belonging to the enterprises are shaped and planned according to the principles of modern agriculture management. (Temel, 2013).

Land consolidation not only consolidates fragmented land, but also improves the standards of landowners in agriculture, technical, social and cultural areas (Uyan, 2016; Cay and Uyan, 2013; Pasakarnis and Maliene, 2010). Land consolidation in this sense is not only limited to the development of agriculture, but also contributes to the development of natural resources and rural development (Li et al., 2012).

The reallocation phase is the most difficult and time consuming part of Land Consolidation (Ertunç and Çay, 2017; İnceyol, 2014). Reallocation is not a definite and restrictive function, but rather an interdependent and complementary element, so the decision maker always faces multiple alternatives. Block reallocation, is a land distribution and settlement problem in which there are complex data and relationships such as farmers' wishes, fixed facilities, road and irrigation network, optimal parcel size, parcel geometry, parcel size, parcel share consolidation, village legal personality, pasture and treasury land status. The reallocation

process is carried out in accordance with the Agricultural Reform Law on Land Regulation in irrigation areas numbered 3083 and the Land Consolidation Regulation (interview-based reallocation model). In this model, enterprices are first placed in blocks according to their first choice, in which case there are naturally occurring excesses and gaps in the blocks. For this reason, the second preferences of the enterprises are reviewed again in order to reset the block gaps. If the first preferences of the enterprises that prefer the blocks with more block area are canceled and the second preference wants the block which is empty, the block is allocated to it.If there are still gaps in the blocks, the third preferences of the enterprises are examined and the same process is repeated here. Although it is understood in this officially applied method, repetition is frequently made at the reallocation stage, but if the project that has taken place at the end of a month-long process does not satisfy the enterprices, the process can be restarted and the reallocation period can be spread over a very wide period. Factors such as the moment mood, experience, and ability of the person performing the reallocation process are directly influential in determining the new parcels.

In the work done, a new low-cost, easy-to-use computer-based reallocation model has been developed that removes the disadvantages of the existing reallocation model and tested in a selected application area.

2. MATERIAL AND METHODS

In the study, the data of Land Consolidation project belonging to the Acıöz Neighborhooh (Figure 1) which have been previously consolidated by General Directorate of Agrarian Reform were used. The size of Land consolidation project belonging to the Acıöz Neighborhooh is 1100.57 hectares, the number of enterprises is 140, the number of cadastral parcels is 247 and the number of blocks is 31 (Figure 2).

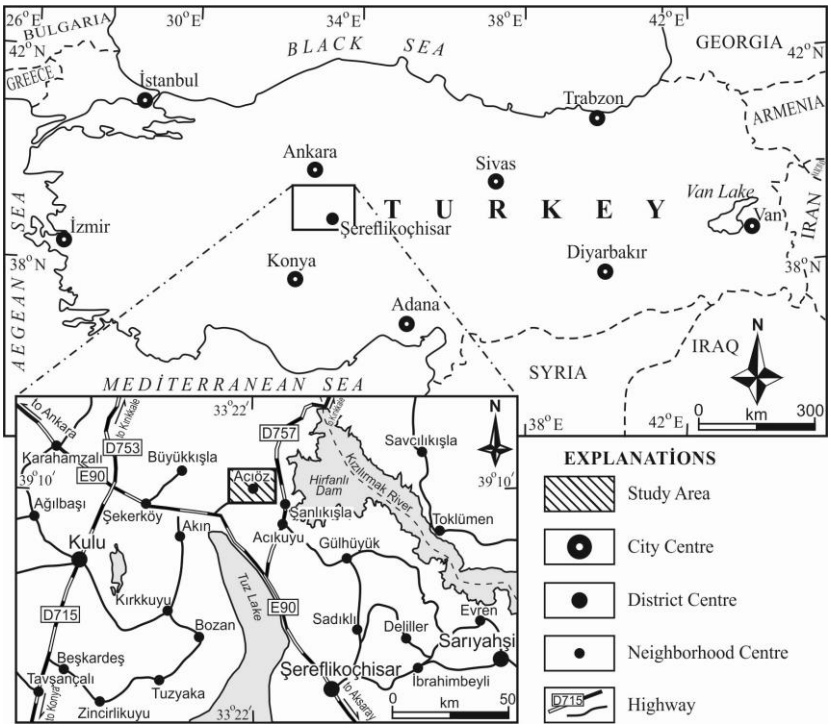

Figure 1. Study area

Figure 2. Cadastral state of study area

In accordance with the provisions of the Agricultural Reform Law on Land Regulation in irrigation areas numbered 3083, block reallocation in land consolidation projects is made according to the interview-based reallocation method. The study was done using block reallocation, interview based, block priority based and hybrid reallocation methods.

