Determination of Land Piece Given to Farmers in Land Reform by Using the Fuzzy Logic Method

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Keywords: Fuzzy logic, land amount, land degree, distribution, land reform, membership degree and function

SUMMARY:
Land reform is generally accepted to mean the redistribution of property or rights in land for the benefit of the landless, tenants and farm laborers. The purpose of land reform is to bring about a more equitable distribution of land ownership and access to land. It is the process of examining and changing laws, regulations and customs relating to land ownership and land tenure.

In this study, a fuzzy logic design methodology is developed for description of land amount and degree given farmers. For this process, land amount (LA), land degree (LD) and treasury land degree (TD) are used as input parameters and distribution amount (DA) as output. Expert view and data are used to form the rule base, which is a composition of membership functions for input and output parameters. It is observed that this system is rapid, equitable and correct than traditional methods, in addition to its high reliability.

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1. INTRODUCTION

According to the conventional definition, redistributive land reform is a public policy that transfers property rights over large private landholdings to small farmers and landless farm workers (Griffin *et al.*, 2002). The universally accepted definition, implicitly and explicitly, excludes non-private lands (ie, 'public', 'state' or 'communal' lands). The underlying assumption in the dominant land reform literature is that lands that are officially classified as 'public/state' properties, especially those used to open up resettlement areas, are lands that are generally not cultivated and inhabited, and are without pre-existing private control. In such conditions, it is logical to conclude that land policies that concern these lands do not recast any land-based production and distribution relationships. The literature on land reform is strong on this point, and rightly so. Yet, it becomes problematic when the use of the same lens is stretched as far as to examine 'public' lands that are, in fact, under varying degrees of cultivation, imbued with private interests and marked by production and distribution relationships between the landed and the landless and land-poor, between the elite and non-elite, often not captured by official census. The failure to recognize the potentially and actually contested nature of much of 'public lands' risks removing them from the reach of redistributive reform, and so risks the continuation of many of the economic, social and political problems are associated with an agrarian structure that is dominated by the landed classes as well (Saturnino and Borras, 2002).

First study of land reform started with 2510 numbered Settlement Law Which come into force in 1934. Land reform started extensively with 4753 numbered Settlement of Farmer Law, which come into force in 1945. With this law, farmers of landless and insufficient land have been provided to be landholdings of sufficient income and productive on accepted land norm by Council of Ministers.

Nowadays, land distribution works are carried out by General Directorate of Agricultural Reform in Turkey. This works are carried out according to 3083 numbered and 22.11.1984 dated law, Agricultural Reform Law for Land Consolidation in Well-Watered Areas, Application Regulations, 4626 numbered and 13,02,2001 dated law Changed Law in Agricultural Reform Law for Land Consolidation in Well-Watered Areas and 18,04,2003 dated law, Technical Instruction for Expropriation, Consolidation, Reallocation.

According to the law 3083, "Agricultural lands distributed or given to its owner at the end of the consolidation are registered to its owner and left is registered to The Treasury. The land registered to its owner can not be divided into smaller parts than the normal size, defined for this region, and not be divided into lots. This situation is defined in the register of title deeds.

The law 3083 has defined the smallest agricultural holding size as distribution norm (Gur and Demirel, 2002).

This law is for agricultural reform studies and consists of agricultural reform precautions. In this law, it is envisaged that making a landowner of farmers who have not land or sufficient land, expropriation of lands of landowners who have more lands than obtained land norm.
With using ranking practices according to the instructions of the law, the farmers are being landowners. Watery and dry farmlands are distributed by using the size of watery and dry farmlands, norms of the allocation, the area to be remained to the owner of it and coefficients of transformation. The land is ranked between the intervals of I-VIII. Four degrees are evaluated between each other with coefficients of transformation given in Table 1. The degrees between V-VIII are not subject to the evaluating.

