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A New Approach Oriented to New Reallotment Model Based on Block Priority Method in Land Consolidation

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Abstract: In this study, a new model, which is used in determining of reallotment plan in land consolidation, have been presented and this model have been applied to Salihli-Yılmaz Village. Then, the results of this model have been compared with results of the conventional method. This method takes account the maximization of the amount of land non-exchanged and is based on linear programming. According to the results from this study, the average number of plots per farm decreases to 1 in plan obtained from this model, while the amount of the non-exchanged land were obtained as high as conventional methods.

Arazi Toplulaştırmasında Blok Öncelik Metodunu Esas Alan Yeni Dağıtım Modeline Yönelik Bir Yaklaşım

Özet: Bu çalışmada, arazi toplulaştırmasında yeni parsel dağıtım planının belirlenmesi amacıyla geliştirilmiş yeni bir model tanıtılmış ve bu model Salihli-Yılmaz Köyü arazi toplulaştırma projesi için uygulanmıştır. Daha sonra bu modelin sonuçları geleneksel yöntemin sonuçlarıyla karşılaştırılmıştır. Bu model, herbir işletme için, toplulaştırma öncesindeki yerinde kalan arazi miktarının maksimizasyonunu esas almakta ve doğrusal programlama tekniğine dayanmaktadır. Uygulamadan elde edilen sonuçlara göre, bu modelle elde edilen planda işletme başına düşen parsel sayısı 1'e çok yaklaşırken, işletmelere eskisi ile aynı yerde verilen arazi miktarı da geleneksel yöntemdeki kadar yüksek bulunmuştur.

Introduction

Land consolidation refers to the process in which fragmented or scattered plots of a farm family or farm are incorporated. For this purpose, firstly the land is divided into blocks by planning an optimal network for road and channel. Secondly the problem of how much land from which block is given to a farm is solved. Some countries where land consolidation is extensively applied investigated the appilcation possibilities of operations research techniques. Klemper (1), Kropff (2), Riemer (3) and Sonnenberg (4) studied how to use different algorithms of the mathematical programming methods in realotment of farm lands.

A method was developed by Kik (5) to investigate the reallotment in the preparatory phase of a land consolidation project. The method depends on the improvement of economical characteristics of farms by means of shortening farm-plot distances and decreasing number of plots. Girgin (6), Büker and etc. (7), Girgin and Kik (8) comparatively examined some of the consolidation projects applied in Turkey through this method and the manual method from the standpoint of farm economics. Avcı (9) compared the results from a model that minimizes both exchanges between classes and plot distances with the results from parcellation plan of the classical method.

Currently a conventional method which is depending on trial-error is used to obtain the preliminary reallotment plan of a land consolidation project in Turkey. The planner first determines the preferences of the land owners and then tries to prepare a plan which can fit to them. Collecting and processing of data and new data generation are mostly performed in automation in recent years. However it calls for the ability of the planner to choose the best reallotment plan among a number of alternative plans. Therefore, an efficient technique is required to make the necessary calculations related to reallotment plan in preparatory phase of a land consolidation project. Such a technique should best meet the prefesences of the land owners. The most common preference of the land owners is that their lands are kept non-exchanged. However, in the projects, at least one of the plots of a farmer having two or more plots is subjected to an exchange. Therefore it is the best way to maximize the amount of land non-exchanged. This problem may be solved by the linear programming method in the phase of preliminary plan preparation of a land consolidation project.

This study presents a new method based on the linear programming to calculate and desing the preliminary reallotment plan in a land consolidation project. The result from the appliaction of the new method to a land consolidation project in Turkey are compared to the conventional method results.

Mathematical Model of Reallotment Plan

In land consolidation projects, first the project area is divided into blocks through roads and channels and then how much land from which block to give which farm is calculated. Assume that there exist i block with B_i size and j farm with S_j size and $\sum B_i=\sum S_j$. What is desired here is how much land in block i should be allocated to farm j. Let this land be X_{ij} and let us determine a block priority coefficient (F_{ij}) for each possible X_{ij}. The problem is now solved by transportation model (10) which is a specific case of the linear programming. Via this model, a land preliminary reallotment plan may be obtained so that maximum non-exchanged lands is achieved.

The objective function of the model:

$$Z_{max}=\sum\sum F_{ij}X_{ij}$$

The constraints:

$$\sum X_{ij}=B_i,\ i=1,2,..,m$$

where B_i is capacity constraint representing block size

$$\sum X_{ij}=A_j,\ j=1,2,..,n$$

where A_j is demand constraint representing farm size

$X_{ij}>=0$ is nonnegativity condition

F_{ij} symbolizes proportional amounts of lands of a farm in each block. The coefficient is calculated as follows:

$$F_{ij}=(S_{ij}/S_j)x100$$

where S_i is total land size of farm j, S_{ii} is land size of farm j in block i according to before land consolidation.