2.1 Interview Based Reallocation Method

During the projecting phase of EC work, interviews with farmers are required to make three preferences regarding where to combine the sites or from which block they are given. This preference order is taken into account when farmers of the project area are placed on blocks. In this way, the block reallocation is called ”Interview based reallocation model”.

2.2 Block Priority-Based Reallocation Model

In the block priority based reallocation method, the reallocation is carried out according to the largest lot owned by the enterprises. In this method, the largest parcels of each operator and the blocks in which these parcels are located shall be determined by making use of the listings of the owners' surnames. The land to be given to the enterprises during reallocation is given from the block with the largest parcel of the operator. If the operator has a fixed facility, it is given from the block in which the fixed facility of the land operator to be distributed is located. According to the block occupancy rate, the enterprises with no blot where the largest parcel is located are sent to the block with the second or third largest parcel. reallocation; the empty spaces in the blocks continue until they are reset.

2.3 Hybrid Method in Land Consolidation Studies

While distributed to parcel blocks, block reallocation is all of the effort to model the most appropriate of the possible solutions. When we look at the processing done, block reallocation is optimization problem. Optimization is the process of doing something better. That is, optimization can also be defined as the best solution to a problem or finding a design.

In this phase, a method is proposed that takes into account the enterprice preferences by using the convergence properties of the optimization methods to the optimum result quickly and can reallocation the minimum space in the block areas. In the realization of this method, the hybrid algorithm was created by using the Fuzzy Logic Method in order to increase the success of Genetic Algorithms (GA) and Genetic Algorithms because the reallocation problem is disconcerting, there are too many options and it is easy to implement. In the hybrid method (FGA method) , the crossover techniques and crossover ratio of the basic GA can vary according to the state of the population. Thus, the FGA can behave according to the structure of the problem.

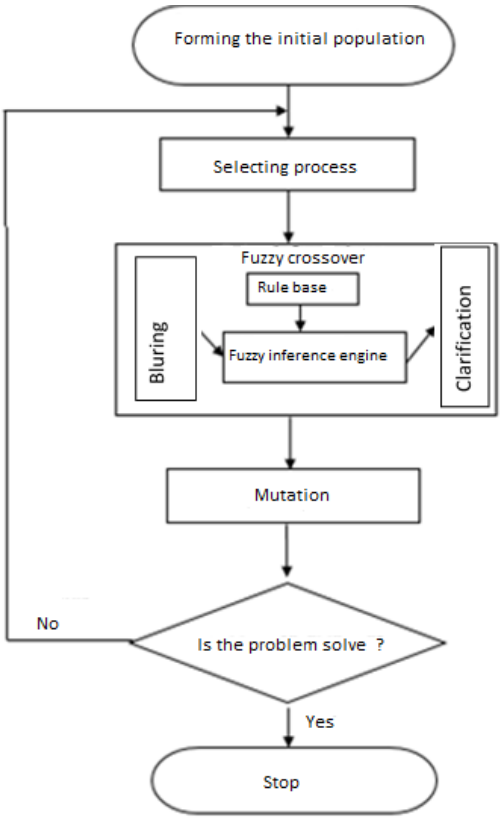

Figure 3. Bulanık genetik algoritma yapısı (Varnamkhasti ve ark., 2012)

In this study, tournament selection method is used while FGA method is applied to the land reallocation problem and it is supported by elitism. Although it varies according to the size of the project, the land reallocation problem has a very wide search space. The population needs to be diversified with different crossover techniques to efficiently and effectively scan this search space. In the study, six different crossover techniques were used, grouped as low, medium and high. The crossover techniques given in Table 1 are used according to the crossover ability (CA) output value obtained by the fuzzy logic by taking into account the diversity of the population. If population diversity is sufficient, lower crossover techniques are selected as level, but when population diversity is less and when all individuals and fitness values are similar to each other, harder crossover techniques are used. Thus, the method has a self-renewing structure in iterations.