Table 1. Coefficients of Transformation

Degree of Soil Coefficients of transformation	Lands of degree of III to the other degrees
I	0.707
II	0.816
III	1.000
IV	1.414

It is not known that whether there is a mathematical relation between the coefficients in the interval of 0.707-1.414. Furthermore, it is not known what fundamentals are used in the evaluating process. The agricultural holdings gross income (AEGI) is obtained by the mean values of last four years. Moreover, AEGI related to the 10 decares of the holdings is used to obtain the size of the watery and dry farmland in the lands of degrees of III. When the agricultural holdings income, which can be found by detecting the indispensable expenses except the land debt services and workmanship from gross holdings income; divided into average agricultural holdings income for watery and dry conditions per each 10 decares land piece; watery and dry agricultural lands' size would be found and this figure is accepted as 1.000 (Takka,1993).
Table 2 shows generally accepted land norm by Council of Ministers in Konya/Turkey.

Table 2. Distribution Norm in Konya/Turkey

District	Zone of Application	Distribution Norm	
		İrrigated (da)	Arid (da)
Selcuklu	Caldere	45	183
Cumra	Abditolu, Turkmencamili, Üchuyukler	50	154
Eregli	Sazgecit	52	228
Cihanbeyli	Hodoglu	51	177

Altinekin	Oguzeli	51	183
Merkez	Egilmez	64	194
Ayranci	Saraykoy	64	194
Cihanbeyli	Taşpınar,Gunyuzu	51	177
Karatay	Akorenkisla	45	183
Selcuklu	Karaomerler	45	183
Yunak	Harunlar	49	197
Ilgin			192
Karatay	Aksakli, Katranci	45	183
	Besagil	45	183
	Yaglibayat, Karadona	45	183

Land amounts, which are given landless farmers, have been used by classical method in land distribution study. However, these calculations should be done by using modern methods, because of technological development and science. Fuzzy logic provides one of the most important modern methods that can be used for this purpose.
The origin of the fuzzy logic approach dates back to 1965 since Lotfi Zadeh's introduction of the fuzzy set theory and its applications. Since then the fuzzy logic concept has found a very wide range of applications in various domains like estimation, prediction, control, approximate reasoning, pattern recognition, medical computing, robotics, optimization and industrial engineering, etc (Sen, 2004).

Zadeh (1965) published his famous paper "Fuzzy sets" in Information and Control providing a new mathematical tool, which enables us to describe and handle vague or ambiguous notions such as "a set of all real numbers, which are much greater than 1", " a set of beautiful women," or "a set of tall men." Since then, fuzzy set theory has been rapidly developed by Zadeh himself and numerous researches, and an increasing number of successful real applications of this theory in a wide variety of unexpected fields have been appearing in open literature. The main idea of fuzzy set theory is quite intuitive and natural. Instead of determining the exact boundaries as in an ordinary set, a fuzzy set allows no sharply defined boundaries because of generalization of a characteristic function to a membership function (Sakawa, 1993)
.
The framework of fuzzy logic is unique in its ability to represent subjective or linguistic knowledge in terms of a mathematical model. For this reason, fuzzy logic provides a natural method for constructing systems that emulate human decision making processes. Literature on the subject of fuzzy logic systems (FLS) is extensive and applications, particularly in the field of fuzzy control and fuzzy expert systems, are prevalent. Mendel (1995) and Klir and Yuan(1995) provide good introductory texts on FLSs, while some examples of applications of FLSs may be found in Sugeno and Park(1993), Maiers and Sherif (1985) and Kandel (1991) and Ramot, et.all. (2003).

Fuzzy logic is a recognized instrument for modeling in many scientific and technical fields. There are also a lot of problems where fuzzy methods can be used to reach better solutions

than classical models can do. It concerns on the one hand questions, where uncertain parameters occur, which cannot be handled by classical methods in adequate way. On the other hand, there are problems where linguistic fuzzy rules can describe relations better than it can be done by crisp mathematical formulas.

