DETERMINATION OF OPTIMUM CROPPING PATTERN OF IRRIGATION FIELDS

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ABSTRACT

DETERMINATION OF OPTIMUM CROPPING PATTERN OF IRRIGATION FIELDS

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Water and nutrients are the main physiological requirements of human beings and therefore vegetal nutrients are of great importance to humans. In order to obtain the required plant diversity under the conditions of variable climate, soil and topography, it is necessary to ensure that the amount of water required by the plant during the growing season is stored in the root zone of the plant, which is called "irrigation". Global warming and population growth factors increase the need for water, which necessitates the most efficient use of existing water resources. The use of stored stormwater for irrigation purpose is one of the main solution methods of irrigation water supply and these storage facilities are made with high cost. The maximum agricultural benefit can be achieved by optimizing the cropping patterns that determine the weighted average of the plant water needs of the irrigation area. In this study, to determine the cropping pattern two different objective functions are used. Those functions are the maximization of irrigation area and the maximization of agricultural profit. The first objective function results in a linear programming problem whereas the second one is a nonlinear programming problem. The solution is obtained by using Microsoft Excel – Solver program using Simplex and GRG methods for two objective functions, respectively. The developed formulation is applied to Çimendere-1, Çimendere-2, Gözsüz, Karaevli, Hüsünlü and Kılavuzlu Ponds in Tekirdağ.

Keywords: Cropping Pattern, Irrigation, Optimization, Linear Programming, Nonlinear Programming

ÖZ

SULAMA SAHALARINDA OPTIMUM BITKI DESENİNİN BELİRLENMESİ

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Su ve besin insanoğlunun başlıca fizyolojik gereksinimlerindendir ve dolayısıyla bitkisel kaynaklı besinler insanlar için büyük önem taşımaktadır. İhtiyaç duyulan bitki çeşitliliğinin değişken iklim, toprak ve topoğrafya koşullarında elde edilebilmesi için bitkinin büyüme mevsimi boyunca gereksinim duyduğu su miktarının bitki kök bölgesinde depolanmasını sağlamak gerekmektedir ki bu özetle "sulama"dır. Küresel ısınma ve nüfus artışı faktörleri su gereksinimini artırmakta; bu da mevcut su kaynaklarının en verimli şekilde kullanılmasını zorunlu kılmaktadır. Havzaya gelen yağışların depolanarak sulama suyu olarak kullanılması sulama suyu temini probleminin başlıca çözüm metodlarındandır ve bu depolama tesisleri yüksek maliyetli yapılardır. Sulama sahasının bitki su ihtiyacı ağırlıklı ortalamasını belirleyen bitki deseninin optimize edilmesi ile maksimum tarımsal fayda sağlanabilmektedir. Bu çalışmada, bitki desenini belirlemek için iki farklı amaç fonksiyonu kullanılmıştır. Bunlar sulama alanının maksimizasyonu ve tarımsal kazanç maksimizasyonudur. Birinci fonksiyon doğrusal programlama, ikinci fonksiyon doğrusal olmayan programlama ile sonuçlanmaktadır. İki amaç fonksiyonu için çözüm Microsoft Excel – Solver programı kullanılarak, sırasıyla Simplex ve GRG yöntemleriyle elde edilmiştir. Geliştirilen formülasyonun Tekirdağ Çimendere-1, Çimendere-2, Gözsüz, Karaevli, Hüsünlü ve Kılavuzlu Göletleri üzerinde uygulaması yapılmıştır.

Anahtar kelimeler: Bitki Deseni, Sulama, Optimizasyon, Doğrusal Programlama, Doğrusal Olmayan Programlama

to my love...

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TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

A	Irrigation Area
AW	Annual available water for irrigation purpose
CD1	Malkara – Çimendere-1 Pond and Irrigation System
CD2	Malkara – Çimendere-2 Pond and Irrigation System
$CIR_{i,j}$	Crop irrigation requirement for crop j in crop rotation group i
$C_{i,j}$	Cost for crop j in crop rotation group i
$DC_{i,j}$	Development period coefficient for crop j in crop rotation group i
$DP_{i,j}$	Development period for crop j in crop rotation group i
DSİ	State Hydraulic Works (Devlet Su İşleri)
GOZ	Malkara – Gözsüz Pond and Irrigation System
GRG	Generalized Reduced Gradients
HUS	Merkez – Hüsünlü Pond and Irrigation System
i	Integer number representing the crop rotation group
j	Integer number representing the crop type in i^{th} crop rotation group
KAR	Merkez – Karaevli Pond and Irrigation System
KLV	Merkez – Kılavuzlu Pond and Irrigation System
LP	Linear Programming
MPR	Modified Planning Report
NLP	Nonlinear Programming
NP	The weighted average of annual net agricultural profit
$NP_{i,j}$	Annual net agricultural profit for crop j in crop rotation group i
$OIE_{i,j}$	Overall irrigation efficiency for crop j in crop rotation group i

PR	Planning Report
$SP_{i,j}$	Sale price for crop *j* in crop rotation group *i*
TDR	Weighted average of Total Delivery Requirement
$TDR_{i,j}$	Total delivery requirement for crop *j* in crop rotation group *i*
TP	Annual Total Agricultural Profit
V_{active}	Active Volume
V_{min}	Volume at Minimum Water Level
V_{nor}	Volume at Normal Water Level
$WAE_{i,j}$	Water application efficiency for crop *j* in crop rotation group *i*
$WCE_{i,j}$	Water conveyance efficiency for crop *j* in crop rotation group *i*
$X_{i,j}$	Percentage distribution for crop *j* in crop rotation group *i*
$X_{i,j\ planning}$	Percentage distribution for crop *j* in crop rotation group *i* given in the planning report
$Xmax_{i,j}$	Upper limit of percentage distribution for crop *j* in crop rotation group *i*
$Xmin_{i,j}$	Lower limit of percentage distribution for crop *j* in crop rotation group *i*
$Y_{i,j}$	Annual yield for crop *j* in crop rotation group *i*

CHAPTER 1

INTRODUCTION

1.1 Statement of the Problem

It is not possible to think of a life without water on earth. The regions that have been called cradle of civilization since ancient times have always been established near the water basins, and civilizations have lived in the lands where water has given life. Societies that have been able to benefit from rivers throughout history have established the most advanced civilizations of their time and those who cannot find it have had to leave their homelands and migrate. Mesopotamia, which is the first source of civilization on earth where the first agricultural activities carried out on its fertile soils and which is also known as "fertile crescent", owes its hosting to the fertile waters of Dicle and Fırat Rivers (DSİ, 2015).

As human population of world increases, water demand of community increases. In 2011, the world population was about 7 billion, it is estimated that the population would have been 9.15 billion in 2050 , in other words, the population will increase with a rate of 30% between 2011 and 2050 (DSİ, 2015).

The most basic needs of a person are fresh water and nourishment. Nourishment is supplied from herbal and animal sources. As humans, plants and animals which are also living beings need water to live and grow, additionally, most of animals which are consumed by humans feed with crops. Therefore, water requirement of people increases indirectly also. Crops need certain amount of water in accordance with a

schedule depending on its kind, this means that it is not possible for a crop to store water in limited rainy seasons. Yıldırım (2013) states that "Irrigation" is delivering the amount of required water that cannot be supplied from natural precipitation to soil, crop's root zone for normal growth of crop. Existence and absence of irrigation specify the technique of farming. In arid or semiarid regions, non-irrigated plantation is called as "dry farming". In dry farming conditions; fertilization, agricultural mechanization and crop diversity is limited and it is highly depended on climatic conditions. In "irrigated farming" conditions; there are sufficient watering, fertilization, agricultural mechanization and crop diversity and crop yields are pretty much with respect to dry farming conditions.

Irrigation works for normal growth of crop require needed water at the right time. If the farm land is far away from water resources such as rivers and ground water wells that are usable during irrigation period, it can be possible to use water from reservoirs that store water during wet periods. Former head of Department of Investigation and Planning of DSİ, Bilen (1988) states that planning studies to find the most economical solutions against the limited investment opportunities, scarce water and land resources are becoming increasingly important.

In addition to field studies, optimization models are needed to determine optimum cropping pattern that is the acreage (surface area) distribution of different crops in any one year in a given farm area (Qāsim, 2012). The optimum cropping pattern refers to maximum agricultural benefits. In order to contribute planning studies, optimization models should be formulated to maximize irrigation area or to maximize agricultural profit.

1.2 Purpose and Scope

The main aim of this study is to demonstrate the importance of determination of optimum cropping pattern that can only be obtained with mathematically implemented optimization models. These optimization models can be formulated by using values determined in two different parts of planning reports. The first data set related with the annual available water for irrigation purpose and crop water requirement that are taken from the "Climate and Water Resources" chapters of planning reports. The other data set which is about economical values and determined cropping pattern that are the content of "Agricultural Economy" chapters of reports.

The optimization problem can be formulated using two different objective functions. The linear optimization problem is formulated which maximizes the irrigation area size as the objective function. The nonlinear optimization problem considers the maximization of agricultural profit as the objective function. In the application of the study, six pond and irrigation system projects which are located in Tekirdağ province are examined in order to compare values obtained from optimization problems and values taken from planning reports which are also prepared by the author of this thesis. In the studies, the effects of different deviation ratios of percentage distribution for crop types are also evaluated.

CHAPTER 2

LITERATURE REVIEW

Hydraulic structures, namely dams, ponds or regulators, are sizable investments for countries. Big budgets are spent for constructions and it is anticipated that sufficient financial return from projects will be achieved. Since it is known that maximum income with minimum investment brings the maximum profit, before making final design and construction of costly structures, conducting optimization studies with low cost engineering services yields a considerable profit. Within the scope of this study, since the objective is to determine optimum cropping pattern providing maximum profit, previous studies related with optimization of cropping pattern are reviewed in order to perform well-prepared study.

Carvallo et al. (1998) performed a comprehensive study considering soil availability, water availability, labor availability, irrigation technology used, costs and prices of the products and agronomic management and market criteria to optimize cropping patterns for conditions existing in Chile. The sensitivity analysis of conducted study represents that deviations in the expenses of exportable products and water cost are considerably influential on the cropping pattern and profit. Whereas the other important factors affecting the area and percentage distribution of crop are water and labor availability. According to results of study, it is stated that increasing labor wages in order to supply larger labor is better than to continue with a limited employment force.

In the scope of the study, Degirmenci and Tulucu (2000) performed a study to obtain optimum land and water resources usage for Harran Plain by considering hydrological, economics and agricultural parameters. In this study, cropping pattern, required

irrigation water for each month and net agricultural return are determined. In addition to canal water, groundwater and drainage water are considered as water resources for irrigation purpose in order to supply required water for aforementioned region. As a consequence, the maximum water capacity of canal is found insufficient in June, July and August which are the months the crop irrigation requirements are at the highest level and additional water resources need, groundwater and drainage water, is determined throughout the three months.

A non-linear, water-benefit function based optimization model with adequate and limited water supplies is formulated by Benli and Kodal (2003) for application to the South-East Anatolian Project (GAP) Region. The model was also solved by a linear programming model (LP) so as to compare linear programming (LP) and nonlinear programming models (NLP). As a result, it can be seen that higher agricultural income can be acquired with a nonlinear programming model under limited water supply and the best irrigation volume ratio for one crop has been calculated with the nonlinear programming model (NLP).

Fayrap and Kızıloğlu (2010) conducted the study to determine optimal crop pattern in suitable irrigation project area in Demirdöven Irrigation Area by linear programming (LP) method. The study was conducted for the arid, normal and rainy years. They stated that increasing the irrigation rate in the irrigation fields can be realized with determination of crop pattern by considering ecological, economic and social conditions of the region, which can provide the highest net income to the agricultural enterprises with the possibility of realization in practice. It is also mentioned that determination of irrigation method, crop pattern and amount of water would be given to crop are carried out by farmers and this leads to failure in the operation of irrigation projects, additionally, alternative operation plans should be prepared in order to use soil and water resources at an optimum level.

The optimized cropping pattern in Saudi Arabia aiming at maximizing the net annual return of agricultural sector is obtained in the study conducted by Alabdulkader et al.

(2012). Since Saudi Arabia is one of the countries badly influenced from the impact of the climate change, in other words, water resources and arable land are scarce in this country, optimization of agricultural issues are crucial. This study is also bridging the gap between the national demand and supply through importing from the world market. The researchers also claim that their study is beneficial not for only researchers but also for decision makers and broader public.

CHAPTER 3

FORMULATION OF OPTIMIZATION PROBLEM

3.1 Problem Definition

"Determination of optimum cropping pattern of irrigation fields" is an issue which is a result of two main phenomenon, crop irrigation requirement and agricultural profit. In the scope of present thesis study, two different objective functions are examined. Both objective functions use the same constraint set.

The first objective is maximizing irrigation area in order to provide agricultural income for as many families as possible. This function is also described as minimizing total delivery (water) requirement since available water is taken as constant in consequence of hydrological studies. A linear programming model (LP) is formulated subject to constraints on equality of summation of crop distributions to unity, lower limits and upper limits of percentage distributions of crop types and equality of percentage distribution summations of crop rotation groups.

The second objective is maximizing annual agricultural profit from whole cultivated area. While the first objective function just depends on parameters of crop irrigation requirement, maximization of annual agricultural profit problem also depends on agricultural economy parameters. Since the decision variables, $X_{i,j}$, are both in nominator and denominator parts of the objective function, the optimization model is nonlinear. A nonlinear programming model (NLP) is also constrained by the same constraints with the first objective function.

OBJECTIVE FUNCTION 1 (OF1) – "Maximization of Irrigation Area"

In the present study, the first objective function used can be defined as the maximization of the irrigation area, *A* of the minimization of total delivery requirement, *TDR*.

Since irrigation area, *A* is defined as the ratio of the annual available water, *AW* and the total delivery requirement, *TDR* (see Eq.(3.8)) and the *AW* is taken as constant value, OF1 can also be defined as "Minimization of Total Delivery Requirement". Hence, minimizing the total delivery requirement is the same thing as maximizing the irrigation area.

The Objective Function 1 is formulated as minimization of total delivery requirement and the objective function of the model is represented as

$$min\ TDR\ =\ \sum_{i=1}^{m}\sum_{j=1}^{n_m}\left(TDR_{i,j}\times X_{i,j}\right) \qquad \textbf{(3.1)}$$

where;

$TDR_{i,j}$: Total delivery requirement for crop *j* in crop rotation group *i (m³/ha/year)*

$X_{i,j}$: Percentage distribution for crop *j* in crop rotation group *i*

i : Integer number representing the crop rotation group (i = 1,2,....,m)

j : Integer number representing the crop type in i^{th} crop rotation group (j = 1,2,....,n_m)

The total delivery requirement, *TDR* is the modification of the crop irrigation requirement, *CIR* considering water losses defined as (Darama, 2009).

$$TDR_{i,j} = \frac{CIR_{i,j}}{OIE_{i,j}} \quad \textbf{(3.2)}$$

where;

$CIR_{i,j}$: Crop irrigation requirement for crop j in crop rotation group i ..... *(m³/ha/year)*

$OIE_{i,j}$: Overall irrigation efficiency for crop *j* in crop rotation group *i*

Overall irrigation efficiency, *OIE* is computed by multiplying water conveyance efficiency, *WCE* and water application (farm) efficiency, *WAE*.

$$OIE_{i,j} = WCE_{i,j} \times WAE_{i,j} \quad \textbf{(3.3)}$$

where;

$WCE_{i,j}$: Water conveyance efficiency for crop *j* in crop rotation group *i*

$WAE_{i,j}$: Water application efficiency for crop *j* in crop rotation group *i*

Water conveyance efficiency, *WCE* is obtained as

$$WCE_{i,j} = \frac{(W_{delivered})_{i,j}}{(W_{introduced})_{i,j}} \quad \textbf{(3.4)}$$

where;

$(W_{delivered})_{i,j}$: Water delivered by conveying system for crop *j* in crop rotation group *i*

$(W_{introduced})_{i,j}$: Water introduced into the conveying system for crop *j* in crop rotation group *i*

$WCE_{i,j}$ is taken as constant value, 0.98 for all crop types and all irrigation methods.

Water application efficiency, *WAE* is obtained as

$$WAE_{i,j} = \frac{(W_{stored})_{i,j}}{(W_{delivered})_{i,j}} \quad \textbf{(3.5)}$$

where;

$(W_{stored})_{i,j}$: Stored water in the soil root zone by irrigation for crop *j* in crop rotation group *i*

$(W_{delivered})_{i,j}$: Water delivered by conveying system for crop *j* in crop rotation group *i*

$WAE_{i,j}$ is taken as 1.00 for crop types to be irrigated by dripping irrigation method and it is taken as 0.80 for crop types to be irrigated by sprinkler irrigation method.

Substitution of (3.2) and (3.3) into (3.1) gives

$$min\ TDR = \sum_{i=1}^{m}\sum_{j=1}^{n_m}\left(\frac{CIR_{i,j}}{WCE_{i,j} \times WAE_{i,j}} \times X_{i,j}\right) \quad \textbf{(3.6)}$$

OBJECTIVE FUNCTION 2 (OF2) – "Maximization of Annual Total Agricultural Profit"

The objective function of the model is represented as

$$max\ TP = A \times NP \quad \textbf{(3.7)}$$

where;

A : Irrigation area .....*(ha)*

NP : Weighted average of annual net agricultural profit.....*(TL/ha/year)*

The size of irrigation area, *A* is obtained as

$$A = \frac{AW}{TDR} \quad \textbf{(3.8)}$$

where;

AW : Annual available water for irrigation purpose..... *(m³/year)*

TDR : Weighted average of total delivery requirement for irrigation area ..... *(m³/ha/year)*

Substitution of (3.2) and (3.3) into (3.8) gives

$$A = \frac{AW}{\sum_{i=1}^{m}\sum_{j=1}^{n_m}\left(\frac{CIR_{i,j}}{WCE_{i,j} \times WAE_{i,j}} \times X_{i,j}\right)} \quad \textbf{(3.9)}$$

The weighted average of annual net agricultural profit, *NP* is obtained as

$$NP = \sum_{i=1}^{m}\sum_{j=1}^{n_m} NP_{i,j} \times X_{i,j} \quad \textbf{(3.10)}$$

where;

$NP_{i,j}$: Annual net agricultural profit for crop j in crop rotation group i .....*(TL/ha/year)*

$X_{i,j}$: Percentage distribution for crop j in crop rotation group i

The annual net agricultural profit $NP_{i,j}$ is obtained as

$$NP_{i,j} = \left(\left(\left(Y_{i,j} \times SP_{i,j}\right) - C_{i,j}\right) \times DC_{i,j}\right) \quad \textbf{(3.11)}$$

where;

$Y_{i,j}$: Annual yield for crop j in crop rotation group i .....*(kg/ha)*

$SP_{i,j}$: Sale price for crop j in crop rotation group i ..... *(TL/kg)*

$C_{i,j}$: Cost for crop j in crop rotation group i..... *(TL/kg)*

$DC_{i,j}$: Development period coefficient for crop j in crop rotation group i

Substitution of (3.9), (3.10) and (3.11) into (3.7) gives the second objective function of the study as;

$$max\ TP = \frac{AW}{\sum_{i=1}^{m}\sum_{j=1}^{n_m}\left(\frac{CIR_{i,j}}{WCE_{i,j} \times WAE_{i,j}} \times X_{i,j}\right)} \times \sum_{i=1}^{m}\sum_{j=1}^{n_m}\left(\left(\left(Y_{i,j} \times SP_{i,j}\right) - C_{i,j}\right) \times DC_{i,j}\right) \times X_{i,j} \quad \textbf{(3.12)}$$

The first constraint of the optimization problems is that sum of percentage distributions of crop types in cropping pattern has to be equal to 1.

$$\sum_{i=1}^{m}\sum_{j=1}^{n_m}(X_{i,j}) = 1 \quad \textbf{(3.13)}$$

where $(X_{i,j})$ = percentage distribution for crop j (1,2,…,n_m) in crop rotation group i (1,2,…,m)

The second constraint is that percentage distribution, $X_{i,j}$ values of crop types has to be between lower and upper limit values. Meanwhile, at the pond projects of State Hydraulic Works, cropping patterns are determined within "Agricultural Economy" studies by agricultural engineers in consequence of field works, survey studies and obtained information from "Provincial Directorates of Agriculture". At the end of study, agricultural engineers state fix values for percentage distributions. On the contrary, in the scope of this study, percentage distributions of crop types are evaluated between limits. These limit values are calculated from cropping pattern values determined at the "planning reports" by enlarging with some deviation ratios. (e.g. 5%, 10%, 15%, 20%, 25% and 30%)

$$Xmin_{i,j} \leq X_{i,j} \leq Xmax_{i,j} \quad \textbf{(3.14)}$$

where $Xmin_{i,j}$ and $Xmax_{i,j}$ = lower and upper limits of percentage distribution for crop *j* in crop rotation group *i*, respectively.

The third constraint is the equality of percentage distribution summations of nonstationary crop rotation groups.

"Crop rotation" can be described as a method of growing different types of crop one after another on an irrigation field. If the same crop types are grown at the specific field, only some types of nutrient from soil are used and soil fertility decreases. In order to increase soil fertility, crop rotation is applied. In the selected projects, cultivated area is divided in four groups. One of the four groups is defined as stationary rotation group and the others are defined as nonstationary group. It is assumed that crop types are fixed for stationary group and groups of crop type change year by year between nonstationary crop rotation groups.

The first crop group *(i=1)* is stationary group, so that, equality feature is valid for second, third and fourth crop groups.

$$\sum_{j=1}^{n_2}(X_{2,j}) = \sum_{j=1}^{n_3}(X_{3,j}) = \sum_{j=1}^{n_4}(X_{4,j}) \quad \textbf{(3.15)}$$

where $(X_{2,j})$ = percentage distribution for crop *j* (1,2,…,n_2) in crop rotation group 2; $(X_{3,j})$ = percentage distribution for crop *j* (1,2,…,n_3) in crop rotation group 3 and $(X_{4,j})$ = percentage distribution for crop *j* (1,2,…,n_4) in crop rotation group 4.

In brief, $X_{i,j}$ parameters are the decision variables of optimization models. The final forms of OF1 and OF2 are given in Eq.(3.6) and Eq.(3.12), respectively. The objective functions are both subject to constraints which are given in Eq.(3.13), Eq.(3.14) and Eq.(3.15). It can be seen that OF1 is a linear function of $X_{i,j}$ whereas OF2 is a nonlinear function of $X_{i,j}$. Hence, the first optimization formulation leads to a linear programming (LP) problem and the second one is a nonlinear programming (NLP) problem.

3.2 Assumptions Made for Optimization Problem

The main objective of this study is comparing optimization results with values given in the planning reports of State Hydraulic Works. In order to make comparison, parameters and some calculated values in planning reports are used for this study also.

The following assumptions and calculated values are considered;

- Sprinkler irrigation system is used for crop types which are cereal, sunflower and clover. Dripping irrigation system is used for the rest of the crop types.
- Water application (farm) efficiency, *WAE* is taken as 0.80 for sprinkler irrigation system and it is taken as 1.00 for dripping irrigation system.
- Water conveyance efficiency, *WCE* is taken as 0.98.
- The crop irrigation requirement, *CIR* values are taken from "Climate and Water Resources" parts of planning reports for each pond project.
- The annual available water, *AW* values are taken from "Climate and Water Resources" parts of planning reports and it is assumed that the available water values are constant for each year.

- Annual yield, sale price, production cost, development period and development period coefficient values for each crop types are taken from "Agricultural Economy" parts of planning reports.
- The percentage distributions of crop types in cropping pattern obtained by agricultural engineers are taken from "Agricultural Economy" parts of planning reports.
- Crop rotation system is considered as it is in planning reports.
- Deviation of percentage distributions of crop types are specified as 5%, 10%, 15%, 20%, 25% and 30%.
- Comments stated in "Agricultural Economy" parts of planning reports by agricultural engineers are considered in order to determine lower and upper limits of percentage distributions.

3.3 Methods and Software Used for Optimization Problems

In the present study, determination of optimal cropping pattern studies are conducted by linear programming (LP) and nonlinear programming (NLP) methods. Solver add-in of Microsoft Excel software is used for optimization problems.

The objective function indicated as Objective Function 1, OF1 aims to minimize total delivery requirement, *TDR* (Eq.(3.6)). Since the objective function and constraints of the objective function are first order equations, it is a linear optimization model and solved by Simplex LP method. As Harmon (2011) stated that, Simplex LP is a method used to solve optimization models containing only basic mathematical operations

which are division, multiplication, subtraction and addition. The Simplex LP solver guarantees the global optimum solution.

The second objective function is solved in order to determine optimal cropping pattern providing maximum annual total agricultural profit, *TP* (Eq.(3.12)). Although constraint equations are linear functions; at the objective function, decision variables are located at both nominator and denominator parts which makes objective function nonlinear. So that, Objective Function 2, OF2 is solved by "GRG Nonlinear Method". GRG stands for "Generalized Reduced Gradients". It is also possible to solve linear programming models by GRG Nonlinear Method, however, it is not recommended since processing time is longer. GRG Method does not guarantee global optimum solution if the optimization model is nonlinear. The initial point of decision variable affects results of the GRG algorithm, for this reason, different results can be obtained with different initial values of decision variables. In order to achieve global optimum solution, solver should be run with various initial values. Alternatively, "Multistart" option can be used to assign different starting points automatically (Harmon, 2011).

CHAPTER 4

APPLICATION FIELDS, DATA AND DATA MODIFICATION

4.1 The Selected Projects for Application

"Tekirdağ the First Group of Pond and Irrigation System Project" conducted under the control of "State Hydraulic Works the 11th Regional Directorate" is used for the application of the present study. The group of projects contains seven pond and irrigation system projects and all but one are used for application of the study. The projects are as follows:

1) Malkara – Çimendere-1 Pond and Irrigation System (CD1)
2) Malkara – Çimendere-2 Pond and Irrigation System (CD2)
3) Malkara – Gözsüz Pond and Irrigation System (GOZ)
4) Merkez – Karaevli Pond and Irrigation System (KAR)
5) Merkez – Hüsünlü Pond and Irrigation System (HUS)
6) Merkez – Kılavuzlu Pond and Irrigation System (KLV)

General layout of the projects on satellite image is given below (Figure 4.1).

Figure 4.1 General layout of the projects on satellite image

4.1.1 General Information about Malkara – Çimendere-1 Pond and Irrigation System

Çimendere-1 Pond is designed for irrigation purpose and general information with broad strokes about the project corresponding with irrigation purpose is given below.

Project Location (Province)		:	Tekirdağ
Project Location (County)		:	Malkara
The Stream Pond Located on		:	Kurtdere
Project Coordinates	Longitude	:	26° 58’ 00’’ - 27° 02’ 15’’
	Latitude	:	40° 46’ 00’’ - 40° 48’ 00’’
Area of Precipitation		:	6.20 km²
Minimum Water Level		:	126.20 m
Normal Water Level		:	133.70 m
Volume at Minimum Water Level	V_{min}	:	0.200 hm³
Volume at Normal Water Level	V_{nor}	:	0.800 hm³
Active Volume	V_{active}	:	0.600 hm³
Annual Available Water for Irrigation	*AW*	:	0.509 hm³
Irrigation Area Elevations		:	122 m – 85 m

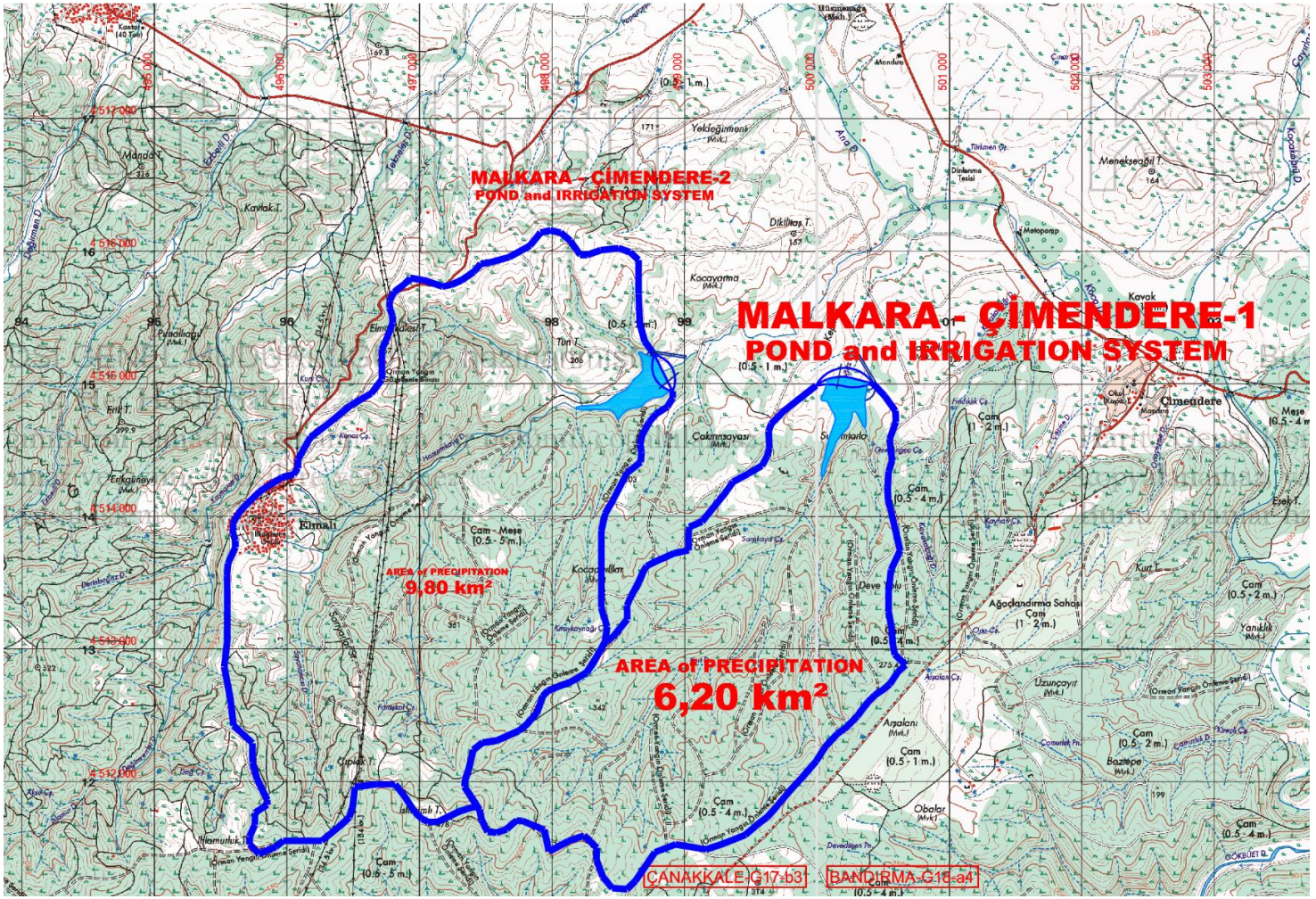

Figure 4.2 Map of Precipitation Area of CD1 Project

4.1.2 General Information about Malkara – Çimendere-2 Pond and Irrigation System

Çimendere-2 Pond is designed for irrigation purpose and general information with broad strokes about the project corresponding with irrigation purpose is given below.

Project Location (Province)		:	Tekirdağ
Project Location (County)		:	Malkara
The Stream Pond Located on		:	Hamamkaya
Project Coordinates	Longitude	:	26° 57’ 00’’ - 27° 01’ 30’’
	Latitude	:	40° 46’ 15’’ - 40° 49’ 45’’
Area of Precipitation		:	9.80 km²
Minimum Water Level		:	132.20 m
Normal Water Level		:	142.50 m
Volume at Minimum Water Level	V_{min}	:	0.147 hm³
Volume at Normal Water Level	V_{nor}	:	1.139 hm³
Active Volume	V_{active}	:	0.992 hm³
Annual Available Water for Irrigation	*AW*	:	0.852 hm³
Irrigation Area Elevations		:	130 m – 88 m

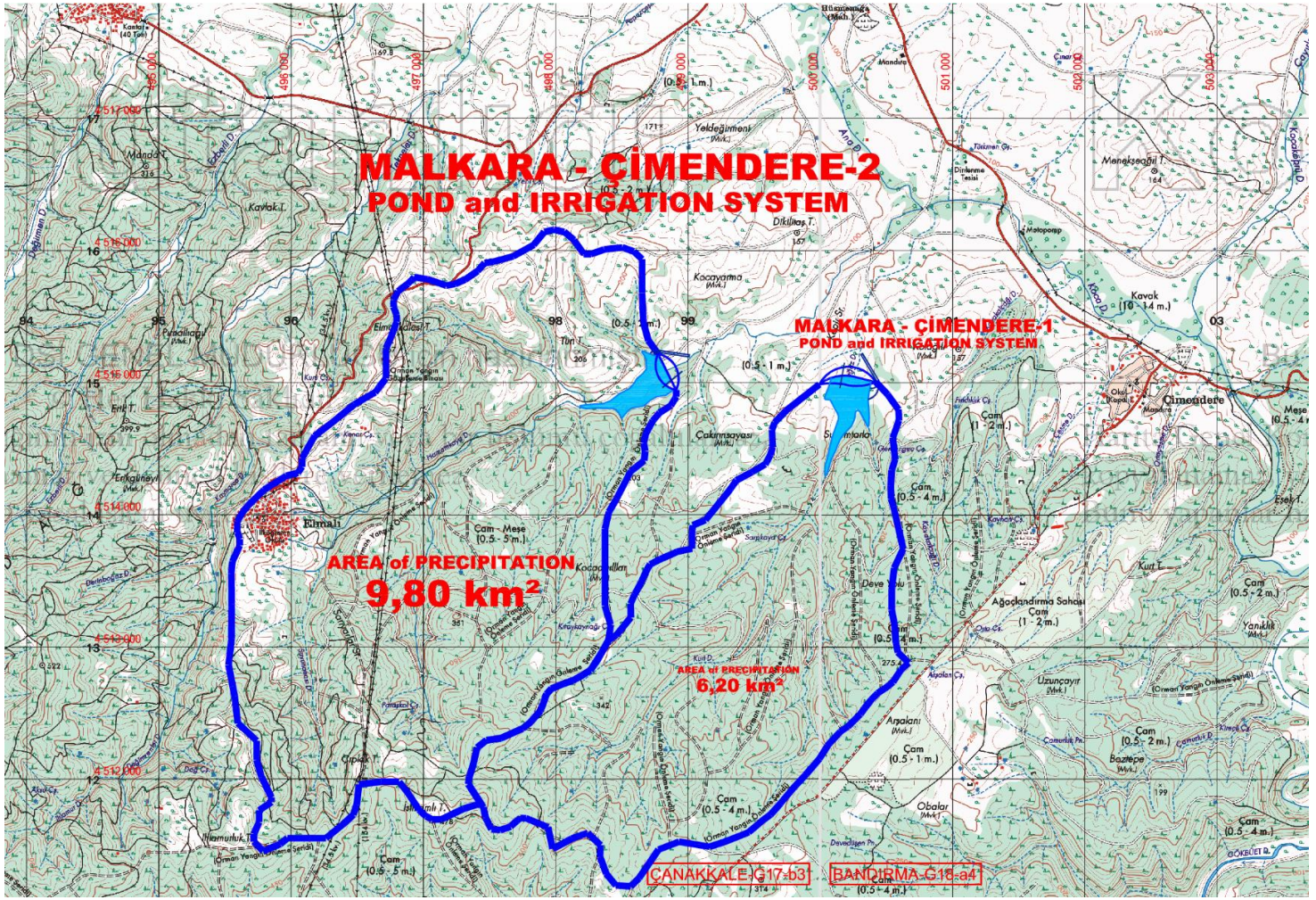

Figure 4.3 Map of Precipitation Area of CD2 Project

4.1.3 General Information about Malkara – Gözsüz Pond and Irrigation System

Gözsüz Pond is designed for irrigation purpose and general information with broad strokes about the project corresponding with irrigation purpose is given below.

Project Location (Province)		:	Tekirdağ
Project Location (County)		:	Malkara
The Stream Pond Located on		:	Balkanaltı
Project Coordinates	Longitude	:	26° 53’ 15’’ - 26° 55’ 30’’
	Latitude	:	40° 46’ 20’’ - 40° 44’ 45’’
Area of Precipitation		:	3.60 km²
Minimum Water Level		:	204.00 m
Normal Water Level		:	214.50 m
Volume at Minimum Water Level	V_{min}	:	0.096 hm³
Volume at Normal Water Level	V_{nor}	:	0.600 hm³
Active Volume	V_{active}	:	0.504 hm³
Annual Available Water for Irrigation	*AW*	:	0.405 hm³
Irrigation Area Elevations		:	192 m – 160 m

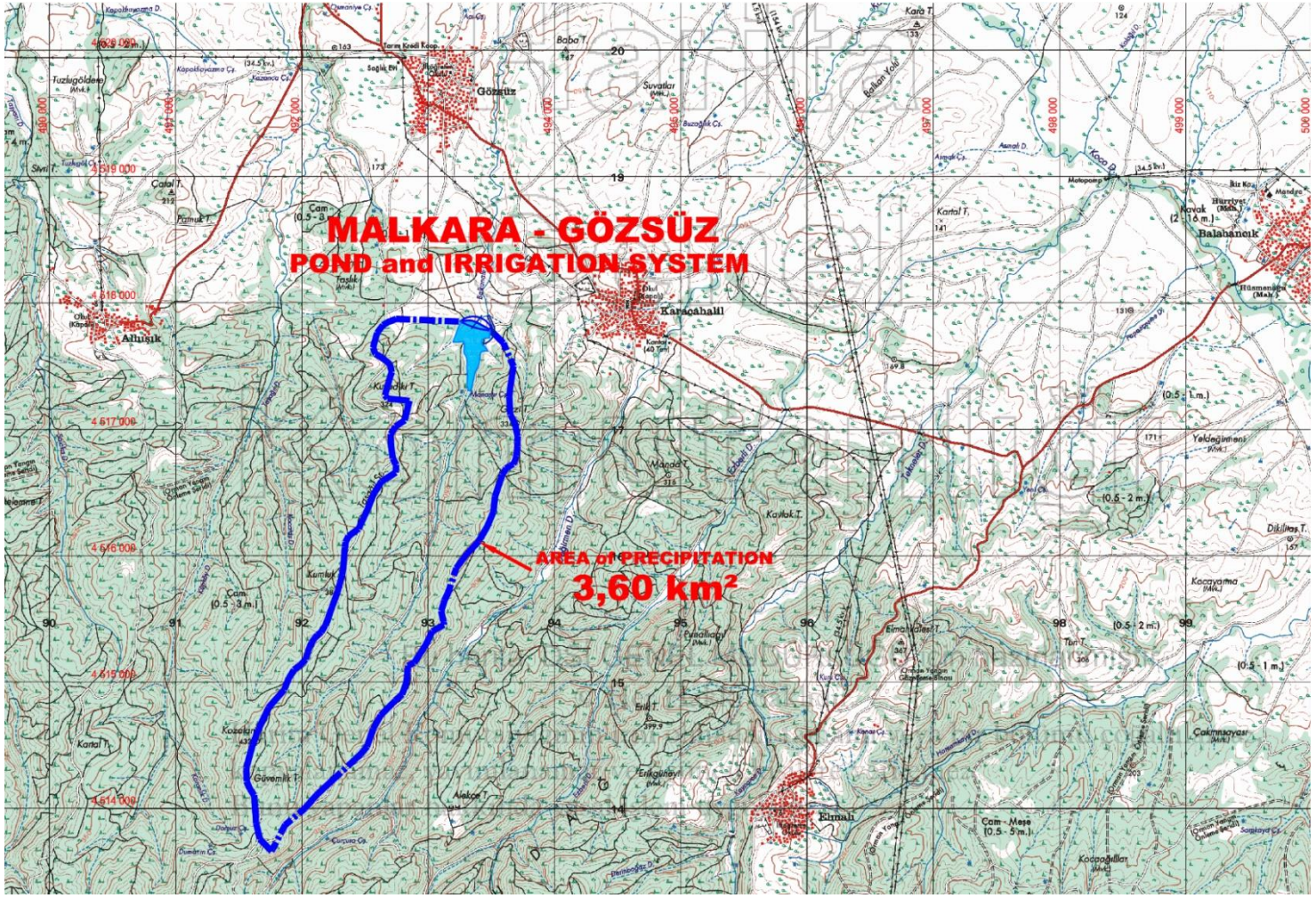

Figure 4.4 Map of Precipitation Area of GOZ Project

4.1.4 General Information about Merkez - Karaevli Pond and Irrigation System

Karaevli Pond is designed for irrigation purpose and general information with broad strokes about the project corresponding with irrigation purpose is given below.

Project Location (Province)		:	Tekirdağ
Project Location (County)		:	Merkez
The Stream Pond Located on		:	Aşağıkoru
Project Coordinates	Longitude	:	27° 36’ 30’’ - 27° 42’ 00’’
	Latitude	:	41° 01’ 00’’ - 41° 07’ 30’’
Area of Precipitation		:	20.00 km²
Minimum Water Level		:	40.70 m
Normal Water Level		:	48.00 m
Volume at Minimum Water Level	V_{min}	:	0.250 hm³
Volume at Normal Water Level	V_{nor}	:	2.050 hm³
Active Volume	V_{active}	:	1.800 hm³
Annual Available Water for Irrigation	*AW*	:	1.420 hm³
Irrigation Area Elevations		:	37 m – 6 m

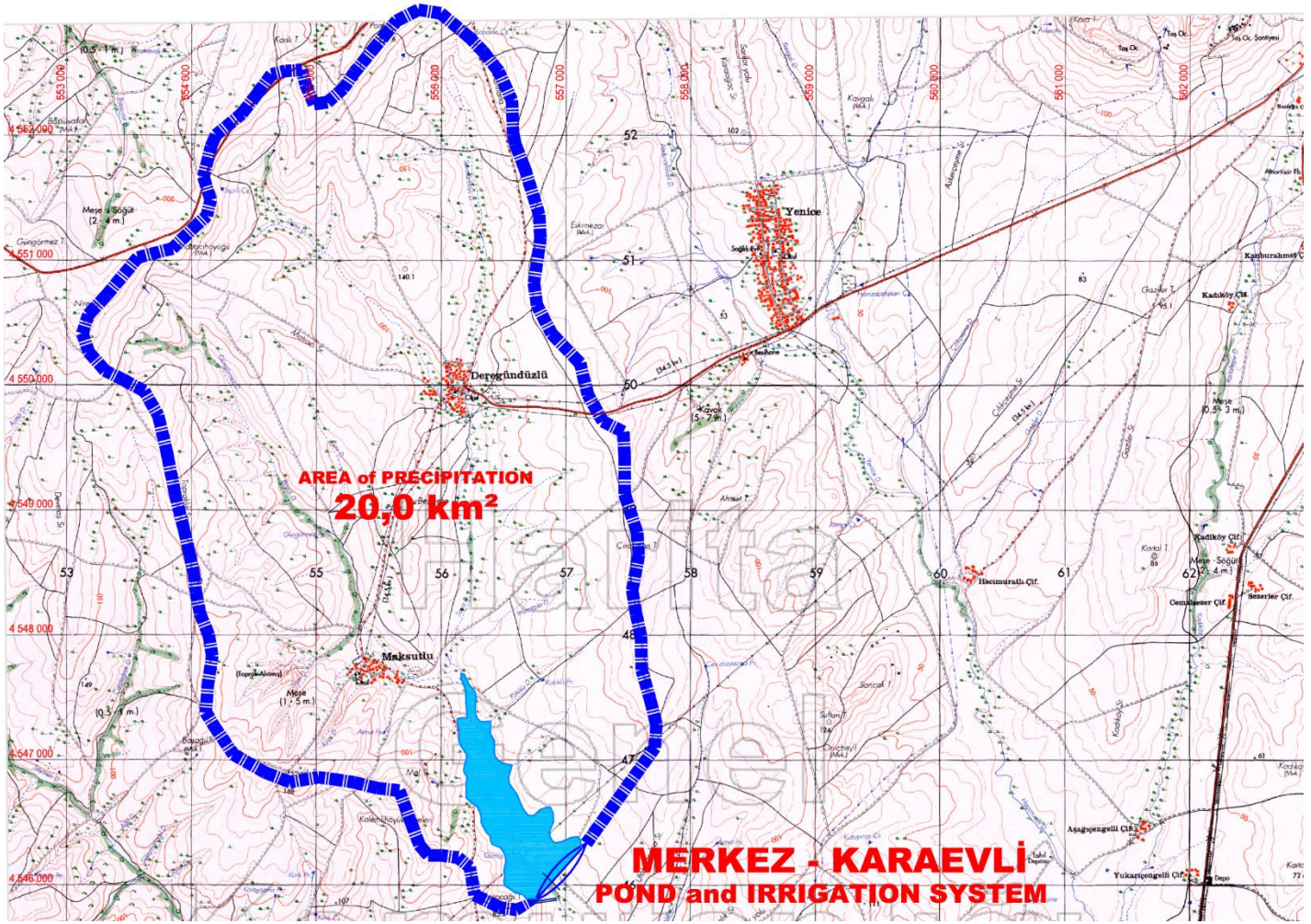

Figure 4.5 Map of Precipitation Area of KAR Project

4.1.5 General Information about Merkez - Hüsünlü Pond and Irrigation System

Hüsünlü Pond is designed for irrigation purpose and general information with broad strokes about the project corresponding with irrigation purpose is given below.

Project Location (Province)		:	Tekirdağ
Project Location (County)		:	Merkez
The Stream Pond Located on		:	Damlarca
Project Coordinates	Longitude	:	27° 34’ 00’’- 27° 37’ 30’’
	Latitude	:	41° 06’ 30’’- 41° 00’ 00’’
Area of Precipitation		:	21.60 km²
Minimum Water Level		:	44.25 m
Normal Water Level		:	50.00 m
Volume at Minimum Water Level	V_{min}	:	0.270 hm³
Volume at Normal Water Level	V_{nor}	:	1.648 hm³
Active Volume	V_{active}	:	1.378 hm³
Annual Available Water for Irrigation	*AW*	:	1.244 hm³
Irrigation Area Elevations		:	75 m – 16 m

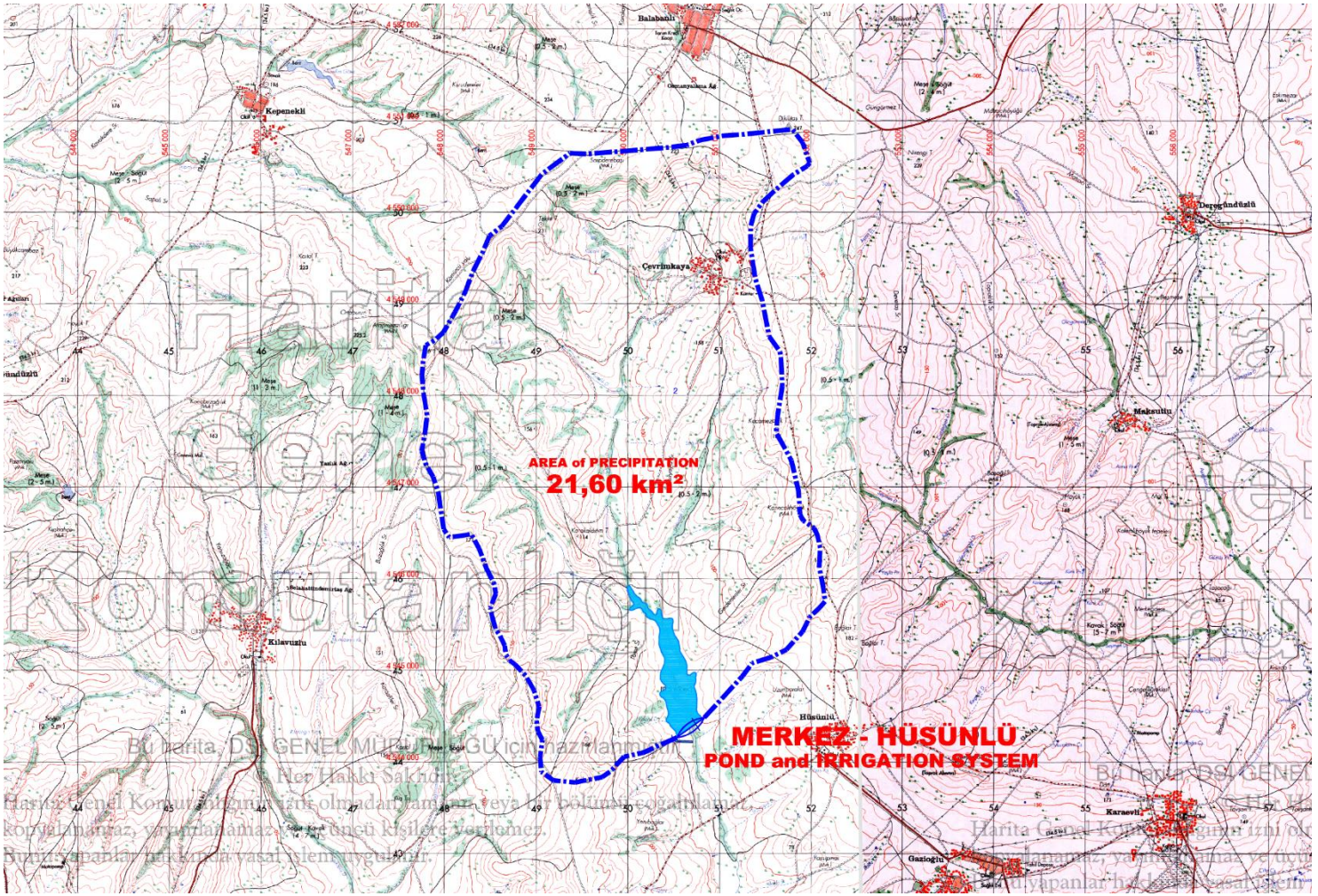

Figure 4.6 Map of Precipitation Area of HUS Project

4.1.6 General Information about Merkez - Kılavuzlu Pond and Irrigation System

Kılavuzlu Pond is designed for irrigation purpose and general information with broad strokes about the project corresponding with irrigation purpose is given below.

