Factors Influencing Farmers' Participation in Participatory Irrigation Management: A Comparative Study of two Irrigation Systems in Northern Areas of Pakistan

Arif Alam*,
Hajime Kobayashi[1],
Ichizen Matsumura[1],
Mohamed Esham[2],
Faridullah[3], and
[1]Balde Boubacar Siddighi

** The United Graduate School of Agricultural Sciences,*
Tottori University, Japan, Email: mirarif80@yahoo.com
[1]Faculty of Agriculture, Tottori University,
[2]Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka,
[3]COMSATS, Institute of Information Technology Abbottabad, Pakistan

Abstract *The purpose of this study was to understand how level of satisfaction with improved (IIS) and traditional irrigation systems (TIS) influences the level of participation in participatory irrigation management (PIM). Data was collected from 78 farmers selected by systematic random sampling technique from two villages (Sultanabad and Parri) belonging to the IIS and TIS from Gilgit district in Gilgit-Batistan northern region of Pakistan. The descriptive analysis shows that four important variables such as adequacy of irrigation water, water availability on fixed turns and condition of present irrigation systems are main factors influencing satisfaction in IIS. However, level of participation except at the main channel is not significantly different between the two systems. The indices of participation in the main and field channels in the IIS are positive, while in the TIS these indices are negative which implies that the level of participation by the TIS farmers is low. Finally, by using regression analysis it is statistically confirmed that farmers' satisfaction, family size, family labour, agricultural income and status of the irrigation system are significant factors influencing farmers` participation in PIM. Moreover, farmer training and guidance provided to the IIS farmers by the NPIW through the WUAs also contribute to enhance the IIS farmers` participation in PIM. Therefore, strengthening of the institutional arrangements in both systems can enhance farmers` participation in PIM in Northern Areas of Pakistan.*

Key words*: Improved Irrigation system (IIS), Traditional irrigation system (TIS), Participatory irrigation management (PIM), Operation & maintenance (O&M), Water user associations (WUAs)*

1. Introduction

Pakistan agriculture is almost completely dependent on irrigation. Where, majority of the population is directly or indirectly dependent on agriculture as a source of livelihood. Water is very essential for agriculture and it is being provided to farmers through canal irrigation system in Pakistan. The canal irrigation system of Pakistan is one of the largest irrigation systems in the world (Afzal and Barbhuiya, 2011). This system is very old and needs major improvement to make it efficient and meet the present demand for irrigation. It can be managed well, if the farmers are involved in its operation and maintenance (O&M). Recently, planners and administrators in Pakistan have realized that the farmers' participation is very important and many projects of such nature are being implemented in different irrigation zones. Moreover, the Provincial Irrigation and Drainage Authorities have been established by legislation in each province and these authorities have formally initiated participatory irrigation management (PIM) in the country. In view of exploiting these participatory institutional changes in the irrigation sector, several pilot projects to organize farmers at the main water channel or watercourse level have already been initiated by the government, non-government organization (NGOs) and community based organizations in the country. Several issues affect the potential for further improving participation in irrigation management. Agricultural diversification is needed to improve farmer income and welfare. If irrigated agriculture is more profitable for farmers then they will be more interested in irrigation management (Bryan and Helmi, 1996). Available water rights and farmer participation in water resources management could help prevent problems and facilitate smoother, more equitable and more efficient processes to improve water use efficiency and reallocate water among competing users (Bryan and Helmi, 1996).

Participation is considered a key factor contributing to the long term sustainability of water user associations (WUAs) in Pakistan. It has been recognized widely that unless the farmers are involved in an organized way in the operation,

management and maintenance, the objectives of irrigation projects cannot be realized to the full extent. Participation is a process in which people express themselves, share, contribute and act with mutual responsibility to promote a common goal. Participation is crucial for agriculture and rural development and is one of the critical components for success of natural resource management. Farmer's participation in decision making is more likely to lead to a sustainable increase in food production and development. PIM refers to the involvement of stakeholders in planning, designing, construction and supervision, policy and decision making, operation and maintenance and evaluation of irrigation systems. Involvement of farmers in all aspects of irrigation management enhances farmers' satisfaction with the irrigation system.