Table 1. Crossover techniques according to the levels

Low	Medium	High
1-point	k-point	Segragation
2-point	Uniform	Inversion

With FGA, not only the level of the crossover technique but also the crossover rate is determined for each iteration by means of fuzzy logic. The crossover rate is evaluated according to the population of the fuzzy logic rule set according to the situation, and the crossover ratio obtained by clarification is directly used. After the crossover is completed, the iteration is completed by applying the mutation operation in the basic GA method. Until the stopping criterion is reached, the process from the elitism and tournament elections to the mutation is repeated.

3. RESULT AND DISCUSSION

The block reallocation phase of land consolidation studies is a process that directly affects the success of the land consolidation. Scientific studies are increasing day by day (Uyan, 2011; İnceyol, 2014; Uyan ve ark. 2015) to ensure that block reallocation is at the top level of the demands of enterprise owners and can be done in a shorter period of time. In this work area, AT-FGA (Hybrid Method) block reallocation algorithm is developed so that block reallocation can be performed automatically using Hybrid method. The AT-FGA block reallocation algorithm was tested on land consolidation project belonging to the Acıöz Neighborhooh (Şereflikoçhisar-Ankara-Turkey). The following results were obtained for the application area (Table 2).

When we examine Table 2, there are 140 enterprises in the field of application. 96 of these enterprise are in the first preference, 16 in the second preference, 3 in the third preference. 25 enterprise are in outside the preferences. Preferred success rate reached 81.5603%.

Table 2. Acıöz AT, FGA automatic block reallocation result table

	Number of Enterprises	1. Preferred	2. Preferred	3. Preferred	Outside the Preferred	Success Rate (%)
Hybrid Method (FGA)	140	96	16	3	25	81.5603

3.1 Examination of models by number of parcel, consolidation ratio and average parcel sizes

When we look at the table in general, there is a decrease in the number of small parcels in accordance with the logic of land consolidation (Table 2).

Table 2. Examination of the models in terms of the number of parcels

The Size of Parcel (Decares)	Cadastral Status	Interview-Based Reallocation Model	Block Priority-Based Reallocation Model	Hybrid Model
	The Number of Parcel	The Number of Parcel	The Number of Parcel	The Number of Parcel
0-5	30	13	12	12
5-10	19	3	17	28

10-20	56	22	23	29
20-30	31	28	15	15
30-40	18	20	5	15
40-50	31	27	10	20
50-60	17	12	5	11
60-80	19	23	25	9
80-100	8	7	20	3
100-120	7	10	5	3
120-150	2	6	6	3
150+	9	9	14	5
Total	**247**	**180**	**157**	**153**
Consolidation Ratio (%)	-	**27**	**36**	**38**

Consolidation rate: In the project area, means the rate of decline of the parcels according to the pre-consolidation situation.

3.2 Examination of models according to average parcel sizes

We can say that the hybrid block reallocation model is more successful when we compare the reallocation models according to the average parcel size (Table 3).

Table 3. The average sizes of parsels of the reallocation models

The Average Parcel Size	Area (m^2)	Increase Percentage (%)
Cadastral status	43 469.44	-
Interview-based reallocation model	59 649.73	37
Block priority-based reallocation model	68 388.22	57
Hybrid block reallocation model	70 176.15	61

3.3 Examination of models in terms of jointly owned parcels

According to Table 4, before reallocation the jointly owned parcels is 32. Number of parcels shareholding after reallocation, 3 for the block priority model, 25 for the interview-based reallocation model, and 8 for the hybrid reallocation model.