Project Location (Province)		:	Tekirdağ
Project Location (County)		:	Merkez
The Stream Pond Located on		:	Damlarca
Project Coordinates	Longitude Latitude	: 27° 30’ 15’’ – 27° 34’ 00’’ : 41° 01’ 30’’ – 41° 05’ 30’’	
Area of Precipitation		:	27.00 km²
Minimum Water Level		:	46.20 m
Normal Water Level		:	53.50 m
Volume at Minimum Water Level	V_{min}	:	0.540 hm³
Volume at Normal Water Level	V_{nor}	:	3.240 hm³
Active Volume	V_{active}	:	2.700 hm³
Annual Available Water for Irrigation	*AW*	:	1.686 hm³
Irrigation Area Elevations		:	70 m – 13 m

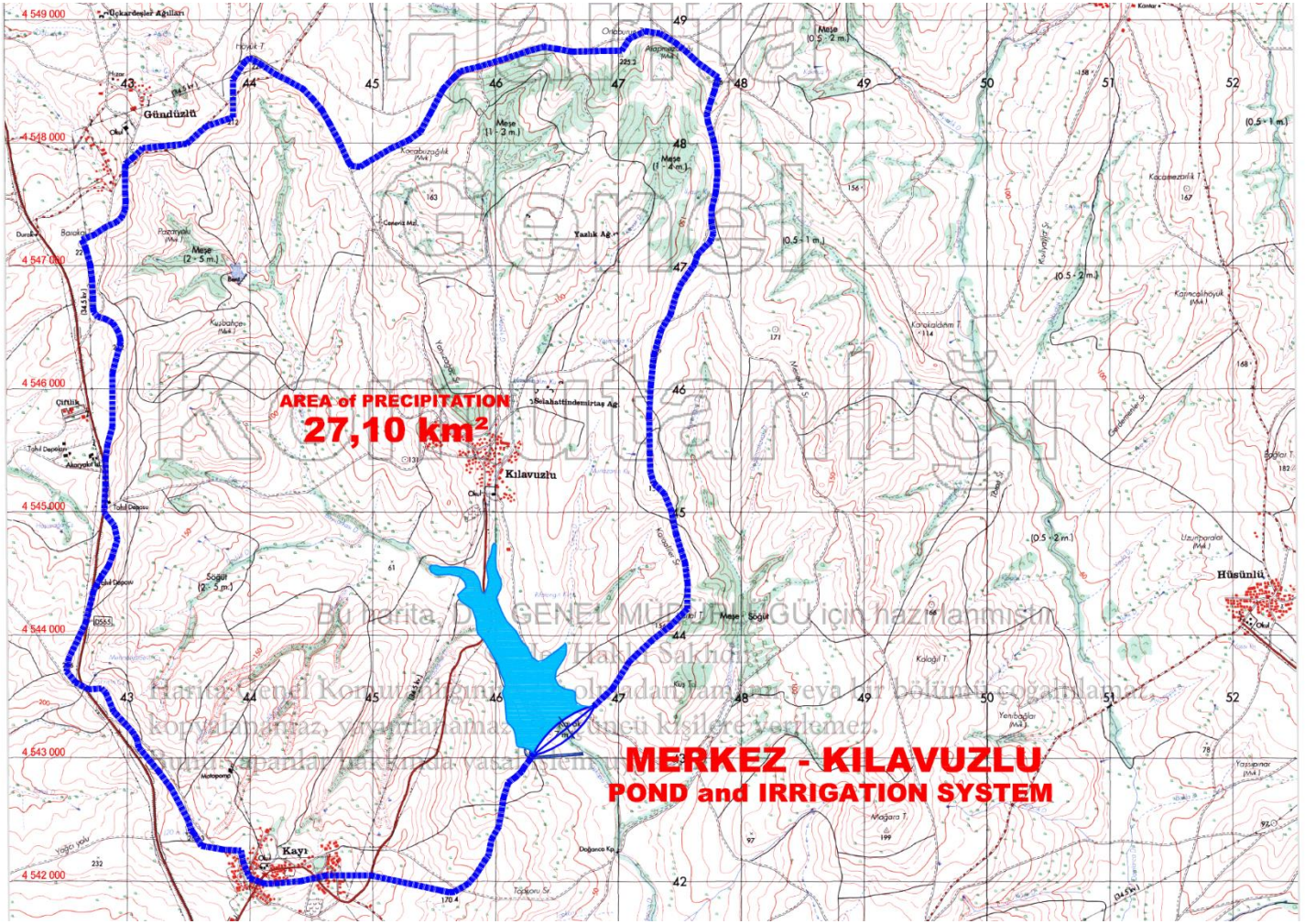

Figure 4.7 Map of Precipitation Area of KLV Project

4.2 Inputs of the Optimization Models

As stated in Section 3.2 (Assumptions Made for Optimization Problem), the objective of the present study is determining results of optimization process and comparing acquired values with the values obtained in planning report studies. In order to be able to compare values that will be obtained from optimization studies and values taken from planning reports, assumptions and some calculations of planning reports need to be used in this study.

In Section 4.1, general information about the selected projects taken from each projects' planning report and maps of "General Command of Mapping" with a scale of 1/25000 that are showing the location of ponds and precipitation areas are given.

Values from two parts of planning reports which are the third part, "Climate and Water Resources" (Hydrology) and the sixth part, "Agricultural Economy" are required to solve optimization problems.

4.2.1 Inputs of Crop Water Needs

In order to determine the size of irrigation area, results of two different studies are necessary. The first one is the total delivery requirement, *TDR* and the other one is annual available water for irrigation, *AW* (Eq.(3.8)).

Darama (2009) describes the total delivery requirement, *TDR* as the modified crop irrigation requirement, *CIR* considering all the losses at the point of diversion.

Basically, the crop irrigation requirement, *CIR* can be described as required water for optimal growth of crop in addition to precipitation and humidity factors (FAO, 1986)

while the total delivery requirement, *TDR* is sum of crop irrigation requirement and possible water losses in due course of transportation of water between water source and plant roots.

The crop irrigation requirement, *CIR* values are taken from "Climate and Water Resources (Hydrology)" parts of planning reports of State Hydraulic Works (DSİ). In planning studies of DSİ, *CIR* values are obtained by using Excel and VBA based program that was coded by *Cengiz KUMKAYA* by consultancy of agricultural engineers, *Medar VANLI* and *Ece TOKER*. The program calculates crop water needs by "Blaney - Criddle Method" and the values are obtained in *mm*. The crop water need is supplied by rainfall and irrigation (FAO, 1986).

The program is free to use, however, it is locked in order to conserve the developed code. Although parameters used in the code cannot be displayed by users, the developed code is approved by General Directorate of State Hydraulic Works (DSİ*)*. The inputs of the program are as follow;

- Latitude of the project location
- Average temperature values in °C for each month
- Average precipitation values in *mm* for each month
- Humidity from winter season in *mm* for each month
- Growth process of crop types

The parameter which converts *TDR* to *CIR*, the overall irrigation efficiency, *OIE* is computed by multiplying water conveyance efficiency, *WCE* and water application (farm) efficiency, *WAE* (Eq.(3.3)).

The efficiency of conveying system is called as water conveyance efficiency, *WCE* which is the ratio of amount of water delivered by conveying system and amount of water introduced into the conveying system (Darama, 2009) (Eq.(3.4)). *WCE* is taken

as constant value, 0.98 for studies. It means that 2 percent water loss by volume is predicted during water distribution process.

The other efficiency phenomenon, water application efficiency, *WAE* is the ratio of amount of stored water in the soil root zone and amount of water delivered by conveying system (Darama, 2009) (Eq.(3.5)). The main factor affecting *WAE* is type of irrigation system. *WAE* is taken as 1.00 for dripping irrigation system and it is taken as 0.80 for sprinkler irrigation system. Hence, it is assumed that conveyed water to the irrigation field can be used without loss by dripping system and there is 20 percent water loss by volume for sprinkler system.

As stated above, the crop irrigation requirement, *CIR* is the difference between the crop water need of a crop and the effective rainfall (FAO, 1986) and these terms vary depending on location of a project.

The crop irrigation requirement, *CIR*, type of irrigation system, water conveyance efficiency, *WCE*, water application efficiency, *WAE*, overall irrigation efficiency, *OIE*) and finally total delivery requirement, *TDR* values of each crop type in a certain cropping pattern for each project are given in the following tables (Table 4.1 - Table 4.6) . Since the *CIR* values obtained by Blaney-Criddle Method are in millimeter (*mm*), they need to be multiplied by "10" to convert them to cubic meters per hectare (m^3/ha).

Table 4.1 Crop water requirement parameters for CD1 Project

Crop Rotation Group	Crop Type	Crop Type	Crop Water Requirement Parameters						
			Irrigation Method	Crop Irrigation Requirement	$CIR_{i,j}$ Crop Irrigation Requirement	$WCE_{i,j}$ Water Conveyance Efficiency	$WAE_{i,j}$ Water Application Efficiency	$OIE_{i,j}$ Overall Irrigation Efficiency	$TDR_{i,j}$ Total Delivery Requirement
i	***j***			*(mm)*	*(m³/ha)*				*(m³/ha)*
1	**1**	CLOVER	Sprinkler	643.70	6,437.00	0.98	0.80	0.78	**8,210.46**
	2	MIXED FRUITS	Drip	426.31	4,263.10	0.98	1.00	0.98	**4,350.10**
2	**1**	CEREAL	Sprinkler	219.53	2,195.30	0.98	0.80	0.78	**2,800.13**
	2	SUNFLOWER	Sprinkler	345.35	3,453.50	0.98	0.80	0.78	**4,404.97**
3	**1**	FORAGE CORN	Drip	360.93	3,609.30	0.98	1.00	0.98	**3,682.96**
	2	MELON	Drip	201.68	2,016.80	0.98	1.00	0.98	**2,057.96**
4	**1**	MIXED VEGETABLES	Drip	347.19	3,471.90	0.98	1.00	0.98	**3,542.76**
	2	CORN	Drip	360.93	3,609.30	0.98	1.00	0.98	**3,682.96**
	3	TOMATO	Drip	461.90	4,619.00	0.98	1.00	0.98	**4,713.27**

Table 4.2 Crop water requirement parameters for CD2 Project

Crop Rotation Group	Crop Type	Crop Type	Crop Water Requirement Parameters						
			Irrigation Method	Crop Irrigation Requirement	$CIR_{i,j}$ Crop Irrigation Requirement	$WCE_{i,j}$ Water Conveyance Efficiency	$WAE_{i,j}$ Water Application Efficiency	$OIE_{i,j}$ Overall Irrigation Efficiency	$TDR_{i,j}$ Total Delivery Requirement
i	***j***			*(mm)*	*(m^3/ha)*				*(m^3/ha)*
1	**1**	CLOVER	Sprinkler	643.70	6,437.00	0.98	0.80	0.78	**8,210.46**
	2	MIXED FRUITS	Drip	426.31	4,263.10	0.98	1.00	0.98	**4,350.10**
2	**1**	CEREAL	Sprinkler	219.53	2,195.30	0.98	0.80	0.78	**2,800.13**
	2	SUNFLOWER	Sprinkler	345.35	3,453.50	0.98	0.80	0.78	**4,404.97**
3	**1**	FORAGE CORN	Drip	360.93	3,609.30	0.98	1.00	0.98	**3,682.96**
	2	MELON	Drip	201.68	2,016.80	0.98	1.00	0.98	**2,057.96**
4	**1**	MIXED VEGETABLES	Drip	347.19	3,471.90	0.98	1.00	0.98	**3,542.76**
	2	CORN	Drip	360.93	3,609.30	0.98	1.00	0.98	**3,682.96**
	3	TOMATO	Drip	461.90	4,619.00	0.98	1.00	0.98	**4,713.27**

Table 4.3 Crop water requirement parameters for GOZ Project

Crop Rotation Group	Crop Type	Crop Type	Crop Water Requirement Parameters						
			Irrigation Method	Crop Irrigation Requirement	$CIR_{i,j}$ Crop Irrigation Requirement	$WCE_{i,j}$ Water Conveyance Efficiency	$WAE_{i,j}$ Water Application Efficiency	$OIE_{i,j}$ Overall Irrigation Efficiency	$TDR_{i,j}$ Total Delivery Requirement
i	***j***			*(mm)*	*(m^3/ha)*				*(m^3/ha)*
1	**1**	CLOVER	Sprinkler	588.95	5,889.50	0.98	0.80	0.78	**7,512.12**
	2	MIXED FRUITS	Drip	410.00	4,100.00	0.98	1.00	0.98	**4,183.67**
2	**1**	CEREAL	Sprinkler	208.94	2,089.40	0.98	0.80	0.78	**2,665.05**
	2	FORAGE CORN	Drip	349.21	3,492.10	0.98	1.00	0.98	**3,563.37**
3	**1**	CORN	Drip	349.21	3,492.10	0.98	1.00	0.98	**3,563.37**
	2	MELON	Drip	193.07	1,930.70	0.98	1.00	0.98	**1,970.10**
	3	ONION	Drip	463.83	4,638.30	0.98	1.00	0.98	**4,732.96**
	4	TOMATO	Drip	448.29	4,482.90	0.98	1.00	0.98	**4,574.39**
4	**1**	SUNFLOWER	Sprinkler	333.95	3,339.50	0.98	0.80	0.78	**4,259.57**

Table 4.4 Crop water requirement parameters for KAR Project

Crop Rotation Group	Crop Type	Crop Type	Crop Water Requirement Parameters						
			Irrigation Method	Crop Irrigation Requirement	$CIR_{i,j}$ Crop Irrigation Requirement	$WCE_{i,j}$ Water Conveyance Efficiency	$WAE_{i,j}$ Water Application Efficiency	$OIE_{i,j}$ Overall Irrigation Efficiency	$TDR_{i,j}$ Total Delivery Requirement
i	***j***			*(mm)*	*(m^3/ha)*				*(m^3/ha)*
1	**1**	CLOVER	Sprinkler	570.39	5,703.90	0.98	0.80	0.78	**7,275.38**
	2	MIXED FRUITS	Drip	400.81	4,008.10	0.98	1.00	0.98	**4,089.90**
	3	VINEYARD	Drip	343.26	3,432.60	0.98	1.00	0.98	**3,502.65**
2	**1**	MIXED VEGETABLES	Drip	311.75	3,117.50	0.98	1.00	0.98	**3,181.12**
	2	MELON	Drip	197.68	1,976.80	0.98	1.00	0.98	**2,017.14**
	3	CORN	Drip	344.50	3,445.00	0.98	1.00	0.98	**3,515.31**
3	**1**	FORAGE CORN	Drip	344.50	3,445.00	0.98	1.00	0.98	**3,515.31**
	2	CEREAL	Sprinkler	201.98	2,019.80	0.98	0.80	0.78	**2,576.28**
4	**1**	SUNFLOWER	Sprinkler	330.62	3,306.20	0.98	0.80	0.78	**4,217.09**

Table 4.5 Crop water requirement parameters for HUS Project

Crop Rotation Group	Crop Type	Crop Type	Crop Water Requirement Parameters						
			Irrigation Method	Crop Irrigation Requirement	$CIR_{i,j}$ Crop Irrigation Requirement	$WCE_{i,j}$ Water Conveyance Efficiency	$WAE_{i,j}$ Water Application Efficiency	$OIE_{i,j}$ Overall Irrigation Efficiency	$TDR_{i,j}$ Total Delivery Requirement
i	***j***			*(mm)*	*(m^3/ha)*				*(m^3/ha)*
1	**1**	CLOVER	Sprinkler	597.32	5,973.20	0.98	0.80	0.78	**7,618.88**
	2	MIXED FRUITS	Drip	400.75	4,007.50	0.98	1.00	0.98	**4,089.29**
2	**1**	FORAGE CORN	Drip	344.45	3,444.50	0.98	1.00	0.98	**3,514.80**
	2	CEREAL	Sprinkler	201.95	2,019.50	0.98	0.80	0.78	**2,575.89**
3	**1**	SUNFLOWER	Sprinkler	330.58	3,305.80	0.98	0.80	0.78	**4,216.58**
	2	CANOLA	Sprinkler	104.15	1,041.50	0.98	0.80	0.78	**1,328.44**
4	**1**	CORN	Drip	344.45	3,444.50	0.98	1.00	0.98	**3,514.80**
	2	MELON	Drip	197.65	1,976.50	0.98	1.00	0.98	**2,016.84**
	3	TOMATO	Drip	436.61	4,366.10	0.98	1.00	0.98	**4,455.20**
	4	ONION	Drip	454.92	4,549.20	0.98	1.00	0.98	**4,642.04**

Table 4.6 Crop water requirement parameters for KLV Project

Crop Rotation Group	Crop Type	Crop Type	Crop Water Requirement Parameters						
			Irrigation Method	Crop Irrigation Requirement	$CIR_{i,j}$ Crop Irrigation Requirement	$WCE_{i,j}$ Water Conveyance Efficiency	$WAE_{i,j}$ Water Application Efficiency	$OIE_{i,j}$ Overall Irrigation Efficiency	$TDR_{i,j}$ Total Delivery Requirement
i	***j***			*(mm)*	*(m^3/ha)*				*(m^3/ha)*
1	**1**	CLOVER	Sprinkler	570.33	5,703.30	0.98	0.80	0.78	**7,274.62**
	2	MIXED FRUITS	Drip	400.75	4,007.50	0.98	1.00	0.98	**4,089.29**
2	**1**	FORAGE CORN	Drip	344.45	3,444.50	0.98	1.00	0.98	**3,514.80**
	2	CEREAL	Sprinkler	201.95	2,019.50	0.98	0.80	0.78	**2,575.89**
3	**1**	SUNFLOWER	Sprinkler	330.58	3,305.80	0.98	0.80	0.78	**4,216.58**
	2	TOMATO	Drip	519.39	5,193.90	0.98	1.00	0.98	**5,299.90**
	3	MELON	Drip	197.65	1,976.50	0.98	1.00	0.98	**2,016.84**
4	**1**	CORN	Drip	344.45	3,444.50	0.98	1.00	0.98	**3,514.80**
	2	MIXED VEGETABLES	Drip	311.72	3,117.20	0.98	1.00	0.98	**3,180.82**
	3	ONION	Drip	333.63	3,336.30	0.98	1.00	0.98	**3,404.39**

4.2.2 Inputs of Annual Available Water for Irrigation

As it is seen from Eq.(3.12), the result of OF2 depends on *AW* values, so that, *AW* values of selected projects are given in this chapter.

As stated in Section 3.2, the annual available water, *AW* amount is calculated within the context of "Climate and Water Resources" part of planning studies considering precipitation, evaporation, seepage and life water. It is assumed that the annual available water amount is constant for each year.

The methodology of determination of annual total water from stream is that the annual rainfall depth which is obtained by empirical methods; e.g. "Turc Method" and "Coutagne Method", is multiplied by precipitation area. In order to determine the annual available water for irrigation purpose, all the losses and releases should be obtained. The losses and releases that should be obtained in certain projects are precipitation loss, seepage loss, life water release, spillway release and domestic water requirement release.

In the light of this information and studies, reservoir operation studies are carried out within the context of "Climate and Water Resources" part of planning reports and results of studies are directly used for this study.

Summaries of reservoir operation studies of the certain projects are given in following tables.

Table 4.7 Summary of reservoir operation study of CD1 Project

(+) Annual Total Water from Stream	0.713 hm^3
Evaporation Loss	0.051 hm^3
Seepage Loss	0.040 hm^3
Life Water Release	0.113 hm^3
(-) Annual Total Water Loss / Release	0.204 hm^3
→ **Annual Available Water for Irrigation**	**0.509 hm^3**

Table 4.8 Summary of reservoir operation study of CD2 Project

(+) Annual Total Water from Stream	1.350 hm^3
Evaporation Loss	0.070 hm^3
Seepage Loss	0.077 hm^3
Life Water Release	0.201 hm^3
Domestic Water	0.150 hm^3
(-) Annual Total Water Loss / Release	0.498 hm^3
→ **Annual Available Water for Irrigation**	**0.852 hm^3**

Table 4.9 Summary of reservoir operation study of GOZ Project

(+) Annual Total Water from Stream	0.504 hm^3
Evaporation Loss	0.033 hm^3
Seepage Loss	0.010 hm^3
Life Water Release	0.056 hm^3
(-) Annual Total Water Loss / Release	0.099 hm^3
→ **Annual Available Water for Irrigation**	**0.405 hm^3**

Table 4.10 Summary of reservoir operation study of KAR Project

(+) Annual Total Water from Stream	1.800 hm^3
Evaporation Loss	0.110 hm^3
Seepage Loss	0.049 hm^3
Life Water Release	0.221 hm^3
(-) Annual Total Water Loss / Release	0.380 hm^3
→ **Annual Available Water for Irrigation**	**1.420 hm^3**

Table 4.11 Summary of reservoir operation study of HUS Project

(+) Annual Total Water from Stream	2.025 hm³
Evaporation Loss	0.101 hm³
Seepage Loss	0.033 hm³
Life Water Release	0.231 hm³
Spillway Release	0.416 hm³
(-) Annual Total Water Loss / Release	0.781 hm³
→ **Annual Available Water for Irrigation**	**1.244 hm³**

Table 4.12 Summary of reservoir operation study of KLV Project

(+) Annual Total Water from Stream	2.700 hm³
Evaporation Loss	0.169 hm³
Seepage Loss	0.054 hm³
Life Water Release	0.291 hm³
Domestic Water	0.500 hm³
(-) Annual Total Water Loss / Release	1.014 hm³
→ **Annual Available Water for Irrigation**	**1.686 hm³**

4.2.3 Inputs of Agricultural Economy

The agricultural economy parts of planning reports were prepared with the guidance of "Sulama Projelerinin Planlama Aşamasında Tarımsal Ekonomi Planlama Mühendislik Hizmetleri Teknik Şartnamesi" published by State Hydraulic Works (DSİ). As mentioned in agricultural economy parts of planning reports, surveys conducted to landowners, verbal and written information obtained from official institutions were used as data for studies.

Some criteria are taken into account in order to determine crop types and percentage distributions of them in cropping patterns. These are as following;

- Climatic conditions of the region,
- General agricultural policies of Turkey,
- Average land sizes,
- Cropping pattern of nearby irrigation fields,
- Tendencies of farmers,
- Growth periods of crop types,
- Crop rotation system,
- Domestic and foreign market demands of agricultural products
- Labor potentials of the region,
- Research results of agricultural research and broadcasting institutions,
- Agricultural Finance Institutions' products based credits and the forecasts and approaches of technical staff conducting research.

It is assumed that the yield of the crops currently being cultivated will increase, the crop rotation system will be applied and the usage of the required inputs (fertilizer, drug) of irrigated farming will become widespread with the occurrence of the irrigation projects.

According to field works, surveys and observations conducted by agricultural engineer, the annual yields, *Y* in kilogram per hectare are estimated, the average unit sale prices, *SP* for year 2013 in TL per kilogram are obtained and production costs, *C* for year 2013 in TL per kilogram of each crop types are calculated. The multiplication of yields and sale prices gives production income in TL per hectare and also the difference between production income and production cost gives agricultural profit. In order to determine net agricultural profit, it is required to consider development and adaptation process of crop types. Achieving predicted cropping pattern and estimated yields of crop types takes time. The required adaptation and development period is 5 years for plants that are currently being grown under dry farming conditions but will be watered; 3 years for plants that are being watered under limited conditions but will be watered properly; 10 years for fruit crop types. As the development and adaptation period increases, the duration that is necessary for reaching the maximum agricultural profit level increases. The calculated agricultural profit values are multiplied by development period coefficients, *DC* which are calculated and given by DSİ so as to get net agricultural profit, *NP*. The interest rate for the project that is taken as 5%, the economic life of dam (or pond) that is taken as 50 years and development and adaptation period of crop type are considered to obtain development period coefficients. The calculated *DC* values taken from the book published by DSİ, "Sulama Projelerinin Planlama Kademesinde Zirai Ekonomi Etüdlerinin Yapılması", are given in Table 4.13.

Table 4.13 The calculated development period coefficient, *DC* values by State Hydraulic Works

Development Period (year)	Developement Coefficient with the Economic Life of 50 Years and the Interest Rate of 5%
1	1,000
2	0.974
3	0.949
4	0.924
5	0.901
6	0.878
7	0.855
8	0.834
9	0,813
10	0.793

The agricultural economy parameters which are ordered as annual yield, *Y*, sale price, *SP*, production cost, *C*, development period, *DP*, development period coefficient, *DC* and annual net agricultural profit, *NP* are identical for the certain crop type all over the province and the parameters are given in Table 4.14 as a database of optimization models. The *NP* values are calculated as stated in Eq.(3.10) and they are directly used in optimization models as constant values.

Table 4.14 The agricultural parameters of the crop types

#	Crop Type	Agricultural Economy Parameters					
		$Y_{i,j}$ **Annual Yield** *(kg/da)*	$SP_{i,j}$ **Sale Price** *(TL/kg)*	$C_{i,j}$ **Production Cost** *(TL/da)*	$DP_{i,j}$ **Development Period** *(year)*	$DC_{i,j}$ **Development Period Coefficient**	$NP_{i,j}$ **Annual Net Agricultural Profit** *(TL/ha)*
1	CANOLA	370	1.00	180.00	3	0.949	**1,803.10**
2	CEREAL	600	1.20	217.00	3	0.949	**4,773.47**
3	CLOVER	1300	0.75	409.00	10	0.793	**4,488.38**
4	CORN	950	0.70	164.00	5	0.901	**4,514.01**
5	FORAGE CORN	5500	0.25	383.00	5	0.901	**8,937.92**
6	MELON	3200	0.70	233.00	3	0.949	**19,046.43**
7	MIXED FRUITS	2500	1.50	301.00	10	0.793	**27,350.57**
8	MIXED VEGETABLES	3000	0.85	675.00	5	0.901	**16,893.75**
9	ONION	2500	0.75	398.00	5	0.901	**13,307.77**
10	SUNFLOWER	400	2.85	216.00	3	0.949	**8,768.76**
11	TOMATO	3000	0.85	450.00	5	0.901	**18,921.00**
12	VINEYARD	900	1.80	263.00	10	0.793	**10,761.01**

In this study, the minimum and the maximum limits of percentage distributions of crop types in the cropping patterns are determined by considering predefined deviations from values obtained in planning studies, so that, determined cropping patterns in planning reports take an important place. The cropping pattern parameters taken from planning reports of each project used in this study are given in Table 4.15 -

Table 4.20. The aftergrowth crops and related parameters are not included in the following tables since they are not used in optimization studies due to reasons which are stated in Section 4.3 (Modification of Planning Report Values).

Table 4.15 CD1 Project - Planning report cropping pattern parameters

Crop Rotation Group ***i***	**Crop Type** ***j***	**Crop Type**	**Cropping Pattern** $X_{i,j\ planning}$ **Percentage Distribution in Planning Report**
1	**1**	CLOVER	**15.00%**
	2	MIXED FRUITS	**7.00%**
2	**1**	CEREAL	**10.00%**
	2	SUNFLOWER	**16.00%**
3	**1**	FORAGE CORN	**16.00%**
	2	MELON	**10.00%**
4	**1**	MIXED VEGETABLES	**6.00%**
	2	CORN	**15.00%**
	3	TOMATO	**5.00%**

Table 4.16 CD2 Project - Planning report cropping pattern parameters

Crop Rotation Group *i*	Crop Type *j*	Crop Type	Cropping Pattern $X_{i,j\ planning}$ Percentage Distribution in Planning Report
1	1	CLOVER	16.00%
	2	MIXED FRUITS	6.00%
2	1	CEREAL	10.00%
	2	SUNFLOWER	16.00%
3	1	FORAGE CORN	16.00%
	2	MELON	10.00%
4	1	MIXED VEGETABLES	5.00%
	2	CORN	16.00%
	3	TOMATO	5.00%

Table 4.17 GOZ Project - Planning report cropping pattern parameters

Crop Rotation Group *i*	Crop Type *j*	Crop Type	Cropping Pattern $X_{i,j\ planning}$ Percentage Distribution in Planning Report
1	1	CLOVER	5.00%
	2	MIXED FRUITS	20.00%
2	1	CEREAL	10.00%
	2	FORAGE CORN	15.00%
3	1	CORN	10.00%
	2	MELON	6.00%
	3	ONION	4.00%
	4	TOMATO	5.00%
4	1	SUNFLOWER	25.00%

Table 4.18 KAR Project - Planning report cropping pattern parameters

Crop Rotation Group *i*	Crop Type *j*	Crop Type	Cropping Pattern $X_{i,j\ planning}$ Percentage Distribution in Planning Report
1	1	CLOVER	6.00%
	2	MIXED FRUITS	10.00%
	3	VINEYARD	6.00%
2	1	MIXED VEGETABLES	10.00%
	2	MELON	6.00%
	3	CORN	10.00%
3	1	FORAGE CORN	16.00%
	2	CEREAL	10.00%
4	1	SUNFLOWER	26.00%

Table 4.19 HUS Project - Planning report cropping pattern parameters

Crop Rotation Group *i*	Crop Type *j*	Crop Type	Cropping Pattern $X_{i,j\ planning}$ Percentage Distribution in Planning Report
1	1	CLOVER	10.00%
	2	MIXED FRUITS	15.00%
2	1	FORAGE CORN	15.00%
	2	CEREAL	10.00%
3	1	SUNFLOWER	10.00%
	2	CANOLA	15.00%
4	1	CORN	10.00%
	2	MELON	6.00%
	3	TOMATO	5.00%
	4	ONION	4.00%

Table 4.20 KLV Project - Planning report cropping pattern parameters

Crop Rotation Group *i*	Crop Type *j*	Crop Type	Cropping Pattern $X_{i,j\ planning}$ Percentage Distribution in Planning Report
1	1	CLOVER	20.00%
	2	MIXED FRUITS	5.00%
2	1	FORAGE CORN	15.00%
	2	CEREAL	10.00%
3	1	SUNFLOWER	14.00%
	2	TOMATO	5.00%
	3	MELON	6.00%
4	1	CORN	15.00%
	2	MIXED VEGETABLES	6.00%
	3	ONION	4.00%

4.3 Modification of Planning Report Values

The processes of determination of crop irrigation requirement, *CIR* and determination of cropping pattern in planning studies are explained in Section 4.2.1 and Section 4.2.3, respectively. Because the aim of this study is to compare values taken from planning reports and values obtained from optimization studies, methodology and acceptances of planning reports should be applied for optimization studies. However it is necessary to modify some acceptances and making corrections so as to make comparison between planning report and optimization study clearly. The modifications and corrections are as following:

- The overall irrigation efficiency, *OIE* values will not be rounded up to two decimal places as done in planning reports.

- The weighted average of total delivery requirement, *TDR* will not be calculated as the ratio of 'the weighted average of crop irrigation requirement' and 'the weighted average of overall irrigation efficiency' as it was carried out in planning report studies.

  Firstly the total delivery requirement of each crop type (Eq.(3.2)) and then the weighted average of these values should be calculated.

  This inequality between two processes stated above is represented below mathematically.

$$\sum_{i=1}^{m}\sum_{j=1}^{n_m}\left(\frac{CIR_{i,j}}{WAE_{i,j}\times WCE_{i,j}}\times X_{i,j}\right)\neq\frac{\sum_{i=1}^{m}\sum_{j=1}^{n_m}CIR_{i,j}\times X_{i,j}}{\left(\sum_{i=1}^{m}\sum_{j=1}^{n_m}WAE_{i,j}\times X_{i,j}\right)\times\left(\sum_{i=1}^{m}\sum_{j=1}^{n_m}WCE_{i,j}\times X_{i,j}\right)}$$

  The right side of above equation is the methodology used in planning studies and the methodlogy at the left side will be used for this study.

- The after growth crop types will be removed from cropping patterns since their percentage distribution were not be evaluated in totality, in other words, the summation of percentage distributions of all crops except for the after growth crop's is equal to 100 percent. In order to calculate the weighted average of some values, e.g. total delivery requirement and annual net agricultural profit, the summation of percentage distributions of all crops in the cropping pattern has to be equal to unity (100 percent).

In the direction of above statements, the calculations of crop water requirement parameters of planning report and modified planning report parameters are given in Appendix A (Table A.1 - Table A.6) and comparisons of planning report parameters and modified planning report parameters are given below (Table 4.21 - Table 4.26).

Table 4.21 CD1 Project - Comparison of planning report parameters and modified parameters

Parameters		Planning Report Values	Modified Planning Report Values
Annual Available Water for Irrigation	***AW***	509,000 m³	* 509,000 m³
Weighted Average of Total Delivery Requirement	***TDR***	4,331.41 m³	4,316.63 m³
Irrigation Area Size	***A*** =(AW/TDR)	** 118.00 ha	117.92 ha
Weighted Average of Annual Net Agricultural Profit	***NP***	10,424.68 TL/ha	10,439.63 TL/ha
Total Annual Agricultural Profit	***TP*** =(A×NP)	1,230,112 TL	1,231,001 TL

* Taken from the planning report (no modification)

** Rounded up to integer in planning studies

Table 4.22 CD2 Project - Comparison of planning report parameters and modified parameters

Parameters		Planning Report Values	Modified Planning Report Values
Annual Available Water for Irrigation	***AW***	852,000 m³	* 852,000 m³
Weighted Average of Total Delivery Requirement	***TDR***	4,357.03 m³	4,356.63 m³
Irrigation Area Size	***A*** =(AW/TDR)	** 196.00 ha	195.56 ha
Weighted Average of Annual Net Agricultural Profit	***NP***	10,097.76 TL/ha	10,087.21 TL/ha
Total Annual Agricultural Profit	***TP*** =(A×NP)	1,979,161 TL	1,972,695 TL

* Taken from the planning report (no modification)

** Rounded up to integer in planning studies

Table 4.23 GOZ Project - Comparison of planning report parameters and modified parameters

Parameters		Planning Report Values	Modified Planning Report Values
Annual Available Water for Irrigation	***AW***	405,000 m³	* 405,000 m³
Weighted Average of Total Delivery Requirement	***TDR***	4,296.39 m³	3,970.82 m³
Irrigation Area Size	***A*** =(AW/TDR)	** 94.00 ha	101.99 ha
Weighted Average of Annual Net Agricultural Profit	***NP***	12,789.70 TL/ha	12,777.31 TL/ha
Total Annual Agricultural Profit	***TP*** =(A×NP)	1,202,232 TL	1,303,208 TL

* Taken from the planning report (no modification)

** Rounded off to integer in planning studies

Table 4.24 KAR Project - Comparison of planning report parameters and modified parameters

Parameters		Planning Report Values	Modified Planning Report Values
Annual Available Water for Irrigation	***AW***	1,420,000 m³	* 1,420,000 m³
Weighted Average of Total Delivery Requirement	***TDR***	3,814.72 m³	3,762.86 m³
Irrigation Area Size	***A*** =(AW/TDR)	** 372.00 ha	377.37 ha
Weighted Average of Annual Net Agricultural Profit	***NP***	11,111.20 TL/ha	11,120.30 TL/ha
Total Annual Agricultural Profit	***TP*** =(A×NP)	4,133,366 TL	4,196,493 TL

* Taken from the planning report (no modification)

** Rounded off to integer in planning studies

Table 4.25 HUS Project - Comparison of planning report parameters and modified parameters

Parameters		Planning Report Values	Modified Planning Report Values
Annual Available Water for Irrigation	***AW***	1,244,000 m³	* 1,244,000 m³
Weighted Average of Total Delivery Requirement	***TDR***	3,778.75 m³	3,661.95 m³
Irrigation Area Size	***A*** =(AW/TDR)	** 329.00 ha	339.71 ha
Weighted Average of Annual Net Agricultural Profit	***NP***	10,579.65 TL/ha	10,588.78 TL/ha
Total Annual Agricultural Profit	***TP*** =(A×NP)	3,480,705 TL	3,597,115 TL

* Taken from the planning report (no modification)

** Rounded off to integer in planning studies

Table 4.26 KLV Project - Comparison of planning report parameters and modified parameters

Parameters		Planning Report Values	Modified Planning Report Values
Annual Available Water for Irrigation	***AW***	1,686,000 m³	* 1,686,000 m³
Weighted Average of Total Delivery Requirement	***TDR***	4,306.58 m³	4,274.77 m³
Irrigation Area Size	***A*** =(AW/TDR)	** 391.00 ha	394.41 ha
Weighted Average of Annual Net Agricultural Profit	***NP***	9,721.25 TL/ha	9,622.17 TL/ha
Total Annual Agricultural Profit	***TP*** =(A×NP)	3,801,009 TL	3,795,056 TL

* Taken from the planning report (no modification)

** Rounded off to integer in planning studies

CHAPTER 5

RESULTS OF OPTIMIZATION PROBLEMS

5.1 Optimization Overview

The crop irrigation requirement, coefficient of irrigation efficiency, estimated crop yield, production sale price and cost, development period coefficient and determined cropping pattern values taken from planning reports prepared under the control of State Hydraulic Works the 11th Regional Directorate are used in the studies.

The optimum cropping patterns are obtained by using two different optimization formulation having two different objective functions for the selected six projects. The first objective is maximizing irrigation area to increase number of family taking advantage of irrigated farming. The second objective that is also accepted by DSİ in studies is maximizing agricultural profit from whole irrigation area.

As stated in previous chapters, required data has been taken from relevant planning reports and then it was required to determine lower and upper limits of crop percentage distributions in order to obtain bound constraint of decision variables, so that similar studies are reviewed. As a result of analyses of similar studies, it is observed that these boundaries had not been obtained in line with the certain rules. In the present study, six boundary sets were determined by decreasing and increasing cropping pattern values obtained in planning studies with accepted deviation ratios which are 5%, 10%, 15%, 20%, 25% and 30%. However, upper limits of "Cereal" crop type are taken as values given in planning report since cereal can be growth at agricultural field that is

not irrigated. In addition to this, in the GOZ project, forage corn crop type's lower limit is taken as given in planning report in that forage corn is growth as animal feed and animal husbandry takes an important place for locals.

To sum up, twelve optimization models for each selected project, in other words, seventy two optimization models have been solved in order to achieve wide range and comparable solution set by using Solver module of Microsoft Excel software. The Objective Function 1 is a linear and the Objective Function 2 is a nonlinear optimization model.

The optimization results; namely, the cropping pattern, $X_{i,j}$ the weighted average of total delivery requirement, *TDR* the weighted average of net agricultural profit, *NP*, the irrigation area size, *A* and the total agricultural profit, *TP* values in tabular form are given in Appendix B (Table B.1 to Table B.36). Additionally, the graphs showing cropping patterns that have been obtained as a result of modified planning reports, Objective Function 1 (maximizing irrigation area) and Objective Function 2 (maximizing total agricultural profit) are given in Figure B.1 to Figure B.36.

There are 9 decision variables in optimization models of CD1, CD2, GOZ and KAR projects and 10 decision variables in HUS and KLV projects' which are equal to number of crop type in the relevant project.

5.2 Summary of Results of Optimization Models

The two main parameters which are the results of optimization problems, the irrigation area size, *A* and total agricultural profit, *TP* are summarized in the following tables and graphs. The tables and graphs demonstrate values determined from planning reports, modified planning reports, Objective Function 1, Objective Function 2 results and change between optimization results and modified planning report values.

Table 5.1 CD1 Project - The irrigation area size, *A* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Irrigation Area Size					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(ha)	*(ha)*	*(ha)*	*change wrt MPR*	*(ha)*	*change wrt MPR*
5%	** 118.00*	*117.92*	**119.15**	1.05%	**118.70**	0.67%
10%	** 118.00*	*117.92*	**120.41**	2.12%	**119.95**	1.73%
15%	** 118.00*	*117.92*	**121.70**	3.21%	**121.00**	2.61%
20%	** 118.00*	*117.92*	**123.02**	4.33%	**122.06**	3.51%
25%	** 118.00*	*117.92*	**124.36**	5.47%	**123.14**	4.43%
30%	** 118.00*	*117.92*	**125.74**	6.64%	**124.24**	5.36%

** Rounded to integer in planning studies*

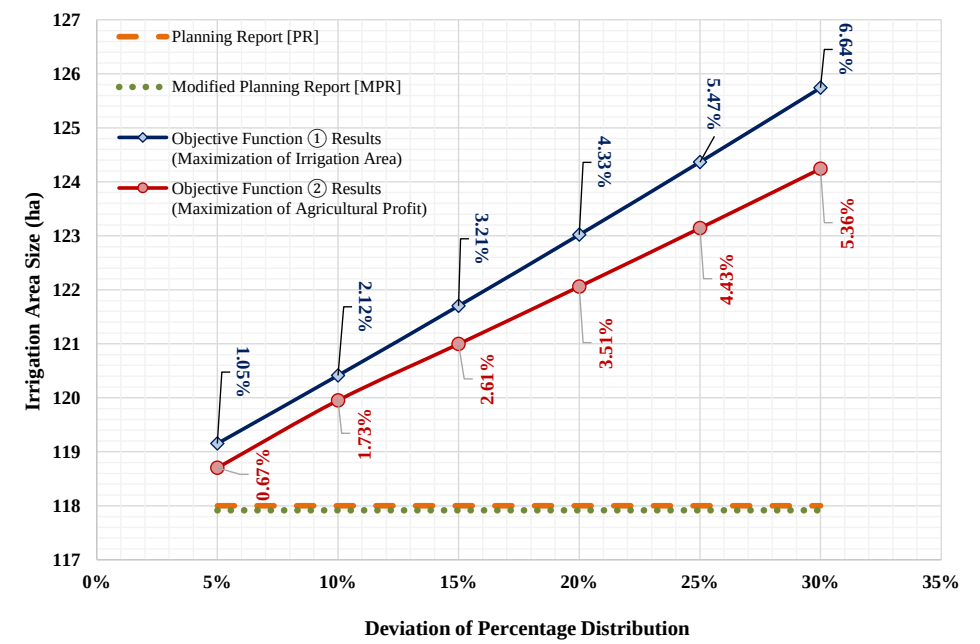

Figure 5.1 CD1 Project - The irrigation area size, *A* results of the planning reports and the optimization models

Table 5.2 CD1 Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Total Agricultural Profit					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(TL)	*(TL)*	*(TL)*	*change wrt MPR*	*(TL)*	*change wrt MPR*
5%	*1,230,112*	*1,231,001*	**1,244,348**	1.08%	**1,267,152**	2.94%
10%	*1,230,112*	*1,231,001*	**1,257,977**	2.19%	**1,303,926**	5.92%
15%	*1,230,112*	*1,231,001*	**1,271,898**	3.32%	**1,341,341**	8.96%
20%	*1,230,112*	*1,231,001*	**1,286,121**	4.48%	**1,379,413**	12.06%
25%	*1,230,112*	*1,231,001*	**1,300,654**	5.66%	**1,418,160**	15.20%
30%	*1,230,112*	*1,231,001*	**1,315,509**	6.86%	**1,457,600**	18.41%

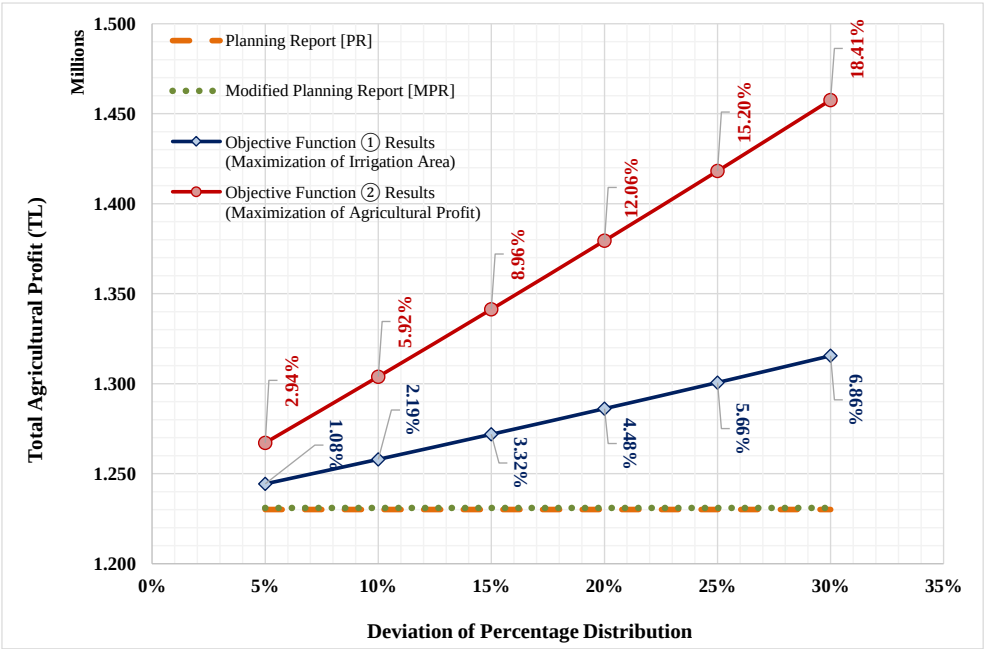

Figure 5.2 CD1 Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Table 5.3 CD2 Project - The irrigation area size, *A* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Irrigation Area Size					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(ha)	*(ha)*	*(ha)*	*change wrt MPR*	*(ha)*	*change wrt MPR*
5%	** 196.00*	*195.56*	**197.68**	1.08%	**196.96**	0.71%
10%	** 196.00*	*195.56*	**199.84**	2.19%	**198.38**	1.44%
15%	** 196.00*	*195.56*	**202.05**	3.32%	**200.95**	2.75%
20%	** 196.00*	*195.56*	**204.31**	4.47%	**202.81**	3.71%
25%	** 196.00*	*195.56*	**206.62**	5.65%	**204.71**	4.67%
30%	** 196.00*	*195.56*	**208.98**	6.86%	**206.64**	5.66%

** Rounded to integer in planning studies*

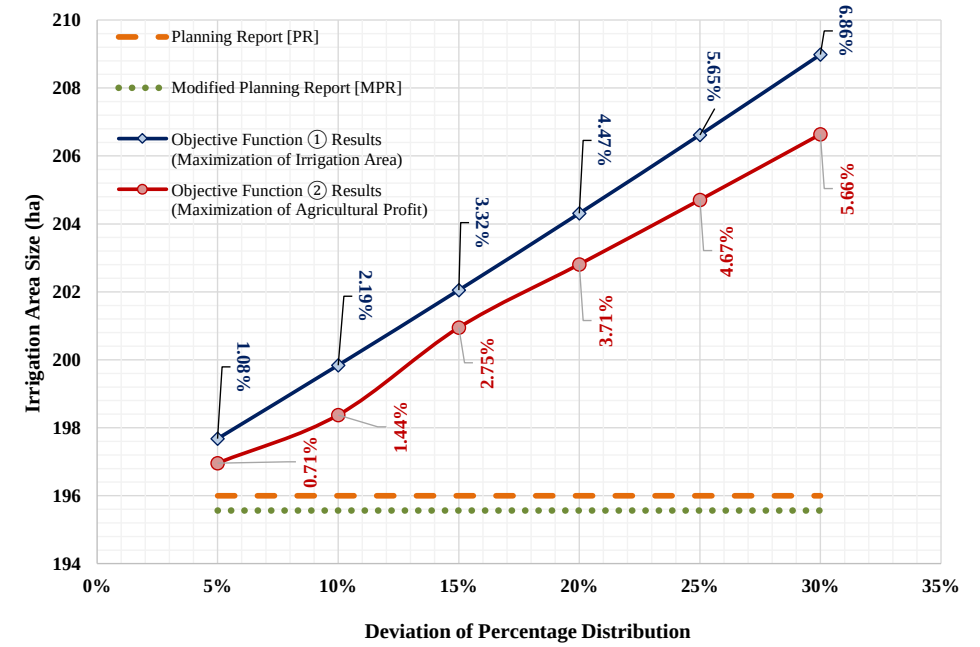

Figure 5.3 CD2 Project - The irrigation area size, *A* results of the planning reports and the optimization models

Table 5.4 CD2 Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Total Agricultural Profit					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(TL)	*(TL)*	*(TL)*	*change wrt MPR*	*(TL)*	*change wrt MPR*
5%	*1,979,161*	*1,972,695*	1,995,813	1.17%	2,030,244	2.92%
10%	*1,979,161*	*1,972,695*	2,019,436	2.37%	2,088,622	5.88%
15%	*1,979,161*	*1,972,695*	2,043,582	3.59%	2,147,997	8.89%
20%	*1,979,161*	*1,972,695*	2,068,268	4.84%	2,208,597	11.96%
25%	*1,979,161*	*1,972,695*	2,093,512	6.12%	2,270,328	15.09%
30%	*1,979,161*	*1,972,695*	2,119,334	7.43%	2,333,227	18.28%

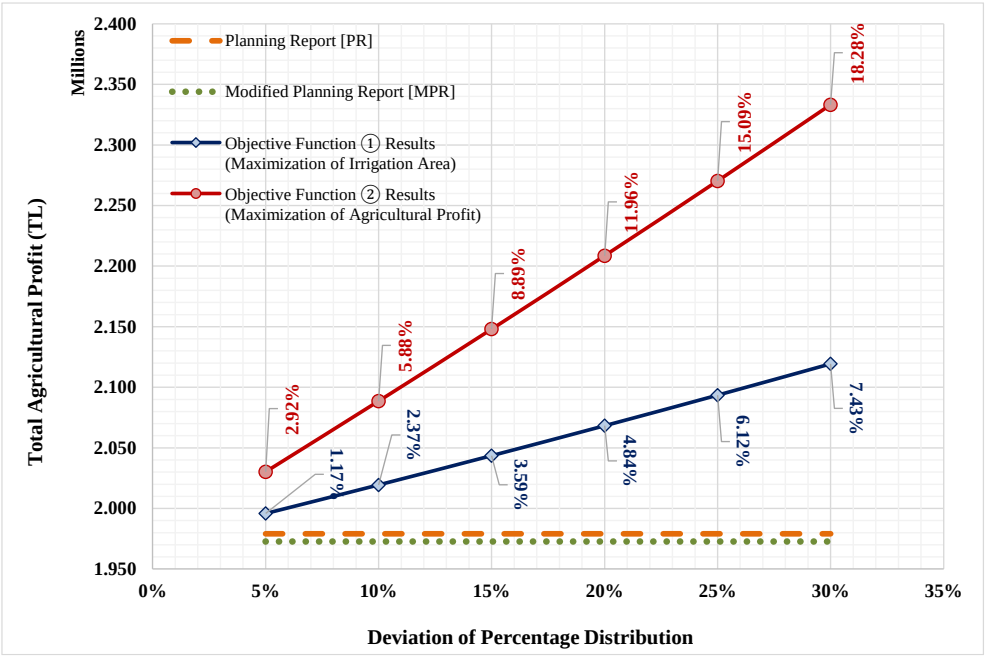

Figure 5.4 CD2 Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Table 5.5 GOZ Project - The irrigation area size, *A* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Irrigation Area Size					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(ha)	*(ha)*	*(ha)*	*change wrt MPR*	*(ha)*	*change wrt MPR*
5%	** 94.00*	*101.99*	**102.57**	0.56%	**102.16**	0.16%
10%	** 94.00*	*101.99*	**103.14**	1.13%	**102.33**	0.33%
15%	** 94.00*	*101.99*	**103.73**	1.70%	**102.50**	0.50%
20%	** 94.00*	*101.99*	**104.32**	2.28%	**102.67**	0.66%
25%	** 94.00*	*101.99*	**104.92**	2.87%	**102.84**	0.83%
30%	** 94.00*	*101.99*	**105.53**	3.46%	**103.01**	1.00%