Çevik and Kösek (11) suggested that priority coefficients of each block are sorted in their ascending magnitudes and land is allocated to the farms beginning from the highest priority coefficient until the block area is all completed. This procedure is executed for all blocks. This means that, of course, if the proportional land of a farm is more in which block, the more probable new land for that farm will be in that block. When this objective is maximized throughout the project area, the best reallotment plan is achieved. In fact, this study in which a new method is developed aims as achieving the optimum plan to maximize the objective above throughout the project area.

Application of The Model

Application Area

Yılmaz which is a village in Gediz River Basin was chosen as the research area where typical Mediterranean Climatic conditions dominate. The most grown products are cotton and sultanas. All the Mediterranean products except citrus are also produced. The basic water resource is Gediz River which is distributed by the DSİ (State Water Affairs) channel network. Gediz River Basin consists of deep alluvial soils with A and C horizons (12).

The area of the Yılmaz Village land consolidation project is 135.160 hectares of which 129.874 hactares in under cultivation. 95 percent of the agricultural lands is private ownership. The number of farms in operation is 87 with 0.323 ha average farm size and the total number of plots, commonly irregular shape, is 402 before land consolidation. Original situation of Yılmaz Village land consolidation project (Plan A) is shown in figure 1. Subsoil drainage, land reclamation and land leveling projects were also applicated associated with the land consolidation project to this area. New Situation of Yılmaz Village land consolidation project (Plan B) is shown in figure 2.

Data Gathering and Calculations

The following procedures were realized to gather the essential data:

Firstly the ownership list and the cadastral map of the project area were obtained. Locations of the farm plots were marked on the map with the scale of 1/5000 as “farm no/plot no” and matching between the ownership list and the map was checked. After removal of the errors, plots of each farm were denoted in the list.

Secondly, the project area was divided into blocks

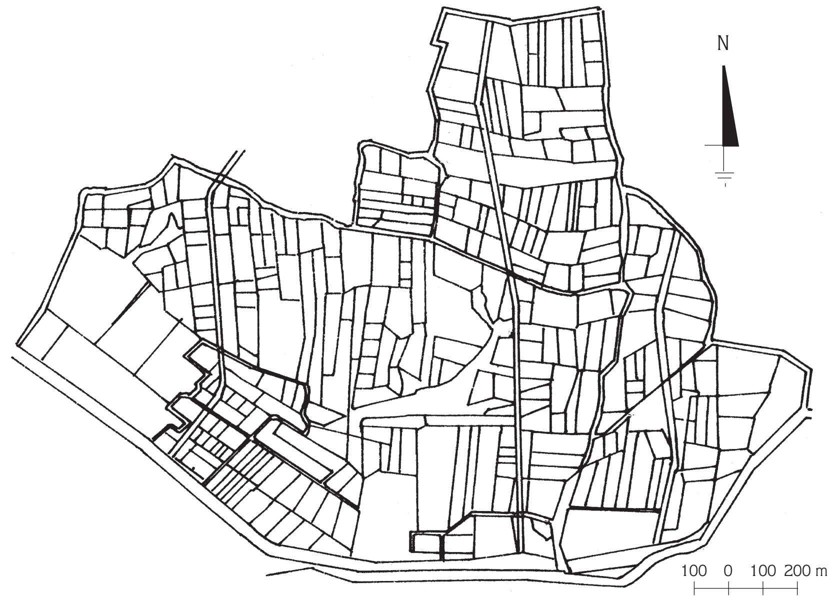

Figure 1. Original situation of Yılmaz Village land consolidation project (Plan A)

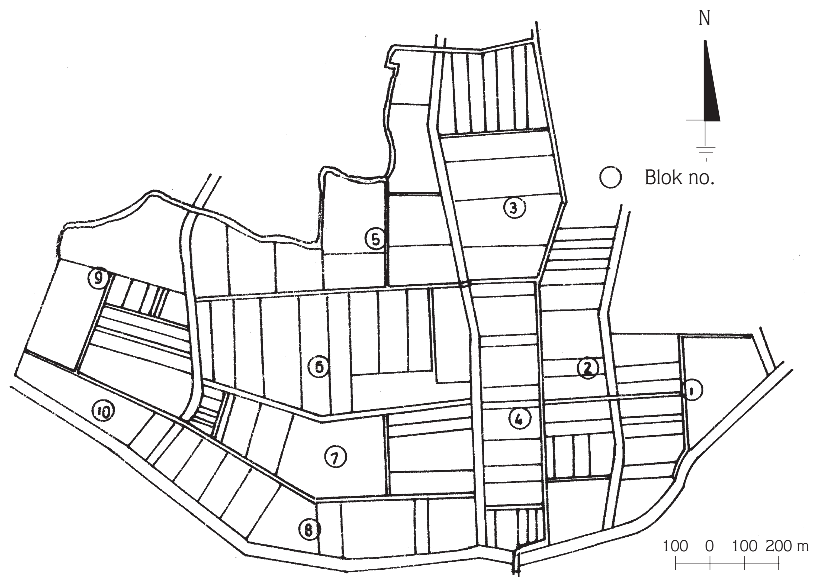

Figure 2. New situation of Yılmaz Village land consolidation project realized by conventional method (Plan B).