In this study, land amount given to farmers in land reform applications is modeled by the fuzzy logic method. the paper is organized such that in the second part, material and used methods are described and then the fuzzy system is developed and applied for this purpose with relevant conclusions.

2. MATERIALS AND METHODS

In this study, distribution norm data for the developed system are taken from the Ilgin District in Turkey. Land Norm of Ilgin District is 192 da. Fuzzy logic method is used for determination of land amounts which are given landless farmers in an application region. For the design process present land amount of farmer (LA), degree of land (LD) and degree of treasury land (land degree which are given farmers) (TD) are used as input parameters and distribution amount (land amount which are given farmers) (DA) as output parameters. The general structure of the fuzzy model is show in Figure 1.

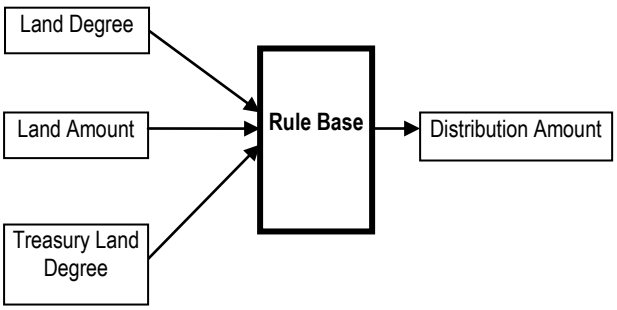

Fig.1. General Structure of Fuzzy Logic Model

2.1. Membership Functions

In the established model, different membership functions are formed for land amount of farmer in addition to degrees of land and treasury land, and distribution amount. The form of the membership functions are given in Figures 2, 3, 4 and 5 for each input and output variables. The units of the used factors are: LA (da-decare), LD (unit), TD (unit) and DA (da-decare). LA scale selected as 0-271 da on its membership function. LD membership function is used from 40 to 100 unit scale. DA membership function has a range of 0-271 da scale for distribution amount. TD membership function uses 40-100 unit scale variation domain.

Fuzzification of the used factors is made by the aid of the following functions, which are determined by the aid both of our expert view and information available in the literature.

LD(A)= $\{a;40 < a < 100$

LA(B)= $\{b;0 < b < 271$

TD(C)= $\{c;40 < a < 100$

DA(D)= $\{d;0 < d < 271$

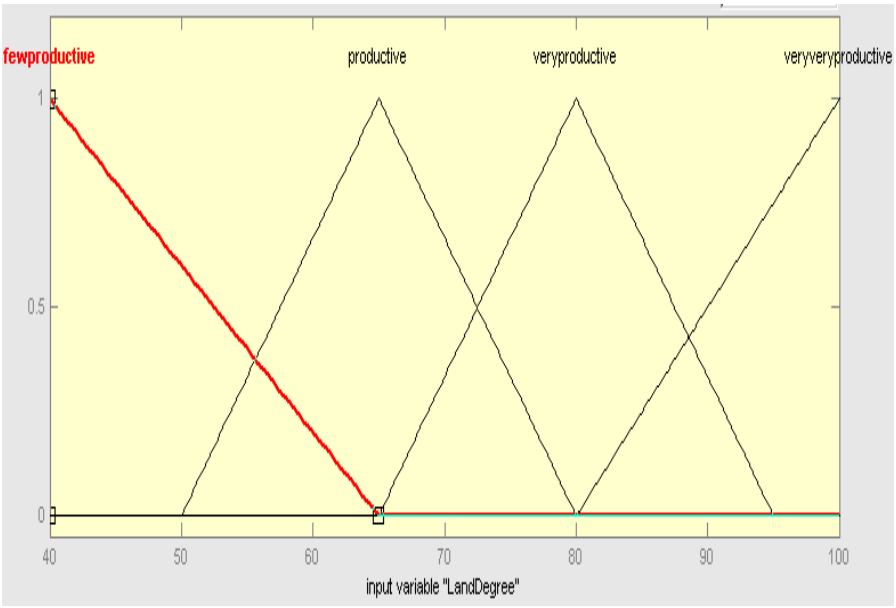

Fig.2. Membership function of Land Degree(LD)

