A STUDY ON THE EFFECTS OF IMPROVED IRRIGATION ON AGRICULTURE LAND USE IN NORTHERN PAKISTAN

EFFET DE L'AMELIORATION D'IRRIGATION SUR L'UTILISATION DES TERRES AGRICOLES AU NORD DU PAKISTAN

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ABSTRACT

In this paper we present a comparative study on improved and traditional irrigation systems and examine the impact of improved system on agriculture crop production and socio economic status of farmers in Northern Pakistan. A case study was undertaken involving farmers using both traditional and improved irrigation systems in the village of Sultanabad. The comparison of the two irrigation systems were undertaken in terms of crop acreage, crop yield and crop production. The study result shows that improved irrigation system contributed not only to increase cultivated area but also increased the cropping intensity due to availability of irrigation water throughout the year. The improved irrigation system has contributed to uplift the socio economic status of the rural farmers as a result of expanding cultivation area, high cropping intensity and high agriculture productivity. The water user associations (WUA) play a significant role in water management; maintenance of channel, water distribution and channel cleaning. The WUAs in the study area are strong and viable community based organizations.

Key words: *Improved irrigation, Water users' Associations, Traditional irrigation, Operational holding, Northern Pakistan.*

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RÉSUMÉ ET LES CONCLUSIONS

Dans les régions du nord du Pakistan à la fois les systèmes d'irrigation améliorés et traditionnels sont pratiqués pour la production agricole. Dans cet article, nous avons effectué une étude comparative sur les systèmes d'irrigation améliorés et traditionnels et a examiné son impact sur la production des cultures agricoles et le statut socio-économique des agriculteurs. Une étude de cas a été réalisée sur la base de données primaire et secondaire. Les données primaires ont été recueillies au moyen de questionnaires et d'entretiens sur les agriculteurs sélectionnés dans certains périmètres d'irrigation des régions du Nord du Pakistan. Données secondaires ont été obtenues auprès des organisations locales, non-gouvernementales et de sources internationales. Les données recueillies ont été analysées et les résultats ont été comparés sur la base de la superficie des cultures, le rendement des cultures et la production agricole. Le résultat de l'étude montre que le système d'irrigation de qualité a augmenté, non seulement la superficie cultivée, mais aussi augmenté l'intensité de culture que les gens peuvent cultiver des plantes plus dans la même zone en raison de la disponibilité de l'eau d'irrigation tout au long de l'année. L'utilisation du système d'irrigation améliorée dans la région ont des effets bénéfiques sur les impacts socio-économiques des populations rurales par domaine de l'agriculture croissante des terres, la productivité, le coût moins la production et des revenus supplémentaires aux agriculteurs, que l'intensité des cultures a augmenté de manière significative en raison de la diffusion du système d'irrigation améliorée.

Il semble que le système d'irrigation améliorés ont un impact direct ou indirect positif sur la croissance économique et la modernisation des régions du Nord du Pakistan. L'occupation des terres dans la zone de recherche pour les agriculteurs sélectionnée n'a pas été l'exception, en moyenne, chaque ménage possédait 2, 3 hectares (5,6 acres) de terres d'exploitation dans le système d'irrigation améliorés (IIS); majorité des 64% des répondants avaient des terres de moins de 2,5 hectares et à seulement 15% des ménages ont plus de 10 hectares d'exploitations opérationnelles. Le gouvernement local et les travaillent à changer le système d'irrigation traditionnels (chaînes de boue et de pierres) à l'amélioration (canaux en béton de ciment et de pierre) système d'irrigation pour améliorer la disponibilité de l'eau. L'effet de système d'irrigation améliorée est de contrôler la perte de l'infiltration d'eau, les problèmes d'érosion des terres et l'efficience de l'eau augmente. Il a été constaté que chaque production agricole dans une meilleure irrigation est de 2,5 fois plus élevé que système d'irrigation traditionnel. Toutefois, les agriculteurs utilisant des systèmes d'irrigation traditionnels ont également besoin de production élevés des ressources disponibles, mais en raison de la rareté de l'eau d'irrigation en particulier en saison sèche, les agriculteurs ne peuvent pas obtenir assez de production pour leurs besoins. Connexion accrue entre la production alimentaire locale et la consommation alimentaire est considérée comme un moyen potentiel pour stimuler l'économie agricole et améliorer l'état nutritionnel des communautés rurales.

