

Futuristic outlook on traditional *karez* systems for sustainable irrigated agriculture in arid Balochistan

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Key Message: This study of four *karez*es in Loralai district of Balochistan suggests that the renewed interest in *karez* for sustainable irrigated agriculture in arid regions has some merits and farmers may participate in such efforts if adequate institutional support is extended.

Abstract: Decay of traditional *karez* systems in favour of tube wells have raised questions about the sustainability of irrigated agriculture and dependent livelihoods in arid regions like Balochistan. As a result, many researchers and policymakers are extending proposals for revival of *karez* system. However, one wonders what farmers think about these proposals. To bring such understanding, we investigated the farmers' reactions by exposing them to such policy proposals. Four *karez*es were purposively selected from district Loralai. The required information was obtained through structured questionnaire from 105 randomly selected farming families. Furthermore, eight

key informant interviews were also conducted for the contextual understanding of the issue. Results reveal that farmers still attach a variety of values to their *karez*es but put economic rationalities at forefront while responding to the idea of bringing back the functionality of their *karez* system. High motivation was observed among farmers earning 50% of their incomes from agriculture, possessing land in *karez* command area and without any alternative source of irrigation i.e. a tube well. Those inspired by robustness of *karez* technology may have to focus on such households to muster meaningful community participation for *karez* rehabilitation. © 2020 Department of Agricultural Sciences, AIU

Keywords: Balochistan, Community participation, Falaj, Qanat, Traditional irrigation systems, Tube well

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Introduction

Groundwater, being a non-excludable and subtractable common pool resource (CPR), is always prone to overexploitation and depletion (Castilla-Rho et al., 2020) especially in low rainfall regions. The reliance on groundwater for irrigated agriculture becomes inevitable in the arid regions in South and Central Asia, such as Balochistan province of Pakistan and adjoining areas of Iran and Afghanistan where rainfall is highly scant and surface water is almost absent (Memon et al., 2019). Constrained with the ecological realities, human civilization in this part of the earth had been quite innovative in the abstraction and management of groundwater resources for practicing irrigated agriculture. One of such artefacts is *karez* system, which may have originated from this region (Goblot, 1979; Beaumont & Bonine, 1989; English, 1998). *Karez* is a centuries-old irrigation system which connects several wells together and uses gravity to bring groundwater over surface and delivered to fulfil the domestic and farm needs.

More importantly, *karez* can be termed as a truly robust and sustainable technology due to its close conformity with environmental, social, and economic dimensions of agricultural development as well as the demonstrated intergenerational transferability. Reportedly, some of the *karez* irrigation systems in Balochistan (English, 1998),

China (Abudu et al., 2011; Abudu et al., 2019; Chunliang et al., 2020) and other regions (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 anthropogenic overexploitation. Social sustainability is associated with its technological character that requires collective action from its construction to maintenance, thus, making it an egalitarian technology. Last but not the least; its economic sustainability is associated with its technological character that does not require any mechanical effort or energy except for annual or bi-annual maintenance (Mustafa & Qazi, 2007; Memon et al., 2017).

Over the last few decades, different regions of the world have experienced death of *karez*es that closely correlates with the ascendancy of pumping technology (van Steenberg, 1995; Ahmed, 2005). The growth of tube wells and the decay of *karez* are not accidental but an outcome of policies triggering 'modernization of agriculture' through massive subsidies (Johnson, 1989; van Steenberg, 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. This is reinforced by the fact that governments in developing

countries are facing difficulties in continuing their support to groundwater extraction through massive subsidies.

