(A study of Loralai District)

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DEDICATION

I dedicate this thesis to my dear mother and my late father. Who never failed to provide me with the best of support in my pursuit of learning.

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Thanks to Almighty Allah who bestowed me with the opportunity to accomplish my dream of getting higher education despite many hurdles all the way.

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Gullali Jogezai

ABSTRACT

Policy supported modernization of groundwater abstraction through tube wells have raised serious concerns about the sustainability of groundwater resources in Balochistan. Many experts believe that traditional technologies such as *Karez* were best suited to arid climate of the region and prescribe their revival. While there is generally good gesture about local interest in the revival of *Karez*, it is yet to establish the farmer's serious motivation in this regard. This is particularly important since the socioeconomic and livelihood sources and technological scenario of the region has been rapidly changing since the last few decades. This research investigated the local enthusiasm towards the revival of *Karez* among the household using *Karez*. Four *Karez* from the Loralai District were purposively selected, comprising of two functional and two non-functional *Karez*es. Furthermore, randomly selected sample of 105 household were investigated through structured questionnaire and eight interviews were also conducted to have in depth knowledge of the issue.

The result shows that tubewell didn't help I the expansion of the agricultural land as it was perceived due to high electricity and maintenance cost. The expansion in the cultivated land was witnessed in the region where *Karez* is revived. People from the functional *Karez* region showed high enthusiasm towards *Karez* revival rehabilitation by contributing enormously financially led by strong leadership. On the other hand, people from the non functional region lacked finance, leadership and were comparatively less motivated. Even though the reliance on the tube well is at peak in all the household chores but respondents still claimed their struggle for *Karez* rehabilitation as their crop production was declining.

The results, however, identifies the necessitates for the commencement of the *Karez* rehabilitation and also clears the curiosities for policy makers whether reviving *Karez* will be

viable in the present state of the district, eventually improving the ground water resources, with the design and implementation of appropriate policies.

Keywords: *Karez, Tubewell, Enthusiasm, Revival, Balochistan*

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ABBREVIATIONS

FK	Functional *Karez*
NFK	Non-functional *Karez*
TW	Tubewell
O & M	Operation and maintenance

GLOSSARY

Karez	An ancient irrigation system consisting of a tunnel dug at a very slight u pward gradient into rising ground so that water from deep withinthe earth runs out to the surface.
Rabi crops	Agricultural crops sown in winter and harvested in the spring
Kharif crops	This crops is the autumn harvest but better known as the monsoon crops in Indian sub continent
Sarishta	Headman/manager for the *Karez* management
Afghanis	Inhabitants of Afghanistan

Chapter 1. **INTRODUCTION**

1.1 Background

Ground holds more than 98 percent of freshwater on earth (Bouwer & Bouwer, 1978) but its distribution among different regions of the world is highly uneven (Asano & Cotruvo, 2004) Being a non-excludable and subtractible Common Pool Resource (CPR), groundwater is always prone to overexploitation and depletion. In many parts of the world, groundwater is under increasing pressure caused by the intensification of human activities, such as agriculture, domestic and industrial uses, and other climatic factors. One of the reasons of exponential increase in groundwater use is partly due to the advances in affordable pumping technology (Moench, 1992; Raqya, 1991).

Increased competition among different uses of groundwater, coupled with high-tech methods of its abstraction, challenges the regional sustainability of these resources. The reliance on groundwater is substantially higher in South Asia, as this region, in association with China, extracts about half of the world's annual groundwater water withdrawals (Shah et al., 2003). For some of the arid regions in South and central Asia, such as Balochistan province of Pakistan and adjoining areas of Iran and Afghanistan where rainfalls are highly scant and surface water is almost absent, the reliance on groundwater becomes inevitable.

Constrained with the ecological realities of the region, human civilization in this part of the earth had been quite innovative in the abstraction and management of groundwater resources. One of such artifact is *Karez*, which many (Beaumont et al., 1989; English, 1998; Goblot, 1979) consider that has originated from this region. More importantly, *Karez* can be termed as a truly sustainable technology due to its close conformity with environmental, social and economic dimensions as well as the demonstrated intergenerational transferability.

Reportedly, some of the *Karez* in Balochistan (English, 1998), Iran (Abudu et al., 2011) and elsewhere (Goblot, 1979) continue to supply groundwater since about 2500 years.

Environmental sustainability of *Karez* is associated with its technological foundations that tap shallow water conveniently provided by nature without any chance of humans' overexploitation of deep aquifers. Social sustainability is associated with its technological character that requires collective action from construction to maintenance thus making it an egalitarian technology. Last but not the least, it economic sustainability is associated with its technological character that does not require any mechanical energy except for annual or bi-annual maintenance.

Over the last few decades, different regions of the world have experienced death of *Karezes* that closely correlates with the ascendancy of pumping technology (Ahmed, 2005; Steenbergen, 1995). The growth of tube wells and the decay of *Karez* are not accidental but outcomes of the deliberate policies supporting this 'modernization project' with massive subsidies (Johnson, 1989; Steenbergen, 1995). Globally millions of farmers installed tube wells, which enabled agricultural expansion as well as cultivation of cash crops. Nevertheless, this groundwater bonanza is over as the water tables in various parts of the world are falling very rapidly.

Besides, governments in developing countries are facing difficulties in continuing their supporting groundwater extraction through massive subsides. For example, in case of Balochistan province of Pakistan, the electric subsidies for tube wells could account for one fifth of the provincial development budget in 2011(Khair et al. 2012). However, such massive subsidies mostly favor rich farmers who could install tube wells but not to those who still rely on dying *Karez*. Tube well connections account for just four percent of the electric connections but consume almost 80 percent of the electricity available to province (Qureshi

& T Akhtar, 2003). Similar situation has resulted in worldwide interest in revival of *Karez* (Appell et al., 2003; Hussain et al., 2008; Khair et al., 2012).

1.2 Problem Statement

Various governments (Lightfoot, 1996), communities (Sun et al., 2009) and NGOs (Oshima, 2008) are attracted towards restoring *Karez* and discourage the growth of tube well. However, in order to enable *Karez* to regain the lost ground there are a couple of issues, which require adequate handling.

First, tube wells have made it possible to expand agriculture resulting improvement in local livelihoods during last few decades. It is difficult to divert farmers from tube wells technology, particularly in a situation where *Karez* provides limited amount of irrigation that cannot facilitate the expansion of agriculture under current irrigation practices. Technologically speaking, this problem is solvable if one can successfully introduce efficient irrigation technologies, such as *Karez* fed drips (Asmon & Rothe, 2006; Hussain et al., 2008), along with water saving crop varieties (Altaf et al., 1999).

Second, one of the important but mostly unrecognized issues in the decay of *Karez* is the skill and labor shortage for the maintenance of *Karezes* in Balochistan (Khan, undated). J. Wessels and Hoogeveen (2002) support this view as they also observed that in the case Syria, regular maintenance is pivotal to keep a *Karez* running. In the case of Balochistan, there had been major socioeconomic transformations over the last few decades, which have changed the entire occupational structure of the rural areas. Khan and Nawaz (1995) also points out the migration of labor toward gulf countries (Appell et al., 2003) for employment as the major factor for decay of *Karez* in Balochistan. Increased income generation in the off-farm encourages rural migration abandonment of *Karez* (Lightfoot, 1996) and local knowledge on *Karez* is also lost with the migration (Vincent, 1995).

Besides, as reported by Mustafa and Qazi (2007) most of the skilled labour was historically coming from Afghanistan. Due to long enduring war, the skill movement from Afghanistan has reduced because of either the death or disappearance of the skillful Afghanis. This situation has resulted operation and maintenance difficulties that ultimately contributing the death of these erstwhile robust irrigation systems (Wessels, 2000).

In this light of above facts, government and NGOs' enthusiasm towards the revival of *Karez* (Appell et al., 2003; Oshima, 2008) is significant and may bring *Karez* back for a while but cannot ensure its long-term sustainability. There is virtually no clue on what will be the operation and maintenance mechanism for *Karez* in future. Besides, there is even no understanding of the experiences, strategies and locally designed solutions, which has enabled some of the farmers to keep their *Karezes* running.

Before appreciating the initiatives of *Karez* revival, one ponders either the future of *Karez* maintenance would be labor or capital intensive. The state of the art understanding of *Karez* and the efforts of their rehabilitation does not answer any of these questions. Lack of answer to these questions may undermine the efforts of *Karez* rehabilitation and thus leaving the issue unabated.