A wide range of PIM studies have identified a multitude of reasons why local farmers have participated or not participated in irrigation management. These reasons include: livelihood dependency of irrigation schemes (Korten, 1986; Ostrom, 1999; Kim & Khiev, 2007), the presence of an efficient and reliable supply of water (Maleza & Nishimura, 2007), the level of benefits that flowed from irrigation schemes (Maleza & Nishimura, 2007), peer pressure (Levi, 1988; Ostrom, 1994), trust in the leadership (Wade, 1988b; Meinzen-Dick et al., 1997; Lopez-Gunn, 2003), local awareness of rules, rights and the importance of participation relative to livelihood and irrigation status (Tewari & Khanna, 2005), the improvement in scheme infrastructure (Meinzen-Dick et al., 1997) and the community's sense of ownership of the scheme (Ostrom, 1990; Meinzen-Dick et al., 1997; Hirschmann, 2003). However, to our knowledge there are no studies done to compare the relationship between level of participation and satisfaction between improved and traditional irrigation systems. Such comparative studies can provide important insights on how improvement to irrigation systems can contribute to farmers' participation in irrigation management. Therefore, in this study, we examine an improved and traditional irrigation systems to understand how level of satisfaction with irrigation system influences the level of participation in PIM based on a field survey in Northern Areas of Pakistan.

2. Material and Methods

2.1 Sampling and data collection

Sampling was based on the systematic random technique. The sample list was obtained from the local government office. A total of 78 farmers, (38 from Sultanabad and 40 from Parri) 39 farmers from improved and 39 farmers from traditional irrigation system (TIS) were chosen. A well-structured and field pre-tested comprehensive interview schedule was used for the collection of detailed information on various aspects of both IIS and the TIS. The data was collected through face to face interview of household heads. Data were collected between October and November, 2009. During this survey data about the household size, farmers' level of education, land ownership, crops cultivated, present sources of irrigation, conditions of watercourses, satisfaction level with present irrigation system (PIS), type and level of participation by farmers, were collected.

2.2 Data analysis

Level of satisfaction was analyzed using Yeh's index of satisfaction (YIS), (Yeh, 1975). The satisfaction index has been used by (Rahman et al, 2001 and Ahmed et al, 2007) to determine the satisfaction index of respondents of various income groups. The index was calculated by subtracting the number of respondents who were dissatisfied from the number of satisfied respondents and then dividing it by the total number of respondents. Putting it into a symbolic form, YIS, can be written into the following expression equation (1):

$$YIS = \frac{S - D}{R} \quad (1)$$

where,
S = the number of respondents satisfied with PIS, D = the number of respondents dissatisfied with PIS and
R = the total number of respondents.
To understand the level of farmers` participation in irrigation management a similar participation index was defined as follow in equation (2):

$$IP = \frac{P - NP}{R} \quad (2)$$

Where,
IP = Index of participation, P = the number of respondents involved in PIM, NP = the number of respondents never participate in PIM and

R = the total number of respondents.
The index ranges from +1 to –1. A positive value indicates that there are more respondents who are satisfied than those who are not satisfied or participation in PIM is higher than non-participation. The larger the value, the more intensive is the degree of satisfaction or participation or dissatisfaction or non-participation. A multiple regression analysis was performed to determine the factors influencing farmers` participation in PIM. The dependent variable, the level of participation was a score developed based on the scale; always =2, sometimes=1, and never=0 participation in PIM at main channel, watercourse and field channel.