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 favour rich farmers who could install tube wells but not to those who still rely on dying *karez* system of irrigation. Tube well connections account for just four percent of the electric connections but consume 80 percent of the electricity available to province (Qureshi et al., 2003). Similar situation has resulted in worldwide interest in revival of *karez* (Appell et al., 2003; Hussain et al., 2008; Khair et al., 2012). Various governments (Lightfoot, 1996), communities (Sun et al., 2009), NGOs (Oshima, 2008) and international agencies (Ashraf & Hasan, 2020) are attracted towards restoring *karez* and discourage the growth of tube well. However, 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), laser-levelling, moisture management etc. Second, one of the important but mostly unrecognized issues in the decay of *karez* is the skill and labour shortage for their maintenance in Balochistan (Khan, 2008). Wessels and Hoogeveen (2003) support this view as they also observed that in the case of Syria where 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 Balochistan's labour toward gulf countries (Appell et al., 2003) for employment as the major factor for decay of the local *karez*s. Increased income generation in the off farm encourages rural migration and abandonment of *karez* (Lightfoot, 1996) and the 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 skilful Afghanis. This situation has resulted operation and maintenance difficulties that contributing the death of these erstwhile robust irrigation systems (Wessels, 2005). In the 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 due to lack of systematic understanding of the farmers attitude toward these traditional systems. Though there are a few studies offering important insights in this domain (Memon et al., 2017, 2019; Qasim et al., 2020) for discrete locations in Pakistan, better site-specific empirical investigations are still required. Thus, the general objective of the study is to explore the potential for the rehabilitation of *karez* systems in Balochistan. The study also aims to assess community's enthusiasm towards the revival, operation and maintenance of *karez*.

Methodology

Study area

Loralai district is inhabited by about 0.4 million people (Pakistan Bureau of Statistics [PBS], 1998), is in the northeast of the Balochistan province (Fig. 1). The mountainous topography comprises of valleys and peaks of different ranges. The various hill ranges consist of formation of earth, limestone, sand, and rock. 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 (Government of Balochistan [GOB], 2011). Agriculture is economic mainstay in the region where it has two cropping seasons of *Rabi* and *Kharif* crops. According to Balochistan Agricultural Statistics of 2008-09, 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 cultivable in given water resources and prevailing irrigation practices. However, if the existing water resources are renovated, the cultivation area can be increased tremendously. There are 1000 *karez*s documented in Balochistan out of which some 50 are in Loralai (International Union for Conservation of Nature [IUCN], 2013).

Data sources

We relied on household questionnaire survey and key informants to assemble the required data. A sample of 105 households was selected at ± 5 percent margin of error and 95 percent confidence level from the population of four *karez*s in the Loralai district. The sample has been distributed among the targeted four *karez*s through proportional allocation approach. Therefore, 27 respondents were selected from the functional *karez* (FK) Zangiwal and 24 from functional *karez* Manzaki. Whereas, 26 and 28 respondents were selected from non-functional *karez* (NFK) i.e. Murdat and Dargai *karez*, respectively as shown in Table 1.

Table 1 Distribution of the sample

Name of <i>karez</i>	Status	Household population	Sample size		
			Size (No.)	% Share in population	% share in total sample
Manzaki <i>karez</i>	Functional	33	24	72.7	22.9
Zangiwal <i>karez</i>	Functional	37	27	73.0	25.7
Dargai <i>karez</i>	Non-functional	39	28	71.8	26.7
Murtat <i>karez</i>	Non-functional	36	26	72.2	24.8
Total		145	105	72.5	100

Sample calculated based on population statistics obtained from union council; Confidence level = 95%; Margin of error = ± 5%