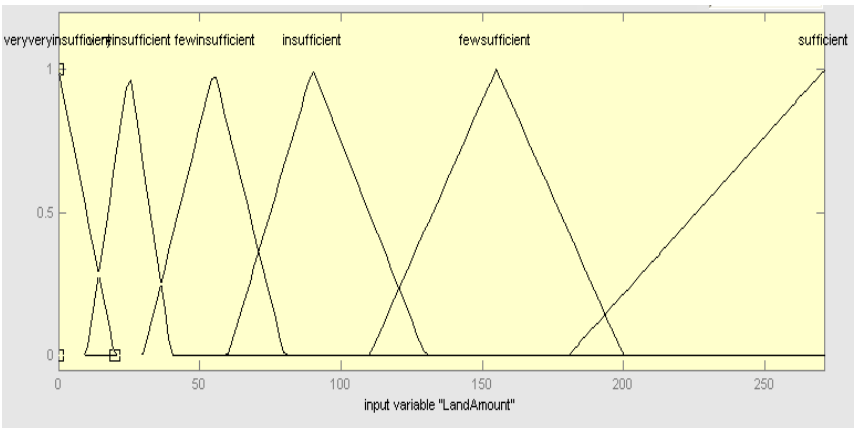

Fig.3. Membership function of Land Amount(LA)

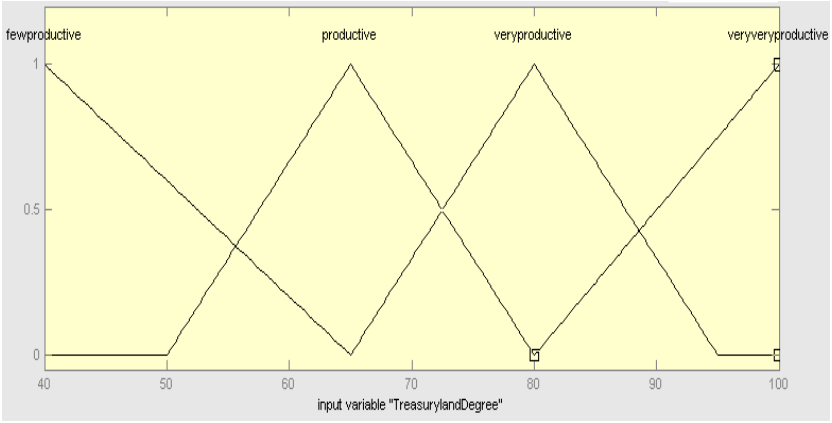

Fig.4. Membership function of Treasury Land Degree(TD)

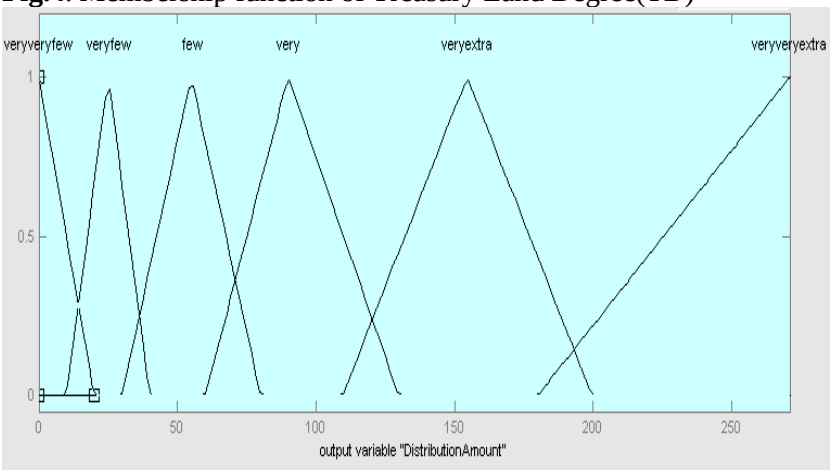

Fig.5. Membership function of distribution amount (DA)