** Rounded to integer in planning studies*

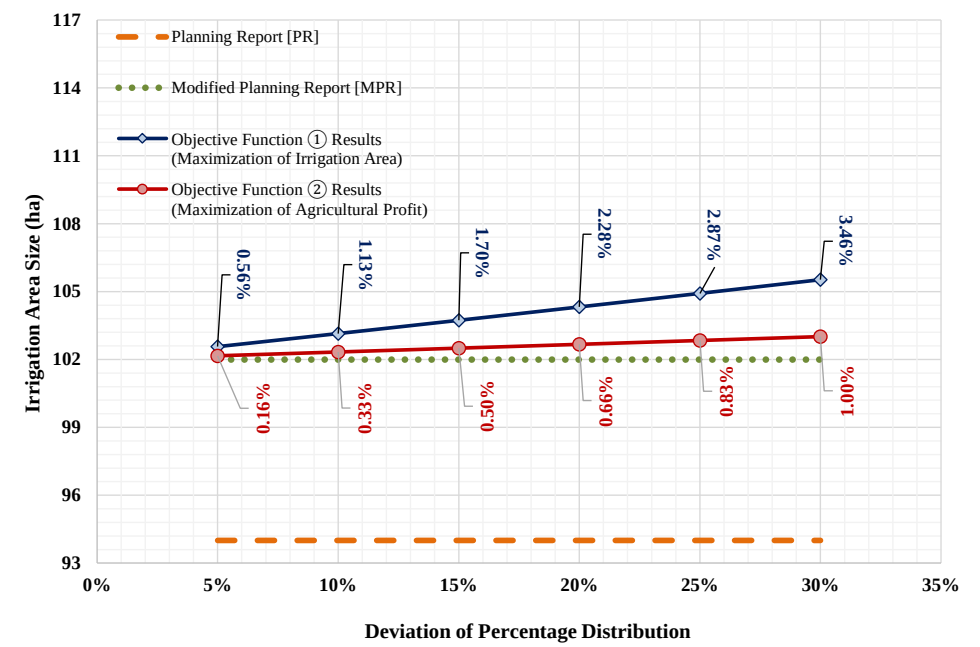

Figure 5.5 GOZ Project - The irrigation area size, *A* results of the planning reports and the optimization models

Table 5.6 GOZ Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Total Agricultural Profit					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(TL)	*(TL)*	*(TL)*	*change wrt MPR*	*(TL)*	*change wrt MPR*
5%	*1,202,232*	*1,303,208*	**1,290,769**	-0.95%	**1,333,464**	2.32%
10%	*1,202,232*	*1,303,208*	**1,278,189**	-1.92%	**1,363,820**	4.65%
15%	*1,202,232*	*1,303,208*	**1,265,467**	-2.90%	**1,394,275**	6.99%
20%	*1,202,232*	*1,303,208*	**1,252,600**	-3.88%	**1,424,832**	9.33%
25%	*1,202,232*	*1,303,208*	**1,239,585**	-4.88%	**1,455,489**	11.69%
30%	*1,202,232*	*1,303,208*	**1,226,419**	-5.89%	**1,486,249**	14.05%

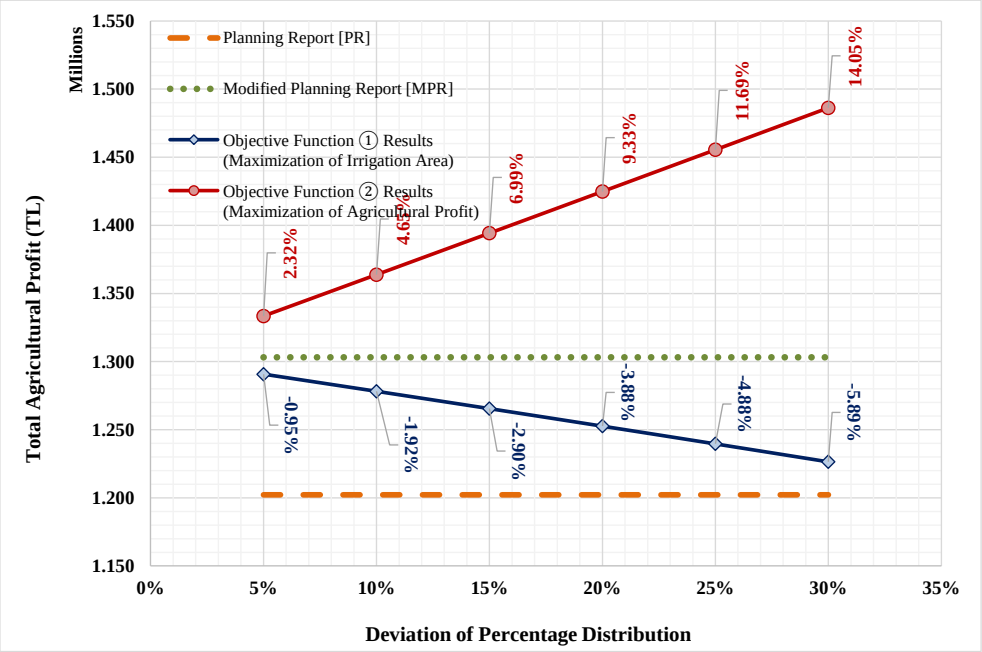

Figure 5.6 GOZ Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Table 5.7 KAR Project - The irrigation area size, *A* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Irrigation Area Size					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(ha)	*(ha)*	*(ha)*	*change wrt MPR*	*(ha)*	*change wrt MPR*
5%	** 372.00*	*377.37*	**379.26**	0.50%	**378.25**	0.23%
10%	** 372.00*	*377.37*	**381.17**	1.01%	**379.13**	0.47%
15%	** 372.00*	*377.37*	**383.10**	1.52%	**380.01**	0.70%
20%	** 372.00*	*377.37*	**385.04**	2.03%	**380.90**	0.93%
25%	** 372.00*	*377.37*	**387.01**	2.55%	**381.79**	1.17%
30%	** 372.00*	*377.37*	**389.00**	3.08%	**382.69**	1.41%

** Rounded to integer in planning studies*

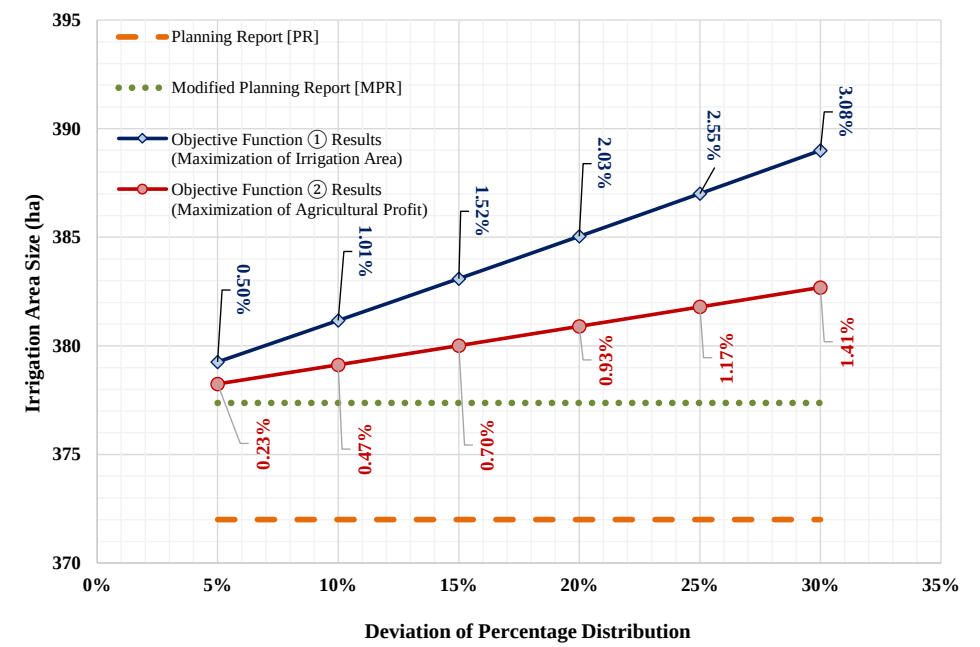

Figure 5.7 KAR Project - The irrigation area size, *A* results of the planning reports and the optimization models

Table 5.8 KAR Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Total Agricultural Profit					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(TL)	*(TL)*	*(TL)*	*change wrt MPR*	*(TL)*	*change wrt MPR*
5%	*4,133,366*	*4,196,493*	**4,220,556**	0.57%	**4,278,741**	1.96%
10%	*4,133,366*	*4,196,493*	**4,244,861**	1.15%	**4,361,370**	3.93%
15%	*4,133,366*	*4,196,493*	**4,269,412**	1.74%	**4,444,386**	5.91%
20%	*4,133,366*	*4,196,493*	**4,294,212**	2.33%	**4,527,789**	7.89%
25%	*4,133,366*	*4,196,493*	**4,319,265**	2.93%	**4,611,583**	9.89%
30%	*4,133,366*	*4,196,493*	**4,344,576**	3.53%	**4,695,771**	11.90%

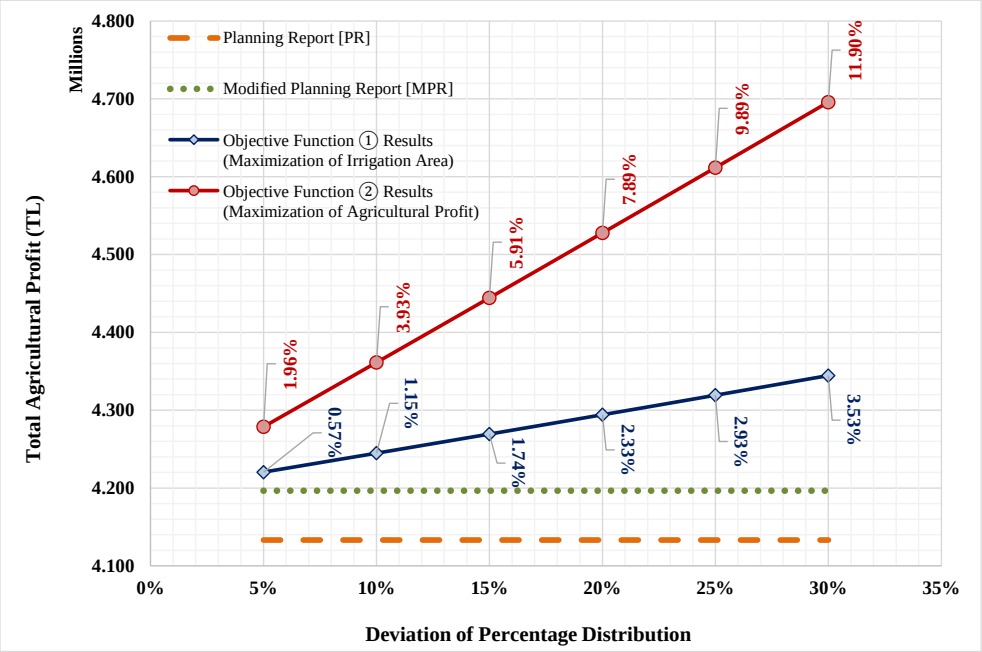

Figure 5.8 KAR Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Table 5.9 HUS Project - The irrigation area size, *A* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Irrigation Area Size					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(ha)	*(ha)*	*(ha)*	*change wrt MPR*	*(ha)*	*change wrt MPR*
5%	** 329.00*	*339.71*	**344.61**	1.44%	**342.31**	0.76%
10%	** 329.00*	*339.71*	**349.65**	2.93%	**344.94**	1.54%
15%	** 329.00*	*339.71*	**354.84**	4.45%	**347.62**	2.33%
20%	** 329.00*	*339.71*	**360.18**	6.03%	**350.34**	3.13%
25%	** 329.00*	*339.71*	**365.69**	7.65%	**353.10**	3.94%
30%	** 329.00*	*339.71*	**371.37**	9.32%	**355.91**	4.77%

** Rounded to integer in planning studies*

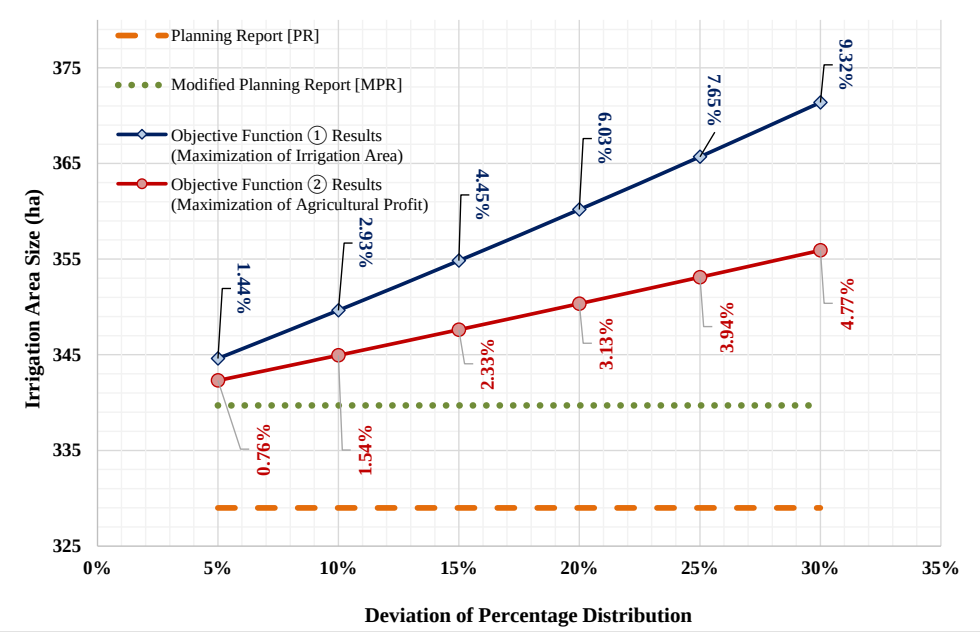

Figure 5.9 HUS - The irrigation area size, *A* results of the planning reports and the optimization models

Table 5.10 HUS Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Total Agricultural Profit					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(TL)	*(TL)*	*(TL)*	*change wrt MPR*	*(TL)*	*change wrt MPR*
5%	*3,480,705*	*3,597,115*	**3,584,300**	-0.36%	**3,701,232**	2.89%
10%	*3,480,705*	*3,597,115*	**3,571,111**	-0.72%	**3,806,953**	5.83%
15%	*3,480,705*	*3,597,115*	**3,557,530**	-1.10%	**3,914,316**	8.82%
20%	*3,480,705*	*3,597,115*	**3,543,540**	-1.49%	**4,023,359**	11.85%
25%	*3,480,705*	*3,597,115*	**3,529,121**	-1.89%	**4,134,122**	14.93%
30%	*3,480,705*	*3,597,115*	**3,514,255**	-2.30%	**4,246,645**	18.06%

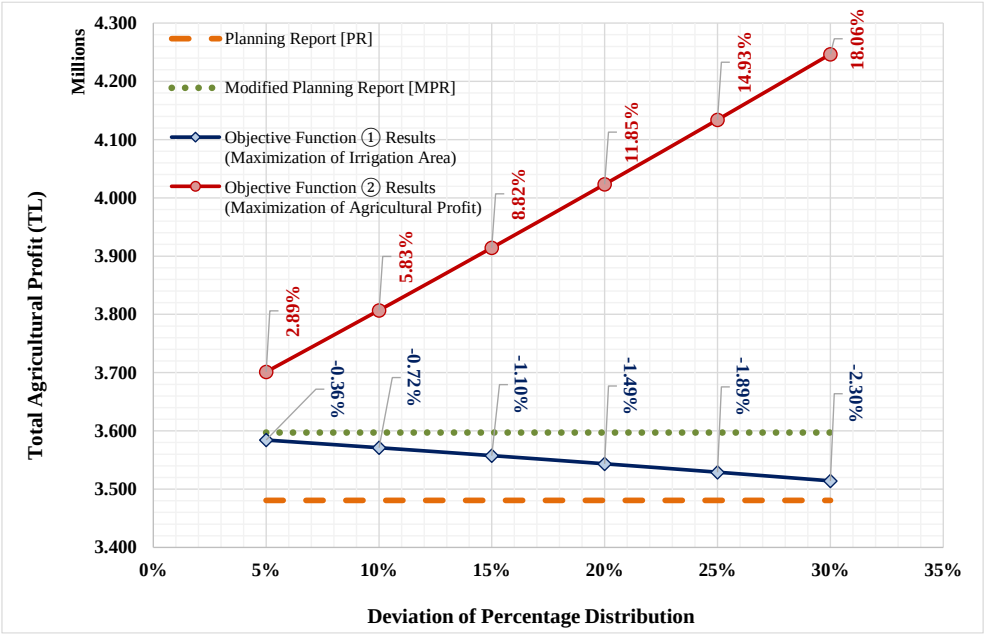

Figure 5.10 HUS - The total irrigation profit, *TP* results of the planning reports and the optimization models

Table 5.11 KLV Project - The irrigation area size, *A* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Irrigation Area Size					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(ha)	*(ha)*	*(ha)*	*change wrt MPR*	*(ha)*	*change wrt MPR*
5%	** 391.00*	*394.41*	**398.76**	1.10%	**397.65**	0.82%
10%	** 391.00*	*394.41*	**403.21**	2.23%	**400.94**	1.66%
15%	** 391.00*	*394.41*	**407.75**	3.38%	**404.29**	2.51%
20%	** 391.00*	*394.41*	**412.41**	4.56%	**407.69**	3.37%
25%	** 391.00*	*394.41*	**417.17**	5.77%	**411.16**	4.25%
30%	** 391.00*	*394.41*	**422.04**	7.00%	**414.68**	5.14%

** Rounded to integer in planning studies*

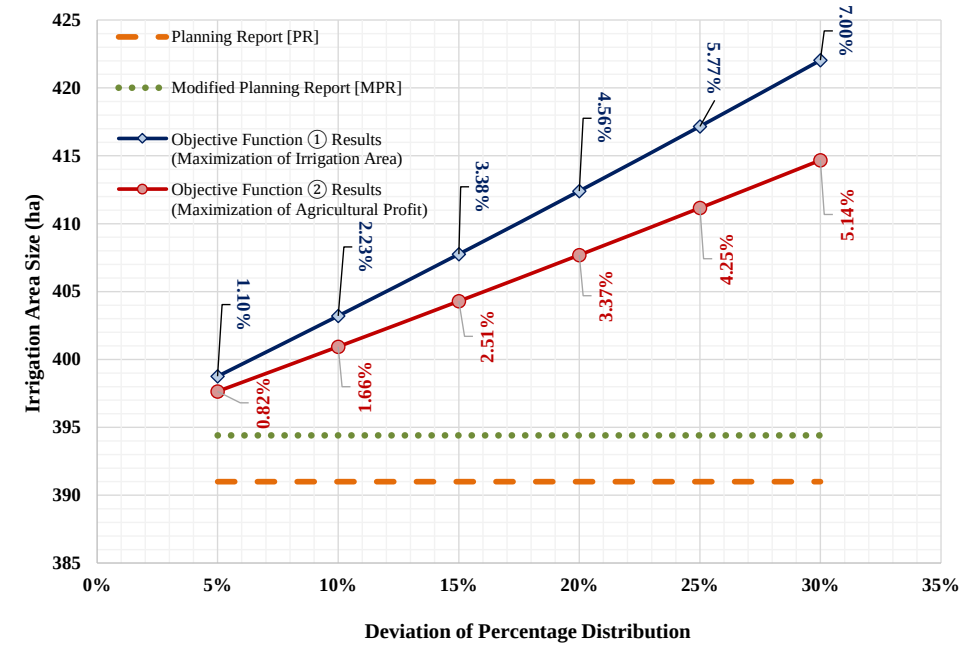

Figure 5.11 KLV Project - The irrigation area size, *A* results of the planning reports and the optimization models

Table 5.12 KLV Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Deviation of Percentage Distribution	Total Agricultural Profit					
	Planning Report [PR]	Modified Planning Report [MPR]	Objective Function ① Results (Maximization of Irrigation Area)		Objective Function ② Results (Maximization of Agricultural Profit)	
	(TL)	*(TL)*	*(TL)*	*change wrt MPR*	*(TL)*	*change wrt MPR*
5%	*3,801,009*	*3,795,056*	**3,852,661**	1.52%	**3,910,044**	3.03%
10%	*3,801,009*	*3,795,056*	**3,911,551**	3.07%	**4,026,936**	6.11%
15%	*3,801,009*	*3,795,056*	**3,971,769**	4.66%	**4,145,781**	9.24%
20%	*3,801,009*	*3,795,056*	**4,033,362**	6.28%	**4,266,628**	12.43%
25%	*3,801,009*	*3,795,056*	**4,096,376**	7.94%	**4,389,527**	15.66%
30%	*3,801,009*	*3,795,056*	**4,160,862**	9.64%	**4,514,532**	18.96%

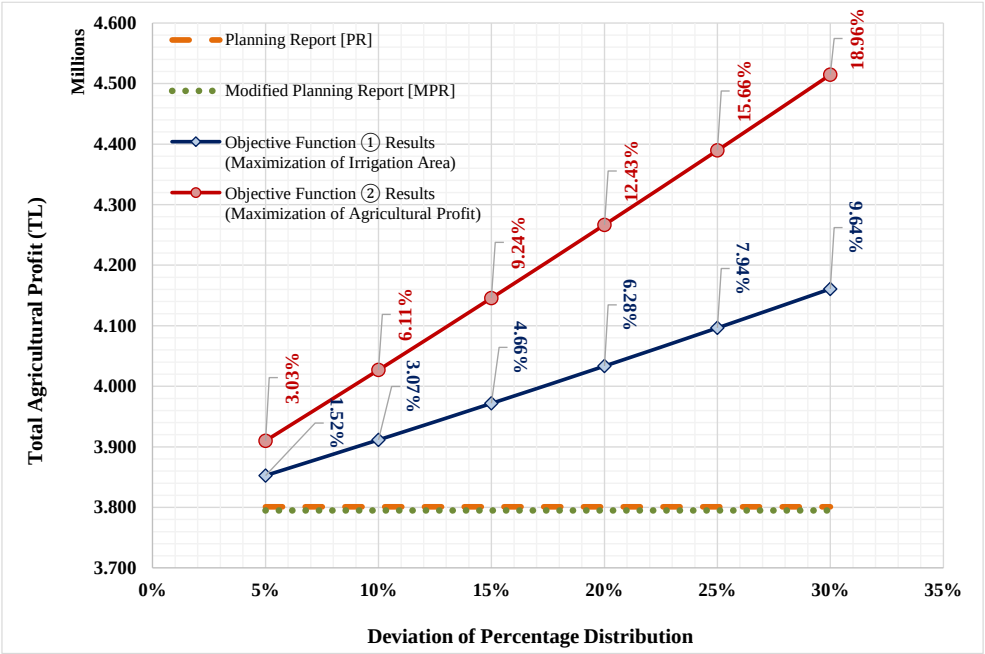

Figure 5.12 KLV Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

5.3 Discussion of the Results

In the linear and nonlinear optimization models of selected projects different deviation ratios namely, 5%, 10%, 15%, 20%, 25% and 30% are used so as to observe the change of results with respect to deviation ratio. As seen from the Figure 5.13 and Figure 5.14 representing the results of GOZ project given as an example, the R-squared values of linear trendlines approach to 1 or they are equal to 1. The R-squared value shows fitness of the trendline to the data so it means that as the deviation ratio of percentage distribution increases, the total agricultural profit, *TP* and the irrigation area size, *A* results increase or decrease linearly.

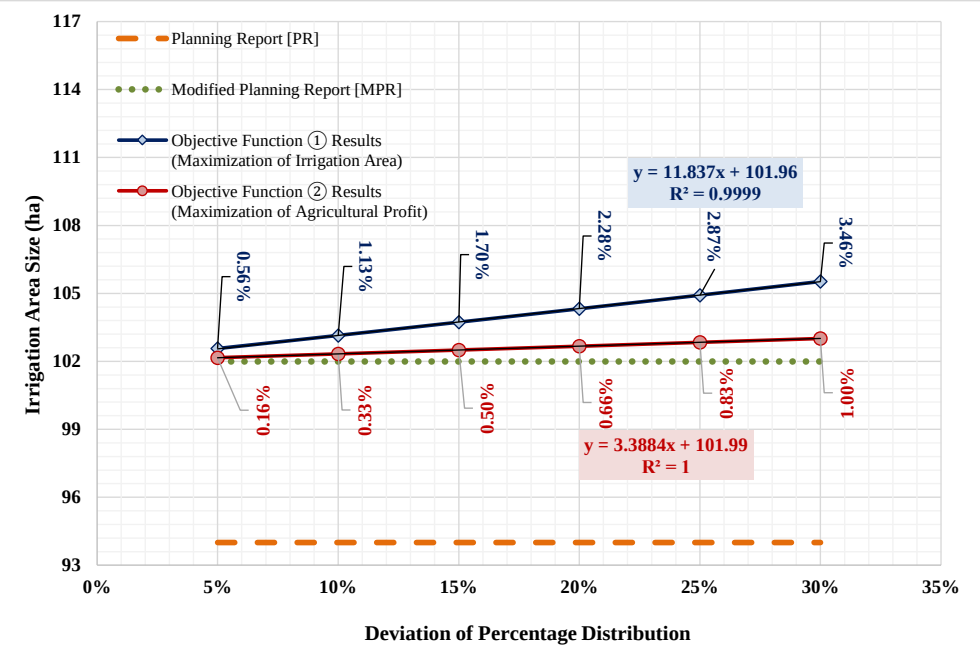

Figure 5.13 GOZ Project - The irrigation area size, *A* results of the planning reports and the optimization models

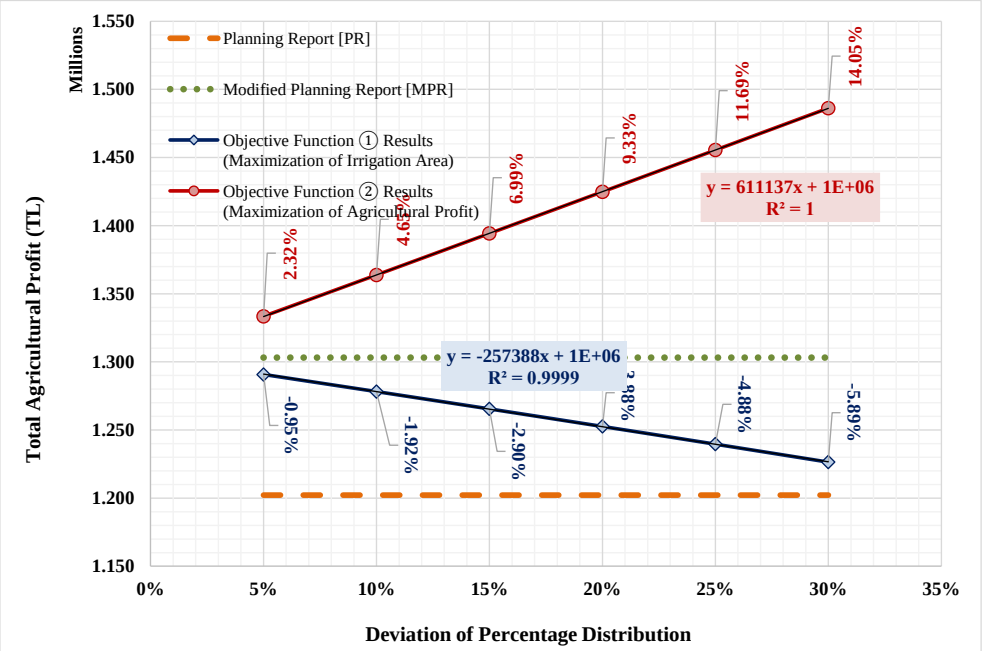

Figure 5.14 GOZ Project - The total irrigation profit, *TP* results of the planning reports and the optimization models

Since the determination of deviation ratios of percentage distribution does not depend on a rule, the present study is conducted with different deviation ratios of $X_{i,j}$. However, it is necessary to specify a certain deviation ratio in order to obtain final results for projects. In the direction of studies conducted by academicians and specialists, it is observed that the average deviation ratio is 25% which is also used for the present study. The results, *TP* and *A*, determined with a deviation ratio of 25% and the general evaluation of the group of pond and irrigation system projects are given in Table 5.13.

Table 5.13 Optimization results of all selected projects solved for 25% of deviation ratio of percentage distribution

Project	Type of Result	Planning Report [PR] Values	Modified Planning Report [MPR] Results	Objective Function ① Results (Maximization of Irrigation Area) Results	change wrt MPR	Objective Function ② Results (Maximization of Agricultural Profit) Results	change wrt MPR
CD1	A (ha)	* 118.00	117.92	**124.36**	**5.47%**	123.14	4.43%
	TP (TL)	1,230,112	1,231,001	1,300,654	5.66%	**1,418,160**	**15.20%**
CD2	A (ha)	* 196.00	195.56	**206.62**	**5.65%**	204.71	4.67%
	TP (TL)	1,979,161	1,972,695	2,093,512	6.12%	**2,270,328**	**15.09%**
GOZ	A (ha)	* 94.00	101.99	**104.92**	**2.87%**	102.84	0.83%
	TP (TL)	1,202,232	1,303,208	1,239,585	-4.88%	**1,455,489**	**11.69%**
KAR	A (ha)	* 372.00	377.37	**387.01**	**2.55%**	381.79	1.17%
	TP (TL)	4,133,366	4,196,493	4,319,265	2.93%	**4,611,583**	**9.89%**
HUS	A (ha)	* 329.00	339.71	**365.69**	**7.65%**	353.10	3.94%
	TP (TL)	3,480,705	3,597,115	3,529,121	-1.89%	**4,134,122**	**14.93%**
KLV	A (ha)	* 391.00	394.41	**417.17**	**5.77%**	411.16	4.25%
	TP (TL)	3,801,009	3,795,056	4,096,376	7.94%	**4,389,527**	**15.66%**
TOTAL	A (ha)	* 1,500.00	1,526.96	**1,605.77**	**5.16%**	1,576.74	3.26%
	TP (TL)	15,826,585	16,095,568	16,578,514	3.00%	**18,279,210**	**13.57%**

TP : The total agricultural profit in TL

A : The irrigation area size in hectare

**** Rounded to integer in planning studies***

The deviation ratio of percentage distributions is taken as 25%

When the TP and A values of PR and MPR are compared, it is seen that there is not huge proportional differences between them except for values of GOZ project. The reason is that the percentage distribution of aftergrowth crop type, forage corn, removed in MPR is 15% which is considerably greater than the other projects' that is 5%.

The linear function, Objective Function 1 and the nonlinear function, Objective Function 2 are solved by using Simplex LP and GRG Nonlinear methods respectively. As stated in Section 3.3, while the Simplex LP method guarantees the global optimum solution for linear models, the GRG Nonlinear method guarantees the global optimum solution for linear models but not for nonlinear models. The initial values of decision variables affect the results, so that Multistart option of GRG Method which provides operations with different initial values is used to get global optimum solutions. In accordance with accepted deviation ratio of cropping pattern that is 25%, the detailed results can be seen in (Appendix B) Table B.5 and Figure B.5 for CD1 project, in Table B.11 and Figure B.11 for CD2 project, in Table B.17 and Figure B.17 for GOZ project, in Table B.23 and Figure B.23 for KAR project, in Table B.29 and Figure B.29 for HUS project, in Table B.35 and Figure B.35 for KLV project.

As seen from table of overall results (Table 5.13) for %25 percent of deviation ratio, in the results of OF1, the rate of change in size of irrigation area, *A* values with respect to values of modified planning reports (MPR) changes between 2.55% to 7.65% and the change in whole irrigation field is 5.16%. The rate of change in total agricultural profit, *TP* values with respect to values of modified planning reports (MPR) changes between -4.88% to 7.94% and the change in whole irrigation field is 3.00%. In the results of OF2, the rate of change in total agricultural profit, *TP* values with respect to MPR values changes between 9.89% to 15.66% and the change in whole irrigation field is 13.57%. The rate of change in size of irrigation area, *A* values with respect to MPR values changes between 0.83% to 4.67% and the change in whole irrigation field is 3.26%.

In the OF1 results of GOZ and HUS projects , although the irrigation area size, *A* and the number of family taking advantage of irrigated farming increase, the total agricultural profit, *TP* from whole cultivated field decrease. In other words, increase in the irrigation area, *A* does not always guarantee higher agricultural profit, *TP*. Only the unit irrigation water requirements of crops are considered if the aim is minimizing total delivery requirement, *TDR*, in other words, maximizing irrigation

area, *A*. Since the unit irrigation water requirement of crop does not correspond to unit agricultural profit per unit irrigation water requirement of crop, in accordance with types of crop in cropping pattern, the total agricultural profit may decrease while the irrigation area increases. In the OF1 results of other projects, both *A* and *TP* values increase. In the OF2 results for all applications, it is seen that both *A* and *TP* parameters increase.

The difference in obtained percentage of distribution, $X_{i,j}$ for a certain crop in consequence of OF1 and OF2 should be also discussed. Table 5.14 and Figure 5.15 are given as an example results. Since the target is achieving minimum crop irrigation requirement, *TDR* in order to maximize the irrigation area size, *A* in OF1 model and maximum agricultural profit, *TP* in OF2 model, it is estimated that the percentage distribution of crop(s) having lower irrigation requirement, $TDR_{i,j}$ in comparison with crops in its crop rotation groups for OF1 optimization model and the percentage distribution of crop(s) having higher net profit in comparison with crops in its crop rotation groups for OF2 optimization model would be as much as possible. For example, as seen from Table 5.14 and Figure 5.15, Corn crop type's irrigation requirement is less than Onion and Tomato's which are another crop types in crop rotation group 1 (i=1) and the net agricultural profit, *NP* of crop is less than the other's. As it is expected, the percentage distribution, $X_{i,j}$ of corn is at the upper limit which is 12.5% in OF1 model and is at lower limit which is 7.50% in OF2 whereas it is 10% in modified planning report studies.

Table 5.14 GOZ Project - 25% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - GÖZSÜZ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 25%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*5.00%*	3.75%	6.25%	7,512.12	4,488.38	**5.00%**	**25.00%**	*375.61*	*224.42*	**3.75%**	**18.75%**	*281.70*	*168.31*	**3.75%**	**28.75%**	*281.70*	*168.31*
	2	MIXED FRUITS	*20.00%*	15.00%	25.00%	4,183.67	27,350.57	**20.00%**		*836.73*	*5,470.11*	**15.00%**		*627.55*	*4,102.59*	**25.00%**		*1,045.92*	*6,837.64*
2	1	CEREAL	*10.00%*	7.50%	10.00%	2,665.05	4,773.47	**10.00%**	**25.00%**	*266.51*	*477.35*	**10.00%**	**27.08%**	*266.51*	*477.35*	**7.50%**	**23.75%**	*199.88*	*358.01*
	2	FORAGE CORN	*15.00%*	15.00%	18.75%	3,563.37	8,937.92	**15.00%**		*534.51*	*1,340.69*	**17.08%**		*608.74*	*1,526.89*	**16.25%**		*579.05*	*1,452.41*
3	1	CORN	*10.00%*	7.50%	12.50%	3,563.37	4,514.01	**10.00%**	**25.00%**	*356.34*	*451.40*	**12.50%**	**27.08%**	*445.42*	*564.25*	**7.50%**	**23.75%**	*267.25*	*338.55*
	2	MELON	*6.00%*	4.50%	7.50%	1,970.10	19,046.43	**6.00%**		*118.21*	*1,142.79*	**7.50%**		*147.76*	*1,428.48*	**7.50%**		*147.76*	*1,428.48*
	3	ONION	*4.00%*	3.00%	5.00%	4,732.96	13,307.77	**4.00%**		*189.32*	*532.31*	**3.00%**		*141.99*	*399.23*	**3.00%**		*141.99*	*399.23*
	4	TOMATO	*5.00%*	3.75%	6.25%	4,574.39	18,921.00	**5.00%**		*228.72*	*946.05*	**4.08%**		*186.79*	*772.61*	**5.75%**		*263.03*	*1,087.96*
4	1	SUNFLOWER	*25.00%*	18.75%	31.25%	4,259.57	8,768.76	**25.00%**	**25.00%**	*1,064.89*	*2,192.19*	**27.08%**	**27.08%**	*1,153.63*	*2,374.87*	**23.75%**	**23.75%**	*1,011.65*	*2,082.58*
		TOTAL						**100.00%**	**100.00%**	**3,970.82**	**12,777.31**	**100.00%**	**100.00%**	**3,860.09**	**11,814.59**	**100.00%**	**100.00%**	**3,938.22**	**14,153.19**

Annual Available Water for Irrigation	**AW**		405,000 m³	405,000 m³	405,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	101.99 ha	**104.92 ha**	102.84 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,303,208 TL	1,239,585 TL	**1,455,489 TL**

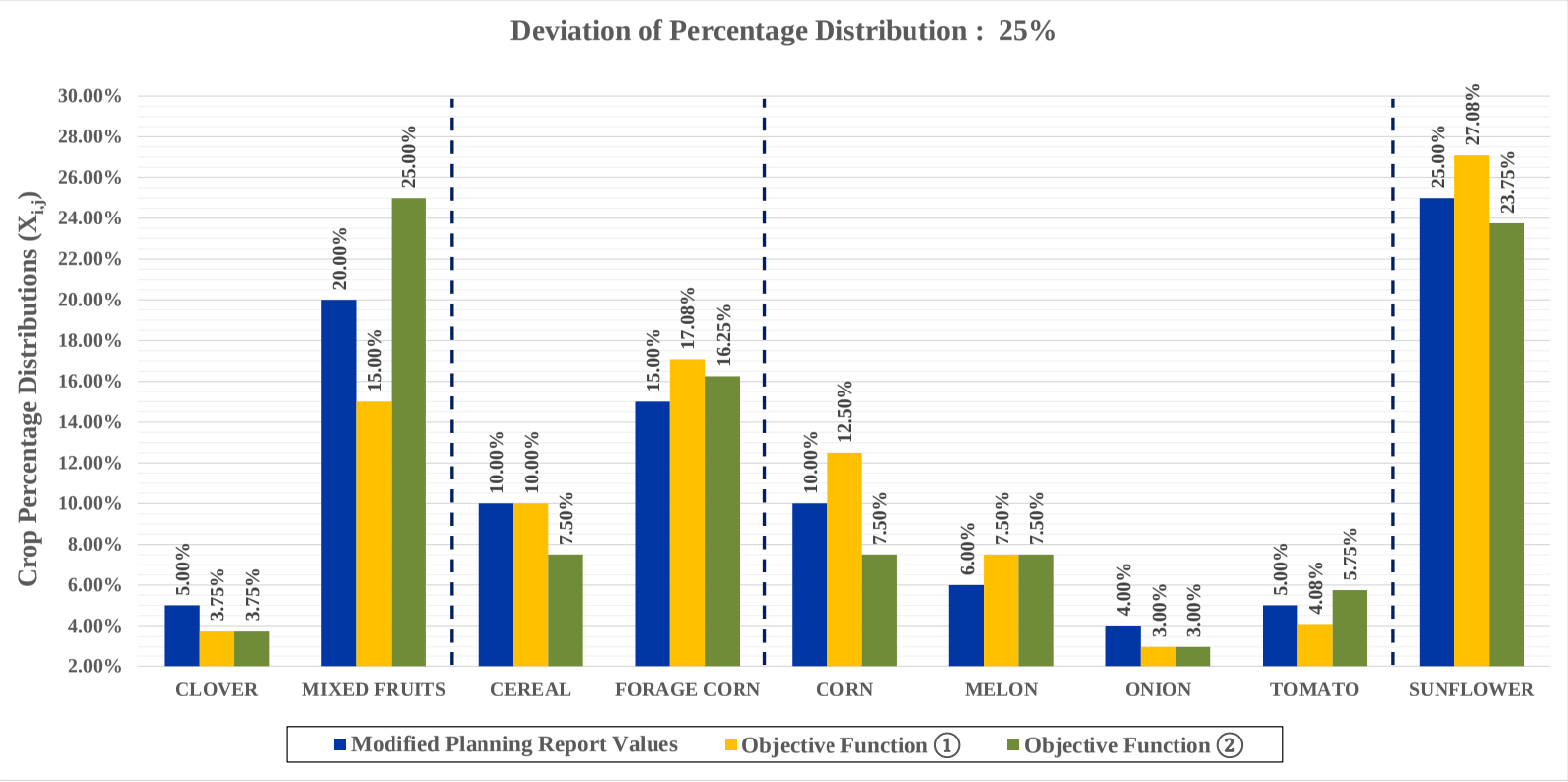

Figure 5.15 GOZ Project - 25% of deviation of crop percentage distribution results

CHAPTER 6

CONCLUSION

6.1 Summary

The aim of the present study is to obtain optimal cropping pattern that directly affects the main characteristics of irrigation system. Cropping pattern depends on available water for irrigation purpose, crop irrigation requirement and net production profit phenomenon, so that to carry out optimization study, related data sets are needed. The two objective functions are used for optimization process. The first objective is maximizing irrigation area in order to provide more family with an opportunity to take advantage of irrigated farming and the other one is maximizing net agricultural profit which is the common method. The objective functions are constrained by minimum and maximum limits of crop distributions together with equality of summation of crop distributions to unity and crop rotation limitations.

The study is initiated after examining studies taking place in literature which are also about optimization of crop pattern. It is seen that there is not too much difference between conducted studies with regard to methodology, however, in some studies, there are more types of parameter constraining decision variables in comparison with the other ones. In order to compare results obtained from optimization models and values available in planning reports, modification on planning reports was required because of reasons stated in Section 4.3. To solve optimization models, Solver add-in of Microsoft Excel software is used. The objective functions, decision variables and constraints are defined for Solver. As mentioned in previous chapters, within the scope

of the present study 72 optimization models are solved. Since defining all parameters for each optimization problem is taking considerable amount of time, a code is developed in VBA defining optimization models by using values in Excel cells in desired format for each case. Thus, it could be possible to obtain results of problems in a very short time. The minimum and maximum limits of decision variables are specified by applying deviation ratios (5%, 10%, 15%, 20%, 25% and 30%) on crop distribution values determined in planning reports. Each optimization model imports required values from "DB" *(DATABASE)* sheet instead of repeating data entry.

OF1 results in linear optimization model and it is solved by Simplex LP method whereas OF2 results in nonlinear optimization model and solved by GRG (Generalized Reduced Gradients) Nonlinear Method. The initial value of decision variables affect the results of optimization and GRG does not guarantee the global optimum solution if the model is nonlinear. Optimization models are solved for different starting values practically to get global optimum solutions thanks to developed code in VBA.

The six pond and irrigation system projects prepared by "State Hydraulic Works the 11^{th} Regional Directorate" are used for application of the study. As stated in Section 5.3, 25% of deviation of crop distribution is accepted as in similar studies performed by researchers and solutions and comparison of solutions with modified planning reports are summarized in Table 5.13. As a result of optimization problems, for the cumulative of projects, it is possible to irrigate 5.16% more cultivation field (OF1) or to get 13.57% more agricultural profit (OF2) which is corresponding to 2.1 million TL per annum in comparison with modified planning reports.

The results point importance of optimization of cropping pattern. Although it is true that determination of cropping pattern is theoretical account in case of implementation gap on agricultural facilities, determination of irrigation area size with limited water source and sizing of hydraulic structure are carried out in the direction of obtained cropping pattern.

State Hydraulic Works (DSİ) is the main investor establishment responsible for the assessment of all water resources of Turkey. Even though the optimization study for designing hydraulic structures is necessitated, it is not obliged for obtaining cropping patterns by DSİ. In accordance with results of this study, it is highly suggested to carry out the optimization studies for determining optimum cropping pattern for each project.

6.2 Future Works

The minimum and maximum limits of each crop distribution can be determined by considering seasonal market limitations. Potential labor availability can be added as a constraint. Furthermore, crop irrigation requirements can be calculated with Penman–Monteith Method which requires more detailed data instead of Blaney-Criddle Method.

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APPENDIX A

CALCULATIONS OF THE PLANNING REPORT TDR VALUES AND MODIFIED PLANNING REPORT TDR VALUES

Table A.1 CD1 Project - Calculations of the planning report *TDR* values and modified planning report *TDR* values

Crop Rotation Group i	Crop Type j	Crop Type	Crop Water Requirement Parameters: Planning Report Values: $X_{i,j}$	$WCE_{i,j}$	*WA of* $WCE_{i,j}$	$WAE_{i,j}$	*WA of* $WAE_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	*WA of* $CIR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*	Modified Planning Report Values: $X_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	$WCE_{i,j}$	$WAE_{i,j}$	$OIE_{i,j}$	$TDR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*
1	1	CLOVER	**15.00%**	0.98	0.15	0.80	0.12	6,437.00	965.55		**15.00%**	6,437.00	0.98	0.80	0.78	8,210.46	1,231.57
	2	MIXED FRUITS	**7.00%**	0.98	0.07	1.00	0.07	4,263.10	298.42		**7.00%**	4,263.10	0.98	1.00	0.98	4,350.10	304.51
2	1	CEREAL	**10.00%**	0.98	0.10	0.80	0.08	2,195.30	219.53		**10.00%**	2,195.30	0.98	0.80	0.78	2,800.13	280.01
	2	SUNFLOWER	**16.00%**	0.98	0.16	0.80	0.13	3,453.50	552.56		**16.00%**	3,453.50	0.98	0.80	0.78	4,404.97	704.80
3	1	FORAGE CORN	**16.00%**	0.98	0.16	1.00	0.16	3,609.30	577.49		**16.00%**	3,609.30	0.98	1.00	0.98	3,682.96	589.27
	2	MELON	**10.00%**	0.98	0.10	1.00	0.10	2,016.80	201.68		**10.00%**	2,016.80	0.98	1.00	0.98	2,057.96	205.80
4	1	MIXED VEGETABLES	**6.00%**	0.98	0.06	1.00	0.06	3,471.90	208.31		**6.00%**	3,471.90	0.98	1.00	0.98	3,542.76	212.57
	2	CORN	**15.00%**	0.98	0.15	1.00	0.15	3,609.30	541.40		**15.00%**	3,609.30	0.98	1.00	0.98	3,682.96	552.44
	3	TOMATO	**5.00%**	0.98	0.05	1.00	0.05	4,619.00	230.95		**5.00%**	4,619.00	0.98	1.00	0.98	4,713.27	235.66
3	1'	FORAGE CORN (Aftergrowth)	**5.00%**					2,186.40	109.32		-	-	-	-	-	-	-
TOTAL			**105.00%**		**0.98**		*** 0.92**		**3905.20**	**4,331.41**	**100.00%**						**4,316.63**

** Rounded up to 2 decimal places*

"WA of" = "The weighted average of"

Table A.2 CD2 Project - Calculations of the planning report *TDR* values and modified planning report *TDR* values

Crop Rotation Group i	Crop Type j	Crop Type	Crop Water Requirement Parameters														
			Planning Report Values								Modified Planning Report Values						
			$X_{i,j}$	$WCE_{i,j}$	*WA of* $WCE_{i,j}$	$WAE_{i,j}$	*WA of* $WAE_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	*WA of* $CIR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*	$X_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	$WCE_{i,j}$	$WAE_{i,j}$	$OIE_{i,j}$	$TDR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*
1	1	CLOVER	**16.00%**	0.98	0.16	0.80	0.13	6,437.00	1029.92		**16.00%**	6,437.00	0.98	0.80	0.78	8,210.46	1,313.67
	2	MIXED FRUITS	**6.00%**	0.98	0.06	1.00	0.06	4,263.10	255.79		**6.00%**	4,263.10	0.98	1.00	0.98	4,350.10	261.01
2	1	CEREAL	**10.00%**	0.98	0.10	0.80	0.08	2,195.30	219.53		**10.00%**	2,195.30	0.98	0.80	0.78	2,800.13	280.01
	2	SUNFLOWER	**16.00%**	0.98	0.16	0.80	0.13	3,453.50	552.56		**16.00%**	3,453.50	0.98	0.80	0.78	4,404.97	704.80
3	1	FORAGE CORN	**16.00%**	0.98	0.16	1.00	0.16	3,609.30	577.49		**16.00%**	3,609.30	0.98	1.00	0.98	3,682.96	589.27
	2	MELON	**10.00%**	0.98	0.10	1.00	0.10	2,016.80	201.68		**10.00%**	2,016.80	0.98	1.00	0.98	2,057.96	205.80
4	1	MIXED VEGETABLES	**5.00%**	0.98	0.05	1.00	0.05	3,471.90	173.60		**5.00%**	3,471.90	0.98	1.00	0.98	3,542.76	177.14
	2	CORN	**16.00%**	0.98	0.16	1.00	0.16	3,609.30	577.49		**16.00%**	3,609.30	0.98	1.00	0.98	3,682.96	589.27
	3	TOMATO	**5.00%**	0.98	0.05	1.00	0.05	4,619.00	230.95		**5.00%**	4,619.00	0.98	1.00	0.98	4,713.27	235.66
3	1'	FORAGE CORN (Aftergrowth)	**5.00%**					2,186.40	109.32		-	-	-	-	-	-	-
TOTAL			**105.00%**		**0.98**		*** 0.92**		**3928.32**	**4,357.03**	**100.00%**						**4,356.63**

** Rounded up to 2 decimal places*

"WA of" = "The weighted average of"

Table A.3 GOZ Project - Calculations of the planning report *TDR* values and modified planning report *TDR* values

Crop Rotation Group i	Crop Type j	Crop Type	Crop Water Requirement Parameters														
			Planning Report Values								Modified Planning Report Values						
			$X_{i,j}$	$WCE_{i,j}$	*WA of* $WCE_{i,j}$	$WAE_{i,j}$	*WA of* $WAE_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	*WA of* $CIR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*	$X_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	$WCE_{i,j}$	$WAE_{i,j}$	$OIE_{i,j}$	$TDR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*
1	1	CLOVER	**5.00%**	0.98	0.05	0.80	0.04	5,889.50	294.48		**5.00%**	5,889.50	0.98	0.80	0.78	7,512.12	375.61
	2	MIXED FRUITS	**20.00%**	0.98	0.20	1.00	0.20	4,100.00	820.00		**20.00%**	4,100.00	0.98	1.00	0.98	4,183.67	836.73
2	1	CEREAL	**10.00%**	0.98	0.10	0.80	0.08	2,089.40	208.94		**10.00%**	2,089.40	0.98	0.80	0.78	2,665.05	266.51
	2	FORAGE CORN	**15.00%**	0.98	0.15	1.00	0.15	3,492.10	523.82		**15.00%**	3,492.10	0.98	1.00	0.98	3,563.37	534.51
3	1	CORN	**10.00%**	0.98	0.10	1.00	0.10	3,492.10	349.21		**10.00%**	3,492.10	0.98	1.00	0.98	3,563.37	356.34
	2	MELON	**6.00%**	0.98	0.06	1.00	0.06	1,930.70	115.84		**6.00%**	1,930.70	0.98	1.00	0.98	1,970.10	118.21
	3	ONION	**4.00%**	0.98	0.04	1.00	0.04	4,638.30	185.53		**4.00%**	4,638.30	0.98	1.00	0.98	4,732.96	189.32
	4	TOMATO	**5.00%**	0.98	0.05	1.00	0.05	4,482.90	224.15		**5.00%**	4,482.90	0.98	1.00	0.98	4,574.39	228.72
4	1	SUNFLOWER	**25.00%**	0.98	0.25	0.80	0.20	3,339.50	834.88		**25.00%**	3,339.50	0.98	0.80	0.78	4,259.57	1,064.89
2	2'	FORAGE CORN (Aftergrowth)	**15.00%**					2,111.80	316.77		-	-	-	-	-	-	-
TOTAL			**115.00%**		**0.98**		*** 0.92**		**3873.60**	**4,296.39**	**100.00%**						**3,970.82**

** Rounded up to 2 decimal places*

"WA of" = "The weighted average of"