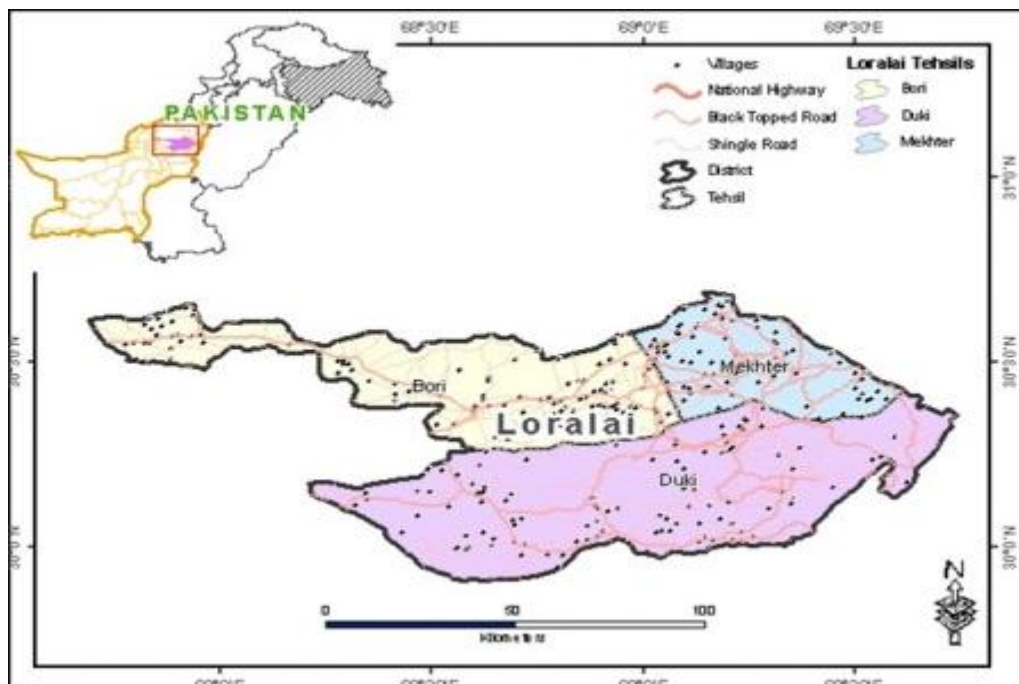


Fig. 1 Map of the study area; Source: (GOB, 2011)

Data collection and analysis

The household perspective and enthusiasm about *karez* usage and revival was investigated through close-ended questionnaire. It comprised of profile information of the respondents and their family along with information on the key parameters such as acquisition of land cultivated or non-cultivated and source of water usage for irrigation. For various parameters where perceptions were investigated, we drafted the perceptive questions such that these compared the respondents’ current perceptions with those the time when *karez* was the only source of irrigation. Since the study was primarily quantitative, descriptive and inferential statistics analysis techniques such as percentages, frequencies and cross-tabulation and linear regression were used.

Results

The first part of the section describes community perceptions on varieties of issues related to *karez* rehabilitation while the analytical part presents the results of regression.

Community views about *karez* utility

The data in Table 2 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 without *karez* and want to keep 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 eventually. Table 2 also reflects that 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 labour in the region. Therefore, four percent of households in FK and 11 percent of households in NFK respondents want to abandon the *karez*. It is very evident that the modernity rhetoric in favour of tube wells has failed to undermine the importance of old age *karez* due to a variety of tangible and non-tangible utilities of *karez* that residents acknowledge.

Communities’ enthusiasm towards *Karez* rehabilitation

Well is there any evidence that local communities are enthusiastic towards rehabilitation of *karez* and if so, what

are the exact bases for their take on this? The results suggest that the importance of *Karez* as a cultural heritage has significantly increased now as compared to the past. Data in Table 3 shows that instead of 13 percent in past, 65 percent gave higher importance to *karez*. The conversation with them revealed that the importance of *karez* was realized since it stopped functioning. *Karez* has been given a high rank now for its historic importance as well. Some 45 percent and 48 percent respondents from FK and NFK, respectively claimed *karez* to be an important historic memoir now. In past, *karez* was considered incredibly important for the irrigation and crop production as they viewed it as the only source but with the increased installation of tube wells, their views have changed. In past 75 percent respondents gave high value to the *karez*, while in present times only 45 percent from the FK gave highly important response for the *karez*.

Respondents claimed that if the subsidized electricity is provided throughout the day then tube well 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 operation and maintenance (O&M) purposes and provided a platform to discuss other issues of common interest. This ritual was the part of the community in past and they considered that it will always be continued. 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. 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 water but now tube well has taken the responsibility of providing clean drinking water. Tube well water is preferred over *karez* water because *karez* water travels a long distance, while the tube well 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 from NFK ranked *karez* as a 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 were considering it highly important. The respondents argued that even though *karez* is important for majority of the reasons, but it is still not the matter of life and death anymore.

Community conditions for cooperation in *karez* rehabilitation

So, is the individual household's commitment to *karez* rehabilitation unconditional? The majority households were strong advocates of *karez* rehabilitation for improving their agricultural activities. Statistics in Table 4 shows that those from the FK were relatively more enthused to initiate *karez* rehabilitation individually even if no one in the community was willing to reciprocate. Whereas the average willingness for rehabilitating *karez* individually in the NFK region was much lower. It was clear that community can participate in *karez* revival

efforts only when at least half (1/2) of the community members are willing to reciprocate. In both *Karez* systems, as the number of willing community members will increase so will be the motivation for those who initially unwilling to reciprocate. This one tends to accept the "tragedy of the commons" hypothesis, that common pool resources may degraded as result of the rise of free ridership and vice versa in its absence.