1.3 Research Objectives

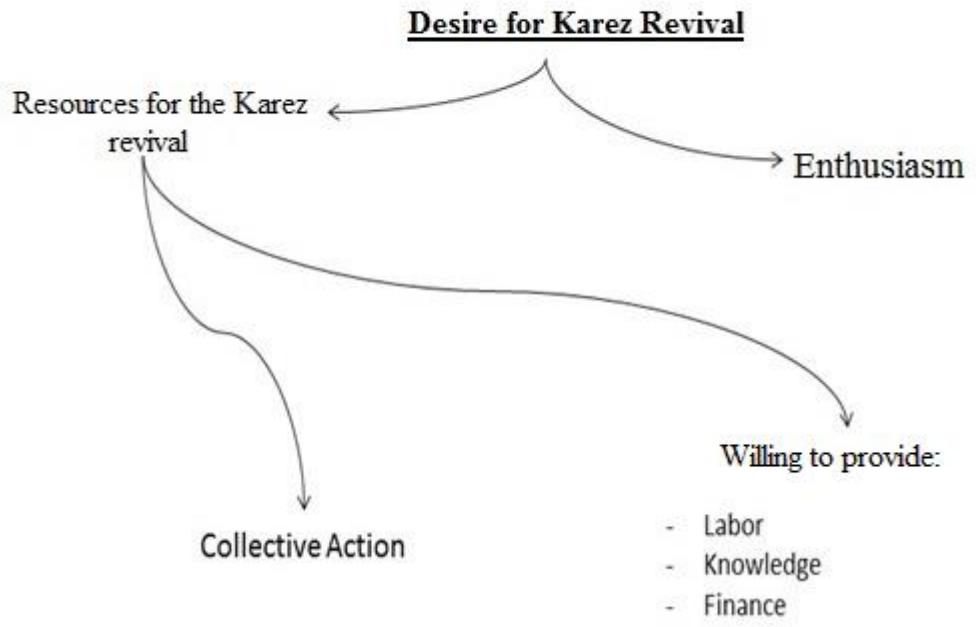
The general objective of the study is to explore the potential for the rehabilitation of *Karez* systems in Balochistan. The specific objectives are:

1. To assess community's enthusiasm towards the revival and Operation & Maintenance of *Karez*
2. To analyze the resources available with community for Operation & Maintenance of *Karez*.

1.4 Rationale for research

Regular maintenance is the key to keep *Karez* running (Wessels, 2008). Even if the *Karez* is revived, the possibilities of its survival in the current state of the province, seems dismal. As skilled labor has moved out for better job opportunities; younger population shows no interest in the traditional water techniques, the social cohesion bond is no longer existing, absence of conflict management system and no strong leadership. In such scenarios, even if the *Karez* is constructed, it is destined to collapse again. Therefore, a thorough investigation of the potential of community based rehabilitation of *Karez* rehabilitation and maintenance is extremely necessary. The overall understanding of the availability of the quantity and quality of the resources required for the maintenance will portray a clear the picture that will show if the revival of the *Karez* is viable or not.

1.5 Conceptual Framework of the Study



Source: Author

Figure 1: Conceptual Framework of the Study

1.6 Scope and Limitations of the study

This study investigated the existing enthusiasm and resources available for the rehabilitation of *Karez* and issues involved in the operation and maintenance of the *Karez* technology once it's revived.

Loralai district has 50 *Karezes* in the region but this study was restricted to only four *Karez* out of which two are functional and two are non-functional. With limited financial resources and security concern in the area, it was not possible to cover all the *Karezes*.

The findings of this study are useful for the irrigation planners and policy makers who are striving for the revival of the *Karez* technique.

1.7 Organization of the Study

Chapter 1 of this study introduces the problem statement and describes the specific problem addressed in the study.

Chapter 2 presents a review of literature and relevant research associated with the problem addressed in this study.

Chapter 3 presents the methodology and procedures used for data collection and analysis.

Chapter 4 contains an analysis of the data and presentation of the results.

Chapter 5 offers a summary and discussion of the researcher's findings, implications for practice, and recommendations for future research.

Chapter 2. **LITERATURE REVIEW**

This chapter explores and describes the literature review related to *Karez* evaluation and the current scenario. First section 2.1 describes *Karez* technology: Theories of its origin and diffusion. Section 2.2 elaborates on Social, Economic and Environmental Sustainability of *Karez* systems. Section 2.3 discusses Tube well technology and its impact on *Karez* systems. Sectional 2.4 explains Responses to the Decay of *Karez* Systems and section 2.5 reveals the Synthesis: State of the art understand on *Karez* issue

2.1 *Karez* Technology: Theories of its Origin and Diffusion

Water has always been an important necessity for husbandry and agriculture in ancient times. Groundwater is an exhaustible resource stock, but each year small proportion around (<5 percent) can be renewed through melting of snow or by seepage into aquifer (Koundouri, 2004). Over the last decades, groundwater use has increased all over the world due to increased competition for industrial, agriculture and domestic use; and has emerged as a key contributor to the economic development of various countries (Llamas et al., 2009; Llamas & Garrido, 2007). This has stressed the groundwater resources, already showing signs of depletion in various regions of the world (Kulkarni, 2005).

Decades back, an increase in population, modernization and water resource scarcity made people think to come up with a permanent water source. This led to a development of new water extraction yet sustainable technique '*Karez system'*. A technique extracts water relying on the gravity, without overexploiting an aquifer (Todd, 1980). "Qanat" which is an Arabic word is most commonly used terminology used in Jordan, Iran and Syria. While "*Karez*" is a Persian term used in few countries of Central Asia such as Pakistan, Western China and Afghanistan (Abudu et al., 2011).

Karez system and its antiquity dates back to the early ages of human civilization. It first appeared about 3,000 year ago in the Middle East (Beaumont et al., 1989; English, 1998). There are numerous factors for the existence of *Karezes* in different regions like geology, topography, hydrology and agricultural activities in that region. Beside these Lightfoot (1996) pointed that *Karez*es are mostly constructed in areas with high discrepancy between potential evapotranspiration (ET) and precipitation. Also in semi-arid areas which receive average annual precipitation of around 400mm or less (Abudu et al., 2011). Whereas areas like Iran, Afghanistan, Pakistan has average rainfall not more than 300mm (Lightfoot, 1996; Rahman, 1981).

Karezes are the subterranean channels dug into sedimentary rock or into alluvium to penetrate the underneath aquifer so as to perforate the underground water table (English, 1998). The aquifer filters the water into the tunnels, which flows down their gentle slope and then comes up in a form of a water stream near a settlement. The gravity flow channels are short of around or less than 5 kilometers in length (Beaumont et al., 1989). The longest can extend up to 40-50 kilometer underneath the ground before it emerges at the point of settlement (English, 1966).

Over the years, *Karez* has been the only sustainable source of water which prevents the depletion of ground water and also keeps it at some reasonable level (English, 1998). *Karez* protects the downstream agriculture land by balancing the salinity of the water and in arid regions. It prevents evaporation, serving as drainage system. Since the population is growing at increasing speed, *Karez* cannot meet water requirements for extensive irrigation and agricultural purposes and with technological advances, *Karez* systems are losing their importance (J. Wessels & Hoogeveen, 2002). The introduction of pumped deep wells frequently started replacing *Karez* which led to abandonment of *Karez* system and resulted in the rapid depletion of the underground water in many arid areas of the world. Not only

technical transformation; but the younger population has lost interest in farming and moved toward the urban area giving up on *Karez* completely.

2.2 Social, Economic and Environmental Sustainability of *Karez* systems

A *Karez* is considered a pivot point and a socio-cultural institution around which all activities occur. As *Karez* systems are maintained collectively, therefore complex relationships have been witnessed, where water is distributed according to shareholder's input of labor, tool, money and land (Hussain et al., 2008). *Karez* systems have always kept the cultural identity alive in the communities and not only that but has turned a major source or rather the only source of domestic water supply and irrigation in some arid areas. In many villages, the extensively spread stake in the water supply system makes social cooperation more strong by widely diffusing the *Karez* ownership through the population (English, 1998).

Karez are usually built by rich people of the region but since *Karez* needs frequent maintenance by repairing and cleaning tunnels with occurrence of some natural calamity leads to rapid division of the *Karez* ownership. The process of dividing water can take date back to some hundred years where *Karez* owners may vary from two to three hundred and some *Karez* water is divided into around 10,000 shares.

English (1989) exemplifies the record of ownership change in the Vakilabad *Karez* constructed in Mahan, in the 1860's which is a town southeast of Kirman. The water initially was divided in six shares among three men and one-sixth of the *Karez* water was assigned in favor of the custodian of the Shrine Shah Ni matullah wali, this share has been extended to one-third of the *Karez* water now owned by twenty of his descendants.

The rest of the water shares were sold of gradually and now around seventy families have share in the *Karez*. *Karez* system plays an important role by linking the local community to plan and manage their existing resources. This management brings solidarity amongst them

with induced sense of decision-making and a sense of belong. Maintenance and sharing of water is managed by the community institutions (Hussain et al., 2008).

Over the years, *Karez* has been the only sustainable source of water which prevents the depletion of ground water and also keeps it at some reasonable level (English, 1998). *Karez* protects the downstream agriculture land by balancing the salinity of the water (Haeri, 2003) and in arid regions it prevents evaporation, serving as drainage system. Therefore, *Karez* system has always kept the dignity and financial status of the poor smooth while providing the essential necessity of life i.e. Water (Saghafian, 2005).

2.3 Tube well technology and its impact on *Karez* systems

Since the population is growing at increasing speed, *Karez* cannot meet water requirements for extensive irrigation and agricultural purposes and with technological advances, *Karez* systems are losing their importance (J. Wessels & Hoogeveen, 2002). The introduction of pumped deep wells frequently started replacing *Karez* which led to abandonment of *Karez* system and resulted in the rapid depletion of the underground water in many arid areas of the world (Mustafa & Qazi, 2007).

Not only technical transformation; but the younger population has lost interest in farming and moved toward the urban area giving up on *Karez* completely (Khan & Nawaz, 1995). *Karez*, which though was less productive but, was one sustainable water supply system in contrast to new electric and diesel pumped well technologies which are productive but less sustainable, (Beaumont et al., 1989), was therefore abandoned. The ancient *Karez* system has been rapidly replaced by deep well around the world which is more productive yet unsustainable. *Karez*-water settlement has been ignored completely on the Iranian plateau and with this rapid change in water technology; the aquifers are draining eventually transforming the life of Iranian villagers (Abudu et al., 2011).

