WELFARE EFFECTS OF ALTERNATIVE IRRIGATION WATER PRICES ON FARM HOUSEHOLDS:

A CASE STUDY OF LAKE URMIA BASIN, IRAN

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By

Farah Asna Ashari

Supervised by

Prof. Dr. Helmut Karl

Prof. Dr. Wilhelm Löwenstein

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LIST OF ABBREVIATIONS

AIC	Akaike's Information Criterion
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium
CIWP	Conservation of Iranian Wetlands Project
CVM	Contingent Valuation Method
DoE	Department of Environment
EMP	Econometric Mathematical Programming
EPA	United States Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
FWD	Fair Water Distribution
GDP	Gross Domestic Product
HH	Household
ICWE	International Conference on Water and Environment
IRR	Iranian Rial
IWRM	Integrated Water Resources Management
IWRMC	Iran Water Resources Management Company
MoAJ	Ministry of Agricultural Jihad-Iran
MoE	Ministry of Energy
MRS	Marginal Rate of Substitution
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square
PMP	Positive Mathematical Programming
RCUWM	Regional Centre on Urban Water Management
RESET	Regression Specification Error Test (RESET) of Ramsey
RTS	Returns to Scale
SAM	Social Accounting Matrix
SCI	Statistical Center of Iran
VIF	Variance Inflation Factor
VES	Variable Elasticity of Substitution
VMP	Value of Marginal Product
WAD	Water Allocation Directive

INTRODUCTION

Statement of the Problem

Human-ecosystem interactions have largely been ignored by people, especially in developing countries. As most ecosystems services are characterized as public goods and there are difficulties in quantifying their value to the society, the costs of consuming ecosystem goods and services are not assigned properly. The effect of human activities on ecosystem has no price and is seldom considered in decision making by governments. Increasing research and knowledge on global environmental change tends to focus more on the relationship between human activities and sustainable development plans. Sustainable development refers to the economic and social development together with the protection of environmental quality. In a sustainable development program, protection and conservation of the ecosystem have the same importance as the key functions of these resources in economic activities.

Most developing countries are significantly dependent on natural resource services through agricultural products for consumption and exchange, as well as agricultural exports and tourism. Rural poor people in developing countries are heavily reliant on subsistence agriculture and more vulnerable to environmental deterioration. Despite the importance of natural resources and environmental goods in rural life, it received less attention when concerning agricultural activities.

Iran as a developing country in the Middle East is experiencing major challenges regarding to water as a major resource in agriculture. The country has an area of more than 1.6 million square kilometers of which about 51 million hectares is cultivable land (Frenken, 2008, p. 185). The annual precipitation ranges from 25 millimeters on the Central Plateau to over 2000 millimeters at the Caspian Coastal Plain (FAO, 2005). Approximately 84.5 percent of the country falls within arid and semiarid zones (ICE, 2016). In the years 2012-14, about 28 percent of the total area was agricultural land of which 16.6 percent were irrigated lands (World Development Indicators , 2016). Population and economic growth, development plans, self-sufficiency goals, and climate change are putting a large pressure on natural resources, and in particular on water resources in the country. Increasing water scarcity is now one of the important challenges for the government and people. As agriculture is the largest water user in the country, meeting these challenges requires policies that improve irrigation water allocation and water efficiency in the sector. On the other hand, farmers in developing countries are usually providing food for the family subsistence from their field and not for the market. Twenty-seven percent of Iran's population lives in rural areas whose main activity is agriculture (Motamed, 2017). Landholders are mainly independent small-scale farmers. In 2003 seventy-two percent of farmers cultivated less than 5 hectares (Frenken, 2008, p. 185). They belong to the lower income group of the country where any policy affecting their income should be considered carefully.

This study is an attempt to examine the effect of water pricing policies in a water-stressed country on farmers' welfare through a case study approach. The aim is to examine the effect of increasing irrigation water prices on farmers' welfare in Iran in order to examine the socio-economic aspects of a natural resource protection target. To study this situation, we took Lake Urmia basin in Iran as a case study.

Lake Urmia is located in the northwest of Iran and the basin with an area of 51,876 square kilometers holds nearly seven percent of Iran's water resources. Massive economic development plans, dam building and diversion of the surface water mainly for irrigation, expansion of agricultural land in the basin in the last thirty years, as well as climate change issues, downward trend of precipitation and drought in the area have affected the water resources in the basin and the whole ecosystem of the lake. The basin is extremely short of water. The water level of the lake has dropped and the area is shrinking at an alarming rate. If this trend continues, the lake might dry up and vanish like the famous Aral Sea. The critical situation of the lake and the basin drew increasing national and international attention to the area since 2000. Several local and international organizations as well as national policy makers have been searching for ways to reassess the development plans, considering the sustainability goals that target socio-economic development as well as the reversal of the loss of environmental resources. This study tries to provide an insight into the socio-economic impacts of a hypothetical water resource policy on subsistence farmers who rely on water for their basic needs.

Scope of the Study

This study is implemented in Lake Urmia basin in Iran. The dominant economic activity in Lake Urmia basin is agricultural activities which accounts for about 75 percent of total water use before urban and industry users (Yekom, 2002). Irrigation water in this area is provided at low charges or free for farmers. This research investigates the impact of hypothetical changes in irrigation water prices on farm households in the basin, in particular on their welfare situation. We measure how increasing irrigation water prices affect farmers' production. It is expected that increasing water prices tend to less production and less farm revenue for the farmers.

The study is based on a cross sectional primary data set collected from 9 villages in 2 districts of the basin in 2013. This data is used to examine the following objectives.

Objective 1: to identify the determinants of crop production

A production function approach is used to find the determinants of crop production in the area and their effect size on the production. This will support us in the next step of the study which will focus on effect of water prices on crop production.

Objective 2: to measure the effect of water price changes on farm households' welfare

A water demand function is used to estimate the effect of irrigation water price changes on water use in agriculture. This result in combination with the results from the first objective is used to measure the effect of changes in irrigation water prices on farmers' water use and crop production. Then the welfare changes due to these changes is calculated. It is expected that increasing irrigation water prices will decrease water use and less water in irrigation will decrease crop production. Therefore, increasing water prices will tend to farm households' welfare loss.

Objective 3: to examine the distributional effects of irrigation water price changes

Finally, we investigate the distributional effects of irrigation water price changes on inequality in the sample. We measure the income distribution among farm households before and after irrigation water price changes to see if this will affect the income distribution in the sample or not.

It should be mentioned that the net welfare effect of changes in water pricing is expected to be positive, irrespective of the welfare effect of the irrigation water price changes on farm households.

Organization of the Study

Following this introduction, the rest of the study is structured in four chapters as follows:

Chapter one as the background of the study provides an overview of the importance of irrigation for agricultural outputs. A summary of some studies on the impact of water pricing schemes on farmers is also presented in this chapter. This helps us discovering the relevant variables, identifying the relevant theory and methodologies as well as establishing the context of the problem. The chapter will be closed by the direction of the thesis which clarifies the research questions in detail.

Chapter two is the base for the theoretical structure as a framework to develop the model of the study. First the methodological approach to natural resource valuation is described to justify the chosen methodology for the study. Then the theoretical foundation of the empirical model used for the research is explained. This will identify the research variables and the relationship between them. Bridging together the theory and practice, the model of the study is constructed at the end of this chapter.

Chapter three is devoted to the main part of the research namely the empirical part of the study. The chapter begins with the description of the research area and its background. This is followed by the sampling and questionnaire design for data collection. The rest of this chapter deals with descriptive and inferential data analysis, quantitative results and their interpretation.

The final chapter begins with highlighting the main findings of the study. The remaining sections of this chapter deal with the limitations and shortcomings of the study and some additional future directions and suggestions.

CHAPTER ONE

RESEARCH BACKGROUND AND FRAMEWORK

1.1. Introduction to Chapter One

Wetlands[1] are one of the most productive, highly variable and dynamic ecosystems in the world with a range of important functions (EPA, 2017). Since 1900, more than half of the world's wetlands have been lost (Barbier E. B., 1993, p. 22). These losses and threats are caused by: (1) the public nature of many wetlands products and services; (2) user externalities imposed on other stakeholders; and (3) policy intervention failures due to a lack of consistency among government policies in different areas, including economics, environment, nature protection, etc. (Turner, et al., 2000, p. 7).

Water resource development plans undertaken to face water scarcity and increase its accessibility for human societies, is one of the major challenges in water and wetland interactions which is critical for ecosystem survival (Barbier E. B., 1993, p. 32). Seckler et al. (1999) point out that water scarcity is the greatest threat to food security, human health and natural ecosystem, especially in arid regions of the world. The authors estimate that by 2025, nearly a quarter of the world's population will experience severe water scarcity.

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[1] Article 1.1. Ramsar Convention on Wetlands: "Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters." (Grobicki, et al., 2016).

Striking a balance between economic development and water resource degradation and depletion secures economic development without imposing excessive costs or loss of environment. Due to the important environmental services provided by water resources, management of water resources involves environmental concerns as well as economic. There are important water uses with high environmental, cultural or social relevance, which are not economically valued. Water as one of the most valuable environmental assets provides a flow of goods and services, physical as well as aesthetic and intrinsic, while many of these water-related services are not valued in markets. For an efficient and sustainable utilization of water resources the non-marketed gaps must be identified and monetized in order to gain the real economic value of water (Turner, Georgious , Clark, Brouwer, & Burke, 2004, p. 11). Governments' control, in allocating water in accordance with these societal needs as well as long-term sustainability and the future generation needs, is required in a multi-interest environment.

Global concern over the intense and rising demand for water has led to the essential need for water resource management in order to ensure efficient allocation and proper distribution. Sustainable management studies may help to identify different water demands among sectors and enhancing welfare through reallocating water supplies. One of the first attempts for understanding and analyzing water values in different uses was provided by Young and Gray (1972). They examined water demand and its determinants as well as the empirical methods for estimating the value of it. Gibbons (1986) tried to update their work by applying different valuation techniques to estimate value of water-use in a number of sectors i.e. municipal, agricultural, industrial, hydropower, recreation and aesthetics. Because of the differences in definitions, time frame and applied procedures, a sector-by-sector comparison of results was not possible. Besides, the physical and economic aspects of water use were not integrated and the external impacts among sectors were not considered.

Integrated Water Resources Management (IWRM) as part of a global effort in use and protection of the water resources has been defined and recommended in the International Conference on Water and Environment (ICWE)[2] stating that:

[2] Dublin International Conference on Water and Environment (ICWE, 1992)

> "IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". [3]

Combining Colin Green's view on economics as "the application of reason to choice" with one of the four Dublin (ICWE) principles, namely "water as an economic good," maintains the requirement of an integrated approach to water resource management and making choices about the allocation and use of water (van der Zaag & Savenije, 2006, p. 7).

Water management in wetlands has often been oriented towards a variety of human uses and interventions that can alter the function of wetlands and eliminate its potential benefits. For the purpose of water retention, man may construct dikes, dams and reservoirs on rivers feeding wetlands to prevent flooding, reduce water shortage for drinking, irrigation and or electricity production purposes. Drainage of polders or fields is carried out to create new land for agricultural, industrial or urban purposes. Different activities such as canalization of waters in wetlands to improve the flows within a river basin or to transfer water to high demand areas, exploitation of surface water and groundwater through pumping or excavation may be distinguished (Schuijt, 2002, p. 7). It is estimated that 87 percent of the wetlands in the United States have been lost due to agricultural development (Maltby, 1986, p. 90).

1.2. Importance of Irrigation in Agriculture

This section deals with the importance of irrigation in agriculture and water efficiency issues in irrigated agriculture in the world plagued by growing water scarcity problems. Irrigated agricultural productivity is greater than rain-fed agriculture. Farmers use less land in irrigated farming than rain-fed for the same yields. Moreover, irrigation also enables expansion of the land under cultivation. Demand pressure for food in developing countries as well as climate change and less reliable rain-fed agriculture, leads the agriculture to more water abstraction and more land expansion. This tends to more stress on water resources especially in arid and semi-arid countries with water scarcity problems (FAO, 2004).

[3] (Hassing, Ipsen, Clausen, Larsen, & Lindgaard-Jørgensen, 2009, p. 3)

Agriculture is identified as the largest user of water to produce food for the world. The Food and Agriculture Organization (FAO) projects an expansion of agricultural lands to 242 million hectares by 2030 for ninety-three developing countries. This analysis anticipates irrigation water withdrawal in developing countries will grow by 14 percent from 2000 to 2030. It is important to highlight that agricultural water use will be in an increasing competition with other water users; i.e. municipal, industrial uses and calls for environmental protection. Therefore, the role of improving water-saving technologies as well as irrigation water management policies to support improved agricultural productivity is considered a cornerstone of food supply, food security, and poverty reduction especially in developing world ((FAO, 2003).

Estimates of total water abstraction from rivers, lakes, and aquifers for irrigation indicate that the volume extracted is considerably larger than consumptive use for irrigation because of the conveyance losses. Water efficiency is the ratio between estimated plant requirements and actual water withdrawal which is an indicator for the level of performance of irrigation system from the water resource to the plant. It is estimated that the average irrigation water efficiency in developing countries is 38 percent. Improving water efficiency is a difficult long-term plan (FAO, 2003).

From the two key ingredients for maximizing agricultural production with limited water resources, people and technology, people are more important. There is no benefit in improving technology if people ignore using it because they don't understand it or don't see any advantage in it, or cannot use it for any reason such as financial barriers. Efficient water use can be made everyone's business by educating children, improving water users' awareness, and class and gender equity in water management schemes (FAO, 2001).

Hagos et al. (2009) quantified the contribution of irrigation to the Ethiopian economy for the 2005/2006 and 2009/2010 cropping seasons. Based on their study irrigation contributed approximately 5.7 percent and 9 percent to agricultural Gross Domestic Product (GDP) in 2005/2006 and 2009/2010 cropping seasons, respectively. They closed their study with some recommendations for developing the planned irrigation infrastructure and enhancing the efficiency and productivity of the agricultural system.

Burke and Moench (Burke & Moench, 2000) stated their concern about the groundwater management in their book published in 2000. They believe that groundwater has not been noticed and considered as other water resources in economic, social, and environmental systems though its quality and quantity affects the groundwater-dependent users who are mostly in agricultural sector. Groundwater services are of fundamental importance to the human society and its problems threatens a wide array of services from food security and clean drinking water to the environmental features. Burke and Moench recommend a high level of stakeholders' participation and more adaptive approaches to local resource management to evolve the system in local, regional, and national level. These are long-term solutions as neither the society nor the aquifer system respond immediately to technical management solutions.

Continuous overexploitation of water resources in many parts of developing world, particularly in arid and semi-arid regions is threatening water resources and food security. Agriculture will remain the dominant user of water placing a serious burden on the environment at the global level. In arid and semi-arid countries, this pressure is expected to be intensified. In these regions irrigation agriculture has still a big potential for increasing water productivity to help food security and poverty reduction as well as more positive contribution in environmental management. Some national development plans such as construction of dams have failed to recognize the externalities of these projects on farmers and pushing them into poverty. Agriculture as the largest water user has also some negative externalities in terms of water. Water pollution, land degradation, over abstraction of ground water are some examples of agricultural negative externalities. The competition for limited water resources increases the pressure on agricultural activities to internalize environmental impacts of irrigation and improve water policies and institutions. In the second half of the twentieth century, a significant share of the overall agricultural budget of many developing countries was allocated to irrigation infrastructure (FAO, 2003). It is argued that environmental trade-offs will be more difficult with more losers than winners in the next decades than in the last few decades (OECD, 2001). However, there are many opportunities for leading agriculture to a more sustainable path, with benefits for both farmers and consumers, North and South. Market signals can be corrected to include the value of environmental goods and services, farmers can be educated to produce in a sustainable way, poor farmers can be supported to react better to environmental and market signals (Mortimore

& Adams, 2001). The favorable pattern of future agro-environmental impacts consists of trade-offs between increased agricultural production and reduced pressures on the environment.

1.3. Impact of Water Pricing Schemes on Farmers

The theoretical framework for this study is taken from several literatures on irrigation water pricing and its effect on farmers' income and welfare. Hoyt's study (1984) in Texas and Washington State showed that water supply restrictions had a small effect on farm profits. Farmers switched to a more water-efficient mode of operation by substituting water with the labor. Only significant increases in water price will induce farmers to invest in the modern irrigation technology.

Echevarria (1998) estimated a constant return to scale agricultural production function of the three primary factors of production, i.e. land, labor, and capital. She used disaggregated Canadian data over the period 1971-1991 for the estimation. According to her results, capital intensity was similar in the three sectors but agriculture was less labor intensive than services and industry. Furthermore, the share of land in value added was estimated to 16 percent. However, the total factor productivity growth in agriculture and manufactures in Canada were the same, i.e. 0.3 percent.

Varela-Ortega et al. (1998) built a dynamic mathematical programming model to compare the price elasticity of irrigation water demand in three regions of Spain with different irrigation systems. Their empirical results showed that in districts with low technical efficiencies, the response to increasing water prices was higher than in districts with modern irrigation systems. They concluded that water demand curves were more elastic in relatively inefficient regions. An OECD[4] (1999) study claimed the same result, that technical endowment has a major effect on agricultural demand response to water pricing.

Acharya and Barbier (2000) applied a production function approach to estimate welfare changes due to hypothetical changes in groundwater recharge in the Hadeja-Nguru wetlands

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[4] Organization for Economic Co-operation and Development (OECD)

in northern Nigeria. Their study indicated that the groundwater recharge function of the wetland was of significant importance for the area.

Perry (2001) estimated the productive value of irrigation water in Iran which was tenfold larger than irrigation water price. He concluded that in this case the required price increase to induce water savings is tenfold.

Scheierling et al. (2003) developed a simulation/mathematical programming model to investigate the farmers' response to the hypothetical increase in irrigation water prices in northeastern Colorado. They analyzed the effect of changes in irrigation water prices on both the demand for withdrawal and the derived demand for consumptive use. The results indicated that the consumptive use demand was significantly less price-responsive than the withdrawal demand.

Tsur et al. (2004) investigated the effect of water price changes on income distribution and efficient allocation of water in South Africa, Turkey and Morocco as case studies. Empirical finding revealed that water price changes could be applied as a tool in order to increase water efficiency use but had a small effect on income distribution. The district analysis indicated that the steeper the demand curve, the lesser responsive farmers were to changes in water prices. Farmers' response to irrigation water prices depended on their capacity to adapt, for example, crop mix, soil type, changing technology, access to market, prices of other inputs and existing water institution.

Scheierling et al. (2006) in a meta-analysis investigated the source of variation in the results of studies on price elasticity of irrigation water demand estimated in 24 studies reported in the United States over the span of 40 years. The mean price elasticity from all studies was -0.48. Results showed that the magnitudes of price elasticity of water demand were affected by the method of analysis. Mathematical programming studies are likely to produce more elastic estimates than econometric studies and the studies based on field experiments. A separate regression for the field experiment studies revealed that the water price had a significantly positive impact on the price elasticity estimates, but the impact is lesser than mathematical programming and larger than econometric studies results.

Birol et al. (2006) presented a survey and critical appraisal of economic valuation techniques to capture the total economic value of water resources in order to define the role of economic valuation techniques in designing efficient, equitable, and sustainable policies for water resource management. These valuation techniques provided a movement from private cost-benefit analysis of a project to an estimation of the social cost-benefit of an activity. In their study production function approach was explained under the revealed preferences method. They also applied a Contingent Valuation Method (CVM) to estimate the non-use value of a wetland in Greece as a case study, in the final part of their work.

Schoengold et al. (2006) used a panel data set from California's San Joaquin Valley to estimate the role of water in farm production function. They measured the price elasticity of farm water demand as a tool in water demand management. The results showed that farmers responded to an increase in the marginal price of water by reducing their water application as well as alternating their land allocation. It was concluded that the price elasticity of agricultural water demand was -0.79, which showed that under moderate prices agricultural water demand was more elastic than found in previous studies.

Huang et al. (2006) introduced increasing irrigation water prices as a policy to provide water users with direct incentives to save water. Results show that in their sample area in China, irrigation water was underpriced and farmers would not respond to the increase in water prices otherwise unless the price was increased to the level of value of marginal product (VMP) which reflected the true value of water. However, this dramatic water price increase could lead to farmers' income losses as well as worsening the crop income distribution. Therefore, an integrated package of policies is needed to achieve water savings without hurting the rural sector.

Fraiture and Perry (2007) in their study examined for what reasons the agricultural water demand is irresponsive at low water prices. They stated that at low water prices, farmers' decisions were independent of price and their water demand was irresponsive to the pricing. Irrigation water use primarily was dependent on the land quality, crop choice, agronomic considerations and structural factors such as availability of capital and labor. They believed that it is only beyond a certain threshold that the demand becomes elastic. In their analysis they did not include some factors influencing effectiveness of pricing, such as risk due to fluctuations in revenue, uncertainty in water supply, and difficulties in implementation, which they claimed these may not significantly affect the conclusion of their study.

Gill and Punt (2010) conducted a study in South Africa on water pricing as an important component of water demand. They applied a Computable General Equilibrium (CGE) model and Social Accounting Matrix (SAM) to investigate the impact of increasing irrigation water tariffs on the economy. The results of their study showed that an increase of water tariffs by 50 percent decreased agricultural production and threatened food security. In addition, higher water tariffs decreased national and household welfare, employment and increased imports and the prices of staple food.

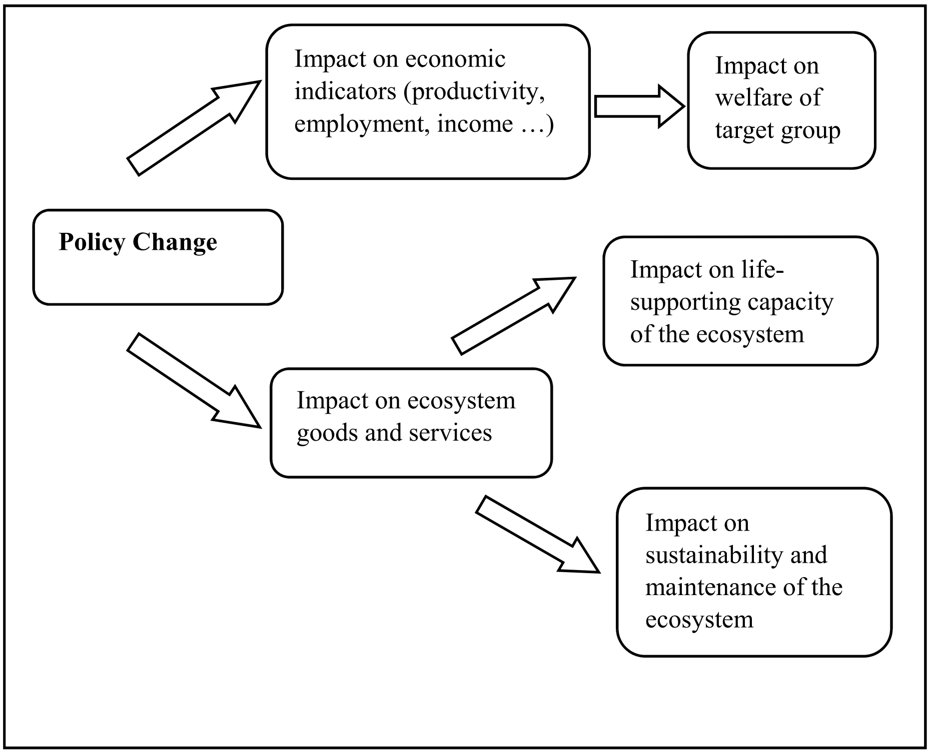
Zamanian et al. (2013) studied the welfare effect of different irrigation water pricing methods in Iran in order to find the optimal allocation considering the social and economic issues. They applied Positive Mathematical Programming (PMP) and Econometric Mathematical Programming (EMP) to measure the welfare effect of alternative water pricing methods. Their results suggested that applying the block tariff in the range or 198 to 853 IRR is an optimal pricing method.

1.4. Direction of This Research

This study deals with the failures of development policy interventions due to lack of attention to environment and nature protection by exemplifying the irrigation districts of one of the ecologically important lakes and its basin, i.e. Lake Urmia, in Iran. There is an overuse of water in Lake Urmia region due to the public goods characteristics of the water along with the unsustainable agricultural development schemes and the lack of reinforcement of sound rules for water users by the government. One attempt of regulating the overuse and increasing the efficiency of water utilization is the imposition of higher prices on the water users. However, a considerable part of the water users in the region consists of poor farmers, who are relying on cheap/free access to water. Therefore, the attempt to increase the efficiency in water utilization by imposing (higher) water prices, potentially, would contradict with the societal goals such as poverty reduction and food security. Higher prices would produce losses to the rural poor and may put food security at risk: higher water prices potentially lead to higher farm expenditure, reduced irrigation, reduced agricultural production (food security at risk), and reduced farm revenues which overall adds up to a reduction in poor farm households' income and aggravates poverty.

Figure 1.1 shows the impact of policy changes to human well-being and ecosystem maintenance.

Figure 1.1. Impact Pathway of Policy Change to Human Well-being and Ecosystem Maintenance



Source: own synthesis

In this study we focus on the impact of a policy on welfare of the target group. The research investigates the hypothetical alternative water prices effect on farm households' welfare. This attempt, as a help for policy makers, determines a more desirable way for water management plans from the socio-economic perspective. From this goal, some research objectives and subsequent questions emerged and developed to design the study. These questions are formulated and summarized as follows:

1- To identify and analyze factors affecting the crop production by farm households

- What are the crop production determinants in the area, including the availability of water for irrigation?
- How much is the effect of each determinant on production?

2- As a corollary of (1), to measure the effect of irrigation water price policies on farm households' welfare

  - What are the impacts of changes in irrigation water prices on crop production and farmers' revenue?
  - To what extent it influences the farm households' welfare?

3- To examine the distributional effect of irrigation water price changes

  - How do alternative irrigation water prices affect the welfare of farm households with different socio-economic status?
  - Do irrigation water price changes affect the income distribution in study sample?

CHAPTER TWO

METHODOLOGICAL AND THEORETICAL FOUNDATION

2.1. Introduction to Chapter Two

This chapter, as the research framework, covers the general methodology and theoretical foundation of the study. After the introduction, sections two and three discuss the framework for total economic value of the environmental goods and services, and summarizes the approaches and methods towards economic valuation. Section four highlights the empirical strategy and the specific method employed by this study and its appropriateness. Sections five and six explain the theoretical framework of the study.

2.2. Ecosystem Valuation

Ecosystem services evaluation is a new field of study where methods to derive are not straightforward (Fisher, Turner, & Morling, 2009, p. 652). From a general classification perspective, total value of an ecosystem is divided into three types: ecological, socio-cultural, and economic value. The ecological value becomes evident in the casual relationship between parts of the system which is determined by provisioning and regulation functions of the ecosystem as well as by ecosystem parameters such as diversity, renewability, rarity (Fisher & Christie, 2012). The socio-cultural value of an ecosystem to human well-being is based on cultural perceptions in human-ecosystem relationship. Therapeutic value, amenity value, and existence value are some of the indicators of socio-cultural value which is made explicit through spiritual, non-material benefits and their intimacy to human life that are typically found in cultural world vision. In some studies, socio-cultural values have been addressed within socio-economic services of the ecosystem (Schmidt, Sachse, & Walz, 2016). The economic value of goods and services provided by a natural ecosystem is based on efficiency and cost-effectiveness of the ecosystem. Productive use, consumptive use, income, and employment are some of the indicators to express the magnitude of the economic value of an ecosystem (Newcome, et al., 2005). A successful integration of ecology, socio-cultural values and economics is required for valuing ecosystem services (National Research Council, 2005).

In environmental economics literature several approaches towards assessing the economic value of environmental resources exist. The two main categories of total economic value used by economists are use value and non-use value. Since Krutilla (1967) total value has usually been divided into use and non-use values measured by the preferences of individuals. Use value comprises the direct and indirect use of the environment. Direct use values are built up of consumptive uses such as fisheries or water uses, and non-consumptive uses such as recreational and educational activities. Indirect use values are functional benefits provided by the ecosystem. This might include some functions such as retention, flood control, and nutrient recycling.