Table A.4 KAR Project - Calculations of the planning report *TDR* values and modified planning report *TDR* values

Crop Rotation Group i	Crop Type j	Crop Type	Crop Water Requirement Parameters														
			Planning Report Values								Modified Planning Report Values						
			$X_{i,j}$	$WCE_{i,j}$	*WA of* $WCE_{i,j}$	$WAE_{i,j}$	*WA of* $WAE_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	*WA of* $CIR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*	$X_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	$WCE_{i,j}$	$WAE_{i,j}$	$OIE_{i,j}$	$TDR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*
1	1	CLOVER	6.00%	0.98	0.06	0.80	0.05	5,703.90	342.23		6.00%	5,703.90	0.98	0.80	0.78	7,275.38	436.52
	2	MIXED FRUITS	10.00%	0.98	0.10	1.00	0.10	4,008.10	400.81		10.00%	4,008.10	0.98	1.00	0.98	4,089.90	408.99
	3	VINEYARD	6.00%	0.98	0.06	1.00	0.06	3,432.60	205.96		6.00%	3,432.60	0.98	1.00	0.98	3,502.65	210.16
2	1	MIXED VEGETABLES	10.00%	0.98	0.10	1.00	0.10	3,117.50	311.75		10.00%	3,117.50	0.98	1.00	0.98	3,181.12	318.11
	2	MELON	6.00%	0.98	0.06	1.00	0.06	1,976.80	118.61		6.00%	1,976.80	0.98	1.00	0.98	2,017.14	121.03
	3	CORN	10.00%	0.98	0.10	1.00	0.10	3,445.00	344.50		10.00%	3,445.00	0.98	1.00	0.98	3,515.31	351.53
3	1	FORAGE CORN	16.00%	0.98	0.16	1.00	0.16	3,445.00	551.20		16.00%	3,445.00	0.98	1.00	0.98	3,515.31	562.45
	2	CEREAL	10.00%	0.98	0.10	0.80	0.08	2,019.80	201.98		10.00%	2,019.80	0.98	0.80	0.78	2,576.28	257.63
4	1	SUNFLOWER	26.00%	0.98	0.25	0.80	0.21	3,306.20	859.61		26.00%	3,306.20	0.98	0.80	0.78	4,217.09	1,096.44
3	1'	FORAGE CORN (Aftergrowth)	5.00%					2,054.20	102.71		-	-	-	-	-	-	-
TOTAL			105.00%		0.98		* 0.92		3439.36	3,814.72	100.00 %						3,762.86

** Rounded up to 2 decimal places*

"WA of" = "The weighted average of"

Table A.5 HUS Project - Calculations of the planning report *TDR* values and modified planning report *TDR* values

Crop Rotation Group	Crop Type	Crop Type	Crop Water Requirement Parameters														
			Planning Report Values								Modified Planning Report Values						
i	j	Crop Type	$X_{i,j}$	$WCE_{i,j}$	*WA of* $WCE_{i,j}$	$WAE_{i,j}$	*WA of* $WAE_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	*WA of* $CIR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*	$X_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	$WCE_{i,j}$	$WAE_{i,j}$	$OIE_{i,j}$	$TDR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*
1	1	CLOVER	**10.00%**	0.98	0.10	0.80	0.08	5,973.20	597.32		**10.00%**	5,973.20	0.98	0.80	0.78	7,618.88	761.89
	2	MIXED FRUITS	**15.00%**	0.98	0.15	1.00	0.15	4,007.50	601.13		**15.00%**	4,007.50	0.98	1.00	0.98	4,089.29	613.39
2	1	FORAGE CORN	**15.00%**	0.98	0.15	1.00	0.15	3,444.50	516.68		**15.00%**	3,444.50	0.98	1.00	0.98	3,514.80	527.22
	2	CEREAL	**10.00%**	0.98	0.10	0.80	0.08	2,019.50	201.95		**10.00%**	2,019.50	0.98	0.80	0.78	2,575.89	257.59
3	1	SUNFLOWER	**10.00%**	0.98	0.10	0.80	0.08	3,305.80	330.58		**10.00%**	3,305.80	0.98	0.80	0.78	4,216.58	421.66
	2	CANOLA	**15.00%**	0.98	0.15	0.80	0.12	1,041.50	156.23		**15.00%**	1,041.50	0.98	0.80	0.78	1,328.44	199.27
4	1	CORN	**10.00%**	0.98	0.10	1.00	0.10	3,444.50	344.45		**10.00%**	3,444.50	0.98	1.00	0.98	3,514.80	351.48
	2	MELON	**6.00%**	0.98	0.06	1.00	0.06	1,976.50	118.59		**6.00%**	1,976.50	0.98	1.00	0.98	2,016.84	121.01
	3	TOMATO	**5.00%**	0.98	0.05	1.00	0.05	4,366.10	218.31		**5.00%**	4,366.10	0.98	1.00	0.98	4,455.20	222.76
	4	ONION	**4.00%**	0.98	0.04	1.00	0.04	4,549.20	181.97		**4.00%**	4,549.20	0.98	1.00	0.98	4,642.04	185.68
2	1'	FORAGE CORN (Aftergrowth)	**5.00%**					2,054.00	102.70		-	-	-	-	-	-	-
TOTAL			**105.00%**		**0.98**		*** 0.91**		**3369.89**	**3,778.75**	**100.00%**						**3,661.95**

** Rounded up to 2 decimal places*

"WA of" = "The weighted average of"

Table A.6 KLV Project - Calculations of the planning report *TDR* values and modified planning report *TDR* values

Crop Rotation Group	Crop Type	Crop Type	Crop Water Requirement Parameters														
			Planning Report Values								Modified Planning Report Values						
i	j		$X_{i,j}$	$WCE_{i,j}$	*WA of* $WCE_{i,j}$	$WAE_{i,j}$	*WA of* $WAE_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	*WA of* $CIR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*	$X_{i,j}$	$CIR_{i,j}$ *(m³/ha)*	$WCE_{i,j}$	$WAE_{i,j}$	$OIE_{i,j}$	$TDR_{i,j}$ *(m³/ha)*	*WA of* $TDR_{i,j}$ *(m³/ha)*
1	1	CLOVER	**20.00%**	0.98	0.20	0.80	0.16	5,703.30	1140.66		**20.00%**	5,703.30	0.98	0.80	0.78	7,274.62	1,454.92
	2	MIXED FRUITS	**5.00%**	0.98	0.05	1.00	0.05	4,007.50	200.38		**5.00%**	4,007.50	0.98	1.00	0.98	4,089.29	204.46
2	1	FORAGE CORN	**15.00%**	0.98	0.15	1.00	0.15	3,444.50	516.68		**15.00%**	3,444.50	0.98	1.00	0.98	3,514.80	527.22
	2	CEREAL	**10.00%**	0.98	0.10	0.80	0.08	2,019.50	201.95		**10.00%**	2,019.50	0.98	0.80	0.78	2,575.89	257.59
3	1	SUNFLOWER	**14.00%**	0.98	0.14	0.80	0.11	3,305.80	462.81		**14.00%**	3,305.80	0.98	0.80	0.78	4,216.58	590.32
	2	TOMATO	**5.00%**	0.98	0.05	1.00	0.05	5,193.90	259.70		**5.00%**	5,193.90	0.98	1.00	0.98	5,299.90	264.99
	3	MELON	**6.00%**	0.98	0.06	1.00	0.06	1,976.50	118.59		**6.00%**	1,976.50	0.98	1.00	0.98	2,016.84	121.01
4	1	CORN	**15.00%**	0.98	0.15	1.00	0.15	3,444.50	516.68		**15.00%**	3,444.50	0.98	1.00	0.98	3,514.80	527.22
	2	MIXED VEGETABLES	**6.00%**	0.98	0.06	1.00	0.06	3,117.20	187.03		**6.00%**	3,117.20	0.98	1.00	0.98	3,180.82	190.85
	3	ONION	**4.00%**	0.98	0.04	1.00	0.04	3,336.30	133.45		**4.00%**	3,336.30	0.98	1.00	0.98	3,404.39	136.18
2	1'	FORAGE CORN (Aftergrowth)	**5.00%**					2,054.00	102.70		-	-	-	-	-	-	-
TOTAL			**105.00%**		**0.98**		*** 0.91**		**3840.62**	**4,306.58**	**100.00%**						**4,274.77**

** Rounded off to 2 decimal places*

"WA of" = "The weighted average of"

APPENDIX B

RESULTS OF OPTIMIZATION PROBLEMS

The obtained optimum cropping patterns and relevant parameters are given in following tables and graphs in the order stated below.

- CD1 Project — Table B.1 to Table B.6; Figure B.1 to Figure B.6
- CD2 Project — Table B.7 to Table B.12; Figure B.7 to Figure B.12
- GOZ Project — Table B.13 to Table B.18; Figure B.13 to Figure B.18
- KAR Project — Table B.19 to Table B.24; Figure B.19 to Figure B.24
- HUS Project — Table B.25 to Table B.30; Figure B.25 to Figure B.30
- KLV Project — Table B.31 to Table B.36; Figure B.31 to Figure B.36

Table B.1 CD1 Project - 5% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-1 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 5%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)
1	1	CLOVER	15.00%	14.25%	15.75%	8,210.46	4,488.38	15.00%	22.00%	1,231.57	673.26	14.25%	20.90%	1,169.99	639.59	14.25%	21.60%	1,169.99	639.59
	2	MIXED FRUITS	7.00%	6.65%	7.35%	4,350.10	27,350.57	7.00%		304.51	1,914.54	6.65%		289.28	1,818.81	7.35%		319.73	2,010.27
2	1	CEREAL	10.00%	9.50%	10.00%	2,800.13	4,773.47	10.00%	26.00%	280.01	477.35	10.00%	26.37%	280.01	477.35	9.50%	26.13%	266.01	453.48
	2	SUNFLOWER	16.00%	15.20%	16.80%	4,404.97	8,768.76	16.00%		704.80	1,403.00	16.37%		720.95	1,435.15	16.63%		732.70	1,458.54
3	1	FORAGE CORN	16.00%	15.20%	16.80%	3,682.96	8,937.92	16.00%	26.00%	589.27	1,430.07	15.87%	26.37%	584.36	1,418.15	15.63%	26.13%	575.77	1,397.30
	2	MELON	10.00%	9.50%	10.50%	2,057.96	19,046.43	10.00%		205.80	1,904.64	10.50%		216.09	1,999.88	10.50%		216.09	1,999.88
4	1	MIXED VEGETABLES	6.00%	5.70%	6.30%	3,542.76	16,893.75	6.00%	26.00%	212.57	1,013.63	6.30%	26.37%	223.19	1,064.31	6.30%	26.13%	223.19	1,064.31
	2	CORN	15.00%	14.25%	15.75%	3,682.96	4,514.01	15.00%		552.44	677.10	15.32%		564.11	691.40	14.58%		537.10	658.29
	3	TOMATO	5.00%	4.75%	5.25%	4,713.27	18,921.00	5.00%		235.66	946.05	4.75%		223.88	898.75	5.25%		247.45	993.35
		TOTAL						100.00%	100.00%	4,316.63	10,439.63	100.00%	100.00%	4,271.86	10,443.38	100.00%	100.00%	4,288.03	10,675.01

Annual Available Water for Irrigation	**AW**		509,000 m^3	509,000 m^3	509,000 m^3
Irrigation Area Size	**A**	*= [AW / TDR]*	117.92 ha	**119.15 ha**	118.70 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,231,001 TL	1,244,348 TL	**1,267,152 TL**

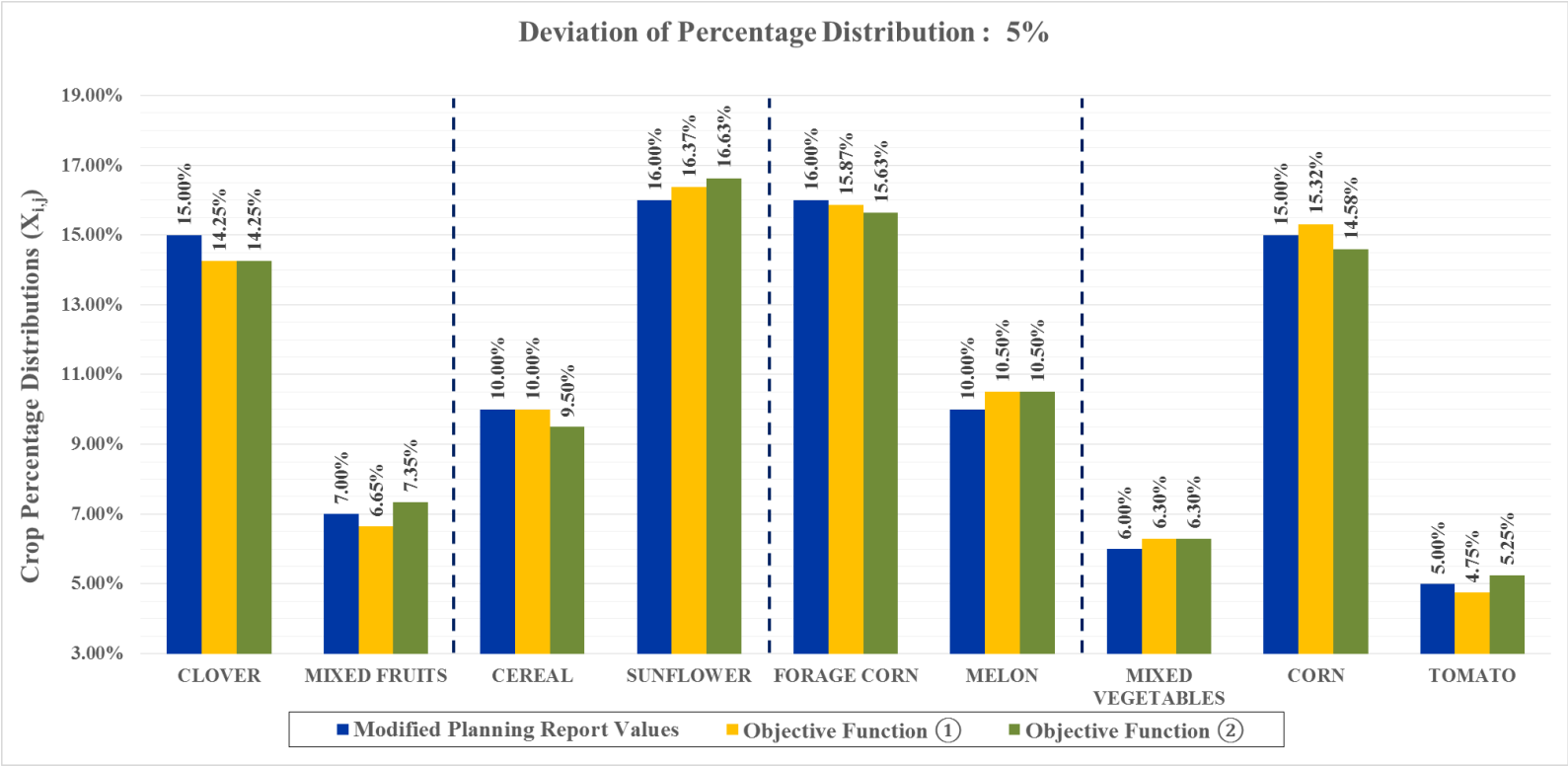


Figure B.1 CD1 Project - 5% of deviation of crop percentage distribution results

Table B.2 CD1 Project - 10% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-1 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 10%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*15.00%*	13.50%	16.50%	8,210.46	4,488.38	**15.00%**	**22.00%**	*1,231.57*	*673.26*	**13.50%**	**19.80%**	*1,108.41*	*605.93*	**13.50%**	**21.20%**	*1,108.41*	*605.93*
	2	MIXED FRUITS	*7.00%*	6.30%	7.70%	4,350.10	27,350.57	**7.00%**		*304.51*	*1,914.54*	**6.30%**		*274.06*	*1,723.09*	**7.70%**		*334.96*	*2,105.99*
2	1	CEREAL	*10.00%*	9.00%	10.00%	2,800.13	4,773.47	**10.00%**	**26.00%**	*280.01*	*477.35*	**10.00%**	**26.73%**	*280.01*	*477.35*	**10.00%**	**26.27%**	*280.01*	*477.35*
	2	SUNFLOWER	*16.00%*	14.40%	17.60%	4,404.97	8,768.76	**16.00%**		*704.80*	*1,403.00*	**16.73%**		*737.10*	*1,467.31*	**16.27%**		*716.54*	*1,426.39*
3	1	FORAGE CORN	*16.00%*	14.40%	17.60%	3,682.96	8,937.92	**16.00%**	**26.00%**	*589.27*	*1,430.07*	**15.73%**	**26.73%**	*579.45*	*1,406.23*	**15.27%**	**26.27%**	*562.27*	*1,364.52*
	2	MELON	*10.00%*	9.00%	11.00%	2,057.96	19,046.43	**10.00%**		*205.80*	*1,904.64*	**11.00%**		*226.38*	*2,095.11*	**11.00%**		*226.38*	*2,095.11*
4	1	MIXED VEGETABLES	*6.00%*	5.40%	6.60%	3,542.76	16,893.75	**6.00%**	**26.00%**	*212.57*	*1,013.63*	**6.60%**	**26.73%**	*233.82*	*1,114.99*	**6.60%**	**26.27%**	*233.82*	*1,114.99*
	2	CORN	*15.00%*	13.50%	16.50%	3,682.96	4,514.01	**15.00%**		*552.44*	*677.10*	**15.63%**		*575.77*	*705.69*	**14.17%**		*521.75*	*639.49*
	3	TOMATO	*5.00%*	4.50%	5.50%	4,713.27	18,921.00	**5.00%**		*235.66*	*946.05*	**4.50%**		*212.10*	*851.45*	**5.50%**		*259.23*	*1,040.66*
		TOTAL						**100.00%**	**100.00%**	**4,316.63**	**10,439.63**	**100.00%**	**100.00%**	**4,227.10**	**10,447.13**	**100.00%**	**100.00%**	**4,243.37**	**10,870.42**

Annual Available Water for Irrigation	**AW**		509,000 m³	509,000 m³	509,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	117.92 ha	**120.41 ha**	119.95 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,231,001 TL	1,257,977 TL	**1,303,926 TL**

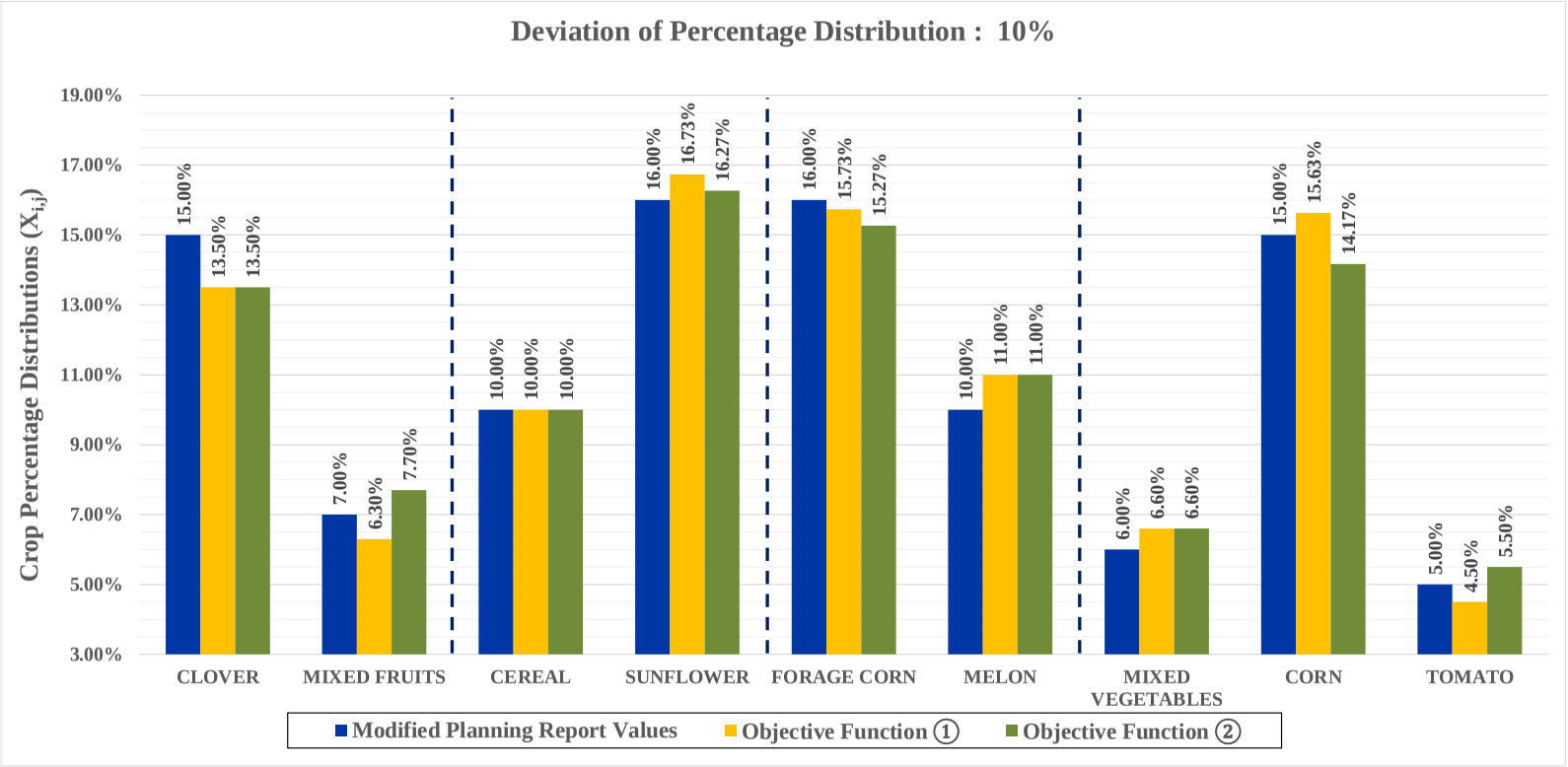


Figure B.2 CD1 Project - 10% of deviation of crop percentage distribution results

Table B.3 CD1 Project - 15% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-1 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 15%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*15.00%*	12.75%	17.25%	8,210.46	4,488.38	**15.00%**	**22.00%**	*1,231.57*	*673.26*	**12.75%**	**18.70%**	*1,046.83*	*572.27*	**12.75%**	**20.80%**	*1,046.83*	*572.27*
	2	MIXED FRUITS	*7.00%*	5.95%	8.05%	4,350.10	27,350.57	**7.00%**		*304.51*	*1,914.54*	**5.95%**		*258.83*	*1,627.36*	**8.05%**		*350.18*	*2,201.72*
2	1	CEREAL	*10.00%*	8.50%	10.00%	2,800.13	4,773.47	**10.00%**	**26.00%**	*280.01*	*477.35*	**10.00%**	**27.10%**	*280.01*	*477.35*	**10.00%**	**26.40%**	*280.01*	*477.35*
	2	SUNFLOWER	*16.00%*	13.60%	18.40%	4,404.97	8,768.76	**16.00%**		*704.80*	*1,403.00*	**17.10%**		*753.25*	*1,499.46*	**16.40%**		*722.42*	*1,438.08*
3	1	FORAGE CORN	*16.00%*	13.60%	18.40%	3,682.96	8,937.92	**16.00%**	**26.00%**	*589.27*	*1,430.07*	**15.60%**	**27.10%**	*574.54*	*1,394.32*	**14.90%**	**26.40%**	*548.76*	*1,331.75*
	2	MELON	*10.00%*	8.50%	11.50%	2,057.96	19,046.43	**10.00%**		*205.80*	*1,904.64*	**11.50%**		*236.67*	*2,190.34*	**11.50%**		*236.67*	*2,190.34*
4	1	MIXED VEGETABLES	*6.00%*	5.10%	6.90%	3,542.76	16,893.75	**6.00%**	**26.00%**	*212.57*	*1,013.63*	**6.90%**	**27.10%**	*244.45*	*1,165.67*	**6.90%**	**26.40%**	*244.45*	*1,165.67*
	2	CORN	*15.00%*	12.75%	17.25%	3,682.96	4,514.01	**15.00%**		*552.44*	*677.10*	**15.95%**		*587.43*	*719.98*	**13.75%**		*506.41*	*620.68*
	3	TOMATO	*5.00%*	4.25%	5.75%	4,713.27	18,921.00	**5.00%**		*235.66*	*946.05*	**4.25%**		*200.31*	*804.14*	**5.75%**		*271.01*	*1,087.96*
		TOTAL						**100.00%**	**100.00%**	**4,316.63**	**10,439.63**	**100.00%**	**100.00%**	**4,182.33**	**10,450.88**	**100.00%**	**100.00%**	**4,206.74**	**11,085.81**

Annual Available Water for Irrigation	**AW**		509,000 m³	509,000 m³	509,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	117.92 ha	**121.70 ha**	121.00 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,231,001 TL	1,271,898 TL	**1,341,341 TL**

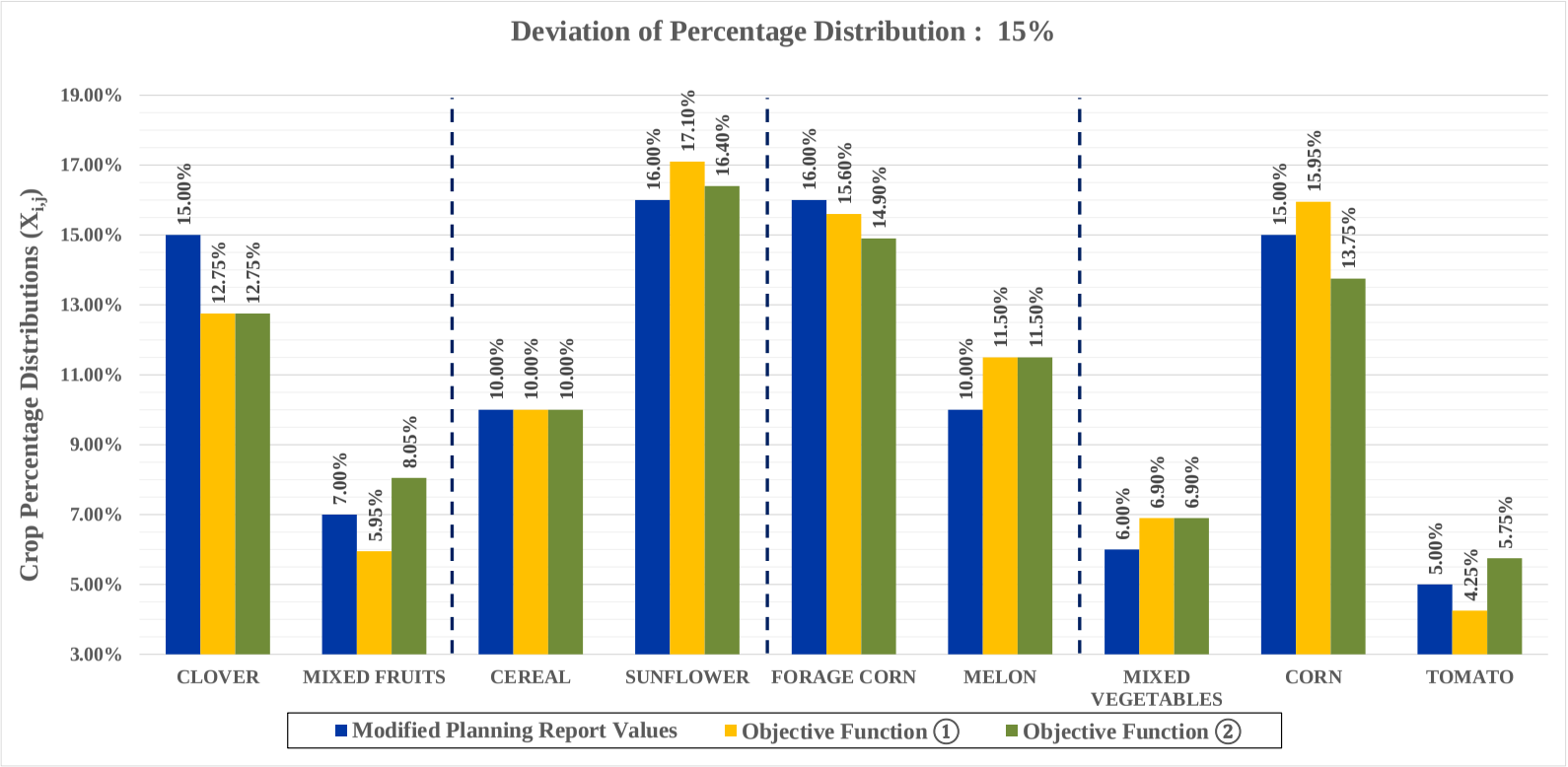


Figure B.3 CD1 Project - 15% of deviation of crop percentage distribution results

Table B.4 CD1 Project - 20% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-1 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 20%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)
1	1	CLOVER	15.00%	12.00%	18.00%	8,210.46	4,488.38	15.00%	22.00%	1,231.57	673.26	12.00%	17.60%	985.26	538.61	12.00%	20.40%	985.26	538.61
	2	MIXED FRUITS	7.00%	5.60%	8.40%	4,350.10	27,350.57	7.00%		304.51	1,914.54	5.60%		243.61	1,531.63	8.40%		365.41	2,297.45
2	1	CEREAL	10.00%	8.00%	10.00%	2,800.13	4,773.47	10.00%	26.00%	280.01	477.35	10.00%	27.47%	280.01	477.35	10.00%	26.53%	280.01	477.35
	2	SUNFLOWER	16.00%	12.80%	19.20%	4,404.97	8,768.76	16.00%		704.80	1,403.00	17.47%		769.40	1,531.61	16.53%		728.29	1,449.77
3	1	FORAGE CORN	16.00%	12.80%	19.20%	3,682.96	8,937.92	16.00%	26.00%	589.27	1,430.07	15.47%	27.47%	569.63	1,382.40	14.53%	26.53%	535.26	1,298.98
	2	MELON	10.00%	8.00%	12.00%	2,057.96	19,046.43	10.00%		205.80	1,904.64	12.00%		246.96	2,285.57	12.00%		246.96	2,285.57
4	1	MIXED VEGETABLES	6.00%	4.80%	7.20%	3,542.76	16,893.75	6.00%	26.00%	212.57	1,013.63	7.20%	27.47%	255.08	1,216.35	7.20%	26.53%	255.08	1,216.35
	2	CORN	15.00%	12.00%	18.00%	3,682.96	4,514.01	15.00%		552.44	677.10	16.27%		599.09	734.28	13.33%		491.06	601.87
	3	TOMATO	5.00%	4.00%	6.00%	4,713.27	18,921.00	5.00%		235.66	946.05	4.00%		188.53	756.84	6.00%		282.80	1,135.26
		TOTAL						100.00%	100.00%	4,316.63	10,439.63	100.00%	100.00%	4,137.57	10,454.63	100.00%	100.00%	4,170.12	11,301.20

Annual Available Water for Irrigation	**AW**		509,000 m³	509,000 m³	509,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	117.92 ha	**123.02 ha**	122.06 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,231,001 TL	1,286,121 TL	**1,379,413 TL**

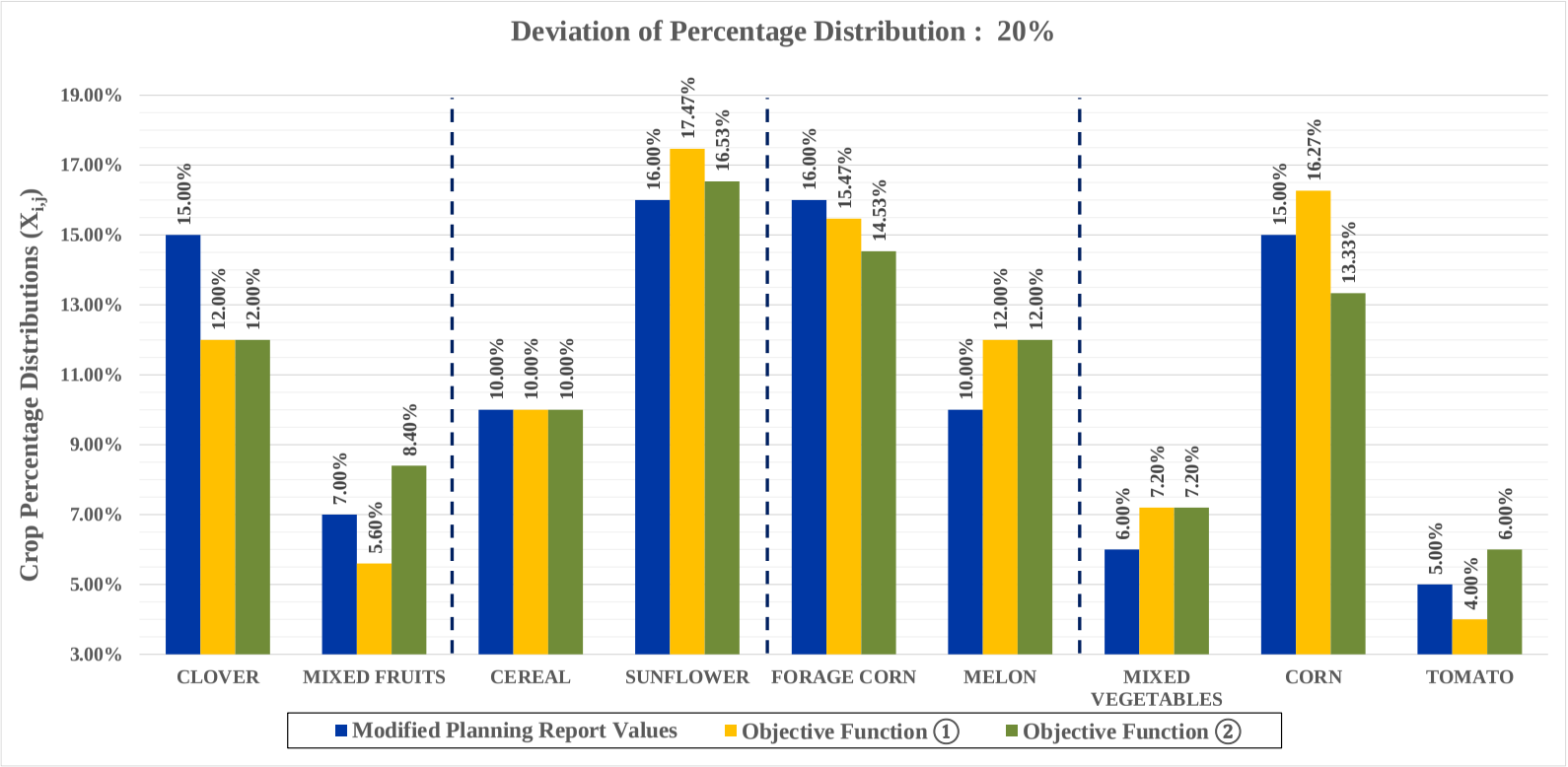


Figure B.4 CD1 Project - 20% of deviation of crop percentage distribution results

Table B.5 CD1 Project - 25% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-1 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 25%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)
1	1	CLOVER	15.00%	11.25%	18.75%	8,210.46	4,488.38	15.00%	22.00%	1,231.57	673.26	11.25%	16.50%	923.68	504.94	11.25%	20.00%	923.68	504.94
	2	MIXED FRUITS	7.00%	5.25%	8.75%	4,350.10	27,350.57	7.00%		304.51	1,914.54	5.25%		228.38	1,435.90	8.75%		380.63	2,393.17
2	1	CEREAL	10.00%	7.50%	10.00%	2,800.13	4,773.47	10.00%	26.00%	280.01	477.35	10.00%	27.83%	280.01	477.35	10.00%	26.67%	280.01	477.35
	2	SUNFLOWER	16.00%	12.00%	20.00%	4,404.97	8,768.76	16.00%		704.80	1,403.00	17.83%		785.55	1,563.76	16.67%		734.16	1,461.46
3	1	FORAGE CORN	16.00%	12.00%	20.00%	3,682.96	8,937.92	16.00%	26.00%	589.27	1,430.07	15.33%	27.83%	564.72	1,370.48	14.17%	26.67%	521.75	1,266.20
	2	MELON	10.00%	7.50%	12.50%	2,057.96	19,046.43	10.00%		205.80	1,904.64	12.50%		257.24	2,380.80	12.50%		257.25	2,380.81
4	1	MIXED VEGETABLES	6.00%	4.50%	7.50%	3,542.76	16,893.75	6.00%	26.00%	212.57	1,013.63	7.50%	27.83%	265.71	1,267.03	7.50%	26.67%	265.71	1,267.03
	2	CORN	15.00%	11.25%	18.75%	3,682.96	4,514.01	15.00%		552.44	677.10	16.58%		610.76	748.57	12.92%		475.72	583.06
	3	TOMATO	5.00%	3.75%	6.25%	4,713.27	18,921.00	5.00%		235.66	946.05	3.75%		176.75	709.54	6.25%		294.58	1,182.56
		TOTAL						100.00%	100.00%	4,316.63	10,439.63	100.00%	100.00%	4,092.80	10,458.38	100.00%	100.00%	4,133.48	11,516.59

Annual Available Water for Irrigation	**AW**		509,000 m³	509,000 m³	509,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	117.92 ha	**124.36 ha**	123.14 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,231,001 TL	1,300,654 TL	**1,418,160 TL**

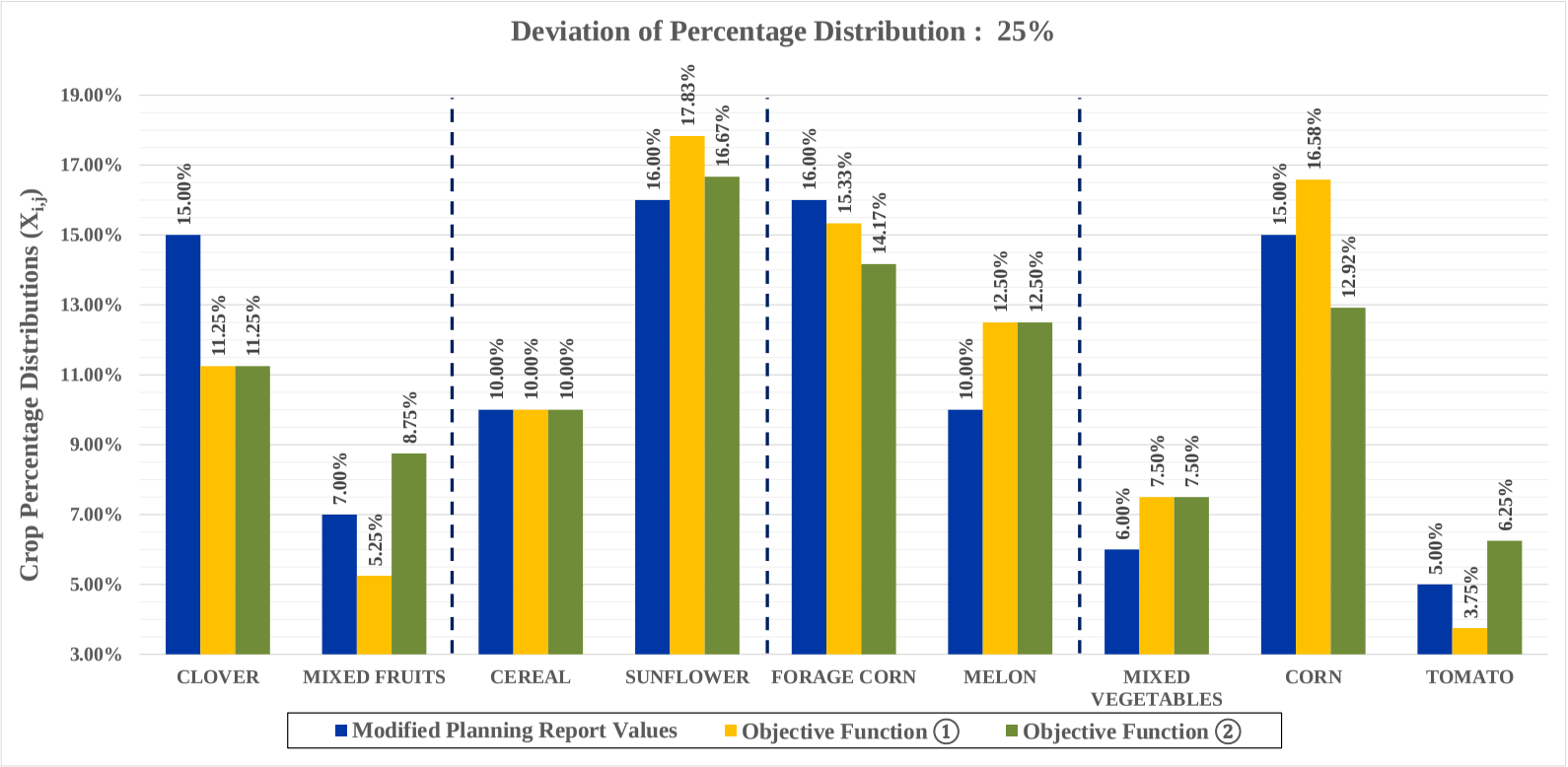


Figure B.5 CD1 Project - 25% of deviation of crop percentage distribution results

Table B.6 CD1 Project - 30% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-1 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 30%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*15.00%*	10.50%	19.50%	8,210.46	4,488.38	**15.00%**	**22.00%**	*1,231.57*	*673.26*	**10.50%**	**15.40%**	*862.10*	*471.28*	**10.50%**	**19.60%**	*862.10*	*471.28*
	2	MIXED FRUITS	*7.00%*	4.90%	9.10%	4,350.10	27,350.57	**7.00%**		*304.51*	*1,914.54*	**4.90%**		*213.16*	*1,340.18*	**9.10%**		*395.86*	*2,488.90*
2	1	CEREAL	*10.00%*	7.00%	10.00%	2,800.13	4,773.47	**10.00%**	**26.00%**	*280.01*	*477.35*	**10.00%**	**28.20%**	*280.01*	*477.35*	**10.00%**	**26.80%**	*280.01*	*477.35*
	2	SUNFLOWER	*16.00%*	11.20%	20.80%	4,404.97	8,768.76	**16.00%**		*704.80*	*1,403.00*	**18.20%**		*801.71*	*1,595.91*	**16.80%**		*740.04*	*1,473.15*
3	1	FORAGE CORN	*16.00%*	11.20%	20.80%	3,682.96	8,937.92	**16.00%**	**26.00%**	*589.27*	*1,430.07*	**15.20%**	**28.20%**	*559.81*	*1,358.56*	**13.80%**	**26.80%**	*508.25*	*1,233.43*
	2	MELON	*10.00%*	7.00%	13.00%	2,057.96	19,046.43	**10.00%**		*205.80*	*1,904.64*	**13.00%**		*267.53*	*2,476.04*	**13.00%**		*267.53*	*2,476.04*
4	1	MIXED VEGETABLES	*6.00%*	4.20%	7.80%	3,542.76	16,893.75	**6.00%**	**26.00%**	*212.57*	*1,013.63*	**7.80%**	**28.20%**	*276.33*	*1,317.71*	**7.80%**	**26.80%**	*276.33*	*1,317.71*
	2	CORN	*15.00%*	10.50%	19.50%	3,682.96	4,514.01	**15.00%**		*552.44*	*677.10*	**16.90%**		*622.42*	*762.87*	**12.50%**		*460.37*	*564.25*
	3	TOMATO	*5.00%*	3.50%	6.50%	4,713.27	18,921.00	**5.00%**		*235.66*	*946.05*	**3.50%**		*164.96*	*662.24*	**6.50%**		*306.36*	*1,229.87*
		TOTAL						**100.00%**	**100.00%**	**4,316.63**	**10,439.63**	**100.00%**	**100.00%**	**4,048.04**	**10,462.13**	**100.00%**	**100.00%**	**4,096.86**	**11,731.99**

Annual Available Water for Irrigation	**AW**		509,000 m³	509,000 m³	509,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	117.92 ha	**125.74 ha**	124.24 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,231,001 TL	1,315,509 TL	**1,457,600 TL**

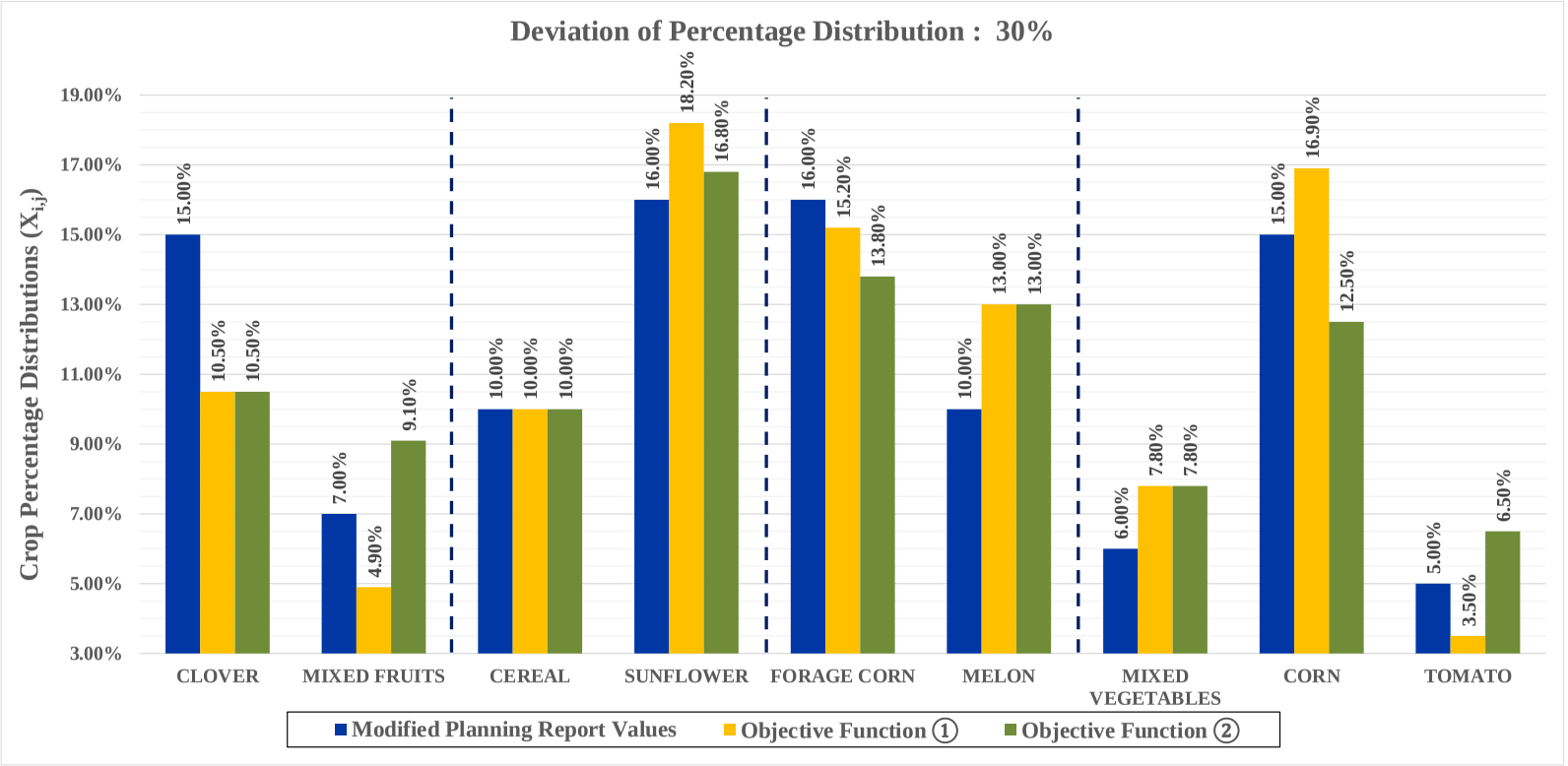


Figure B.6 CD1 Project - 30% of deviation of crop percentage distribution results

Table B.7 CD2 Project - 5% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-2 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 5%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*16.00%*	15.20%	16.80%	8,210.46	4,488.38	**16.00%**	**22.00%**	*1,313.67*	*718.14*	**15.20%**	**20.90%**	*1,247.99*	*682.23*	**15.20%**	**21.50%**	*1,247.99*	*682.23*
	2	MIXED FRUITS	*6.00%*	5.70%	6.30%	4,350.10	27,350.57	**6.00%**		*261.01*	*1,641.03*	**5.70%**		*247.96*	*1,558.98*	**6.30%**		*274.06*	*1,723.09*
2	1	CEREAL	*10.00%*	9.50%	10.00%	2,800.13	4,773.47	**10.00%**	**26.00%**	*280.01*	*477.35*	**10.00%**	**26.37%**	*280.01*	*477.35*	**9.50%**	**26.17%**	*266.01*	*453.48*
	2	SUNFLOWER	*16.00%*	15.20%	16.80%	4,404.97	8,768.76	**16.00%**		*704.80*	*1,403.00*	**16.37%**		*720.95*	*1,435.15*	**16.67%**		*734.16*	*1,461.46*
3	1	FORAGE CORN	*16.00%*	15.20%	16.80%	3,682.96	8,937.92	**16.00%**	**26.00%**	*589.27*	*1,430.07*	**15.87%**	**26.37%**	*584.36*	*1,418.15*	**15.67%**	**26.17%**	*577.00*	*1,400.28*
	2	MELON	*10.00%*	9.50%	10.50%	2,057.96	19,046.43	**10.00%**		*205.80*	*1,904.64*	**10.50%**		*216.09*	*1,999.88*	**10.50%**		*216.09*	*1,999.88*
4	1	MIXED VEGETABLES	*5.00%*	4.75%	5.25%	3,542.76	16,893.75	**5.00%**	**26.00%**	*177.14*	*844.69*	**5.25%**	**26.37%**	*185.99*	*886.92*	**5.25%**	**26.17%**	*185.99*	*886.92*
	2	CORN	*16.00%*	15.20%	16.80%	3,682.96	4,514.01	**16.00%**		*589.27*	*722.24*	**16.37%**		*602.78*	*738.79*	**15.67%**		*577.00*	*707.20*
	3	TOMATO	*5.00%*	4.75%	5.25%	4,713.27	18,921.00	**5.00%**		*235.66*	*946.05*	**4.75%**		*223.88*	*898.75*	**5.25%**		*247.45*	*993.35*
		TOTAL						**100.00%**	**100.00%**	**4,356.63**	**10,087.21**	**100.00%**	**100.00%**	**4,310.01**	**10,096.20**	**100.00%**	**100.00%**	**4,325.74**	**10,307.89**

Annual Available Water for Irrigation	**AW**		852,000 m³	852,000 m³	852,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	195.56 ha	**197.68 ha**	196.96 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,972,695 TL	1,995,813 TL	**2,030,244 TL**