Karez differs from deep wells because of their sustainability as the rate of flow of water in *Karez* system relies on the water table level; therefore, it is a renewable source of water (Abudu et al., 2011). Whereas deep wells ignores the recharge rate of the aquifer and extracts groundwater depending on the need and requirement which leads to overexploitation and unsustainable ground water resources (English, 1998).

However, both *Karez* and new pumping technologies have their own distinctive advantages and disadvantages. They can be simultaneously be operational in the same area but in areas pumping technologies completely destroys the *Karez* system and drain off the aquifer. English (1998) stated that ‘‘the self- limiting features of *Karezes* that make them a sustainable technology can, however, be their biggest drawback, particularly when they are compared with the range of technologies available today.’’

When it comes to sustainability, *Karez* has an upper hand and more sustainable. Deep wells have the aptitude to withdraw excess of water from the aquifer as per the demand which makes it very attractive for the short period because the water is ultimately treated as non renewable resource in the area (Abudu et al., 2011). Though *Karez* system cannot meet the growing demand of water need and agricultural extension in arid regions (English, 1998) but in long run it is more sustainable to be practiced. Even if deep wells are restricted to certain extraction regulations and policies it can be beneficial in long run.

English (1998) elaborates deep well’s advantages and disadvantages over *Karez*. It can be constructed anywhere near centers and markets without the hindrance of soil conditions, where it can draw from deep aquifer where no seasonal variation occurs. Water is drawn according to the requirements, which serves best for water conservation. Deep well, unlike *Karez*, mine aquifer makes it an attractive This enables people to exploit the underground

water table and turn groundwater into non-renewable resource in areas where *Karez* system is abandoned for deep wells.

2.4 Responses to the Decay of *Karez* Systems

Over the decades, people have realized the importance of *Karez* system which can be judged by the fact that *Karez* is considered one of the three big projects in China (Ahmad, 2007) while the other two in list are Great wall and Beijing-Hang Zhou Canal. The abrupt increase in the *Karez* decay has instilled a great worry in the regions which relies n *Karez* system extensively (Khair et al., 2012). Irrigation has been effected thoroughly with the decay of *Karez* which has disturbed the livelihood of farmers and deteriorated their economic conditions (Appell et al., 2003; Sun et al., 2009). Health issues and diseases have increased as water flowing through *Karez* is filtered through silt which kills bacteria, while standing water from well causes numerous health issues (Appell et al., 2003).

Since *Karez* has been a source of providing water to communities for decades and has been one of important community based method of irrigation and consuming water should be reinstate. The restoration of *Karez* will improve the livelihood of poor, future calamities can be reduced leading to more sustainability (Hussain et al., 2008). People residing in the arid regions embraced *Karez* despite being costly because of its ability of providing scarce water while using existing capital (Rahman, 1981).

2.5 Synthesis of Literature Review

As the increased knowledge about *Karez* revival has prevailed around the countries therefore, various factors are to be considered which decides the cost and time required in the construction of a *Karez*. These factors are resources/capital of the owner, geographical conditions, specific water need and the length of the *Karez*. Socio-economic and environmental factors contribute are the major factors too (Kahlown & Hamilton, 1994).

Now with increased in inflation and wages, the construction and maintenance of *Karez* will be very prohibitive. Political instability in the developing countries discourages the *Karez* revival but with the political and economic stability investors will be encouraged to finance in new *Karez* system (Munir & Kahlown, 1988).

To maintain lifestyle, the profit from *Karez* is not adequate for user household due to increased competition, socio-economic changes, increased population and modernization. If value added crops, cultural heritage value and ecotourism are promoted then the revival of *Karez* can help in worthwhile revenue. Hussain et al. (2008) outlined a few strategic responses for *Karez* rehabilitation; to devise an integrated water conservation system where every drop of rain water is stored at homes, in dams and check dams through efficient use of water. Introduction of water delivery mechanism can help in the efficient use of water by using modern irrigation techniques (trickle, sprinkle, etc). Hussain et al. (2008) also stress on research side by growing crops which needs less water and holds the soil in place, this can help in the revival of *Karez* system.

While it is not humanly possible to revive all the *Karez* but considerable number of *Karezes* should be revitalized. There are numerous appropriate conditions under which *Karez* rehabilitation can be viable. The existence of stable groundwater is required with reliable underground tunnel construction, which can be done through strong social unity among the locals, availability of skilled workers, clear distribution of ownership rights of *Karez* and willingness of the water users to show strong commitment. A strong leadership can be one important aspect too for *Karez* successful renovation (Wessels, 2000).

Different countries have realized the importance of *Karez* technology and working extensively on its rehabilitation for rescuing the groundwater from further deterioration. Appell et al. (2003); M. Khan and Nawaz (1995) focus more on the rehabilitation of the

Karez system while Hussain et al. (2008) research focuses on the social, cultural financial capital required for the *Karez* rehabilitation. (Wessels, 2008) research in Syria encourages the possibility of modern irrigation practices through *Karez* when it is coupled with gravity driven drips, without any need of mechanical energy. In Syria efforts were put in *Karez* revival where community was trained and well organized for *Karez* maintenance (Wessels, 2008). While in Turpan, government and local communities are working hard to revive and preserve the ancient irrigation system (Sun et al., 2009). People residing in the arid regions embraced *Karez* despite being costly because of its ability of providing scarce water while using existing capital (Appell et al., 2003). Literature distinguishes successful *Karez* revival into exploration and planning, construction and maintenance (Ahmad, 2007). Regular maintenance is the key to keep *Karez* running (Wessels, 2008).

Chapter 3. **METHODOLOGY**

This chapter has discussed the methodology that has been used in the research. Section 3.2 has a detailed discussion about the study area which is followed by section 3.3 with an account on the data source. Section 3.4 gives detail on the sampling technique and sample size, while section 3.5 describes data collection tools and techniques. Last section, 3.6 shows the data analysis methods of descriptive analysis.

3.1 Study Area

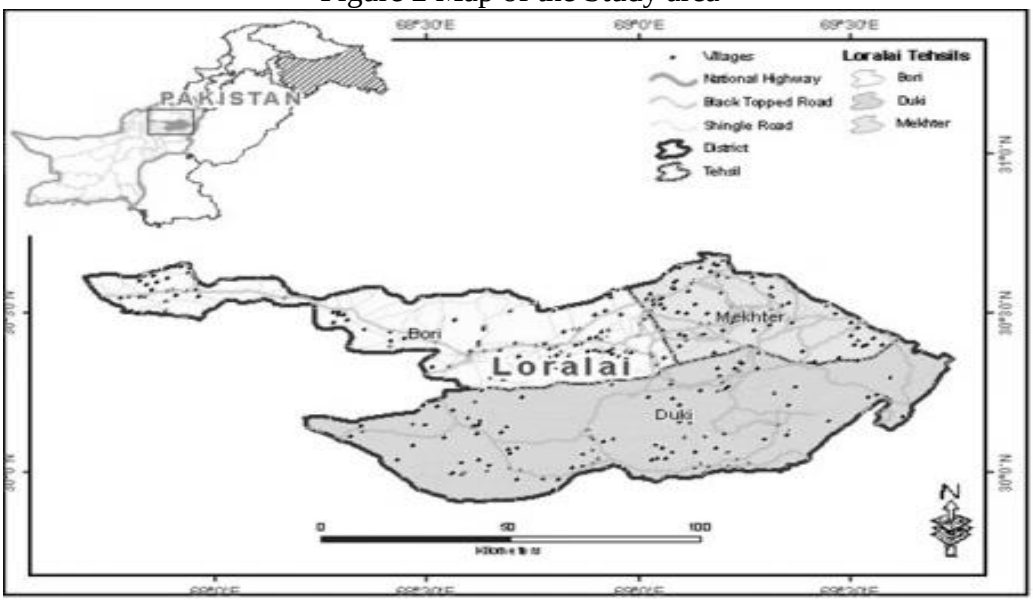
Loralai District, inhabited by 250147 people (PCO 1998), is located in the northeast of the Balochistan Province. The district is mountainous geographically with valleys running through different ranges. The various hill ranges consists formation of earth, limestone, sand and rocky. Due to a variety of elevations, the climate of the area varies but it is mostly dry and cold in winters while mild in summers. Considering the climatic conditions, the area is distributed into continental, sub-tropical and semi-arid highlands. Maximum rainfall occurs in the month of March and in the monsoon season i.e., July and August. Temperature in the area ranges from maximum temperature 26.6°C to minimum temperature of 11°C (UNICEF 2011).

Agriculture is the major occupation in the region where it has two cropping seasons of *Rabi* and *kharif* crops. According to Balochistan Agricultural Statistics of 200-09, Loralai lies in the tropical agro-ecological zone with 190,054 hectares potential agricultural area. Out of this, only 23.7 percent of the land is available for the agriculture while majority of the area is considered no cultivable due to water scarcity and various other constraints. However, if the existing water resources are renovated, the cultivation area can be increased tremendously.

There are 1000 *Karezes* documented in Balochistan out of which 50 are located in Loralai (IUCN 2013). Many advancement possibilities are present in the agriculture sector of the

district, which can lead to tremendous growth and fast development, but the irrigation scarcity is the main constraint. Nevertheless, the uncultivated land can be cultivated by futurist approach of renovating existing water resources and properly conserving the floodwater. This will help increase the cultivable land of the district.