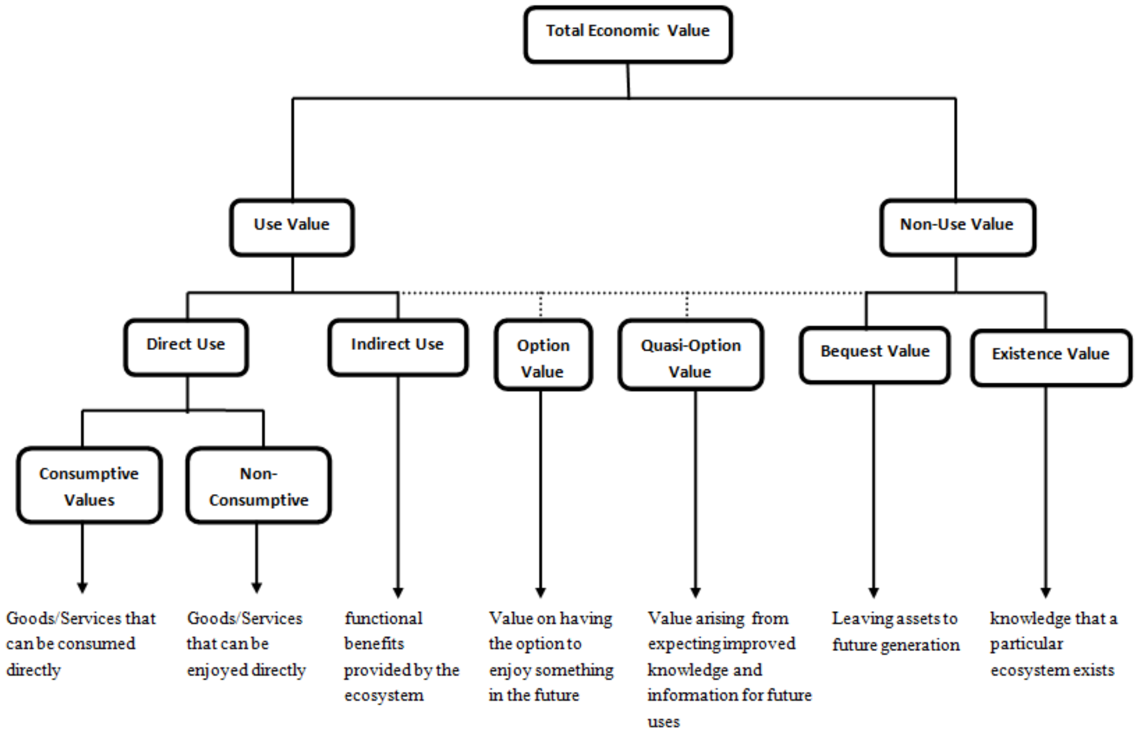
Non-use value, also referred to as passive use value, includes non-instrumental values of an ecosystem. The knowledge that a particular ecosystem exists (existence value) and continues to exist to be passed on to descendants to enjoy it in future (bequest value) has a kind of value and importance for some people even if they never use or see the resource or the amenity. They might be willing to pay for the species conservation or animals' welfare. Existence value, bequest value, and altruistic value are different types of non-use value which are not associated with any use of the ecosystem.

Finally, option and quasi-option values are potential future uses of an ecosystem which arise because people are not aware and certain about their future demands. It can be a form of insurance (option value) or wafting for improved knowledge and information for probable future uses of currently unknown goods and services (quasi-option value). While these two values are sometimes included among non-use values, they may also be considered as use values.

In general, some of the elements of total economic value are easier to measure than others. Non-marketed values are more difficult to be assessed and policy makers fail to consider them in their development policies and management decisions.

The scope of this study is to measure the economic value of nature, to be precise water as a specific element of nature in the case study region. Therefore, we focus on one aspect of the value (economic value) of one specific element of the ecosystem (water). Next section covers the methods for measuring economic valuation of natural resources for different types of values in order to choose the proper method for the study.

Figure 2.1. Total Environmental Economic Value



Source: Adopted from Turner et al. (2010), Brander et al (2010), and Barbier (2007).

2.3. Economic Valuation Methods If Nature Is a Factor of Production

Monetary-based valuation of natural resources has an extensive literature. Mitchell and Carson (1989) believe that the principal distinction among methods for measuring the economic value of environmental goods and services is based on the source of data. The source of data can be either how people act in the real world or their responses to questions of what they would do in a hypothetical situation. Based on the source of data, Mitchell and Carson (1989) distinguished between revealed preferences and stated preferences methods (Freeman III, 2003).

This study examines the economic evaluation of nature when it is used as an input in production. Because of the inverted U-shape relation between per capita income and environmental quality which is empirically documented in the environmental Kuznets curve literature, the demand for environmental quality in developing countries is low (McConnell & Bockstael, 2005, p. 624). Methods for measuring natural resources as an input in production function is not extensively studied compared to direct effects of environmental changes on consumption. This imbalance is a consequence of the fact that environmental changes have a small effect on manufactured goods in comparison to agricultural activities. Moreover, the environmental studies have emerged from developed world, where agriculture and natural resource extraction have a smaller share of economic activities rather than manufacture sectors. Since agriculture and natural resource extraction in developing countries are more important than in developed countries, and natural resource extraction and environmental degradation is largely influenced by agricultural activities, valuing the environment as an input is most common in developing countries (McConnell & Bockstael, 2005, p. 621).

What is in principle available in terms of tools for measuring the economic values of natural resources as an input in production are stated and revealed preferences methods. Stated preferences consist of a survey or experimental setting to simulate a market. The data is drawn from people's answers to hypothetical questions. The term Contingent Valuation Method (CVM) is used for the various approaches based on this form of questioning in a hypothetical market for measuring the economic value of environmental goods and services (Bockstael & Freeman III, 2005).

Despite of substantial progress in stated preferences techniques, they are more difficult to use in developing countries than the developed world. A choice modeling method was first applied in a pilot study for this research. The results from the pilot study were not satisfactory because many respondents found it difficult to assume a hypothetical market. A significant number of the respondents were not willing to pay for natural resources because of their low level of income or their expectations from the government to support them with low prices for farming inputs including water prices. Although they were aware of the importance and expressed a positive attitude toward the conservation of Lake Urmia basin, they were more concerned with their livelihood than protecting the natural resources. The unsatisfactory results from the pilot study led us to think of another method for doing the research. It is for similar reasons that tools involving actual economic markets are more reliable and applicable in developing countries. These tools aim at environmental goods and services which are tradable in markets or contribute in producing tradable goods and services.

The second category of economic valuation methods for natural resources as an input are revealed preferences methods. Revealed preferences methods are observed methods based on models that explain the actual behavior of people in real economic choices reflecting their utility maximization. In some cases, where the environmental goods and services do not have an offering price, the value held by people for the environmental goods and services in question is examined by the relationship between market goods and the environmental service (Bockstael & Freeman III, 2005). Hedonic pricing method, cost-based methods, market prices methods, and productivity methods are the most common methods within this approach which are in principle applicable for measuring economic valuation of nature as an input.

Hedonic pricing method: This method uses the information about the implicit demand for an environmental attribute of marketed goods. It is mostly used through changes in houses or property prices that reflect the changes in biodiversity or ecosystem services (Brander, et al., 2010, p. 19). This method could be applied in the case study region if data on the effect of water supply on the prices of farm land or housing were available. Water as a factor of production can affect farm revenue. More farm revenue motivates more people to enter farming activity in the area and tends to higher prices for farm land and housing in the area.

Farm land and housing prices in the area did not have an active market with high trading volume. Very few lands or houses are bought or sold in a year. Farmers have no clear estimation of their land or house prices (see section 3.6.2). A set of data for water prices and associated land prices is needed in this method. Due to the difficulties in collecting reliable and precise data, this method could not be applied for this study.

Cost-based methods: These methods estimate the costs of recreating the ecosystem services through artificial means. Cost-based methods focus on avoiding damages due to loss or at-risk services (damage cost avoided), the cost of replacing ecosystem services (replacement cost method), or the cost of providing substitute services (substitute cost method). These techniques do not provide a correct measure of the economic value of ecosystem but can be an approach to demonstrate the importance of the resource to policy makers. Some studies refer to these methods as "circumstantial evidence" or "imputed willingness to pay" (Brander, et al., 2010, p. 17).

Market prices methods: In a well-functioning market the price of goods or services times their marginal product is an indicator of their value. This approach is applied for ecosystem products or services that are bought and sold in actual markets (Brander, et al., 2010, p. 17). Adjusted market prices are a type of market price-based methods used to derive shadow prices[5] for distorted prices because of imperfect (non-competitive) markets, policy interventions and transfer payments (e.g. taxes and subsidies). When prices are not reflecting the real preferences and marginal costs, by examining the reaction of demand to variation in prices, the analyst can estimate the consumer surplus and hence value (Fisher, Bateman, & Turner, 2011, p. 6).

Productivity method: Productivity method, also known as production function approach, is used to estimate the contribution of ecosystem goods or services to the production of marketed goods along with other inputs. This method is applied where the environmental quality or quantity affects the productivity of land, labor and/or capital and therewith has an impact on the produced quantity of the marketed goods (Mäler, Gren Inge, & Folke, 2005). Any enhancement in using the ecosystem goods and services results in higher revenues

[5] Shadow pricing is a proxy value of a good, often defined by what an individual must give up to gain an extra unit of the good.

and/or lower variable costs, increases the quantity of the marketed goods and leads to an increase in the producer's surplus (Freeman III, 2003, p. 259). In such setting, the economic value of the ecosystem factor can be measured by observing the changes in producer's surplus from selling the marketed good that result from variations in the use of ecosystem factor (Brander, et al., 2010, p. 17).

In this study a production function method and adjusted market prices are used to capture the economic value of water, as a natural resource, in agricultural productions. These methods are used to estimate the value of goods and services which contribute to produce a marketed output. Decreasing water use as an input will affect the output. Since farmers act as price takers in the crops market, i.e. a perfectly elastic demand curve, the total net economic loss in the market can be estimated from changes in farmers' surplus resulting from decreased farm revenue. This loss is what governments should pay to farmers to compensate their loss to keep their welfare at the original level after reducing their water use.

One of the advantages of these methods is that they use standard, accepted economic methods, namely demand curve and economic surplus. Our experience with the pilot study with stated preferences methods indicates that results from these methods are more adequate and reliable than stated methods for the case study region. On the other hand, the scarcity of good quality data and limitations in data collection in the study region inclined the researcher to an approach that data requirements are limited and easier to obtain among several revealed methods.

2.4. Theoretical Foundation

This section elaborates the theory for measuring the welfare effects of changes in irrigation water prices as a natural resource. One of the revealed preferences methods, i.e. a productivity method in the context of farm households' production is applied in the research. This has the potential to assist policy makers in their decision-making process regarding compensation paid to the farmers to avoid social fallout, which might result from increased irrigation water supply prices. By establishing a link from production function, where water is one of the inputs, to the output and to the household revenue, the impact of raising water prices on farmers' revenue and their welfare will be addressed. This section begins with a background and brief description of producer surplus concept. Production function and profit maximization are discussed and followed by the effects of changes in the level of natural resources as a factor of production on producers' welfare. This will be ended by the theoretical perspective of price elasticity of demand which will be used for measuring water use changes in response to water price changes.

In the theories of value Walras (1834-1910) and Marshall (1842-1924) separately accommodated the interactions of both supply and demand as determinants of value within their equilibrium framework. The price and quantities traded in a market economy are determined at the intersection of consumer's demand and producer's supply which leads to the highest possible welfare for both and to the most efficient allocation of resources. Therefore, supply and demand curves are the fundamental necessities in determining the value in economics.

However, for untradeable goods and services, it is difficult to have the direct supply and demand curves. This is the case for most of the natural resources and environmental goods and services. Consumers use natural resources and pay only for explicit costs while implicit costs are not taken into account. This is the key concept in natural resources valuation, i.e. failure to notice the environmental costs of an economic activity brings up the external effects of an action. Side effects or externalities occur when some consequences of an activity are not reflected in the market price. In this case, unrelated parties in a certain activity may bear some costs or gain some benefits without being involved in that activity. The value of natural resources or the external costs or benefits of a production on environment is measured by use of a variety of indirect and direct methods.

In neoclassical welfare economics, individuals' welfare depends not only on their consumption of marketed goods and services, but also on non-market goods and services provided by environmental resources, although they might be free in supply. To obtain the monetary value and welfare information for changes in non-marketed goods or to overcome the market failures, two main approaches are available. We can either ask people directly about their preferences in stated preferences methods (Bateman, et al., 2002; Mitchell and Carson, 1989) or measure their revealed preferences from observation of their behavior in the markets (Bockstael & McConnell, 2007).

In this study we review the underlying welfare estimation theory through the pathway of production function. Moreover, this study applies a valuation technique, which tries to measure the value of natural resources when these resources enter as a factor into the private goods production framework. The real value of natural resource will be inferred from market transactions for the private goods. For this purpose, we can measure the changes in producer surplus for the marketed goods associated with the changes of the natural resources or environmental goods and services by the area over the supply curve.

Producer surplus is an important concept when discussing the effect of government intervention in the market. Economic welfare is the sum of consumer and producer surplus. In a market such as the case in this research, firms are price-taker and suppliers with a little influence on the market, and do not have pricing power. To explain the supply behavior of a firm in a perfect competition framework one can say that this firm faces a market demand, which is so large and would easily absorb any variation of the firm's output at an unchanged price. It means the market demand is not fully elastic, but the fraction of demand that firm is confronted with is elastic. Therefore, the changes in production costs affect only the producer costs and the burden cannot be conveyed to the consumers.[6] This leads to a fall in producer surplus which is the main concern of this study.

Some restrictive assumptions and propositions in reviewing the theories and presenting the economic model in the study are considered. Leaving any of these assumptions aside complicates the study.

- In principal, welfare accrues to each and every human being, but it is interdependent within a household. For this reason the household is introduced as the appropriate unit of analysis (McConnell & Bockstael, 2005). In addition, practically most data are available or collectable from households but not from individuals.

- Since the households' welfare originates in the context of firm's production, as consumption and production are not separable in the sample data, the theory is explored on the basis of firm's decision making process. Households are considered as small firms in a competitive market, i.e. price-taker firms, which sell their product

[6] Changes in Consumer surplus is zero.

in the market. In this market every individual producer has a horizontal demand curve at the level of the market price for its individual production, even though the market demand is sloping downwards.

- Due to the lack of data for every single product of the farms (inputs and costs for every product), the farm production is assumed as an aggregate product. Consequently, the model is designed for a multiple-product farm, of which overall output value is the monetary value of individual products.

- Variations in input use for farmers in the study sample are too small to affect the input prices.

- The absence of interdependency among units of the study is also a major assumption for the welfare measurement. This assumption helps to measure the total welfare effect of a change by adding the welfare effect on every single firm. If agents are in some way interdependent and their joint actions affect prices in the market, or externalities of a firm's action affects other economic agents, these effects should be considered in the model and analysis (McConnell & Bockstael, 2005).

- Producers cannot take a different production plan during the study to adjust themselves to changes (McConnell & Bockstael, 2005).

- Change in the price of factors of production affects not only the supply and revenue of the producer but also the leisure time and the utility derived from the quantity of the factor withheld from the market. The study measures the welfare changes resulted from the producer revenue changes, however the welfare changes derived from reallocation of released factors are not considered.

- Producers' behavior changes if they face uncertainty. This study ignores risk and uncertainty as an assumption. The analysis is limited to short time, static elements and partial equilibrium model (McConnell & Bockstael, 2005).

As a prelude to present the basic model for the study, it is started with the production function. The production function captures the effects of a change in the provision of water, which then translates into changes in supply and in producer's surplus. This justifies deeper exploration into the properties of the production function.

Various functional forms have been used in the literature to describe the relationship between the combination of inputs and agricultural products, which is defined as production function in economics (Bockstael and McConnell 2007; Carson and Bergstrom 2003). A mathematical production function explains the technical relationship that transforms resources to goods and services (Debertin, 2012). In particular, production function in economics represents the maximum amount of output that can be produced with given quantities of employed inputs under a given technology. There are different classifications for production functions. One is grouping them to Constant Elasticity of Substitution (CES) production functions and Variable Elasticity of Substitution (VES) production functions.

The elasticity of substitution measures how production factors can be substituted for one another. It can be measured by the percentage change in the capital-labor ratio to a percentage change in Marginal Rate of Substitution (MRS). For the production function *Y= f (K, L)* where *Y* is the output, *K* is the stock of capital, *L* is the amount of labor, the elasticity of substitution (σ) is given by:

$$\sigma = \frac{\frac{d(\frac{K}{L})}{K/L}}{\frac{d\left(f'_L/f'_K\right)}{\left(f'_L/f'_K\right)}} \qquad (2.1)$$

Where

$$f'_K = \frac{\partial F}{\partial K}$$

$$f'_L = \frac{\partial F}{\partial L}$$

$$MRS_{LK} = f'_L/f'_K$$

In a general production function, $\sigma = \frac{1}{1-\rho}$, where ρ is the substitution parameter (Arrow, Chenery, Minhas, & Solow, 1961).

In a CES production function, the elasticity of substitution has a constant percentage change in the capital-labor ratio to a percentage change in MRS. In special cases this is given as:

If ρ = 0, the elasticity of substitution σ = 1 and *K* and *L* are substitutes and *f (K, L)* is a linear homogeneous Cobb-Douglas production function with the usual convex isoquants.

If ρ = 1, the elasticity of substitution $\sigma = \infty$ and *K* and *L* are perfect substitutes so that the isoquants are linear.

If $\rho \to -\infty$, the elasticity of substitution $\sigma \to 0$ and, *K* and *L* are complementary factors of production, nevertheless, substitution is not possible, and *f (K, L)* is a linear limitational production function with rectangular isoquants.

In a VES production function, the elasticity of substitution (σ and ρ) is variable. The VES family includes Transcendental Logarithmic production function and Diewert production function.

We have now seen the range of different production functions with respect to homogeneity and elasticity of substitution. This research applies the most common one of the variety of functional forms to explain the impact on welfare by water price changes (see section 3.6.1).

2.5. Neoclassical Production Function and Profit Maximization

In a neoclassical production function, *Y= Af (K, L)*, output is produced by two factors of production, where *Y* is the output, *K* is the stock of capital, *L* is the amount of labor and *A* is exogenously determined level of technology. The function is homogenous of first degree and shows constant returns to the scale.

This study deals with this function, of which the output (*Y*) is the aggregate crop output produced by an individual producer which is dependent on a set of inputs decomposed into capital (*K*), labor (*L*), land (*Land*), intermediate inputs (*I*), and water (*W*) on a basis of a given technology (*A*). $\beta_i s$ represent the elasticity of output with respect to the capital, labor, land, intermediate inputs, and water. Exogenous changes in water amount are only moderated by production function. Changes in water price are moderated by profit maximizing demand for water. We want to work with water amount changes.

$$Y = AK_0^{\beta_1} L^{\beta_2} Land^{\beta_3} I^{\beta_4} . W^{\beta_5} \qquad (2.2)$$

In the short term fixed capital cannot change, so K_0 introduces a constant capital which implies that partial variation of production factors is assumed. Land can also be varied as farmers can rent out or rent in the land or leave the land fallowed.

The associated cost of producing *Y* is considered as:

$$C = q_{K_0}.K_0 + q_L.L + q_{Ln}.Land + q_I.I + q_w.W \qquad (2.3)$$

Where *C* is the cost for producing *Y*, q_{K_0}, q_L, q_{Ln}, q_w, q_I are the respective prices of the fixed capital, labor, land, intermediate inputs, and water.

The firm's goal is to maximize profit, defined as the difference between total revenue and total cost. A firm, which produces for a competitive market, takes price as exogenous, and changes in its output cannot affect the market. Producer profit is given by:

$$G = p_Y.Y - q_{K_0}.K_0 - q_L.L - q_{Ln}.Land - q_I.I - q_w.W \qquad (2.4)$$

Where *G* denotes gain, p_Y is the output price, and $p_Y.Y$ indicates revenue. The rest of the above formula indicates the cost function.

If water is free, q_w= 0, exogenous variation in water quantity is only affecting output and the production costs are unchanged.

$$dY = Y(K_0, L_0, Land_0, I_0, W_1) - Y(K_0, L_0, Land_0, I_0, W_0) \qquad (2.5)$$

Where W_0 and W_1 are water amounts before and after change, respectively and the other variables remain unchanged.

If water is a private good and farmers have to pay for it, water quantity and water price become endogenous, and changes in water prices are moderated by profit maximizing demand for water.

Now, assume that the firm's profit maximization objective is given by

$$max\ G = p_Y.Y - q_{K_0}.K_0 - q_L.L - q_{Ln}.Land - q_I.I - q_w.W \qquad (2.6)$$

Subject to technology constraints: $\mathrm{t}(\mathrm{y}, \mathrm{x}|\mathrm{K}_0) = 0$

Equation (2.4) can be used to illustrate how to measure welfare changes from the firm's perspective. First order condition for profit maximizing for quantity of water from Equation (2.6) is:

$$\frac{dG}{dW} = p_{Y}.\, AK_0^{\beta_1}L^{\beta_2}Land^{\beta_3}I^{\beta_4} - q_W \qquad (2.7)$$

To maximize the gain for quantity of water the derivative of gain with respect to quantity of water is equal to zero, thus $\frac{dG}{dW} = 0$

By dividing the right side of the Equation (2.7) by output price we get:

$$\frac{p_{Y}.\, AK_0^{\beta_1}L^{\beta_2}Land^{\beta_3}I^{\beta_4}}{p_Y} = \frac{q_W}{p_Y}$$

Determinants of the demand for water that can be derived from (2.6) and (2.7) are q_W (price of water), L (labor quantity), $Land$ (land size), I (intermediate inputs quantity), and P_Y (output price)

Based on Equation (2.2) the left side of this equation indicates dY/dW, therefore:

$$\frac{dY}{dW} = \frac{q_W}{p_Y}$$

This equation states that marginal productivity of water equals water price divided by the price of output which is the water price related to the output price or real price of water.

Farmers choose water at the price of

$$\frac{dY}{dW} \cdot p_Y = q_w$$

Here, dY/dW denotes the marginal productivity of water. If water is public good and free, $q_w = 0$, diminishing returns brings the marginal productivity of water down to zero. From these equations water demand is defined by water price, labor, land, intermediate inputs, and output price.

In this study farmers use both free and paid water for irrigation.

The cost for paid water $Q_W = q_W.W$ and the average price of water for those who use paid water (W_{Pa}) and free water (W_{Fr}) is

$$\frac{Q_W}{W_{Pa} + W_{Fr}} = q_W \qquad (2.8)$$

Equation (2.4.) can be used to illustrate how to measure welfare changes from the firm's perspective.

$$G + q_{K_0}.K_0 = p_Y.Y - q_L.L - q_{Ln}.Land - q_I.I - q_w.W$$

As K_0 is independent of the input prices and output quantity, exogenous changes in any of the input prices has no effect on K_0 and can only affect profit. This means that the profit function is a good measure for welfare evaluation. Notice that we cannot use the concept of profits in place of quasirents[7] if the firm shuts down due to exogenous changes. In this case the firm would lose $G + (q_{K_0}.K_0)$ which is greater than profit.

Now a natural resource input (W) -an exogenous variable- changes from W_0 to W_1. It is assumed that the firm continues to operate no matter whether W_0 or W_1 were available. If the producer surplus without the change in the water quantity is G_0 plus fixed costs, and if the producer surplus with the change in the water quantity is G_1 plus fixed costs then the change in producer surplus equals:

$$(G_1 + \textit{fixed costs}) - (G_0 + \textit{fixed costs}) = G_1 - G_0 = dG$$

$$\begin{aligned} dG = {} & (p_Y.Y_1 - q_L.L_0 + q_{Ln}.Land_0 - q_I.I_0 - q_w.W_1) \\ & - (p_Y.Y_0 - q_L.L_0 - q_{Ln}.Land_0 - q_I.I_0 - q_w.W_0) \qquad (2.9) \end{aligned}$$

In this equation 0 denotes the existing level of variables and 1 denotes the levels after a change in water quantity.

Note that proportionate increase in other factors of production has decreasing marginal returns at given water quantity (W). It is assumed that the firm produces only one output and if the continued production of this output is not profitable the firm will shut down. The change in natural resource as a factor of production tends to change the revenue as a function of output as well as change in costs as a function of output, input prices and W.

Denoting the marginal cost of Y as $C_Y(Y, q_{inputs}, W)$, Equation (2-9) takes the following form:

If $C(0, q_{inputs}, W_0) = C(0, q_{inputs}, W_1)$

$$= \left(p_Y.Y_1 - \int_0^{w^1} C_Y(Y, q_{inputs}, W_1)\, dY\right) - \left(p_Y.Y_0 - \int_0^{w^0} C_Y(Y, q_{inputs}, W_0)\, dY\right) \qquad (2.10)$$

---

[7] Alfred Marshall (1930) advanced producer's net profit as an alternative for profit, which is the difference between total revenue and total variable cost and called quasirents (QR). This is the area above the supply curve and below the price, commonly called producer surplus. Despite the distinction between quasirents as an economic concept and producer surplus as a geometric area, we consider them equivalent (Just, Hueth, & Schmitz, 2004).

The last condition states if the farm ceases to produce Y, the only costs are fixed costs which are equal irrespective of the level of water; $G(K_0, W_0) = G(K_0, W_1)$.

Determinants of the demand for water are water price, labor, land, intermediate inputs, and output price.

For measuring how farmers change their water use in response to the water price, we need to estimate the price elasticity of demand for water. From a theoretical perspective two functional forms of demand, i.e. additive or multiplicative form are possible. From the empirical perspective, we explored that the multiplicative demand function is more suitable for our data.

A multiplicative demand function for water is assumed as:

$$W_i = \alpha_0 q_{w_i}^{-\alpha_1} L_i^{\alpha_2} Land_i^{\alpha_3} I_i^{\alpha_4} P_{Y_i}^{\alpha_5} \qquad (2.11)$$

Where W_i is the water consumed by farm household i, q_{w_i} is the price of water, L_i is the labor quantity, $Land_i$ is the land quantity, I_i is the intermediate inputs quantity, and $p_{Y\,i}$ is the output price, all for farm household i. Substituting the Equation (2.11) in the formula for price elasticity of demand ($E_{q_w} = \frac{dW}{dq_w} . \frac{q_w}{W}$):

$$\frac{dW}{dq_w} = \alpha_0 \, (-\alpha_1) \, q_{w_i}^{\alpha_1 - 1} \, L_i^{\alpha_2} Land_i^{\alpha_3} I_i^{\alpha_4} P_{Y_i}^{\alpha_5} \qquad (2.12)$$

$$\frac{q_w}{W} = \frac{q_{w_i}}{\alpha_0 \, q_{w_i}^{-\alpha_1} \, L_i^{\alpha_2} Land_i^{\alpha_3} I_i^{\alpha_4} P_{Y_i}^{\alpha_5}} \qquad (2.13)$$

By multiplying Equations (2.12) and (2.13) the associated elasticity of demand will be -α_1.

The elasticity of demand shows the responsiveness of farm households' demand for water to water price changes which can lead us to farm households' production change and welfare effects of these changes.

CHAPTER THREE

THE IMPACT OF WATER PRICING ON FARMING: CASE STUDY LAKE URMIA

3.1. Introduction to Chapter Three

This chapter, as the research design and analysis, covers three principals of the empirical part of the study. The first part is about the characteristics and irrigation water use patterns of the case study region where the survey was implemented. Then sampling, instrumentation, and data collection is explained. The last section consists of post-fieldwork practices; processing and organizing the collected data, data analysis and interpretation of the results.

3.2. Research Area

3.2.1. Iran

The main objective of this study is to investigate the production function as a methodology for measuring the welfare effects of alternative irrigation water prices on farm households and applying it in a case of one of the ecologically important lakes in Iran, Lake Urmia basin. This section briefly introduces the case study district which is based on official and unofficial documents prepared by governmental and international agencies.