The mathematical functions of each membership function, for instance, for LD linguistic expressions are given as follows.

$$\mu_{\text{fewproductive}}(A)=\begin{cases}\dfrac{65-a}{65}; 0<a<65\\ 0; othercases\end{cases}$$

$$\mu_{\text{productive}}(A)=\begin{cases}0; & a\le 50\\ \dfrac{a-50}{15}; & 50<a\le 65\\ \dfrac{80-a}{15}; & 65<a<80\\ 0; & a\ge 80\end{cases}$$

$$\mu_{veryproductive}(A)=\begin{cases}0; & a \le 65\\ \dfrac{a-65}{15}; & 65 < a \le 80\\ \dfrac{95-a}{15}; & 80 < a < 95\\ 0; & a \ge 95\end{cases}$$

and

$$\mu_{veryveryproductive}(A)=\begin{cases}\dfrac{a-80}{20}; & 80 < a \le 100\\ 0; & othercases\end{cases}$$

For the input factor TD the linguistic expressions (Few Productive, Productive, Very Productive and Very Very Productive) are determined similarly. For other input factor LA the linguistic expressions are Very Very Insufficient, Very Insufficient, Few Insufficient, Insufficient, Few Sufficient and Sufficient. For the output factor DA the linguistic expressions are Very Very Few, Very Few, Few, Very, Very Extra and Very Very Extra. For example, for LD, LA and TD the membership functions are attached the following, respectively:

μ_{fp}(LD)={1/40+0.31/45+0.23/50+0.16/55+0.08/60+0/65}
μ_{p}(LD)={0/50+0.33/55+0.67/60+1/65+0.67/70+0.33/75+0/80}
μ_{vp}(LD)={0/65+0.33/70+0.67/75+1/80+0.67/85+0.33/90+0/95}
μ_{vvp}(LD)={0/80+0.25/85+0.5/90+0.75/95+1/100}

μ_{vvi}(LA)={1/0+0.5/10+0/20}
μ_{vi}(LA)={0/10+0.67/20+1/25+0.33/30+0/40}
μ_{fi}(LA)={0/30+0.4/40+0.8/50+1/55+0.2/60+0.6/70+0/80 }
μ_{i}(LA)={0/60+0.33/70+0.67/80+1/90+0.25/100+0.5/110+0.75/120+0/130}
μ_{fs}(LA)={0/110+0.22/120+0.44/130+0.67/140+0.89/150+1/155+0.11/160+0.33/170+0.56/180+0.78/190+0/200}
μ_{s}(LA)={0/180+0.22/200+0.44/220+0.66/240+0.88/260+1/271}
μ_{fp}(TD)={1/40+0.31/45+0.23/50+0.16/55+0.08/60+0/65}
μ_{p}(TD)={0/50+0.33/55+0.67/60+1/65+0.67/70+0.33/75+0/80}
μ_{vp}(TD)={0/65+0.33/70+0.67/75+1/80+0.67/85+0.33/90+0/95}
μ_{vvp}(TD)={0/80+0.25/85+0.5/90+0.75/95+1/100}

2.2. Rule Base

A convenient rule base is necessary to run the fuzzy model. Although in total 96 rules are formed, but parts of the developed fuzzy rules are shown in the Table 3. It is important that the rules are not completely written for all possibility cases, because implausible ones are not considered at all. Figures 6 and 7 present relationships between input, land amount of farmer, degree of land, and distribution amounts.