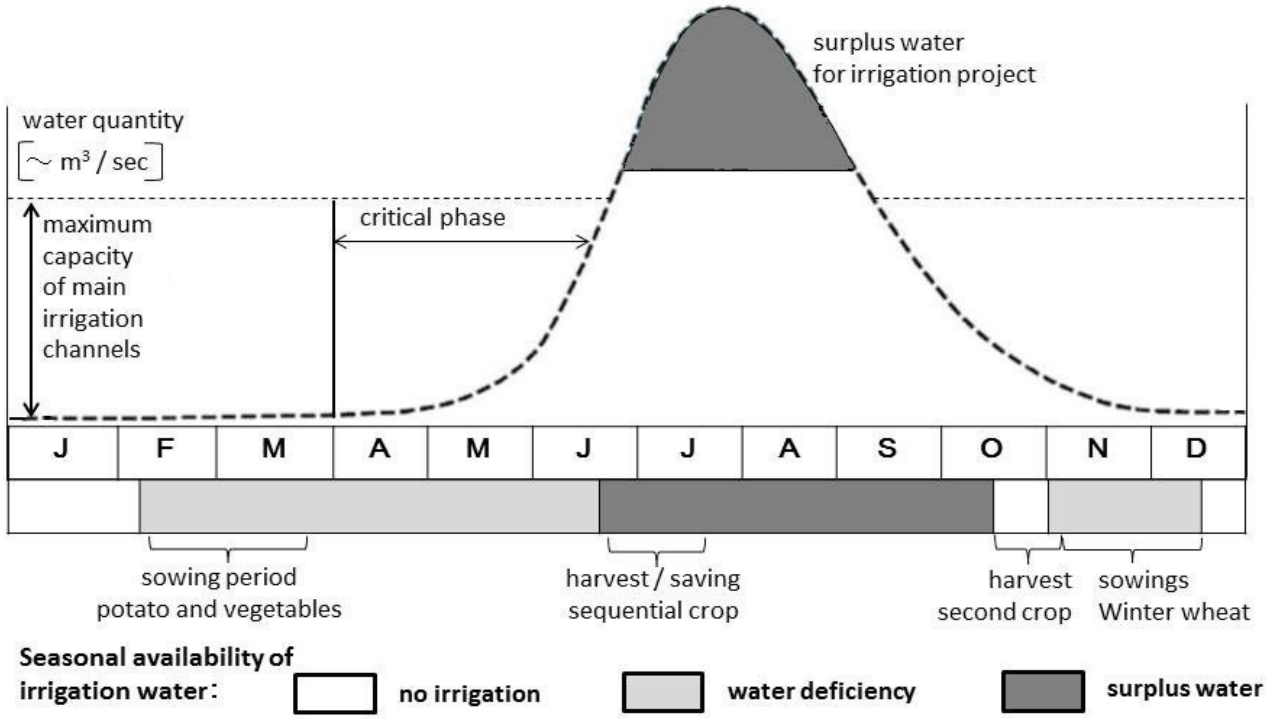
3. Results and Discussion

3.1 Background of study area and irrigation system

3.1.1 Study area

The study was conducted in Sultanabad and Parri two selected villages from Gilgit district, Northern Areas (NAs) of Pakistan. Sultanabad, which is located 7 km south east of Gilgit city along both sides of Karakoram highway, are considered as an important agricultural area situated in the suburban of Gilgit city. Parri is located along with Karakoram highway about 29 kilometers towards south of Gilgit city. These villages face water scarcity problems, especially in dry crop growing season (February to April). Water availability during this period is very critical for crop production (figure 1). The climate is dry continental, characterized by a great variation in average temperatures from 40 ºC between May and October to -4 ºC or less in November to April. The annual rainfall in Gilgit is 150 mm. The majority of the households grew several crops i. e., wheat, potato, vegetable, fodder etc. in dry (rabi) season and maize, vegetable and fodder in (kharif) wet season.
In NAs of Pakistan the irrigation schedule which is characterized by water scarcity (dry) and surplus (wet) seasons (Arif et al., 2011). The amount of surplus water is available only for a very short period compared to water scarcity season, as all water is already allocated through traditional water rights. The figure1 shows the maximum and minimum water availability and cropping patterns in NAs. The water availability in the wet season July to September is very high but shortfalls are more frequent during the winter (dry) season, when the quantity is comparatively limited. Such water scarcity is common in NAs of Pakistan and affects the selection of crops and production.

Figure 1: water availability and irrigation pattern in Gilgit district of Northern Pakistan



Source: Adopted from Kreutzmann, (2011)

3.1.2 Irrigation systems in the study area

Throughout Gilgit district and elsewhere in the NAs, agriculture depends on irrigation water supplied through small traditional irrigation channels called Kuhls in local term. These are small, often lengthy channels usually constructed and maintained through the collective efforts of farmers and villagers. Channels carry water directed through crude intake "structures" from mountain streams fed by snow melt, glacial melt and/or springs for distribution through water channels. Water losses occur at field level due to seepage, overflow, silt-loaded banks, vegetation, holes etc. (Kahlown et al. 1998). Due to the present water crises and reduced river flows, farmers are getting less water for crop cultivation. To overcome these problems, National Program for Improvement of Watercourses (NPIW) setup in Gilgit-Baltistan during 2003/2004 with the aim of improving irrigation infrastructure has attempted to improve the irrigation system from traditional to lined (channels made by cement concrete and stone). A total of 600 watercourses are constructed in 2009/2010 and lining of around1,200 are underway in NAs of Pakistan. Lining of watercourses is one of the main water management measures. Lining enables to reduce the seepage from the watercourses. Local government funds 80% of the capital outlay for watercourse improvement through the NPIW, while farmers share the remaining 20% in terms of cash or labour.