Figure 2 Map of the Study area



Source: *District profile by Government of Balochistan*, 2011

3.2 Data Sources

A primary source of data collection technique has been used to collect data for the study by investigating household and key informants directly. To understand the importance and enthusiasm from a lay man perspective, a structured questionnaire was applied at household level. However, 8 key informant were also interviewed so as have a clearer understanding of the issue.

3.3 Sampling Technique and Sample Size

The sample size for the study is 105 respondents selected randomly. The sample size is calculated at 5 percent confidence interval and 95 percent confidence level from the population of four *Karezes* in the Loralai district. The sample has been distributed among the

targeted four *Karezes* according to its total population through proportional allocation approach. Therefore, 27 respondents were selected from the functional *Karez* Zangiwal and 24 from functional *Karez* Manzaki. Whereas, 26 and 28 respondents were selected from non-functional *Karez* i.e. Murtat and Dargai *Karez*, respectively as shown in the Table 3.1.

Table 3-1: Distribution of the sample

Category and Name of *Karez*		Population	Sample size		
			Size (No.)	Percentage of population	Percentage of sample
Functional					
	Manzaki *Karez*	33	24	72.7	22.9
	Zangiwal *Karez*	37	27	73.0	25.7
	Subtotal		51	145.7	48.6
Non functional					
	Dargai *Karez*	39	28	71.8	26.7
	Murtat *Karez*	36	26	72.2	24.8
	Subtotal		54		51.4
Total/Average		145	105	144	100

Source: Sample calculated based on population statistics obtained from Union council
Notes: Confidence Level = 95%
Margin of Error = ± 5%

3.4 Data Collection Tools and Technique

The household perspective and enthusiasm about *Karez* usage and revival was investigated through close-ended questionnaire. The questionnaire was organized in a way to complete the requirement of the objectives and to accumulate the essential information from the respondents. The questionnaire comprised of profile information of the respondent and their family along with the key parameters information on the acquisition of land cultivated or non-cultivated, source of water usage for land irrigation.

Questionnaire also inquired temporal change in the sources of domestic water; assess the local irrigation trade for market tube irrigation, willingness for cooperation in *Karez* rehabilitation and analysis of the overall enthusiasm towards *Karez* operation and maintenance with rehabilitation process. Besides, communities were also asked about the kind of resources they were willing to contribute for the rehabilitation of *Karez*. Altogether

34 close ended questions in the questionnaire were investigated which inquired data on both ordinal and ratio scales.

3.5 Data Analysis

As the study is quantitative, therefore descriptive statistic approach had been used for the analysis of data. The data is analyzed through percentages, frequencies and cross-tabulation to assess the survey data in understandable and comprehensible way.

Chapter 4. **STUDY AREA PROFILE**

This chapter sets a scene for understanding the succeeding chapters. It gives details of the study area location, profile of the studied *Karez* systems and socioeconomic characteristics of the respondents and their families.

4.1 Profile of the Functional *Karez*s (FK)

4.1.1 Zangiwal

Zangiwal *Karez* was established in the year of 1943 and is located at a distance of 5km[1] from Loralai Cantt. The *Karez* originates from a streambed having loose gravel and soil. It is 5km long has 48 shafts and irrigates about 140 acre of land. During the severe drought spell in the region, the *Karez* was dried completely by the year 2000. The installation of tubewell was fast. However, due to electricity shortage; community started facing acute shortage of irrigation water. In 2003, the prolonged rainy season raised water table and created a hope for the revival of this *Karez*. Community started repair and cleansing work of shafts and mother well of *Karez* with cooperation resulting in significant increase in the water discharge of the *Karez*.

4.1.2 Manzaki

Manzaki *Karez*, constructed in the year 1951 is at a distance of 17 kilometers from the Loralai city1[2]. *Karez* was the primary source of water for drinking and irrigated agriculture. It is 1.5km long feeding 50 acres of land. Due to long drought period in year 1997 water yield of this *Karez* gradually reduced until it completely dried in 2000. This situation adversely affected the local agriculture of the dependent households. Hoping that once the drought spell is over, their *Karez* will start flow, the local people were regularly maintaining the *Karez*

[1] National Highway Authority sign board in Loralai
[2] National Highway Authority sign board in Loralai

structures throughout the drought period despite being completely dead. Therefore, once water table came up, the rehabilitation and cleaning of said *Karez* was faster and cheaper. So far, the *Karez* flow has improved 30 percent.

4.2 Profile of the Non-functional *Karez* (NFK)

4.2.1 Murtat

Murtat *Karez* was constructed in the year 19451[3] from the foothills and in the hard rock formation. It lies at distance of 15Km2[4] from the Loralai City. This region of the Loralai submerged with floodwater in 1996 that led to the collapse of *Karez* shaft wells. Even though the water flow was witnessed *Karez* channels for a year, but it did not serve the purpose of irrigation. During the unfortunate drought period, the local community ignored timely maintenance of this *Karez* leading to its complete redundancy. Now, the rehabilitation of the Murtat *Karez* requires huge capital, which the local people cannot afford by their own. The community, however, is looking for external support from government or any NGO to rehabilitate their *Karez*. If successful, this intervention will benefit to 26 HH (128) beneficiaries).

4.2.2 Dargai

The local community established the Dargai *Karez* in the year of 1939[5]. It is 5km long[6], has 30 shafts and is able to serve 104 acres of land. The 1997-2000 droughts led gradual decline in the water delivery from this *Karez*, which resulted a decline in the agricultural production. Now when drought period is already over and the groundwater table has risen, still there are no marks of water delivery in this *Karez*. Therefore, communities are not confident in starting its rehabilitation. If it can be revived by any mean, it will increase irrigated area, improve

[3] Sharista- Key informant
[4] National Highway Authority sign board in Loralai
[5] Key informant
[6] National Highway Authority sign board in Loralai

availability of water both for drinking and agriculture propose, irrigation scheduling will also improve and increase agriculture production.

4.3 Profile of the Respondents and Their Family

The data on the household composition of the population is depicted for the FK and NFK in. The data highlights that more than one quarter of the respondents fall in the age group of 41 and 43 while 4 percent and 9 percent of the respondents fall in the age group of 71-85 for FK and NFK, respectively. Young generation has very limited knowledge about the farming and the associated issues therefore respondents below 40 years of age comprises of 31 percent for FK while 35 percent for NFK. Majority of the respondents were household heads both in FK and NFK and were married.

Furthermore, about one-fourth of the respondents were matriculate, two-forth had tertiary level of education and only 6 percent were uneducated in FK. In NFK, more than one-fourth completed tertiary level of education, around one-fourth were matriculate while only 2 percent of the respondents were uneducated. The average family size was nine members in FK and eight members in NFK. The gender composition of family shows greater number of female. The ratio of adult male to female in FK was 2:3, and a girl to boys was 3:2. In NFK there is equal number of adult male to female 1:1 while girls to boys ratio was 3:2.

Table 4-1: Profile of respondents and their family

Parameter	Category of *Karez*		Parameter	Category of *Karez*	
	Functional	Non-Functional		Functional	Non-functional
Age of respondents (%)			Education of respondents (%)		
25 - 40 years	31	35	Uneducated	6	2
41 - 55 years	**41**	**43**	Primary	18	15
56 - 70 years	24	13	Secondary	14	31
71 - 85 years	4	9	Matriculate	24	17
Total	100	100	Tertiary	**39**	**35**
			Total	100	100
Marital status of respondents (%)					
Married	80	70	Respondents' status in family (%)		
Unmarried	12	15	Head	**71**	63
Other	8	15	Member	29	37
Total	100	100	Total	100	100
Family composition [$\bar{x}$ (n)]					
Female (adult)	3 (51)	2 (54)			
Male (adult)	2 (51)	2 (54)			
Girls	3 (28)	3 (36)			
Boys	2 (39)	2 (43)			
Family size	9 (51)	8 (54)			

Source: Field Survey 2015

4.4 Household Income and its Constituents

Farming and agriculture is the major source of income of the common inhabitants of Loralai district. Therefore, despite having different income sources, the income from crop production dominates all others, and accounts for on average 54 percent and 51 percent of household incomes in FK and NFK, respectively. The income data is divided into three income groups i.e. low, moderate and high-income groups as shown in the table 4.2. The population comprises majority of the people with moderate monthly income, 84 percent in FK while 88 percent in NFK which is evident from the table 4.2. Income from the job or business stands second, while, remittances hold a very small portion of the income source for only 7 percent respondents in FK and 9 percent respondents in NFK.

Table 4-2: Income and its sources

Income and its constituents	Income Groups (averages)					
	Low		Moderate		High	
	N	Mean	N	Mean	N	Mean
Functional						
Monthly income	4	18750	43	73419	4	217500
Crop Production	4	80	43	54	4	55
Leasing out assets	0		11	30	2	35
Job or business	3	27	35	44	2	55
Remittances	0		4	24	0	
Non Functional						
Monthly income	4	20000	48	63833	2	200000
Crop Production	4	73	48	51	2	40
Leasing out assets	0		15	25	1	60
Job or business	3	37	42	45	1	60
Remittances	0		5	16	0	

Notes:
- Averages of income sources are calculated based on their percentage share in total income.
- Monthly incomes are in Pakistani Rupee (1 USD was equal to 102 PKR on 23rd March 2015)

Chapter 5. **DATA ANALYSIS**

The preceding chapter summarizes the collected data and analyzed statistically. This chapter clarifies the differences in people from the FK and NFK in different aspects regarding the importance towards *Karez* and its timely rehabilitation. In doing so, the section 5.1 explores the sources used for the household activities. Section 5.2 provides the sources of land possessions and their cultivation status by the people of both *Karezes* and leads to section 5.3 which explores thoroughly the Reasons for uncultivated land. Section 5.4 portrays the fact about Local irrigation trade – market for tube well irrigation. Whereas section 5.5 identifies Community conditions for cooperation in *Karez* Rehabilitation and section 5.6 discusses Contribution towards operation and maintenance of *Karez*. Section 5.7 and section 5.8 explains community views about *Karez* utility and Respondents' enthusiasm towards *Karez* rehabilitation respectively.