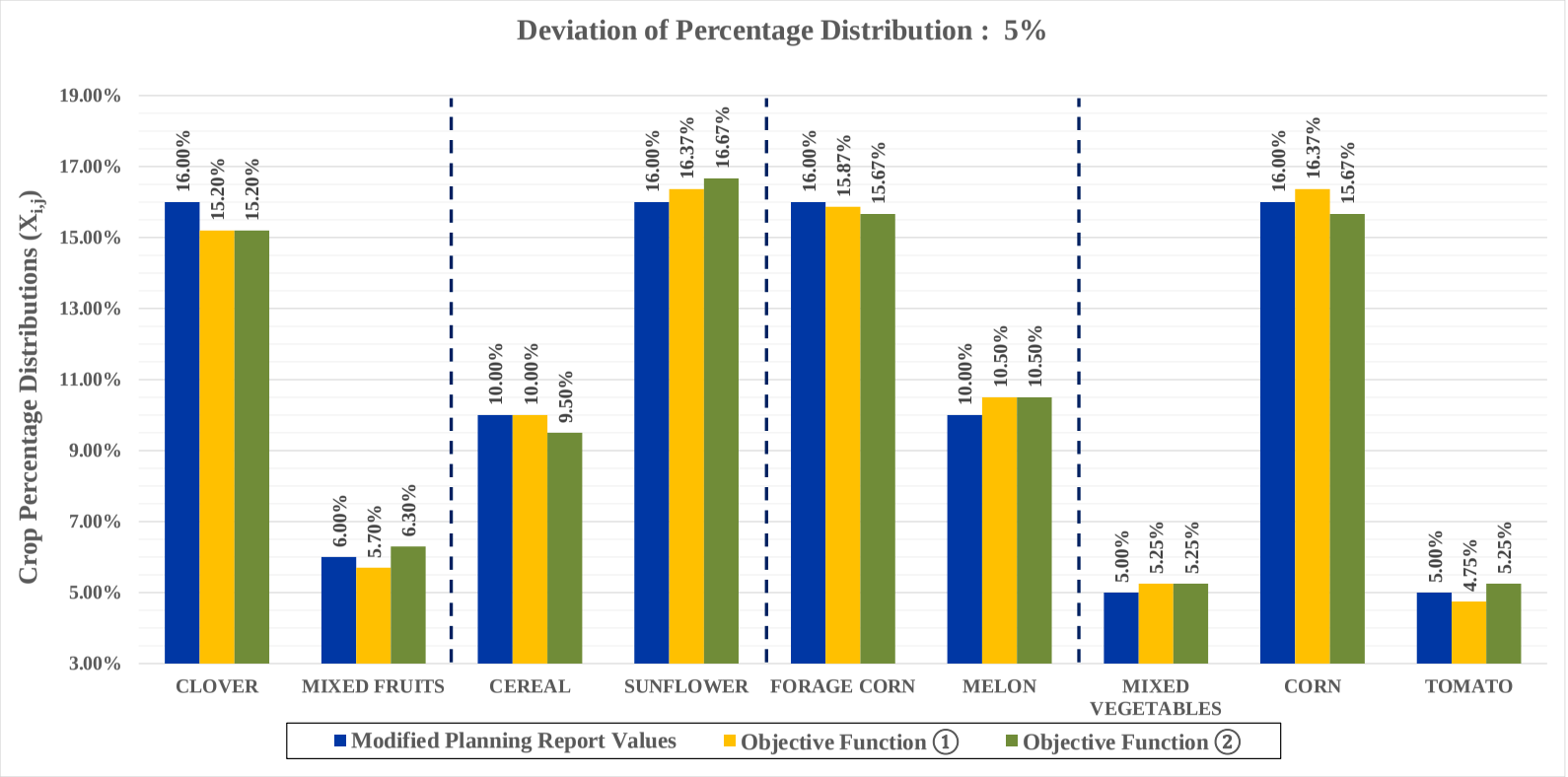


Figure B.7 CD2 Project - 5% of deviation of crop percentage distribution results

Table B.8 CD2 Project - 10% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-2 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 10%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*16.00%*	14.40%	17.60%	8,210.46	4,488.38	**16.00%**	**22.00%**	*1,313.67*	*718.14*	**14.40%**	**19.80%**	*1,182.31*	*646.33*	**14.40%**	**21.00%**	*1,182.31*	*646.33*
	2	MIXED FRUITS	*6.00%*	5.40%	6.60%	4,350.10	27,350.57	**6.00%**		*261.01*	*1,641.03*	**5.40%**		*234.91*	*1,476.93*	**6.60%**		*287.11*	*1,805.14*
2	1	CEREAL	*10.00%*	9.00%	10.00%	2,800.13	4,773.47	**10.00%**	**26.00%**	*280.01*	*477.35*	**10.00%**	**26.73%**	*280.01*	*477.35*	**9.00%**	**26.33%**	*252.01*	*429.61*
	2	SUNFLOWER	*16.00%*	14.40%	17.60%	4,404.97	8,768.76	**16.00%**		*704.80*	*1,403.00*	**16.73%**		*737.10*	*1,467.31*	**17.33%**		*763.53*	*1,519.92*
3	1	FORAGE CORN	*16.00%*	14.40%	17.60%	3,682.96	8,937.92	**16.00%**	**26.00%**	*589.27*	*1,430.07*	**15.73%**	**26.73%**	*579.45*	*1,406.23*	**15.33%**	**26.33%**	*564.72*	*1,370.48*
	2	MELON	*10.00%*	9.00%	11.00%	2,057.96	19,046.43	**10.00%**		*205.80*	*1,904.64*	**11.00%**		*226.38*	*2,095.11*	**11.00%**		*226.38*	*2,095.11*
4	1	MIXED VEGETABLES	*5.00%*	4.50%	5.50%	3,542.76	16,893.75	**5.00%**	**26.00%**	*177.14*	*844.69*	**5.50%**	**26.73%**	*194.85*	*929.16*	**5.50%**	**26.33%**	*194.85*	*929.16*
	2	CORN	*16.00%*	14.40%	17.60%	3,682.96	4,514.01	**16.00%**		*589.27*	*722.24*	**16.73%**		*616.28*	*755.34*	**15.33%**		*564.72*	*692.15*
	3	TOMATO	*5.00%*	4.50%	5.50%	4,713.27	18,921.00	**5.00%**		*235.66*	*946.05*	**4.50%**		*212.10*	*851.45*	**5.50%**		*259.23*	*1,040.66*
		TOTAL						100.00%	100.00%	4,356.63	10,087.21	100.00%	100.00%	4,263.38	10,105.20	100.00%	100.00%	4,294.85	10,528.55

Annual Available Water for Irrigation	**AW**		852,000 m³	852,000 m³	852,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	195.56 ha	**199.84 ha**	198.38 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,972,695 TL	2,019,436 TL	**2,088,622 TL**

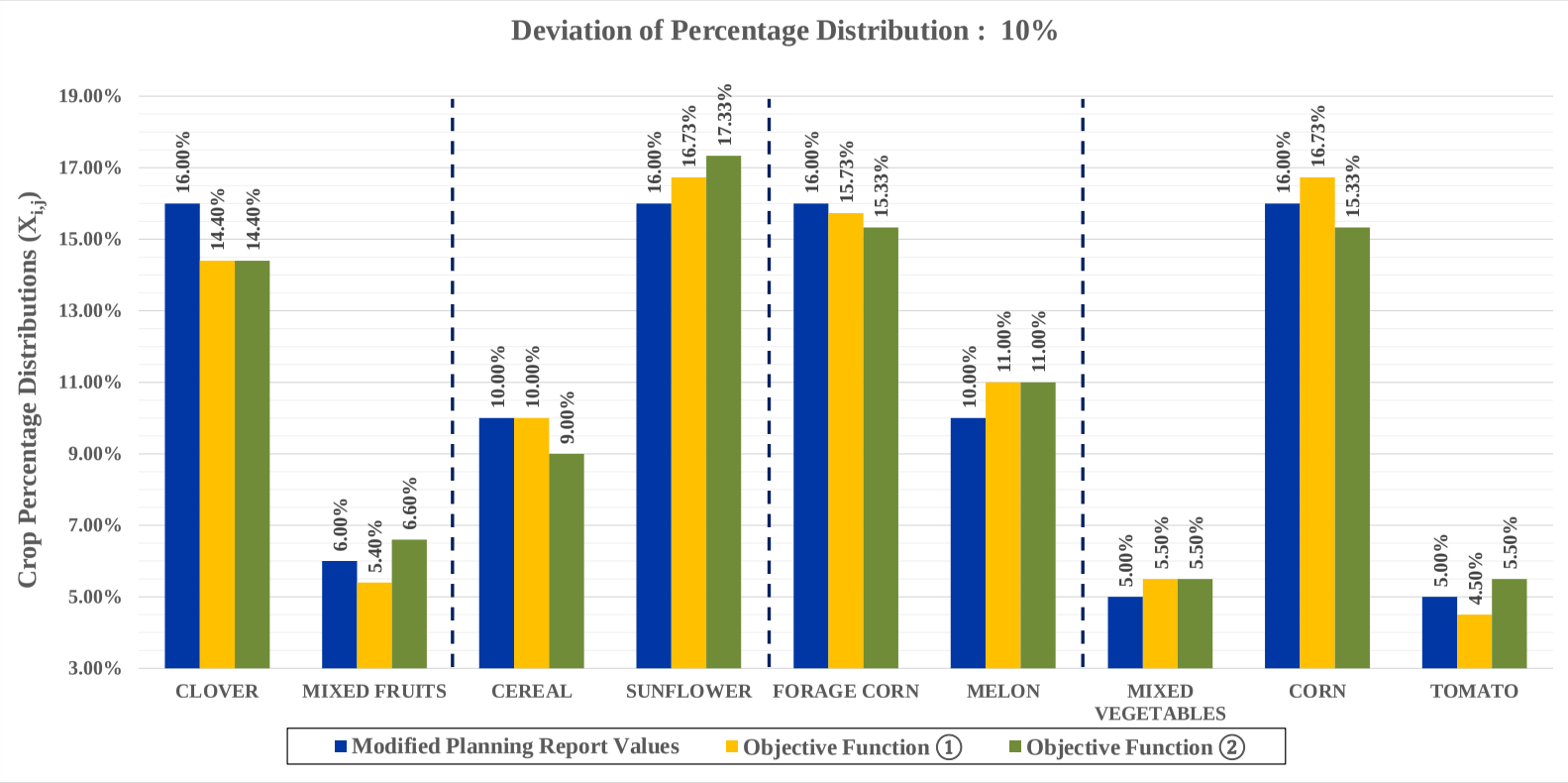


Figure B.8 CD2 Project - 10% of deviation of crop percentage distribution results

Table B.9 CD2 Project - 15% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-2 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 15%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*16.00%*	13.60%	18.40%	8,210.46	4,488.38	**16.00%**	**22.00%**	*1,313.67*	*718.14*	**13.60%**	**18.70%**	*1,116.62*	*610.42*	**13.60%**	**20.50%**	*1,116.62*	*610.42*
	2	MIXED FRUITS	*6.00%*	5.10%	6.90%	4,350.10	27,350.57	**6.00%**		*261.01*	*1,641.03*	**5.10%**		*221.86*	*1,394.88*	**6.90%**		*300.16*	*1,887.19*
2	1	CEREAL	*10.00%*	8.50%	10.00%	2,800.13	4,773.47	**10.00%**	**26.00%**	*280.01*	*477.35*	**10.00%**	**27.10%**	*280.01*	*477.35*	**10.00%**	**26.50%**	*280.01*	*477.35*
	2	SUNFLOWER	*16.00%*	13.60%	18.40%	4,404.97	8,768.76	**16.00%**		*704.80*	*1,403.00*	**17.10%**		*753.25*	*1,499.46*	**16.50%**		*726.82*	*1,446.85*
3	1	FORAGE CORN	*16.00%*	13.60%	18.40%	3,682.96	8,937.92	**16.00%**	**26.00%**	*589.27*	*1,430.07*	**15.60%**	**27.10%**	*574.54*	*1,394.32*	**15.00%**	**26.50%**	*552.44*	*1,340.69*
	2	MELON	*10.00%*	8.50%	11.50%	2,057.96	19,046.43	**10.00%**		*205.80*	*1,904.64*	**11.50%**		*236.67*	*2,190.34*	**11.50%**		*236.67*	*2,190.34*
4	1	MIXED VEGETABLES	*5.00%*	4.25%	5.75%	3,542.76	16,893.75	**5.00%**	**26.00%**	*177.14*	*844.69*	**5.75%**	**27.10%**	*203.71*	*971.39*	**5.75%**	**26.50%**	*203.71*	*971.39*
	2	CORN	*16.00%*	13.60%	18.40%	3,682.96	4,514.01	**16.00%**		*589.27*	*722.24*	**17.10%**		*629.79*	*771.90*	**15.00%**		*552.44*	*677.10*
	3	TOMATO	*5.00%*	4.25%	5.75%	4,713.27	18,921.00	**5.00%**		*235.66*	*946.05*	**4.25%**		*200.31*	*804.14*	**5.75%**		*271.01*	*1,087.96*
		TOTAL						**100.00%**	**100.00%**	**4,356.63**	**10,087.21**	**100.00%**	**100.00%**	**4,216.76**	**10,114.19**	**100.00%**	**100.00%**	**4,239.89**	**10,689.29**

Annual Available Water for Irrigation	**AW**		852,000 m³	852,000 m³	852,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	195.56 ha	**202.05 ha**	200.95 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,972,695 TL	2,043,582 TL	**2,147,997 TL**

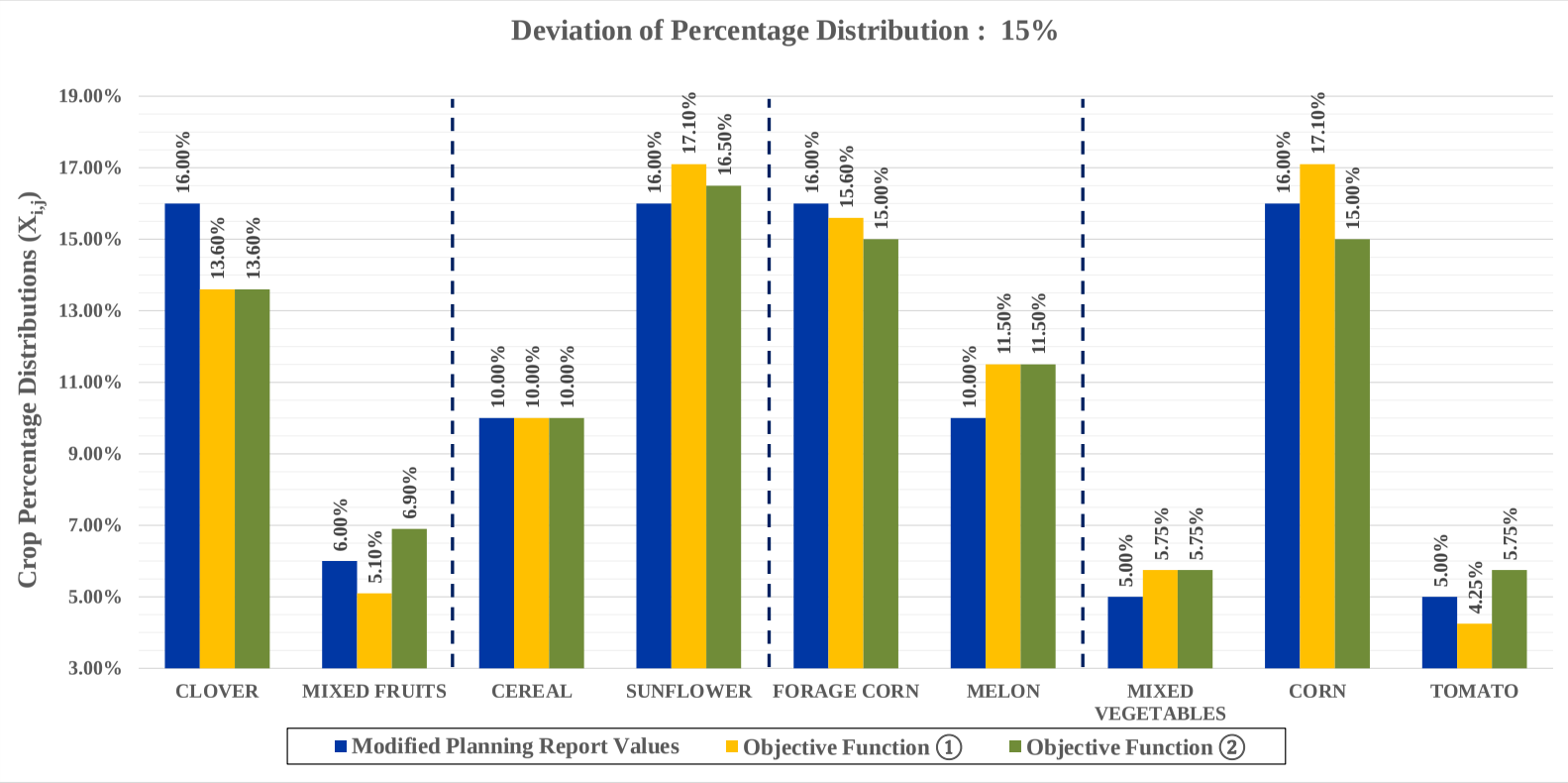


Figure B.9 CD2 Project - 15% of deviation of crop percentage distribution results

Table B.10 CD2 Project - 20% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-2 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 20%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*16.00%*	12.80%	19.20%	8,210.46	4,488.38	**16.00%**	**22.00%**	*1,313.67*	*718.14*	**12.80%**	**17.60%**	*1,050.94*	*574.51*	**12.80%**	**20.00%**	*1,050.94*	*574.51*
	2	MIXED FRUITS	*6.00%*	4.80%	7.20%	4,350.10	27,350.57	**6.00%**		*261.01*	*1,641.03*	**4.80%**		*208.80*	*1,312.83*	**7.20%**		*313.21*	*1,969.24*
2	1	CEREAL	*10.00%*	8.00%	10.00%	2,800.13	4,773.47	**10.00%**	**26.00%**	*280.01*	*477.35*	**10.00%**	**27.47%**	*280.01*	*477.35*	**10.00%**	**26.67%**	*280.01*	*477.35*
	2	SUNFLOWER	*16.00%*	12.80%	19.20%	4,404.97	8,768.76	**16.00%**		*704.80*	*1,403.00*	**17.47%**		*769.40*	*1,531.61*	**16.67%**		*734.16*	*1,461.46*
3	1	FORAGE CORN	*16.00%*	12.80%	19.20%	3,682.96	8,937.92	**16.00%**	**26.00%**	*589.27*	*1,430.07*	**15.47%**	**27.47%**	*569.63*	*1,382.40*	**14.67%**	**26.67%**	*540.17*	*1,310.89*
	2	MELON	*10.00%*	8.00%	12.00%	2,057.96	19,046.43	**10.00%**		*205.80*	*1,904.64*	**12.00%**		*246.96*	*2,285.57*	**12.00%**		*246.96*	*2,285.57*
4	1	MIXED VEGETABLES	*5.00%*	4.00%	6.00%	3,542.76	16,893.75	**5.00%**	**26.00%**	*177.14*	*844.69*	**6.00%**	**27.47%**	*212.57*	*1,013.63*	**6.00%**	**26.67%**	*212.57*	*1,013.63*
	2	CORN	*16.00%*	12.80%	19.20%	3,682.96	4,514.01	**16.00%**		*589.27*	*722.24*	**17.47%**		*643.29*	*788.45*	**14.67%**		*540.17*	*662.05*
	3	TOMATO	*5.00%*	4.00%	6.00%	4,713.27	18,921.00	**5.00%**		*235.66*	*946.05*	**4.00%**		*188.53*	*756.84*	**6.00%**		*282.80*	*1,135.26*
		TOTAL						**100.00%**	**100.00%**	**4,356.63**	**10,087.21**	**100.00%**	**100.00%**	**4,170.13**	**10,123.18**	**100.00%**	**100.00%**	**4,200.97**	**10,889.97**

Annual Available Water for Irrigation	**AW**		852,000 m³	852,000 m³	852,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	195.56 ha	**204.31 ha**	202.81 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,972,695 TL	2,068,268 TL	**2,208,597 TL**

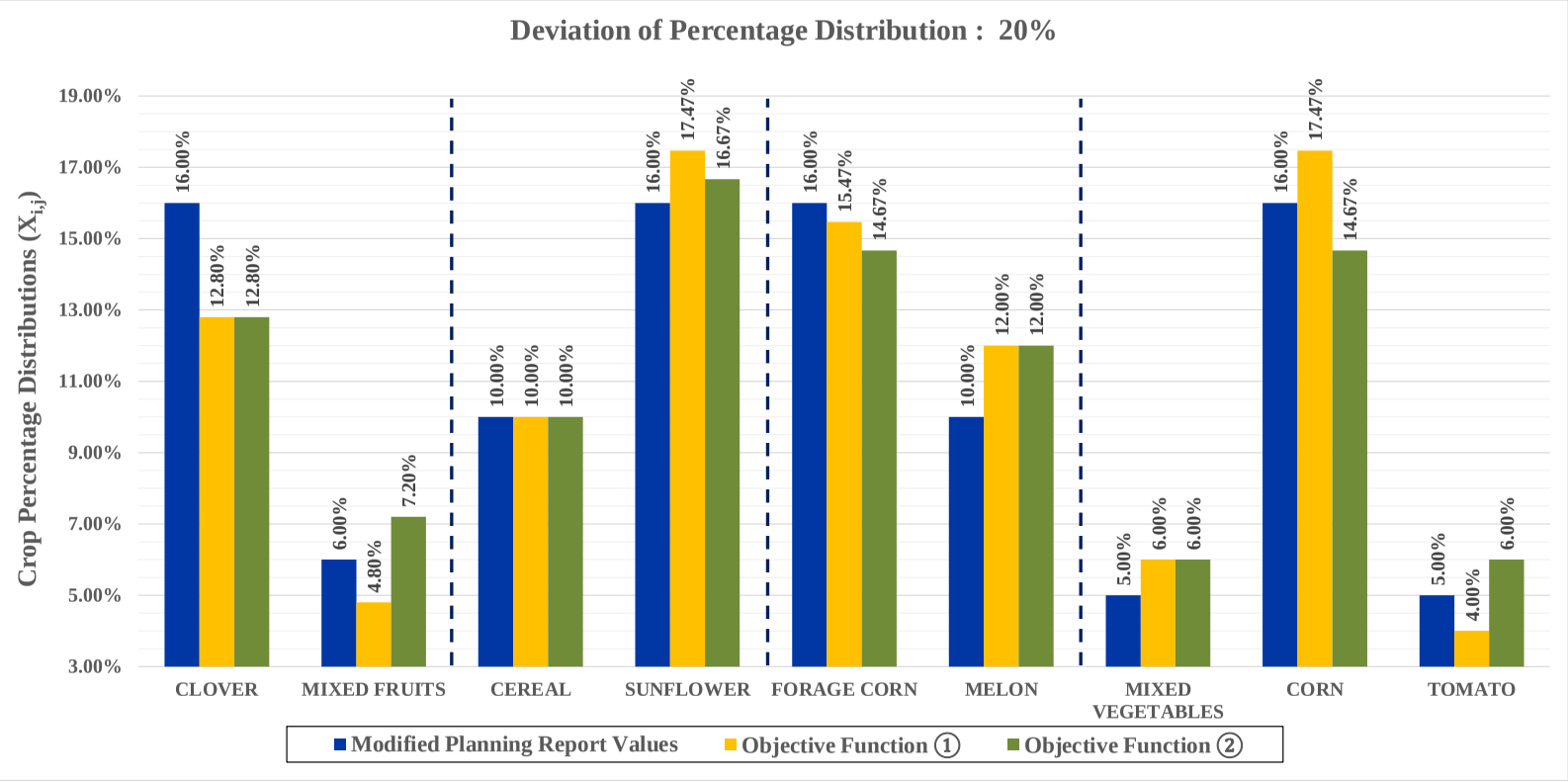


Figure B.10 CD2 Project - 20% of deviation of crop percentage distribution results

Table B.11 CD2 Project - 25% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-2 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 25%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*16.00%*	12.00%	20.00%	8,210.46	4,488.38	**16.00%**	**22.00%**	*1,313.67*	*718.14*	**12.00%**	**16.50%**	*985.26*	*538.61*	**12.00%**	**19.50%**	*985.26*	*538.61*
	2	MIXED FRUITS	*6.00%*	4.50%	7.50%	4,350.10	27,350.57	**6.00%**		*261.01*	*1,641.03*	**4.50%**		*195.75*	*1,230.78*	**7.50%**		*326.26*	*2,051.29*
2	1	CEREAL	*10.00%*	7.50%	10.00%	2,800.13	4,773.47	**10.00%**	**26.00%**	*280.01*	*477.35*	**10.00%**	**27.83%**	*280.01*	*477.35*	**10.00%**	**26.83%**	*280.01*	*477.35*
	2	SUNFLOWER	*16.00%*	12.00%	20.00%	4,404.97	8,768.76	**16.00%**		*704.80*	*1,403.00*	**17.83%**		*785.55*	*1,563.76*	**16.83%**		*741.51*	*1,476.08*
3	1	FORAGE CORN	*16.00%*	12.00%	20.00%	3,682.96	8,937.92	**16.00%**	**26.00%**	*589.27*	*1,430.07*	**15.33%**	**27.83%**	*564.72*	*1,370.48*	**14.33%**	**26.83%**	*527.89*	*1,281.10*
	2	MELON	*10.00%*	7.50%	12.50%	2,057.96	19,046.43	**10.00%**		*205.80*	*1,904.64*	**12.50%**		*257.24*	*2,380.80*	**12.50%**		*257.25*	*2,380.81*
4	1	MIXED VEGETABLES	*5.00%*	3.75%	6.25%	3,542.76	16,893.75	**5.00%**	**26.00%**	*177.14*	*844.69*	**6.25%**	**27.83%**	*221.42*	*1,055.86*	**6.25%**	**26.83%**	*221.42*	*1,055.86*
	2	CORN	*16.00%*	12.00%	20.00%	3,682.96	4,514.01	**16.00%**		*589.27*	*722.24*	**17.83%**		*656.79*	*805.00*	**14.33%**		*527.89*	*647.01*
	3	TOMATO	*5.00%*	3.75%	6.25%	4,713.27	18,921.00	**5.00%**		*235.66*	*946.05*	**3.75%**		*176.75*	*709.54*	**6.25%**		*294.58*	*1,182.56*
		TOTAL						**100.00%**	**100.00%**	**4,356.63**	**10,087.21**	**100.00%**	**100.00%**	**4,123.51**	**10,132.17**	**100.00%**	**100.00%**	**4,162.06**	**11,090.66**

Annual Available Water for Irrigation	**AW**		852,000 m³	852,000 m³	852,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	195.56 ha	**206.62 ha**	204.71 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,972,695 TL	2,093,512 TL	**2,270,328 TL**

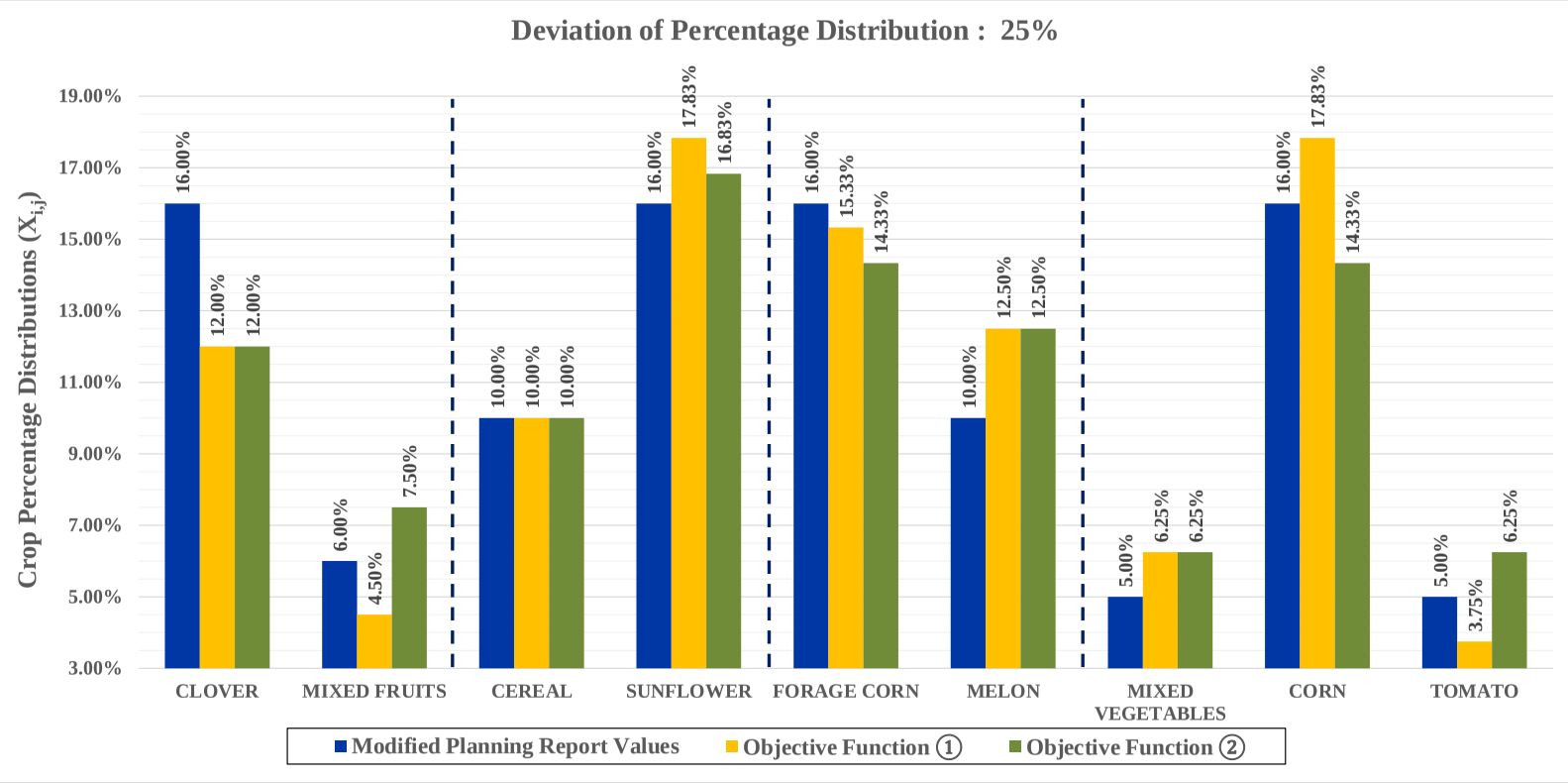


Figure B.11 CD2 Project - 25% of deviation of crop percentage distribution results

Table B.12 CD2 Project - 30% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - ÇİMENDERE-2 POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 30%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*16.00%*	11.20%	20.80%	8,210.46	4,488.38	**16.00%**	**22.00%**	*1,313.67*	*718.14*	**11.20%**	**15.40%**	*919.57*	*502.70*	**11.20%**	**19.00%**	*919.57*	*502.70*
	2	MIXED FRUITS	*6.00%*	4.20%	7.80%	4,350.10	27,350.57	**6.00%**		*261.01*	*1,641.03*	**4.20%**		*182.70*	*1,148.72*	**7.80%**		*339.31*	*2,133.34*
2	1	CEREAL	*10.00%*	7.00%	10.00%	2,800.13	4,773.47	**10.00%**	**26.00%**	*280.01*	*477.35*	**10.00%**	**28.20%**	*280.01*	*477.35*	**10.00%**	**27.00%**	*280.01*	*477.35*
	2	SUNFLOWER	*16.00%*	11.20%	20.80%	4,404.97	8,768.76	**16.00%**		*704.80*	*1,403.00*	**18.20%**		*801.71*	*1,595.91*	**17.00%**		*748.85*	*1,490.69*
3	1	FORAGE CORN	*16.00%*	11.20%	20.80%	3,682.96	8,937.92	**16.00%**	**26.00%**	*589.27*	*1,430.07*	**15.20%**	**28.20%**	*559.81*	*1,358.56*	**14.00%**	**27.00%**	*515.61*	*1,251.31*
	2	MELON	*10.00%*	7.00%	13.00%	2,057.96	19,046.43	**10.00%**		*205.80*	*1,904.64*	**13.00%**		*267.53*	*2,476.04*	**13.00%**		*267.53*	*2,476.04*
4	1	MIXED VEGETABLES	*5.00%*	3.50%	6.50%	3,542.76	16,893.75	**5.00%**	**26.00%**	*177.14*	*844.69*	**6.50%**	**28.20%**	*230.28*	*1,098.09*	**6.50%**	**27.00%**	*230.28*	*1,098.09*
	2	CORN	*16.00%*	11.20%	20.80%	3,682.96	4,514.01	**16.00%**		*589.27*	*722.24*	**18.20%**		*670.30*	*821.55*	**14.00%**		*515.61*	*631.96*
	3	TOMATO	*5.00%*	3.50%	6.50%	4,713.27	18,921.00	**5.00%**		*235.66*	*946.05*	**3.50%**		*164.96*	*662.24*	**6.50%**		*306.36*	*1,229.87*
		TOTAL						**100.00%**	**100.00%**	**4,356.63**	**10,087.21**	**100.00%**	**100.00%**	**4,076.88**	**10,141.16**	**100.00%**	**100.00%**	**4,123.14**	**11,291.35**

Annual Available Water for Irrigation	**AW**		852,000 m³	852,000 m³	852,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	195.56 ha	**208.98 ha**	206.64 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,972,695 TL	2,119,334 TL	**2,333,227 TL**

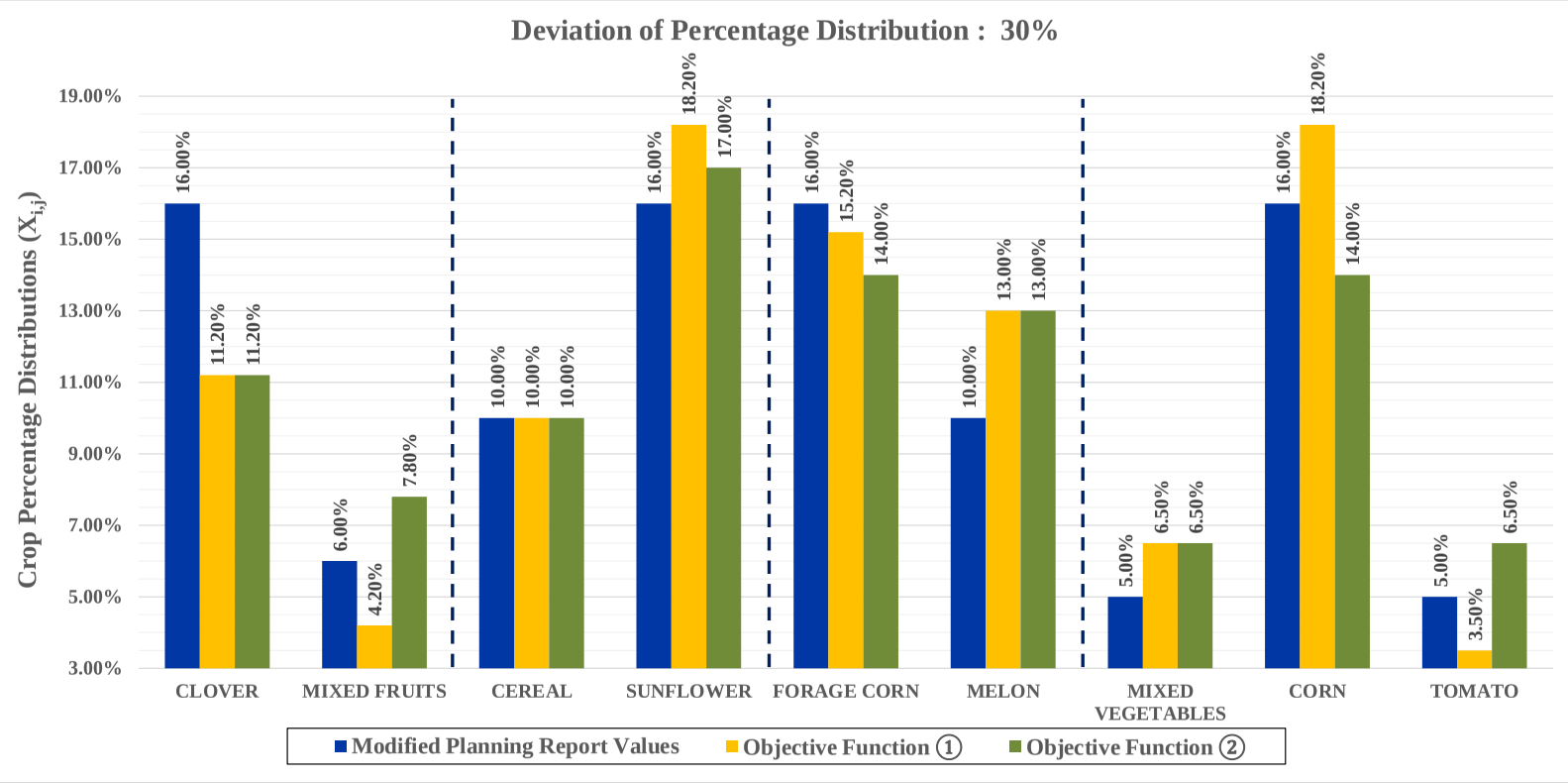


Figure B.12 CD2 Project - 30% of deviation of crop percentage distribution results

Table B.13 GOZ Project - 5% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - GÖZSÜZ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 5%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*5.00%*	4.75%	5.25%	7,512.12	4,488.38	**5.00%**	**25.00%**	*375.61*	*224.42*	**4.75%**	**23.75%**	*356.83*	*213.20*	**4.75%**	**25.75%**	*356.83*	*213.20*
	2	MIXED FRUITS	*20.00%*	19.00%	21.00%	4,183.67	27,350.57	**20.00%**		*836.73*	*5,470.11*	**19.00%**		*794.90*	*5,196.61*	**21.00%**		*878.57*	*5,743.62*
2	1	CEREAL	*10.00%*	9.50%	10.00%	2,665.05	4,773.47	**10.00%**	**25.00%**	*266.51*	*477.35*	**10.00%**	**25.42%**	*266.51*	*477.35*	**9.50%**	**24.75%**	*253.18*	*453.48*
	2	FORAGE CORN	*15.00%*	15.00%	15.75%	3,563.37	8,937.92	**15.00%**		*534.51*	*1,340.69*	**15.42%**		*549.35*	*1,377.93*	**15.25%**		*543.41*	*1,363.03*
3	1	CORN	*10.00%*	9.50%	10.50%	3,563.37	4,514.01	**10.00%**	**25.00%**	*356.34*	*451.40*	**10.50%**	**25.42%**	*374.15*	*473.97*	**9.50%**	**24.75%**	*338.52*	*428.83*
	2	MELON	*6.00%*	5.70%	6.30%	1,970.10	19,046.43	**6.00%**		*118.21*	*1,142.79*	**6.30%**		*124.12*	*1,199.93*	**6.30%**		*124.12*	*1,199.93*
	3	ONION	*4.00%*	3.80%	4.20%	4,732.96	13,307.77	**4.00%**		*189.32*	*532.31*	**3.80%**		*179.85*	*505.70*	**3.80%**		*179.85*	*505.70*
	4	TOMATO	*5.00%*	4.75%	5.25%	4,574.39	18,921.00	**5.00%**		*228.72*	*946.05*	**4.82%**		*220.33*	*911.36*	**5.15%**		*235.58*	*974.42*
4	1	SUNFLOWER	*25.00%*	23.75%	26.25%	4,259.57	8,768.76	**25.00%**	**25.00%**	*1,064.89*	*2,192.19*	**25.42%**	**25.42%**	*1,082.64*	*2,228.73*	**24.75%**	**24.75%**	*1,054.24*	*2,170.27*
		TOTAL						**100.00%**	**100.00%**	**3,970.82**	**12,777.31**	**100.00%**	**100.00%**	**3,948.68**	**12,584.76**	**100.00%**	**100.00%**	**3,964.29**	**13,052.46**

Annual Available Water for Irrigation	**AW**		405,000 m³	405,000 m³	405,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	101.99 ha	**102.57 ha**	102.16 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,303,208 TL	1,290,769 TL	**1,333,464 TL**

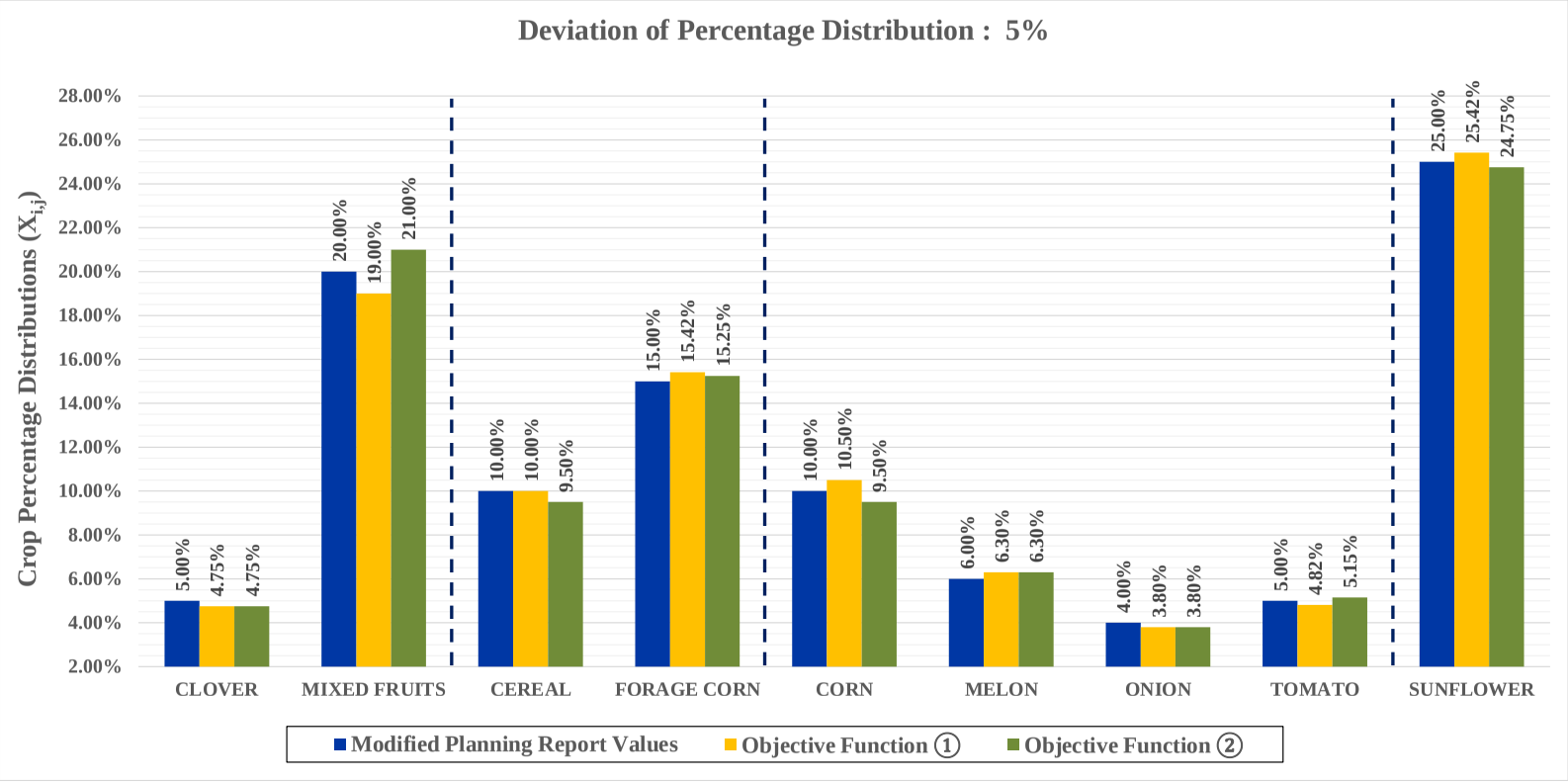


Figure B.13 GOZ Project - 5% of deviation of crop percentage distribution results

Table B.14 GOZ Project - 10% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - GÖZSÜZ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 10%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*5.00%*	4.50%	5.50%	7,512.12	4,488.38	**5.00%**	**25.00%**	*375.61*	*224.42*	**4.50%**	**22.50%**	*338.05*	*201.98*	**4.50%**	**26.50%**	*338.05*	*201.98*
	2	MIXED FRUITS	*20.00%*	18.00%	22.00%	4,183.67	27,350.57	**20.00%**		*836.73*	*5,470.11*	**18.00%**		*753.06*	*4,923.10*	**22.00%**		*920.41*	*6,017.13*
2	1	CEREAL	*10.00%*	9.00%	10.00%	2,665.05	4,773.47	**10.00%**	**25.00%**	*266.51*	*477.35*	**10.00%**	**25.83%**	*266.51*	*477.35*	**9.00%**	**24.50%**	*239.85*	*429.61*
	2	FORAGE CORN	*15.00%*	15.00%	16.50%	3,563.37	8,937.92	**15.00%**		*534.51*	*1,340.69*	**15.83%**		*564.20*	*1,415.17*	**15.50%**		*552.32*	*1,385.38*
3	1	CORN	*10.00%*	9.00%	11.00%	3,563.37	4,514.01	**10.00%**	**25.00%**	*356.34*	*451.40*	**11.00%**	**25.83%**	*391.97*	*496.54*	**9.00%**	**24.50%**	*320.70*	*406.26*
	2	MELON	*6.00%*	5.40%	6.60%	1,970.10	19,046.43	**6.00%**		*118.21*	*1,142.79*	**6.60%**		*130.03*	*1,257.06*	**6.60%**		*130.03*	*1,257.06*
	3	ONION	*4.00%*	3.60%	4.40%	4,732.96	13,307.77	**4.00%**		*189.32*	*532.31*	**3.60%**		*170.39*	*479.08*	**3.60%**		*170.39*	*479.08*
	4	TOMATO	*5.00%*	4.50%	5.50%	4,574.39	18,921.00	**5.00%**		*228.72*	*946.05*	**4.63%**		*211.95*	*876.67*	**5.30%**		*242.44*	*1,002.82*
4	1	SUNFLOWER	*25.00%*	22.50%	27.50%	4,259.57	8,768.76	**25.00%**	**25.00%**	*1,064.89*	*2,192.19*	**25.83%**	**25.83%**	*1,100.39*	*2,265.26*	**24.50%**	**24.50%**	*1,043.59*	*2,148.35*
		TOTAL						**100.00%**	**100.00%**	**3,970.82**	**12,777.31**	**100.00%**	**100.00%**	**3,926.53**	**12,392.22**	**100.00%**	**100.00%**	**3,957.78**	**13,327.66**

Annual Available Water for Irrigation	**AW**		405,000 m³	405,000 m³	405,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	101.99 ha	**103.14 ha**	102.33 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,303,208 TL	1,278,189 TL	**1,363,820 TL**

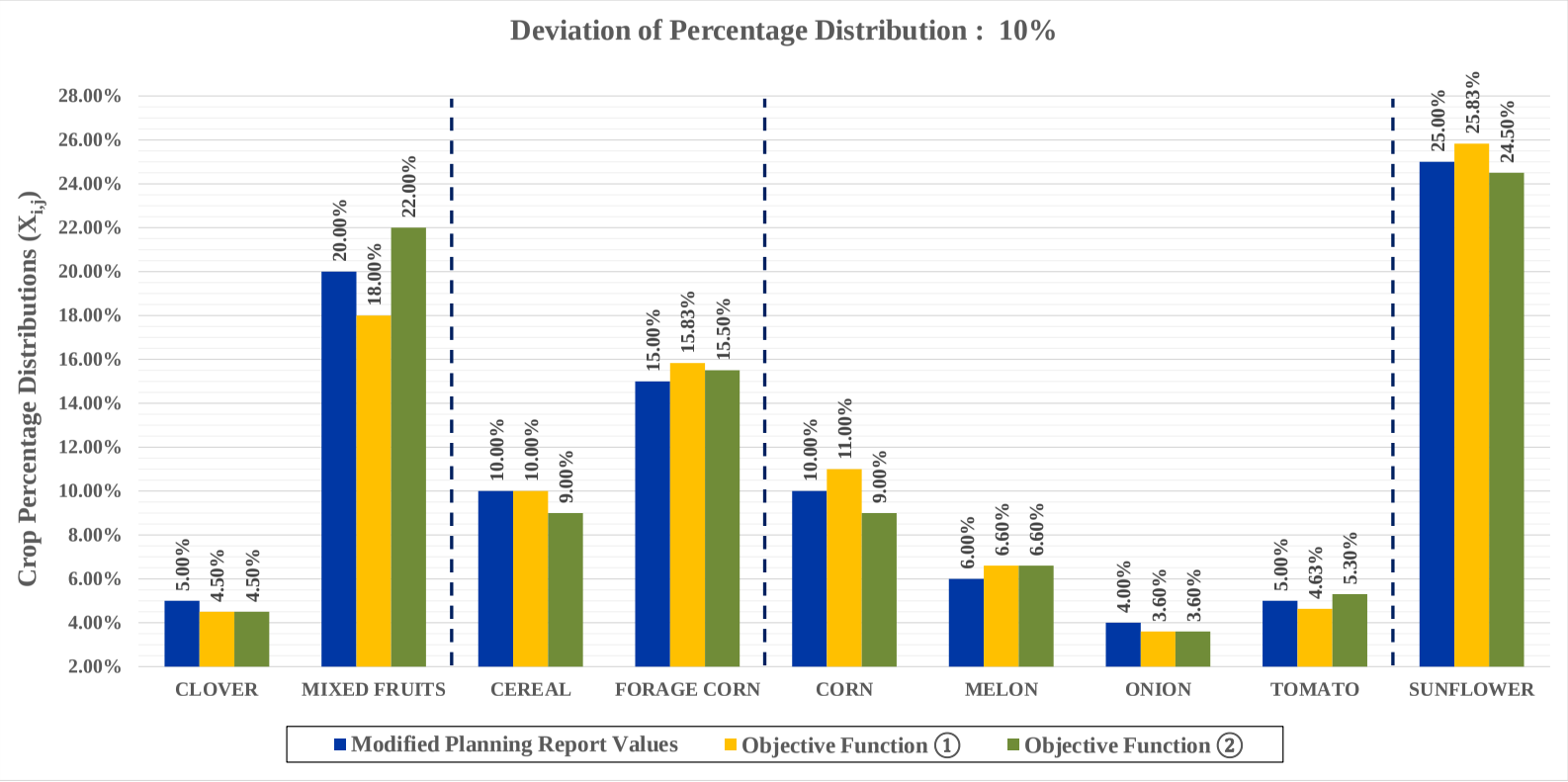


Figure B.14 GOZ Project - 10% of deviation of crop percentage distribution results