Il est conclu que les associations d'usagers de l'eau (WUA) jouent un rôle supérieur dans la gestion de l'eau;. maintenance de la voie, de distribution d'eau et le nettoyage des canaux L'AUE zone d'étude est forte et viable. La force des AUE dépend de l'approche adoptée pour la formation des WUA, la structure de l'organisation et le degré de participation des membres aux activités de l'organisation. Tous les agriculteurs sont membres de l'WUA, y compris canal principal et le canal secondaire de l'eau sans obstacles socio-économiques, et ils participent activement à l'irrigation et les activités de gestion de l'organisation, la mobilisation des ressources sous la forme d'espèces et en nature.

Mots clés : *Amélioration de l'irrigation, Associations des Usagers d'eau, irrigation traditionnelle, exploitation opérationnelle, nord du Pakistan.*

(Traduction française telle que fournie par les auteurs)

1. INTRODUCTION

Over 1 million people live in the Northern areas (NAs) of Pakistan, with 60 to 84 per cent of their income derived from agriculture and livestock (AKRSP,2000). The farmers there practice subsistence agriculture with wheat, maize, vegetables, fodder and varieties of fruits being the major cultivated crops. Annual precipitation ranges between 150 mm to 400mm in the valley bottoms. Water from glacial melt is mainly used for irrigation. The glaciers feeding the NAs contribute significantly to the stream-flow, especially during the dry season (Konovalov, 1997; Hagg and Braun, 2005). NAs of Pakistan are mountainous and about 90% of the lowland flow of the River Indus and its tributaries originate from mountain areas, mainly from the Hindukush, Karakorum, and western Himalaya, from the front ranges and foot hills (Linger et al 1998). The crop production in this area is completely dependent on irrigation derived from high altitude snow and ice melt (MacDonald, 1998). Water availability, especially during dry season is a serious problem in the semi-arid countries of central Asia, including Pakistan. Water is a very precious resource throughout the NAs due to limitations such as low valley precipitation and variability of flow in the Indus River (Ahmed and Joyia, 2003). To achieve sustainable production from irrigated agriculture, it is imperative to improve the utilization of the resources such as water, irrigation infrastructure and land (Molden et. al 1998).

The operational land holdings play a significant role in the adoption of new technology. Per capita land holding in NAs is 0.124 hectares (0.5 acres), which is decreasing day by day due to land fragmentation and rapid urbanization (Dawn, 2003). The local government and NGOs are attempting to change the irrigation system from traditional (mud and stone channels) to improved (lined channels) irrigation system to control loss of water in seepage, soil erosion and increase water use efficiency. Sustainable and efficient irrigation systems will contribute to raise farm income by expanding arable land, reducing out-migration, improving wage rate and off-farm employment (Biltonen et al 2003).

In the context of the importance of improving irrigation infrastructure, this study compares an improved irrigation system with a traditional irrigation system to examine the impact of improved system on agriculture crop production and socio economic status of farmers in Northern areas of Pakistan.

2. MATERIALS AND METHODS

2.1. Study area

The study was conducted in the village of Sultanabad, situated at a distance of about 7 km south east of Gilgit city, during August and September 2008. This study area was selected for comparison, as both the traditional irrigation system (TIS) and the improved irrigation system (IIS) were available in the village. Moreover, the village is easily accessible, as it is on

the Karakoram highway. The sample of the present study consisted of 29 randomly selected farmers utilizing improved and traditional irrigation systems.

2.2. Data collection

The study was carried out based on primary and secondary data. Primary data were collected through questionnaires and interviews from the village farmers. Secondary data was obtained from local and international publications. The data were analyzed from an economic point of view such as how productive and efficient is the farm management and water resources utilization by farmers in irrigated area and to identify management issues related to the irrigation system.

3. RESULTS AND DISCUSSION

3.1 Comparison between traditional and improved irrigation system

The comparison between the TIS and the IIS is presented in Table 1. The IIS has direct as well as indirect positive impact on economic growth and modernization of the NAs of Pakistan. Since water resources are becoming the most limiting for production in the region, increase in water use efficiency via improving irrigation system and effective management with the involvement of formally setup WUAs contribute greatly to ensure food security and sustainable agriculture in the region.