3.1.3 Institutional structure

The irrigation system in study area involves different stakeholders of the local community such as water users, farmers' organization, WUAs, sub WUAs, watchmen and the local government. However, national government and also NGOs are playing supportive roles in the management of irrigation. Figure 2 shows the main relationships between specific stakeholders and their interaction with the physical irrigation management system in the study area. The NPIW is providing guidance to the IIS user related irrigation management through WUAs. Farmers' organization participation in irrigation management provides an important opportunity for improvement through working with WUAs in a more systematic way. These farmer organizations in the study area contribute to participatory management in numerous ways such as decision-making and planning, resource mobilization and management, communication and coordination and conflict resolution. In the IIS, farmer organization is responsible to provide all information about irrigation channels to the officials.

In the both improved and TIS, WUAs play an important role to encourage more farmer participation in irrigation management. WUAs contribute to design and construction; O&M fee collections, record keeping, etc. There are few differences between the two systems such as in the IIS guidance related O&M, farmers training comes from NPIW through WUAs, which enhance farmers' level of understanding related to irrigation management and enable farmers to participate in PIM.

3.2 Farm household characteristics

The age of the selected respondents in this study ranged from 37 to 72 years with a mean of 52 years in improved irrigation system (IIS) and 30 to 75 years with mean of 57 years in the TIS, (Table 1). The farmers in the IIS are younger than the TIS; younger farmers are more likely to participate in irrigation management. The level of education measured in terms of number of years of schooling is statistically significant, indicating that farmer household heads in IIS are better educated. Relatively better level of education is an advantage as it can form the basis for motivating farmers to participate in irrigation management. All the farmers cultivate own land. The average cultivated land which includes extent of cereals, vegetables and fruits in both seasons. The IIS farmers own more land compared to the TIS farmers, which implies that farmers in the IIS will need more water compared to the TIS farmers.

Figure 2: Structure of water management in irrigation systems in Gilgit-Baltistan