5.1 Use of *Karez* and Tubewell Water for Household Activities

Results reveal that tube well is the major source of water, as the household utilize it for drinking, washing and cooking purpose. The use of *Karez* water has drastically decreased over the period of 30 years due to inevitable drought that prevailed for years in the region. With no other alternative, tubewell usage has increased during the last 15 years for different domestic purposes. The water from the revived *Karez* fulfils the demand of more than half of the respondents for washing clothes. However, people from the NFK use tubewell for this purpose.

Even though *Karez* has been revived in the region, the residents of the area (24 percent) still use tube well water for cooking and drinking purpose. 10 to 15 years back, *Karez* was on the verge of drying while tubewell installation was increased. In this period, people were utilizing both the sources for their domestic use as per the availability either. In the FK

region, the *Karez* water stayed for longer than the NFK region, therefore majority of the people were utilizing *Karez* water than the tubewell water in FK region. The table 5.1 reflects that the usage of tube well is preferred for household activities over *Karez* water.

Table 5-1: Historic account of people's sources water for domestic use

Domestic Use	*Karez* – [% ($\bar{x}$)]			Tube well – [% ($\bar{x}$)]		
	At present	10-15 years ago	15-30 years ago	At Present	10-15 years ago	15-30 years ago
	Functional *Karez* (N = 51)					
Drinking	23.5 (32)	92.2 (79)	100 (100)	100 (92)	62.7 (43)	0
Cooking	23.5 (29)	98.0 (81)	100 (100)	100 (93)	54.9 (38)	0
Washing	60.8 (51)	96.1 (87)	100 (100)	94.1 (73)	39.2 (45)	0
	Nonfunctional *Karez* (N = 54)					
Drinking	0	77.8 (65)	100 (100)	100 (100)	79.6 (62)	0
Cooking	0	75.9 (63)	100 (100)	100 (100)	81.5 (64)	0
Washing	0	81.1 (75)	100 (100)	100 (100)	66.7 (57)	0

Source: Field Survey 2015

5.2 Sources of Land Possessions and Their Cultivation Status

Major source of land possession is inherited by the people both in NFK and FK in the Loralai district. People claimed that greater part of the land was cultivated before but the menace of drought led to drying of the majority of the land as they couldn't afford tubewell and its associated cost. Cultivated land on average is larger in the FK region than the NFK region.

Table 5-2: Sources of land possessions and their cultivation status

Source/Status		Functional (N = 51)		Non-functional (N = 54)	
		Within command	Outside command	Within command	Outside command
Inherited	Total	7.5 (45)	7.2 (45)	6.4 (52)	5.8 (45)
	Cultivated	4.7 (38)	5.7 (31)	4.1 (35)	5.3 (37)
	Uncultivated	6.2 (25)	6.2 (24)	5.4 (35)	3.3 (20)
Purchased	Total	2.1 (10)	3.3 (11)	1.6 (9)	2.4 (13)
	Cultivated	2.3 (8)	3.3 (11)	1.6 (9)	2.4 (13)
	Uncultivated	1.2 (2)	0.4 (1)	0	0.4(1)
On lease	Total	2.1 (6)	1.4 (2)	2.2 (2)	2.3 (4)
	Cultivated	2.1 (6)	1.4 (2)	2.2 (2)	2.3 (4)
	Uncultivated	0		0	
Total	Total	7.3 (51)	7.2 (50)	6.5 (54)	5.7 (53)
	Cultivated	4.7 (45)	5.4 (39)	4.3 (38)	4.9 (48)
	Uncultivated	6.0 (27)	5.9 (25)	5.2 (36)	3.2 (21)

Source: Field Survey 2015
Notes: Figures in table are averages and The sample Landholdings are in hectares

On average, a household obtained about 2.1 hectares of land through purchasing and leasing, within the command of FK, while 3.3 and 1.4 outside the *Karez* in KFA as shown in the table 5.2. Land possessed through leasing is all under cultivation in all regions.

The land remain unculitated due to several reasons in Loralai District, the table 5.3 represents the ranking of these reasons. Drought is the major reason for uncultivated land within the in FK region, highlighted by 70 and 60 percent of the respondents for the land within *Karez* command and land outside *Karez* command respectively. Balochistan was hit by drught in 1997. It is followed by land infertility as second major reason for uncultivated land. Lack of labor is considered as the third major reason for uncultivated land by 30 percent of the respondents.

Table 5-3: Reasons for leaving land uncultivated

Reasons	For land within *Karez* command				For land outside *Karez* command			
	1st	2nd	3rd	NA	1st	2nd	3rd	NA
Functional	(n = 27)				(n = 25)			
Lack of labor	11	19	30	41	8	12	24	56
No irrigation	0	11	15	74	0	4	12	84
Drought	70	30	0	0	60	28	0	12
Other inputs	4	11	22	63	8	12	28	52
Land infertility	15	30	22	33	12	32	20	36
Disinterest	0	0	11	89	8	8	12	72
Non Functional	(n = 36)				(n = 21)			
Lack of labor	0	11	28	61	14	10	24	52
No irrigation	3	17	25	56	14	14	29	43
Drought	42	42	6	11	29	24	5	43
Other inputs	0	14	31	56	0	14	29	57
Land infertility	58	14	8	19	43	29	10	19
Disinterest	0	0	6	94	0	10	5	86

Source: Field Survey 2015
Notes: Figures in table are percentages

In NFK region, land infertility was considered responsible for leaving lands uncultivated followed by drought as the second most important reason. Less than 5 percent respondents consider inadequacy of complete absence irrigation as a reason for leaving their lands uncultivated within the *Karez* command lands. Similarly, in lands outside the command of *Karez*, 29 percent people consider land infertility as the reason for them to leave their land

uncultivated. The overall data in table 5.3 shows that drought remain the major reason for transforming the lands as uncultivated.

5.3 Local Irrigation Trade – Market for Tubewell Irrigation

The data in the table 5.5 shows the local irrigation trade market for tube well irrigation. It is evident from the table that respondents with land holding of 26 hectares or larger did not involve in local water trade both in FK and NFK. Smaller the land holding farmers mostly prefer to buy irrigation both in the FK and NFK instead of installing their own tubewells. Majority of the selling takes place in the land holding between 11 to 20 hectares in both FK and NFK. As the land size increases, there is a decrease in selling and buying percentage in both FK and NFK.

Table 5-4: Local irrigation trade – market for tube well irrigation

Land size	Functional *Karez* (%)				Non-functional *Karez* (%)			
(ha)	N	Selling	Buying	Neither	N	Selling	Buying	Neither
1 – 5	28	12	27	68	30	12	24	57
6 – 10	11	9	26	64	13	9	9	70
11 – 15	5	60	0	40	6	17	0	83
16 – 20	2	0	0	100	3	67	0	33
21 – 25	4	50	0	50	2	50	0	50
26 & above	1	0	0	100	0	0	0	100
Total	51	18	20	65	54	17	15	61

Source: Field Survey 2015

5.4 Community Views about *Karez* Utility

The data in table 5.8 shows that 41 percent of the respondents from both FK and NFK stand with *Karez* rehabilitation as they cannot think of their better crop production with *Karez* and wants it flowing. However, 41 percent respondents from FK and 35 percent from NFK want *Karez* revival being sure that tubewell will deplete the underground aquifers in the long-run.

As reflected by the table 5.8, eight percent of the FK respondents shared that their family feels emotionally attached to the *Karez* therefore they want it flowing. As *Karez* requires laborious maintenance and there is a shortage of the skilled labors in the region. This is why 4

percent of households in FK and 11 percent of households in NFK respondents want to abandon the *Karez*.

Table 5-5: Community views about *Karez* utility

Reasons	Category of *Karez*	
	Functional	Non-functional
Reasons to keep *Karez* flowing:		
My family feels emotionally attached to the *Karez*	8	7
Cannot think of our crop production without the *Karez*	41	41
Many NGOs consider *Karez* as environment friendly	4	4
Being confident that TW will deplete aquifer	41	35
There is a group pressure to keep *Karez* flowing	2	2
Reasons to lay off *Karez*		
Karez maintenance is laborious and we lack labor	4	11
Now we have tube-wells, which are more reliable	0	0
Karez deliver very little water, we have no charm in it	0	0
Now my family does not rely primarily on agriculture	0	0
Total	100	100

5.5 Communities' Enthusiasm towards *Karez* Rehabilitation:

The importance of *Karez* as a cultural heritage has significantly increased now as compare to past. Data shows in the table 5.6 shows that in the past 13 percent while now 65 percent high importance has been given to *Karez*. The conversation with them revealed that the importance of *Karez* was realized when it's stopped functioning. *Karez* has been given a high rank now for its historic importance. 45 percent and 48 percent respondents from FK and NFK respectively claim *Karez* to be an important historic memoir now. In past *Karez* was considered highly important for the irrigation and crop production as they viewed it as the only source but with the increased installation of the TW, their views have changed. In past 75 percent respondents gives high value to the *Karez* while in present 45 percent from the FK gives highly important response for the *Karez*.