Table 3.Fuzzy Rules

Rule No	*LD*	*LA*	*TD*	*DA*
Rule1	fewproductive	veryveryinsufficient	fewproductive	veryveryextra
Rule2	fewproductive	veryveryinsufficient	productive	veryveryextra
Rule3	fewproductive	veryveryinsufficient	veryproductive	veryextra
…….				
Rule21	productive	veryveryinsufficient	fewproductive	veryveryextra
Rule22	productive	veryveryinsufficient	productive	veryextra
Rule23	productive	veryveryinsufficient	veryproductive	veryextra
……				
Rule41	veryproductive	veryveryinsufficient	fewproductive	veryveryextra
Rule42	veryproductive	veryveryinsufficient	productive	veryextra
Rule43	veryproductive	veryveryinsufficient	veryproductive	veryextra
……				
Rule61	veryveryproductive	veryveryinsufficient	fewproductive	veryveryextra
Rule62	veryveryproductive	veryveryinsufficient	productive	veryextra
Rule63	veryveryproductive	veryveryinsufficient	veryproductive	veryextra
……				

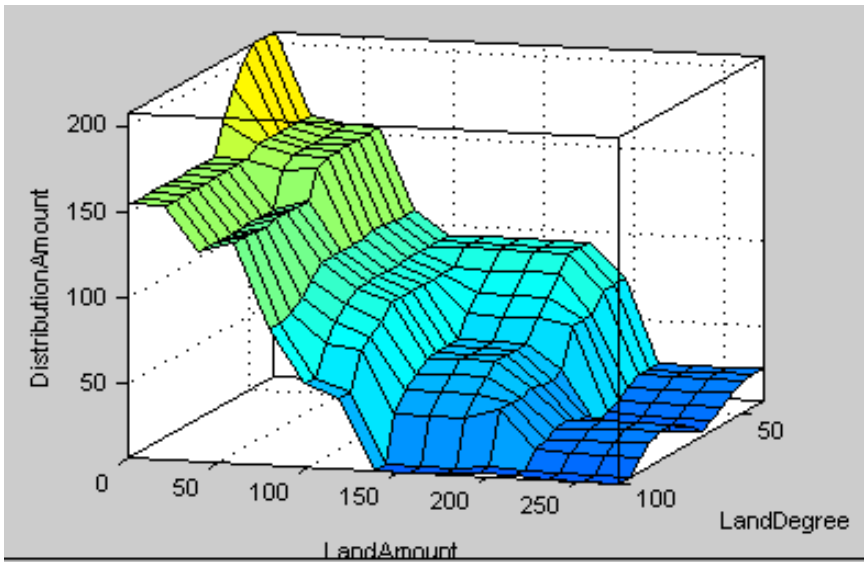

Fig.6. Relationship between inputs and DA

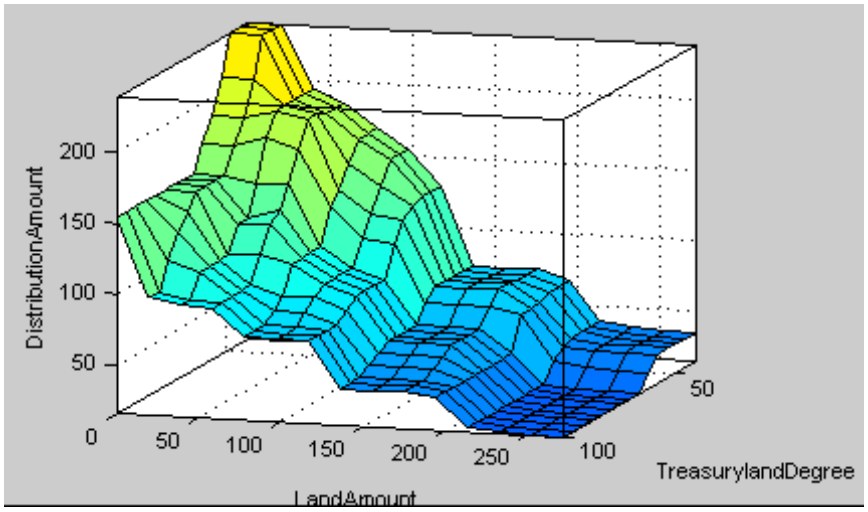

Fig.7. Relationship between inputs and DA

Just for the sake of argument it is illuminating to explain, For example, Rule 1, Rule 21 and Rule 41 as follows:
Rule1:IF LD=fewproductive and LA= veryveryinsufficient and TD= fewproductive, then DA= veryveryextra, i.e. if the farmer's LD is fewproductive and farmer's LA is veryveryinsufficient and treasury land degree (land degree which are given farmers) is fewproductive, THEN Distribution amount (land amount which are given farmers) is veryveryextra.