Table B.15 GOZ Project - 15% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - GÖZSÜZ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 15%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)
1	1	CLOVER	5.00%	4.25%	5.75%	7,512.12	4,488.38	5.00%	25.00%	375.61	224.42	4.25%	21.25%	319.26	190.76	4.25%	27.25%	319.26	190.76
	2	MIXED FRUITS	20.00%	17.00%	23.00%	4,183.67	27,350.57	20.00%		836.73	5,470.11	17.00%		711.22	4,649.60	23.00%		962.24	6,290.63
2	1	CEREAL	10.00%	8.50%	10.00%	2,665.05	4,773.47	10.00%	25.00%	266.51	477.35	10.00%	26.25%	266.51	477.35	8.50%	24.25%	226.53	405.74
	2	FORAGE CORN	15.00%	15.00%	17.25%	3,563.37	8,937.92	15.00%		534.51	1,340.69	16.25%		579.05	1,452.41	15.75%		561.23	1,407.72
3	1	CORN	10.00%	8.50%	11.50%	3,563.37	4,514.01	10.00%	25.00%	356.34	451.40	11.50%	26.25%	409.79	519.11	8.50%	24.25%	302.89	383.69
	2	MELON	6.00%	5.10%	6.90%	1,970.10	19,046.43	6.00%		118.21	1,142.79	6.90%		135.94	1,314.20	6.90%		135.94	1,314.20
	3	ONION	4.00%	3.40%	4.60%	4,732.96	13,307.77	4.00%		189.32	532.31	3.40%		160.92	452.46	3.40%		160.92	452.46
	4	TOMATO	5.00%	4.25%	5.75%	4,574.39	18,921.00	5.00%		228.72	946.05	4.45%		203.56	841.98	5.45%		249.31	1,031.20
4	1	SUNFLOWER	25.00%	21.25%	28.75%	4,259.57	8,768.76	25.00%	25.00%	1,064.89	2,192.19	26.25%	26.25%	1,118.14	2,301.80	24.25%	24.25%	1,032.94	2,126.42
		TOTAL						100.00%	100.00%	3,970.82	12,777.31	100.00%	100.00%	3,904.38	12,199.68	100.00%	100.00%	3,951.26	13,602.84

Annual Available Water for Irrigation	**AW**		405,000 m³	405,000 m³	405,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	101.99 ha	**103.73 ha**	102.50 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,303,208 TL	1,265,467 TL	**1,394,275 TL**

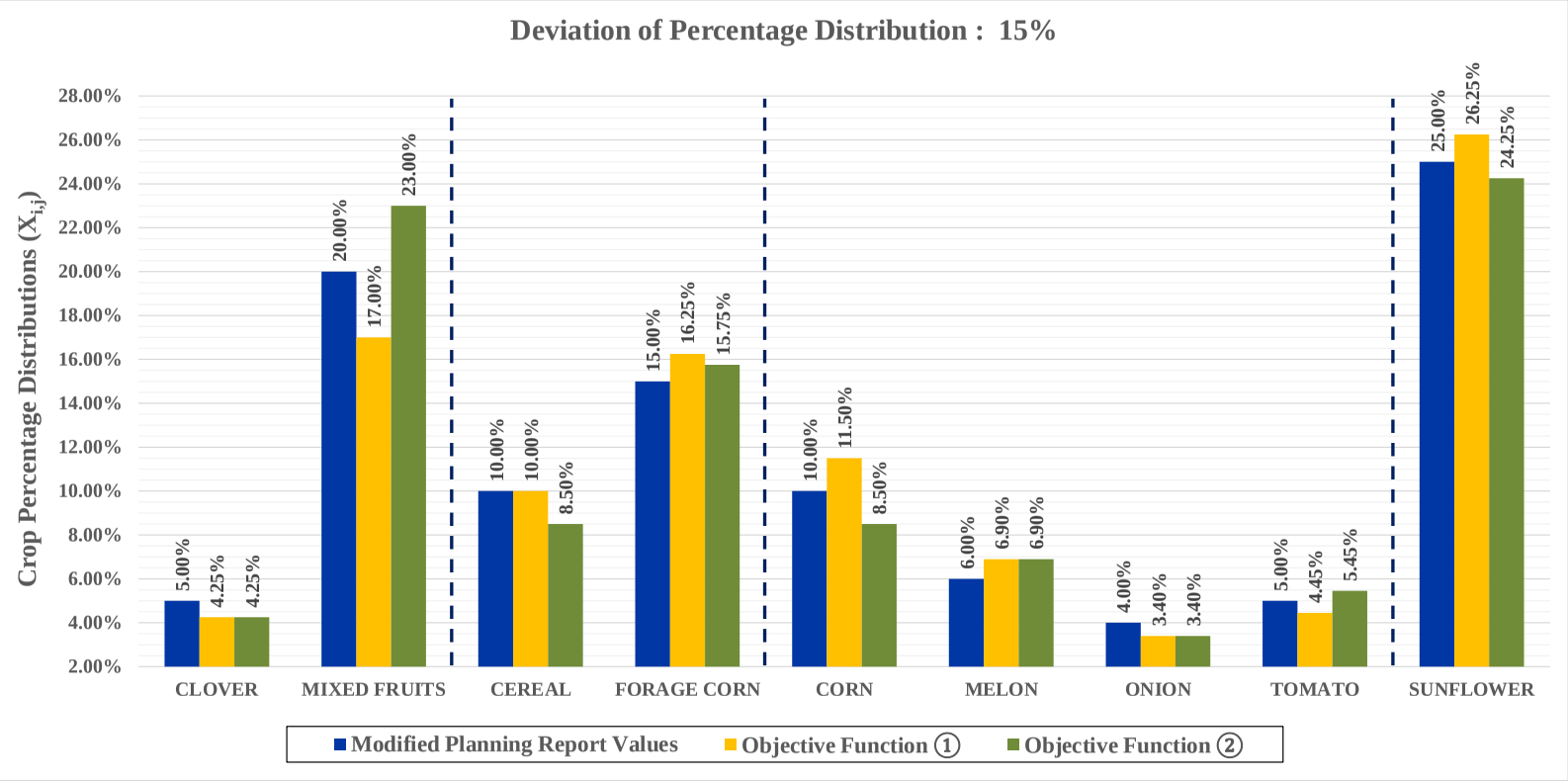


Figure B.15 GOZ Project - 15% of deviation of crop percentage distribution results

Table B.16 GOZ Project - 20% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - GÖZSÜZ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 20%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*5.00%*	4.00%	6.00%	7,512.12	4,488.38	**5.00%**	**25.00%**	*375.61*	*224.42*	**4.00%**	**20.00%**	*300.48*	*179.54*	**4.00%**	**28.00%**	*300.48*	*179.54*
	2	MIXED FRUITS	*20.00%*	16.00%	24.00%	4,183.67	27,350.57	**20.00%**		*836.73*	*5,470.11*	**16.00%**		*669.39*	*4,376.09*	**24.00%**		*1,004.08*	*6,564.14*
2	1	CEREAL	*10.00%*	8.00%	10.00%	2,665.05	4,773.47	**10.00%**	**25.00%**	*266.51*	*477.35*	**10.00%**	**26.67%**	*266.51*	*477.35*	**8.00%**	**24.00%**	*213.20*	*381.88*
	2	FORAGE CORN	*15.00%*	15.00%	18.00%	3,563.37	8,937.92	**15.00%**		*534.51*	*1,340.69*	**16.67%**		*593.89*	*1,489.65*	**16.00%**		*570.14*	*1,430.07*
3	1	CORN	*10.00%*	8.00%	12.00%	3,563.37	4,514.01	**10.00%**	**25.00%**	*356.34*	*451.40*	**12.00%**	**26.67%**	*427.60*	*541.68*	**8.00%**	**24.00%**	*285.07*	*361.12*
	2	MELON	*6.00%*	4.80%	7.20%	1,970.10	19,046.43	**6.00%**		*118.21*	*1,142.79*	**7.20%**		*141.85*	*1,371.34*	**7.20%**		*141.85*	*1,371.34*
	3	ONION	*4.00%*	3.20%	4.80%	4,732.96	13,307.77	**4.00%**		*189.32*	*532.31*	**3.20%**		*151.45*	*425.85*	**3.20%**		*151.45*	*425.85*
	4	TOMATO	*5.00%*	4.00%	6.00%	4,574.39	18,921.00	**5.00%**		*228.72*	*946.05*	**4.27%**		*195.17*	*807.30*	**5.60%**		*256.17*	*1,059.58*
4	1	SUNFLOWER	*25.00%*	20.00%	30.00%	4,259.57	8,768.76	**25.00%**	**25.00%**	*1,064.89*	*2,192.19*	**26.67%**	**26.67%**	*1,135.88*	*2,338.34*	**24.00%**	**24.00%**	*1,022.30*	*2,104.50*
		TOTAL						**100.00%**	**100.00%**	**3,970.82**	**12,777.31**	**100.00%**	**100.00%**	**3,882.24**	**12,007.13**	**100.00%**	**100.00%**	**3,944.74**	**13,878.01**

Annual Available Water for Irrigation	**AW**		405,000 m³	405,000 m³	405,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	101.99 ha	**104.32 ha**	102.67 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,303,208 TL	1,252,600 TL	**1,424,832 TL**

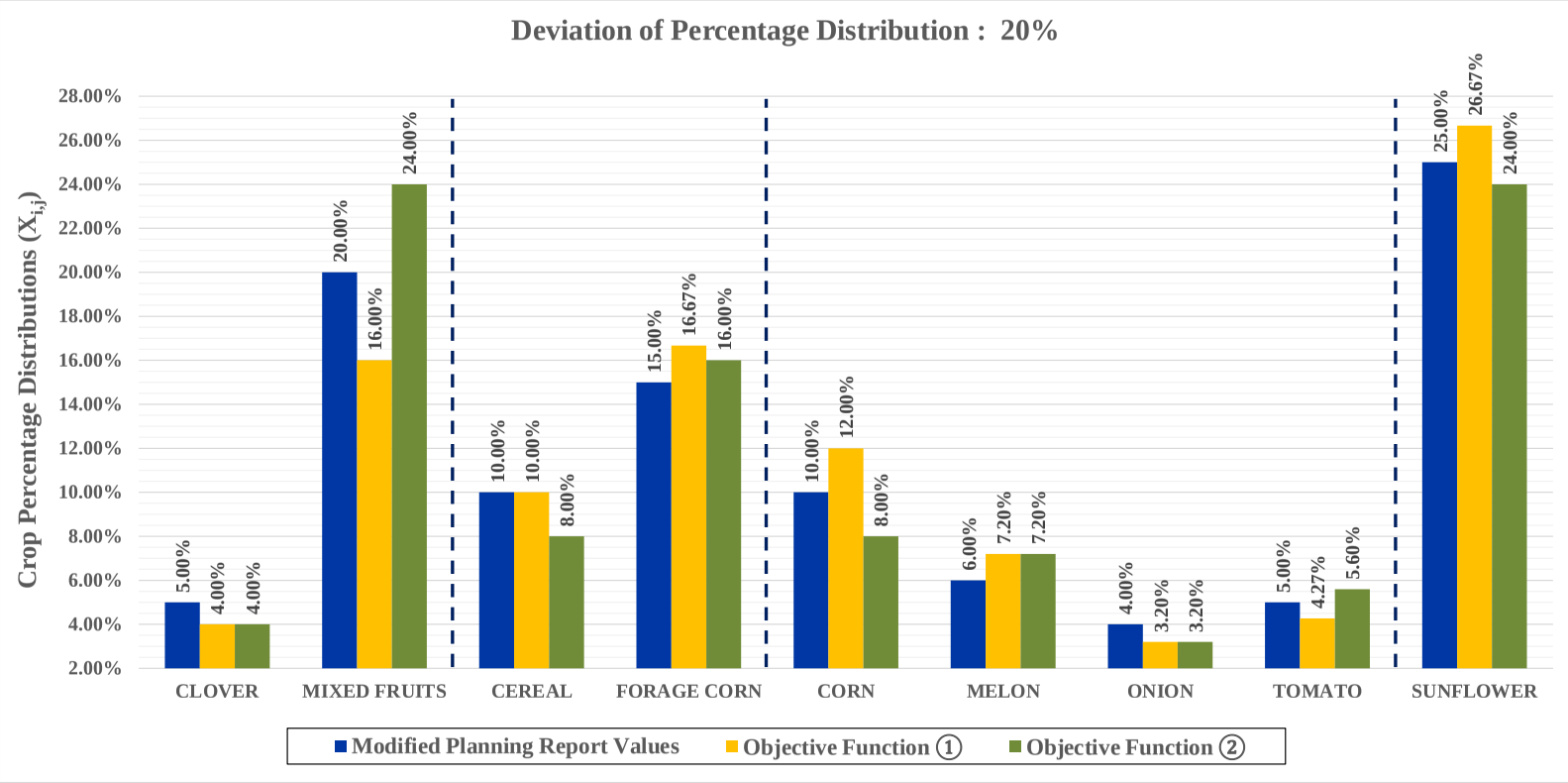


Figure B.16 GOZ Project - 20% of deviation of crop percentage distribution results

Table B.17 GOZ Project - 25% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - GÖZSÜZ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 25%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*5.00%*	3.75%	6.25%	7,512.12	4,488.38	**5.00%**	**25.00%**	*375.61*	*224.42*	**3.75%**	**18.75%**	*281.70*	*168.31*	**3.75%**	**28.75%**	*281.70*	*168.31*
	2	MIXED FRUITS	*20.00%*	15.00%	25.00%	4,183.67	27,350.57	**20.00%**		*836.73*	*5,470.11*	**15.00%**		*627.55*	*4,102.59*	**25.00%**		*1,045.92*	*6,837.64*
2	1	CEREAL	*10.00%*	7.50%	10.00%	2,665.05	4,773.47	**10.00%**	**25.00%**	*266.51*	*477.35*	**10.00%**	**27.08%**	*266.51*	*477.35*	**7.50%**	**23.75%**	*199.88*	*358.01*
	2	FORAGE CORN	*15.00%*	15.00%	18.75%	3,563.37	8,937.92	**15.00%**		*534.51*	*1,340.69*	**17.08%**		*608.74*	*1,526.89*	**16.25%**		*579.05*	*1,452.41*
3	1	CORN	*10.00%*	7.50%	12.50%	3,563.37	4,514.01	**10.00%**	**25.00%**	*356.34*	*451.40*	**12.50%**	**27.08%**	*445.42*	*564.25*	**7.50%**	**23.75%**	*267.25*	*338.55*
	2	MELON	*6.00%*	4.50%	7.50%	1,970.10	19,046.43	**6.00%**		*118.21*	*1,142.79*	**7.50%**		*147.76*	*1,428.48*	**7.50%**		*147.76*	*1,428.48*
	3	ONION	*4.00%*	3.00%	5.00%	4,732.96	13,307.77	**4.00%**		*189.32*	*532.31*	**3.00%**		*141.99*	*399.23*	**3.00%**		*141.99*	*399.23*
	4	TOMATO	*5.00%*	3.75%	6.25%	4,574.39	18,921.00	**5.00%**		*228.72*	*946.05*	**4.08%**		*186.79*	*772.61*	**5.75%**		*263.03*	*1,087.96*
4	1	SUNFLOWER	*25.00%*	18.75%	31.25%	4,259.57	8,768.76	**25.00%**	**25.00%**	*1,064.89*	*2,192.19*	**27.08%**	**27.08%**	*1,153.63*	*2,374.87*	**23.75%**	**23.75%**	*1,011.65*	*2,082.58*
		TOTAL						**100.00%**	**100.00%**	**3,970.82**	**12,777.31**	**100.00%**	**100.00%**	**3,860.09**	**11,814.59**	**100.00%**	**100.00%**	**3,938.22**	**14,153.19**

Annual Available Water for Irrigation	**AW**		405,000 m³	405,000 m³	405,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	101.99 ha	**104.92 ha**	102.84 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,303,208 TL	1,239,585 TL	**1,455,489 TL**

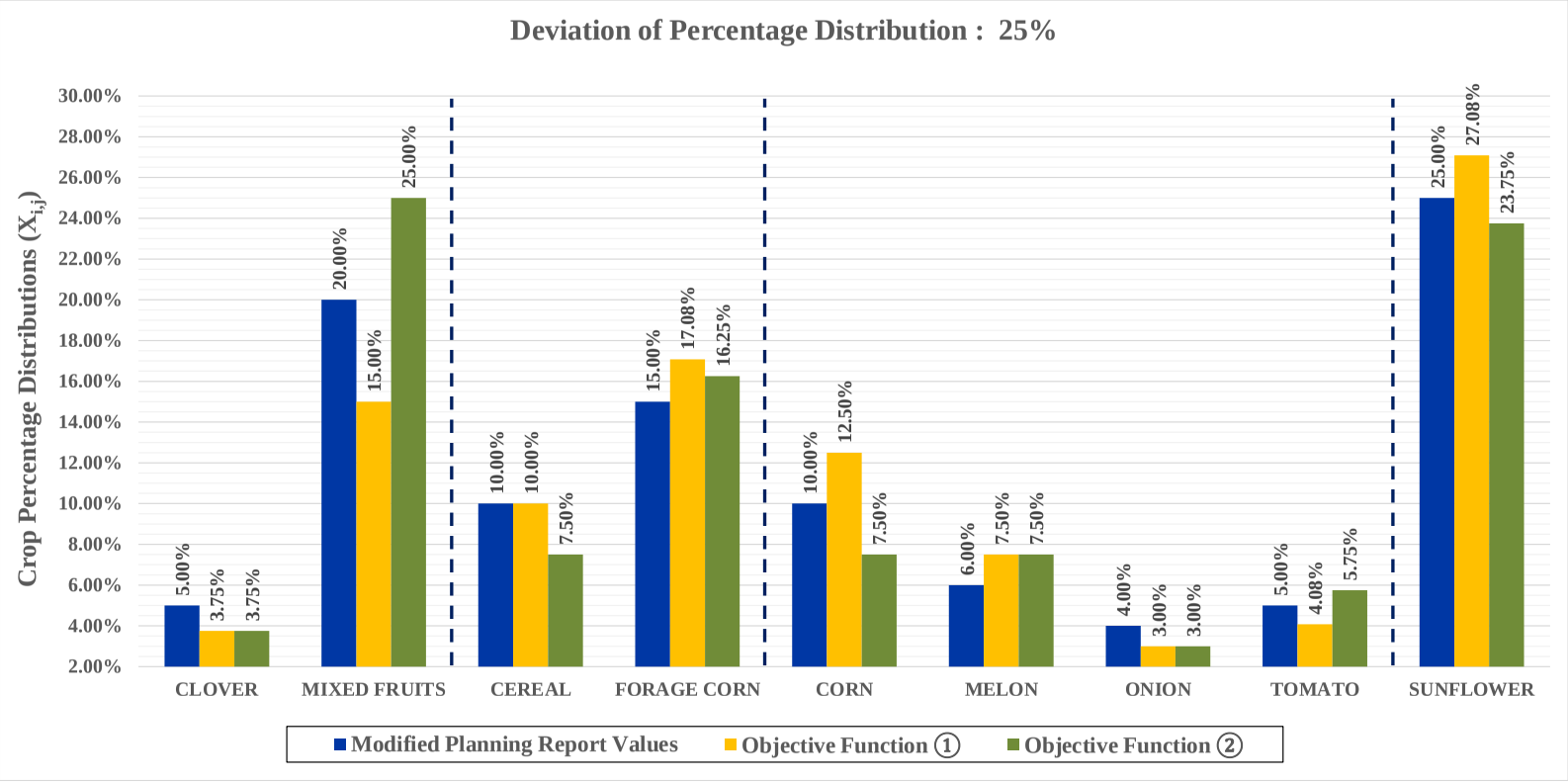


Figure B.17 GOZ Project - 25% of deviation of crop percentage distribution results

Table B.18 GOZ Project - 30% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MALKARA - GÖZSÜZ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 30%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*5.00%*	3.50%	6.50%	7,512.12	4,488.38	**5.00%**	**25.00%**	*375.61*	*224.42*	**3.50%**	**17.50%**	*262.92*	*157.09*	**3.50%**	**29.50%**	*262.92*	*157.09*
	2	MIXED FRUITS	*20.00%*	14.00%	26.00%	4,183.67	27,350.57	**20.00%**		*836.73*	*5,470.11*	**14.00%**		*585.71*	*3,829.08*	**26.00%**		*1,087.76*	*7,111.15*
2	1	CEREAL	*10.00%*	7.00%	10.00%	2,665.05	4,773.47	**10.00%**	**25.00%**	*266.51*	*477.35*	**10.00%**	**27.50%**	*266.51*	*477.35*	**7.00%**	**23.50%**	*186.55*	*334.14*
	2	FORAGE CORN	*15.00%*	15.00%	19.50%	3,563.37	8,937.92	**15.00%**		*534.51*	*1,340.69*	**17.50%**		*623.59*	*1,564.14*	**16.50%**		*587.95*	*1,474.75*
3	1	CORN	*10.00%*	7.00%	13.00%	3,563.37	4,514.01	**10.00%**	**25.00%**	*356.34*	*451.40*	**13.00%**	**27.50%**	*463.24*	*586.82*	**7.00%**	**23.50%**	*249.43*	*315.98*
	2	MELON	*6.00%*	4.20%	7.80%	1,970.10	19,046.43	**6.00%**		*118.21*	*1,142.79*	**7.80%**		*153.67*	*1,485.62*	**7.80%**		*153.67*	*1,485.62*
	3	ONION	*4.00%*	2.80%	5.20%	4,732.96	13,307.77	**4.00%**		*189.32*	*532.31*	**2.80%**		*132.52*	*372.62*	**2.80%**		*132.52*	*372.62*
	4	TOMATO	*5.00%*	3.50%	6.50%	4,574.39	18,921.00	**5.00%**		*228.72*	*946.05*	**3.90%**		*178.40*	*737.92*	**5.90%**		*269.89*	*1,116.33*
4	1	SUNFLOWER	*25.00%*	17.50%	32.50%	4,259.57	8,768.76	**25.00%**	**25.00%**	*1,064.89*	*2,192.19*	**27.50%**	**27.50%**	*1,171.38*	*2,411.41*	**23.50%**	**23.50%**	*1,000.99*	*2,060.65*
		TOTAL						**100.00%**	**100.00%**	**3,970.82**	**12,777.31**	**100.00%**	**100.00%**	**3,837.94**	**11,622.04**	**100.00%**	**100.00%**	**3,931.69**	**14,428.34**

Annual Available Water for Irrigation	**AW**		405,000 m³	405,000 m³	405,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	101.99 ha	**105.53 ha**	103.01 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	1,303,208 TL	1,226,419 TL	**1,486,249 TL**

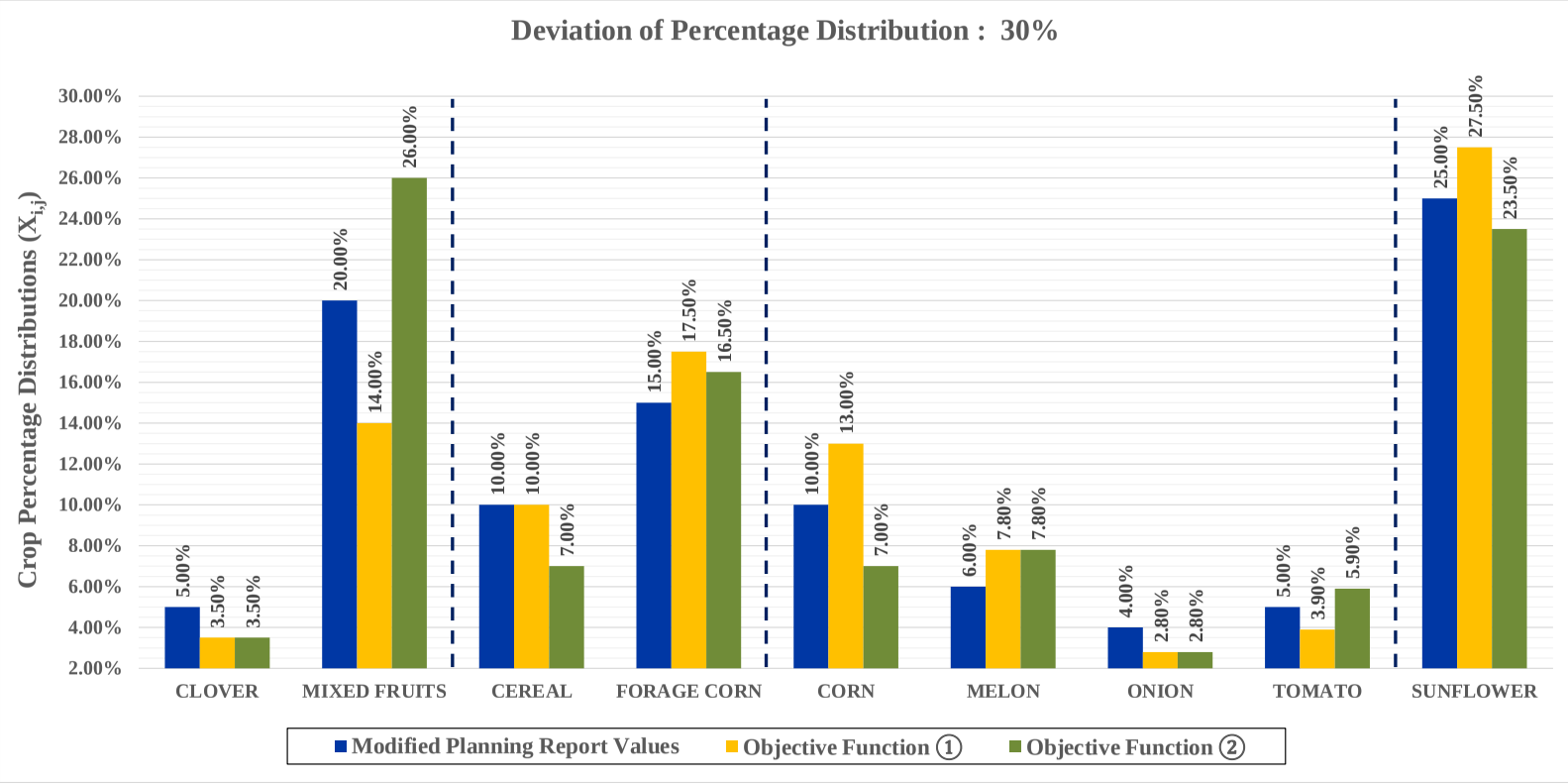


Figure B.18 GOZ Project - 30% of deviation of crop percentage distribution results

Table B.19 KAR Project - 5% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KARAEVLİ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 5%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*6.00%*	5.70%	6.30%	7,275.38	4,488.38	**6.00%**		*436.52*	*269.30*	**5.70%**		*414.70*	*255.84*	**5.70%**		*414.70*	*255.84*
	2	MIXED FRUITS	*10.00%*	9.50%	10.50%	4,089.90	27,350.57	**10.00%**	**22.00%**	*408.99*	*2,735.06*	**9.50%**	**21.50%**	*388.54*	*2,598.30*	**10.50%**	**21.90%**	*429.44*	*2,871.81*
	3	VINEYARD	*6.00%*	5.70%	6.30%	3,502.65	10,761.01	**6.00%**		*210.16*	*645.66*	**6.30%**		*220.67*	*677.94*	**5.70%**		*199.65*	*613.38*
2	1	MIXED VEGETABLES	*10.00%*	9.50%	10.50%	3,181.12	16,893.75	**10.00%**		*318.11*	*1,689.38*	**10.37%**		*329.78*	*1,751.32*	**10.23%**		*325.54*	*1,728.80*
	2	MELON	*6.00%*	5.70%	6.30%	2,017.14	19,036.94	**6.00%**	**26.00%**	*121.03*	*1,142.22*	**6.30%**	**26.17%**	*127.08*	*1,199.33*	**6.30%**	**26.03%**	*127.08*	*1,199.33*
	3	CORN	*10.00%*	9.50%	10.50%	3,515.31	4,514.01	**10.00%**		*351.53*	*451.40*	**9.50%**		*333.95*	*428.83*	**9.50%**		*333.95*	*428.83*
3	1	FORAGE CORN	*16.00%*	15.20%	16.80%	3,515.31	8,937.92	**16.00%**	**26.00%**	*562.45*	*1,430.07*	**16.17%**	**26.17%**	*568.31*	*1,444.96*	**16.53%**	**26.03%**	*581.20*	*1,477.74*
	2	CEREAL	*10.00%*	9.50%	10.00%	2,576.28	4,773.47	**10.00%**		*257.63*	*477.35*	**10.00%**		*257.63*	*477.35*	**9.50%**		*244.75*	*453.48*
4	1	SUNFLOWER	*26.00%*	24.70%	27.30%	4,217.09	8,768.76	**26.00%**	**26.00%**	*1,096.44*	*2,279.88*	**26.17%**	**26.17%**	*1,103.47*	*2,294.49*	**26.03%**	**26.03%**	*1,097.85*	*2,282.80*
		TOTAL						**100.00%**	**100.00%**	**3,762.86**	**11,120.30**	**100.00%**	**100.00%**	**3,744.12**	**11,128.37**	**100.00%**	**100.00%**	**3,754.15**	**11,312.00**

Annual Available Water for Irrigation	**AW**		1,420,000 m³	1,420,000 m³	1,420,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	377.37 ha	**379.26 ha**	378.25 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	4,196,493 TL	4,220,556 TL	**4,278,741 TL**

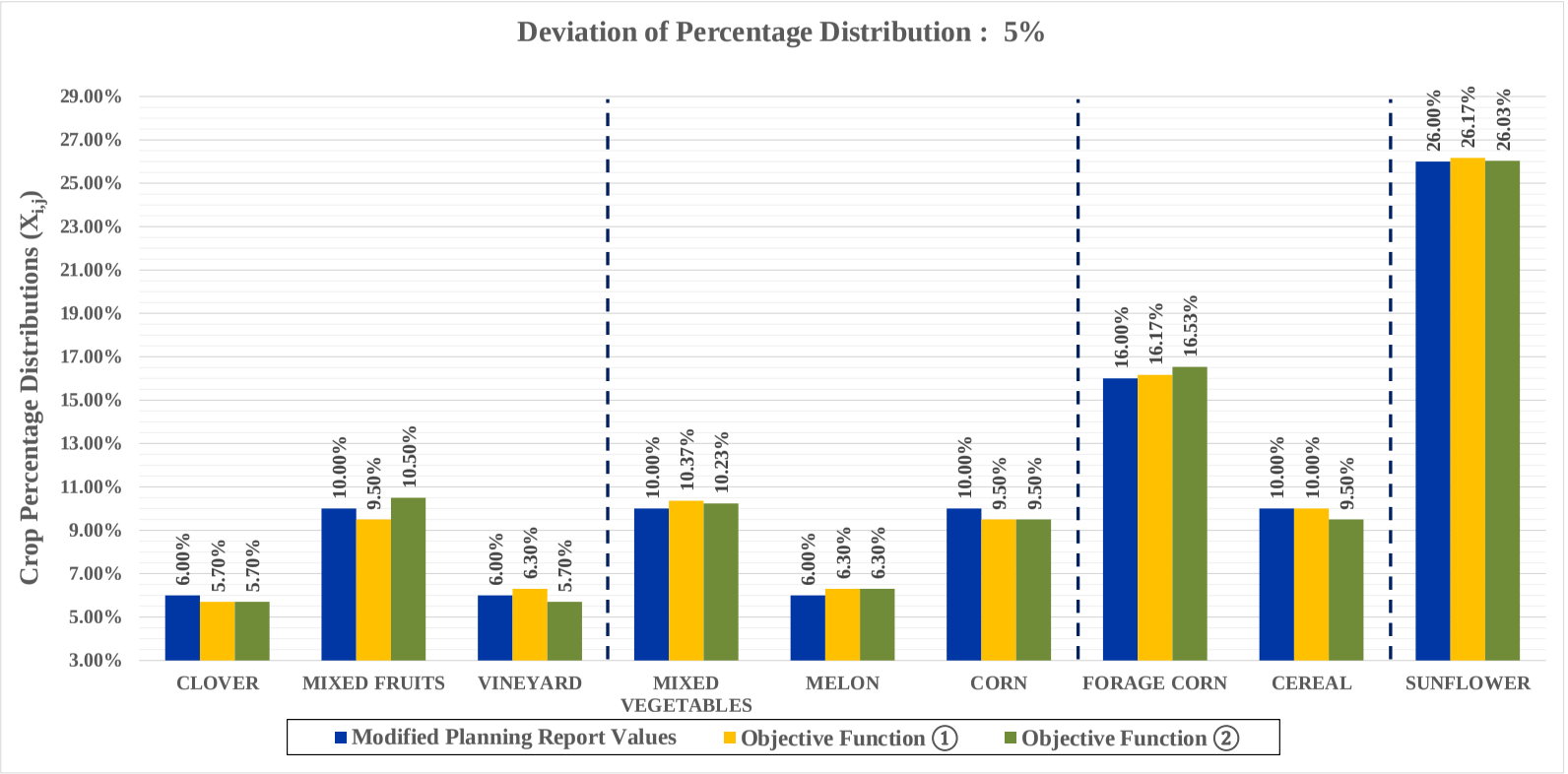


Figure B.19 KAR Project - 5% of deviation of crop percentage distribution results

Table B.20 KAR Project - 10% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KARAEVLİ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 10%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)
1	1	CLOVER	6.00%	5.40%	6.60%	7,275.38	4,488.38	**6.00%**		436.52	269.30	**5.40%**		392.87	242.37	**5.40%**		392.87	242.37
	2	MIXED FRUITS	10.00%	9.00%	11.00%	4,089.90	27,350.57	**10.00%**	**22.00%**	408.99	2,735.06	**9.00%**	**21.00%**	368.09	2,461.55	**11.00%**	**21.80%**	449.89	3,008.56
	3	VINEYARD	6.00%	5.40%	6.60%	3,502.65	10,761.01	**6.00%**		210.16	645.66	**6.60%**		231.18	710.23	**5.40%**		189.14	581.09
2	1	MIXED VEGETABLES	10.00%	9.00%	11.00%	3,181.12	16,893.75	**10.00%**		318.11	1,689.38	**10.73%**		341.44	1,813.26	**10.47%**		332.96	1,768.21
	2	MELON	6.00%	5.40%	6.60%	2,017.14	19,036.94	**6.00%**	**26.00%**	121.03	1,142.22	**6.60%**	**26.33%**	133.13	1,256.44	**6.60%**	**26.07%**	133.13	1,256.44
	3	CORN	10.00%	9.00%	11.00%	3,515.31	4,514.01	**10.00%**		351.53	451.40	**9.00%**		316.38	406.26	**9.00%**		316.38	406.26
3	1	FORAGE CORN	16.00%	14.40%	17.60%	3,515.31	8,937.92	**16.00%**	**26.00%**	562.45	1,430.07	**16.33%**	**26.33%**	574.17	1,459.86	**17.07%**	**26.07%**	599.95	1,525.41
	2	CEREAL	10.00%	9.00%	10.00%	2,576.28	4,773.47	**10.00%**		257.63	477.35	**10.00%**		257.63	477.35	**9.00%**		231.86	429.61
4	1	SUNFLOWER	26.00%	23.40%	28.60%	4,217.09	8,768.76	**26.00%**	**26.00%**	1,096.44	2,279.88	**26.33%**	**26.33%**	1,110.50	2,309.11	**26.07%**	**26.07%**	1,099.26	2,285.72
		TOTAL						**100.00%**	**100.00%**	**3,762.86**	**11,120.30**	**100.00%**	**100.00%**	**3,725.38**	**11,136.43**	**100.00%**	**100.00%**	**3,745.43**	**11,503.68**

Annual Available Water for Irrigation	**AW**		1,420,000 m³	1,420,000 m³	1,420,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	377.37 ha	**381.17 ha**	379.13 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	4,196,493 TL	4,244,861 TL	**4,361,370 TL**

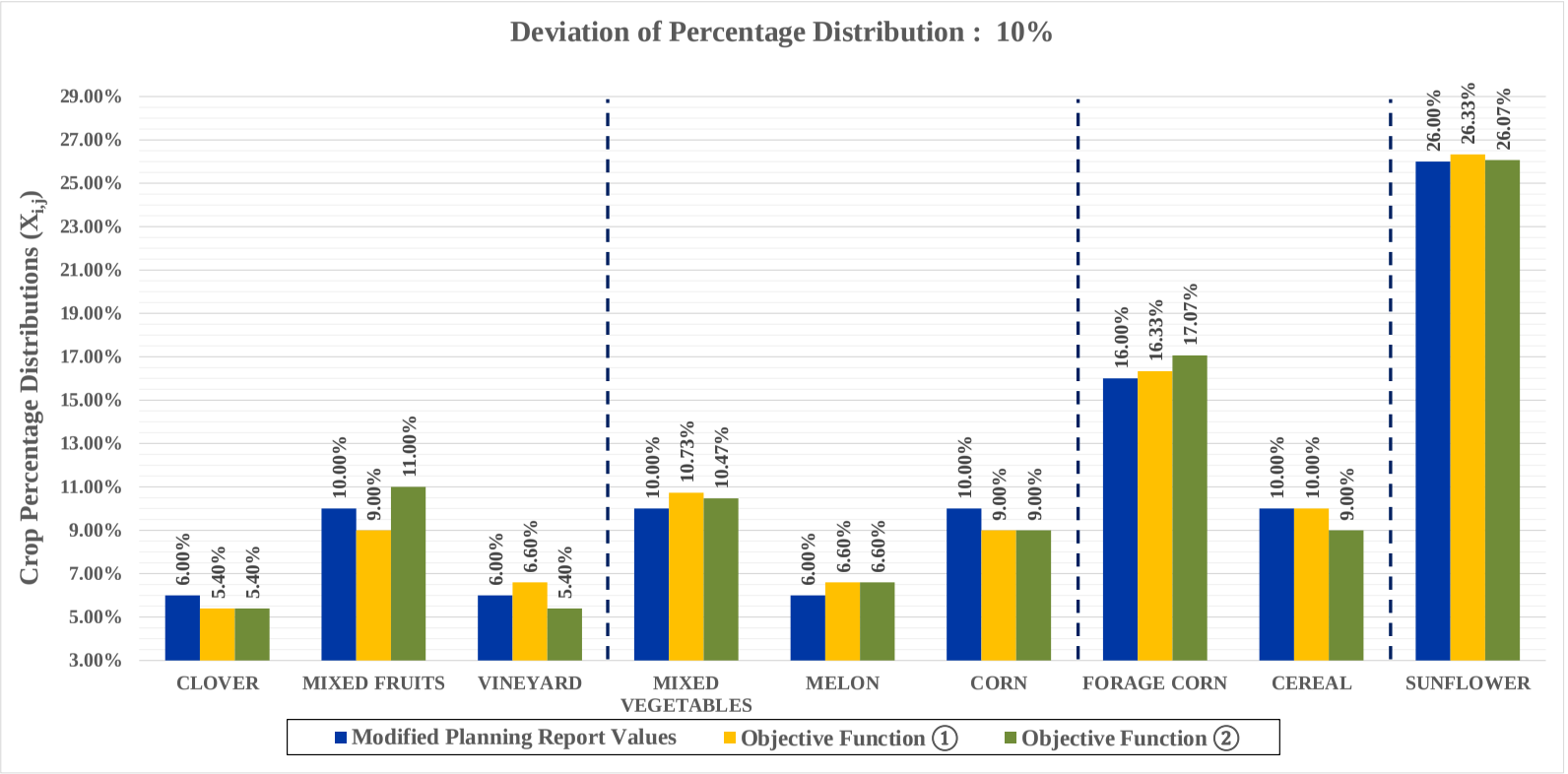


Figure B.20 KAR Project - 10% of deviation of crop percentage distribution results

Table B.21 KAR Project - 15% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KARAEVLİ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 15%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*6.00%*	5.10%	6.90%	7,275.38	4,488.38	**6.00%**		*436.52*	*269.30*	**5.10%**		*371.04*	*228.91*	**5.10%**		*371.04*	*228.91*
	2	MIXED FRUITS	*10.00%*	8.50%	11.50%	4,089.90	27,350.57	**10.00%**	**22.00%**	*408.99*	*2,735.06*	**8.50%**	**20.50%**	*347.64*	*2,324.80*	**11.50%**	**21.70%**	*470.34*	*3,145.32*
	3	VINEYARD	*6.00%*	5.10%	6.90%	3,502.65	10,761.01	**6.00%**		*210.16*	*645.66*	**6.90%**		*241.68*	*742.51*	**5.10%**		*178.64*	*548.81*
2	1	MIXED VEGETABLES	*10.00%*	8.50%	11.50%	3,181.12	16,893.75	**10.00%**		*318.11*	*1,689.38*	**11.10%**		*353.10*	*1,875.21*	**10.70%**		*340.38*	*1,807.64*
	2	MELON	*6.00%*	5.10%	6.90%	2,017.14	19,036.94	**6.00%**	**26.00%**	*121.03*	*1,142.22*	**6.90%**	**26.50%**	*139.18*	*1,313.55*	**6.90%**	**26.10%**	*139.18*	*1,313.55*
	3	CORN	*10.00%*	8.50%	11.50%	3,515.31	4,514.01	**10.00%**		*351.53*	*451.40*	**8.50%**		*298.80*	*383.69*	**8.50%**		*298.80*	*383.69*
3	1	FORAGE CORN	*16.00%*	13.60%	18.40%	3,515.31	8,937.92	**16.00%**	**26.00%**	*562.45*	*1,430.07*	**16.50%**	**26.50%**	*580.03*	*1,474.76*	**17.60%**	**26.10%**	*618.69*	*1,573.08*
	2	CEREAL	*10.00%*	8.50%	10.00%	2,576.28	4,773.47	**10.00%**		*257.63*	*477.35*	**10.00%**		*257.63*	*477.35*	**8.50%**		*218.98*	*405.74*
4	1	SUNFLOWER	*26.00%*	22.10%	29.90%	4,217.09	8,768.76	**26.00%**	**26.00%**	*1,096.44*	*2,279.88*	**26.50%**	**26.50%**	*1,117.53*	*2,323.72*	**26.10%**	**26.10%**	*1,100.66*	*2,288.65*
		TOTAL						**100.00%**	**100.00%**	**3,762.86**	**11,120.30**	**100.00%**	**100.00%**	**3,706.64**	**11,144.49**	**100.00%**	**100.00%**	**3,736.72**	**11,695.38**

Annual Available Water for Irrigation	**AW**		1,420,000 m³	1,420,000 m³	1,420,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	377.37 ha	**383.10 ha**	380.01 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	4,196,493 TL	4,269,412 TL	**4,444,386 TL**

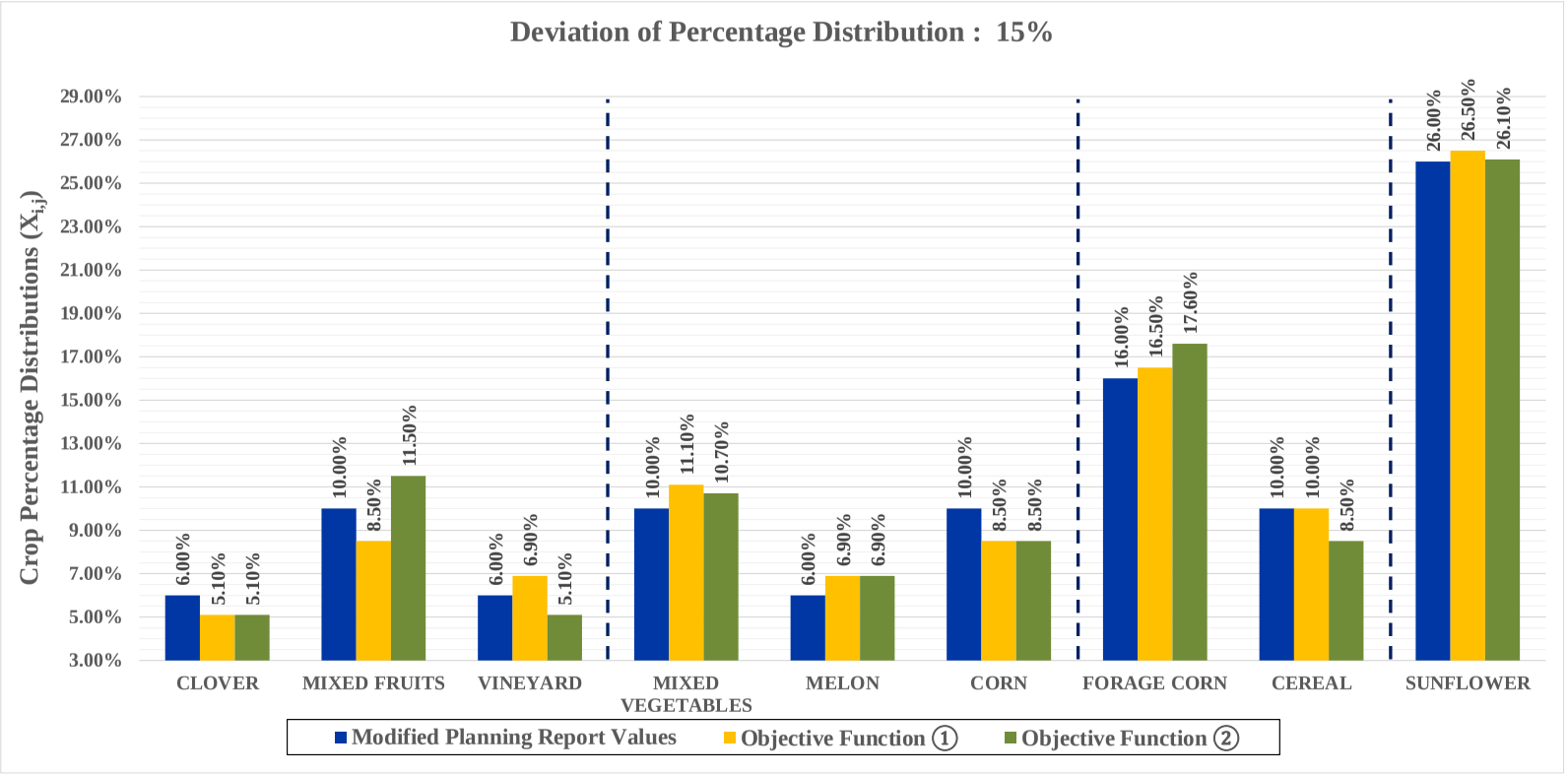


Figure B.21 KAR Project - 15% of deviation of crop percentage distribution results

Table B.22 KAR Project - 20% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KARAEVLİ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 20%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*6.00%*	4.80%	7.20%	7,275.38	4,488.38	**6.00%**		*436.52*	*269.30*	**4.80%**		*349.22*	*215.44*	**4.80%**		*349.22*	*215.44*
	2	MIXED FRUITS	*10.00%*	8.00%	12.00%	4,089.90	27,350.57	**10.00%**	**22.00%**	*408.99*	*2,735.06*	**8.00%**	**20.00%**	*327.19*	*2,188.05*	**12.00%**	**21.60%**	*490.79*	*3,282.07*
	3	VINEYARD	*6.00%*	4.80%	7.20%	3,502.65	10,761.01	**6.00%**		*210.16*	*645.66*	**7.20%**		*252.19*	*774.79*	**4.80%**		*168.13*	*516.53*
2	1	MIXED VEGETABLES	*10.00%*	8.00%	12.00%	3,181.12	16,893.75	**10.00%**		*318.11*	*1,689.38*	**11.47%**		*364.77*	*1,937.15*	**10.93%**		*347.80*	*1,847.06*
	2	MELON	*6.00%*	4.80%	7.20%	2,017.14	19,036.94	**6.00%**	**26.00%**	*121.03*	*1,142.22*	**7.20%**	**26.67%**	*145.23*	*1,370.66*	**7.20%**	**26.13%**	*145.23*	*1,370.66*
	3	CORN	*10.00%*	8.00%	12.00%	3,515.31	4,514.01	**10.00%**		*351.53*	*451.40*	**8.00%**		*281.22*	*361.12*	**8.00%**		*281.22*	*361.12*
3	1	FORAGE CORN	*16.00%*	12.80%	19.20%	3,515.31	8,937.92	**16.00%**	**26.00%**	*562.45*	*1,430.07*	**16.67%**	**26.67%**	*585.88*	*1,489.65*	**18.13%**	**26.13%**	*637.44*	*1,620.75*
	2	CEREAL	*10.00%*	8.00%	10.00%	2,576.28	4,773.47	**10.00%**		*257.63*	*477.35*	**10.00%**		*257.63*	*477.35*	**8.00%**		*206.10*	*381.88*
4	1	SUNFLOWER	*26.00%*	20.80%	31.20%	4,217.09	8,768.76	**26.00%**	**26.00%**	*1,096.44*	*2,279.88*	**26.67%**	**26.67%**	*1,124.56*	*2,338.34*	**26.13%**	**26.13%**	*1,102.07*	*2,291.57*
		TOTAL						**100.00%**	**100.00%**	**3,762.86**	**11,120.30**	**100.00%**	**100.00%**	**3,687.90**	**11,152.55**	**100.00%**	**100.00%**	**3,728.01**	**11,887.07**

Annual Available Water for Irrigation	**AW**		1,420,000 m³	1,420,000 m³	1,420,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	377.37 ha	**385.04 ha**	380.90 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	4,196,493 TL	4,294,212 TL	**4,527,789 TL**

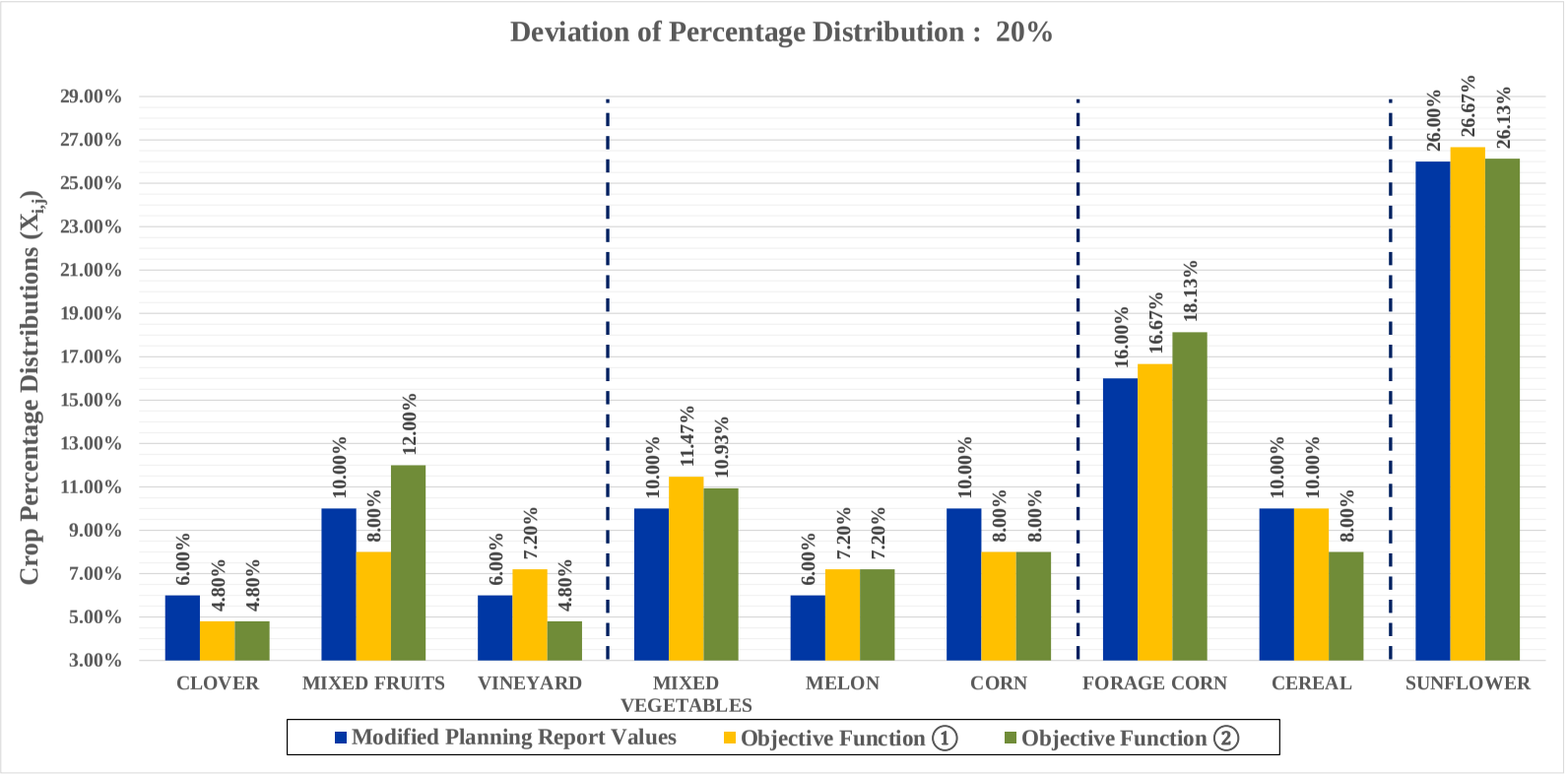


Figure B.22 KAR Project - 20% of deviation of crop percentage distribution results