Iran is located in the mid-latitude belt of arid and semi-arid regions of the earth with limited availability of water resources which has confronted the state with water management challenges. Water scarcity across the country has a growing influence on development plans in several sectors which rely on water resources. The country has 0.36 percent of the world's freshwater resources while about 1 percent of the world's population lives there (IWRMC, 2005). Annual rainfall in Iran varies from 50 mm in the Central Kavir Desert to 2275 mm in the Caspian Sea basin with an overall annual average rainfall of 228 mm of which almost 66 percent evaporates. Agricultural activities are a significant contributor to the economy of Iran. In the interest of attaining food security and self-sufficiency, and being prepared to mitigate the impact of international sanctions against Iran, agricultural development plans have always received special attention by government. However, the environmental and socio-economic rationales for these plans are questioned. Nearly one-third of the total area of Iran is appropriate for agricultural activities (FAOSTAT, 2012) and an estimated of 18.03 percent of the labor force was engaged in the agricultural sector in 2015 (World Development Indicators , 2016). Agriculture accounts for an average of 11 percent of the GDP (Iran Economy Stats, 2012). Almost all arable land (99 percent) in Iran is run and managed by private sector. More than 90 percent of rural agricultural households possess lands with small and medium farm sizes. Farming activity is determined by adequate water accessibility which is mostly scattered throughout different regions of the country (Keshavarz, Ashraft, Hydari, Pouran, & Farzaneh, 2005, p. 156) and the living condition of rural population is strongly affected by water resources.

Agricultural sector consumed 92 percent of the 93.3 billion cubic meters water use in 2014. Eighty-five percent of food supply and 90 percent of raw materials used in industry derived from this sector (Keshavarz & Dehghanisani, 2007). Groundwater is the main source of water in agriculture; legal as well as illegal groundwater abstraction covers about 70 percent of water use in agriculture levels (Hashemi M., 2012, pp. 88-89). The 1982 Fair Water Distribution (FWD) act states that water as a common pool property belongs to the state. Private well owners own much of the groundwater which is controlled by issuing water allocation permits, although there are illegal and informal abstractions which cannot be controlled. Surface water is mostly abstracted through traditional water rights. Iran is the 5th country in the world in terms of irrigated land area (Hashemi M., 2012, p. 91).

There was no specific water allocation law in Iran before 1943. Users freely used water under customary water rights and water allocation was based on land rights. The Bill for the establishment of the Irrigation Bongah (a governing agency for irrigation) was established in 1943 to bring some order to the water sector. Provincial water companies which were established in the mid-1960s did not have control over water allocation. In 1968, as a first step to have a central control over water allocation, The Nationalization of Water Act allowed water charging for distribution of water (drinking, industrial, and irrigation). In the 1970s water allocation for irrigation networks was enforced, but this considered only a small percentage of water abstraction. The 1982 FWD act specified formal water allocation rules enforced by central authorities. In 1990 the Bill for creating the "Water and Wastewater Company", and in 1998 the Bill for creating "Rural Water and Wastewater Company" were passed to distribute their quota of water to the households, industries, and farms. However, the main problem with unauthorized wells as well as unauthorized abstraction from unregulated rivers remained and their information is not public and sometimes even hidden from the Ministry of Energy (MoE) by regional water companies. The 2003 Water Allocation Directive (WAD) improved the water allocation rules from an economic perspective to an environmental and physical resources perspective. The application of the 2003 WAD is still limited due to failures in identifying the provincial and inter-provincial water allocation conflicts (Hashemi M., 2012, pp. 152-154).

3.2.2. Lake Urmia Basin

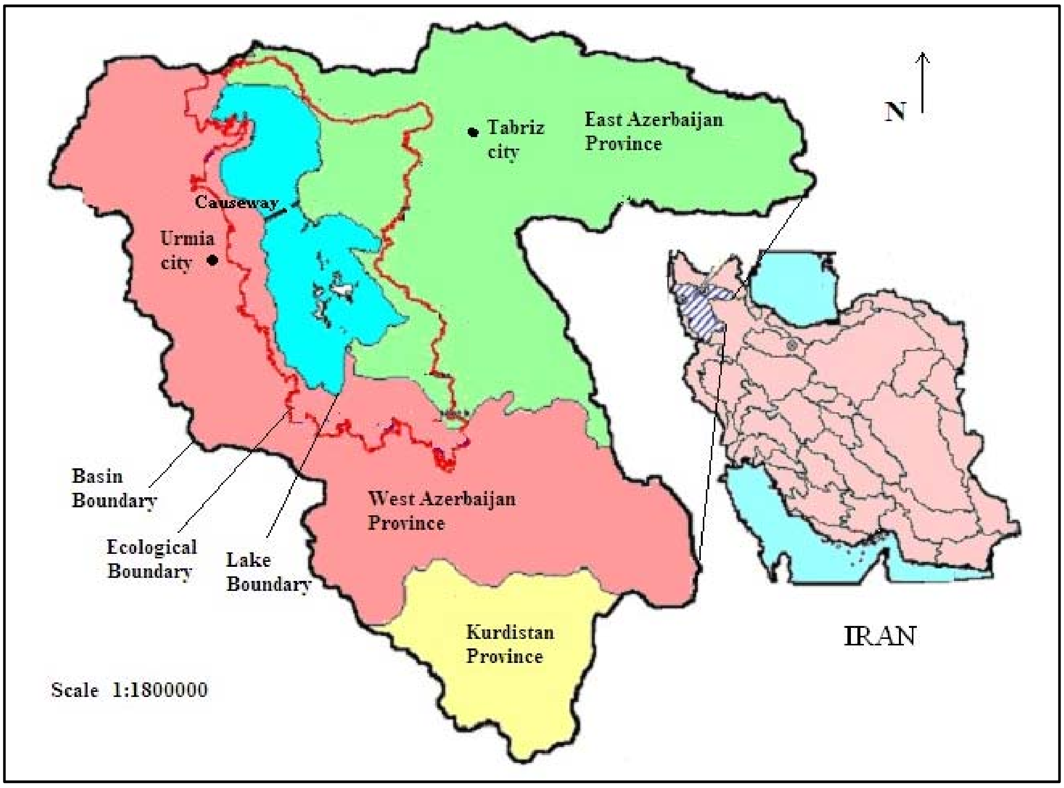
Lake Urmia, a major water body located in the northwestern corner of Iran, with a ca.5000 km2 surface, is the third largest saline lake in the world and the largest lake in the Middle East. It was declared a "Wetland of International Importance" by the Ramsar Convention in 1975[8]. The lake basin[9] is one of the largest agricultural regions in Iran encompassing three percent of the total surface of Iran. With more than 21 percent of annual rainfall of the country

[8] The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources (http://www.ramsar.org/)

[9] A basin is a natural depression in the surface of the land. A lake basin is a geographic land area draining into a lake; also referred to as drainage basin or watershed. Source: European Environmental Agency

it is considered to be one of the most water abundant basins in the country (Roostaei, 2004, p. 2). Administratively, the lake basin as a closed drainage catchment, is part of the three districts; West Azerbaijan, East Azerbaijan, and Kurdistan which covers a total extent of 51876 Km^2. Total population of the basin was estimated 5.9 million people in 2010 (Hashemi M., 2012, p. 132). Figure 3.1 shows the location of the lake in relation to the basin (case study region) and the country.

Figure 3.1. Location of the Case Study Region



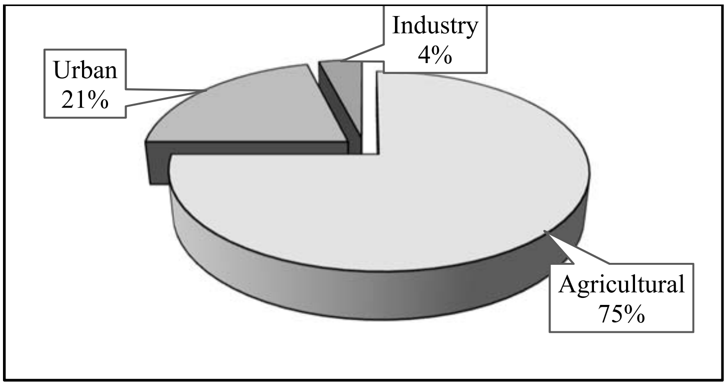
Source: https://aquapedia.waterdiplomacy.org/wiki/index.php?title=File:Urmia2.jpg [10]

The basin is a multi-ethnic (Turks and Kurds) and multi-religion (Islam; Shiite and Sunni, Christians; Armenian and Assyrian) area which requires significant attention to cross-cultural conflicts in water allocation process. There are 17 permanent rivers, 12 seasonal rivers and 39 flood routes which terminate at the lake (Hashemi M., 2008).

[10] Ecological zone is the entire lake plus surrounding wetlands and other habitats which have a strong ecological connectivity with the lake.

The dominant economic activities in the basin are mainly agricultural followed by industrial and tourism. Agriculture is cited as the principal user of raw water in the basin with 75 percent of water use in the lake basin which is supplied through surface and groundwater sources. Urban supply is accounted for of 21 percent of the water consumption in the area followed by industry with 4 percent (mostly textile industry). Figure 3.2 illustrates the water consumption per sector.

Figure 3.2. Water Consumption by Sector in Lake Urmia Basin



Source: (Yekom, 2002)

The lake has been subject to extensive draining resulting to a critical condition of declining water level and increasing salinity for the last decades. The extensive demand for water due to an increase in population and agricultural activities resulted in depriving the lake of replenishment water and lessening the quality and quantity of the water in the lake. Most of the wetland derived goods and services have been lost in recent years threatening the globally important biodiversity provided by the lake and the basin ecosystem. The lake water level dropped to 1270.42 meters in 2013 which is 3.5 meters below the ecological sustainable level and the lake area has reduced by 46 percent to 2700 Km^2 (Jabbari, 2011). Growing attention to the deteriorating environmental condition of the lake has started since 1990s. The surface area of the lake is declining (Figure 3.3). Since 1995 the lake area has shrunk to less than half of its size with falling water level (Hashemi M., 2012, p. 124 and 150). Since the lake basin holds about 7 percent of Iran's water resources, Iranian policymakers, particularly the MoE started paying growing attention to the lake in the last decades and it has been registered on the political agenda since 2000. As mentioned before, irrigation is capturing the major share of water resources in Lake Urmia basin. Demand for water has increased in response to agricultural development plans. Surface water inflows to the lake have been diverted to irrigation schemes and underground water resources have been overexploited to meet agricultural demand that has imposed some significant pressures on the lake's ecosystem. The opportunity costs associated with diverting the water away from the lake has not been realized and incorporated into the development plan for the region.

Table 3.1 provides a breakdown of the total economic value components related to Lake Urmia.

Table 3.1. Total Economic Value of Lake Urmia

	Use Values	Non-Use Values	
Direct Use	**Indirect Use**	**Option**	**Existence and Bequest**
Landscape Recreation Mud Spa Artemia harvest[11] Salt harvest	Biodiversity Climatic moderation Sediment and Contaminant Retention Stabilizing salt deposits Research, Training and Education Ground water recharge / discharge	Potential future uses	Culture /heritage values

Source: Created by the author based on (Barbier E. B., 1993) and (Yekom, 2002)

Some research has already been devoted to Lake Urmia and its basin problems in recent years (Hashemi M. (2012), Oloumi Zad, Ravesteijn, Hermans, & van Beek (2012), Nabavi, Daniell, & Najafi (2016), Najafi & Tavakoli Nabavi (2014), and Amini & Hesami (2016)).

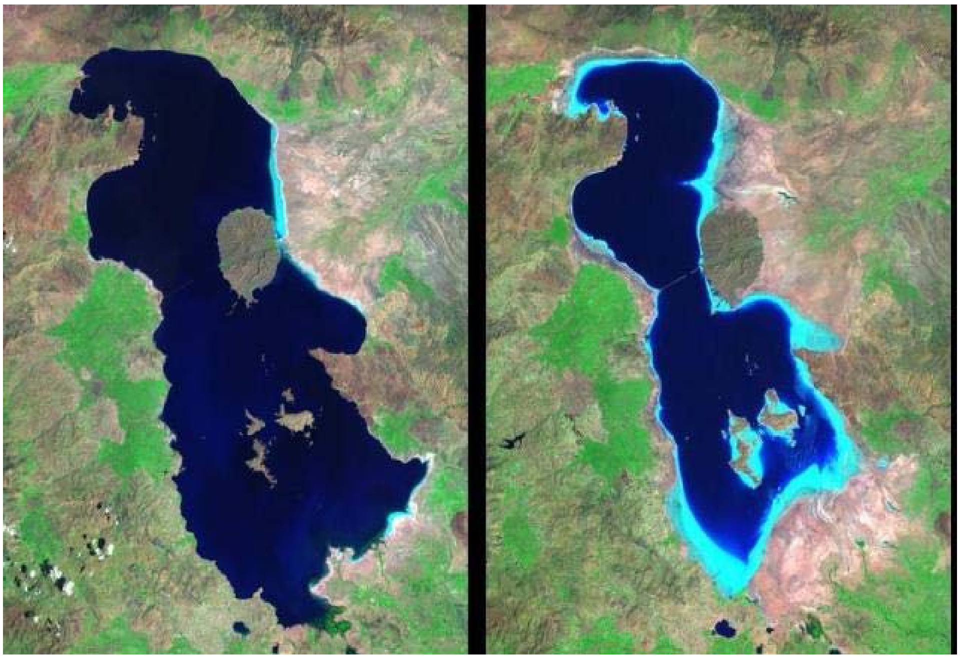
Hassanzade et al. (2012) showed that changes in inflows are responsible for 65 percent of the reduction in the lake's water level. Overuse of water resources and climate changes accounted for this loss. Many ground and surface water bodies are significantly polluted and over-extracted by agricultural activities in the basin. The factors affecting the water quality and quantity of the lake are twofold: firstly, overexploitation of water resources that influences the water inflow from the rivers to the lake; secondly, the groundwater exchange

[11] Since 2002, the lower Artemia densities due to the high salinity of the lake changed it to an unprofitable industry. Although there are still some illegally unreported harvestings, there is not any official reports and information about Artemia harvesting in Urmia.

with the lake that affects the water quality and quantity of the lake. Senobar (1993) studied the impact of water quality of the lake on groundwater in the basin. He noted that increasing salinity of the lake water has permeated into the underground water resources near to the lake which has a direct impact on agricultural activities in the area.

Haghi (2013) investigated the socio-economic consequences of decreasing quality and quantity of water in Lake Urmia basin. Health and well-being issues, high internal displacement rates, low social participation, and reduced reliance on state authorities are the significant consequences identified by his study. This can be considered as externalities of unsustainable agricultural development on the lake ecosystem.

Figure 3.3. Satellite Imagery Showing Changes in Lake Urmia



August 1, 1985 August 1, 2010

Source: Earth Resources Observation and Science (EROS) Center, US Geological Survey
http://eros.usgs.gov/oroumeih-lake

3.2.3. Current Situation and Issues of Lake Urmia Basin

This section introduces the current situation and issues of Lake Urmia basin toward a better understanding of the case study region.

The 1938 administrative divisions and internal boundaries still show some degree of regional disparity and provincial inequality because of unbalanced power distribution among provinces. There have always been some ethno-religious tensions in the region. Ethnical and cultural identities are more dominant than national identity among Kurds and Turks living in this basin. East Azerbaijan is more industrialized compared to West Azerbaijan, and Kurdistan is less developed among the three. Most developmental projects have not performed well because of the imbalance of political power distribution among provinces (Farzanegan, 2001). There is huge political lobbying by provincial governors and members of Parliament to obtain economic incentives to their constituents (Hashemi M., 2012, p. 138). Besides other effects, the cost of conflicts and inequality in the region has also affected the environmental protection and sustainable development.

Iran's population doubled from 27 million to 55 million in 20 years during 1968 to 1988. The comprehensive and effective family planning program launched in 1989 had one of the fastest drops ever recorded in population growth from about 7 births per woman to less than two births per woman. The population boom started in 1976, and continued during the 1979 revolution and 1980-1988 Iran-Iraq war by Khomeini's Islamic edict. This led to an increase in the population in a short time which resulted in a big socio-economic environmental pressure (Aghajanian & Mehryar, 1999). The population growth acted as a pressure on water sources because of the increased demand for water. The rate of increase in urban land use in the ecological zone of the lake in 1990s was 500 percent (Yekom, 2002). Increased urban population and water demand raised inter-provincial conflicts for water resources.

Irrigation water demand in the lake basin increased because the lake basin, as one of the main agricultural regions in the country, was charged to produce food for more population than before. During 40 years, since 1970, 37 dams were built in East Azerbaijan, West Azerbaijan, and Kurdistan. The modern irrigation networks have an approximate 20 years lag behind the dam building. Despite the lack of adequate data on water demand there is a consensus on low water efficiency (less than 30 percent) in agricultural sector which has the highest water demand in the basin. About 45 percent of the water supply in the basin comes from the groundwater of which 87 percent is used in agricultural sector. Most of the aquifers suffer from negative recharge and low quality returns (Hashemi M., 2012, pp. 138-139).

Since the mid-1990s the level, surface, and quality of water in Lake Urmia have become an issue which indicates the impact of water resource mismanagement and climate change on the ecosystem of the region. At present no baseline data are available on pollution indicators of the lake except for some scattered studies. Water diversion increased the slat concentration and water balance in the lake. Building dams increased the sediment flows to the lake. Hydrodynamic alternation and the quality and salinity balance of the lake are affected by the highway across the lake. The land use policy on the basin has resulted in a loss of rangeland and wetland area as well as an increase in reservoir (dam) area without the appropriate irrigation and drainage constructions. Construction of the Kalantary Highway between Tabriz and Urmia cities across the lake has a major impact on the hydrological and hydrodynamic functions of the lake. Increased salinity caused the demise of the only organism of the lake, Artimea. Pelicans and flamingos lost their habitat. The lake ecosystem is almost on its death-bed. There are concerns that in the nearby future the ecosystem issues in the region will affect human well-being and health in the basin.

> "responses are the actions taken by groups (and individuals) in society as well as the governments' attempts to prevent, compensate, ameliorate or adapt to changes in the state of the environment" (Gabrielsen & Bosch, 2003, p. 9).

Some of the responses to prevent or adapt to above mentioned issues are introduced here. In 1963, the Water and Power ministry and regional water and power organizations were established. Introducing the FWD act and the comprehensive water planning and management law are two main responses during 1970-1990. From 1990 Integrated Water Resource Management (IWRM) became the standard. These rules aim to empower the MoE to become the guardian of groundwater and surface water to make the allocation decisions. This takes the river basin approach instead of the old provincial demands for water allocation. In practice the MoE failed in implementing a sustainable water management strategy in Lake Urmia basin and many customary rules prevailed over formal rules (Hashemi M., 2012, pp. 147-151).

Increasing public awareness and policy makers' recognition of the lake basin ecosystem problems in recent years, led to the formulation of water management policies. Hashemi (2012) developed a framework for implementing the IWRM, with paradigmatic focus on Iran, and Lake Urmia basin as a case study. The study concluded that the participatory process has enhanced the efficacy of the water governance system. However, the effectiveness of water allocation will be compromised unless an adaptive water allocation approach is implemented, and basin-wide water use efficiency measures are taken. Salehnia (2004) developed a choice experiment model to examine the public's willingness to pay to improve the environmental quality of Lake Urmia and satellite wetlands. The main finding of the research is that the major concerns of people are water quantity of the lake followed by water quality, number of flamingos, and Artemia stock, respectively.

Overuse of irrigation water in Lake Urmia basin is creating environmental degradation problems. Environmental degradation is any deleterious or undesirable change or disturbance to the environment. It happens through depletion of resources, destruction of ecosystem, habitat destruction, extinction of wildlife and pollution (Johnson, Ambrose, Bassett, & Winter-Nelson, 1997, p. 143). Environmental degradation in agriculture is a type of environmental market failure that occurs when the producers do not have to pay the full cost of resources such as air, water and soil (Pearson, Gotsch, & Bahri, 2004, p. 93). Even if the farm households responsible for environmental degradation understand the impact of their act on the resources, they rarely concern about it as they are more focused on their day-to-day livelihood than possible future impacts of their actions.

An agricultural production system is unsustainable in the presence of environmental market failures. Government interventions can correct market failures and build a sustainable production system; however, it is very difficult to measure the accurate costs (private and social costs) of production in practice (Pearson, Gotsch, & Bahri, 2004, p. 94). There are some interactions between natural resource management and social issues such as poverty (Tamas, 2003, p. 10). It is important to consider these linkages in order to avoid the conflicts between social and environmental policy objectives (Pye , et al., 2008, p. 29). Some arguments explicitly state that poverty is a major cause of environmental degradation (Anantha, 1998, p. 2169). Poor inhabitants, particularly in developing regions, rely on natural resources for their livelihood and have no choices other than exploitation of these resources (Heady C., 1998, p. 1). On the other hand, environmental policies impact the society in different ways. Government policies for reducing resource degradation through limiting activities that make use of the given resource would harm the groups of people relying on the resource for their livelihood. One of the concerns of environmental policies in relation to socio-economic groups is the effect of the policy on poverty as well as the distributional impacts of the policy.

Because of the interlinkage between environmental and social policies, it is important to take an integrated approach and consider the effect of the environmental policies on socio-economic groups. Considering the social dimensions of environmental policies and its effect on different communities is one of the concerns of policy makers. As an attempt to estimate the cost of reversing the ongoing degradation of the lake and its basin, this study examines the reallocation cost of water resources. Towards this end, the farm households' welfare changes due to the variation in water use for irrigation are measured. This information is an asset for policy makers and development managers to assess the outcome of their policies and projects and to know how to compensate farmers for releasing some water from agriculture in favor of the lake.

3.2.4. Water Use and Irrigation Patterns in Lake Urmia Basin

Sustainability of irrigated agriculture depends partly on whether producers adopt more efficient irrigation systems that integrate improved on-farm water management practices with efficient irrigation application systems. Population and economic growth, urbanization, food security and self-sufficiency goals, development plans, and climate change are some of the driving forces on water demand in Iran. Recent changes in social and public values with regard to water quality and environmental issues were added to these forces placing greater pressure on water management in the area. There are failures in water abstraction monitoring and forcing legal registration for paying fees for water use. About 11 percent of groundwater and 50 percent of surface water used for irrigation in Iran is not registered (Hashemi, 2012, p 297). The following sections provide some information on irrigation water use in Lake Urmia basin. We describe water use characteristics as well as adopting and practicing water conservation programs in Lake Urmia basin as an important tool for sustainable irrigation to provide an in depth analysis of the estimation results.

Rain-Fed vs. Irrigation Farming

In the study sample 99 percent of farm revenue comes from irrigated lands whereas only 1 percent of farm revenue comes from rain-fed lands indicating that irrigated agriculture makes a significant contribution to the agricultural revenue. Water use efficiency in irrigation is less than 30 percent in Lake Urmia basin. (Hashemi, 2012, p 139). This makes designing agricultural water conservation policies and water use efficiency an important component of sustainable water management programs in agriculture.

Water-Land, Water-Output, and Output-Water Ratios

Table 3.2 compares the water-land, water-output, and output-water ratio in agriculture between the sample districts of the study, i.e. Ajabshir and Shabestar. For more information about sample districts see section 3.5.1. To calculate these ratios total water cost, total land size, and total farm revenue are derived for both districts from the survey data, then the ratios for each district are calculated. This table shows that water-land and water-output ratio in Ajabshir is higher than Shabestar. In other words, one unit of land in Ajabshir uses more water than one unit of land in Shabestar (480,164 vs. 119,393) and one unit of output in Ajabshir uses more water than one unit of output in Shabestar (0.03 vs. 0.02). The last row of the Table shows that one unit of water produces 51 unit of output in Shabestar and 31 unit of output in Ajabshir.

Table 3.2. Water-Land, Water-Output , and Output -Water Ratios

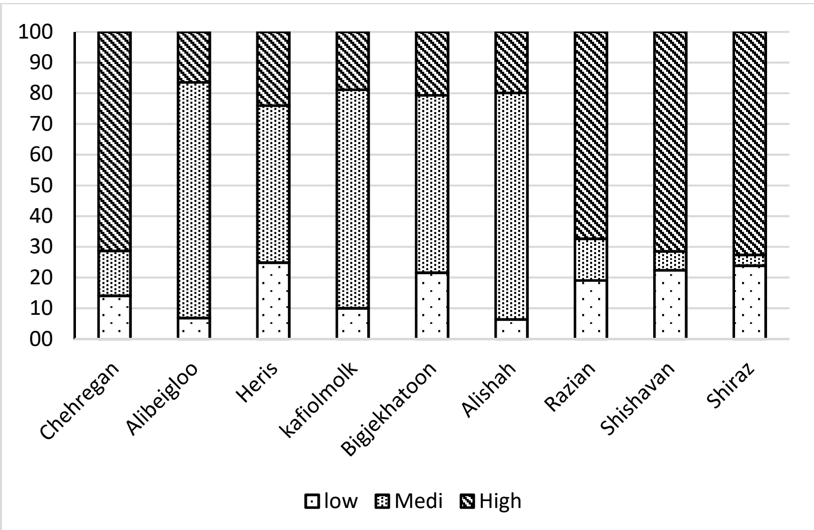
	Shabestar	Ajabshir	Total Sample
Water-Land	119393	480164	256676
Water- output	0.020	0.032	0.027
Output -Water	51	31	37
No. of observations			259

Source: Own field research data

Crop Water Needs

Crops water needs are classified as low, medium, and high to have an estimation of water use of different crop types. For this purpose, we asked a local expert to put all the crops in our survey in these three categories. Then the farm revenue for every farm household from each category of crops is calculated. The sum of revenue for low, medium, and high water need crops for each village and district is calculated. For an easier comparison the results are presented in percentage. Figure 3.4 indicates the share of crop of total farm revenue in the sampled villages. Based on the sample data 73.0 percent of total low-water-use crops and 79.8 percent of total high-water-use crops were produced in Ajabshir while 86.9 percent of medium-water-use crops were produced in Shabestar (Appendix A-1). This can be a reason for high mean of water use in Ajabshir when comparing it to Shabestar (see table 3.10). Shishavan, Shiraz, and Razian had the highest percentage of low-water-use and high-water-use crops among all villages. These three villages are located in Ajabshir district.

Figure 3.4. Share of Crop Type of Total Farm Revenue in Sampled Villages



Source: Own field research data

Table 3.3 indicates that more than 70 percent of the produced crops in Ajabshir were high-water-use. In Shabestar the majority was with medium-water-use crop.

Table 3.3. Share of Crop Type of Total Farm Revenue in Districts (Percentage)

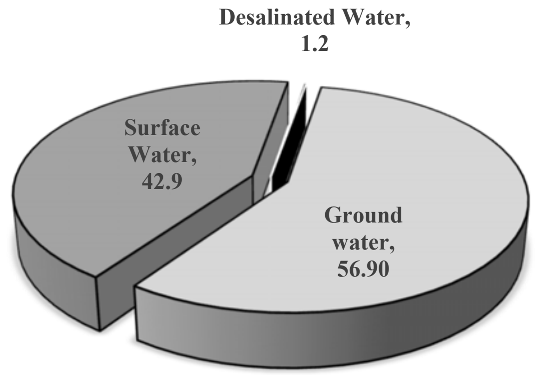
Districts	Water Use			
	Low	Medium	High	Total
Shabestar	11.7	62.6	25.6	100
Ajabshir	22.3	6.6	71.1	100
	17.9	29.7	52.4	100

Source: Own field research data

Source of water for irrigation:

Groundwater is the major source of water withdrawal in all sectors; agricultural, municipal, and industrial sectors in Iran. Figure 3.5 presents the water withdrawal by source in Iran.

*Figure **3.5**. Percentage of Water Withdrawal by Source in Iran in 2004*



Source: AQUASTAT Survey 2008 (Frenken, 2008, p. 190).

Groundwater is the main source of agricultural water use in Iran which is estimated at about 70 percent when illegal abstractions are also taken in consideration (Hashemi M., 2012, p. 89). Appendix A-2 shows the category of water sources for irrigation in percentage in the case study region which indicates most farms rely on groundwater resources. In Shabestar district 91.9 percent of water used in irrigation comes from wells. The second source of water is surface water through rivers by 6.6 percent. A few number of farmers receive a part of their water demand through rain, Qanats[12] (English, 1998) and springs. Farmers in Ajabshir had only two water sources for irrigation. Wells provided for 83 percent of their need and dams provided for 17 percent of it.