taking such factors as present and planned roads, irrigation and drainage networks, topographic conditions, slope and land degree boundaries and the areas of lands (A) with different class/degree in each block were measured by digital planimeter.

The land areas were transformed to first class land values through the following formula (13);

DS=(E/100)A where A is area, E is land indice of this area.

The sum of these values (DS) was considered as the block value figure (B_i).

Thirdly, the new map of blocks was placed over the former ownership map and each farm's plot areas in different blocks were measured digital planimeter for value figures to be calculated. Summing up the value figures gave us land size of the farm in the relevant block (S_{ij}).

Fourthly, land value figures of the farms were found (S'_j) by summing up all the lands of each farm in all the blocks (S'_{ij}).

Fiftly, when the farmer shares in the common establishments (14) were subtracted from S'_j values, S_j

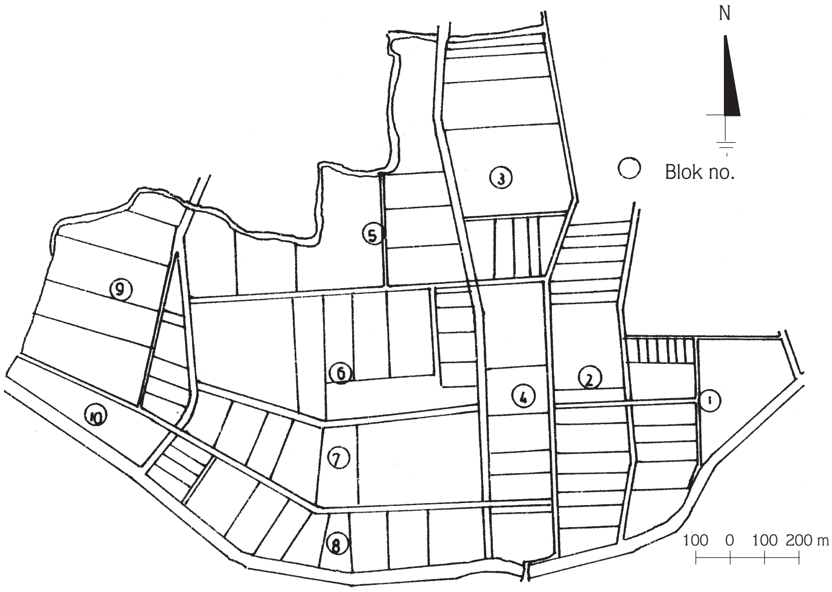

Figure 3. Reallotment plan (Plan C) designed by block priority method of Yılmaz Village land consolidation project.

Table 1. Number of farms and number of plots before and after consolidation.

Farm sizes (ha)	Number of plots	Plan A		Plan B		Plan C	
		Number of plots	Aver.number of plots	Number of plots	Aver.Number of plots	Number of plots	Aver.Number of plots
0.1-1.0	58	145	2.5	61	1.1	58	1.0
1.1-2.0	14	87	6.2	20	1.4	15	1.1
2.1-3.0	8	60	7.5	14	1.8	11	1.4
3.1-4.0	3	40	13.3	5	1.7	5	1.7
4.1+	4	70	17.5	10	2.5	7	1.8
Total	87	402	4.6	110	1.3	96	1.1

values that are the main criteria for reallotment were obtained that enabled us equalize $\sum B_i$ and $\sum S_j$.

Sixthly, F_{ij} coefficients were computed by means of a particular sofware and transportation model related to land consolidation reallotment plan was constructed and solved by computer. In the model, B_i, S_j and F_{ij} were used as source capacity, quantity of demand and coefficients matrice, respectively. The output of the model shows that how much land as value figure is allocated to which farm in which block.

Seventhly, the plots were placed into the blocks according to the reallotment plan after balancing procedure for unexpected very little plots. Since the plot sizes are in the unit of value figure, these values were transformed into the unit of area via the formula A=(100/E)DS and were placed in the related block. This is the alternative plan or Plan C and given in figure 3.

Comparing Consolidation Plans

The conventional method results (Plan B) and the new introduced method results (Plan C) were compared to number of total plot, average plot area, exchanging situation of farm lands and land areas non-exchanged.