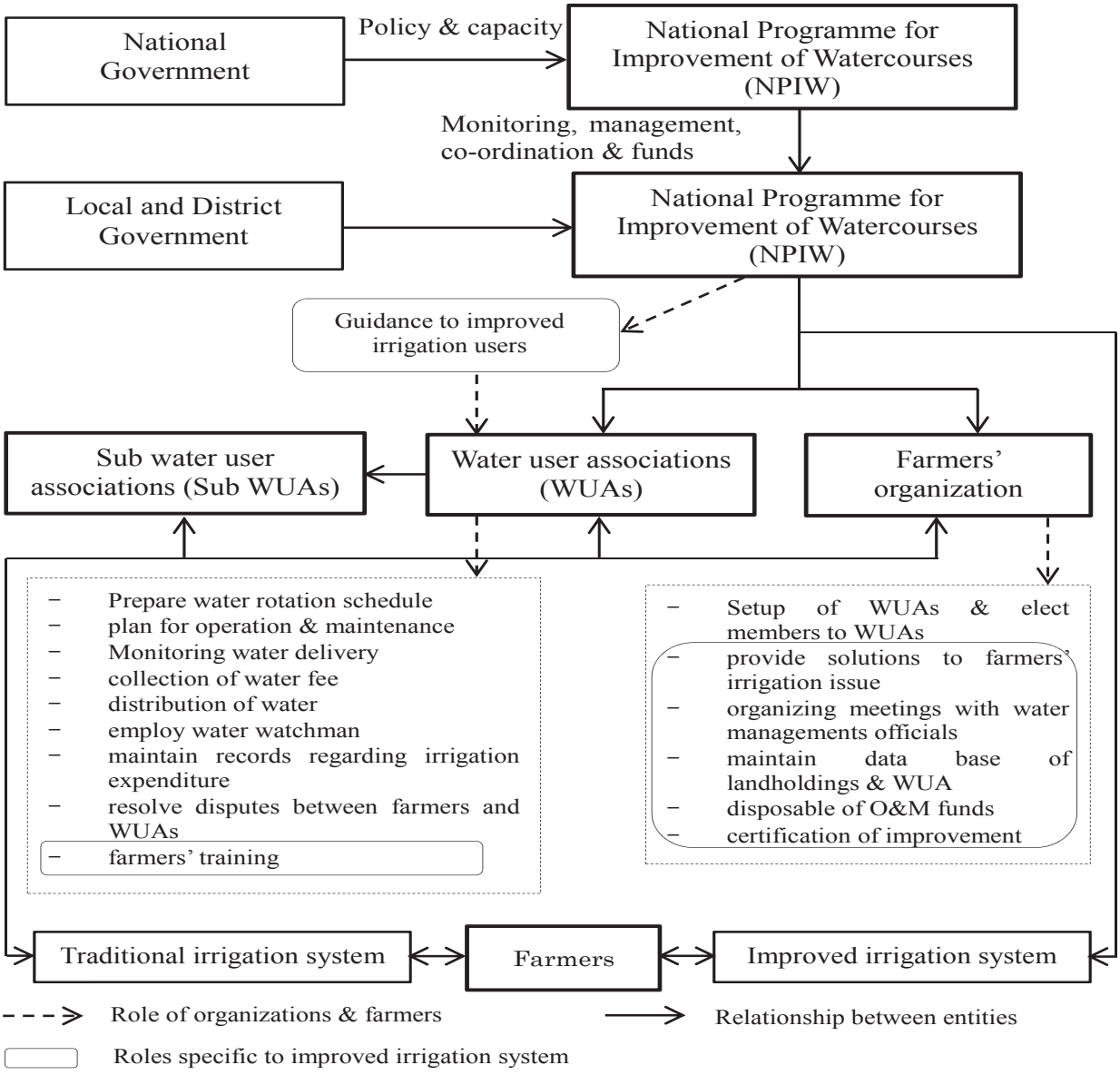


Table 1: Characteristics of surveyed farmers

Particulars	IIS	TIS	p-value
Age of household head (years)	52.0	57.0	0.063
Education level of household head (years)	6.0	4.1	0.030
Family size of households (person)	10.8	11.6	0.145
Cultivated area (acres)	6.1	4.2	0.000
Average agriculture income (rupees)[1)]	157,180.1	86,879.1	0.000
Household income (rupees)[2)]	392,749.2	374,891.3	0.152

Source: Own estimated; author's field survey (2009)
Note: 1) Agriculture income is crop income - farm management cost

2) Household income is crop income + non-farm income except (livestock) income

Almost all households are engaged in agriculture and it is the major source of livelihood in the area. The agricultural income of IIS farmer is significantly higher than that of TIS farmers. Moreover, the share of agricultural income of the IIS farmer's total income is higher than that of the TIS farmers i.e. 40% and 23%, respectively.

3.2.1 Satisfaction with present irrigation system

Satisfaction with the present irrigation systems was measured using three point scale (highly satisfied, satisfied and dissatisfied). According to Table 2a, 69% of respondents are satisfied and 31% of them are dissatisfied with the present condition of the IIS. However in the TIS 74% of respondents are dissatisfied, 15% are satisfied and only 10% of them are highly satisfied with the TIS. It is clear that the satisfaction level of the IIS farmers is higher than the TIS farmers. It is mainly due to poor condition of the TIS in terms of condition of irrigation channels, and less water availability in dry season. Water availability has been found to be the cardinal factor influencing farmer's participation in community irrigation projects (Madhava and Chackacherry, 2004).

Satisfaction with water adequacy shows that in the IIS, 13% of the respondents are highly satisfied with adequacy of irrigation water, while, 44% of the respondents are satisfied and 44% are dissatisfied. On the other hand, in the TIS, 90% of the respondents are dissatisfied due to water scarcity problems. Therefore, there is a significant difference between the IIS and the TIS. It is mainly because farmers in the TIS located at tail reach of watercourses are receiving less water. This implies that some farmers in the IIS at both head and tail of the water channels are having access to sufficient water. However, in practice, either because of the seepage or stealing of water by farmers close to the water source or conveyance losses, farmers located at the tail reaches of both systems generally get disproportionately less water. The results of the IIS indicate that 23% farmers are highly satisfied with availability of water on their fixed turns, 38% of them are satisfied and 38% of respondents are dissatisfied. However, in the TIS 13% of the respondents' are satisfied receiving water on fixed turns, while 87% of them are dissatisfied with water turns particularly in water scarce seasons (Table 2a).