3.3. Sampling

Data collection in this research has been done in two main parts with different sampling techniques which are somehow interconnected. In the first part various reference documents such as files, statistical records, government publications, and other written texts were reviewed to clarify the issue and important concerns for empirical part of the study. To this end a survey of relevant official documents, statistical and census reports, internet sources and existing information about the topic and the basin was conducted. Interviews with the experts in the field study have been done to collect more information about the agricultural system and related environmental problems in the area. The experts were selected by the researcher based on a non-probability purposive sampling method.[13]

The second phase of data collection was conducted through a multistage sample selection. Sampling procedure, sample size and the response from our sample (participation) influence the representativeness of our sample.

The theoretical population is all farmer households living in Lake Urmia basin and the accessible population are those living in the most damaged regions near to the lake. The adequate sample size for this phase was estimated as followed. In order to determine the number of households that should be taken as sample elements we use Slovin's formula (Tejada & Punzalan, 2012, p. 129) to determine the proper sample size. In this formula $n = N / (1 + Ne^2)$, Where n = the sample size, N = the population size, and e = error tolerance.

There is not an updated official estimation of the population living in the basin. Total population of the basin in 2010 provided by the provincial stakeholders is 5,900,000 people (Hashemi M., 2012, p. 136). Based on the 2011 national census 71 percent of the population

[12] "Qanats are gently sloping subterranean tunnels dug far enough into alluvium or water-bearing sedimentary rock to pierce the underground water table and penetrate the aquifer beneath". (English, 1998. P 188)

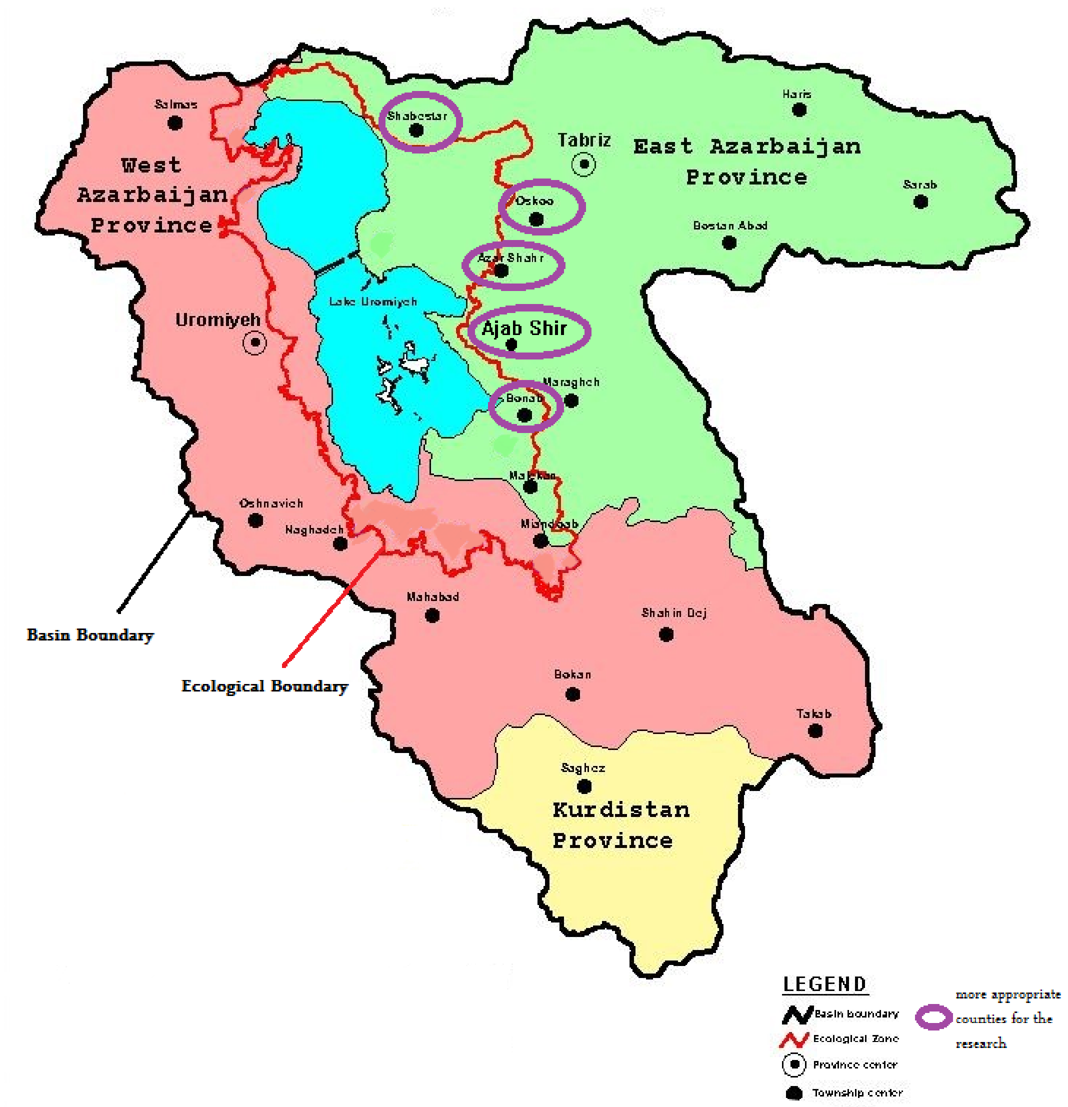
[13] Those who are appropriate for the study are selected.

lives in the urban areas while 29 percent lives in rural areas, the rural household size is 3.7 (National Population and Housing Census, 2011). Applying these estimations, the approximate number of rural households in the basin was 462,432 in 2010-2011. With the confidence level of 95 percent (i.e. an error margin of 0.05) and total population of 462,432 rural households, the proper sample size for this population calculated by Slovin's formula is 277 households (in practice 300 questionnaire were filled in).

We can also use Green's (1991) rules of thumbs to check if we have taken a representative sample. According to his rules for testing multiple correlations, the minimum acceptable size for n is $50+8k$ and for testing individual explanatory variables we need at least $104+k$ sample size, where k is the number of independent variables in the model (Field A., 2009). In this study with 4 predictors we need a sample size of 50+8*4 to test the overall fit of the regression model and 104+4 sample size if we are interested in the contribution of the individual predictors.

A multistage sample selection was conducted to collect data. The most damaged areas affected by lake problems are located on the east coast. Due to wind direction, topography of the region, and shallow wells (more brackish) agricultural activities in the five districts near the lake are most affected by the lake degradation consequences. The districts Shabestar, Osku, Azarshahr, Ajabshir, and Bonab are selected for our study based on a purposive sampling method as they are more appropriate for the research. Two districts out of these five are selected in a cluster sampling method. Then nine villages from these two districts are drawn randomly. The next step is defining the households for being interviewed. A number of the rural households in each village were available. According to our total sample size and rural household proportion of these villages, the sample size for each village was defined. As the sample frame for the rural households was not available, we used the map of the villages and dividing it to different blocks. Drawing block groups within villages and households within blocks is the last stage of sampling. If a household was not willing to participate in our survey or the main activity of the household was not farming, or the selected house was not a residence place but a shop, school, etc., the next household in their neighborhood was selected for the study. Assistant data collectors who knew the local language (Azeri-Turkish) helped filling in the questionnaires during a face-to-face interview to have higher response rates and more accurate data.

Figure 3.6. Selected Districts by Purposive Sampling Method



Source: Adopted form https://aquapedia.waterdiplomacy.org/wiki/index.php?title=File:Urmia2.jpg

For the main survey we yield 300 questionnaires with the response rate of 100 percent. Cultural etiquette of the region demands hospitality and cooperation with guests, and in combination with their curiosity, all households asked to participate in this study did comply. Due to giving social desirable answers, loss of interest during the interview, fatigue or disappointment, some cases had to be deleted from the sample after checking the questionnaires for data cleaning. The rest of data cleaning process will be explained more in the data cleaning section (see section 3.5.1).

3.4. Instrumentation

This study collected data through three devices; documented evidence, interviews with experts, and a questionnaire.

Relevant regional, national and international descriptive reports and materials were reviewed for gaining a preliminary background and developing an understanding of the intricacies of the study region. This information was completed by interviews with experts in the field (see Appendix F). The interviews helped the researcher to understand the issue and related concerns from the experts' perspective which brightened the orientation of the overall organization of the empirical part of the study. This also helped in wording and language that should be used in the questionnaire. The process of collecting this part of data was conducted at the very beginning of the study to provide an insight into the issue and assist the researcher in identifying the characteristics of case study region. The main sources for documented evidence were desktop study and internet-based contents including national and international[14] online databases and reports. Part of the evidence was collected directly from library and document centers of national agencies as well as interviews and meetings with agricultural experts which were held before developing the survey questionnaire. Some examples of secondary information collected for the study are the number and names of the districts and villages, population of the basin and its detailed information for sampling, and farm output prices for comparison and correcting mistakes in the questionnaire. The second phase of data collection was conducted in 2013 by means of a structured face-to-face questionnaire designed to obtain data for the empirical model of the research. This study attempts to identify and analyze factors affecting the crop production by farm households and measure their welfare due to water supply alternatives. Variables affecting crop production and welfare measures are categorized into cost and production function which are not definitely specified as such in the questionnaire. The questionnaire is based on research tools of similar studies and related literature.

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[14] Ministry of Agricultural Jihad-Iran (MoAJ); Provincial representatives
Department of Environment-Iran (DoE)
Statistical Center of Iran (SCI)
Conservation of Iranian Wetlands Project (CIWP)

3.4.1. Development of the Questionnaire

The fundamental point in questionnaire design is to define the right and reliable questions used to collect the relevant data in order to answer the research objectives. The questionnaire began with a general introduction explaining the purpose of the study and ethical issues. Respondents were free to decide whether or not to participate in the study. They were assured that their information on the questionnaire will be confidential and they have the right to leave if they feel uncomfortable at any point of time. Since the questionnaire is completed by help of an interviewer, they were asked to express appreciation to the respondent.

The main body of the questionnaire was composed of the following nine sections: household composition, farming systems, human capital, intermediate inputs, capital, wealth index, land holding, total income of households, and household expenditure. Each section has items comprising closed and open-ended questions.

To check or improve the validity and reliability of the questionnaire a number of approaches was adopted. The order of questions and the grouping of the items on the same topic was designed to keep the flow of the interview smooth and help the respondents to understand and answer the questions easily. Some sensitive questions, such as income, were placed at the end of the questionnaire in order not to provoke respondents from completing the questionnaire. A few important questions, such as water use and water expenses, were asked again in a different part of the questionnaire to check the consistency of the answers. Along all these concerns, the questionnaire was discussed with the researcher's two supervisors and some experts in the field to test the content validity, and required modifications were conducted.

After drafting the questions, data collectors were selected from a group of graduate students in social sciences from one of the local universities of the study region to ensure their familiarity with culture and language of the respondents as well as doing surveys. Interviewers received basic training and instructions regarding the research background, details on data collection and researcher's expectations from them. A pilot study was conducted with ten percent of the projected sample size, 30 households, aimed at examining whether the questions are unambiguous, easy to answer, with recordable and countable answers which can be used to produce valid and reliable data. Before starting the main survey any problems encountered during the pilot survey should be ironed out. The main concern for data collecting in the area was the language barrier, because the questionnaire was prepared in English and Persian. The official language of the region is Persian but the local language is Azeri-Turkish. The pilot study was more focused on examining if the interviewers' explanation in Azeri-Turkish was understandable and unambiguous enough for the respondent who might have problems in understanding some terms or questions in Persian. The pilot study showed that there was no need to translate the questionnaire to Azeri-Turkish. Some small/minor amendments suggested by interviewers or encountered during the pilot study were implemented before the final version. The households participating in pilot study were excluded from the actual research sample.

3.5. Data Processing

The first step in any data analysis is to generate a clean analysis-ready data set that has all the variables of interest in it. After coding and importing the data into a statistical program data will be screened for errors, missing data will be replaced and multiple variables are combined into one.

3.5.1. Screening and Cleaning the Data

Data processing is defined as the practice of transforming raw data from field collection into a cleaned and corrected state so that it can be used for analysis (Kveder & Galico, 2008, p. 3). In the first stage of this process all data was entered in a computer readable format, SPSS and Stata. For some calculations and analysis estimations Excel is used. At the time the data was entered a number of checks were performed to randomly selected questionnaires to reduce errors and typos.

By controlling the dataset, cases which may affect the quality of the analysis were excluded. These were the incomplete-response cases in which crucial questions for the analysis such as those related to their production and revenues were illegible or refused to be answered. If more than 5 percent of responses in a case failed for any reason, this case was removed from the dataset, as well.

Then data cleaning was continued with 273 questionnaires. At this stage the data set was screened for identifying range errors and inconsistencies in the dataset. Any data outside the expected range[15] or inconsistent was flagged for referring to the original questionnaire for more investigation, correction or explanation. Some examples of these corrections were; working days in a week are more than 7 days (data is not in the correct range), a child at age 2 is married, the work skills of a labor in years was more than the participants' age.

Some of these problems could be amended by examining the uniformity of responses between different variables. For example, due to sensitive nature of the variable in this study, there are two questions investigating water quantity, price, and resources used by farmers which can support each other. If the issue could not be resolved, we tried to have the best guess to correct the data or treated it as a missing value. Table 3.4 gives an overview of the distribution of the sampled households.

Table 3.4. Surveyed Villages and Distribution of the Sampled Households

Districts	village	No. of Surveyed HH	%-Share of Total	Total	%-Share of total
Shabestar	Chehregan	34	11.3	195	65
	Heris	25	8.3		
	Alibeyglu	32	10.7		
	Kafiolmolk	30	10.0		
	Ali Shah	51	17.0		
	Beygjekhatun	23	7.7		
Ajabshir	Shishavan	48	16.0	105	35
	Razian	24	8.0		
	Shiraz	33	11.0		
Total		300	100.0		

Source: Own field research data

[15] Finding outliers by drawing boxplot
Min. and Max for categorical variables' frequencies
Min., Max., Mean, and standard deviation for numerical variables' frequencies

3.5.2. Dealing with Missing Values

If any data on any variable from any participant is not present, and this absence is not appropriate, the researcher is dealing with illegitimately missing or incomplete data. In this study 0.9 percent of data was missing and treated with a "listwise deletion" which excludes a case if it contains one or more missing values. For this reason, the number of observations in the various estimations and calculations are different because the variables in various estimations are different and depending on the missing values in each variable some cases might be removed from the estimation.

3.5.3. Consolidating Scattered Information

At the last stage of preparing the final data file for analysis a number of calculations were implemented in the cleaned screened data to define the variables of the model. For this purpose, duplicated control questions were merged in one variable. There were also some variables which were based on several questions. In this case the final variable is created by combining the results. The final file with 273 cases is then ready to analyze.

3.6. Empirical Model and Variable Definition

3.6.1. Empirical Model

In order to assess the welfare effect of altering irrigation water prices in Lake Urmia basin this study examines the farmers' surplus changes as producers who are price-taker in a competitive market for their supply. For this purpose, we start with estimating farm households' income.

Household cash income in the study region consists of a variety of sources including the farming income, human resources income, non-farm income, and transferred income through remittances and governmental subsidies. Transferred and non-farm income is not affected by water input in production function in short term. Therefore, it is not involved in the model and analysis. Labor income will be affected by altering water input in agricultural activities through reallocation of labor due to changes in household farming income. In this study the labor reallocation is withheld as an assumption due to complexity and lack of data, although the trade-off between labor-leisure choices is indirectly affected by farm revenue. In conclusion we only look at farming income for the empirical estimations. For this purpose we calculated farm revenue by multiplying the quantity of harvested crops by the price for one unit of the crop. The farm revenue in national currency is applied as farm income in our estimations.

In the theoretical section the neoclassical production function with the multiplication of production factors was presented (see Equation 2.2) to develop the principals of how to capture the effect of water price changes on the output. Constant and variable elasticity of substitution (CES and VES) production functions belong to this class. The variable-elasticy-of-substitution production functions are not applicable here as these kind of functions need a large number of cases which have different technology and machinery for production. The sample of this study is less than 300 cases with almost the same level of technology and machinery for farming. Therefore, the CES production function is the choice for this study. The elasticity of substitution (σ) tells us about the substitution of labor, land, and capital. If σ is very low it means that the substitution is very difficult, while high σ means that the substitution is easy. As there is no information whether the substitution in the case study area is easy or not, it is assumed that it is feasible; neither easy nor difficult. This specifies the Cobb-Douglas production function. The basic form of the Cobb-Douglas production function in economic literature $Y = AK^{\alpha}L^{\beta}$, is a homogenous production function characterized by $\sigma = 1$.

The original Cobb-Douglas production function can be easily estimated by transforming to logarithms. The estimated coefficients represent output elasticities of individual variables and the sum of these elasticities indicates the nature of return to scale. In the original function the output (*Y*) will be produced by combining Labor (*L*) and physical capital (*K*). This study considered a log-linear expanded form of the Cobb-Douglas production function in terms of the number of inputs.

$$ln\, Y_i^{fa} = lnA + \beta_1 lnK_i + \beta_2 lnL_i + \beta_3 lnLand_i + \beta_4 lnI_i + \beta_5 lnW_i + \varepsilon \qquad (3.1)$$

with $i = 1, 2, \ldots, n$ farming households

Farm output (Y^{fa}) is produced by combining capital (*K*), labor in terms of man-day (*L*), Land size (*Land*), intermediate inputs, i.e. seed, fertilizer, and pesticide (*I*), and water (*W*). "*A*" indicates the total factor productivity[16] which is assumed the same for all farms in the study as the farming technology is assumed to be the same throughout the case study region in short term. β_1, β_2, β_3, β_4, β_5 are the corresponding parameters to the variables, and ε is the random disturbance associated with the production function. From a theoretical perspective the coefficient for water is expected to have a positive sign and equal to 1 in size.

3.6.2. Variable Definition

Farm Revenue: Farm output is the quantity of harvested crops for each farming household for one farming year. To uniform different variation of crops output for all farmers in the study, farm revenue is applied in the production function. Farm revenue is calculated as the quantity of harvested crops multiplied by the price for per unit of the crop, regardless of selling, inventory increasing or consuming the crop, in the last farming year of data collection time. Price-checked against the official statistics as well as the average price given by other respondents made this data reasonably accurate. Farm revenue for each household is gross cash in national currency (Iranian Rial, IRR). [17]

Irrigated and rain-fed lands under cultivation data are provided separately. Since 99 percent of annual agricultural revenue of the sample is from irrigated lands, rain-fed data is dropped from the study[18].

Capital: Capital is defined as the value of machinery and equipment that can be calculated as the sum of *qi*Ci*, where *i* = 1, …, *n* capital goods, *q* being the present sales price of capital good '*i*' and *C* being the quantity of the capital good '*i*' that is used by the farmer. Parish and Dillon (1955) introduced a list of diverse approaches to the classification of capital input in a review of the literature of production function from farm sample data. In this study respondents were asked to give the best guess for their farm machinery and tools if they were

[16] Total factor productivity can be measured as an economy's long term technological change.
[17] For calculation and estimations we used the historically and colloquially known currency,i.e. Toman. One Toman is equal to one Rial multiplied by 10.

[18] All rain-fed lands are located in Shabestar district in Heris and Ali Beiglu villages.

supposed to sell it at the time of data collection. Agricultural machinery is almost the same among households and doesn't vary significantly. In addition, the other variables used in the analysis are the cost of input for the year of the study. But the machinery price does not reflect the true machinery expenses in production for the farming year (such as depreciation, repair, and fuel cost). Hence capital is not entered in the estimations.

Land: "Land under cultivation" size in hectare is used for the analysis. Every household answered to this question based on the size of the land they owned or rented in the survey year. Errors in value of the land are more plausible than size as farmers might not know the exact value of their land before they really sell it. As explained before two different land categories were observed during the survey in the area; rain-fed and irrigated farms. Rain-fed farms were too small in size and production in proportion to irrigated farms to be counted in the study. More important, the investigation aiming to assess the water resources effects focuses on irrigated farms exclusively.

Labor: The labor variable used in this analysis is in terms of annual days of working labor on farm including all types of employment such as hired, family members, relatives, or working on neighbors' farm in turn (borrowing and lending labor to each other). As the farmer and their family working on their own farm are not usually paid workers, and the neighbor and relative labors are sometimes paid in kind, the labor working days are considered more accurate than labor costs to be applied in the estimations. This measure ignores the quality and skill of the labor as well as the number of hours the labor works per day which might be different from case to case.

Intermediate inputs: Materials used as inputs in farming such as seeds, pesticides, and fertilizers are components of this variable. The elements of this variable are estimated by multiplying the quantity of each element by its price to have a uniform expenditure measure for the intermediate inputs. Farmers gave an estimation of the quantity of these inputs in form of packs, weights, bags or sometimes the expenditure for these inputs. All this information was uniformed in form of costs. The variable is the sum of these expenditures in national currency (Iranian Rial, IRR).

Water: Water as a component of intermediate input is investigated separately in the study. Due to the importance of this variable a modification is implemented and water is measured separately from other intermediate inputs. The main reason for separating water from the other intermediate inputs is that water differs from other intermediate inputs due to its public- or club-goods characteristics. In contrast to the other intermediate inputs which must be purchased at market prices, most farmers can at least partly use water for free. Further, the paid-for water is not charged with market prices but at a fee that is set by the Iranian authorities rather than as the result of supply and demand on the water market.

Households pay only for piped water for home use and well water for farm use. The rest of water sources, if used, are free. Farmers were asked to provide a best guess for their monthly average water cost. They were also asked on the annual bill they pay for water abstraction from the well. The reason for asking the same question in two different forms is to have the possibility to double check the answers. Farmers do not have an adequate estimation of their water quantity use. Therefore, water quantities are derived from water costs by dividing the water cost to water price. Water prices are taken from secondary data resources.

3.7. Descriptive Analysis

Data analysis is the following step after data validating and coding which ranges from preliminary descriptive analysis –such as means and frequencies of the main variables- to extremely complex multivariate analyses. It presents the large number of observations in a manageable form to infer the population characteristics from the sample data. This section starts with univariate analysis, followed by multivariate analysis while bivariate analysis is applied if necessary. The purpose of univariate analysis is to describe the characteristic of the sample involving each single variable in the data set to provide us a basic picture of what the sample looks like. Description by enumeration and visual presentation are two common ways for univariate analysis. The descriptive analysis or univariate analysis is the first step of data analysis which serves as an introduction to shed light on the main focus of the study. This provides the basic features of the collected data in order to gain a better understanding of the sample and measures. The analysis focuses on basic descriptive statistics such as means and frequencies, and some simple graphics to emerge patterns to generate insights from data and create a statistical summary of the set of data. In bivariate analysis two measurements are made on each observation which is beyond simply descriptive analysis. This is a simple form of multivariate analysis which deals with the relationship between two variables to have a better description of the sample. In multivariate analysis more than one variable is observed simultaneously to analyze data.

The survey that provided the underlying data for this study was conducted in February to April 2013 in East Azerbaijan, Iran. Interviewed participants took effort that every interviewee was actually living in the region and their main source of income and activity was farming. Some 300 households were surveyed. The original collected data from the survey was cleaned and ordered to obtain a sample of 273 cases deemed usable which contains 91 percent of the original data. A brief descriptive report of the characteristics of the data is first presented here as the preliminary findings to get an idea of what the data looks like. This is the descriptive statistics of the variables which will be used in multivariate analysis, including mean, median and standard deviation.

3.7.1. Descriptive Analysis of Variables of the Study

Farm Revenue

Farm households were asked for their harvested amount of the annual last crop and its price. Since farmers did not have an estimation of the amount of crop grown for home consumption and for sale in the market, it was not possible to separate this data.

Table 3.5. Descriptive Statistics of Farm Revenue in US Dollar[19]

Villages	Mean	Median	SD	Districts	Mean	Median	SD
Chehregan	1940	1724	1306	Shabestar	3028	2674	2245
Alibeigloo	4500	4153	2917				
Heris	1672	1017	1404				
Kafiolmolk	2920	3104	1155				
Bigjekhatoon	4137	3450	3474				
Alishah	3204	3189	1664				
Razian	6197	5136	3131	Ajabshir	7723	5419	7356
Shishavan	7984	4521	8516				
Shiraz	8485	5988	7831				

Source: Own field research data

[19] 1 US Dollar = 24774 IRR, (UNdata, 2014)

As already explained in the variable definition (see section 3.6.2) farm revenue is calculated as the quantity of harvested crops multiplied by the market price for per unit of the crop to compute a uniform variable for every household called "farm revenue". Table 3.5 presents the mean and standard deviation of farm revenue in US dollar in nine villages, and two districts in the study for the year of study. Large variation was found in farm revenue in two districts.

Land

The data regarding the size of land in hectare is presented in Table 3.6. This shows the land size under cultivation during the last year of farming activity. There is not a large variation in land size in the two districts and nine villages in the study. Mean land size varies from 1.11 to 1.60 hectare in villages and is 1.3 hectare in both districts. The large standard deviation of land size in Shiraz village is the reason for larger standard deviation in land size in Ajabshir district.

Table 3.6. Descriptive Statistics of Land Size in Hectare

Villages	Mean	Median	SD	Districts	Mean	Media	SD
Chehregan	1.36	1.00	0.95	Shabestar	1.3	1	0.9
Alibeigloo	1.32	1.20	0.98				
Heris	1.60	1.00	1.07				
Kafiolmolk	1.30	1.00	0.85				
Bigjekhatoon	1.11	1.00	0.73				
Alishah	1.13	1.00	0.75				
Razian	1.39	1.20	0.91	Ajabshir	1.3	1	1.3
Shishavan	1.14	1.00	0.59				
Shiraz	1.43	1.00	2.16				

Source: Own field research data

Labor

Descriptive statistic of labor participated in the farm activity in villages and districts of the study sample are shown in Table 3.7. Labor is expressed in man-day units which is the work one person can do in a day. We used labor data in man-days unit in descriptions and estimations. Though labors can work full day or be the children or wife of the farmer who have other occupations and may not be employed as a full-time labor in the farm.

Table 3.7. Descriptive Statistics of Labor in Man-day

Villages	Mean	Median	SD	Districts	Mean	Median	SD
Chehregan	1086	940	607	Shabestar	897	771	578
Alibeigloo	924	926	310				
Heris	1409	1234	883				
Kafiolmolk	850	771	432				
Bigjekhatoon	569	570	264				
Alishah	672	514	444				
Razian	421	489	177	Ajabshir	646	452	489
Shishavan	858	617	591				
Shiraz	510	394	354				

Source: Own field research data

Intermediate Inputs (US Dollar)

Intermediate inputs are the expenditures of chemicals, fertilizers, and seeds in US dollar. The descriptive statistics related to this variable is presented in Table 3.8. Farm households were asked about the amount and price of the chemicals, seeds, and fertilizers they applied in the last year of farming. These data are used to calculate the intermediate inputs expenditures. Mean expenditure in Ajabshir is larger than Shabestar with a larger standard deviation.

Table 3.8. Descriptive Statistics of Intermediate Inputs Expenditures in US Dollar

Villages	Mean	Median	SD	Districts	Mean	Median	SD
Chehregan	62	49	55	Shabestar	83	61	68
Alibeigloo	97	66	71				
Heris	114	99	74				
Kafiolmolk	87	53	75				
Bigjekhatoon	79	68	71				
Alishah	75	62	62				
Razian	198	179	134	Ajabshir	130	98	124
Shishavan	86	68	67				
Shiraz	142	102	152				

Source: Own field research data

Irrigation Water Volume in Cubic Meter

Farmers stated that they have access to both free and paid water for irrigation. They irrigate their land by six sources of irrigation; well irrigation system, spring water, traditional irrigation channels, rain-fed irrigation, river, and dam water. The only source of irrigation that farmers pay for it was well. The other sources are free of charge. They were asked about the annual water costs they pay for irrigation. From the annual water expenses (their annual bill for water) and the secondary data for irrigation water prices, we calculated the amount of paid water.

The farmers also provided an estimation of the percentage of free and paid water that they use for irrigation. For example, one farmer would use 70 percent water from the well which should pay for it, and 30 percent from the river which is free. From the stated percentages the amount of free water was calculated. Descriptive data regarding to free and paid water volume is presented in Table 3.9 and Table 3.10 for villages and districts of the sample. Paid as well as free water volumes used in irrigation are significantly higher in Ajabshir than Shabestar. Mean water amount in Ajabshir is larger than Shabestar with a larger standard deviation. The large difference in Shabestar and Ajabshir farm revenue (Table 3.5) could be explained by the large difference in intermediate expenditures as well as the amount of water used in these two districts. Adopting modern agricultural practices by using improved seeds, chemicals, fertilizer, and water influences the farm output and income.