Respondents claimed that if the subsidized electricity is provided throughout the day then TW can be used as a major source of irrigation and crop production. *Karez* always played a role in bringing the community people together for its O & M purposes and this gathering helped in discussion of various village issues. This ritual was the part of the community in

past and they considered it will always continue. However, with the deterioration of *Karez*, this ritual was ignored and the gathering almost disappeared. Respondents now realize how important *Karez* was for the community therefore 56 percent from FK and 50 percent from NFK consider *Karez* important for the social cohesion.

Table 5-6: Community perception of the importance of *Karez*

Importance of *Karez* as	FK (n = 51)		Sig.	NFK (n = 54)		Sig.
	Past	Present		Past	Present	
	$\bar{x}$ (SD)	$\bar{x}$ (SD)		$\bar{x}$ (SD)	$\bar{x}$ (SD)	
Cultural heritage	3.3 (1.0)	4.6 (0.5)	.000	3.4 (1.0)	3.9 (0.9)	.001
Historic symbol	3.2 (1.0)	4.4 (0.6)	.000	3.3 (1.0)	4.2 (0.8)	.000
Source of irrigation	4.6 (0.7)	4.3 (0.7)	.027	4.7 (0.6)	4.0 (0.8)	.000
Source of domestic water	4.8 (0.7)	3.6 (0.9)	.000	4.9 (0.4)	3.2 (0.8)	.000
Place of social cohesion	3.8 (1.2)	3.9 (0.8)	.291	4.1 (1.0)	3.8 (0.8)	.043
Survival in arid environs	4.7 (0.8)	3.5 (0.9)	.000	4.8 (0.5)	3.0 (1.0)	.000

Source: Field Survey 2015

Notes: -Ranking obtained through Likert Scale was summarized through WAI method of Miah (1993)
-Statistical significance was checked through *t*-test

A sharp decline is shown in the importance of *Karez* for drinking water i.e highly important ranked by 88 percent in past and 11 percent in present. People argued that in past only *Karez* was providing the clean drinking but now TW has taken the responsibility of providing clean drinking water. TW water is preferred over *Karez* water because *Karez* water travels a long distance while the TW water is instantly available at home, easy to collect and more reliable for drinking. In the past, *Karez* was termed as an only source of survival in the arid regions. Resultantly, 86 percent from FK and 85 percent respondents form NFK ranked *Karez* as highly important source in the past, however now a sharp shift in the views is reflected as 12 percent respondents from FK and only 6 percent from NFK considering it highly important. The respondents argued that even though *Karez* is really important for majority of the reason, but it's still not the matter of life and death.

5.6 Community Conditions for Cooperation in *Karez* Rehabilitation

The majority households were strong advocates of *Karez* rehabilitation for improvement in their agricultural activates. Statistics in table 5.6 show that 23 percent respondents from the

FK agreed and 1.9 partially agreed to initiate *Karez* rehabilitation individually even if no one in the community was willing to reciprocate. Whereas rehabilitating *Karez* individually in the non-functional region, 14 percent agreed and 85 percent partially agreed. 49 percent respondents from FK and 59 percent from the NFK agreed to contribute to *Karez* revival when half (1/2) of the community is willing to reciprocate.

Among the respondents 96 percent agreed and 2 partially agreed to contribute in *Karez* rehabilitation only if entire community will reciprocate in the FK region while 100 percent of the respondents from NFK hold the same view. The table 5.6 indicates the fact that very few of the respondents were willing to initiate *Karez* rehabilitation individually despite being enthusiastic about the *Karez* revival in the region.

Table 5-7: Community conditions for cooperation in *Karez* rehabilitation

Conditions	FK [$\bar{x}$ (SE)] (N = 51)	NFK [$\bar{x}$ (SE)] (N = 54)
We wish someone else keep our *Karez* flowing	2.0 (0.0)	2.0 (0.0)
Only if all of the community will reciprocate	1.9 (0.0)	2.0 (0.0)
If 3/4 of all of the community will reciprocate	1.7 (0.1)	1.7 (0.1)
If 1/2 of all of the community will reciprocate	1.4 (0.1)	1.5 (0.1)
If 1/4 of all of the community will reciprocate	1.1 (0.1)	1.1 (0.1)
If 1/10 all of the community will reciprocate	0.8 (0.1)	0.7 (0.1)
My household will initiate even if no one comes forward	0.3 (0.1)	0.1 (0.0)

Source: Field Survey 2015
Notes: The distribution of all statement across RVKS and RDKS is same. The Independent Samples Mann-Whitney U Test suggest retaining the null hypothesis

5.7 Contribution towards Operation and Maintenance of *Karez*

With the end of the drought spell, the revival of the *Karez* started immediately by the local inhabitants in the command areas of few *Karezes* in Loralai. To keep the *Karez* functional, every stakeholder contributes into its operation and maintenance. The data in table 5.7 shows that all of the respondents from the FK claimed that their family contributes in *Karez* rehabilitation by one way or the other.

However, 7 percent from the NFK declined any help for the *Karez* rehabilitation. Family of the 33 percent respondents from revived *Karez* (i.e Zangiwal and Manzaki *Karez*) make

financial contribution to *Karez* O&M while 16 percent contributes in form of sharing labor. In NFK region, 30 percent respondents claimed their help in O&M activities of the *Karez*, whereas family of 22 percent respondents provides technical help required for the *Karez*.

The technical skills required for *Karez* construction and its maintenance are diminishing with the passage of time and very few people in the region are appropriately skilled. Therefore only 10 percent of the families from functional and 22 percent families from the NFK contribute to *Karez* revival in the form of technical assistance, which mostly comprises of elderly cohort of the respondents.

The table 5.7 also shows that the resources required during the initiation of dried/collapsed *Karez* like finance and the families of respondents provide the overall support from the FK that led to the rehabilitation of the *Karez* in the region. Whereas in the NFK region, only 17 percent of the respondents family are willing to extend help financially and are more inclined towards contributing in managing O & M of the *Karez*, which is a source required after the *Karez* rehabilitation. NFK are those systems, which deteriorated and collapsed more severely as compared to FK, implying that these require more finance and technical skills. Lack of these resources is one major reason of NFK still not rehabilitated by the community.

The people from FK region are more educated as shown the table 5.1, they timely realized the cons associated with the tubewell irrigation, with thorough knowledge of how tubewell has deteriorated the water table; therefore they are steadfast in rehabilitating the *Karez* with a strong leadership in the region. However, the scenario in NFK is entirely different, as they lack strong leadership.

Table 5-8: Contribution towards operation and maintenance of *Karez*

My family will contribute	Functional	Non-functional
No contribution	0	7
Only financial	33	17
Only in form of sharing labor	16	19
Only in form of managing O& M activities	17	30
Only in form of technical assistance.	10	22
All in terms of finance, labor, managerial & technical support	24	5
Other contribution	0	0

Source: Field Survey 2015
Notes: All figures are in percentage

Chapter 6. SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Discussions

This study aimed to investigate the importance of the *Karez* and enthusiasm toward its revival among the respondents of Loralai district. To achieve the objective of the study, four *Karez* were selected, two of which are revived by the community after the drought spell has ended and are functional now. Whereas two *Karezes* selected are still non functional. The randomly selected sample comprised of 105 household and nine in-depth interviews were conducted from users of the targeted *Karez*.

The drought period which started in the year of 1997 in the Loralai district that lasted for more than six years, deteriorated many *Karezes* and people were forced to choose the alternative water source like tubewell. People who relied on *Karez* water for their domestic purposes over the years, shifted towards tubewell water. The results of the study shows that majority of the households from the FK region has started using *Karez* water again for different household chores. The respondents claimed that it's a source of pride to switch back to traditional technique of water source which is sustainable if properly maintained. The NFK households are still using the tubewell water, which is getting more troublesome due to electricity shortage in the region and high maintenance cost. As the literature pointed, the poor farmers cannot bear the high electricity charges for tubewell and are looking for the ways the ways to revive *Karez* to meet their domestic as well as irrigation needs

The literature shows strong importance towards expansion of irrigation land by the tubewell but the scenario in Loralai district appeared different. The result reflects that household from the FK region acquires larger portion of land which is cultivated as well as uncultivated. Larger portion of land in FK *Karez* remains uncultivated primarily due to drought spell in the area and non affordability of high cost of tubewell, as claimed by many respondents.

Therefore they strived hard for the revival of their *Karez* and now they are gradually expanding their cultivated lands. NFK has less cultivated land and uncultivated land in possession in the command area of the *Karez* as compared to FK. The land remains uncultivated in the NFK region majorly because of the infertile land and the drought period added more to its infertility. It is also evident from the results that both FK and NFK *Karez* possess land which is inherited by them.

The respondents viewed *Karez* as an important source of irrigation and were strong advocate of its revival in the region where it's still not functional. However, despite their enthusiasm, very few of them were willing to initiate *Karez* rehabilitation individually. They stressed on the point that half of the community should take part in *Karez* rehabilitation as it's requires mutual cooperation for maintenance and sustainability, whereas one person cannot look after it. The respondents from FK claimed their role in the *Karez* rehabilitation and its maintenance in many aspects, financial contribution holds the major part.

On the other hand, few of the respondents from NFK declined any help towards *Karez* rehabilitation whereas majority claimed to provide help in O & M and technical assistance. These can be attributed as major reasons that the respondents from FK could revive their *Karez* much before than the respondents from NFK who are still trying to rehabilitate it. The availability of skilled labor in both regions, however, remains less which is one the main reason in hindrance of *Karez* revival. There is also a marked difference between the leadership existence in both the regions. People from the FK had more profound knowledge about the importance of the *Karez* and they had better leadership. Whereas, people from NFK lacks the influential people in the region and having very little insight about *Karez* rehabilitation.