Rule 21: IF LD= productive and LA= veryveryinsufficient and TD= fewproductive, then DA= veryveryextra, i.e. if the farmer's LD is productive and farmer's LA is veryveryinsufficient and treasury land degree (land degree which are given farmers) is fewproductive, THEN Distribution amount (land amount which are given farmers) is veryveryextra.
Rule 41:IF LD=veryproductive and LA= veryveryinsufficient and TD= fewproductive, then DA= veryveryextra, i.e. if the farmer's LD is fewproductive and farmer's LA is veryveryinsufficient and treasury land degree (land degree which are given farmers) is fewproductive, THEN Distribution amount (land amount which are given farmers) is veryveryextraextra.

2.3. Defuzzification

At this stage, truth degrees (α) of the rules are determined for the each rule by aid of the min. and then by taking max. between working rules. For example, for LD=80 unit, LA=73 da, TD=80 unit, the rules 51 and 91 will be fired with the following results:
α_{51} = min(productive LD, veryinsufficient LA, veryproductive) = min(1, 0.43, 1) = 0.43.
α_{91} = min(productive LD, insufficient LA, veryproductive) = min(1, 0.28, 1) = 0.28.
From Mamdani max-min inference it is possible to obtain the membership function of the constructed system as max(α_{51}, α_{91})=0.43, which means Very DA. Consequently, one can calculate the crisp output. For instance, the crisp value of the DA is calculated by the method centroid defuzzifier by the following formula as,

$$z^* = \frac{\int u_c(z).z dz}{\int u_c(z) dz}$$

As also seen from the Fig. 8, the value of DA= 94. This means that the land amount, which is given to farmers (distribution amount) is 94.