Table 3.9. Descriptive Statistics of Irrigation Water Volume in M^3 (Villages)

	Total Water			Paid Water			Free Water		
Villages	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Chehregan	23062	21818	9617	19807	20000	6817	3255	0	6306
Alibeigloo	25674	26364	5437	21643	21818	4973	4031	0	6520
Heris	22229	24242	14030	16166	18182	9238	6063	3896	8398
Kafiolmolk	25997	27273	22821	22473	27273	18967	3525	0	8139
Bigjekhatoon	20303	20000	7166	20000	20000	6779	303	0	1389
Alishah	42398	45455	9880	42398	45455	9880	0	0	0
Razian	135053	121212	58754	108538	109091	35774	26515	12121	35406
Shishavan	123047	123543	52628	96405	90909	35624	26642	0	48781
Shiraz	173105	109091	344607	144575	90909	311337	28530	15909	42840

Source: Own field research data

Table 3.10. Descriptive Statistics of Irrigation Water Volume in M3 (Districts)

Districts	Total Water			Paid Water			Free Water		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Shabestar	28622	27273	14928	26073	23636	14327	2549	0	6021
Ajabshir	141699	118182	198046	114490	90909	176854	27209	10101	43676

Source: Own field research data

Irrigation Water Price (US Dollar)

Irrigation water price in the study year was 0.0022 US Dollar per cubic meter[20]. By dividing the total amount of water (paid and free) with the secondary data for irrigation water price, we have an average price for irrigation water which differs among farmers. However, this difference is not large. Nine households out of 273, all from Shabestar district, did not declare their water costs for irrigation although they stated the percentage of free and paid water used in farming. These farmers are removed from the sample in some calculations and estimations. Table 3.11 shows irrigation water prices in the sample villages.

Table 3.11. Descriptive Statistics of Irrigation Water Price in US Dollar

Villages	Mean	Median	SD	Districts	Mean	Median	SD
Chehregan	0,002	0,002	0,001				
Alibeigloo	0,002	0,002	0,000				
Heris	0,001	0,002	0,001	Shabestar	0.002	0.002	0.001
Kafiolmolk	0,002	0,002	0,000				
Bigjekhatoon	0,002	0,002	0,000				
Alishah	0,002	0,002	0,000				
Razian	0,002	0,002	0,001				
Shishavan	0,002	0,002	0,001	Ajabshir	0.002	0.002	0.001
Shiraz	0,002	0,002	0,000				

Source: Own field research data

[20] The irrigation water price which is applied in this study is taken from a Persian source which is a very low price. https://www.isna.ir/news/92031809615
To cross check we looked into the international publications. Perry (2001, p. 11) used 0.004 US Dollar per cubic meter in his study which also a very low price. The difference between the price he applied and what we had for the year 2013 is due to the irrigation water price changes from 2001 to 2013 and the exchange rate for Iranian Rial to US Dollar.

Water Costs in Lake Urmia Basin

Table 3.12 indicates the number and percentage of households in three categories. Those who pay for irrigation water in full or partially or free of charge. Out of 273 cases in the sample 176 households paid for all water they use in irrigation which covers 47 percent of farmers in Ajabshir and 74.3 percent of farmers in Shabestar. Some 89 households used both free and paid water in irrigation. This covers 51 percent of farmers in Ajabshir and 22.3 percent of farmers in Shabestar. Finally, 8 farmers in the whole sample have full access to free water for irrigation; 2 percent of farmers in Ajabshir and 3.4 percent of farmers in Shabestar.

Table 3.12. Households Classification by Irrigation Water Costs

	Shabestar		Ajabshir		Total	
	No. of HH	Percent	No. of HH	Percent	No. of HH	Percent
Free Water	6	3.4	2	2.0	8	2.9
Free and paid water	39	22.3	50	51.0	89	32.6
100 percent paid	130	74.3	46	47	176	64.5
total	175	100	98	100	273	100

Source: Own field research data

3.7.2. Water Conservation in the Sample Area

As already mentioned agriculture is the major user of water in Lake Urmia basin, accounting for 93.8 percent of available water use in the basin. Water shortages in traditional irrigation systems are partly due to lack of water conservation methods. This increases the pressure on farmers to use water as efficiently as possible. The importance of farmers' roles as the main stakeholders in managing water resources cannot be exaggerated. Farmers in the survey were questioned about their water conservation practices. Results show that 61.5 percent of farmers in the sample do not apply any water conservation method and 38.5 percent of them practice at least one method of water conservation.

In order to examine if water expenses have any effect on water conservation practices, the sample is split into three groups; those who have free water for irrigation, those who partly pay for irrigation, and those who fully pay for the water they use in irrigation. Their water conservation practices were examined. The results in Table 3.13 indicate that farm households who use free water do not apply any water conservation program. But those who pay for the water (partially or fully), apply some water conservation programs. The percentage is about 40 percent in both groups. This can be partly due to very low water prices in irrigation that farmers do not apply water conservation programs.

Table 3.13. Water Conservation Programs for Farmers with Different Water Expenditure

	Percentage of Farm HH with at Least One Water Conservation Program	Percentage of Farm HH with No Water Conservation Program	Total
Farmers with full access to free water	0	0	100
Farmers who partly pay and partly use free water	41	59	100
Farmers who fully pay for water	39	61	100

Source: Own field research data

Applied water conservation methods

Farmers in the sample study practice some water conservation methods presented in Table 3.14. Among different methods of water conservation, reduced tillage had been the most stated method applied by farmers. Reduced tillage composes 35 percent of total conservation methods. Deficit irrigation (application of water below full crop-water requirements) [21] is the second applied method with 34 percent of total. About 20 percent of applied water conservation methods are covered by watering techniques and irrigation system improvements; mulching and drip irrigation. Adoption of modern irrigation methods such as drip irrigation, and sprinkler irrigation increases the efficiency of water applied. However due to warm climate and high evaporation drip irrigation is not a proper method for water conservation in Iran. Irrigation ponds as an artificial reservoir to preserve water for later use and drought tolerant crops are two other ways used by 11 percent of farmers.

[21] Under conditions of limited water supply, overall production is increased by extending the area under irrigation rather than by meeting full crop water requirements over a limited area. http://www.fao.org/nr/water/cropinfo_alfalfa.html

Reasons for Poor Conservation Practices

Farmers were asked about their reasons for not adopting water conservation practices. Several barriers were identified (Figure 3.7). More than 50 percent of farmers pointed out financial problems as a reason for poor water conservation practices which put this problem on top of the list. Other reasons for sticking to traditional inefficient systems for watering crops included lack of knowledge and lack of motivation with almost the same share of total reasons. Small land size that makes using the techniques and tools costly was also a cause for low water conservation practices.

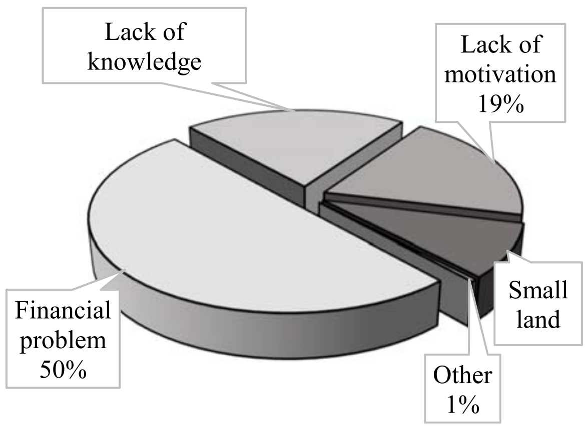
Table 3.14. Percentage of Applied Water Conservation Methods

Method	Shabestar	Ajabshir	Total Sample
Reduced tillage	37	32	35
Deficit irrigation	32	40	34
Improved irrigation systems	19	22	20
Storage ponds	8	0	6
Drought-tolerant crops	4	6	5
Total applied methods	100	100	100

*Some farmers apply more than one method

Source: Own field research data

Figure 3.7. Reasons for Poor Water Conservation Practices



Source: Own field research data

Major Constraints in Farming

Farmers were asked about the major constraints in farming in the past five years. Their answers to this question are presented in Table 3.15 in decreasing order. Water shortage is the most reported constraint among others. More than 99 percent of farmers pointed this as their major issue in the last five years. Water shortage, natural disaster, and hardly affordable prices of inputs are issues that almost all farmers encountered. These results emphasize the importance of water and environmental issues in the area and its effect on farming and farmers' welfare.

Table 3.15. Stated Major Constraints in Farming in the Past Five Years

Constrains	Percentage of farmers
Water shortage	99.3
Natural disasters	99
Hardly affordable prices of inputs	96.7
Lack of credit/capital	61
Lack of improved seed & fertilizer	41
Lack of chemicals	39.3
Labor shortage	30
Lack of infrastructure (road, marketing)	21.3
Lack of farm implements	20.7
Lack of farm land	15
Others (state support, wrong decisions without considering farmers issues)	7.7

Source: Own field research data

In Section 3.7.2 the irrigation across and within the study districts was reviewed to improve our understanding of water use in irrigation as well as adaptability to water conservation and requirements for improving water management in the area. Brekke et al. point out that the critical link between climate change and sustainability is adaptability. One adaptation to water shortage is to optimize the use of existing water resources (Brekke, et al., 2009, pp. 29-30). However, Schaible and Aillary believe that water conservation policies are limited in their ability to help the irrigated agriculture to adjust to the future of increasingly water-scarce world. A production system that involves several components such as crop choice, irrigation system type, field-level physical/environmental characteristics, and water supply conditions should be considered to promote a more sustainable future for irrigated agriculture (Schaible & Aillery, 2012, p. 49). Based on poor results from the case study in water conservation adopting more efficient irrigation methods in the basin as an influencing factor to cope with water scarcity and ecosystem degradation in the basin should be considered.

3.8. Model Estimation

To estimate the influence of independent variables on dependent variables a multiple regression was used. The independent variables tested were land, labor, intermediate inputs, and total water quantity. The dependent variable was the households' revenue from their farm, namely farm revenue. The number of included observations in the estimation were 251 after deleting the cases with missing data using the listwise[22] deletion method for handling missing data.

Two methods were applied, enter (model 1) and backward stepwise (model 2). The enter method includes full set of independent variables simultaneously[23] in the model while backward stepwise method starts with all variables then deleting the most statistically insignificant variable based on the model fit criterion, by repeating this process all insignificant variables will be excluded from the model[24]. We used both methods and then determined which one was a better fit for the model to be used for the rest of the study. Results of the regression run for both models are presented in Table 3.16.

3.8.1. Post Estimation Tests

Multiple regression was used to predict the value of agricultural output that can be obtained from different combinations of labor, land, intermediate inputs, and water. In a multiple regression, some basic assumptions about data and estimators should be met to have reliable

[22] In this method, the entire case (household) is excluded from analysis if a single value is missing
23 The simultaneous enter method forces all independent variables in the model at once on equal footing irrespective of the priority in terms of the theory, research goals (hierarchical) or statistical significance (stepwise).
24 In this method all independent variables are entered into the model. The weakest variable is removed and the model is estimated again. If the strength of model decreases the variable will be re-entered to the model. This ends up with the only useful independent variables in the model.

coefficients and correct results of the analysis. As pre-assumptions to carry out a multiple regression model, the dependent variable should be continuing along with two or more independent variables, either continuous or categorical, which was correct in this study data set. Some more general assumptions are required in order to have valid results in a multiple regression estimation. If these assumptions are not met the validity of the results and assertions of the study are questionable. "Knowledge and understanding of the situations when violations of assumptions lead to serious biases, and when they are of little consequence, are essential to meaningful data analysis" (Pedhazur, 1997, p. 33).

Table 3.16. Estimation of the Sample Households' Farm Revenue

	Model 1		**Model 2**	
Independent Variables	Coefficients	Std. Err.	Coefficients	Std. Err.
Constant	9.513442***	0.90	9.603551***	0.88
lnL ln labor in man-days	0.1303779*	0.08	0.1313555*	0.08
lnLand ln land size	0.324306***	0.08	0.3339968***	0.08
lnI ln intermediate inputs	0.0102488	0.02	-	-
lnW ln water amount	0.5055527***	0.06	0.5076382***	0.06
Adjusted R-Square	0.3338		0.3357	
F-Statistic	F(4, 246)=32.32		F(3, 247)=43.12	
Prob > F	0.000		0.000	

Note: The dependent variable in both models is $\ln Y^{fa}$ (ln farm revenue). The sample size covers observation of 251 farm households. The estimation method in model 1 is enter and in model 2 is backward stepwise.

*** significant at 1 percent level
** significant at 5 percent level
* significant at 10 percent level

Source: Own field research data

The aim of this section is assessing the assumptions of the estimated model and some post estimate tests. Four principal assumptions of multiple linear regression; i.e.

- residuals are normally distributed,

- there is a linear relationship between dependent and independent variables,
- homoscedasticity of errors,
- there is not multicollinearity between regressors,

are presented here (Osborne & Waters, 2002), as well as the effect size test and the test for Goodness-of-Fit. These assumptions are examined by post estimation tests while running regression estimations.

Normally-distributed Residuals

A normal distribution of error term is an assumption in Ordinary Least Square (OLS) models. For sufficiently large samples this assumption is not a serious issue, however meeting this assumption increases the consistency of estimators (Pallant (2007) and Lumley, Diehr, Emerson, & Chen (2002)). The normal distribution of residuals could be checked by visual examination of a plot or a variety of statistical tests such as Kolmogorov-Smirnov test, Shapiro-Wilk test, Jarque-Bera test, and Anderson-Darling test (Jarque & Bera (1980) and Razali & Wah (2011)).

The results from Shapiro-Wilk test of normality in this study (Table 3.17) showed that the error terms were not normally distributed. Nevertheless, as mentioned above several studies state that violation of the normality assumption does not have a major consequence on the result of the studies with big sample sizes. Therefore, the analysis for the study was conducted through OLS regression.

Table 3.17. Shapiro-Wilk Test of Normality

	Model 1			Model 2		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	0.985	251	0.008	0.984	252	0.007
Standardized Residual	0.985	251	0.008	0.984	252	0.007

Source: Own field research data

Linear in Parameters

Standard multiple regression can estimate only the linear relationship between independent variable(s) and dependent variable. The regression model is linear in parameters, which means the dependent variable is a linear function of independent variables separately and collectively, although the independent and dependent variables can be nonlinear. Using theory and previous research as a reference for linear relationship between dependent and independent variables is the first but not foolproof method for testing this assumption. Regression Specification Error Test (RESET) of Ramsey (Studenmund, 1987, pp. 212-214) is designed to examine the functional form misspecification (Ramsey, 1969).

H_0: the functional form of the model is correctly specified

H_1: the functional form of the model is not correctly specified

A natural logarithm of Cobb-Douglas production function used in this study covers this assumption based on theory and previous studies. In addition, the result of Ramsey RESET test is presented in Table 3.18. The F-statistic in both models had a p-value greater than 0.05 which means we cannot reject the null hypothesis and model is fit for linearity (Giles, 2012).

Table 3.18. Ramsey RESET Test

Model 1		**Model 2**	
F (3, 243)	1.58	F (3, 244)	1.53
Prob > F	0.1945	Prob > F	0.2068

Source: Own field research data

Homoscedasticity of errors

Homoscedasticity of errors or homogeneity of variance means that the variance of errors around the regression line is almost constant across all levels of the independent variable. If the variances of errors at different levels of independent variables are not the same, heteroscedasticity occurs. This assumption can be checked by a graphical method of a plot of the standardized residuals versus the regression standardized predicted value. Homoscedasticity of errors is met when the residuals are relatively evenly scattered around the line. It can be tested also by performing some statistical tests including White's General

Heteroscedasticity Test, Koenker–Bassett (KB) test (Bickel, 2007), and Breusch–Pagan (Williams, 2015). The Breusch-Pegan test was run to have a statistical approach in testing the homogeneity of variances[25].

H0: data is homoscedastic (there is constant variance)

H1: data is heteroscedastic

In this test squared residuals are regressed against independent variables to see if there is a relationship between them. The F-test significance of this regression rejects the null hypothesis of homoscedasticity of variance indicating that variances of residuals are a function of one or more of the independent variables and the assumption of homoscedasticity is violated. There was not a significant relationship between the fitted values and squared predictions. The results in Table 3.19 show that the null hypothesis cannot be rejected and data is homoscedastic in both models.

Table 3.19. Homoscedasticity Test (Breusch-Pegan Test)

Model 1		**Model 2**	
Chi2(1)	1.50	Chi2(1)	1.71
Prob > chi2	0.2212	Prob > chi2	0.1911

Source: Own field research data

Multicollinearity

A relationship between two or more than two independent variables is called collinearity or multicollinearity, respectively. In real econometric estimations, any multiple regressions suffer from some level of multicollinearity. A perfect collinearity tends to unreliable and unstable regression estimates. High or perfect correlations among predictors is problematic, however the moderate correlations are inevitable in most models (Gujarati D. N., 2003, p. 210). The widely used collinearity diagnostic test is the Variance Inflation Factor (VIF). VIF equals to 1 when there is no collinearity (Gujarati D. N., 2003, p. 355). VIF greater than 10 means there are concerns over multicollinearity and needs further investigation. The VIF of

[25] Regression residuals are heterogeneously distributed along the independent variables.

the independent variables of the estimated model in this study were less than 10 meeting the assumption of multicollinearity (Table 3.20).

Table 3.20. Collinearity Diagnostics (VIF)

	Model 1	**Model 2**
lnL ln labor in man-days	1.30	1.30
lnLand ln land size	1.38	1.30
lnI ln intermediate inputs	1.09	-
lnW ln water amount	1.08	1.07

Source: Own field research data

The contribution of inputs involved in production will be discussed below. The regression coefficients are elasticities of the output (here, farm revenue) with respect to every factor of production (here, land, labor, intermediate inputs, and water). Below the results in Table 3.16 are interpreted.

Intermediate inputs: The coefficient of intermediate inputs was not significant, showing that increasing the liquid capital did not systematically influence the farm output.[26] This is not consistent with the theoretical expectations which could be related to the empirical difficulties in collecting the correct data for this variable. Farmers did not have a clear idea about their expenses on seeds, fertilizers, and chemicals. They usually knew the quantity of used inputs. Some of these inputs were from the previous farming year. Some were from their own products (seeds, fertilizer) which they even did not know the exact quantity.

Labor: keeping other independent variables constant, 1 percent change in terms of labor was associated with 0.13 percent change in farm revenue in both models. The standard error as an estimate of the standard deviation of the coefficient in both models was 0.08. This coefficient was significant at 90 percent level.

[26] The capital data collected was the value that farmers put on their annual use of capital. The data in this case was unreliable as they did not have a clear estimation of how much they spend on capital.

Land: Land size is used for estimating the influence of land on production. Land value is a function of the quality as well as access to the market, transportation and some other factors which are not affecting crop production. The only factor in land value which affects production is the quality which can be assumed relatively homogeneous in the same area. Furthermore, Parish and Dillon (1955) state that high quality lands need more labor and capital to be farmed more intensively. Keeping the other independent variables constant, 1 percent change in land size was associated with 0.32 percent change in farm revenue in model 1 and 0.33 percent change in farm revenue in model 2. The standard error in both models was 0.08 and the coefficient in both models was significant at 95 percent level.

Water: The last independent variable in Table 3.16 is water measured in cubic meter. The coefficient stated if water quantity is increased by 1 percent, we expected farm revenue to be increased by 0.51 percent. The standard error in both models was 0.06 and the coefficient in both models was significant at 95 percent level.

3.8.2. Effect Size

An effect size is a measure of the magnitude of an observed effect in the sample. In this study three different effect sizes are measured; Eta squared (η^2), partial eta squared (η_p^2), omega squared (ω^2), and partial omega squared (ω_p^2). Eta Squared (η^2) indicates the proportion that can be attributed to a specific independent variable out of the total variation in dependent variable. By adding more variables to the model the proportion attributed to each variable decreases. This makes it difficult to compare the effect size of a single variable in different studies. Partial Eta squared (η_p^2) is an attempt to solve this problem. The variation explained by other independent variables is removed from the calculation to measure only the variation explained by a specific independent variable plus the unexplained variation in dependent variable. Therefore, one can compare the effect of same variable in different studies (Richardson, 2011). In small samples Eta squared is biased and overestimates the population variance. To solve this problem in small samples Omega squared (ω^2) is used to measure the effect size. Since omega squared uses the unbiased measures of the variance components, it is always smaller than eta squared. The results for these effect sizes for model 1 and 2 are presented in Table 3.21 and Table 3.22.

In Table 3.21 the overall η^2 indicates that model 1 accounted for approximately 34.4 percent of the variability in farm revenue. The partial η^2 for independent variables indicates that 1.1 percent of the variability in dependent variable was explained by labor, 6.5 percent was explained by land, and 23.7 percent was explained by water. The overall ω^2 indicates that our model accounted for approximately 33.4 percent of the variability in farm revenue. The partial ω^2 for independent variables indicates that 1 percent of the variability was explained by labor, 6.2 percent was explained by land, and 23.5 percent was explained by water. The 95 percent confidence interval for η^2 and ω^2 for the model and all variables except intermediate inputs and labor, did not contain zero which states the results were significant at this level in line with the p-values.

Table 3.21. Effect Size Model 1

Variable	η^2	95 percent Confidence intervals		ω^2	95 percent Confidence intervals	
lnL ln labor in man-days	0.0109959	0.0	0.0501234	0.0069756	0.0	0.0462621
lnLand ln land size	0.0654392	0.0183366	0.1319626	0.0616401	0.0143461	0.128434
lnI ln intermediate inputs	0.0011882	0 .0	0.0241944	0.0	0.0	0.0202277
lnW ln water amount	0.2380335	0.1513798	0.3225307	0.2349361	0.1479301	0.3197767
Model	0.344472	0.2442531	0.4186169	0 .333813	0.2319646	0.4091635

Source: Own field research data

In Table 3.22 the overall η^2 indicates that model 2 accounted for approximately 34.4 percent of the variability in farm revenue. The partial η^2 for independent variables indicates that 1.1 percent of the variability was explained by labor, 7.3 percent was explained by land, and 24 percent was explained by water. The overall ω^2 indicates that our model accounted for approximately 33.6 percent of the variability in farm revenue. The partial ω^2 for independent variables indicated that 1 percent of the variability was explained by labor, 7 percent was explained by land, and 23.7 percent was explained by water. The 95 percent confidence interval for η^2 as well as ω^2 for the model and all variables except labor, did not contain zero which states the results were significant at this level in line with p-values.

Results from both models indicates that water had the largest effect in variability in farm revenue with a significant difference from other variables. Cohen convention for η^2 for small, medium, and large effect size are 0.0099, 0.0588, and 0.1379, respectively (Cohen J., 1988). Based on his convention the water effect size in this estimation is considered large.

Table 3.22. Effect Size Model 2

Variable	η^2	95 percent Confidence intervals		ω^2	95 percent Confidence intervals	
lnL ln labor in man-days	0.0111523	0.0	0.0503341	0.0071489	0.0	0.0464893
lnLand ln land size	0.0726103	0.0225248	0.1409289	0.0688557	0.0185674	0.1374508
lnW ln water amount	0.2401298	0.1534453	0.3244682	0.2370534	0.1500179	0.3217332
Model	0.3436922	0.2465094	0.4201537	0.3357208	0.2373577	0.4131111

Source: Own field research data

3.8.3. Goodness-of-Fit and Model Selection

In order to find out the goodness-of-fit we used the adjusted R-square to avoid the R-square drawback which its value increases when the number of independent variables increase. The adjusted R-square was used to show the explanatory power of the model. The adjusted R-square in model 1 and model 2 were 0.3338 and 0.3357 respectively, which stated that the strength of the model 2 is slightly larger than model 1 (Table 3.16). These numbers mean that 33 percent of the changes in the dependent variable in model 1 and 34 percent of the changes in the dependent variable in model 2 were explained by the independent variables.

As we had two models in model estimation regressions, a model selection measure is applied here to compare models containing different combination of predictors. The Akaike's Information Criterion (AIC), as a mean of model selection, is corrected for model complexity based on the number of estimated parameters. This criterion is not intrinsically interpretable but can be used to see how changing the model affects the fit. The smaller AIC is the better fit of the data (Field A., 2009, S. 304 and 737). This statistic is a measure of the relative quality of statistical model for a given set of data. It states a relative estimate of the information lost when a given model is used. Table 3.23 shows the result for AIC and AIC adjusted for sample size (though the sample sizes in both models here are equal) for model 1 and model 2 to choose the optimal set of independent variables. The results identify that model 2, backward stepwise, had a better fit than model 1, enter, in terms of containing information and not overfitting the data.

Table 3.23. AIC for Model 1 and Model 2

	AIC	Adjusted AIC
Model 1	558.1954	2.223886
Model 2	556.4938	2.217107

Source: Own field research data

3.9. Districts Differences

The descriptive statistics show that farm revenue, intermediate inputs, and water use were significantly higher in Ajabshir, while labor was lower. Land size and water price were almost the same in both districts (see section 3.7.1). In this section, a dummy variable introducing the districts (Shabestar and Ajabshir) is added to the model to investigate the location specific differences. The original regression equation estimated in Equation (3.1) is:

$$ln\, Y_i^{fa} = lnA + \beta_1 lnK_i + \beta_2 lnL_i + \beta_3 lnLand_i + \beta_4 lnI_i + \beta_5 lnW_i + \varepsilon$$

Following (Dougherty, 2016, p. 230) we add DIS as the dummy variable to the equation. The new equation will be:

$$ln\, Y = ln\, Y^{fa} + \beta DIS \qquad (3.2)$$

$$lnY - lnY^{fa} = \beta DIS$$

$$\frac{Y}{Y^{fa}} = e^{\beta DIS}$$

We have two states for *DIS*; 0 and 1.

$$If DIS = 0 \;\; then \;\; \frac{Y}{Yfa} = 1 \qquad percent\Delta Y\, (DIS; 0 \dashrightarrow 1) = e^{\beta - 1} \qquad (3.3)$$

$$If DIS = 1 \;\; then \;\; \frac{Y}{Yfa} = e^{\beta} \qquad percent\Delta Y\, (DIS; 1 \dashrightarrow 0) = e^{-\beta} - 1 \qquad (3.4)$$

A hierarchical regression was run to understand the role of the districts in the analysis. In the first block, all independent variables of the theoretical model were included in the equation.

The “Dummy districts” variable was added in the second block in order to test if it accounts for a significant variance beyond other independent variables. Table 3.24 shows the results in two models. Model I predictors were land, labor, intermediate inputs, and total water. Model II predictors were model I predictors plus the districts variable. The presented results in Table 3.24 show that R square in model I and model II were 0.344 and 0.375, respectively. F changes with p-values less than 0.05 in both models indicated that the changes accounted for R square change were statistically significant. Therefore, adding the district variable to the model will add predictive power to the model.

Table 3.24. Model Summary of Changes in Statistics in a Hierarchical Regression of the Study

Model	R Square	Adjusted R	R Square Change	F Change	Sig. F Change
I	0.344	0.334	0.344	32.303	0.000
II	0.375	0.362	0.030	11.910	0.001

Model I. Predictors: (Constant), lnLand, lnL, lnI, lnW.

Source: Own field research data

To examine the difference between two districts, we add the dummy district variable to the model first to see the differences between the intercepts in the model. Table 3.25 shows the results for adding dummy districts to model 1 and model 2 (the same models as presented in Section 3.8 with an additional variable; district). This indicates that district variable had a statistically significant parameter in the model. The coefficient for district variable was 0.62 in both models. Replacing this number in Equation (3.4) for going from district 1 (Shabestar) to district 0 (Ajabshir), the farm revenue will increase by 46 percent. This result is in line with our descriptive analysis which stated mean farm revenue in Ajabshir was higher than Shabestar (see table 3.5).

3.9.1. Post estimation Tests

Normally-distributed Residuals

The results from Shapiro-Wilk test of normality (Table 3.26) showed that the error terms were normally distributed in both models.