Table 1. Comparison between traditional and improved irrigation systems (Comparaison entre les systèmes d'irrigation traditionnelles et améliorées)

	Improved irrigation system	Traditional Irrigation system
Facilities	1. Channels laid with concrete therefore, no leakage and soil erosion. 2. Rapid water conveyance. 3. Takes less time for cleaning the channels.	1. Channels are constructed with mud and stones therefore, leakage of water and soil erosion occur. 2. Slow water conveyance. 3. Cleaning is time consuming and labor intensive.
Water user associations (WUAs)	1. To control irrigation facilities needs some gropes of (WUAs). 2. Local government provides the employment.	1. Needs more groups and also sub-groups of WUAs. 2. Voluntary work.
Distribution of irrigation water	Water availability is high therefore, irrigation interval is shorter	Water availability is low therefore water is rationed and irrigation interval is longer.

While on the other hand, traditional irrigation channels lack control device for effective conveyance and distribution. These unlined traditional channels have higher conveyance losses through seepage and evaporation resulting in water scarcity. This situation constrains crop production and leads to low household income.

3.2 Land use

Table 2. Comparison of land use between traditional and improved irrigation system (Comparaison de l'utilisation des terres entre le système d'irrigation traditionnelles et améliorées)

(Unit: acre[6], person & %)

			Improved irrigation user	Traditional irrigation user
Number of farmers			10	19
Average total area (acre)			12.7	8.3
Average irrigated area (acre)			10.9	6.2
Average cultivated area (acre)			9.1	5.0
Cover rate of cultivated area			72.1	60.0
Cropping ratio* (%)	Dry season	Wheat	33.4	21.3
		Potato	14.8	12.4
		Vegetable	21.6	15.5
	Wet season	Maize	67.4	51.1
		Vegetable	5.9	4.0
		Barley	16.3	20.5
	Fruits		15.9	19.2
Utilization rate of arable land** %			175.3	144.1

Source: field survey 2008.
Note: * cropping ratio is the ratio between cultivation area of a particular crop and total cropped area, ** Utilization rate is the ratio between wet and dry season cropped area and total arable area

Agriculture being the main livelihood of communities in the study area the main goals of irrigation development should be to improve irrigation channels to ensure farmers receive on time sufficient water to cultivate their fields. Improved irrigation system can be usually found in valley bottoms or flood plains. Normally, these areas are dry for a considerable period of the year. As shown in Table 2, analysis of field survey data shows significant difference in land use between improved and traditional irrigation system especially in dry season.

The land in study area is very limited with the average land holdings of only 12.7 acre per farm household in improved irrigation system, and 8.3 acres per farm household in traditional irrigation system in the study area. The irrigated land represents 86% of the total area for IIS, of which 72% of the total land is cultivated with crops and 14% consist of orchards and grasses and the balance 14% is arid land. The irrigated area for TIS is about 75% of the total land area of which crops are cultivated in about 60% of land area and 15% is covered by orchards and grasses, the balance 25% of the total area is arid land. The farmer using improved irrigation system owns land 1.5 times higher than farmers using traditional irrigation

6 1 acre = 0.4047 hectares

system. Dry season data shows that land use by farmers using IIS is significantly different from farmers using TIS. It was observed that the cropping ratio of wheat crop in dry season is significantly different between improved and TIS (Table 2).

3.3 Crop Production

Total production of each crop in dry and wet seasons per household member in improved and traditional irrigation system is shown in Table 3. It was found that production of each crop in improved irrigation system is significantly higher than TIS particularly in dry season mainly due to larger size of landholding and availability of irrigation water in dry season.

Table 3. Average production of each crop per person, 2007 (La production moyenne de chaque culture par personne, 2007)

(Unit: Kg)

Seasons	Crops	Average production/ person*	
		Improved	Traditional
Dry season	Wheat	111.6	29.1
	Potato	54.2	32.2
	Fodder	106	55.4
	Vegetable	133.2	42.9
Wet season	Maize	175	75.5
	Barley	54.5	16.4
	Vegetable	59.9	59.6
Fruit		96.1	65.4

Source: field survey 2008
Notes: * number of household members in IIS and TIS is 11.3 and 10.4 respectively

Foods from the grain products along with vegetables and fruits are essential to provide a balanced nutrition for the households. Per capita food availability and access to a balanced diet are serious concerns for farm households using traditional irrigation system especially in the dry season due to lack of irrigation water.