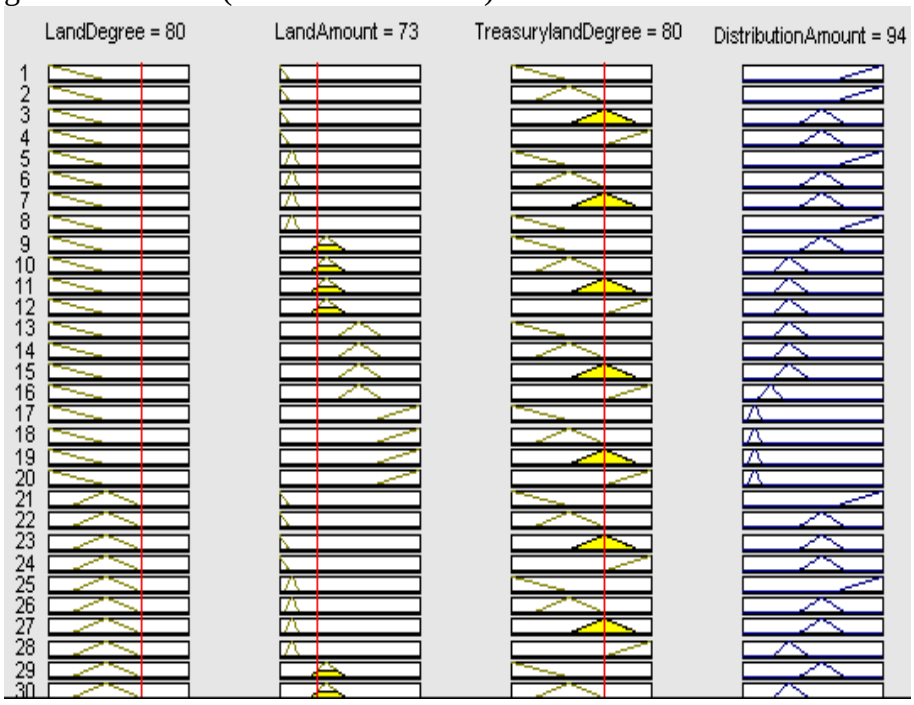

Fig.8. Calculation of the value DA for the values LD= 80 unit, LD= 73 da and TD= 80 unit.

3. DISCUSSION AND CONCLUSION

The methodology developed in this paper is applied the first time to land amount distribution to farmers with fuzzy logic and system approach. The results of the developed Fuzzy Logic Model (FLM) are compared with the results of the traditional methodology as shown in Table 4. It is possible to conclude from this table that the finding land amount given to farmers by FLM abides closely with the data, which is the traditional way of distribution of the land amount. For this purpose the linguistic variables are considered as six fuzzy sets. If one selects more fuzzy sets for the linguistic variables, then the results can be closer to the traditional values, hence a very suitable model is obtained for land amount distribution to the farmers. The study also shows that LA is an important factor in finding land amount, and few LA cause increase in the DA. This system is rapid, equitable and correct than traditional methods, has also a high reliability. In additional to that its accuracy is controlled by line with 45^0 as the plot of fuzzy system solution versus the traditional data values as shown in Figure 9.

Table 4. Comparison of the FES and Traditional Method

LD	*LA*	*TD*	*Traditional Method*	*Fuzzy Logic Method*
60	10	60	182	179
60	20	60	178	177
90	50	90	86	94
80	70	80	87	94
80	20	60	167	177
-	0	80	157	155
42	100	90	86	94
90	30	70	150	155
50	100	80	99	94
80	50	70	131	135
70	80	80	91	94
45	100	80	99	94

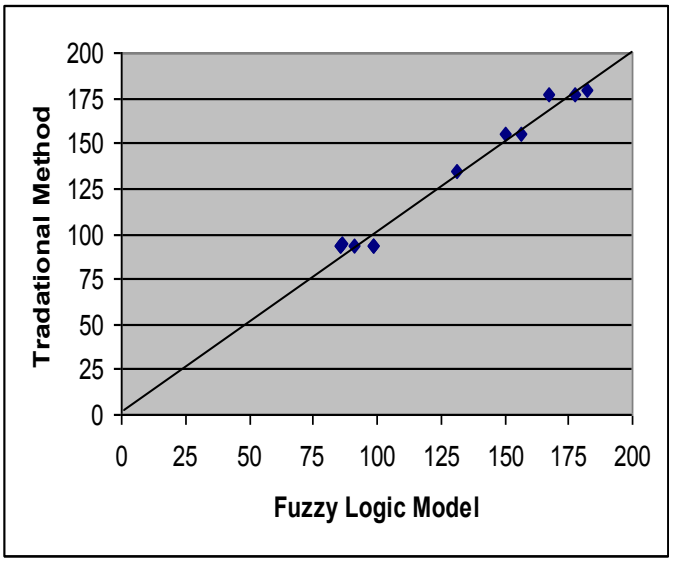

Fig.9. Accuracy of Fuzzy Logic Model by Line with 45^0

This paper describes a design of fuzzy system model for determination of land amount given to farmers, which can be used easily by operator of land reform. This system can be developed further with increasing the knowledge rules from one side and with the increase in the number of linguistic variables on the other side.

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