Table 3.25. Estimation of the Sample Households' Farm Revenue

	Model 1		Model 2	
Independent Variables	Coefficients	Std. Err.	Coefficients	Std. Err.
Constant	12.89734***	1.32	12.98608***	1.31
lnL ln labor in man-days	0.1798244**	0.08	0.180819**	0.08
lnLand ln land size	0.3511014***	0.08	0.3598039***	0.07
lnI ln intermediate inputs	0.0091358	0.02	-	-
lnW ln water amount	0.2000652 *	0.11	0.201162*	0.20
DIS district (dummy)	-0.6226392***	0.18	-0.6241917***	0.18
Adjusted R-Square	0.3620		0.3639	
F-Statistic	F(5, 245)=29.37		F(4, 246)=36.76	
Prob > F	0.000		0.000	

Note: The dependent variable in both models is $\ln Y^{fa}$ (ln farm revenue). The sample size covers observation of 251 farm households. The estimation method in model 1 is enter and in model 2 is backward stepwise. This estimation has one more independent variable than the previous estimation in Table 3.16; district as a dummy variable.

*** significant at 1 percent level
** significant at 5 percent level
* significant at 10 percent level

Source: Own field research data

Table 3.26. Shapiro-Wilk Test of Normality

	Model 1			Model 2		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	0.037	251	0.086	0.041	252	0.076
Standardized Residual	0.037	251	0.086	0.041	252	0.076

Source: Own field research data

Linear in Parameters

The result of Ramsey RESET test (Table 3.27) indicated that both models were fit for linearity. The F-statistic has a p-value greater than 0.05 which means we could not reject the null hypothesis and models were fit for linearity (Giles, 2012).

Table 3.27. Ramsey RESET Test

Model 1		**Model 2**	
F (3, 242)	1.35	F (3, 243)	1.24
Prob > F	0.2590	Prob > F	0.2948

Source: Own field research data

Homoscedasticity of errors

The results in Table 3.28 shows that the null hypothesis could not be rejected and data were homoscedastic in both models.

Table 3.28. Homoscedasticity Test (Breusch-Pegan Test)

Model 1		**Model 2**	
Chi2(1)	1.19	Chi2(1)	1.30
Prob > chi2	0.2746	Prob > chi2	0.2541

Source: Own field research data

Multicollinearity

The VIF of the independent variables of the estimated model were less than 10 meeting the assumption of multicollinearity (Table 3.29).

Table 3.29. Collinearity Diagnostics (VIF)

	Model 1	**Model 2**
lnL ln labor in man-days	1.35	1.35
lnLand ln land size	1.39	1.32
lnI ln intermediate inputs	1.09	-
lnW ln water amount	3.74	3.73
DIS district (dummy)	3.78	3.78

Source: Own field research data

Goodness-of-Fit and Model Selection

A model selection measure was applied to compare models containing different combinations of predictors. The Akaike's Information Criterion (AIC), for model complexity based on the number of estimated parameters shows that model 2, backward stepwise, had a better fit than model 1, enter, in terms of containing information and not overfitting the data (Table 3.30).

Table 3.30. AIC for Model 1 and Model 2

	AIC	Adjusted AIC
Model 1	548.3299	2.223886
Model 2	546.5785	2.217107

Source: Own field research data

3.9.2. Chow Test for District Differences

To examine the difference between two districts we added the dummy district variable and tested the differences between intercepts. Before examining the slope differences between districts, the interaction variables were added to the model. To create the interaction variables, first we centered the original continuous variable (to avoid multicollinearity). Then the centered variable was multiplied by the district variable.

Table 3.31. Estimation of Households' Farm revenue (with Interaction Variables)

	Model 1		**Model 2**	
Independent Variables	Coefficients	Std. Err.	Coefficients	Std. Err.
Constant	14.80403***	0.81	15.18253***	0.49
lnL ln labor in man-days	0.2516294**	0.11	0.2063039***	0.08
lnLand ln land size	0.2987316**	0.12	0.3543895***	0.074
lnI ln intermediate inputs	0.0081247	0.03	-	-
DIS district (dummy)	-0.7281312***	0.12	-0.7277246***	0.12
lnL_DIS ln labor in man-days (centered)* district (dummy)	-0.1476724	0.15	-	-
lnLand_DIS ln land size (centered)* district (dummy)	0.1117276	0.15	-	-
lnI_DIS ln intermediate inputs (centered)* district (dummy)	0.0138751	0.038	-	-
lnW_DIS ln water amount (centered)* district (dummy)	0.3497121**	0.13	0.3629077***	0.13
Adjusted R-Square	0.3666		0.3735	
F-Statistic	F(8, 244)=19.24		F(4, 246)=38.26	
Prob > F	0.000		0.000	

Note: The dependent variable in both models is lnY^{fa} (ln farm revenue). The sample size covers observation of 253 and 251 farm households in Model 1 and Model 2, respectively. The estimation method in model 1 is enter and in model 2 is backward stepwise. This estimation has five more independent variables than the first estimation in Table 3.16. District as a dummy variable and four interaction terms created from our independent variables and district are added to the model to estimate the relation between dependent and independent variables after controlling for district.

***significant at 1 percent level
**significant at 5 percent level

Source: Own field research data

Product variables, lnL_DIS, lnLand_DIS, lnI_DIS, lnW_DIS[27], are the variables introduced for the differences between districts in independent variables. Result for the new regression for both models (enter and backward stepwise) presented in Table 3.31 stated that the only significant coefficient for product variables was lnW_DIS. This means that water use in Shabestar and Ajabshir were significantly different. All estimations and post-estimate tests related to these two regression models are enclosed in Appendix C.

The Chow test examines the differences between two regressions, whether the coefficients estimated over one district are equal to the coefficients estimated over the other one. The null hypothesis for this test says model is the same between two districts, so there is no significant improvement in fit from running two regressions. Table 3.32 shows the results for Chow test for model 1 and 2. The p-value for F-test in both models was less than 0.05. The null hypothesis was rejected which means model parameters were not the same between two districts. Either the constant or one of the slopes in the models with and without the dummy variable and interaction variables were not the same. But as the size of the sample for each district was small we could not do the estimations and calculations for production function and welfare changes for two separate samples. Therefore, we continue the analysis on the whole sample (basically 273).

Table 3.32. Chow Test for Differences Among Parameters Between Districts

Model 1	Model 2
F (5,241)=3.69	F (2,246)=49.33
Prob > F= 0.0031	Prob > F= 0.000

Source: Own field research data

3.10. Elasticity of Demand

The following step is to estimate the elasticity of demand for irrigation water in the sample area. As already explained in chapter two, the multiplicative function model is used to estimate the elasticity of demand for water.

[27] lnL_DIS = ln labor in man-days (centered)* district (dummy)
lnLand_DIS = ln land size (centered)* district (dummy)
lnI_DIS = ln intermediate inputs (centered)* district (dummy)
lnW_DIS = ln water amount (centered)* district (dummy)

The multiplicative function introduced in Equation (2.11) is:

$$W_i = \alpha_0 q_{w_i}^{-\alpha_1} L_i^{\alpha_2} Land_i^{\alpha_3} I_i^{\alpha_4} P_{Y_i}^{\alpha_5}$$

Where W_i is the water consumed by farm household i, q_{w_i} is the price of water, L_i is the labor quantity (in man-days), $Land_i$ is the land quantity (land size in hectares), I_i is the intermediate inputs quantity (expenses in IRR), and $p_{Y\,i}$ is the output price, all for farm household i.

The ln-transformed model was estimated by a backward stepwise regression for 241 observations after removing outliers from the sample for the variables used in this estimation. Results are presented in Appendix D. We already knew from Equations (2.12) and (2.13) that the gradient of the farm household demand curve for water is α_1 which is the coefficient for the price of water in the estimated regression. The point-price elasticity of demand [28] for water was -0.89 in the study sample. The elasticity of demand for water less than one indicates that changes in water consumption due to water price changes were less than one and in the opposite direction; increasing the water price decreases the water consumption. Increasing water prices stimulates users to use less water which will result in reduced production. Farmers in Iran are not far from the poverty line. Increasing irrigation water prices will increase agricultural costs and will harm farmers' production, income, and welfare.

In empirical literature most studies indicate that farmers are low responsive to water price changes. Bar-Shira et al. (2006) estimated water demand elasticity of -0.3 in the short run and -0.46 in the long run for the agricultural sector in Israel in the period 1992-1997. Scheirling et al. (2006, p. 1) apply a meta-regression model to investigate price elasticity of irrigation water demand of 53 studies. They came up to a mean of -0.48.

Schoengold et al (2006) study estimated the price elasticity of agricultural water demand in sample farms located 90 miles north of Los Angeles farms by -0.79, which is greater than that found in previous studies. Sadeghi et al. (2010) estimated water price elasticity of demand for barley for 26 provinces in Iran during 2001-2006. They explain that the very low, near to zero, price elasticity of water demand is that water has no substitute in agriculture as

[28] Point-price elasticity of demand method minimizes the difference between the starting and ending points, i.e. it is the elasticity at a specific point on the demand curve. Point-price elasticity of demand uses differential calculus to calculate the elasticity for an infinitesimal change in price and quantity at any given point on the demand curve. Sloman, John (2006). p.55.

well as the water price is very low. Zare (Zare Mehrjerdi, 2006) estimated price elasticity of water demand for groundwater in Kerman, Iran. He concluded that increasing water abstract costs would not impact the rate of extraction.

3.11. Scenarios and Results

The analysis in this section is based on a hypothetical water price scenario to simulate the imposition of higher water prices on farm households' welfare. We calculated the farm households' reaction to a price increase from the price elasticity of water demand. Then the water quantity change was substituted in the production function to calculate the farm households' revenue.

To quantify the total welfare effects of the water price change in the study sample, the procedure described in chapter 2 (see section 2.5) was followed. Keeping all other inputs constant the water was assumed the only varying input in production. We applied several hypothetical flat water prices imposed to sample farmers to measure the changes in water use as well as their welfare. These were just hypothetical prices used for simulation to examine the farm households' welfare due to irrigation water price changes. The analysis was continued by considering three hypothetical scenarios where a 50, 75 and 100 percent increase in price is applied to water used in irrigation (Berbel, Calatrava, & Garrido, 2007).

In this simulation, farmers were price-taker and their revenue was equal to the average price of the output in the market multiplied by their output. It was assumed that water is the only input that changes, so the cost of production change was the result of changes in water price and quantity. In our simulation we assumed that farmers would not substitute the reduction in water intake - arising from higher water prices - with other production factors such as labor, land, intermediate inputs and capital. An increase in water prices usually drives farmers to improve their irrigation system as the first candidate to have more efficient use of more expensive water.

Poverty is the major limiting factor here. Most farmers in Lake Urmia basin are small-scale farmers with an average household size of 6 to 7 people, who operate on fields that add up to a total land area of just 1 to 2 hectare per family (see table 3.6). Because of this poverty, most farmers will have very limited means to substitute a reduction of available irrigation water by investing into better irrigation technologies. Therefore, poverty is a good justification for a scenario in which farmers only respond to the implementation of higher water prices by a reduction of output.

Using the above explained estimations in Equation (2.10) the producer surplus was calculated from changes in producer revenue and costs as:

$$\left(p_Y.Y_1 - \int_0^{w^1} C_Y\left(Y, q_{inputs}, W_1\right) dy\right) - \left(p_Y.Y_0 - \int_0^{w^0} C_Y\left(Y, q_{inputs}, W_0\right) dy\right)$$

This was calculated for individual farmers. The sum of farmers "producer surplus" change indicates the total welfare change due to hypothetical changes in water price.

The results for these three scenarios are presented in Table 3.33. Per hectare welfare change indicates the proportion of total welfare change to the cultivated lands. Per capita welfare change indicates the proportion of the total welfare change to the total household members in the sample.

Daily per capita welfare loss due to water price changes varies from 0.6 to 1.2 US Dollar which is a significant loss for poor farm families in the sample compared to their per capita daily income (2.8 US Dollar). After a hypothetical 50 percent increase in water prices farmer households lose 21.6 percent of their farm revenue. They will lose 32.4 percent and 43.2 percent of their farm revenue for 75 percent and 100 percent increase in water prices, respectively.

Percentage change in water consumption presented in the last row of the Table for three scenarios state that by increasing water prices to 50, 75, and 100 percent, water consumption decreases by 44.5, 66.8, and 89 percent, respectively.

3.12. Equity and Distributional Effects

In this section the influence of farm households' socio-economic status on their welfare loss and the distributional effect of changes in irrigation water prices is examined. Regardless of the fact that data limitation does not allow to do more detailed analysis, this analysis still give us a good indication of welfare loss distribution.

Table 3.33. Welfare Change for Hypothetical Increase in Water Price in Two Districts

Water price increase	50 percent	75 percent	100 percent
Per hectare welfare change US Dollar	-838.4	-1257.5	-1676.7
Per capita welfare change (Annual) US Dollar	-220.5	-330.8	-441.1
Per capita welfare change (Daily) US Dollar	-0.6	-0.9	-1.2
Welfare change as percentage of farm revenue	-21.6	-32.4	-43.2
Percentage change in water consumption	-44.5	-66.8	-89.0

Source: Own field research data

3.12.1. Quantile Regression

To identify the effect of irrigation water price changes on farm revenue with respect to the farm revenue level we apply a quantile regression method. Quantile regression models the relation between a set of independent variables and specific percentiles of dependent variable. This can specify how some percentiles of the farm revenue may be more (or less) affected by independent variables than other percentiles. The regression coefficients for the same variable in different quantiles reflect these differences. The dependent variable of the study is divided in three groups; 0.25, 0.50, 0.75 cumulative quantiles. The last regression is the regression for the whole data. Data is sorted and selected based on the dependent variable from low to high. Table 3.34 presents the results for quantile regression. These results indicate the effect of independent variables along the distribution of dependent variable.

Intermediate inputs coefficient for all quantiles and OLS model was not significant. The other variables were significant in some quantiles and not significant in some other quantiles. The significant variables are shown with one or two stars in Table 3.34.

Table 3.34. Estimation of the Sample Households' Farm Revenue via OLS and Quantile Method

Independent Variables	Q(0.25)	Q(0.50)	Q(0.75)	OLS
Constant	10.18058***	9.886831***	10.84514 ***	9.513442***
	(1.07)	(0.89)	(1.6)	(0.9)
lnL	-0.0126842	0.0984697	0.1565109	0.1303779*
ln labor in man-days	(0.09)	(0.08)	(0.14)	(0.08)
lnLand	0.4980308***	0.282968***	0.221903	0.324306***
ln land size	(0.09)	(0.08)	(0.14)	(0.08)
lnI	0.0111839	0.012382	-0.0006985	0.0102488
ln intermediate inputs	(0.02)	(0.02)	(0.03)	(0.02)
lnW	0.4833433***	0.4839147***	0.417001***	0.5055527***
ln water amount	(0.07)	(0.06)	(0.10)	(0.06)

The dependent variable in all columns is lnYfa (ln farm revenue). The parentheses below the coefficients report standard errors. The original number of the observations which quantile regression was implemented in was 251.

*** significant at 1 percent level
** significant at 5 percent level
* significant at 10 percent level

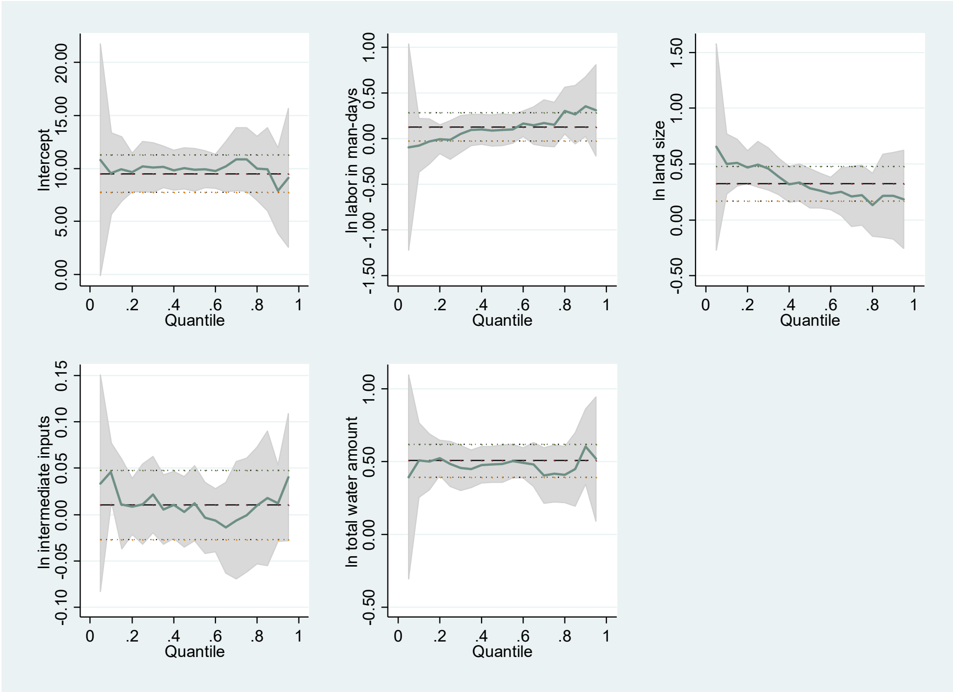
Source: Own field research data

The OLS coefficients for all variables were clearly inside the 95 percent confidence intervals for each variable in three quantiles. This indicates that the quantile coefficients were not significantly different from the OLS coefficients.[29] The complete table containing the confidence intervals is attached in the appendix (see Appendices E).

Figure 3.8 shows a method to visualize the change in quantile coefficients along with confidence intervals. In each plot, the regression coefficient at a given quantile indicates the effect on farm revenue of one percent change in that variable, assuming that the other variables are fixed. Green lines represent the slope coefficient for the quantile of the x axis and the gray shadows around it are the confidence intervals for that specific variable. The dashed lines are the least squares estimate and the dotted lines are its confidence intervals at 95 percent level.

[29] For example, water coefficient in OLS (0.5055527) is inside the 95 % confidence interval for the water coefficient in $Q_{0.25}$ (0.3477287, 0.618958) which means water coefficient in this quantile is not significantly different from water coefficient in the OLS model.

Figure 3.8. Graphical Representation of the Quantile Regression Estimates



Source: Own field research data

The quantile slope estimates were not statistically different from the least squares estimate. The OLS coefficients for intercept, land, and water were significantly far away from zero (the confidence intervals were above 0 in y axis). The confidence intervals for intermediate inputs and labor (as this graphs are at 95 percent level) included zero which means the coefficient for these two variables were not significantly different from zero. These graphs confirmed the table results that the quantile coefficients did not considerably differ from the OLS regression and these results did not give us a better picture of the effect of independent variables on dependent variables.

3.12.2. Farm Revenues and Annual Expenditures as Wealth Proxy

Data limitations prevent the development of the study on wealth index and producer welfare loss relationship. Because of this limitation farm revenue is used as a proxy for economic status of farm households. Farm revenue data was sorted in an increasing order. After this the sample was divided into five equal groups. Each group contained 20 percent of the sample size from lowest to the highest farm revenue. Quantile 1 corresponded to the 20 percent of the population having the lowest farm revenue, quantile 5 corresponded to the 20 percent of the population having the highest farm revenue. As we already calculated the welfare loss for each farm household, we could calculate the welfare loss for each quantile by adding up their loss. This was calculated only for the first scenario, i.e. increasing water prices by 50 percent because the water price changes are proportional (50,75,100 percent) and have a similar proportional effect. The results are presented in Table 3.35. Results show that as the farm households get richer they suffer more from the water price changes. But the difference is too small to be considered. The water consumption column shows that the richer quantiles have proportionally (compared to their share of revenue) less changes in water consumption than poorer. One explanation can be that poorer farmers cannot afford the new prices for water and decrease their consumption as much as possible. The ratio of the highest to the lowest quantiles for farm revenue, welfare loss, decrease in water consumption are 11.9, 13, and 3.2 respectively. In a perfect equality this ratio would equals to 1. Though the results for farm revenue and welfare loss are not very different, water consumption decrease is much closer to equity and far from the two other ratios. This states that inequality in farm revenue and welfare loss is larger than inequality in water consumption decrease.

Table 3.35. Distribution of Effects of Changes in Irrigation Water Prices by Farm Revenue Quantiles

Lowest farm revenue to the highest	%-Shares of farm revenue	%-Share of welfare loss	%-Share of decrease in water consumption
First quantile (Poorest)	4.3	4.0	9.6
Second quantile	10.2	9.9	15.6
Third quantile	14.2	14.0	20.9
Forth quantile	20.7	20.6	22.8
Fifth quantile (Richest)	50.6	51.5	31.1
Total	100	100	100
Ratio of the highest to the lowest	11.9	13.0	3.2

Source: Own field research data

In another try for examining the effect of households' socio-economic status on their welfare loss, households' annual expenditure was used as a variable to represent the socio-economic status of the household. They were asked about their expenditures on investment such as purchasing assets or on consumption such as food, clothing, and so on. The independent variable socio-economic status includes three groups; low, medium, and high based on low, medium, and high annual expenditures, respectively. A one-way analysis of variance was conducted to compare the effect of households' expenditure on their welfare loss. The null hypothesis states there is no difference in households' welfare loss based on the households' expenditure. First, test of homogeneity of variance was conducted to test whether the variance of households' welfare loss is the same in three socio-economic groups. The significance value for Levene's test was less than 0.05 which means the data violated the homogeneity of variance and there were unequal variances across three groups. Therefore, the Brown-Forsythe and Welch tests of equality of means were conducted because they are robust to homogeneity of variances. The Anova showed that the effect of households' expenditure on their welfare loss was significant; $F(2, 215) = 142.7$, $P= 0.000$. Thus, there was significant evidence to reject the null hypothesis and conclude that there was a significant difference in households' welfare loss due to changes in irrigation water prices based on their socio-economic status. According to Cohen's convention the effect size of 0.6 indicated that the difference between means of welfare loss in three groups was medium. Post hoc comparisons to evaluate pairwise differences among group means were conducted by the Games-Howell test since variances were unequal. This revealed a significant pairwise difference among the mean of welfare changes of households with low, medium, and high socio-economic status. The 95 percent confidence intervals contained zero which means the results are significant at 0.05 level (Appendix E-3).

Then the welfare loss in the three different groups was calculated. Results presented in Table 3.36 shows that the low socio-economic group with 7 percent of annual expenditures suffered 24 percent of the total welfare loss. The medium socio-economic group with 19 percent of annual expenditures suffered 33 percent of the total welfare loss. The low socio-economic group with 74 percent of annual expenditures suffered 42 percent of the total welfare loss. These results indicate that households with a higher socio-economic status bear less than households with lower socio-economic status from the welfare loss due to increasing irrigation water prices which is not in line with the results in Table 3.35. In this table share of welfare loss ratio is much closer to equity (1.7) than the share of expenditures (10.7). Results on decrease in water consumption are consistent with results in Table 3.35 indicating that proportionally (compared with their share of expenditure) households with low socio-economic status had more decrease in their water consumption than households with high socio-economic status.

Table 3.36. Share of Total Welfare Loss Based on Households' Socio-Economic Status

Socio-Economic Status	%- Share of Annual Expenditure	%- Share of Welfare Loss	%-Share of decrease in water consumption
Low	7	24	21.4
Medium	19	34	39
High	74	42	39.6
Total	100	100	100
Ratio of the highest to the lowest	10.7	1.7	1.8

Source: Own field research data

3.12.3. Lorenz Curve and Gini Coefficient

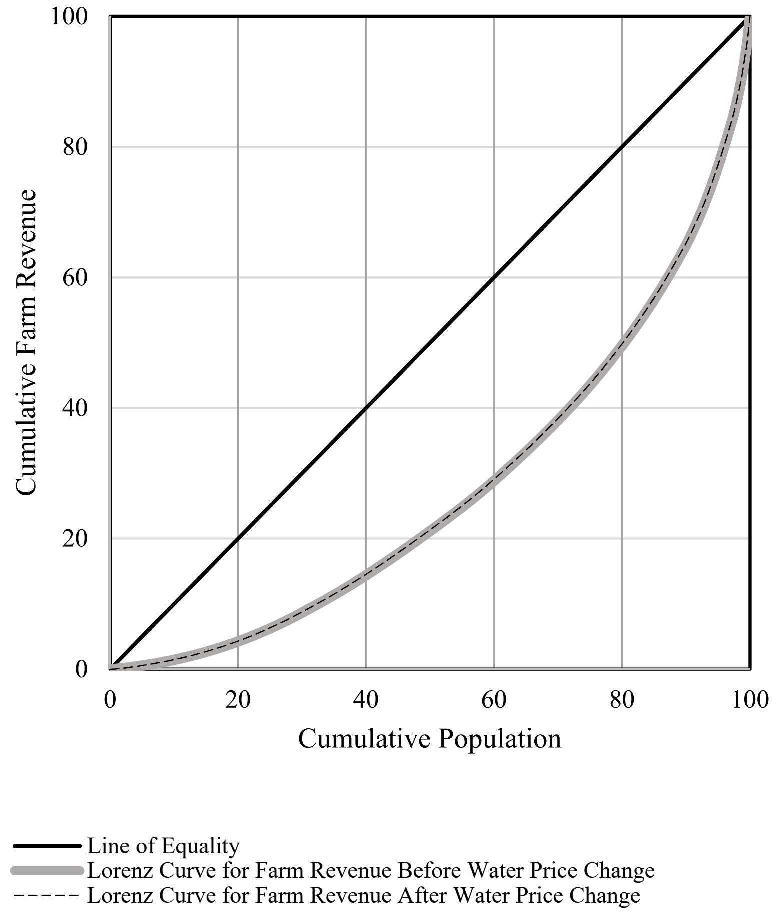
Lorenz curve which is used to illustrate the farm revenue distribution after and before water price changes does not show any changes in farm revenue distribution. The gray solid line is the curve before price changes and the dotted line is the curve after irrigation water price changes. The Lorenz curve graph confirms the previous findings that water price changes do not have a significant effect on income distribution.

As a tool for income distribution within the sample, a Gini income inequality coefficient discussed in Tsur and Dinar (1995, p. 24) is adjusted and calculated.

$$G = 1 + \frac{1}{n} - \frac{2}{n^2\mu}\sum_{i=1}^{n} i\,.\,y_i \qquad (3.5)$$

where y_i represents revenue for farm household i, n is the number of farm households, and μ is the mean farm households' revenues ($\mu = \frac{1}{n}\sum_{i=1}^{n} y_i$).

Figure 3.9. Lorenz Curve for Wealth Distribution Before and After Water Price Change



Source: Own field research data

The Gini coefficient is calculated for farm revenue under the original as well as the hypothetical 50 percent increase in irrigation water price. A Gini coefficient equal to zero means all sample members have equal share of the income while a Gini coefficient equal to 1 means one member of the sample gets all the income and the rest earn nothing. The Gini coefficients calculated for before and after water price changes in this study are almost 0.45.

Tsur and Dinar's (1995) and (2004) studies conclude that irrigation water pricing has little effect on income distribution. However Huang et al. (2006) in their study about irrigation water pricing policy in rural China concluded that doubling irrigation cost increases the Gini coefficient of households' income to 9.8 percent and increases the inequality.

There is a technical issue here that affects our data and does not allow us to see if there is a distributional effect or not. Actually our sample and data cannot answer the question if there is any distributional effect or not. We have estimated the relation between farm revenue and land size, water amount, and labor in production function. We have also estimated the relation between water price and water amount in water demand function. These functions are estimated for the whole data of the surveyed farm households, not for different quantiles (different farm revenue quantiles from poorest to the richest). Therefore, we have coefficients which are identical for all revenue groups. There cannot be a distributional effect under the approaches that we are not differentiating regressions for different revenues (or any other wealth index). Because of this technical reason we are not able to distinguish whether there are different behaviors in different quantiles. Our sample size does not allow us to do a statistically reliable quantile regression, the high correlation between water quantity use and land size and farm revenue pervert the analysis, and lack of good data on households' socio-economic status does not let us to investigate the wealth effect on welfare loss.