Table B.23 KAR Project - 25% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KARAEVLİ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 25%

INPUTS											OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
	1	CLOVER	*6.00%*	4.50%	7.50%	7,275.38	4,488.38	**6.00%**		*436.52*	*269.30*	**4.50%**		*327.39*	*201.98*	**4.50%**		*327.39*	*201.98*
1	2	MIXED FRUITS	*10.00%*	7.50%	12.50%	4,089.90	27,350.57	**10.00%**	**22.00%**	*408.99*	*2,735.06*	**7.50%**	**19.50%**	*306.74*	*2,051.29*	**12.50%**	**21.50%**	*511.24*	*3,418.82*
	3	VINEYARD	*6.00%*	4.50%	7.50%	3,502.65	10,761.01	**6.00%**		*210.16*	*645.66*	**7.50%**		*262.70*	*807.08*	**4.50%**		*157.62*	*484.25*
	1	MIXED VEGETABLES	*10.00%*	7.50%	12.50%	3,181.12	16,893.75	**10.00%**		*318.11*	*1,689.38*	**11.83%**		*376.43*	*1,999.09*	**11.17%**		*355.23*	*1,886.47*
2	2	MELON	*6.00%*	4.50%	7.50%	2,017.14	19,036.94	**6.00%**	**26.00%**	*121.03*	*1,142.22*	**7.50%**	**26.83%**	*151.29*	*1,427.77*	**7.50%**	**26.17%**	*151.29*	*1,427.77*
	3	CORN	*10.00%*	7.50%	12.50%	3,515.31	4,514.01	**10.00%**		*351.53*	*451.40*	**7.50%**		*263.65*	*338.55*	**7.50%**		*263.65*	*338.55*
3	1	FORAGE CORN	*16.00%*	12.00%	20.00%	3,515.31	8,937.92	**16.00%**	**26.00%**	*562.45*	*1,430.07*	**16.83%**	**26.83%**	*591.74*	*1,504.55*	**18.67%**	**26.17%**	*656.19*	*1,668.41*
	2	CEREAL	*10.00%*	7.50%	10.00%	2,576.28	4,773.47	**10.00%**		*257.63*	*477.35*	**10.00%**		*257.63*	*477.35*	**7.50%**		*193.22*	*358.01*
4	1	SUNFLOWER	*26.00%*	19.50%	32.50%	4,217.09	8,768.76	**26.00%**	**26.00%**	*1,096.44*	*2,279.88*	**26.83%**	**26.83%**	*1,131.59*	*2,352.95*	**26.17%**	**26.17%**	*1,103.47*	*2,294.50*
		TOTAL						**100.00%**	**100.00%**	**3,762.86**	**11,120.30**	**100.00%**	**100.00%**	**3,669.16**	**11,160.61**	**100.00%**	**100.00%**	**3,719.29**	**12,078.76**

Annual Available Water for Irrigation	**AW**		1,420,000 m³	1,420,000 m³	1,420,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	377.37 ha	**387.01 ha**	381.79 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	4,196,493 TL	4,319,265 TL	**4,611,583 TL**

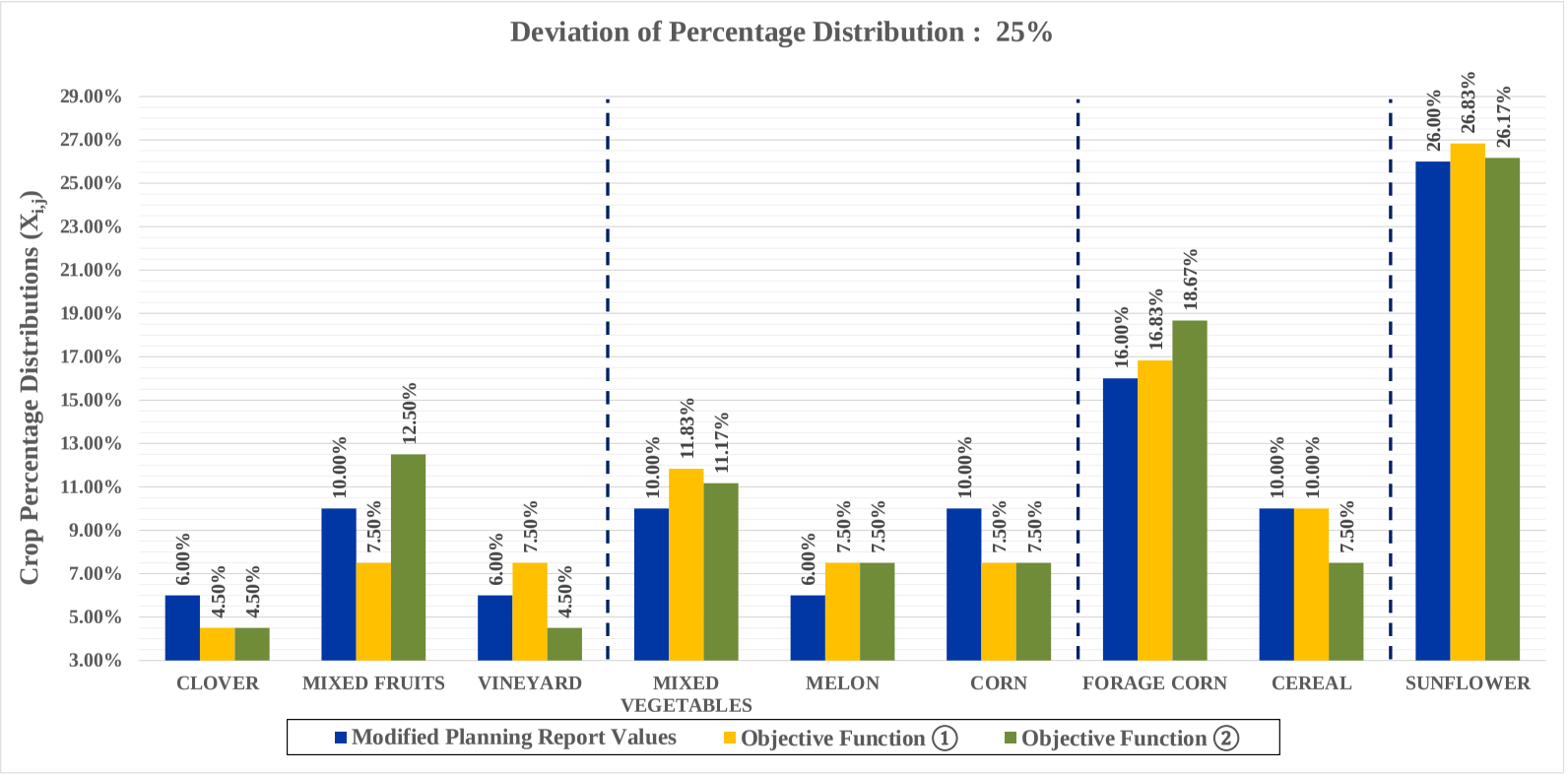


Figure B.23 KAR Project - 25% of deviation of crop percentage distribution results

Table B.24 KAR Project - 30% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KARAEVLİ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 30%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*6.00%*	4.20%	7.80%	7,275.38	4,488.38	**6.00%**		*436.52*	*269.30*	**4.20%**		*305.57*	*188.51*	**4.20%**		*305.57*	*188.51*
	2	MIXED FRUITS	*10.00%*	7.00%	13.00%	4,089.90	27,350.57	**10.00%**	**22.00%**	*408.99*	*2,735.06*	**7.00%**	**19.00%**	*286.29*	*1,914.54*	**13.00%**	**21.40%**	*531.69*	*3,555.57*
	3	VINEYARD	*6.00%*	4.20%	7.80%	3,502.65	10,761.01	**6.00%**		*210.16*	*645.66*	**7.80%**		*273.21*	*839.36*	**4.20%**		*147.11*	*451.96*
2	1	MIXED VEGETABLES	*10.00%*	7.00%	13.00%	3,181.12	16,893.75	**10.00%**		*318.11*	*1,689.38*	**12.20%**		*388.10*	*2,061.04*	**11.40%**		*362.65*	*1,925.89*
	2	MELON	*6.00%*	4.20%	7.80%	2,017.14	19,036.94	**6.00%**	**26.00%**	*121.03*	*1,142.22*	**7.80%**	**27.00%**	*157.34*	*1,484.88*	**7.80%**	**26.20%**	*157.34*	*1,484.88*
	3	CORN	*10.00%*	7.00%	13.00%	3,515.31	4,514.01	**10.00%**		*351.53*	*451.40*	**7.00%**		*246.07*	*315.98*	**7.00%**		*246.07*	*315.98*
3	1	FORAGE CORN	*16.00%*	11.20%	20.80%	3,515.31	8,937.92	**16.00%**	**26.00%**	*562.45*	*1,430.07*	**17.00%**	**27.00%**	*597.60*	*1,519.45*	**19.20%**	**26.20%**	*674.94*	*1,716.08*
	2	CEREAL	*10.00%*	7.00%	10.00%	2,576.28	4,773.47	**10.00%**		*257.63*	*477.35*	**10.00%**		*257.63*	*477.35*	**7.00%**		*180.34*	*334.14*
4	1	SUNFLOWER	*26.00%*	18.20%	33.80%	4,217.09	8,768.76	**26.00%**	**26.00%**	*1,096.44*	*2,279.88*	**27.00%**	**27.00%**	*1,138.61*	*2,367.57*	**26.20%**	**26.20%**	*1,104.88*	*2,297.42*
		TOTAL						**100.00%**	**100.00%**	**3,762.86**	**11,120.30**	**100.00%**	**100.00%**	**3,650.42**	**11,168.67**	**100.00%**	**100.00%**	**3,710.58**	**12,270.45**

Annual Available Water for Irrigation	**AW**		1,420,000 m³	1,420,000 m³	1,420,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	377.37 ha	**389.00 ha**	382.69 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	4,196,493 TL	4,344,576 TL	**4,695,771 TL**

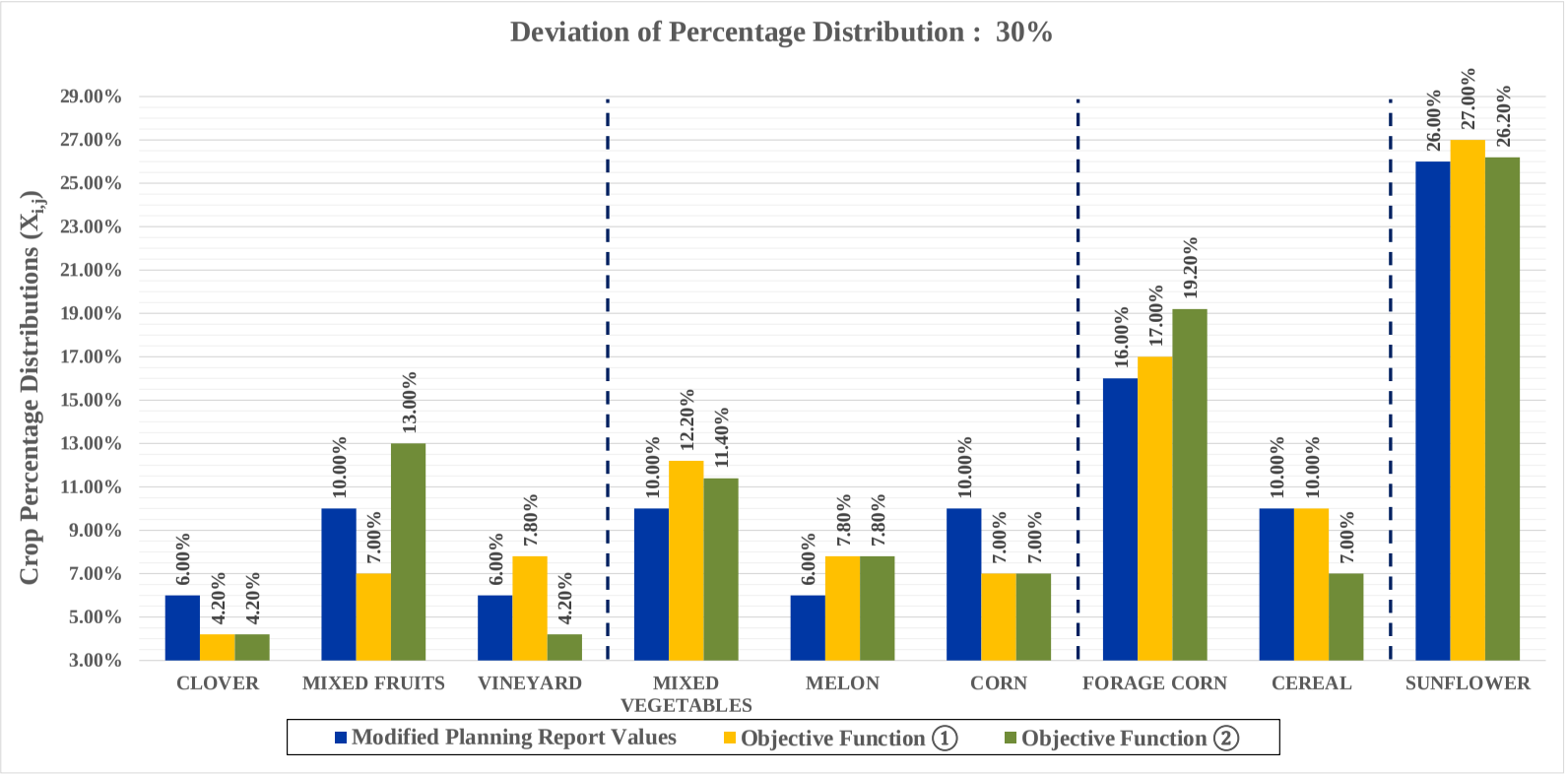


Figure B.24 KAR Project - 30% of deviation of crop percentage distribution results

Table B.25 HUS Project - 5% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - HÜSÜNLÜ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 5%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
i	j		$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$ (m^3/ha)	$NP_{i,j}$ (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)
1	1	CLOVER	10.00%	9.50%	10.50%	7,618.88	4,488.38	**10.00%**	**25.00%**	*761.89*	*448.84*	**9.50%**	**23.75%**	*723.79*	*426.40*	**9.50%**	**25.25%**	*723.79*	*426.40*
	2	MIXED FRUITS	15.00%	14.25%	15.75%	4,089.29	27,350.57	**15.00%**		*613.39*	*4,102.59*	**14.25%**		*582.72*	*3,897.46*	**15.75%**		*644.06*	*4,307.71*
2	1	FORAGE CORN	15.00%	14.25%	15.75%	3,514.80	8,937.92	**15.00%**	**25.00%**	*527.22*	*1,340.69*	**15.42%**	**25.42%**	*541.86*	*1,377.93*	**15.42%**	**24.92%**	*541.86*	*1,377.93*
	2	CEREAL	10.00%	9.50%	10.00%	2,575.89	4,773.47	**10.00%**		*257.59*	*477.35*	**10.00%**		*257.59*	*477.35*	**9.50%**		*244.71*	*453.48*
3	1	SUNFLOWER	10.00%	9.50%	10.50%	4,216.58	8,768.76	**10.00%**	**25.00%**	*421.66*	*876.88*	**9.67%**	**25.42%**	*407.60*	*847.65*	**9.50%**	**24.92%**	*400.58*	*833.03*
	2	CANOLA	15.00%	14.25%	15.75%	1,328.44	1,803.10	**15.00%**		*199.27*	*270.47*	**15.75%**		*209.23*	*283.99*	**15.42%**		*204.80*	*277.98*
4	1	CORN	10.00%	9.50%	10.50%	3,514.80	4,514.01	**10.00%**	**25.00%**	*351.48*	*451.40*	**10.50%**	**25.42%**	*369.05*	*473.97*	**9.50%**	**24.92%**	*333.91*	*428.83*
	2	MELON	6.00%	5.70%	6.30%	2,016.84	19,036.94	**6.00%**		*121.01*	*1,142.22*	**6.30%**		*127.06*	*1,199.33*	**6.30%**		*127.06*	*1,199.33*
	3	TOMATO	5.00%	4.75%	5.25%	4,455.20	18,921.00	**5.00%**		*222.76*	*946.05*	**4.82%**		*214.59*	*911.36*	**5.25%**		*233.90*	*993.35*
	4	ONION	4.00%	3.80%	4.20%	4,642.04	13,307.77	**4.00%**		*185.68*	*532.31*	**3.80%**		*176.40*	*505.70*	**3.87%**		*179.49*	*514.57*
		TOTAL						**100.00%**	**100.00%**	**3,661.95**	**10,588.78**	**100.00%**	**100.00%**	**3,609.91**	**10,401.12**	**100.00%**	**100.00%**	**3,634.16**	**10,812.61**

Annual Available Water for Irrigation	**AW**		1,244,000 m³	1,244,000 m³	1,244,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	339.71 ha	**344.61 ha**	342.31 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,597,115 TL	3,584,300 TL	**3,701,232 TL**

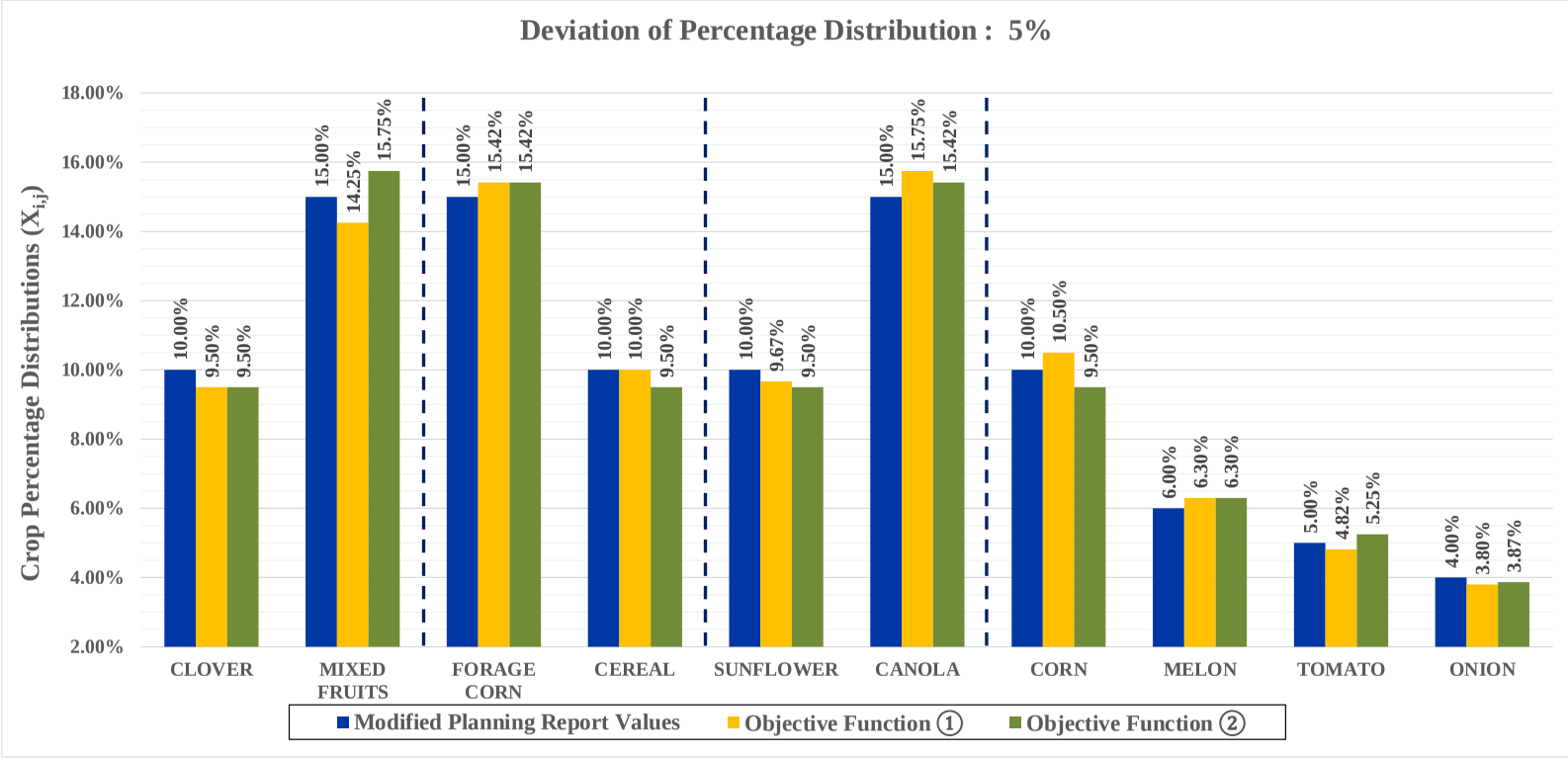


Figure B.25 HUS Project - 5% of deviation of crop percentage distribution results

Table B.26 HUS Project - 10% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - HÜSÜNLÜ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 10%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)			(m^3/ha)	(TL/ha)
1	1	CLOVER	*10.00%*	9.00%	11.00%	7,618.88	4,488.38	**10.00%**	**25.00%**	*761.89*	*448.84*	**9.00%**	**22.50%**	*685.70*	*403.95*	**9.00%**	**25.50%**	*685.70*	*403.95*
	2	MIXED FRUITS	*15.00%*	13.50%	16.50%	4,089.29	27,350.57	**15.00%**		*613.39*	*4,102.59*	**13.50%**		*552.05*	*3,692.33*	**16.50%**		*674.73*	*4,512.84*
2	1	FORAGE CORN	*15.00%*	13.50%	16.50%	3,514.80	8,937.92	**15.00%**	**25.00%**	*527.22*	*1,340.69*	**15.83%**	**25.83%**	*556.51*	*1,415.17*	**15.83%**	**24.83%**	*556.51*	*1,415.17*
	2	CEREAL	*10.00%*	9.00%	10.00%	2,575.89	4,773.47	**10.00%**		*257.59*	*477.35*	**10.00%**		*257.59*	*477.35*	**9.00%**		*231.83*	*429.61*
3	1	SUNFLOWER	*10.00%*	9.00%	11.00%	4,216.58	8,768.76	**10.00%**	**25.00%**	*421.66*	*876.88*	**9.33%**	**25.83%**	*393.55*	*818.42*	**9.00%**	**24.83%**	*379.49*	*789.19*
	2	CANOLA	*15.00%*	13.50%	16.50%	1,328.44	1,803.10	**15.00%**		*199.27*	*270.47*	**16.50%**		*219.19*	*297.51*	**15.83%**		*210.34*	*285.49*
4	1	CORN	*10.00%*	9.00%	11.00%	3,514.80	4,514.01	**10.00%**	**25.00%**	*351.48*	*451.40*	**11.00%**	**25.83%**	*386.63*	*496.54*	**9.00%**	**24.83%**	*316.33*	*406.26*
	2	MELON	*6.00%*	5.40%	6.60%	2,016.84	19,036.94	**6.00%**		*121.01*	*1,142.22*	**6.60%**		*133.11*	*1,256.44*	**6.60%**		*133.11*	*1,256.44*
	3	TOMATO	*5.00%*	4.50%	5.50%	4,455.20	18,921.00	**5.00%**		*222.76*	*946.05*	**4.63%**		*206.42*	*876.67*	**5.50%**		*245.04*	*1,040.66*
	4	ONION	*4.00%*	3.60%	4.40%	4,642.04	13,307.77	**4.00%**		*185.68*	*532.31*	**3.60%**		*167.11*	*479.08*	**3.73%**		*173.30*	*496.82*
		TOTAL						**100.00%**	**100.00%**	**3,661.95**	**10,588.78**	**100.00%**	**100.00%**	**3,557.87**	**10,213.46**	**100.00%**	**100.00%**	**3,606.38**	**11,036.44**

Annual Available Water for Irrigation	**AW**		1,244,000 m^3	1,244,000 m^3	1,244,000 m^3
Irrigation Area Size	**A**	*= [AW / TDR]*	339.71 ha	**349.65 ha**	344.94 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,597,115 TL	3,571,111 TL	**3,806,953 TL**

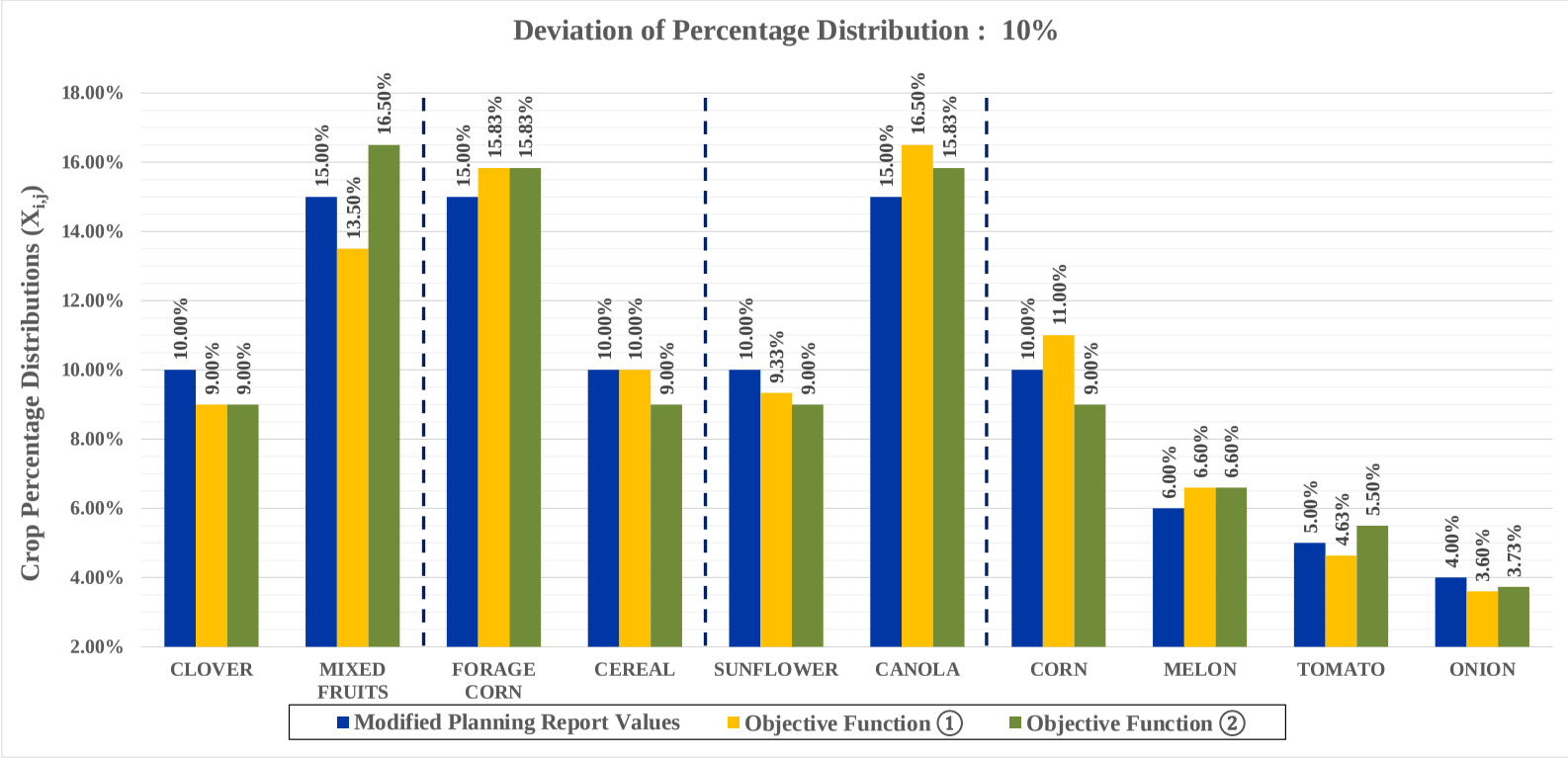


Figure B.26 HUS Project - 10% of deviation of crop percentage distribution results

Table B.27 HUS Project - 15% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - HÜSÜNLÜ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 15%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
i	j		$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$ (m^3/ha)	$NP_{i,j}$ (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)
1	1	CLOVER	10.00%	8.50%	11.50%	7,618.88	4,488.38	10.00%	25.00%	761.89	448.84	8.50%	21.25%	647.60	381.51	8.50%	25.75%	647.60	381.51
	2	MIXED FRUITS	15.00%	12.75%	17.25%	4,089.29	27,350.57	15.00%		613.39	4,102.59	12.75%		521.38	3,487.20	17.25%		705.40	4,717.97
2	1	FORAGE CORN	15.00%	12.75%	17.25%	3,514.80	8,937.92	15.00%	25.00%	527.22	1,340.69	16.25%	26.25%	571.15	1,452.41	16.25%	24.75%	571.16	1,452.41
	2	CEREAL	10.00%	8.50%	10.00%	2,575.89	4,773.47	10.00%		257.59	477.35	10.00%		257.59	477.35	8.50%		218.95	405.74
3	1	SUNFLOWER	10.00%	8.50%	11.50%	4,216.58	8,768.76	10.00%	25.00%	421.66	876.88	9.00%	26.25%	379.49	789.19	8.50%	24.75%	358.41	745.34
	2	CANOLA	15.00%	12.75%	17.25%	1,328.44	1,803.10	15.00%		199.27	270.47	17.25%		229.16	311.03	16.25%		215.87	293.00
4	1	CORN	10.00%	8.50%	11.50%	3,514.80	4,514.01	10.00%	25.00%	351.48	451.40	11.50%	26.25%	404.20	519.11	8.50%	24.75%	298.76	383.69
	2	MELON	6.00%	5.10%	6.90%	2,016.84	19,036.94	6.00%		121.01	1,142.22	6.90%		139.16	1,313.55	6.90%		139.16	1,313.55
	3	TOMATO	5.00%	4.25%	5.75%	4,455.20	18,921.00	5.00%		222.76	946.05	4.45%		198.26	841.98	5.75%		256.17	1,087.96
	4	ONION	4.00%	3.40%	4.60%	4,642.04	13,307.77	4.00%		185.68	532.31	3.40%		157.83	452.46	3.60%		167.12	479.08
		TOTAL						100.00%	100.00%	3,661.95	10,588.78	100.00%	100.00%	3,505.83	10,025.80	100.00%	100.00%	3,578.60	11,260.28

Annual Available Water for Irrigation	**AW**		1,244,000 m³	1,244,000 m³	1,244,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	339.71 ha	**354.84 ha**	347.62 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,597,115 TL	3,557,530 TL	**3,914,316 TL**

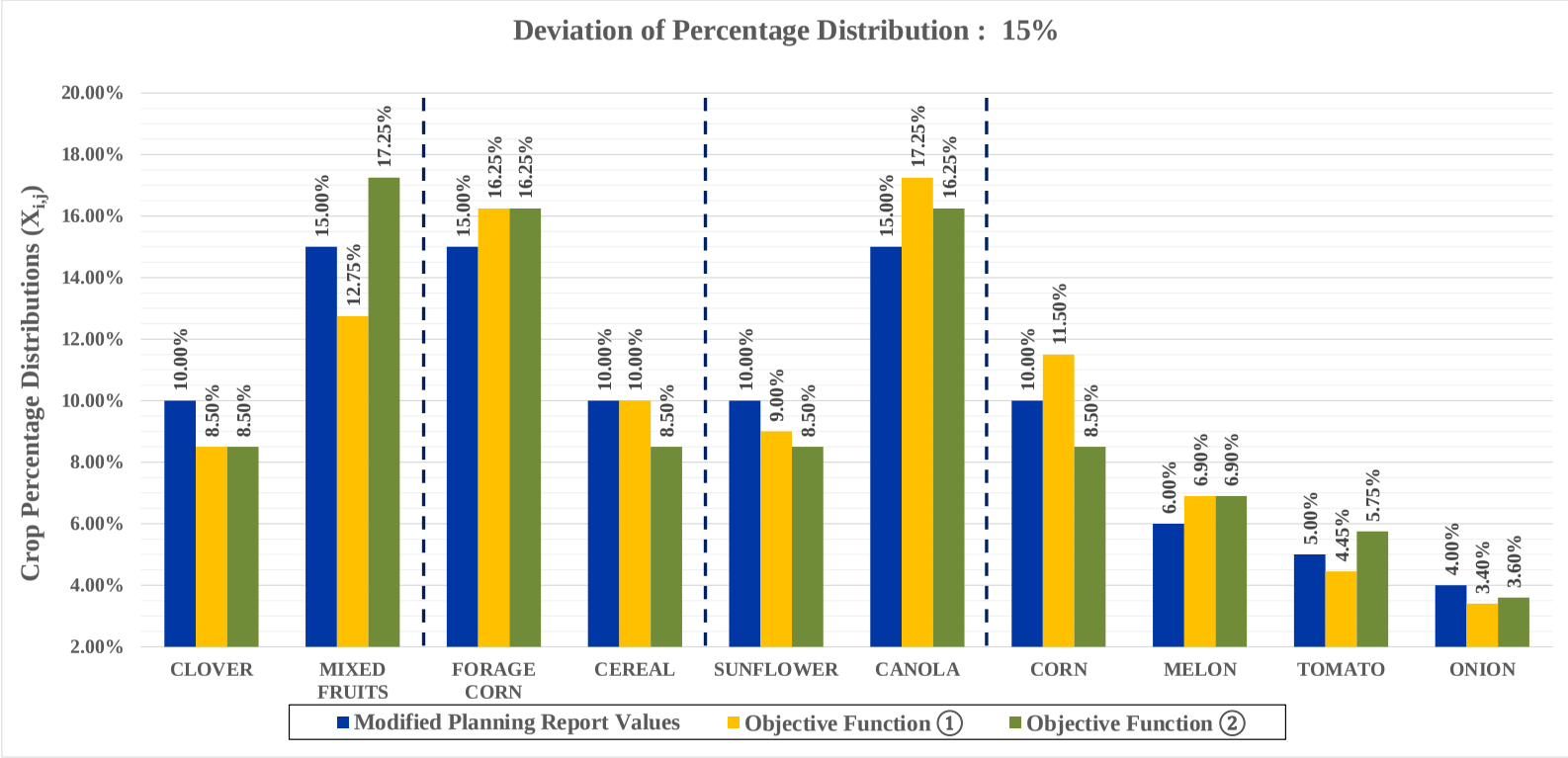


Figure B.27 HUS Project - 15% of deviation of crop percentage distribution results

Table B.28 HUS Project - 20% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - HÜSÜNLÜ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 20%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
i	j		$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$ (m^3/ha)	$NP_{i,j}$ (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)
1	1	CLOVER	10.00%	8.00%	12.00%	7,618.88	4,488.38	**10.00%**	**25.00%**	*761.89*	*448.84*	**8.00%**	**20.00%**	*609.51*	*359.07*	**8.00%**	**26.00%**	*609.51*	*359.07*
	2	MIXED FRUITS	15.00%	12.00%	18.00%	4,089.29	27,350.57	**15.00%**		*613.39*	*4,102.59*	**12.00%**		*490.71*	*3,282.07*	**18.00%**		*736.07*	*4,923.10*
2	1	FORAGE CORN	15.00%	12.00%	18.00%	3,514.80	8,937.92	**15.00%**	**25.00%**	*527.22*	*1,340.69*	**16.67%**	**26.67%**	*585.80*	*1,489.65*	**16.67%**	**24.67%**	*585.80*	*1,489.65*
	2	CEREAL	10.00%	8.00%	10.00%	2,575.89	4,773.47	**10.00%**		*257.59*	*477.35*	**10.00%**		*257.59*	*477.35*	**8.00%**		*206.07*	*381.88*
3	1	SUNFLOWER	10.00%	8.00%	12.00%	4,216.58	8,768.76	**10.00%**	**25.00%**	*421.66*	*876.88*	**8.67%**	**26.67%**	*365.44*	*759.96*	**8.00%**	**24.67%**	*337.33*	*701.50*
	2	CANOLA	15.00%	12.00%	18.00%	1,328.44	1,803.10	**15.00%**		*199.27*	*270.47*	**18.00%**		*239.12*	*324.56*	**16.67%**		*221.41*	*300.52*
4	1	CORN	10.00%	8.00%	12.00%	3,514.80	4,514.01	**10.00%**	**25.00%**	*351.48*	*451.40*	**12.00%**	**26.67%**	*421.78*	*541.68*	**8.00%**	**24.67%**	*281.18*	*361.12*
	2	MELON	6.00%	4.80%	7.20%	2,016.84	19,036.94	**6.00%**		*121.01*	*1,142.22*	**7.20%**		*145.21*	*1,370.66*	**7.20%**		*145.21*	*1,370.66*
	3	TOMATO	5.00%	4.00%	6.00%	4,455.20	18,921.00	**5.00%**		*222.76*	*946.05*	**4.27%**		*190.09*	*807.30*	**6.00%**		*267.31*	*1,135.26*
	4	ONION	4.00%	3.20%	4.80%	4,642.04	13,307.77	**4.00%**		*185.68*	*532.31*	**3.20%**		*148.55*	*425.85*	**3.47%**		*160.92*	*461.34*
		TOTAL						**100.00%**	**100.00%**	**3,661.95**	**10,588.78**	**100.00%**	**100.00%**	**3,453.79**	**9,838.14**	**100.00%**	**100.00%**	**3,550.82**	**11,484.10**

Annual Available Water for Irrigation	**AW**		1,244,000 m³	1,244,000 m³	1,244,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	339.71 ha	**360.18 ha**	350.34 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,597,115 TL	3,543,540 TL	**4,023,359 TL**

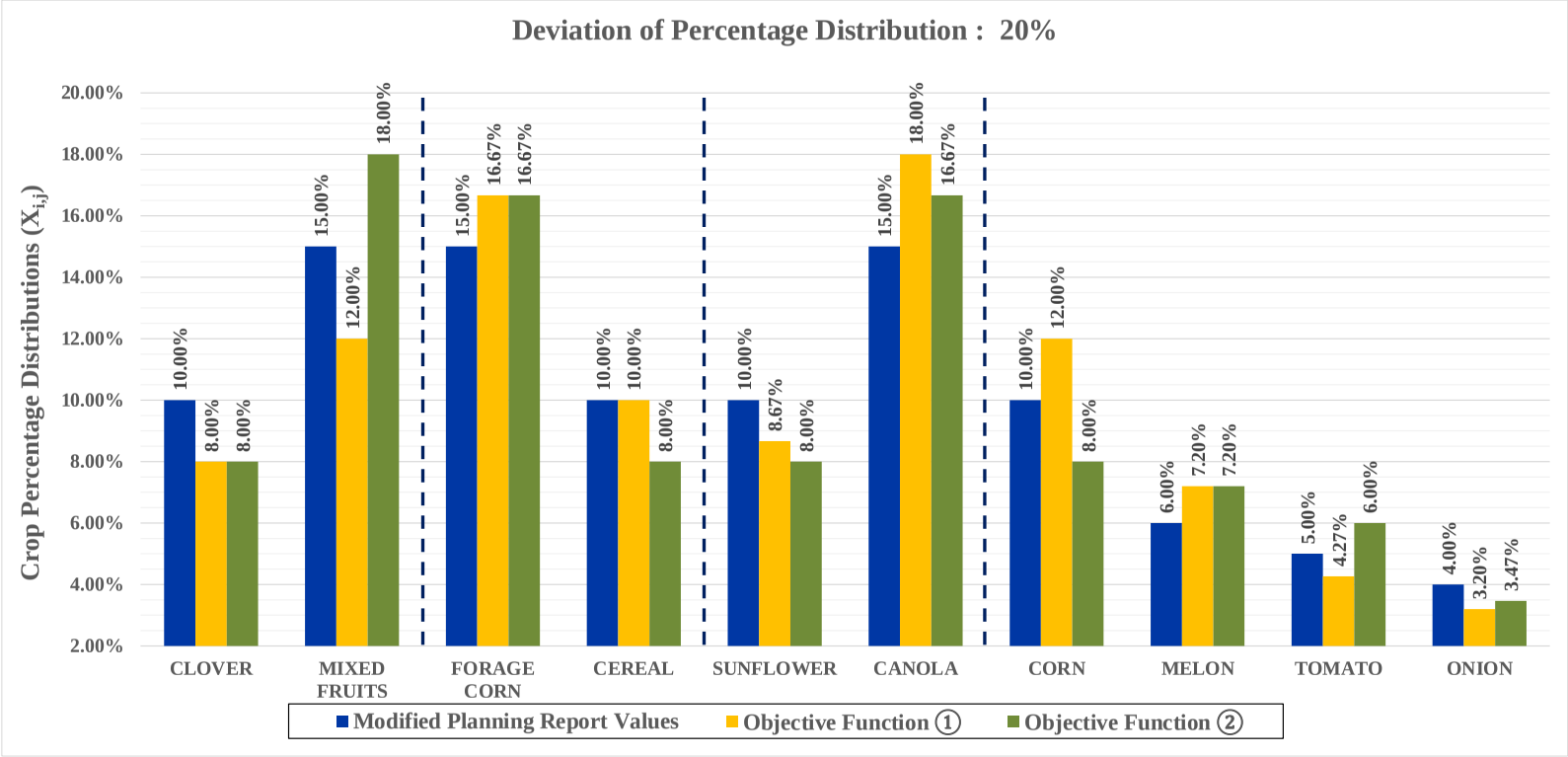


Figure B.28 HUS Project - 20% of deviation of crop percentage distribution results

Table B.29 HUS Project - 25% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - HÜSÜNLÜ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 25%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
i	j		$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$ (m^3/ha)	$NP_{i,j}$ (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)
1	1	CLOVER	10.00%	7.50%	12.50%	7,618.88	4,488.38	10.00%	25.00%	761.89	448.84	7.50%	18.75%	571.42	336.63	7.50%	26.25%	571.42	336.63
	2	MIXED FRUITS	15.00%	11.25%	18.75%	4,089.29	27,350.57	15.00%		613.39	4,102.59	11.25%		460.04	3,076.94	18.75%		766.74	5,128.23
2	1	FORAGE CORN	15.00%	11.25%	18.75%	3,514.80	8,937.92	15.00%	25.00%	527.22	1,340.69	17.08%	27.08%	600.44	1,526.89	17.08%	24.58%	600.44	1,526.89
	2	CEREAL	10.00%	7.50%	10.00%	2,575.89	4,773.47	10.00%		257.59	477.35	10.00%		257.59	477.35	7.50%		193.19	358.01
3	1	SUNFLOWER	10.00%	7.50%	12.50%	4,216.58	8,768.76	10.00%	25.00%	421.66	876.88	8.33%	27.08%	351.38	730.73	7.50%	24.58%	316.24	657.66
	2	CANOLA	15.00%	11.25%	18.75%	1,328.44	1,803.10	15.00%		199.27	270.47	18.75%		249.08	338.08	17.08%		226.94	308.03
4	1	CORN	10.00%	7.50%	12.50%	3,514.80	4,514.01	10.00%	25.00%	351.48	451.40	12.50%	27.08%	439.35	564.25	7.50%	24.58%	263.61	338.55
	2	MELON	6.00%	4.50%	7.50%	2,016.84	19,036.94	6.00%		121.01	1,142.22	7.50%		151.26	1,427.77	7.50%		151.26	1,427.77
	3	TOMATO	5.00%	3.75%	6.25%	4,455.20	18,921.00	5.00%		222.76	946.05	4.08%		181.92	772.61	6.25%		278.45	1,182.56
	4	ONION	4.00%	3.00%	5.00%	4,642.04	13,307.77	4.00%		185.68	532.31	3.00%		139.26	399.23	3.33%		154.73	443.59
		TOTAL						100.00%	100.00%	3,661.95	10,588.78	100.00%	100.00%	3,401.75	9,650.48	100.00%	100.00%	3,523.04	11,707.93

Annual Available Water for Irrigation	**AW**		1,244,000 m³	1,244,000 m³	1,244,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	339.71 ha	**365.69 ha**	353.10 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,597,115 TL	3,529,121 TL	**4,134,122 TL**

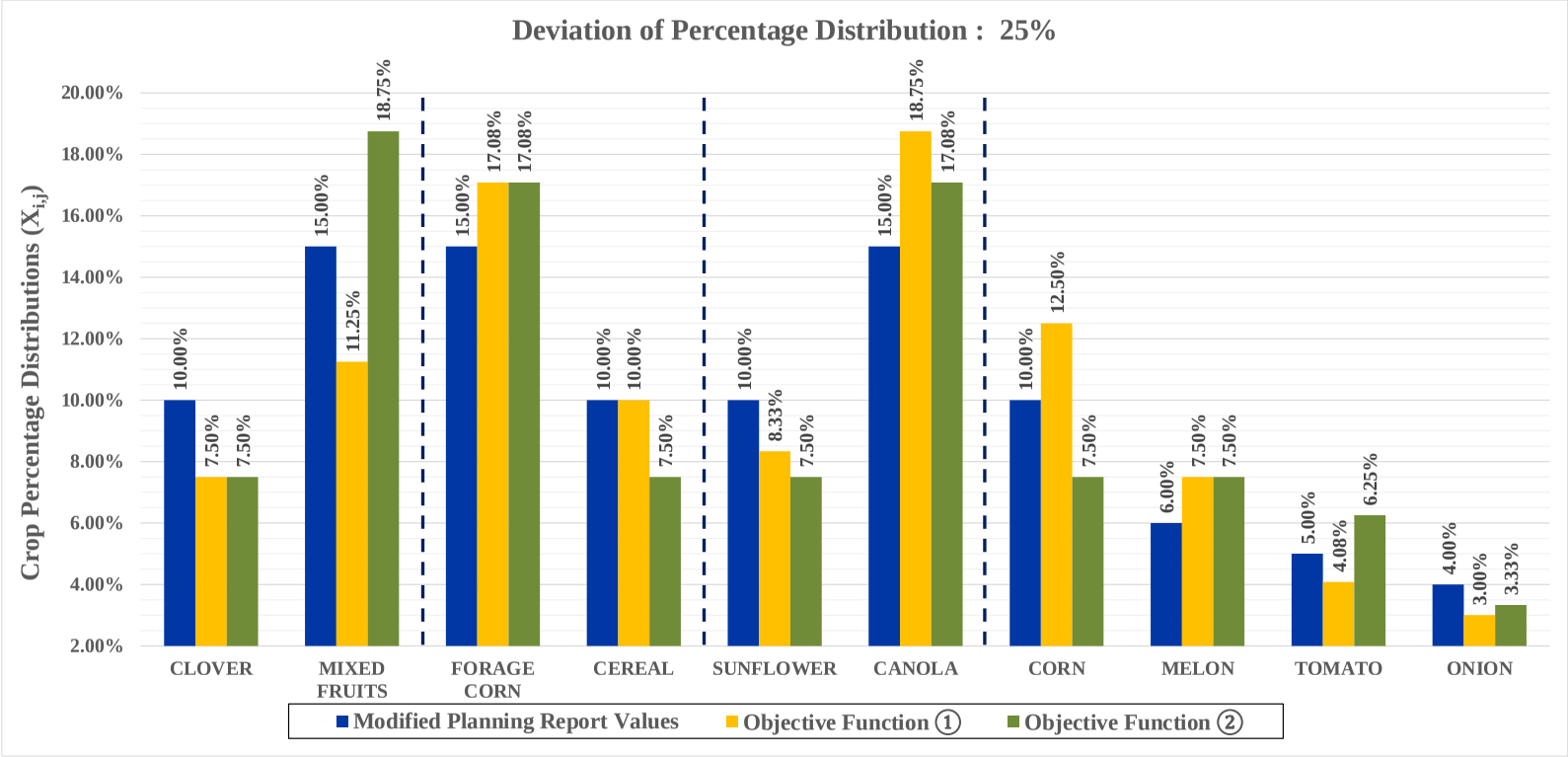


Figure B.29 HUS Project - 25% of deviation of crop percentage distribution results

Table B.30 HUS Project - 30% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - HÜSÜNLÜ POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 30%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
i	j		$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$ (m^3/ha)	$NP_{i,j}$ (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)
1	1	CLOVER	*10.00%*	7.00%	13.00%	7,618.88	4,488.38	**10.00%**	**25.00%**	*761.89*	*448.84*	**7.00%**	**17.50%**	*533.32*	*314.19*	**7.00%**	**26.50%**	*533.32*	*314.19*
	2	MIXED FRUITS	*15.00%*	10.50%	19.50%	4,089.29	27,350.57	**15.00%**		*613.39*	*4,102.59*	**10.50%**		*429.38*	*2,871.81*	**19.50%**		*797.41*	*5,333.36*
2	1	FORAGE CORN	*15.00%*	10.50%	19.50%	3,514.80	8,937.92	**15.00%**	**25.00%**	*527.22*	*1,340.69*	**17.50%**	**27.50%**	*615.09*	*1,564.14*	**17.50%**	**24.50%**	*615.09*	*1,564.14*
	2	CEREAL	*10.00%*	7.00%	10.00%	2,575.89	4,773.47	**10.00%**		*257.59*	*477.35*	**10.00%**		*257.59*	*477.35*	**7.00%**		*180.31*	*334.14*
3	1	SUNFLOWER	*10.00%*	7.00%	13.00%	4,216.58	8,768.76	**10.00%**	**25.00%**	*421.66*	*876.88*	**8.00%**	**27.50%**	*337.33*	*701.50*	**7.00%**	**24.50%**	*295.16*	*613.81*
	2	CANOLA	*15.00%*	10.50%	19.50%	1,328.44	1,803.10	**15.00%**		*199.27*	*270.47*	**19.50%**		*259.05*	*351.60*	**17.50%**		*232.48*	*315.54*
4	1	CORN	*10.00%*	7.00%	13.00%	3,514.80	4,514.01	**10.00%**	**25.00%**	*351.48*	*451.40*	**13.00%**	**27.50%**	*456.92*	*586.82*	**7.00%**	**24.50%**	*246.04*	*315.98*
	2	MELON	*6.00%*	4.20%	7.80%	2,016.84	19,036.94	**6.00%**		*121.01*	*1,142.22*	**7.80%**		*157.31*	*1,484.88*	**7.80%**		*157.31*	*1,484.88*
	3	TOMATO	*5.00%*	3.50%	6.50%	4,455.20	18,921.00	**5.00%**		*222.76*	*946.05*	**3.90%**		*173.75*	*737.92*	**6.50%**		*289.59*	*1,229.87*
	4	ONION	*4.00%*	2.80%	5.20%	4,642.04	13,307.77	**4.00%**		*185.68*	*532.31*	**2.80%**		*129.98*	*372.62*	**3.20%**		*148.55*	*425.85*
		TOTAL						**100.00%**	**100.00%**	**3,661.95**	**10,588.78**	**100.00%**	**100.00%**	**3,349.71**	**9,462.82**	**100.00%**	**100.00%**	**3,495.25**	**11,931.76**