Contribution towards operation and maintenance of *karez*

What kind of resources people are willing to extend for *karez* rehabilitation? Results suggest that all the respondents from the FK claimed that their family contributes in *karez* rehabilitation by one way or the other (Table 5). However, 7 percent from the NFK declined any help for the *karez* rehabilitation. Family of the 33 percent respondents from revived *karez* (Zangiwal and Manzaki *karez*) make financial contribution to *karez* O&M, while 16 percent contributes in form of sharing labour. In NFK region, 30 percent respondents claimed their help in O&M activities of the *karez*, whereas family of 22 percent respondents showing willingness to extend technical help required for the *karez* rehabilitation. 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. Table 5 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 respondent's 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 of the major reasons of NFK still not rehabilitated by the community.

Regression analysis

While most of the previous analysis helped describing community views, one wonders what explains farmers' high degree of motivation for *karez* rehabilitation. Bringing such understanding, the forefronts may help to initiate rehabilitation interventions in various other areas as well. Regression results presented in Table 6 shed light on five important variables that may explain farmers' motivation for *karez* rehabilitation. The model explains about one third of the variation in farmers' motivation as witnessed from R² value 0.305. Overall the model is a good fit as evident from high F Statistics (8.251) and higher statistical significance (.000) (See ANOVA in Table 6).

Table 2 Community views about *karez* utility (%)

Reasons	Category of <i>karez</i> (%)	
	Functional (FK)	Non-functional (NFK)
Reasons to keep <i>karez</i> flowing		
My family feels emotionally attached to the <i>karez</i>	8	7
Cannot think of our crop production without the <i>karez</i>	41	41
Many NGOs consider <i>karez</i> as environment friendly	4	4
Being confident that TW will deplete aquifer	41	35
There is a group pressure to keep <i>karez</i> flowing	2	2
Reasons to lay off <i>karez</i>		
<i>Karez</i> maintenance is laborious and we lack labor	4	11
Now we have tube-wells, which are more reliable	0	0
<i>Karez</i> 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

The results reveal that farmers who have cultivated land elsewhere or those who own a tube well in the command area of a *karez* whose rehabilitation is being considered will not be much interested in the rehabilitation idea. Thus, a household having cultivated land outside the command area of *karez* in question will be 1.5 units less motivated about the idea of *karez* rehabilitation compared to a household having entire of its land located within the command area of the *karez* in question. Ownership of tube well also exhibits the similar tendency but less severe as those having access to alternate irrigation sources would

show one unit less motivation that those who lack alternates. On the contrary, households having more diversified occupations but earning more than 50 percent of their household incomes from crop farming would be highly motivated for *karez* rehabilitation. Besides, those who consider *karez* as critical to their agricultural engagement will also be willing in *karez* rehabilitation. These results collectively reinforce the fact that economic rationale is the crucial driver for community participation in these landmark irrigation systems even though communities attach a variety of other values to them.

Table 3 Community perception of the importance of *karez*

Importance of <i>Karez</i> as	FK (n = 51)			NFK (n = 54)		
	Past	Present	Sig.	Past	Present	Sig.
	\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; Ranking obtained through Likert scale was summarized through WAI method of Miah (1993); Statistical significance was checked through *t*-test

Table 4 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 <i>Karez</i> 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; The distribution of all statement across FK and NFK is same. The Independent Samples Mann-Whitney U Test suggest retaining the null hypothesis

Table 5 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; All figures are in percentage

Table 6 Determinants of farmers' motivation for *karez* rehabilitation

Modelled Variables	Un st. Coeff		St. Co-effi B	T	Sig.
	B	SE			
(Constant)	7.817	1.053		7.426	.000
Cultivated land elsewhere	-1.570	.507	-.282	-3.096	.003
Tube well in karez command	-.999	.474	-.191	-2.106	.038
Occupational diversity	.976	.323	.274	3.023	.003
Crop farming makes >50% of HH income	1.329	.377	.312	3.527	.001
HHs view karez as critical to crop cultivation	1.263	.387	.296	3.268	.002
Summary	R .552a	R ² .305	Adjusted R ² .268	SE of the Estimate 1.79839	
ANOVA ¹					
	Sum of squares	DF	Mean of Squares	F Statistics	Sig.
Regression	133.423;	5	26.685	8.251	.000 ^b
Residuals	304.017;	94	3.234		
Totals	437.440	99			

a. Dependent variable; Summative index of farmers motivation for karez rehabilitation

Discussion

This study investigated the importance of the *karez* and enthusiasm toward its revival among the respondents of Loralai district. To achieve the objective of the study, four *karezes* 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 eight in-depth interviews were conducted from users of the targeted *karez* systems.