SUMMARY AND CONCLUSIONS

Water markets can be used to reallocate water from agriculture to improve the environmental condition of the ecosystem of the water resources. To estimate the value of natural resources in an ecosystem, either traded in the market or used as a factor of production in marketed goods, economists use the producer or consumer surplus. This study applied a production function as a methodology to measure the economic impacts that are associated with introducing hypothetical new water prices to the agricultural sector. This measures the economic loss of farmers caused by a policy which is environmentally useful and is aiming to improve the social welfare. However, defining a policy that meets economic objectives as well as environmental goals is a big challenge.

The sample data for the study was collected in Lake Urmia basin, located in the northwest of Iran. The environmental degradation caused by water overuse is considered as a serious problem in the region threatening the future security of the ecosystem of the basin. The direct use of the lake is little which made it hard to measure the real value of it although it is ecologically important for the surrounding ecosystem. Therefore, production function was used to estimate the value of water as a factor of production to measure the contribution of water to the marketed production. The analysis investigated the impact of changes in irrigation water prices on farm households' welfare to provide scientific support for more adequate water management policies and water allocation in this region.

The case examined here was a market for agricultural production in which farmers were price taker. In this sense, the total economic welfare changes due to changes in water prices affects only the farmers' production and revenue. Crop consumers experience no changes in their consumption and welfare in this regard. However, for investigating the aggregate effects of the intervention we need to measure the benefits that the society obtains of this action after reallocating the resource. The ultimate goal of reallocation of water is to make the other sectors in the area benefit from using released water. This effect was not considered in this study.

Assuming that the employed function and method was the best fitting with reasonable accurate results, the analysis can be used as a tool in making decisions on water price and policies regarding to natural resource management in the studied basin. This is not the final and best answer but an enlightening step towards considering sustainability and natural resources scarcity as well as socio-economic targets in development policies in the area.

Research Findings

Data for the empirical research was collected on a sample of 300 farm households in 9 villages in Lake Urmia basin in 2013. After data cleaning the descriptive and inferential statistics were used for data analyzing. The descriptive part described farm production factors in the area and the main variables of the study. A descriptive analysis section on water conservation programs and practices in the study region was added to provide an insight into how successful these programs have been and what the drawbacks and problems of these programs are.

The first research objective of this study was to examine factors affecting the agricultural production function in the area. We extended the basic agricultural production factors; i.e. labor, land, and capital, to labor, land, water, and intermediate inputs such as fertilizer, seeds, and chemicals. The intermediate inputs coefficient was not significant in our estimations. The regression findings stated that land, water, and labor were significantly affecting the agricultural production function in the study region. A significant constant in the model was understood as there were other variables not included in the model which systematically affect the production function. The partial effect size for independent variables indicated that more than one-third of the changes in farm output was explained by changes in labor, land

and water and almost one-fourth of the changes in farm output was explained by irrigation water consumption. This indicates the importance of water in the field study region.

The second objective discussed the effect of irrigation water price changes on farm households' revenue and welfare. This was tested with the effect of a hypothetical increase in irrigation water prices on farm households' welfare. Results indicated that increasing the water price tends to reductions in water intake as well as in farm households' welfare. As the water price increases more, the gap between water use and welfare loss increases. In higher water prices percentage reduction in water consumption is more than percentage loss in welfare.

The last objective of the study was to examine the influence of the households' socio-economic status on welfare loss due to irrigation water price changes and the distributional effects of these changes. Unfortunately, due to the small sample size and high correlation between water quantity use, land size and farm revenue the distributional effect of water price increase could not be strongly covered for the sample and only some calculations and simple estimations were performed. Irrigation water pricing is a sensitive policy intervention as farmers rely on their farm revenue for their basic needs. The equity consideration of the study sample was examined by farm revenue as well as households' expenditure as indexes for households' socio-economic status, but the results from two indexes were inconsistent.

Research Limitation and shortcomings

Some research has already been devoted to Lake Urmia and its basin problems in recent years which mainly focus on political ecology, managing conflicts and socio-technical management aspects of the issue. The socio-economic aspects, as a pillar of sustainable development policies, has been little considered in the region. The major contribution of the current study is to provide a better understanding of the socio-economic consequences of development policies in the region as well as giving some insight to the future management plans for the basin. This also adds to the literature of applying productivity method in economic evaluation of nature.

Despite national and international conservation projects concerning the Lake, there is still a lack of local research capacity which results in lack of data, design, administration, and analysis. Because of this deficiency, local people as well as local authorities should be stimulated to be involved, participate and support research on these issues. The main concerns of conducting this survey were the lack of adequate data and difficulties in data collection. Data and resource constraints make research in developing countries more difficult. More complicated models were required to assess the impact of water price changes on farmers' welfare. Additional welfare effects have not been taken into account in this study. The welfare effects of released resources after price changes were also not taken into account. All inputs other than water were assumed not to be affected by the hypothetical price changes policies in the study. Labor and other released inputs due to reduction in production may bring some welfare for the households which should also be considered. These shortcomings are due to difficulties in collecting data. Data on households' socio-economic status was not sufficiently accurate to be applied in measuring the distribution of welfare changes among households. Respondents were sometimes hesitant to declare their income which might be due to the lack of trust around data security from the farmers' side to talk about their income and expenses or a lack of knowledge and information regarding the importance of giving the accurate response about their financial status.

Additional Future Directions

In the Dublin Conference on Water and the Environment it was declared that water should be considered an economic good and that water pricing should be used to help manage the resource (ICWE 1992)[30]. This study is an attempt to develop water pricing schemes in one of the critical regions in Iran. Lake Urmia basin is experiencing water scarcity problems due to extensive water abstraction and consumption for irrigation, coupled with an increasing population, climate change, development plans in industry and so on. Current price levels and schemes do not provide strong incentives for farmers to use irrigation water efficiently and innovatively to reduce their water use. Out of more than 273 sample households only

[30] ICWE (1992) The Dublin statement and report of the conference. In: International conference on water and the environment, Dublin

176 households said that they pay for all the water they use for watering their farm. The rest of sample had access to free water at different levels. Moreover, the price for paid water was very low. There is significant room for more research in a broader economic framework integrated with other disciplines to increase the water efficiency and improve water management policies in the region. Some suggestions for future studies are introduced in the following paragraphs.

This study assumed households as the unit of the study. Investigating welfare change when assuming crops or farms as the unit of the study, instead of households, can improve our knowledge for policy suggestions. Each crop has different water needs, and every farm has different characteristics which can be considered in agricultural crop selection and irrigation systems. Crop-water production function is a good estimator of the value of water for different crops (Hassan & Mungatana, 2006, p. 259). A similar procedure in this study can be applied for calculating the producer surplus as a result of changing water prices and measuring the price elasticity of water consumption to evaluate the potential of price policy as an instrument for water management and conservation.

Water pricing for irrigation in the study sample was flat rate. Performing research on other water pricing schemes improves the knowledge and information for making policies. Block rates or some combination rates may influence farmers' decisions for irrigation systems in favor of water saving methods and encourages them to be more innovative. Block rates may also result in more equity in water uses among farmers.

The study was conducted as a cross sectional short-term research. A long-term research will be more complicated. Decreasing water use in irrigation for several years in a row may cause degradation of farm land. This is an issue that also should be considered in future studies.

We did not enter capital in the estimations (explained in section 3.6.2), therefore, future studies should consider the effect of capital and technologies as well as other inputs.

As mentioned before, this is not the final and best answer to water management plans in Lake Urmia basin. An integrated and comprehensive framework considering the ecological, environmental, and socio-economic effect is necessary to meet the regional and national objectives of sustainable development plans.

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APPENDICES

Appendix A (Section 3.2. Research Area)

Appendix A-1: Share of Crop Type of Total Output of the Sampled Districts

	Water Use		
Districts	Low	Medium	High
Shabestar	27	86.9	20.2
Ajabshir	73.0	13.2	79.8
Total	100	100	100

Appendix A-2: Source of Water for Irrigation in the Sample (Percentage)

Source	Shabestar	Ajabshir	Total
Well	91.9	83	88.6
River	6.6	0	4.1
Qanats	0.7	0	0.4
Rain	0.8	0	0.5
Dam	0	17	6.4
Total	100	100	100
No. of observations			251

Appendix B (Section 3.8. Model Estimation)

Appendix B-1: Table 3.16. Estimation of the Sample Households' Farm Revenue

Model 1:

```
. regress lnYfa lnL lnLand lnI lnW

      Source |       SS           df       MS      Number of obs   =       251
-------------+----------------------------------   F(4, 246)       =     32.32
       Model |  68.5931698         4  17.1482924   Prob > F        =    0.0000
    Residual |  130.532381       246  .530619434   R-squared       =    0.3445
-------------+----------------------------------   Adj R-squared   =    0.3338
       Total |  199.125551       250  .796502202   Root MSE        =    .72844

------------------------------------------------------------------------------
       lnYfa |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnL |   .1303779   .0788351     1.65   0.099        -.0249    .2856557
      lnLand |    .324306   .0781398     4.15   0.000      .1703976    .4782145
         lnI |   .0102488   .0189457     0.54   0.589     -.0270677    .0475653
         lnW |   .5055527   .0576697     8.77   0.000      .3919633    .6191421
       _cons |   9.513442   .9016037    10.55   0.000      7.737595    11.28929
------------------------------------------------------------------------------
```

Model 2:

```
. stepwise, pr(0.1): regress lnYfa lnL lnLand lnI lnW
                      begin with full model
p = 0.5890 >= 0.1000  removing lnI

      Source |       SS           df       MS      Number of obs   =       251
-------------+----------------------------------   F(3, 247)       =     43.12
       Model |  68.4378914         3  22.8126305   Prob > F        =    0.0000
    Residual |  130.687659       247  .529099835   R-squared       =    0.3437
-------------+----------------------------------   Adj R-squared   =    0.3357
       Total |  199.125551       250  .796502202   Root MSE        =    .72739

------------------------------------------------------------------------------
       lnYfa |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnL |   .1313555   .0787014     1.67   0.096    -.0236559     .286367
      lnLand |   .3339968   .0759497     4.40   0.000     .1844052    .4835884
         lnW |   .5076382   .0574583     8.83   0.000     .3944676    .6208089
       _cons |   9.603551   .8848132    10.85   0.000      7.86081    11.34629
------------------------------------------------------------------------------
```

Appendix B-2: Table 3.17. Shapiro-Wilk Test of Normality

Model 1:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	,062	251	,021	,985	251	,008
Standardized Residual	,062	251	,021	,985	251	,008

a. Lilliefors Significance Correction

Model 2:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	,059	252	,033	,984	252	,007
Standardized Residual	,059	252	,033	,984	252	,007

a. Lilliefors Significance Correction

Appendix B-3: Table 3.18. Ramsey RESET Test

Model 1:

```
. ovtest

Ramsey RESET test using powers of the fitted values of lnYfa
       Ho:  model has no omitted variables
                 F(3, 243) =      1.58
                  Prob > F =      0.1945
```

Model 2:

```
. ovtest

Ramsey RESET test using powers of the fitted values of lnYfa
       Ho:  model has no omitted variables
                 F(3, 244) =      1.53
                  Prob > F =      0.2068
```

Appendix B-4: Table 3.19. Homoscedasticity Test (Breusch-Pegan Test)

Model 1:

```
.
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnYfa

         chi2(1)      =     1.50
         Prob > chi2  =   0.2212
```

Model 2:

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnYfa

         chi2(1)      =     1.71
         Prob > chi2  =   0.1911
```

Appendix B-5: Table 3.20. Collinearity Diagnostics (VIF)

Model 1:

```
. vif
```

Variable	VIF	1/VIF
lnLand	1.38	0.726068
lnL	1.30	0.767958
lnI	1.09	0.918376
lnW	1.08	0.928779
Mean VIF	1.21	

Model 2:

```
. vif
```

Variable	VIF	1/VIF
lnLand	1.30	0.766347
lnL	1.30	0.768362
lnW	1.07	0.932948
Mean VIF	1.23	

Appendix B-6: Table 3.21. Effect Size Model 1

```
. estat esize
```

Effect sizes for linear models

Source	Eta-Squared	df	[95% Conf.	Interval]
Model	.344472	4	.2442531	.4186169
lnL	.0109959	1	.	.0501234
lnLand	.0654392	1	.0183366	.1319626
lnI	.0011882	1	.	.0241944
lnW	.2380335	1	.1513798	.3225307

```
. estat esize, omega
```

Effect sizes for linear models

Source	Omega-Squared	df	[95% Conf.	Interval]
Model	.333813	4	.2319646	.4091635
lnL	.0069756	1	.	.0462621
lnLand	.0616401	1	.0143461	.128434
lnI	0	1	.	.0202277
lnW	.2349361	1	.1479301	.3197767

Appendix B-7: Table 3.22. Effect Size Model 2

```
. estat esize
```

Effect sizes for linear models

Source	Eta-Squared	df	[95% Conf.	Interval]
Model	.3436922	3	.2465094	.4201537
lnL	.0111523	1	.	.0503341
lnLand	.0726103	1	.0225248	.1409289
lnW	.2401298	1	.1534453	.3244682

```
. estat esize, omega
```

Effect sizes for linear models

Source	Omega-Squared	df	[95% Conf.	Interval]
Model	.3357208	3	.2373577	.4131111
lnL	.0071489	1	.	.0464893
lnLand	.0688557	1	.0185674	.1374508
lnW	.2370534	1	.1500179	.3217332

Appendix B-8: Table 3.23. AIC for Model 1 and Model 2

Model 1:

```
. estat ic
```

Akaike's information criterion and Bayesian information criterion

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	251	-327.0981	-274.0977	5	558.1954	575.8227

Note: N=Obs used in calculating BIC; see **[R] BIC note**.

```
.
. glm lnYfa lnL lnLand lnI lnW

Iteration 0:   log likelihood =  -274.0977

Generalized linear models                          No. of obs      =        251
Optimization     : ML                              Residual df     =        246
                                                   Scale parameter =   .5306194
Deviance         =  130.5323807                    (1/df) Deviance =   .5306194
Pearson          =  130.5323807                    (1/df) Pearson  =   .5306194

Variance function: V(u) = 1                        [Gaussian]
Link function    : g(u) = u                        [Identity]

                                                   AIC             =   2.223886
Log likelihood   = -274.0977042                    BIC             =  -1228.729
```

lnYfa	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnL	.1303779	.0788351	1.65	0.098	-.024136	.2848918
lnLand	.324306	.0781398	4.15	0.000	.1711548	.4774573
lnI	.0102488	.0189457	0.54	0.589	-.0268841	.0473818
lnW	.5055527	.0576697	8.77	0.000	.3925222	.6185833
_cons	9.513442	.9016037	10.55	0.000	7.746331	11.28055

Model 2:

```
. estat ic

Akaike's information criterion and Bayesian information criterion
```

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	251	-327.0981	-274.2469	4	556.4938	570.5956

Note: N=Obs used in calculating BIC; see **[R] BIC note**.

```
. stepwise, pr(0.1):glm lnYfa lnL lnLand lnI lnW
                      begin with full model
p = 0.5885 >= 0.1000  removing lnI

Generalized linear models                          No. of obs      =        251
Optimization     : ML                              Residual df     =        247
                                                   Scale parameter =   .5290998
Deviance         =  130.6876592                    (1/df) Deviance =   .5290998
Pearson          =  130.6876592                    (1/df) Pearson  =   .5290998

Variance function: V(u) = 1                        [Gaussian]
Link function    : g(u) = u                        [Identity]

                                                   AIC             =   2.217107
Log likelihood   = -274.2469075                    BIC             =  -1234.099
```

lnYfa	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnL	.1313555	.0787014	1.67	0.095	-.0228964	.2856075
lnLand	.3339968	.0759497	4.40	0.000	.1851382	.4828554
lnW	.5076382	.0574583	8.83	0.000	.3950221	.6202543
_cons	9.603551	.8848132	10.85	0.000	7.869349	11.33775

Appendix C (Section 3.9. Districts Differences)

Appendix C-1: Table 3.25. Estimation of the Sample Households' Farm Revenue (variable district is added to the model)

Model 1:

```
. regress lnYfa lnL lnLand lnI lnW DIS
```

Source	SS	df	MS
Model	74.620221	5	14.9240442
Residual	124.50533	245	.508185018
Total	199.125551	250	.796502202

Number of obs	=	251
F(5, 245)	=	29.37
Prob > F	=	0.0000
R-squared	=	0.3747
Adj R-squared	=	0.3620
Root MSE	=	.71287

lnYfa	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnL	.1798244	.0784752	2.29	0.023	.0252524	.3343965
lnLand	.3511014	.0768649	4.57	0.000	.199701	.5025018
lnI	.0091358	.0185437	0.49	0.623	-.0273896	.0456612
lnW	.2000652	.1051375	1.90	0.058	-.0070235	.407154
DIS	-.6226392	.1807985	-3.44	0.001	-.978757	-.2665214
_cons	12.89734	1.320614	9.77	0.000	10.29614	15.49855

Model 2:

```
. stepwise, pr(0.1): regress lnYfa lnL lnLand lnI lnW DIS
                      begin with full model
p = 0.6227 >= 0.1000  removing lnI

      Source |       SS           df       MS      Number of obs   =       251
-------------+----------------------------------   F(4, 246)       =     36.76
       Model |  74.4968765         4  18.6242191   Prob > F        =    0.0000
    Residual |  124.628674       246  .506620626   R-squared       =    0.3741
-------------+----------------------------------   Adj R-squared   =    0.3639
       Total |  199.125551       250  .796502202   Root MSE        =    .71177

------------------------------------------------------------------------------
       lnYfa |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnL |    .180819   .0783284     2.31   0.022     .0265392    .3350988
      lnLand |   .3598039   .0746925     4.82   0.000     .2126856    .5069223
         DIS |  -.6241917   .1804926    -3.46   0.001    -.9796997   -.2686836
         lnW |    .201162    .104952     1.92   0.056    -.0055572    .4078812
       _cons |   12.98608   1.306258     9.94   0.000      10.4132    15.55896
------------------------------------------------------------------------------
```

Appendix C-2: Table 3.26. Shapiro-Wilk Test of Normality (variable district is added to the model)

Model 1:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	,037	251	,200*	,990	251	,086
Standardized Residual	,037	251	,200*	,990	251	,086

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Model 2:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	,041	252	,200*	,990	252	,076
Standardized Residual	,041	252	,200*	,990	252	,076

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Appendix C-3: Table 3.27. Ramsey RESET Test (variable district is added to the model)

Model 1:

```
. ovtest

Ramsey RESET test using powers of the fitted values of lnYfa
       Ho:  model has no omitted variables
                 F(3, 242) =      1.35
                  Prob > F =      0.2590
```

Model 2:

```
.
. ovtest

Ramsey RESET test using powers of the fitted values of lnYfa
       Ho:  model has no omitted variables
                 F(3, 243) =      1.24
                  Prob > F =      0.2948
```

Appendix C-4: Table 3.28. Homoscedasticity Test (variable district is added to the model)

Model 1:

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnYfa

         chi2(1)      =     1.19
         Prob > chi2  =   0.2746
```

Model 2:

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnYfa

         chi2(1)      =     1.30
         Prob > chi2  =   0.2541
```

Appendix C-5: Table 3.29. Collinearity Diagnostics (variable district is added to the model)

Model 1:

```
. vif
```

Variable	VIF	1/VIF
DIS	3.78	0.264410
lnW	3.74	0.267628
lnLand	1.39	0.718629
lnL	1.35	0.742251
lnI	1.09	0.918097
Mean VIF	2.27	

Model 2:

```
. vif
```

Variable	VIF	1/VIF
DIS	3.78	0.264491
lnW	3.73	0.267748
lnL	1.35	0.742742
lnLand	1.32	0.758697
Mean VIF	2.55	

Appendix C-6: Table 3.30. AIC for Model 1 and Model 2 (variable district is added to the model)

Model 1:

```
. estat ic
```

Akaike's information criterion and Bayesian information criterion

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	251	-327.0981	-268.165	6	548.3299	569.4827

Note: N=Obs used in calculating BIC; see **[R] BIC note**.

```
. glm lnYfa lnL lnLand lnI lnW DIS

Iteration 0:   log likelihood = -268.16497

Generalized linear models                     No. of obs      =        251
Optimization     : ML                         Residual df     =        245
                                              Scale parameter =    .508185
Deviance         =  124.5053295               (1/df) Deviance =    .508185
Pearson          =  124.5053295               (1/df) Pearson  =    .508185

Variance function: V(u) = 1                   [Gaussian]
Link function    : g(u) = u                   [Identity]

                                              AIC             =   2.184581
Log likelihood   = -268.1649675               BIC             =  -1229.231
```

lnYfa	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnL	.1798244	.0784752	2.29	0.022	.0260159	.333633
lnLand	.3511014	.0768649	4.57	0.000	.2004489	.501754
lnI	.0091358	.0185437	0.49	0.622	-.0272092	.0454807
lnW	.2000652	.1051375	1.90	0.057	-.0060005	.406131
DIS	-.6226392	.1807985	-3.44	0.001	-.9769978	-.2682805
_cons	12.89734	1.320614	9.77	0.000	10.30899	15.4857

Model 2:

```
. estat ic

Akaike's information criterion and Bayesian information criterion
```

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	251	-327.0981	-268.2892	5	546.5785	564.2057

Note: N=Obs used in calculating BIC; see **[R] BIC note**.

```
. stepwise, pr(0.1):glm lnYfa lnL lnLand lnI lnW DIS
                      begin with full model
p = 0.6223 >= 0.1000  removing lnI

Generalized linear models                          No. of obs      =        251
Optimization     : ML                              Residual df     =        246
                                                   Scale parameter =   .5066206
Deviance         =   124.628674                    (1/df) Deviance =   .5066206
Pearson          =   124.628674                    (1/df) Pearson  =   .5066206

Variance function: V(u) = 1                        [Gaussian]
Link function    : g(u) = u                        [Identity]

                                                   AIC             =   2.177603
Log likelihood   = -268.2892359                    BIC             =  -1234.633
```

lnYfa	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnL	.180819	.0783284	2.31	0.021	.0272982	.3343398
lnLand	.3598039	.0746925	4.82	0.000	.2134094	.5061985
DIS	-.6241917	.1804926	-3.46	0.001	-.9779507	-.2704326
lnW	.201162	.104952	1.92	0.055	-.0045402	.4068642
_cons	12.98608	1.306258	9.94	0.000	10.42586	15.5463

Appendix C-7: Effect Size Model 1 (variable district is added to the model)

```
. estat esize

Effect sizes for linear models
```

Source	Eta-Squared	df	[95% Conf.	Interval]
Model	.3747396	5	.2720394	.4452175
lnL	.0209825	1	.0001325	.0684313
lnLand	.0784781	1	.0258879	.1485482
lnI	.0009897	1	.	.0232169
lnW	.0145643	1	.	.0571172
DIS	.0461728	1	.0085197	.1064285

```
. estat esize, omega

Effect sizes for linear models
```

Source	Omega-Squared	df	[95% Conf.	Interval]
Model	.3619791	5	.2571831	.4338954
lnL	.0169865	1	0	.0646289
lnLand	.0747167	1	.0219119	.1450729
lnI	0	1	.	.01923
lnW	.0105421	1	.	.0532687
DIS	.0422797	1	.0044729	.1027812

Appendix C-8: Effect Size Model 2 (variable district is added to the model)

```
. estat esize

Effect sizes for linear models
```

Source	Eta-Squared	df	[95% Conf.	Interval]
Model	.3741201	4	.2743713	.4468029
lnL	.0212035	1	.0001959	.0686848
lnLand	.0861976	1	.0307896	.1578545
DIS	.0463623	1	.0086521	.1065534
lnW	.0147142	1	.	.0572857

```
. estat esize, omega

Effect sizes for linear models
```

Source	Omega-Squared	df	[95% Conf.	Interval]
Model	.3639432	4	.2625725	.4378078
lnL	.0172246	1	0	.064899
lnLand	.082483	1	.0268497	.1544311
DIS	.0424858	1	.0046222	.1029215
lnW	.010709	1	.	.0534536

Appendix C-9: Estimation of the Sample Households' Farm Revenue (variable district is and interaction variables are added to the model)

Model 1:

```
. regress lnYfa lnL lnLand lnI  lnL_DIS lnLand_DIS lnI_DIS lnW_DIS DIS

      Source |       SS           df       MS      Number of obs   =       253
-------------+----------------------------------   F(8, 244)       =     19.24
       Model |    77.39885         8  9.67485625   Prob > F        =    0.0000
    Residual |  122.727404       244  .502981163   R-squared       =    0.3868
-------------+----------------------------------   Adj R-squared   =    0.3666
       Total |  200.126254       252  .794151801   Root MSE        =    .70921

------------------------------------------------------------------------------
       lnYfa |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnL |   .2516294   .1112391     2.26   0.025     .0325179    .4707409
      lnLand |   .2987316    .119489     2.50   0.013       .06337    .5340932
         lnI |   .0081247   .0289667     0.28   0.779    -.0489319    .0651814
     lnL_DIS |  -.1476724   .1538513    -0.96   0.338    -.4507185    .1553736
  lnLand_DIS |   .1117276   .1555143     0.72   0.473    -.1945942    .4180493
     lnI_DIS |   .0138751   .0378307     0.37   0.714    -.0606413    .0883915
     lnW_DIS |   .3497121    .135235     2.59   0.010     .0833351    .6160892
         DIS |  -.7281312   .1201354    -6.06   0.000    -.9647659   -.4914965
       _cons |   14.80403   .8066321    18.35   0.000     13.21518    16.39288
------------------------------------------------------------------------------
```

Model 2:

```
. stepwise, pr(0.1):regress lnYfa lnL lnLand lnI lnW lnL_DIS lnLand_DIS lnI_DIS lnW_DIS DIS
                      begin with full model
p = 0.8549 >= 0.1000  removing lnI_DIS
p = 0.5444 >= 0.1000  removing lnW
p = 0.3513 >= 0.1000  removing lnI
p = 0.3358 >= 0.1000  removing lnLand_DIS
p = 0.3725 >= 0.1000  removing lnL_DIS

      Source |       SS           df       MS      Number of obs   =       251
-------------+----------------------------------   F(4, 246)       =     38.26
       Model |  76.3678563         4  19.0919641   Prob > F        =    0.0000
    Residual |  122.757694       246  .499015017   R-squared       =    0.3835
-------------+----------------------------------   Adj R-squared   =    0.3735
       Total |  199.125551       250  .796502202   Root MSE        =    .70641

------------------------------------------------------------------------------
       lnYfa |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnL |   .2063039   .0780108     2.64   0.009     .0526496    .3599583
      lnLand |   .3543895   .0736664     4.81   0.000     .2092923    .4994868
         DIS |  -.7277246   .1181711    -6.16   0.000    -.9604808   -.4949685
     lnW_DIS |   .3629077   .1327003     2.73   0.007     .1015341    .6242813
       _cons |   15.18253   .4915829    30.88   0.000     14.21428    16.15078
------------------------------------------------------------------------------
```

Appendix C-10: Shapiro-Wilk Test of Normality (variable district and interaction variables are added to the model)

Model 1:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	,042	251	,200*	,984	251	,008
Standardized Residual	,042	251	,200*	,984	251	,008

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Model 2:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	,045	254	,200*	,987	254	,025
Standardized Residual	,045	254	,200*	,987	254	,025

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Appendix C-11: Ramsey RESET Test (variable district and interaction variables are added to the model)

Model 1:

```
. ovtest

Ramsey RESET test using powers of the fitted values of lnYfa
       Ho:  model has no omitted variables
                 F(3, 241) =      0.67
                  Prob > F =      0.5703
. ovtest

Ramsey RESET test using powers of the fitted values of lnYfa
       Ho:  model has no omitted variables
                 F(3, 238) =      0.54
                  Prob > F =      0.6523
```

Model 2:

```
. ovtest

Ramsey RESET test using powers of the fitted values of lnYfa
       Ho:  model has no omitted variables
                  F(3, 243) =      0.79
                   Prob > F =      0.4986
```

Appendix C-12: Homoscedasticity Test (variable district and interaction variables are added to the model)

Model 1:

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnYfa

         chi2(1)      =     1.67
         Prob > chi2  =   0.1967
```

Model 2:

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnYfa

         chi2(1)      =     1.78
         Prob > chi2  =   0.1827
```

Appendix C-13: Collinearity Diagnostics (variable district and interaction variables are added to the model)

Model 1:

. vif

Variable	VIF	1/VIF
lnLand_DIS	3.72	0.268613
lnLand	3.41	0.293202
lnL_DIS	3.07	0.325665
lnL	2.85	0.350708
lnI	2.69	0.371763
lnI_DIS	2.65	0.376686
DIS	1.71	0.585005
lnW_DIS	1.69	0.590773
Mean VIF	2.73	

Model 2:

. vif

Variable	VIF	1/VIF
DIS	1.65	0.607767
lnW_DIS	1.63	0.611690
lnL	1.36	0.737560
lnLand	1.30	0.768271
Mean VIF	1.48	

Appendix C-14: Effect Size (variable district and interaction variables are added to the model)

Model 1:

```
. estat esize
```

Effect sizes for linear models

Source	Eta-Squared	df	[95% Conf.	Interval]
Model	.3867501	8	.2760948	.449942
lnL	.0205402	1	.0000244	.0678026
lnLand	.0249765	1	.0010131	.0751218
lnI	.0003223	1	.	.0178489
lnL_DIS	.0037616	1	.	.0334937
lnLand_DIS	.0021109	1	.	.028219
lnI_DIS	.000551	1	.	.0202868
lnW_DIS	.0266754	1	.0014426	.0778342
DIS	.1308523	1	.061724	.2100367

```
. estat esize, omega
```

Effect sizes for linear models

Source	Omega-Squared	df	[95% Conf.	Interval]
Model	.3666436	8	.2523602	.4319074
lnL	.016526	1	0	.0639822
lnLand	.0209805	1	0	.0713314
lnI	0	1	.	.0138237
lnL_DIS	0	1	.	.0295326
lnLand_DIS	0	1	.	.0242363
lnI_DIS	0	1	.	.0162716
lnW_DIS	.0226864	1	0	.0740548
DIS	.1272902	1	.0578786	.2067991

Model 2:

```
. estat esize
```

Effect sizes for linear models

Source	Eta-Squared	df	[95% Conf.	Interval]
Model	.3835161	4	.2840462	.4556621
lnL	.0276437	1	.001748	.0791111
lnLand	.0859884	1	.0306563	.1576005
DIS	.1335703	1	.0640132	.2127422
lnW_DIS	.0295058	1	.0022785	.0820064

```
. estat esize, omega

Effect sizes for linear models
```

Source	Omega-Squared	df	[95% Conf.	Interval]
Model	.373492	4	.2724046	.4468111
lnL	.023691	1	0	.0753677
lnLand	.0822729	1	.0267159	.1541761
DIS	.1300482	1	.0602084	.209542
lnW_DIS	.0255607	1	0	.0782747

Appendix C-15: AIC for Model 1 and Model 2 (variable district and interaction variables are added to the model)

Model 1:

```
. estat ic

Akaike's information criterion and Bayesian information criterion
```

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	253	-329.3347	-267.4783	9	552.9567	584.7572

Note: N=Obs used in calculating BIC; see **[R] BIC note**.