Table 4. The number of jointly owned parcels occurred with the reallocation methods

The Number of Share in Parcel	Cadastre	Interview-Based Reallocation Model	Block Priority-Based Reallocation Model	Hybrid Model
1	215	155	154	142
2	17	15	1	10
3	3	2	-	-
4	3	1	-	-
5	1	1	-	-
6	4	3	1	1
7	2	2	-	-
8	2	1	1	-
9	-	-	-	-
10	-	-	-	-
11	-	-	-	-
13	-	-	-	-
The number of jointly owned parcel	**32**	**25**	**3**	**8**
Total	**247**	**180**	**157**	**153**

3.4 Number of parcels per enterprise in models

According to the Table 5, the number of parcels per enterprises with single parcel before reallocation is 57 (40.71%). This number is 85 (60.71%) for the interview model, 135 (96.5%) for the block priority model and 122 (87.14%) for the hybrid reallocation model after reallocation

Table 5. The number of parcels per enterprise in the reallocation models

The Number of Parcels	CADASTRAL		INTERVIEW-BASED REALLOCATION MODEL		BLOCK PRIORITY-BASED REALLOCATION MODEL		HYBRID MODEL	
	The Number of Enterprises	%	The Number of Enterprises	%	The Number of Enterprises	%	The Number of Enterprises	%
1	57	40.71	85	60.71	135	96.50	122	87.14
2	33	23.57	36	25.71	1	0.70	17	12.15
3	23	16.43	9	6.43	-	-	-	
4	13	9.29	7	5.00	1	0.70	-	
5	8	5.71	-	-	1	0.70	1	0.71

6	3	2.14	1	0.71	-	-	-	-
7	1	0.71	-	-	-	-	-	-
8	-	-	-	-	1	0.70	-	-
11	1	0.71	2	1.43	-	-	-	-
15	1	0.71	-	-	1	0.70	-	-
TOTAL	140	100	140	100	140	100	140	100

3.5 Distances of the parcels in the models to the village center

The distance between the center of the parcels belonging to one enterprise in the application areas and the center of the village was determined by measuring the shortest transportation distances taking into account the existing road network. Then averages of these values were taken. In the study carried out by Ayrancı (1997), in all cases, it is stated that in terms of enterprise economics and land use, the distance enterprise parcels and the village center is 3 km.

According to Table 6, the ratio of the parcels up to 3 km from the village center distance is 75% before the AT, 77% in the interview based model, 74% in the parcel plan based on the block priority based model and 72% in the hybrid reallocation model. Accordingly, the interview-based model has been more successful in terms of the distance of the enterprise parcels to the village center.

Table 0. The distance to Neighborhood center of the enterprise parcels belonging to Acıöz Neighborhood

	CADASTRAL		**INTERVIEW-BASED REALLOCATION MODEL**		**BLOCK PRIORITY-BASED REALLOCATION MODEL**		**HYBRID MODEL**	
Distance (m)	**The Number of Parcels**	**%**	**The Number of Parcels**	**%**	**The Number of Parcels**	**%**	**The Number of Parcels**	**%**
0-500	11	4.4	9	5.0	8	5.2	17	11.1
501-1000	66	26.7	36	20.0	27	17.2	28	18.3
1001-1500	36	14.6	26	14.4	24	15.3	15	9.8
1501-2000	33	13.4	25	13.9	21	13.4	21	13.7
2001-2500	22	8.9	24	13.4	19	12.1	18	11.8
2501-3000	18	7.3	18	10.0	17	10.8	11	7.2
3001-3500	20	8.1	16	8.9	22	14.0	20	13.1
3501-4000	26	10.5	13	7.2	9	5.7	12	7.8
4001-4500	14	5.7	13	7.2	9	5.7	10	6.6

4501-5000	1	0.4	-	0	1	0.6	1	0.6
5000+	-	0	-	0	-	0	-	0
TOTAL	**247**	**100**	**180**	**100**	**157**	**100**	**153**	**100**

3.6 The aspect ratios of the enterprise parcels in the models

Considering the factors related to the culture technical services of the aspect ratio in the consolidation projects, it is appropriate to choose from values between 1/4 and 1/5 (Çevik and Tekinel, 1989). Depending on the size of the land, this ratio can be between 1/2 and 1/7 in compulsory cases (Banger and Şişman, 2001; Çay, 2013).

According to Table 7, the parcels of 1/4 - 1/5 are 7.7% in cadastral parcels before land consolidation, 5% in interview-based model, 6.4% in block-based model and 5.2% in hybrid reallocation model. Width/length ratio the parcels between ½ and 1/7 were 49.4% in cadastral parcels, 44.3% in the interview-based model, 61% in the block-based model and 55.5% in the hybrid model.