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 tube well. People who relied on *karez* water for their domestic purposes over the years, shifted towards tube well water (Khair et al., 2012). The results of this study show that majority of the households from the FK region has started using *karez* water again for different household chores. The respondents claimed that it is a source of pride to switch back to traditional technique of water source, which is sustainable if properly maintained, which is similar to the findings of a previous research study (Qasim et al., 2020). The NFK households are still using the tube well water, which is getting more troublesome due to electricity shortage in the region and high maintenance cost. As the literature pointed (Memon et al., 2019), the poor farmers cannot bear the high electricity charges for tube well and are looking for the ways to revive *karez* to meet their domestic as well as irrigation needs.

The literature shows a general tendency towards expansion of irrigation through tube well but the scenario in Loralai district is not fully compliant with this rule (Khair et al., 2012; Memon et al., 2019). The results reflect that households from the FK region acquire larger parcels of land but can cultivate them only partially. Larger portion of land in FK *karez* remains uncultivated primarily due to drought spell in the area and non-affordability of excessive cost of tube well 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 in both FK and NFK *karez* possess farmers normally inherit lands and the instances of land purchasing are rare.

The respondents viewed *karez* as an important source of irrigation and were strong advocate of its revival in the region where it is 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 requires 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. These findings has general implications which go behind immediate national boundaries and may applicable to adjoining areas of Afghanistan and Iran where such efforts of *karez*-based agricultural expansion are also underway (Groninger & Pense, 2013; Abudu et al., 2019; Al-manmi et al., 2019; Ashraf & Hasan, 2020).

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 labour in both regions, however, remains less which is one the main reason in hindrance of *karez* revival – an aspect of rehabilitation also highlighted by other researchers (Mustafa & Qazi, 2007). There is also a marked difference between the leadership existences 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 lack the influential people in the region and having little insight about *karez* rehabilitation. Thus, as Memon et al. (2017) observed,

communities may have been experiencing different constraints from each other which must be considered while formulating policies and programmes for revival of *karez*.

Karez rehabilitation is very essential to protect the agriculture activities from being deteriorated in the Loralai district and area sharing similar biophysical constraints. 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 tube well, 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 the 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 tube well caught the attention of the time, they completely abandoned the *karez*. Respondents now also realize that *karez* played a key 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. Considering that such realization of *karez* importance is not unique to the study area (Groninger & Pense, 2013; Abudu et al., 2019; Al-manmi et al., 2019), these findings may have larger policy implications.

Conclusion

When a region comes across any calamity or a disaster, a latest technology is introduced to tackle with the situation. In such scenarios, people do not investigate long term pros and cons of the latest 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 save their crop production, but the *karez* should not have been abandoned completely. Now that people have realized the importance of *karez*, they are striving to rehabilitate it. Tube well usage is very costly for the local due to its high maintenance cost and high electricity charges, therefore, it did not help in the expansion of agricultural land as was perceived initially. On the other hand, *karez* once revived, needs small maintenance cost, which is divided by many shareholders. People from the Zangiwal and Manzaki *karez* region realized the importance of *karez* and strived to rehabilitate it by 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 shareholders refuse to participate, and majority

wants to initiate the process of rehabilitation when all the shareholders extend their help. *Karez* has not only regained 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 O&M.

Recommendations

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 beforehand to cope up with the situation. Based on the finding of the study, following are few recommendations to deal with the situation of such bewilderedness and not starting from the scratch. As agriculture is the major source of the people of the Loralai district, the rehabilitation of the *karez* is of major concern. Government may intervene in the rehabilitation of *karez* in drought hit regions where people are unable to initiate it due to financial constraints, lack of skilled labour or non-availability of modern machinery. The rehabilitation of the *karez* technology should be based on modern irrigation methods to make it energy and cost efficient. Efforts must 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 extent as many skilled people have migrated to other areas and the new generation lack such knowledge. Training the locals about the proper usage of *karez* water along with application of modern technology should be provided by the Government or NGOs in the region. *Karez* rehabilitation must be in line with the conservation of the water by adaptation of water saving technologies.

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