Table: (2a) Level of satisfaction with present irrigation system

Variables		Categories and number of samples		
Overall satisfaction		**Highly satisfied**	**Satisfied**	**Dissatisfied**
level with present	IIS	27 (69)	0	12 (31)
irrigation system	TIS	4 (10)	6 (15)	29 (74)
Adequacy of		**Highly satisfied**	**Satisfied**	**Dissatisfied**
irrigation	IIS	5 (13)	17 (44)	17 (44)
Water	TIS	0	4 (10)	35 (90)
Availability of		**Highly satisfied**	**Satisfied**	**Dissatisfied**
water on	IIS	9 (23)	15 (38)	15 (38)
fixed turns	TIS	0	5 (13)	34 (87)
Condition of		**Highly satisfied**	**Satisfied**	**Dissatisfied**
present	IIS	27 (69)	9 (23)	3 (8)
irrigation system	TIS	3 (8)	5 (13)	31 (79)

Note: Values in parenthesis are %, Source: own estimated based on authors field survey 2009

Table: (2b) Indices of satisfaction

Index of satisfaction	IIS	TIS	t-stat
Overall satisfaction with present irrigation system	0.38 (1.38)	-0.49 (0.40)	7.041***
Adequacy of irrigation water	0.13 (0.92)	-0.79 (0.12)	4.838***
Availability of water on the fixed turns	0.23 (1.00)	-0.74 (0.20)	4.496***
Condition of present irrigation system	0.85 (1.50)	-0.01 (0.36)	7.020***

Note: Values in parenthesis are mean

*** significant at 1%, ** significant at 5% and *** significant at 10%,

Water distribution depends on the water availability in the main irrigation channels. Though, farmers are given their share of water according to the size of their landholding, which is decided by the sub WUAs. Water is distributed to the fields on a continuous flow basis during the water abundance period. When the water is abundant in quantity, the main gate at the intake is regulated to provide water to all the watercourses. When the water is scarce in dry season, it is distributed on a rotational basis. Under the rotation (warabandi) system, each household in the channels takes its irrigation turn on a specific day, at a specified and equal period of time. However, the number of gates to be opened or closed at the watercourses depends on the volume of water available at the main channel rather than on the farmers' requirements. This type of rotation does not seem to work well, since the length of the watercourses and the volume of water channeled differ largely. Water theft, hence, is quite a common offence during periods of scarcity or drought. Physical condition of PIS in the area directly affects the efficiency of the irrigation system. According to farmers in the IIS, the structures are satisfactory. As 69% farmers expressed that the present condition is highly satisfied, 23% of them are satisfied and 8% respondents are dissatisfied. However, 79% farmers in the TIS report the physical condition is dissatisfactory, 13% and 8% of them said satisfied and highly satisfied, respectively (Table 2a).

3.2.2 Indices of satisfaction with present system

To compare the degree of satisfaction between the two systems composite satisfaction indices were computed. Table 2b present the indices of farmers' level of satisfaction with various elements of the present irrigation system in the study area. The overall result in Table 2b shows that the indices of farmers in the IIS is positive and mean values are better compared to the TIS and mostly highly statistically significant. However, the overall satisfaction of farmers in the IIS is moderate and the highest level of satisfaction is reported on condition of present irrigation system. Negative indices for all elements in the TIS reflect dissatisfaction with the irrigation system.

3.2.3 Participation in irrigation management

Farmers through WUAs and farmers organization participate in irrigation management. The activities mainly include maintenance of the common portion of the channels (cutting grasses, reconstruction of damage portion, removal of silt and cleaning channels etc.), which is an annual contribution from all farmers, either in the form of labour or cash. Spring is the time for general annual maintenance, before the first irrigation for the new crop year. Maintenance of field channels not common to the system, it is the responsibility of individual farmers. Main irrigation channel in study areas are common property of all villagers and it is maintained collectively through the farmer organization and WUA. All stakeholders are participating in O&M of irrigation channels. The result shows that all respondents participate in watercourse level, while 54% and 41% of the respondents participating in main channel and branch level in the IIS, respectively. While, participation of the TIS farmers at watercourse level is 100%, field branch level is 33% and for main channel is 36%. The overall participation in irrigation management by farmers in the IIS is higher compared to the TIS (Table 3a). This is probably because farmers in the IIS are comparatively satisfied with the IIS which motivates them to participate in PIM.

Table: (3a) Level of participation in present irrigation system

Variables		**Categories and number of samples**		
Level of participation		**Main channel level**	**Watercourse level**	**Field branch level**
in irrigation	IIS	21 (54)	39 (100)	16 (41)
Management	TIS	14 (36)	39 (100)	13 (33)
Frequency of		**Often**	**Twice a year**	**Once a year**
watercourses	IIS	8 (21)	21(54)	10 (26)
Cleaning	TIS	9 (23)	19 (49)	11 (28)

Note: Values in parenthesis are %,

Table: (3b) Indices of participation

Index of participation	IIS	TIS	t-stat
Farmers level of participation in main channel	0.29 (1.08)	-0.03 (0.72)	1.703*
Farmers level of participation in water course	1 (2.00)	1 (2.00)	-
Farmers level of participation in field branch	0.03 (0.82)	-0.18 (0.66)	0.753