Table 7. Width / length ratios of the enterprise parcels belonging to Acıöz region

Width / Length Group	CADASTRAL		INTERVIEW-BASED REALLOCATION MODEL		BLOCK PRIORITY-BASED REALLOCATION MODEL		HYBRID REALLOCATION MODEL	
	The Number of Parcels	%	The Number of Parcels	%	The Number of Parcels	%	The Number of Parcels	%
0-0.10	4	1.6	3	1.7	1	0.6	1	0.6
0.10-0.12	3	1.2	2	1.1	4	2.5	-	-
0.12-0.14	-	-	3	1.7	3	1.9	1	0.6
0.14-0.16	5	2.0	2	1.1	3	1.9	5	3.3
0.16-0.18	4	1.6	1	0.6	4	2.5	2	1.3
0.18-0.20	3	1.2	3	1.7	1	0.6	3	1.9
0.20-0.25	19	7.7	9	5.0	10	6.4	8	5.2
0.25-0.30	24	9.7	14	7.7	19	12.1	15	9.8
0.30-0.35	12	4.9	13	7.2	15	9.6	14	9.1
0.35-0.40	19	7.7	13	7.2	13	8.3	10	6.5
0.40-0.45	20	8.1	11	6.1	11	7.0	15	9.9
0.45-0.50	16	6.5	14	7.7	7	4.5	13	8.5
0.50-0.60	29	11.7	19	10.6	15	9.6	20	13.1
0.60-0.70	26	10.6	21	11.7	20	12.7	16	10.5
0.70-0.80	19	7.7	23	12.8	10	6.4	15	9.9
0.80-0.90	24	9.7	16	8.9	11	7.0	11	7.2
0.90-1.00	20	8.1	13	7.2	10	6.4	4	2.6

4. CONCLUSION

According to the results obtained, the consolidation rate in the interview-based reallocation model is 27% while the hybrid model is 38%. after the AT, in the interview-based model the jointly owned parcel is 25 and the hybrid model is 8. According to the number of parcels per enterprise, the hybrid model is also more successful than the interview-based method. It is also observed that the AT-FGA reallocation model is generally more successful than the interview priority reallocation model when compared with the preferential reallocation models after the AT.

According to the results obtained, the hybrid block allocation model, which also takes into account the enterprise preferences, automatically makes the block reallocation. The developed model almost coincides with the results obtained from the interview priority model currently used in practice and the automatic reallocation of blocks in this model will result in considerable time and cost savings for large land consolidation projects. The hybrid block reallocation model developed for this reason can be proposed for block reallocation in land regulation studies. The results obtained from the application area show that the FGA block reallocation model can be accepted by farmers. According to these results, AT-FGA block reallocation model developed for block reallocation in land arrangment works can be proposed.

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REFERENCES

Ayrancı, Y., 1997, Tokat-Yukarı Çandır Köyünde Coğrafik Bilgi Sistem Destekli Arazi Toplulaştırması, PhD Thesis, Ankara University, Graduate School of Natural Sciences, Ankara, 117 p.

Banger, G. and Şişman, A., 2001, Kırsal Alan Düzenlemelerinde Yöneylem Araştırması Tekniklerinin Uygulanması, Harita ve Kadastro Mühendisliği Dergisi, Ankara, 87, pp. 82-98.

Boztoprak, T., Demir, O., Çoruhlu, Y.E. and Nişancı, R., (2015), Arazi Toplulaştırmasının tarımsal işletmelere etkilerinin araştırılması, Selçuk University, Mühendislik Fakültesi Dergisi, C:3, No:3, ISSN: 2147-9364.

Çay, T. and Uyan, M., 2013, Evaluation of reallocation criteria in land consolidation studies using the Analytic Hierarchy Process (AHP). Land Use Policy, 30, pp.541-548.

Çay, T., 2013, Arazi Düzenlemesi ve Mevzuatı, Dizgi Ofset, Konya, 342 p.

Çevik, B. and Tekinel, O., 1989, Arazi Toplulaştırması, Çukurova University, Faculty of Agriculture, Textbook, No: 45, Adana.