Karez rehabilitation is very essential to protect the agriculture activities from being deteriorated in the Loralai district. Respondents from both the region i.e FK and NFK, stressed on the fact that revival and sustainability of *Karez* is very important for their crop production. They were also aware of the fact that the excessive use of the tubewell, which is the only source of the water in many parts of the region, will deplete the water table in the region, which is already on verge of drying.

Karez now holds strong historical importance in the region and is more valued as compared to the days it was completely functional. Many respondents agreed that they took *Karez* for granted and agreed that they could have *Karez* structure maintained during the drought spell. But since tubewell caught the attention of the time, they completely abandoned the *Karez*. Respondents now also realize that *Karez* played a major role in bringing community together in the past, where different issues of the society were discussed and solved. This ritual is vanished with the *Karez* and now the community wants to revive the *Karez* to revive the lost ritual.

6.2 Conclusions

When a region is struck by any calamity or a disaster, a new technology is introduced to tackle with the situation. In such scenarios, people do not look into long term pros and cons of the new technology and adopt it to meet the need of the time. The locals of Loralai district adopted the tube well technology when the area was facing the deadly drought, without realizing its long term effects on the aquifers and water table. No doubt it was the need of the time to safe their crop production, but the *Karez* should not have been abandoned completely and single tubewell installation should have been adopted in a particular land. Now that people have realized the importance of *Karez,* they are striving to rehabilitate it.

Tubewell usage is very costly for the local due to its high maintenance cost and high electricity charges, therefore, it didn't not help in the expansion of agricultural land as was perceived initially. On the other hand, *Karez* once revived, needs very small maintenance cost, which is divided by many share holders. People from the Zangiwal and Manzaki *Karez* region realized the importance of *Karez* and strived to rehabilitate it by mutual cooperation of the all shareholders which was led by a strong leadership.

They showed strong enthusiasm and contributed in every aspect of *Karez* rehabilitation and its sustainability, especially in the form of financial contribution which helped in the initiation of making *Karez* functional. Both the *Karezes* were not very deteriorated and needed comparatively less cost to rehabilitate as compared to Murtat and Dargai *Karez*, which still needs to be rehabilitated. NFK lacks financial assistant, strong leadership and commitment towards *Karez* rehabilitation, as few share holders refuse to participate and majority wants to initiate the process of rehabilitation when all the share holders extent their help.

Karez has not only gained its long lost importance for crop production but also stands as an important historical and cultural symbol. Locals have realized the dire need of reviving *Karez* to protect the agricultural land from turning barren and then keep it sustainable by proper operation & maintenance.

6.3 Recommendation

Calamities like drought or flood as occurred in the recent past can occur in the future as well. The key to survival is to adopt appropriate policy measures before hand to cope up with the situation. Based on the finding of the study, following are few recommendation to deal with the situation of such bewilderedness and not starting from the scratch again.

- As agriculture is the major source of the people of the Loralai district, the rehabilitation of the *Karez* is of major concern. There is a need of Government intervention in the rehabilitation of the *Karez* in drought hit regions where people are unable to initiate it due to financial constraints, lack of skilled labor or non availability of modern machinery.

- The rehabilitation of the *Karez* technology should be based on modern irrigation methods so as to make it energy and cost efficient. Efforts have to be put to adopt modern techniques to increase the crop production and expand the agriculture land by using *Karez* water efficiently.

- The technical skills about *Karez* maintenance has diminished to large extend as many skilled people have migrated to other areas and the new generation has no knowledge. Training the locals about the proper usage of *Karez* water along with application of modern technology should be provided by the Government or functional NGOs in the region.

- *Karez* rehabilitation has to be in line with the conservation of the water by adaptation of water saving technology.

6.4 Suggestions for Future Research:

This research considered only functional and non-functional *Karezes*, whereas there are couple of *Karezes* which maintained its flow even during the drought and didn't get dry. Commitment and enthusiasm level of the shareholder of such *Karez* can be assessed and results obtained can be implemented in the areas where *Karez* is rehabilitating, to keep them flowing even in any calamity.

The shareholders of the targeted *Karezes* are comparatively financially well off therefore no noteworthy difference in the responses could be determined. There are *Karezes* to be rehabilitated that satisfy the needs of small farmer, such community can be explored to identify the major lapse in *Karez* non-revival.

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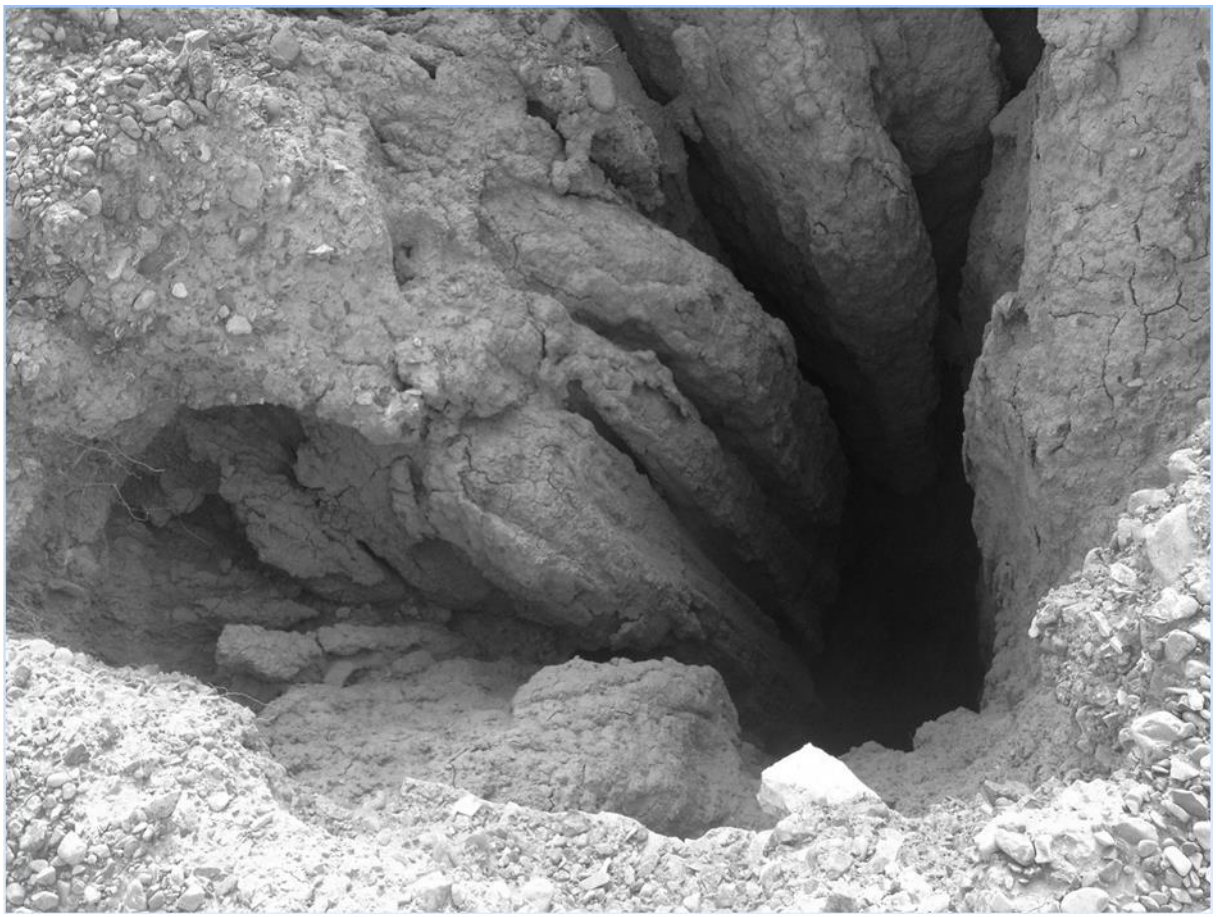
APPENDIX:



Source: Arthor

Picture 1: Destroyed vertical well of Murtat Karez

Source: Arthor

Picture 2: Murtat Karez

Source: Arthor

Picture 3: Destroyed small reservoir of Dargai Karez

Source: Arthor

Picture 4: Zangiwal Karez

QUESTIONNAIRE:

I. Coversheet Information:

Questionnaire code _____ Date of Interview _____

Name of *Karez* _____

Status of *Karez* 1= operational
2= non-operational

Name of interviewer _____

II. Profile of the respondent and his family

Q1. What is your name and contact No? _____

Q2. Your age? _____ (Years)

Q3. Your marital status? _____
1 married
2 = single
3 = Other

Q4. What highest educational degree/certificate/level have you obtained? (1:uneducated. 2:Primary, 3:secondary, 4:matriculate, 5:Tiertiary) _____

Q5. How would you describe yourself in family? _____
1 = as household head
2 = as a member

Q6. What is your family's average monthly income? _____ (in PKR)

Q7. What are the major sources of your household income? (Composition of income from different sources)

Crop production	_____	%
Rent of plots of lands	_____	%
Job or business other than agriculture	_____	%
Remittances	_____	%
Other sources (specify) _____	_____	%

Total of all income sources should make 100 %

Q8. What is the size of your family? _____ No of Persons

Q9. Kindly provide **following** details about the composition of your family:

Note: reconcile the totals of all below given responses with the figure provided in response to Q8

1. What is the dependency ratio in the family? (No of persons):

Earner(s)	Dependent (Adults)	Dependent (children)	Dependent (old age)
_____	_____	_____	_____

2. What is the gender composition of your family? (No of persons):

Male (14 yr. & above)	Male (below 14 yrs.)	Female (14 yr. & above)	Female (below 14 yrs.)
_____	_____	_____	_____

3. What is the educational composition of your family? (No of persons):

Illiterate	Just literate	Primary	Secondary
_____	_____	_____	_____
Matriculate	Intermediate	Bachelor	Master & above
_____	_____	_____	_____

Q10. Where from your family fulfils its domestic water needs? Kindly provide the breakup of its reliance on different sources of drinking water in percentage of total water consumption.