```
.
. glm lnYfa lnL lnLand lnI lnL_DIS lnLand_DIS lnI_DIS lnW_DIS DIS

Iteration 0:   log likelihood = -267.47834

Generalized linear models                         No. of obs      =        253
Optimization     : ML                             Residual df     =        244
                                                  Scale parameter =   .5029812
Deviance         =  122.7274037                   (1/df) Deviance =   .5029812
Pearson          =  122.7274037                   (1/df) Pearson  =   .5029812

Variance function: V(u) = 1                       [Gaussian]
Link function    : g(u) = u                       [Identity]

                                                  AIC             =   2.185599
Log likelihood   = -267.4783353                   BIC             =   -1227.42
```

lnYfa	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnL	.2516294	.1112391	2.26	0.024	.0336047	.4696541
lnLand	.2987316	.119489	2.50	0.012	.0645374	.5329258
lnI	.0081247	.0289667	0.28	0.779	-.0486489	.0648984
lnL_DIS	-.1476724	.1538513	-0.96	0.337	-.4492154	.1538705
lnLand_DIS	.1117276	.1555143	0.72	0.472	-.1930748	.41653
lnI_DIS	.0138751	.0378307	0.37	0.714	-.0602717	.0880219
lnW_DIS	.3497121	.135235	2.59	0.010	.0846564	.6147679
DIS	-.7281312	.1201354	-6.06	0.000	-.9635921	-.4926702
_cons	14.80403	.8066321	18.35	0.000	13.22306	16.385

Model 2:

```
. estat ic

Akaike's information criterion and Bayesian information criterion
```

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	251	-327.0981	-266.3909	5	542.7818	560.409

Note: N=Obs used in calculating BIC; see **[R] BIC note**.

```
. stepwise, pr(0.1):glm lnYfa lnL lnLand lnI lnW lnL_DIS lnLand_DIS lnI_DIS lnW_DIS DIS
                      begin with full model
p = 0.8547 >= 0.1000  removing lnI_DIS
p = 0.5439 >= 0.1000  removing lnW
p = 0.3504 >= 0.1000  removing lnI
p = 0.3348 >= 0.1000  removing lnLand_DIS
p = 0.3716 >= 0.1000  removing lnL_DIS

Generalized linear models                         No. of obs      =        251
Optimization     : ML                             Residual df     =        246
                                                  Scale parameter =    .499015
Deviance         =  122.7576943                   (1/df) Deviance =    .499015
Pearson          =  122.7576943                   (1/df) Pearson  =    .499015

Variance function: V(u) = 1                       [Gaussian]
Link function    : g(u) = u                       [Identity]

                                                  AIC             =   2.162477
Log likelihood   = -266.3908901                   BIC             =  -1236.504
```

lnYfa	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnL	.2063039	.0780108	2.64	0.008	.0534055	.3592023
lnLand	.3543895	.0736664	4.81	0.000	.2100061	.498773
DIS	-.7277246	.1181711	-6.16	0.000	-.9593357	-.4961136
lnW_DIS	.3629077	.1327003	2.73	0.006	.10282	.6229954
_cons	15.18253	.4915829	30.88	0.000	14.21905	16.14602

Appendix C-16: Chow Test for District Differences (variable district and interaction variables are added to the model)

Model 1:

```
. . test DIS lnL_DIS lnLand_DIS lnI_DIS lnW_DIS

 ( 1)  DIS = 0
 ( 2)  lnL_DIS = 0
 ( 3)  lnLand_DIS = 0
 ( 4)  lnI_DIS = 0
 ( 5)  lnW_DIS = 0

       F(  5,   241) =    3.69
            Prob > F =    0.0031
```

Model 2:

```
. . test DIS lnW_DIS

 ( 1)  DIS = 0
 ( 2)  lnW_DIS = 0

       F(  2,   246) =   49.33
            Prob > F =    0.0000
```

Appendix D (Section 3.10. Elasticity of Demand)

Appendix D-1: Estimation of the water demand function

```
. stepwise, pr(0.05): regress lnW lnI lnLand lnL lnpY lnqW
                      begin with full model
p = 0.0621 >= 0.0500  removing lnLand

      Source |       SS           df       MS      Number of obs   =       241
-------------+----------------------------------   F(4, 236)       =     13.91
       Model |  31.2274007         4  7.80685017   Prob > F        =    0.0000
    Residual |  132.485819       236  .561380591   R-squared       =    0.1907
-------------+----------------------------------   Adj R-squared   =    0.1770
       Total |   163.71322       240  .682138417   Root MSE        =    .74925

------------------------------------------------------------------------------
         lnW |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lnI |    .205813   .0537266     3.83   0.000      .099968     .311658
        lnqW |  -.8948166   .2119317    -4.22   0.000    -1.312336    -.477297
         lnL |   -.243597   .0735575    -3.31   0.001    -.3885103   -.0986838
        lnpY |   .2100792   .0781428     2.69   0.008     .0561327    .3640258
       _cons |   9.661428   1.084256     8.91   0.000      7.52537    11.79749
------------------------------------------------------------------------------
```

Appendix D-2: Shapiro-Wilk Test of Normality

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	,045	253	,200*	,976	253	,000
Standardized Residual	,045	253	,200*	,976	253	,000

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Appendix D-3: Ramsey RESET Test

```
. ovtest

Ramsey RESET test using powers of the fitted values of lnW
       Ho:  model has no omitted variables
                 F(3, 233) =      1.12
                  Prob > F =      0.3417
```

Appendix D-4: Homoscedasticity Test

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnW

         chi2(1)      =     0.20
         Prob > chi2  =   0.6577
```

Appendix D-5: Collinearity Diagnostics

```
. vif
```

Variable	VIF	1/VIF
lnL	1.03	0.970665
lnI	1.03	0.973551
lnqW	1.02	0.975670
lnpY	1.02	0.978336
Mean VIF	1.03	

Appendix E (Section 3.12. Equity and Distributional Effects)

Appendix E-1: Estimation of the Sample Households' Farm revenue via OLS and Quantile Method

```
. reg lnYfa lnL lnLand lnI lnW
```

Source	SS	df	MS
Model	68.5931698	4	17.1482924
Residual	130.532381	246	.530619434
Total	199.125551	250	.796502202

Number of obs	=	251
F(4, 246)	=	32.32
Prob > F	=	0.0000
R-squared	=	0.3445
Adj R-squared	=	0.3338
Root MSE	=	.72844

lnYfa	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnL	.1303779	.0788351	1.65	0.099	-.0249	.2856557
lnLand	.324306	.0781398	4.15	0.000	.1703976	.4782145
lnI	.0102488	.0189457	0.54	0.589	-.0270677	.0475653
lnW	.5055527	.0576697	8.77	0.000	.3919633	.6191421
_cons	9.513442	.9016037	10.55	0.000	7.737595	11.28929

```
. qreg lnYfa lnL lnLand lnI lnW , quantile (0.25)
Iteration  1:  WLS sum of weighted deviations =  64.156394

Iteration  1: sum of abs. weighted deviations =  65.196298
Iteration  2: sum of abs. weighted deviations =  64.753972
Iteration  3: sum of abs. weighted deviations =  61.586753
Iteration  4: sum of abs. weighted deviations =  57.847974
Iteration  5: sum of abs. weighted deviations =  57.071077
Iteration  6: sum of abs. weighted deviations =  56.962033
Iteration  7: sum of abs. weighted deviations =  56.323467
Iteration  8: sum of abs. weighted deviations =  55.777885
Iteration  9: sum of abs. weighted deviations =  55.549426
Iteration 10: sum of abs. weighted deviations =  54.961701
Iteration 11: sum of abs. weighted deviations =  54.821615
Iteration 12: sum of abs. weighted deviations =  54.801892
Iteration 13: sum of abs. weighted deviations =   54.45275
Iteration 14: sum of abs. weighted deviations =  54.263109
Iteration 15: sum of abs. weighted deviations =  54.127281
Iteration 16: sum of abs. weighted deviations =  53.913657
Iteration 17: sum of abs. weighted deviations =  53.897218
Iteration 18: sum of abs. weighted deviations =   53.89514

.25 Quantile regression                             Number of obs =        251
  Raw sum of deviations  72.6975 (about 15.49)
  Min sum of deviations 53.89514                    Pseudo R2     =     0.2586
```

lnYfa	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnL	-.0126842	.0941214	-0.13	0.893	-.1980707	.1727024
lnLand	.4980308	.0932913	5.34	0.000	.3142791	.6817824
lnI	.0111839	.0226193	0.49	0.621	-.0333684	.0557361
lnW	.4833433	.068852	7.02	0.000	.3477287	.618958
_cons	10.18058	1.076427	9.46	0.000	8.060393	12.30077

```
. qreg lnYfa lnL lnLand lnI lnW , quantile (0.50)
Iteration  1:  WLS sum of weighted deviations =  68.480133

Iteration  1: sum of abs. weighted deviations =  68.435421
Iteration  2: sum of abs. weighted deviations =  68.378811
Iteration  3: sum of abs. weighted deviations =  68.319778
Iteration  4: sum of abs. weighted deviations =  68.306864
Iteration  5: sum of abs. weighted deviations =  68.306591
Iteration  6: sum of abs. weighted deviations =  68.306088
Iteration  7: sum of abs. weighted deviations =  68.305598

Median regression                                  Number of obs =        251
  Raw sum of deviations    82.81 (about 15.96)
  Min sum of deviations  68.3056                   Pseudo R2     =     0.1752
```

lnYfa	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnL	.0984697	.0778486	1.26	0.207	-.0548651	.2518046
lnLand	.282968	.0771621	3.67	0.000	.1309854	.4349506
lnI	.012382	.0187086	0.66	0.509	-.0244675	.0492316
lnW	.4839147	.0569481	8.50	0.000	.3717467	.5960828
_cons	9.886831	.890322	11.10	0.000	8.133204	11.64046

```
. qreg lnYfa lnL lnLand lnI lnW , quantile (0.75)
Iteration  1:  WLS sum of weighted deviations =  65.678308

Iteration  1: sum of abs. weighted deviations =  83.204384
Iteration  2: sum of abs. weighted deviations =  65.690912
Iteration  3: sum of abs. weighted deviations =  64.990992
Iteration  4: sum of abs. weighted deviations =   64.59237
Iteration  5: sum of abs. weighted deviations =  63.524909
Iteration  6: sum of abs. weighted deviations =  61.839854
Iteration  7: sum of abs. weighted deviations =  60.697105
Iteration  8: sum of abs. weighted deviations =  60.602161
Iteration  9: sum of abs. weighted deviations =  60.069235
Iteration 10: sum of abs. weighted deviations =  59.706041
Iteration 11: sum of abs. weighted deviations =  58.368271
Iteration 12: sum of abs. weighted deviations =  57.966645
Iteration 13: sum of abs. weighted deviations =  57.833748
Iteration 14: sum of abs. weighted deviations =  57.611728
Iteration 15: sum of abs. weighted deviations =   57.56709

.75 Quantile regression                            Number of obs =        251
  Raw sum of deviations 66.80749 (about 16.469999)
  Min sum of deviations 57.56709                   Pseudo R2     =     0.1383
```

lnYfa	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnL	.1565109	.1399643	1.12	0.265	-.1191703	.4321922
lnLand	.221903	.13873	1.60	0.111	-.0513471	.495153
lnI	-.0006985	.0336363	-0.02	0.983	-.0669504	.0655535
lnW	.417001	.1023872	4.07	0.000	.2153336	.6186683
_cons	10.84514	1.600713	6.78	0.000	7.692284	13.99799

Appendix E-2: Homoscedasticity Test

```
. estat hettest lnL lnLand lnI lnW , iid

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: lnL lnLand lnI lnW

         chi2(4)      =     4.95
         Prob > chi2  =   0.2928
```

Appendix E-3: One-Way Anova Test (Section 3.12.3)

Test of Homogeneity of Variances

WelfareChange

Levene Statistic	df1	df2	Sig.
57,191	2	215	,000

ANOVA

WelfareChange

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	36985571980000000,000	2	18492785990000000,000	142,662	,000
Within Groups	27869637990000000,000	215	129626223200000,000		
Total	64855209980000000,000	217			

Robust Tests of Equality of Means

WelfareChange

	Statistic[a]	df1	df2	Sig.
Welch	206,875	2	110,574	,000
Brown-Forsythe	143,597	2	75,452	,000

a. Asymptotically F distributed.

Multiple Comparisons

Dependent Variable: WelfareChange

Games-Howell

(I) SEE	(J) SEE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
LowerClass	MiddleClass	-5622394,912*	352946,397	,000	-6462464,38	-4782325,45
	HigherClass	-29960274,480*	2280498,904	,000	-35416915,04	-24503633,91
MiddleClass	LowerClass	5622394,912*	352946,397	,000	4782325,45	6462464,38
	HigherClass	-24337879,570*	2298993,701	,000	-29835173,09	-18840586,04
HigherClass	LowerClass	29960274,480*	2280498,904	,000	24503633,91	35416915,04
	MiddleClass	24337879,570*	2298993,701	,000	18840586,04	29835173,09

*. The mean difference is significant at the 0.05 level.

Appendix F (List of Interviewed Experts in the Field)

No.	Name	Affiliation	Contact
1	Dr. Ali Nazaridoust	Program Analyst in UNDP-Iran's Energy, Environment and Disaster Risk Management Unit, Tehran, Iran (Former National Project Manager at The Department of Environment - Conservation of Iranian Wetlands Project, Tehran, Iran).	ali.nazaridoust@undp.org
2	Hojat Jabbari	Technical Director of West Azerbaijan Provincial Office of DoE, Iran (Former Head of Regional Council Secretariat of Lake Urmia Basin Management, West Azerbaijan, Iran).	jabbari@yahoo.com
3	Dr. Mostafa Panahi	Assistant Professor at the Faculty of Environment and Energy of Islamic Azad University, Science and Research Branch, Tehran, Iran.	m.panahi@srbiau.ac.ir
4	Dr. Mir Mohsen Hosseini Ghomi	Deputy Head of Natural Environment and Biodiversity, Environmental Research Bureau, East Azerbaijan, Iran.	Ghomi.tabriz@gmail.com
5	Alireza Seyed Ghoreishi	Director of Public Environmental Awareness and Education Office, West Azerbaijan, Iran (Former Expert of The Local Water Management Council, West Azerbaijan, Iran).	+98(0)4412750899
6	Ali Najafi	Site Coordinator of East Azerbaijan in Conservation of Iranian Wetlands Project, East Azerbaijan, Iran.	najafi2@yahoo.com
7	Madjid Rahmani Moghadam	Director of Hamyarane Ziste Sabz – NGO, Tabriz, East Azerbaijan, Iran.	https://t.me/NGOhamyaran

Appendix G (Questionnaire)

Ethics statement

1. The following information has been collected for academic purposes and the objectives of the research are made clear to all responsible persons and stakeholders.
2. The participation in the data collection process has been voluntary and was conducted at a convenient time for the interviewee.
3. All data recording and collection mechanisms have been made clear to all target groups.
4. Respondents have the right to leave/withdraw at any point of time if they, for any reason, feel uncomfortable.
5. Personal and sensitive issues have been kept in a confidential and accountable manner in the data collection process.
6. Cultural and traditional aspects of the people have been respected in the data collection process (i.e. the data collection process is sensitive to cultural values and norms)
7. The data collection process is objective, scientifically and ethically sound, and protected from political interference.

Introduction:

Enumerators, please introduce the purpose of the survey and state the confidentiality of the responses. Use the introductory sheet provided to you. Farmers should not be asked to answer the questions that are shown in "Bold Italic" fonts.

QUESTIONNAIRE NUMBER: ______________________________

Survey Identification:	
District	
City	
Village	
Data collector	
Supervisor	
Interview date	

Type of respondent:

Head of the household ☐

Member of the household ☐

The rest of the questionnaire should be answered based on activities of a household head

A "household" includes all members of a common decision-making unit (usually within one residence) that are eating from the same pot or sharing the same household resources. These include dependents that are away from home.

A. HOUSHOLD COMPOSITION

1. Identify the characteristics of the household members

No	Gender	Age	Dependent	Economic Activity		Education					Marital Status					
				Farm activity (Month)	Non-farm activity (Months)	No. of years of formal schooling	High school Diploma	BA/BSc	MA/BSc	PhD	Single	Married	Divorced /separated	Widowed	Spouse left for job	Others (specify)
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																

Total number of members in the Household:

B. FARMING SYSTEMS

2. Do you practice crop rotation?	Yes ☐ No ☐
3. If yes, describe the common crop sequence? 1- ---------------------------- 2- ---------------------------- 3- ---------------------------- 4- ----------------------------	

4. Have you changed your commodities in the past five years (switching from one production to another one?)	Yes ☐ No ☐
5. If yes, how often?	
6. Which crops?	

7. Do you use water conservation practices?	Yes ☐ No ☐
8. If yes, which method? Reduced tillage Drought tolerant crops Crop selection (from a summer crop to cool season crop) Deficit irrigation (application of water below full crop-water requirements) Reduced evaporation (drip irrigation, mulching) Others (Please specify)	
9. Reasons for poor conservation practices Lack of knowledge Financial problem Small land size Lack of motivation Others (Please specify)	

10. What have been your major constraints in farming in the past five years?

Lack of credit/capital

Lack of improved seed and fertilizer

Lack of chemicals

Lack of farm implements

Lack of infrastructure (e.g. roads, markets)

Labor shortage

Land holding

Water shortage

Natural disasters *(Please specify)

High and unaffordable prices of inputs

Others

*Such as lack of rainfall, flooding/over-precipitation.

11. Mention the main measures/strategies taken by households as a result of the above challenges?

12. Please indicate the source(s) of water (in percentage) for the following purposes:										
Purpose	**Source**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
	Piped water (purified)	**Piped water (unpurified)**	**Water vendor**	**Well**	**Stream /river**	**Irrigation canal**	**Rainwater**	**Spring**	**Dam**	**Total**
Drinking water										100%
Personal hygiene (bathing)										100%
Washing clothes										100%
Irrigating crops / farmland										100%
Other:										100%

13. Please estimate your total monthly expenses (in Rial) for fetching water in each case:						
Purpose	***Source No.***	**expenses**	***Source No.***	**expenses**	***Source No.***	**expenses**
Drinking water						
Personal hygiene (bathing)						
Washing clothes						
Irrigating crops / farmland						
Other:						

C. HUMAN CAPITAL

14. Labor used on farm												
	Family labor or hired labor	**Gender**	**Age**	**Number of years of experience in farming**					**Average working hours a day**	**Average working days a week**	**Average working months a year**	**Average daily wage**
				Tillage /land preparation	**Planting & fertilizing**	**Weeding**	**Harvesting & threshing**	**Marketing**				
Farm Head												
L. 1												
L. 2												
L. 3												
L. 4												
L. 5												
L. 6												
L. 7												
L. 8												
L. 9												
L. 10												

D. INTERMEDIATE INPUTS

15. List the expenditures for agricultural inputs			
	Type	**Amount used (kg or liters)**	**Unit price**
Fertilizer			
Improved seed			
Scion			
Chemicals			
Water			

E. CAPITAL

16. Number, value and ownership for farming productive assets			
Asset	**Number**	**Current value (How much can you sell it for?)**	**Type of ownership (personal or group ownership)**
Ox-ploughs			
Knapsack sprayers			
Plowing machine			
Seed drill			
Power tiller			
Pickup trucks			
Combine			
Tractor			
Heavy truck			
Thresher			
Motorcycle / Bicycle			
Wheelbarrows			
Water pumps			
Working animals			
Storage structures (Please specify)			
Other productive equipment (Please specify)			

F. WEALTH INDEX (NUMBER OF CONSUMER DURABLES)

17. Value of household assets in Rials.						
Non-productive Asset	**1**		**2**		**3**	
	Type	**Value**	**Type**	**Value**	**Type**	**Value**
House						
Furniture and furnishings						
Household appliances e.g. iron, stove, …						
Electronic equipment e.g. TV, …						
Non-commercial vehicle (saloon car)						

18. Non-farm business physical capital by the household (such as non-farm land leased for private business, non-farm machinery purchased, animals)		
No.	**Type**	**Value**
1.		
2.		
3.		

G. LAND HOLDING

19. Describe farm size allocation of the household?					
		Rain-fed area		**Irrigated area**	
		Hectares	**Value (Rial)**	**Hectares**	**Value (Rial)**
Total farm size owned					
Total land rented in					
Total land rented out					
Total land Sharecropped					
Under Cultivation	Cereal crops				
	Vegetables and fruits				
	Fruit trees				
	Forage				
	Beans				
Fallow land					
Grazing land					

H. TOTAL INCOME OF HOUSEHOLDS

20. How much is the total annual income of the household?									
21. Describe the major crops grown annually (current year) and the farm income of the household (crop production income)									
Crop type	**Irrigated yield-quantity**	**Rain-fed yield-quantity**	**Price/ quantity**	**Total**	**Crop type**	**Irrigated yield-quantity**	**Rain-fed yield-quantity**	**Price/ quantity**	**Total**
Alfalfa					Oat				
Almond					Onion				
Apple					Paprika				
Apricot					Pea				
Beans					Peach				
Berry					Pear				
Blueberry					Plum				
Canola					Potato				
Cherry					Quince				
Cucumber					Sour Cherry				
Grapes					Tomato				
Greengage					Walnut				
Lentil					Watermelon				
Maize					Wheat				
Nectarine					Zucchini				

22. Explain the non-farm income of the household (annual)	
Source	**Amount (Rial)**
Wages from working in farms	
Remittance (national migrants)	
Remittance (international migrants)	
Off-farm business	
Others (such as pension, please identify)	
Total	

I. HOUSEHOLD EXPENDITURE

23. Explain the proportion (share) of allocation of the total budget of the household for investment and consumption (Annually or monthly, specify)		
	Consumption expenses	**Proportion of budget**
Purchase of asset/input		
Savings (Bank)		
Farm assets/inputs		
Non-farm assets		
Food, clothing, footgear and cosmetics		
Tobacco/cigarettes		
Health care/medicine		
Household bills (such as fuel, water, electricity, telephone bills)		
House repairs & maintenance		
Furniture/blankets & bed sheets		
Contribution/offerings to religious activities/ associations/groups		
Petrol for non-productive machines (generators, saloon cars, etc.)		
Education/training/school fees/school books and supplies		
Social/cultural ceremonial costs: only main events		
Travel expenses		
Other expenses (please specify)		

CURRICULUM VITAE

Personal Information

Name:	Farah Asna Ashari
Nationality:	Iranian
Email Address:	Farah.asnaashari@rub.de

Education

PhD in International Development Studies — June 2018
Ruhr University Bochum, Germany

M.A in Population and Development — September 2005
(On United Nations Population Fund collaboration)

M.A in Economic Systems Planning — September 2000

B.A in Economics — February 1997

Professional Appointments

High School Certified Teacher — 1999 - 2010
Statistics, Mathematics Economics and Social Science, Tehran, Iran

Instructor in Population and Economic fields — 2003 - 2007
University of Applied Science and Technology, Tehran, Iran

Researcher at the Institute for Trade Studies and Research — 2008 - 2010
Ministry of Commerce, Tehran, Iran

Conference Presentations

- Distributional Effects of Irrigation Water Price Changes, a Case Study in Lake Urmia Basin. Presentation in the session on "Population and Vulnerability to Environmental Change" at the XXVIII IUSSP International Population Conference, October 29 - November 4, 2017, Cape Town, South Africa.

- Basic Factors of Agricultural Production, the Case of Lake Urmia Basin. Presented at the international alumni conference on "Doing Good with

Business? Corporate Social Responsibility, Social Entrepreneurship, and Fair Trade", November 2016, Bochum, Germany.

- Water Conservation Program and Practice in Irrigated Agriculture in Iran: A Case Study of Lake Urmia Basin. Presented at Tropentag, September 19 - 21, 2016, Vienna, Austria.

- Estimating Reallocation Cost of Water Resources through Agricultural Production Function. Poster presentation at Tropentag, September 16 - 18, 2015, Berlin, Germany.

- Compensating Farmers to Release Water from Irrigation in Support of the Ecosystem. Poster presentation at "Global Day", June 2015, RUB International Office in Bochum, Germany.

- Water Pricing and Externalities, Poster Presentation at the "Development Day at University Alliance Metropolis Ruhr (UAMR)", November 2013, University of Duisburg-Essen, Germany.

- A Test and Modification of Zipf's Hypothesis; the Case of Migration to Tehran Accepted for presentation at the XXVI International Population Conference of the IUSSP, October 2009, Marrakech, Morocco.

- The Flow of Iranian Women's Life, A Historical-Demographic Study (1956 - 2006). Accepted for presentation at the "Gender at the Crossroads: Multi Disciplinary Perspectives" 3rd International Conference on Women's Studies, April 2009, Eastern Mediterranean University, Center for Women's Studies in Famagusta, Cyprus.

- Assessment, Adjustment, and Correction of Iran National Censuses in 1976, 1986, 1996. Accepted for presentation at the 2006 IAOS Conference, Ottawa, Canada.

- Population ageing and age at retirement in Iran in 50 coming years. Presented at the sixth annual population conference, December 2005, Islamabad, Pakistan.

Community Involvement

Acting as reviewer:

- Research School PLUS of Ruhr-University Bochum (Assessing Proposals for Research Funding)

- International Journal for Equity in Health

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DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgement has been made in the text.

Farah Asna Ashari

Bochum, 2018