Dinçbilek, B., 2012, Arazi Toplulaştırmasının toplu yağmurlama sulamada sistem planlaması ve maliyetine etkisi, PhD Thesis, Ankara University, Graduate School of Natural Sciences, Ankara.

Ertunç, E. and Çay, T., 2016, Arazi Toplulaştirmada Dağitim İçin Yeni Yazilim Geliştirmesi Üzerine Bir Çalişma, TMMOB Harita ve Kadastro Mühendisleri Odası, 6. Türkiye Harita Bilimsel ve Teknik Kurultayı, 3-6 Mayıs 2017, Ankara.

İnceyol, Y., 2014, Arazi düzenleme çalışmalarında Genetik Algoritma uygulaması, Doktora Tezi, PhD Thesis, Selçuk University, Graduate School of Natural Sciences, Konya.

İşcan, F., 2009, Arazi Düzenleme Çalışmalarında Bulanık Mantık Uygulaması, PhD Thesis, Selçuk University, Graduate School of Natural Sciences, Konya.

Li, I., Chen, Y., Gao, H. and Li, D., 2012, A Hybrid Registration Approach of Remote Sensing Images for Land Consolidation, Intelligent Automation and Soft Computing, Vol.18, No.8, pp.1121-1132.

Pasakarnis, G. and Maliene, V., 2010, Towards Sustainable Rural Development in Central and Eastern Europe: Applying Land Consolidation, Land Use Policy, 27, pp.545-549.

Temel, M., 2013, Kırsal alanların Korunarak Kalkınmasında ve Planlanmasında Bir Araç Olarak Arazi Toplulaştırması: Avrupa Birliği Türkiye Karşılaştırması, Master Thesis, Gazi University, Graduate School of Natural Sciences, Ankara.

Uyan, M., 2011, Arazi Düzenlemesi Çalışmalarında Mekansal Karar Destek Sistemleri Kurulumu ve Uygulaması, Doktora Tezi, *Selçuk Üniversitesi Fen Bilimleri Enstitüsü*, Konya.

Uyan, M., Cay, T., Inceyol, Y. ve Hakli, H., 2015, Comparison of designed different land reallocation models in land consolidation: A case study in Konya/Turkey, *Computers and Electronics in Agriculture*, 110, 249-258.

Uyan, M., 2016, Determination of Agricultural soil index using geostatistical analysis and GIS on land consolidation projects: A case study in Konya/Turkey, Computers and Electronics in Agriculture, 123, pp.402-409.

Varnamkhasti, M. J., Lee, L. S., Bakar, M. R. ve Leong, W. J. A., 2012, Genetic Algorithm with Fuzzy Crossover Operator and Probability, *Hindawi Publishing Corporation Advances in Operations Research*, 2012, 16.

BIOGRAPHICAL NOTES

Ela ERTUNÇ was born in Gaziantep-Turkey. She graduated from the Department of Geomatics Engineering of Engineering Faculty of Selçuk University in 2010 and from the Department of Civil Engineering of Engineering Faculty of Selçuk University in 2011 in Konya. She completed her master in 2013 from the Institute of Science and Technology of Selçuk University on Land Management program. She completed her PhD study at Selcuk University (2018). She has worked as a Research Assistant in the same University for 5 years now.

Dr. Tayfun Cay is a Prof. Dr. of Geomatic Engineering at the Selcuk University of Konya, Turkey. He has been with Selcuk University since1989. He completed his PhD study at Selcuk University (1994), in "Project planning and management in land consolidation activities" subject. He has an MSc from Selcuk University, Department of Geomatic Engineering (1989), and a BSc from Selcuk University (1987), in Geomatic Engineering. His researchinterests; Land consolidation, public works, cadastre law, project planning andmanagement and GIS.

CONTACTS

Ela ERTUNÇ
Selçuk University, Faculty of Engineering, Department of Geomatic Engineering
Aleaddin Keykubat Campus, 42030-Selçuklu
Konya
Turkey
Tel: +90 332 223 18 99
e-mail: elaertunc@selcuk.edu.tr

Tayfun ÇAY
Selçuk University, Faculty of Engineering, Department of Geomatic Engineering
Aleaddin Keykubat Campus, 42030-Selçuklu
Konya
Turkey
Tel: +90 332 223 19 44
e-mail: tcay@selcuk.edu.tr