Water for Drinking

Period	*Karez*	Tube-well	water supply	Other (specify)___
At the present	_____	_____	_____	_____
10-15 years ago	_____	_____	_____	_____
15-30 years ago	_____	_____	_____	_____

Regardless of the application of a cell, total of each t should make 100 %

Water for Cooking

Period	*Karez*	Tube-well	water supply	Other (specify)___
At the present	_____	_____	_____	_____
10-15 years ago	_____	_____	_____	_____
15-30 years ago	_____	_____	_____	_____

Regardless of the application of a cell, total of each t should make 100 %

Water for Washing

Period	*Karez*	Tube-well	water supply	Other (specify)___
At the present				
10-15 years ago				
15-30 years ago				

Regardless of the application of a cell, total of each t should make 100 %

III. Land and Water

Q11. Please provide details of your family's agricultural land in the **command** area of _____*Karez*:

	Land area	Cultivated	Uncultivated	Irrigation source of cultivated land		
	(in acres)	(in acres)		at the present	10-15 years ago	15-30 years ago
Inherited						
Leased						
Purchased						
Other____						
Total						

Q12. What has been the key reason for leaving some of the land uncultivated as reported in response to Q11?

Reasons	Ranking
Lack of labor	
Scarcity of irrigation due to drought	
Lack of inputs other than labor and irrigation	
Infertility of land	
Lack of interest in agriculture	
Other reasons (specify) _____	

You can choose only three reasons. The reasons should be ranked as under:

1 = Most important reason

2 = 2nd most important reason

3 = 3rd most important reasons

If the respondent has not reported any uncultivated land, please skip this question and move to next

Q13. Please provide details of your family's agricultural land in the command area of elsewhere (exclude the area reported in response to Q11):

	Land area	Cultivated	Uncultivated	Irrigation source of cultivated land		
	(in acres)	(in acres)		at the present	10-15 years ago	15-30 years ago
Inherited						

Leased						
Purchased						
Other____						
Total						

respondent must report land in at least one of the above cells.

If respondent has reported some uncultivated land, kindly ask Q14, otherwise skip it.

1 = *Karez*
2 = Tube-well
3 = *Karez*+ TW
4= rain-fed
5 = Other (specify)

_____

Q14. What among following reasons best justifies your decision to leave some of the land uncultivated as you reported in Q13?

Reasons	Ranking
Lack of labor	
Scarcity of irrigation due to drought	
Scarcity of irrigation due to other reasons_____	
Lack of inputs other than labor and irrigation	
Infertility of land	
Lack of interest in agriculture	
Other reasons (specify) _____	

You can choose only three reasons. The reasons should be ranked as under:

1 = Most important reason
2 = 2nd most important reason
3 = 3rd most important reasons

If the respondent has not reported any uncultivated land, please skip this question and move to next

Q15. Do you possess any tube-well in the command area of this *Karez*?

_____

1 = Yes (continue sequence)

2 = No (skip Q16 to Q21)

Q16. How many tube-wells do you own in the command of this *Karez*? (No.) _____

Q17. Please provide installation and deepening history (timeline) of all your tube-wells:

Tube well 1

Year[1]	Depth[2] (in meters)	Cost (In PKR)
____installed		

Tube Well 2

Year[1]	Depth[2] (in meters)	Cost (In PKR)
____installed		

Notes for Q17:
1. Year is the year of installation or deepening
2. Depth in the first row is the initial depth at the time of tube-well installation. For the subsequent years, the depth is the new depth after deepening
3. Use additional sheet if number of tube wells exceeds two

Q18. Generally, how often your tube-well pumps require repair? _____

Q19. Generally, how often tube-well electric motors require repair? _____

Q20. Generally, how often tube-well diesel engines require repair? _____

These codes applies to Q18, Q19 and Q20 ➔

1 = Monthly
2 = Quarterly
3 = Semi-annually
4 = annually
5 = bi-annually
6 = larger than all above

Q21. Do you sell tube-well irrigation to other farmers? _____ (1= Yes, 2= No)

Q22. Do you buy irrigation from other tube well owners? _____ (1= Yes, 2= No)

IV. Enthusiasm towards *Karez*

Q23. Keeping in view your household's views about *Karez*, rate following statement based on following given importance scale:

Not at all important — Moderately important — Highly important

1 | 2 | 3 | 4 | 5

	In the past (about 15-20 years ago)	At the present
Cultural heritage (physical symbol of intergenerational prestige)		
Historical symbol (a memoir of past events important for us)		
A source of irrigation and crop cultivation and livelihood		
A source of healthy and clean drinking water and domestic use		
A place of social cohesion (point of community cooperation)		
A source of survival in arid environment (matter of life and death)		

Q24. Select *just* one of the following statements that *best* describes your family's views about *Karez*: (tick mark (✓) only one of the following statements.)

a) My family feels emotionally attached to the *Karez*, that's why we want it flowing. ____

b) Since now we have tube-wells, which are more reliable, its fine to abandon the *Karez*. ____

c) Cannot think of our crop production without the *Karez*, so want to see it flowing. ____

d) *Karez* require laborious maintenance, since we do not have labor so it's fine to abandon it. ____

e) Many NGOs consider *Karez* as environment-friendly, so it must be good to keep it flowing. ____

f) *Karez* deliver very little water, we have no charm in investing in *Karez* maintenance. ____

g) Now my family does not rely primarily on agriculture, so we are no more interested in *Karez*. ____

h) Being confident that tube wells will deplete aquifer, we want to keep *Karez* functional. ____

i) There is group pressure to keep *Karez* flowing, therefore its fine to keep it functional ____

j) Any other statement_____ ____

Q25. Use scale at right to rate all of the following statements:

	Disagree	Partially agree	Agree
Scale ➔	1	2	3

I wish someone make it sure that *Karez* keeps flowing _____

I will contribute in *Karez* rehabilitation only if all of the community will reciprocate _____

I will contribute in *Karez* rehabilitation even if ¾ of the community will reciprocate _____

I will contribute in *Karez* rehabilitation even if ½ of the community will reciprocate _____

I will contribute in *Karez* rehabilitation even if ¼ of the community will reciprocate _____

I will contribute in *Karez* rehabilitation even if $^{1}/_{10}$ of the community will reciprocate _____

I will initiate *Karez* rehabilitation myself even if none of the community is willing to reciprocate _____

General notes for the subsequent questions:

- If the respondent belongs to a rehabilitated/functional *Karez*, ask **Error! Reference source not found.** to Q30 by following specific instructions given besides each of this question. In this case, skip Q31 to Q34.
- If the respondent belongs to an abandoned/non-functional *Karez*, skip **Error! Reference source not found.** to Q30 & ask Q31 to Q34.

Q26. Do you claim *Karez* share for irrigation purposes? _____

1= Yes (skip **Error! Reference source not found.**)

2= No (ask **Error! Reference source not found.**)

Q27. Have you withdrawn claim from *Karez* water? _____

1 = Just temporarily

2 = Permanently

Q28. Do you participate in the *Karez*'s O&M activities? _____

1= Yes (ask **Error! Reference source not found.**)

2= No (skip **Error! Reference source not found.**,)

Q29. What contribution you have been making for the O&M of *Karez*?

tick mark (✓) the most appropriate statement

_____ My family makes financial contribution only

_____ My family contributes only in form of sharing labor

_____ My family contributes only in form of managing O& M activities

_____ My family contributes only in form of technical assistance.

_____ My family contributes all in terms of finance, labor, managerial and technical support

_____ My family makes other contribution (specify)_____ _____

Notes for Q30: If respondent has said “No” in response to **Error! Reference source not found.** and “Yes” to **Error! Reference source not found.**, then ask Q30

Q30. Despite not claiming irrigation from *Karez*, why you still contribute in the O&M of *Karez*? tick mark (✓) the most appropriate statement

_____ It’s a community compulsion to retain my share on *Karez* irrigation

_____ I consider it as a contribution for common good

_____ Other reasons (specify)_____

Q31. In case if *Karez* is rehabilitated, will you claim your irrigation share? _____

Q32. Have you withdrawn claim from *Karez* water? _____

Q33. Will you participate in the *Karez*’s O&M/rehabilitation activities? _____

Q34. What contribution you are willing to do for the rehabilitation and routine O&M of your *Karez*?

tick mark (✓) the most appropriate statement

_____ My family will contribute only financially

_____ My family will contribute only in form of sharing labor

_____ My family will contribute only in form of managing O& M activities

_____ My family will contribute only in form of technical assistance.

_____ My family will contribute all in terms of finance, labor, managerial & technical support

_____ My family will make other contribution (specify)_____

Q35. Any other comment regarding issues inquired through this questionnaire. Any special point which you think might be relevant to this study?

Thank you for your cooperation