Note: Values in parenthesis are mean, Source: own estimated based on authors field survey 2009
*** significant at 1%, ** significant at 5% and *** significant at 10%

The cleaning of watercourses is very common activity among the farmers' in the study area. The results indicate that 21% of farmers in the IIS participate often, 54% twice a year and 26% once a year. However, 23%, 49% and 28% of the respondents participate in the TIS often, twice a year and once a year respectively Table 3a. Improved channels were designed with slopes and sections in regime to minimize scouring and silt deposits. But due to water from glacier and snow melt carry a substantial amount of silt which is loaded in channels and deposited on irrigated lands. These silt accumulation reduces channel cross-sectional area, which means that operating water levels must be raised to maintain flows. Major silt cleaning efforts are required each year in several times minimum once a year at the both systems. All stakeholders have to participate in this activity affording labour or maintenance fee (in cash).

3.2.4 Indices of participation in PIM

To determine the level of participation in both the IIS and the TIS index score were calculated. Results shown in Table 3b indicate that the level of participation in main channel was statistically significant while, field branch level was not statistically significant. The index scores of participation in main channel were positive and moderate, while participation level for field branch was low in the IIS. The negative indices of participation in main channel and field branch level indicates that the participation of farmer in the TIS is comparatively low than those farmer in the IIS.

3.2.5 Factors influencing farmers' participation in PIM

A multiple regression analysis was performed to determine the factors influencing farmers` participation in PIM. According to the results presented in Table 4 satisfaction, family size, part time family labours, agricultural income, irrigation system dummy and village distance to the main market were statistically significant. These results imply that higher the overall satisfaction with the present irrigation system farmers are more likely to participate in irrigation management. Higher the level agricultural income more the participation this finding is consistent with Maleza & Nishimura (2007) who reports that farmers obtaining higher returns from agriculture are more likely to participate in irrigation management. Moreover, the irrigation system dummy is significant implying that farmers in the IIS participate more in irrigation management since their satisfaction level is high with the improved irrigation system.

Table 4: Results of multiple regression analysis

Variables	Coefficients	t-stat
Satisfaction level of farmers	1.767	8.055***
Age of household head	0.008	0.715
Family size	0.068	3.193***
Part time family labour	0.031	2.178**
Cultivated area	-0.010	-0.240
Agriculture income	0.001	4.060***
Location of farmers[1)]	0.232	1.513
Irrigation system dummy[2)]	0.482	2.956***
Distance (km)[3)]	0.054	5.830***

Note: Adjusted R^2 value = 0.823, F-value = 41.025, n = 78
[1)] (Head=1 and Tail=0), [2)] (IIS=1 and TIS=0) [3)] (Sultanabad=1 and Parri=2)

*** significant at 1%, ** significant at 5% and *** significant at 10%

Family size shows a significant relationship with participation. It indicates that the larger family size encourage farmers to participate in irrigation management. The variable village to city is significant implying that farmers in Sultanabad are more inclined to participate in PIM than Pari. This is because Sultanabad is located closer to the city center and farmers have better access to markets. This confirms the findings of Bandeth (2010) where farmers with better economic status are more inclined to participate in PIM.

4. Conclusions

This study examined the farmers' satisfaction level with various aspects of two irrigation systems; improved and traditional to understand how level of satisfaction influences farmer participation in PIM in Gilgit district of NAs Pakistan. Data related to farmers' satisfaction and participation obtained from the two systems were analyzed using Yeh's index of satisfaction and participation. Moreover, to determine the factors influencing farmers` participation in PIM multiple regressions analysis was performed.

The estimated indices of satisfaction shows that four important variables adequacy of irrigation water, water availability on fixed turns and condition of present irrigation systems are significantly different between the two systems. However, level of participation except at main channel is not significantly different between the two systems. The indices of participation in main channel and field channel in the IIS are positive while in the TIS these indices are negative implying that the level of participation of the TIS famers is low.

Findings from regression analysis show that farmers' satisfaction, family size, part time family labour, agricultural income, status of the irrigation system and the distance from village to city are significant factors influencing farmers` participation in PIM. Overall this study establishes that the level of satisfaction with irrigation system is an important determinant of farmers` participation in PIM. Therefore, these findings imply that improvement of irrigation system in terms of developing physical infrastructure and efficient distribution of water can enhance farmers` participation in PIM. Moreover, farmer training and guidance provided to IIS farmer by NPIW through WUA as well as the active role of the farmer organizations contribute to enhance IIS farmers` participation in PIM. Therefore, strengthening of the institutional arrangements in both systems can enhance farmers` participation in PIM.