Annual Available Water for Irrigation	**AW**		1,244,000 m³	1,244,000 m³	1,244,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	339.71 ha	**371.37 ha**	355.91 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,597,115 TL	3,514,255 TL	**4,246,645 TL**

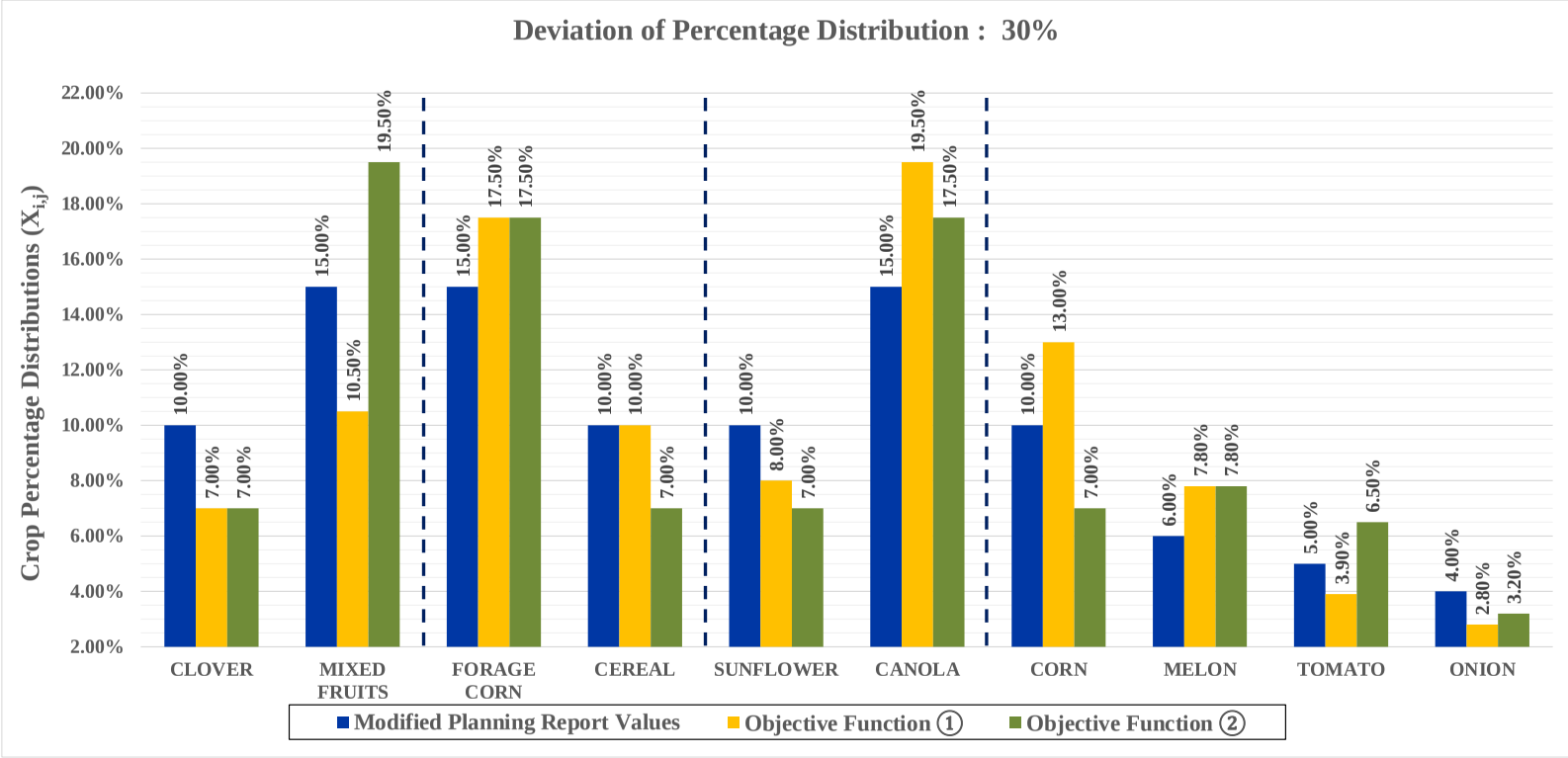


Figure B.30 HUS Project - 30% of deviation of crop percentage distribution results

Table B.31 KLV Project - 5% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KILAVUZLU POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 5%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
i	j		$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$ (m³/ha)	$NP_{i,j}$ (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m³/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m³/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m³/ha)	NP (TL/ha)
1	1	CLOVER	20.00%	19.00%	21.00%	7,274.62	4,488.38	20.00%	25.00%	1,454.92	897.68	19.00%	23.75%	1,382.18	852.79	19.00%	24.25%	1,382.18	852.79
	2	MIXED FRUITS	5.00%	4.75%	5.25%	4,089.29	27,350.57	5.00%		204.46	1,367.53	4.75%		194.24	1,299.15	5.25%		214.69	1,435.90
2	1	FORAGE CORN	15.00%	14.25%	15.75%	3,514.80	8,937.92	15.00%	25.00%	527.22	1,340.69	15.42%	25.42%	541.86	1,377.93	15.75%	25.25%	553.58	1,407.72
	2	CEREAL	10.00%	9.50%	10.00%	2,575.89	4,773.47	10.00%		257.59	477.35	10.00%		257.59	477.35	9.50%		244.71	453.48
3	1	SUNFLOWER	14.00%	13.30%	14.70%	4,216.58	8,768.76	14.00%	25.00%	590.32	1,227.63	14.37%	25.42%	605.78	1,259.78	13.70%	25.25%	577.67	1,201.32
	2	TOMATO	5.00%	4.75%	5.25%	5,299.90	18,921.00	5.00%		264.99	946.05	4.75%		251.75	898.75	5.25%		278.24	993.35
	3	MELON	6.00%	5.70%	6.30%	2,016.84	19,036.94	6.00%		121.01	1,142.22	6.30%		127.06	1,199.33	6.30%		127.06	1,199.33
4	1	CORN	15.00%	14.25%	15.75%	3,514.80	4,514.01	15.00%	25.00%	527.22	677.10	14.92%	25.42%	524.29	673.34	14.75%	25.25%	518.43	665.82
	2	MIXED VEGETABLES	6.00%	5.70%	6.30%	3,180.82	16,893.75	6.00%		190.85	1,013.63	6.30%		200.39	1,064.31	6.30%		200.39	1,064.31
	3	ONION	4.00%	3.80%	4.20%	3,404.39	13,307.77	4.00%		136.18	532.31	4.20%		142.98	558.93	4.20%		142.98	558.93
		TOTAL						100.00%	100.00%	4,274.77	9,622.17	100.00%	100.00%	4,228.13	9,661.65	100.00%	100.00%	4,239.94	9,832.95

Annual Available Water for Irrigation	**AW**		1,686,000 m³	1,686,000 m³	1,686,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	394.41 ha	**398.76 ha**	397.65 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,795,056 TL	3,852,661 TL	**3,910,044 TL**

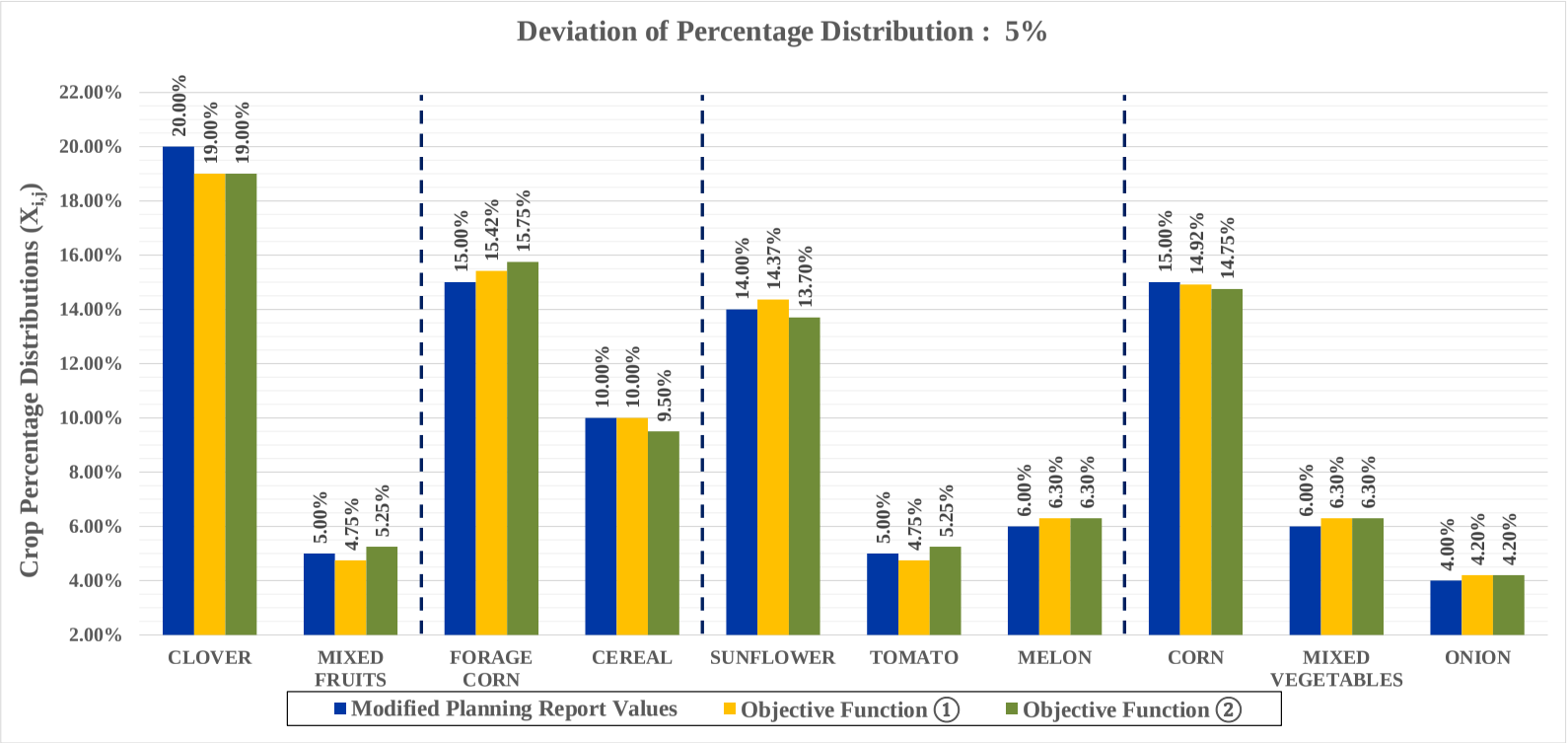


Figure B.31 KLV Project - 5% of deviation of crop percentage distribution results

Table B.32 KLV Project - 10% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KILAVUZLU POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 10%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
i	j		$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$ (m^3/ha)	$NP_{i,j}$ (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)
1	1	CLOVER	20.00%	18.00%	22.00%	7,274.62	4,488.38	**20.00%**	**25.00%**	*1,454.92*	*897.68*	**18.00%**	**22.50%**	*1,309.43*	*807.91*	**18.00%**	**23.50%**	*1,309.43*	*807.91*
	2	MIXED FRUITS	5.00%	4.50%	5.50%	4,089.29	27,350.57	**5.00%**		*204.46*	*1,367.53*	**4.50%**		*184.02*	*1,230.78*	**5.50%**		*224.91*	*1,504.28*
2	1	FORAGE CORN	15.00%	13.50%	16.50%	3,514.80	8,937.92	**15.00%**	**25.00%**	*527.22*	*1,340.69*	**15.83%**	**25.83%**	*556.51*	*1,415.17*	**16.50%**	**25.50%**	*579.94*	*1,474.76*
	2	CEREAL	10.00%	9.00%	10.00%	2,575.89	4,773.47	**10.00%**		*257.59*	*477.35*	**10.00%**		*257.59*	*477.35*	**9.00%**		*231.83*	*429.61*
3	1	SUNFLOWER	14.00%	12.60%	15.40%	4,216.58	8,768.76	**14.00%**	**25.00%**	*590.32*	*1,227.63*	**14.73%**	**25.83%**	*621.24*	*1,291.93*	**13.40%**	**25.50%**	*565.02*	*1,175.01*
	2	TOMATO	5.00%	4.50%	5.50%	5,299.90	18,921.00	**5.00%**		*264.99*	*946.05*	**4.50%**		*238.50*	*851.45*	**5.50%**		*291.49*	*1,040.66*
	3	MELON	6.00%	5.40%	6.60%	2,016.84	19,036.94	**6.00%**		*121.01*	*1,142.22*	**6.60%**		*133.11*	*1,256.44*	**6.60%**		*133.11*	*1,256.44*
4	1	CORN	15.00%	13.50%	16.50%	3,514.80	4,514.01	**15.00%**	**25.00%**	*527.22*	*677.10*	**14.83%**	**25.83%**	*521.36*	*669.58*	**14.50%**	**25.50%**	*509.65*	*654.53*
	2	MIXED VEGETABLES	6.00%	5.40%	6.60%	3,180.82	16,893.75	**6.00%**		*190.85*	*1,013.63*	**6.60%**		*209.93*	*1,114.99*	**6.60%**		*209.93*	*1,114.99*
	3	ONION	4.00%	3.60%	4.40%	3,404.39	13,307.77	**4.00%**		*136.18*	*532.31*	**4.40%**		*149.79*	*585.54*	**4.40%**		*149.79*	*585.54*
		TOTAL						**100.00%**	**100.00%**	**4,274.77**	**9,622.17**	**100.00%**	**100.00%**	**4,181.49**	**9,701.12**	**100.00%**	**100.00%**	**4,205.11**	**10,043.73**

Annual Available Water for Irrigation	**AW**		1,686,000 m³	1,686,000 m³	1,686,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	394.41 ha	**403.21 ha**	400.94 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,795,056 TL	3,911,551 TL	**4,026,936 TL**

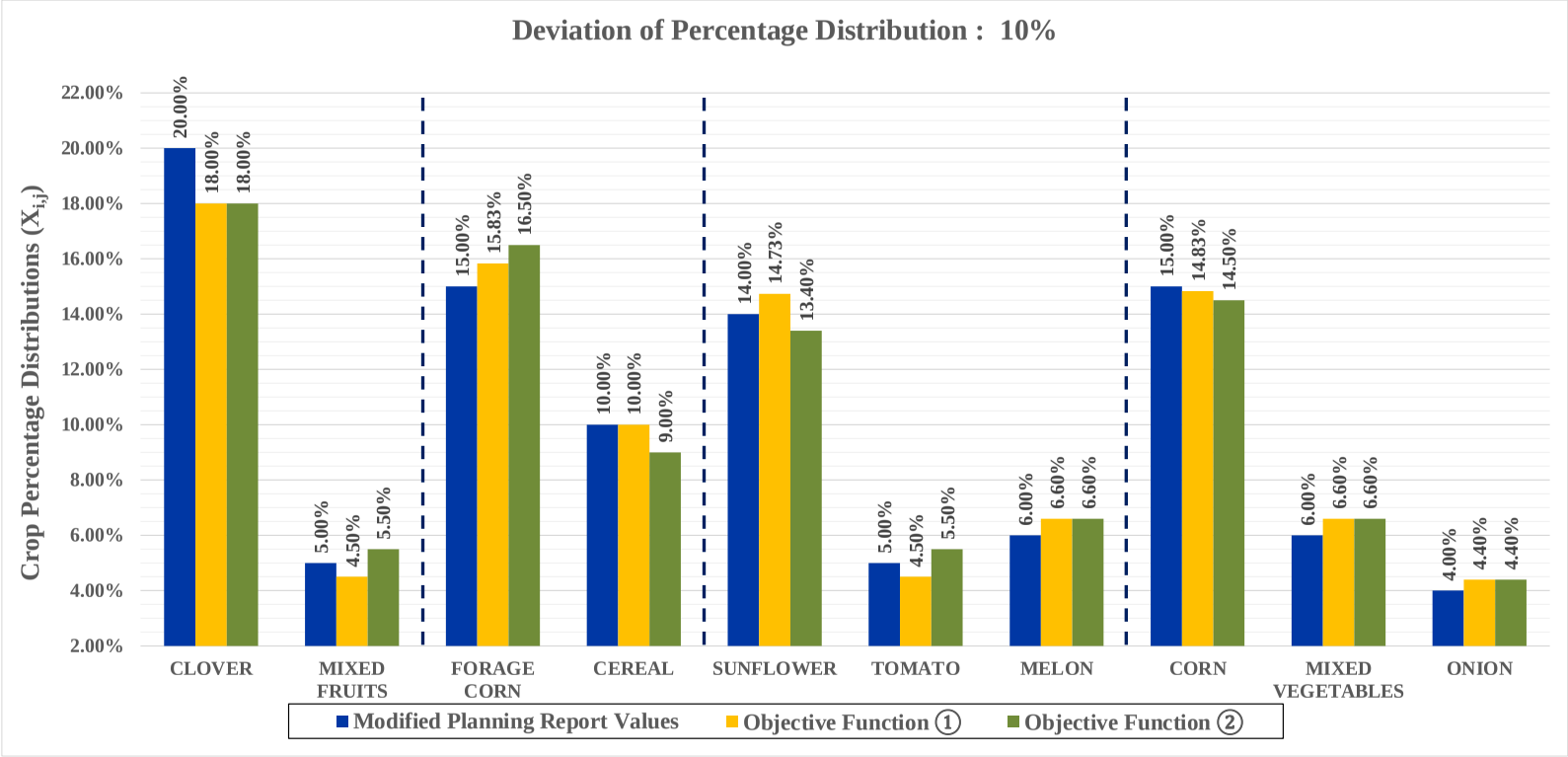


Figure B.32 KLV Project - 10% of deviation of crop percentage distribution results

Table B.33 KLV Project - 15% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KILAVUZLU POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 15%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
i	j		$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$ (m^3/ha)	$NP_{i,j}$ (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)
1	1	CLOVER	20.00%	17.00%	23.00%	7,274.62	4,488.38	**20.00%**	**25.00%**	*1,454.92*	*897.68*	**17.00%**	**21.25%**	*1,236.68*	*763.02*	**17.00%**	**22.75%**	*1,236.68*	*763.02*
	2	MIXED FRUITS	5.00%	4.25%	5.75%	4,089.29	27,350.57	**5.00%**		*204.46*	*1,367.53*	**4.25%**		*173.79*	*1,162.40*	**5.75%**		*235.13*	*1,572.66*
2	1	FORAGE CORN	15.00%	12.75%	17.25%	3,514.80	8,937.92	**15.00%**	**25.00%**	*527.22*	*1,340.69*	**16.25%**	**26.25%**	*571.15*	*1,452.41*	**17.25%**	**25.75%**	*606.30*	*1,541.79*
	2	CEREAL	10.00%	8.50%	10.00%	2,575.89	4,773.47	**10.00%**		*257.59*	*477.35*	**10.00%**		*257.59*	*477.35*	**8.50%**		*218.95*	*405.74*
3	1	SUNFLOWER	14.00%	11.90%	16.10%	4,216.58	8,768.76	**14.00%**	**25.00%**	*590.32*	*1,227.63*	**15.10%**	**26.25%**	*636.70*	*1,324.08*	**13.10%**	**25.75%**	*552.37*	*1,148.71*
	2	TOMATO	5.00%	4.25%	5.75%	5,299.90	18,921.00	**5.00%**		*264.99*	*946.05*	**4.25%**		*225.25*	*804.14*	**5.75%**		*304.74*	*1,087.96*
	3	MELON	6.00%	5.10%	6.90%	2,016.84	19,036.94	**6.00%**		*121.01*	*1,142.22*	**6.90%**		*139.16*	*1,313.55*	**6.90%**		*139.16*	*1,313.55*
4	1	CORN	15.00%	12.75%	17.25%	3,514.80	4,514.01	**15.00%**	**25.00%**	*527.22*	*677.10*	**14.75%**	**26.25%**	*518.43*	*665.82*	**14.25%**	**25.75%**	*500.86*	*643.25*
	2	MIXED VEGETABLES	6.00%	5.10%	6.90%	3,180.82	16,893.75	**6.00%**		*190.85*	*1,013.63*	**6.90%**		*219.48*	*1,165.67*	**6.90%**		*219.48*	*1,165.67*
	3	ONION	4.00%	3.40%	4.60%	3,404.39	13,307.77	**4.00%**		*136.18*	*532.31*	**4.60%**		*156.60*	*612.16*	**4.60%**		*156.60*	*612.16*
		TOTAL						**100.00%**	**100.00%**	**4,274.77**	**9,622.17**	**100.00%**	**100.00%**	**4,134.85**	**9,740.60**	**100.00%**	**100.00%**	**4,170.29**	**10,254.51**

Annual Available Water for Irrigation	**AW**		1,686,000 m³	1,686,000 m³	1,686,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	394.41 ha	**407.75 ha**	404.29 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,795,056 TL	3,971,769 TL	**4,145,781 TL**

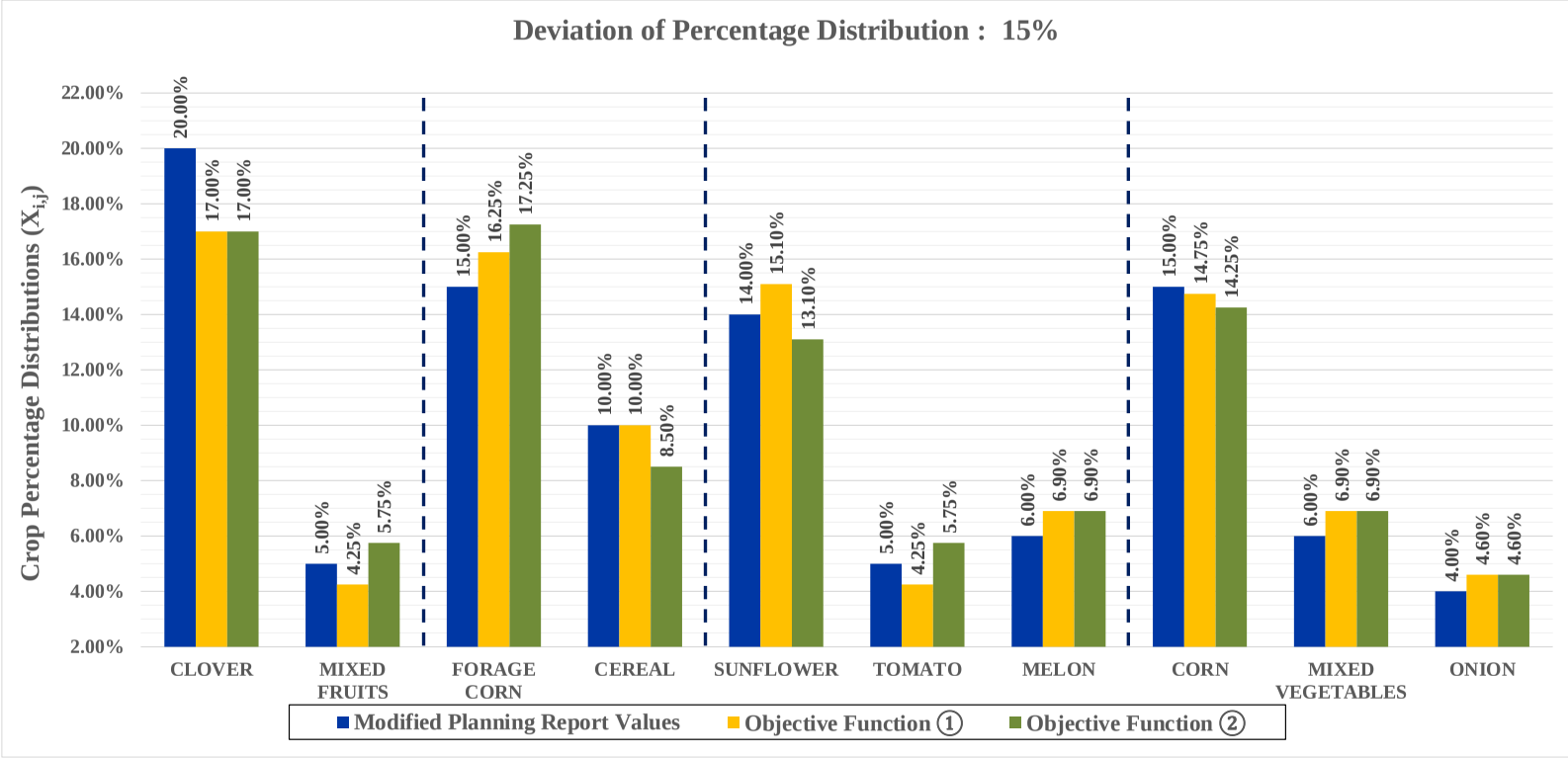


Figure B.33 KLV Project - 15% of deviation of crop percentage distribution results

Table B.34 KLV Project - 20% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KILAVUZLU POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 20%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
i	j		$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$ (m^3/ha)	$NP_{i,j}$ (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)
1	1	CLOVER	20.00%	16.00%	24.00%	7,274.62	4,488.38	20.00%	25.00%	1,454.92	897.68	16.00%	20.00%	1,163.94	718.14	16.00%	22.00%	1,163.94	718.14
	2	MIXED FRUITS	5.00%	4.00%	6.00%	4,089.29	27,350.57	5.00%		204.46	1,367.53	4.00%		163.57	1,094.02	6.00%		245.36	1,641.03
2	1	FORAGE CORN	15.00%	12.00%	18.00%	3,514.80	8,937.92	15.00%	25.00%	527.22	1,340.69	16.67%	26.67%	585.80	1,489.65	18.00%	26.00%	632.66	1,608.83
	2	CEREAL	10.00%	8.00%	10.00%	2,575.89	4,773.47	10.00%		257.59	477.35	10.00%		257.59	477.35	8.00%		206.07	381.88
3	1	SUNFLOWER	14.00%	11.20%	16.80%	4,216.58	8,768.76	14.00%	25.00%	590.32	1,227.63	15.47%	26.67%	652.16	1,356.23	12.80%	26.00%	539.72	1,122.40
	2	TOMATO	5.00%	4.00%	6.00%	5,299.90	18,921.00	5.00%		264.99	946.05	4.00%		212.00	756.84	6.00%		317.99	1,135.26
	3	MELON	6.00%	4.80%	7.20%	2,016.84	19,036.94	6.00%		121.01	1,142.22	7.20%		145.21	1,370.66	7.20%		145.21	1,370.66
4	1	CORN	15.00%	12.00%	18.00%	3,514.80	4,514.01	15.00%	25.00%	527.22	677.10	14.67%	26.67%	515.50	662.05	14.00%	26.00%	492.07	631.96
	2	MIXED VEGETABLES	6.00%	4.80%	7.20%	3,180.82	16,893.75	6.00%		190.85	1,013.63	7.20%		229.02	1,216.35	7.20%		229.02	1,216.35
	3	ONION	4.00%	3.20%	4.80%	3,404.39	13,307.77	4.00%		136.18	532.31	4.80%		163.41	638.77	4.80%		163.41	638.77
		TOTAL						100.00%	100.00%	4,274.77	9,622.17	100.00%	100.00%	4,088.20	9,780.08	100.00%	100.00%	4,135.46	10,465.28

Annual Available Water for Irrigation	**AW**		1,686,000 m³	1,686,000 m³	1,686,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	394.41 ha	**412.41 ha**	407.69 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,795,056 TL	4,033,362 TL	**4,266,628 TL**

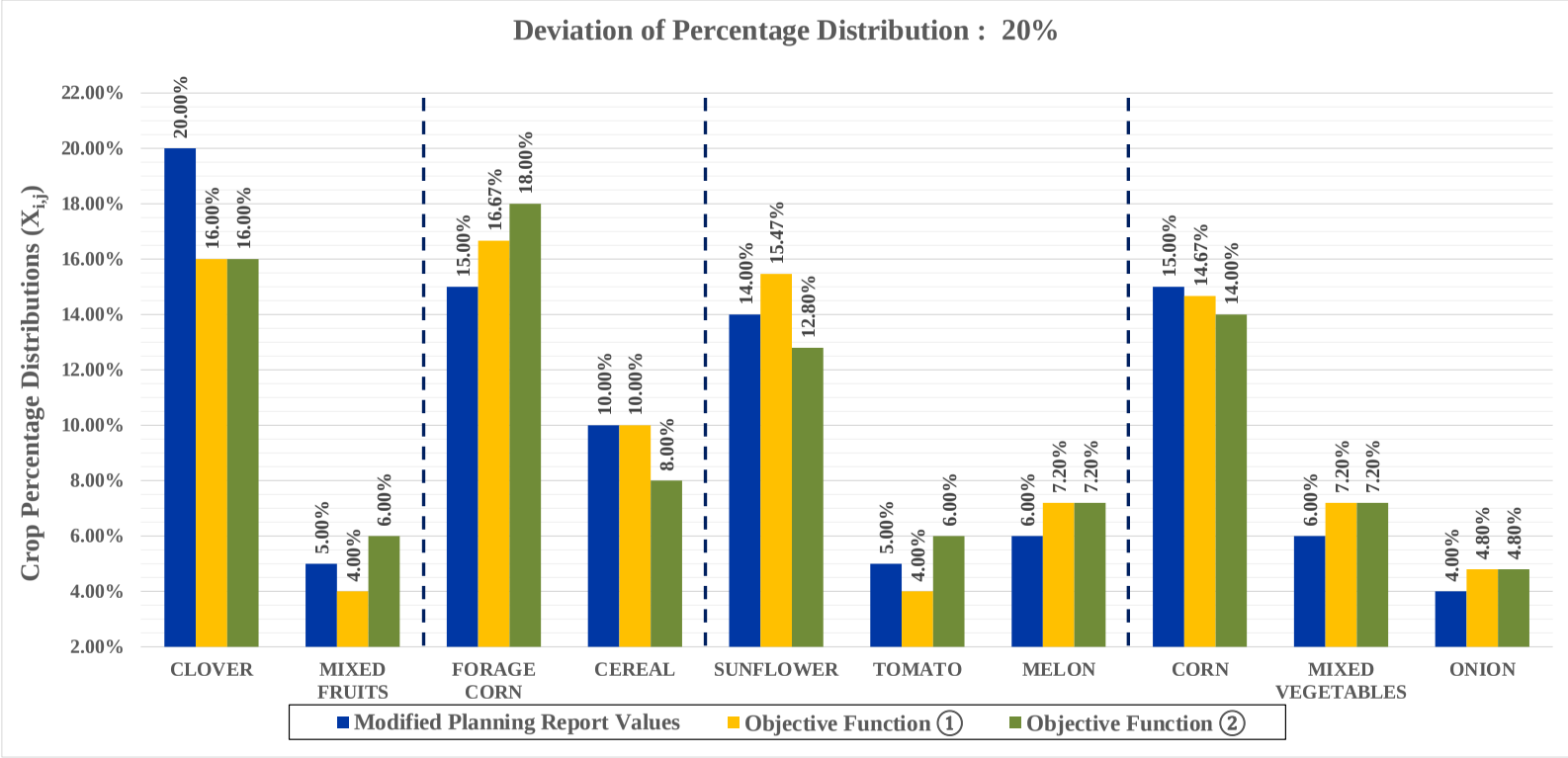


Figure B.34 KLV Project - 20% of deviation of crop percentage distribution results

Table B.35 KLV Project - 25% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KILAVUZLU POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 25%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
			$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$	$NP_{i,j}$	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP	$X_{i,j}$	$\sum X_{i,j}$	TDR	NP
i	j					*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*			*(m³/ha)*	*(TL/ha)*
1	1	CLOVER	*20.00%*	15.00%	25.00%	7,274.62	4,488.38	**20.00%**	**25.00%**	*1,454.92*	*897.68*	**15.00%**	**18.75%**	*1,091.19*	*673.26*	**15.00%**	**21.25%**	*1,091.19*	*673.26*
	2	MIXED FRUITS	*5.00%*	3.75%	6.25%	4,089.29	27,350.57	**5.00%**		*204.46*	*1,367.53*	**3.75%**		*153.35*	*1,025.65*	**6.25%**		*255.58*	*1,709.41*
2	1	FORAGE CORN	*15.00%*	11.25%	18.75%	3,514.80	8,937.92	**15.00%**	**25.00%**	*527.22*	*1,340.69*	**17.08%**	**27.08%**	*600.44*	*1,526.89*	**18.75%**	**26.25%**	*659.02*	*1,675.86*
	2	CEREAL	*10.00%*	7.50%	10.00%	2,575.89	4,773.47	**10.00%**		*257.59*	*477.35*	**10.00%**		*257.59*	*477.35*	**7.50%**		*193.19*	*358.01*
3	1	SUNFLOWER	*14.00%*	10.50%	17.50%	4,216.58	8,768.76	**14.00%**	**25.00%**	*590.32*	*1,227.63*	**15.83%**	**27.08%**	*667.63*	*1,388.39*	**12.50%**	**26.25%**	*527.07*	*1,096.10*
	2	TOMATO	*5.00%*	3.75%	6.25%	5,299.90	18,921.00	**5.00%**		*264.99*	*946.05*	**3.75%**		*198.75*	*709.54*	**6.25%**		*331.24*	*1,182.56*
	3	MELON	*6.00%*	4.50%	7.50%	2,016.84	19,036.94	**6.00%**		*121.01*	*1,142.22*	**7.50%**		*151.26*	*1,427.77*	**7.50%**		*151.26*	*1,427.77*
4	1	CORN	*15.00%*	11.25%	18.75%	3,514.80	4,514.01	**15.00%**	**25.00%**	*527.22*	*677.10*	**14.58%**	**27.08%**	*512.57*	*658.29*	**13.75%**	**26.25%**	*483.28*	*620.68*
	2	MIXED VEGETABLES	*6.00%*	4.50%	7.50%	3,180.82	16,893.75	**6.00%**		*190.85*	*1,013.63*	**7.50%**		*238.56*	*1,267.03*	**7.50%**		*238.56*	*1,267.03*
	3	ONION	*4.00%*	3.00%	5.00%	3,404.39	13,307.77	**4.00%**		*136.18*	*532.31*	**5.00%**		*170.22*	*665.39*	**5.00%**		*170.22*	*665.39*
		TOTAL						**100.00%**	**100.00%**	**4,274.77**	**9,622.17**	**100.00%**	**100.00%**	**4,041.56**	**9,819.55**	**100.00%**	**100.00%**	**4,100.63**	**10,676.06**

Annual Available Water for Irrigation	**AW**		1,686,000 m³	1,686,000 m³	1,686,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	394.41 ha	**417.17 ha**	411.16 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,795,056 TL	4,096,376 TL	**4,389,527 TL**

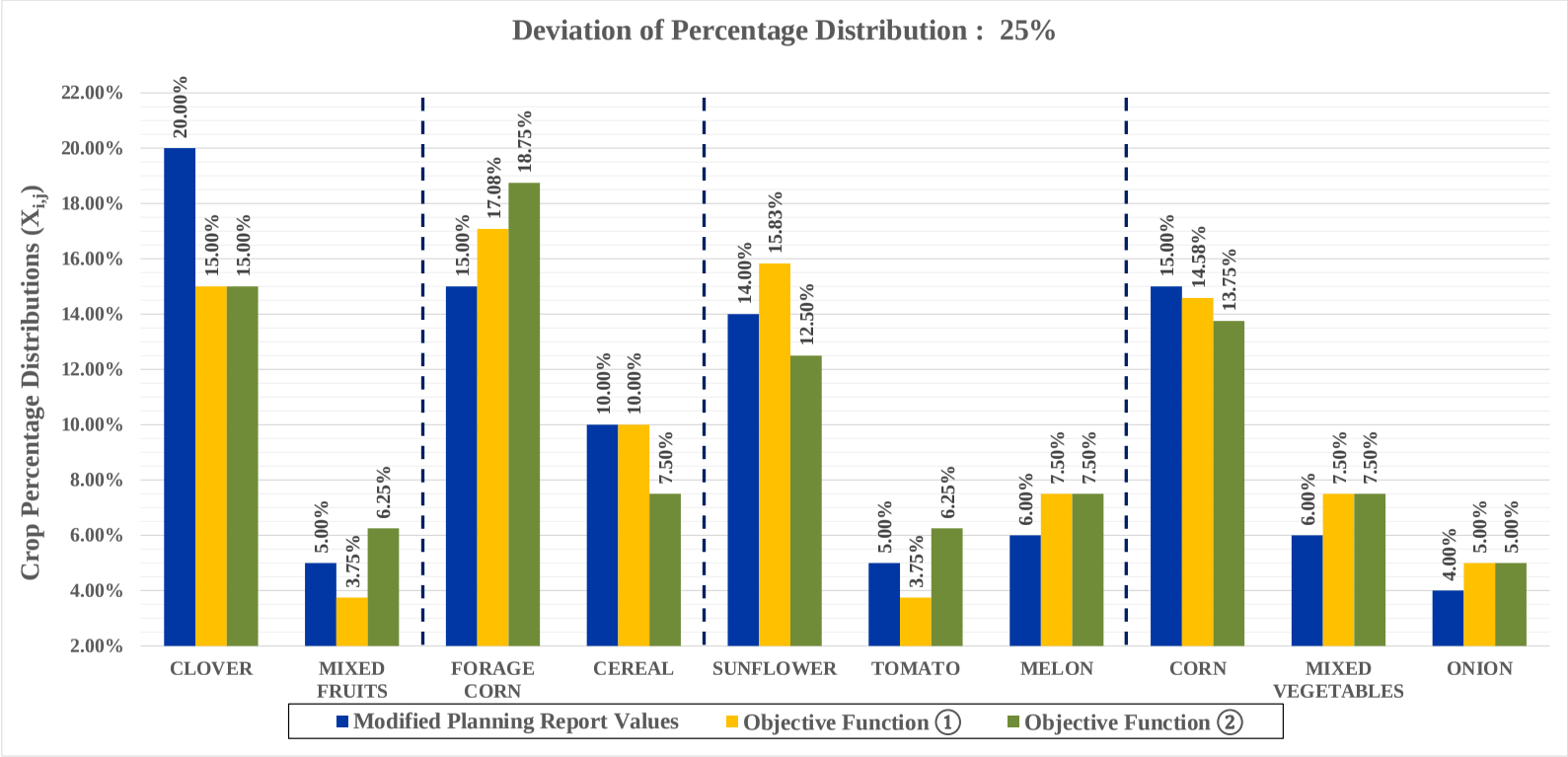


Figure B.35 KLV Project - 25% of deviation of crop percentage distribution results

Table B.36 KLV Project - 30% of deviation of crop percentage distribution results

MARMARA - TEKİRDAĞ - MERKEZ - KILAVUZLU POND and IRRIGATION SYSTEM

Deviation of Percentage Distribution : 30%

INPUTS												OPTIMIZATION RESULTS							
Crop Rotation Group	Crop Type	Crop Type	Lower and Upper Limits of Percentage Distributions ($X_{i,j}$)			Crop Irrigation Requirement	Agricultural Economy	Modified Planning Report Values				Objective Function ①	Optimization Solutions for Maximum Irrigation Area			Objective Function ②	Optimization Solution for Maximum Agricultural Profit		
i	j		$X_{planning}$	X_{min}	X_{max}	$TDR_{i,j}$ (m^3/ha)	$NP_{i,j}$ (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)	$X_{i,j}$	$\sum X_{i,j}$	TDR (m^3/ha)	NP (TL/ha)
1	1	CLOVER	20.00%	14.00%	26.00%	7,274.62	4,488.38	**20.00%**	**25.00%**	*1,454.92*	*897.68*	**14.00%**	**17.50%**	*1,018.45*	*628.37*	**14.00%**	**20.50%**	*1,018.45*	*628.37*
	2	MIXED FRUITS	5.00%	3.50%	6.50%	4,089.29	27,350.57	**5.00%**		*204.46*	*1,367.53*	**3.50%**		*143.13*	*957.27*	**6.50%**		*265.80*	*1,777.79*
2	1	FORAGE CORN	15.00%	10.50%	19.50%	3,514.80	8,937.92	**15.00%**	**25.00%**	*527.22*	*1,340.69*	**17.50%**	**27.50%**	*615.09*	*1,564.14*	**19.50%**	**26.50%**	*685.39*	*1,742.89*
	2	CEREAL	10.00%	7.00%	10.00%	2,575.89	4,773.47	**10.00%**		*257.59*	*477.35*	**10.00%**		*257.59*	*477.35*	**7.00%**		*180.31*	*334.14*
3	1	SUNFLOWER	14.00%	9.80%	18.20%	4,216.58	8,768.76	**14.00%**	**25.00%**	*590.32*	*1,227.63*	**16.20%**	**27.50%**	*683.09*	*1,420.54*	**12.20%**	**26.50%**	*514.42*	*1,069.79*
	2	TOMATO	5.00%	3.50%	6.50%	5,299.90	18,921.00	**5.00%**		*264.99*	*946.05*	**3.50%**		*185.50*	*662.24*	**6.50%**		*344.49*	*1,229.87*
	3	MELON	6.00%	4.20%	7.80%	2,016.84	19,036.94	**6.00%**		*121.01*	*1,142.22*	**7.80%**		*157.31*	*1,484.88*	**7.80%**		*157.31*	*1,484.88*
4	1	CORN	15.00%	10.50%	19.50%	3,514.80	4,514.01	**15.00%**	**25.00%**	*527.22*	*677.10*	**14.50%**	**27.50%**	*509.65*	*654.53*	**13.50%**	**26.50%**	*474.50*	*609.39*
	2	MIXED VEGETABLES	6.00%	4.20%	7.80%	3,180.82	16,893.75	**6.00%**		*190.85*	*1,013.63*	**7.80%**		*248.10*	*1,317.71*	**7.80%**		*248.10*	*1,317.71*
	3	ONION	4.00%	2.80%	5.20%	3,404.39	13,307.77	**4.00%**		*136.18*	*532.31*	**5.20%**		*177.03*	*692.00*	**5.20%**		*177.03*	*692.00*
		TOTAL						**100.00%**	**100.00%**	**4,274.77**	**9,622.17**	**100.00%**	**100.00%**	**3,994.92**	**9,859.03**	**100.00%**	**100.00%**	**4,065.81**	**10,886.84**

Annual Available Water for Irrigation	**AW**		1,686,000 m³	1,686,000 m³	1,686,000 m³
Irrigation Area Size	**A**	*= [AW / TDR]*	394.41 ha	**422.04 ha**	414.68 ha
Total Agricultural Profit	**TP**	*= [A × NP]*	3,795,056 TL	4,160,862 TL	**4,514,532 TL**

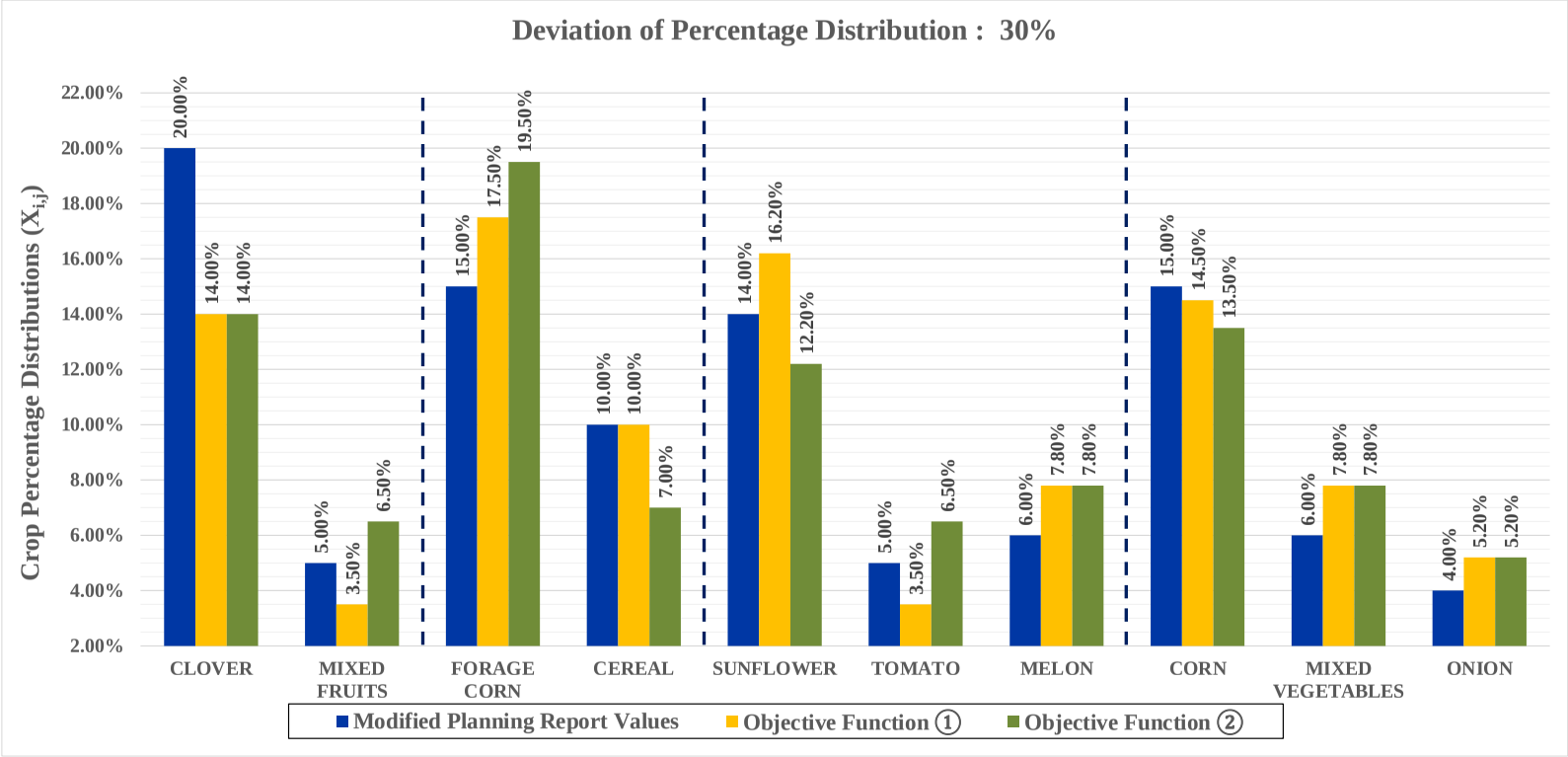
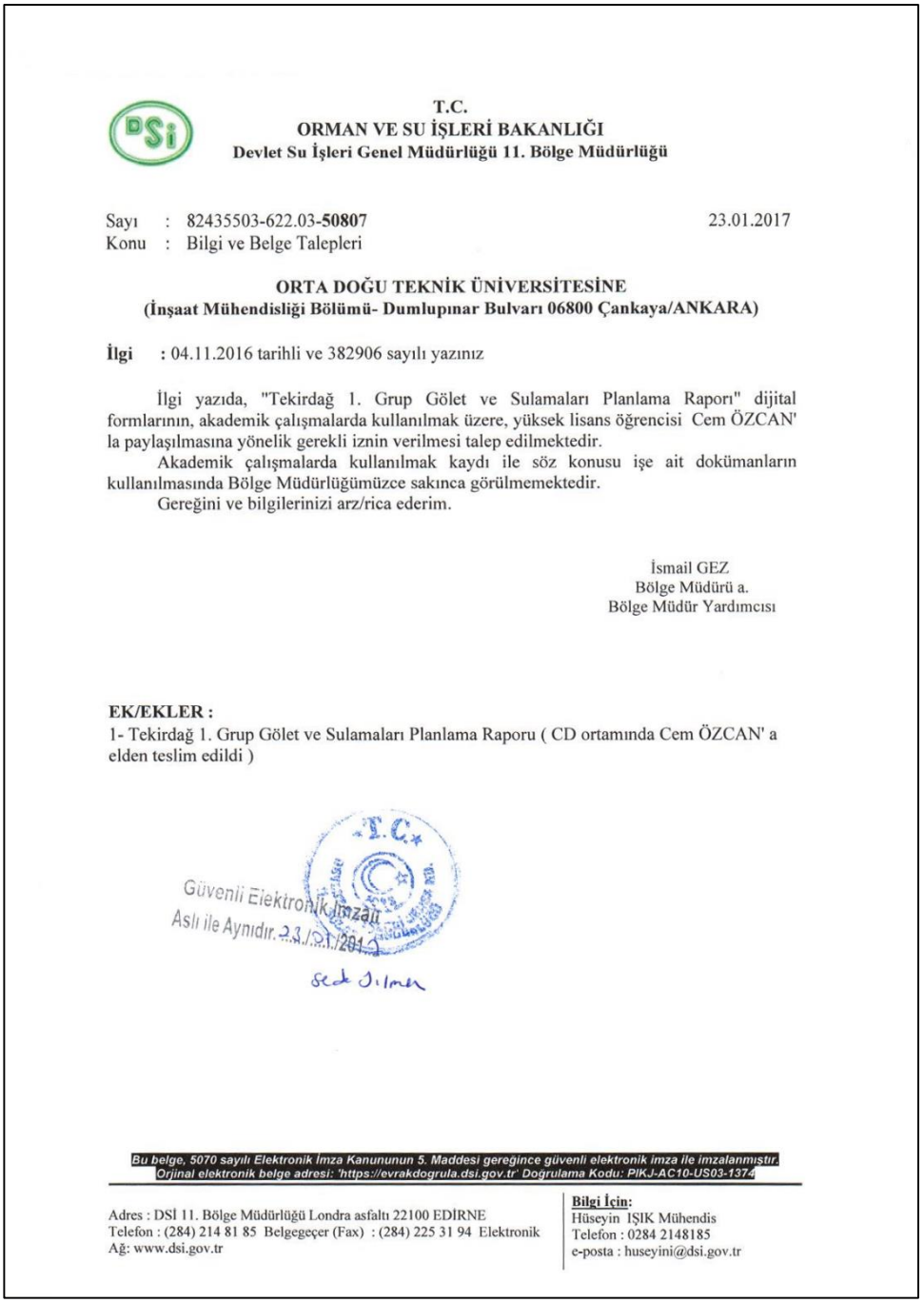


Figure B.36 KLV Project - 30% of deviation of crop percentage distribution results

APPENDIX C

PERMISSION LETTER REGARDING DATA USE



T.C.
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Devlet Su İşleri Genel Müdürlüğü 11. Bölge Müdürlüğü

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Konu : Bilgi ve Belge Talepleri

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