Findings and Discussion

Plot Numbers

One of the most significant factors in land consolidation is to decrease the number of plot per farm (15). Number of plot and average number of plot by farm size groups in the research area are presented in table 1. As is seen from table 1, number of plot in Plan A and Plan B are 402 and 110, respectively, while in Plan C is 96.

Table 2. Average plot area for plans

Farm sizes (ha)	Average plot area (ha)		
	Plan A	Plan B	Plan C
0.1-1.0	0.1691	0.4020	0.4228
1.1-2.0	0.2129	0.9263	1.2351
2.1-3.0	0.3252	1.3939	1.7740
3.1-4.0	0.2462	1.9701	1.9701
4.1+	0.2796	1.1957	2.7961
Average	0.2288	0.8362	0.9582

Table 3. Scattering situation of land over the project area

Number of blocks	Number of farm in Plan A		Number of farm in Plan B		Number of farm in Plan C	
	Number	%	Number	%	Number	%
1	40	45.9	70	80.5	79	90.8
2	19	21.8	15	17.2	7	8.1
3	12	13.8	2	2.3	1	1.1
4	5	5.8	-	-	-	-
5	5	5.8	-	-	-	-
6	5	5.8	-	-	-	-
7	1	1.1	-	-	-	-
Total	87	100.0	87	100.0	87	100.0

Table 4. Non-exchanged land by alternative plans

Farm size (ha)	Area (ha)	Plan B		Plan C	
		Area(ha)	%	Area(ha)	%
0.1-1.0	24.5233	17.9538	73.2	20.7042	84.4
1.1-2.0	18.5263	12.0787	65.2	11.8180	63.8
2.1-3.0	19.5144	14.9876	76.8	13.7240	70.3
3.1-4.0	9.8503	6.4262	65.2	5.9189	60.1
4.1+	19.5729	12.2626	62.7	10.6041	54.2
Total	91.9872	63.7089	69.3	62.7692	68.2

Number of plot much more decreases particularly in larger farm size groups. This is typical because large farms have more number of plot. Average plot numbers per farm in Plan A is 4.6 while those in Plan B and Plan C are 1.3 and 1.1, respectively. Average plot numbers per farm in larger farm groups is again more than the smaller ones. A general word by evaluating table 1 is that the Plan C provides “more convenient” results.

Average Plot Size

Land consolidation enlarges the sizes of plots for cultural procedures by incorporating fragmented and scattered lands. In the study area the average plot area in

Plan A is 0.2288 ha, while this area in Plan B and Plan C are 0.8362 ha and 0.9582 ha, respectively. The increase is 265 percent in first and 319 percent in second. Table 2 shows that the Plan C givers much better results for all farm size groups.

Scattering Situation of Land

Distributions of farms by the number of blocks where land belonging to one farm exist are given in table 3 according to parcellation patterns for tree plans. As can be seen from table 3, the rate of farms whose lands are in one block is 45.9% in Plan A. The land of other farmers is scattered in two to seven blocks. This rate is 80.5% in Plan B and 90.8% in Plan C. Number of farms having lands in 2 or 3 blocks in parcellation patterns for Plan B and Plan C was found too lower than ones of Plan A, even no 4 blocks. After land consolidation, land belonging to one farm is concentrated as possible as in one block. When compared the Plan B and Plan C from the standpoint of the performance of gathering lands in one block, Plan C is clearly seen to be more successful (table 3).

Non-exchanged Lands

Lands that were allocated at the original situation were given in table 4 by the Plan B and Plan C. The rate of non-exchanged lands is 69.3% for the Plan B and 68.2% for the Plan C, that is the Plan B is 1.1% more successful. However, average number of plot per farm in Plan B was 1.3 and total plot number was 110 while for the Plan C was 1.1 and 96 respectively. Hence the Plan C is 1.1% less advantageous in non-exchanged lands but 14.4% more advantageous than the Plan B in decreasing of plot number. Another important factor in land consolidation is to move the little plots where lands are most intensive. Since the farms are in different sizes and their lands are scattered, it is too hard to fulfill this. Therefore, any plan that can both perform this and decrease average plot number per farm down to 1 as much as possible may be more acceptable than the others. In the study, parcellation pattern of the Plan C is clearly seen to be more reasonable than the Plan B. This is avaliable for all the size groups.

Conclusion

It is possible to determine the optimal reallotment plan by using the linear programming technique in land consolidation. A reallotment plan designed by such method is not effected by background of the planner and lack of related merit since it depends a mathematical basic. Moreover the fact that computer use is a basis for applying such methods the planner should interfere the procedure with only balancing to prevent the occurrence of too little plots. Therefore numerous plans and projects can be obtained in a certain time. The plan from the new developed method gave us an average number of plot per farm that is very close to 1 as is desired and provided

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