Management of the water resources for irrigation uses should incorporate a participatory approach by involving not only the governmental agencies (NPIW) but also the users' and other stakeholders, in an effective and decisive manner, in various aspects of planning, designing, development and management of the water resources schemes. Necessary legal and institutional changes should be made at various levels for this purpose. Appropriate role of WUAs and farmer organization should particularly be involved in the operation, maintenance and management of water infrastructures or facilities at appropriate levels progressively.

References

Afzal, M. and Barbhuiya, S. (2011). Effects of Extreme Weather Events in Pakistan and Their Impacts on Sustainable Development. University of the West of Scotland, UK.

Ahmad, K. M., Md.Eftekhar, H., Md.Nurul, I., Md.Iqbal, S. (2007). Urban environmental quality mapping: A perception study on chittagong metropolitan city. Kathmandu Uni. Journal of Sci. Eng. and Tech. Vol. I, No. iv

Arif, A., Kobayashi, H., Matsumura, I. and Esham, M. (2011). A comparative economic analysis of crop production between improved and traditional irrigation system: A case study of a village from Gilgit district in NAs of Pakistan. Journal of Rural Problem., Vol. 47, No. 1, pp.132-137

Bandeth, R. (2010). Participatory irrigation management and the factors influence the success of farmer's water user communities: A case study in Cambodia.

Bryan, B. and Helmi. (1996). Participatory Irrigation Management in Indonesia: Lessons from Experience and Issues for the Future. A background paper prepared for the Economic Development Institute, W. Bank, November 4-8

Chamber, R. (1988). Managing canal irrigation, practical analysis from South Asia. Cambridge Univ. Press, New York.

Hirschmann, D. (2003). Aid dependence, sustainability and technical assistance: Designing a monitoring and evaluation system in Tanzania. Public management Review. 5(2): 225-244

Kahlown, M. A., Shafique, M. S. and Iqbal, M. (1998). Improved irrigation methods for efficient use of irrigation water under different water-table depths. Mona Reclamation Experimental Project, WAPDA, Bhalwal, Pub. No. 231.

Kim, S. S. and Khiev, D. (2007). Challenges in water resources management for farmer water user communities. Cambodia Development Review, 11(3): 5-8

Korten, D.C. (1986). Community manatgement: Asian experience and perspectives. West Hartford: Kumarian Press.

Kreutzmann H. (2011). Scarcity within Opulence: Water Management in the Karakoram Mountains Revisited J. Mt. Sci. 8: 525–534

Levi, M. (1988). Of rule and revenue. Berkeley: University of California Press.

Lopez-Gunn, E. (2003). The role of collective action in water governance: A comparative study of groundwater user association In La Mancha aquifers in Spain. Water International, 28(3): 367-378.

Madhava C. K. and George C. (2004). Factors influencing farmer participation in irrigation management. Journal of Tropical Agriculture, 42(1-2), 77-79

Maleza, M. C. and Nishimura, Y. (2007). Participatory processes and outcomes: The case of national irrigation system management in Bohol, Philippines. Irrigation and Drainage, 56(1): 21-28

Meinzen-Dick, R., Mendoza, M., Sadoulet, L., Abiad-Shelds, G., and Subramanian, A. (1997). Sustainable water user associations: Lessons from a literature review.

Ostrom, E. (1990). Governing the commons: The evolution of institutions for collective action. UK: Cambridge University Press.

Ostrom, E. (1999). Self- governance and forest resources. Jakarta: Centre for International Forestry Research.

Ostrom, E. (1994). Institutional analysis, design principles and threats to sustainable community governance and management of commons, p. 34-50.

Rahman, M. M. Dewan, A. M. and Islam, M. S. (2001), Degradation of Urban Environment: A Case Study of Citizen's Perception in Chittagong City. The Oriental Geographer, Vol. 45, Number 1, (January, 2001), PP.35-52.

Tewari, D. D. and Khanna, S. (2005). Building and energizing water institutions: A case study of irrigation management transfer in Gujrat. Journal of Environmental System, 31(3): 201- 221.

Wade, R. (1988b). The management of irrigation system: How to evoke trust and avoid prisoners' dilemma. World Development, 16(4): 489-500).

Yeh, S.H.K. (1975). Public housing in Singapore: a multidisciplinary study. Singapore, University Press for Housing and Development Board.