Wheat is mainly grown as a winter crop in the valleys and terraces within the double-cropped zone. In the dry season (*Rabi*), almost all farmers devote a major part of their land (up to 70 %) to wheat. However, maize is grown in the both mono and double cropping zones during the wet season (*Kharif*). Farmers belonging to mono cropping zone prefer to grow maize crop, because the mono cropping zone has very short growing period and maize productivity is higher than wheat in this zone.

The crop production data consisting of area, yield and production is summarized in Table 4. The data reveals that there are significance differences in crop production between the two systems particularly in the dry season.

Table 4. Difference between improved and traditional irrigation system for significant and non-significant (Différence entre le système d'irrigation améliorés et traditionnels pour les importantes et non significatives)

(Unit: acre, kg/acre)

Crops		Irrigation type	Average production parameters		
			Area	Yield	Production
Dry season	Wheat	Improved	3.05**	413.44 **	1,261.00**
		Traditional	1.07	283.92	302.63
	Potato	Improved	1.35**	453.33	612.00**
		Traditional	0.62	542.13	335.26
	Fodder	Improved	1.80	665.56 **	1,198.00**
		Traditional	1.45	398.18	576.32
	Vegetables	Improved	1.98 **	762.03*	1,505.00**
		Traditional	0.78	574.92	446.32
Wet season	Maize	Improved	6.15 **	321.46	1,977.00**
		Traditional	2.55	307.42	784.74
	Barley	Improved	0.54	570.37	308.00
		Traditional	0.20	864.00	170.53
	Vegetables	Improved	1.49	455.89	677.00
		Traditional	1.03	603.59	619.47
Fruits		Improved	1.45 *	748.97	1,086.00**
		Traditional	0.96	708.49	680.53

Source: field survey 2008 Notes: (**) Significant at 1%, (*); significant at 5%

Farmers using IIS mostly grow wheat and vegetables in dry season. The farmers using TIS mostly grow fodder crops in dry season besides wheat and maize. Farmers using IIS use 37% of land for wheat, 24% for vegetables and 22% for fodder production while farmers using TIS use 27% land for wheat crop, 20% for vegetables and 37% land for fodder in dry season. Wheat and vegetable crops require more water than fodder crops therefore, farmers using TIS are compelled to cultivate more fodder than other crops in dry season. In wet season, farmers using IIS use 64% of total land to grow maize and 15% of total land for vegetables. Farmers using TIS use 54% of total land for maize and 22% for vegetables. In the wet season there is not much difference between IIS and TIS with respect cropping area due to availability of water. During dry season farmers using IIS obtained higher yields than farmers using TIS. One exception was potato yield which was less than farmers using TIS due to a crop disease during the season of survey. Higher yield during wet season is due to availability of irrigation water to IIS users. Moreover, availability of water had encouraged farmers using IIS to use more inputs like fertilizer and agro chemicals.

Crops are grown mostly for household consumption; only small amount of crop production is transported outside the village because of poor roads and lack of transport facilities. The

overall results indicate that the IIS in the area can alone significantly contribute to the livelihood of the farmers in terms of income generation and in enhancing household food security.

3.4 Management of the irrigation system

Role of different stakeholders in management of irrigation facilities in the study area are summarized in Table 5. The main stakeholders are the government, water user association (WUA), sub water user association and farmers. To manage the irrigation facilities in the area all stakeholder play an important role, while the WUAs take a leading role. Water User Associations are voluntary associations of farmer and farmers groups having the role of joint operations on the irrigation network of water resources management and reclamation, water conservation and other activities. Also WUAs provide a basis for improved and integrated local management of water resources. Sub water user association's work for the maintenance of channel and water distribution from sub channel to the farmers' field.

WUAs in the study area play a major role in maintenance of channel, water distribution and channel cleaning. The role of WUAs is indispensable particularly during the dry season. In traditional irrigation system, 84% of the maintenance and repair of channel are undertaken by farmers under the supervision of water user associations, called *Allasheri*. However, in improved irrigation system 40% maintenance is done by government and 60% is done by WUAs (*Allasheri*). Government support for the TIS for maintenance of channel, cleaning and water distribution is negligible. In dry season only 20% of IIS user use spring water, while 37% of TIS users use spring water. According to farmers 90% perceive that IIS is the major contributing factor to increase agriculture production in the area.

Table 5. Management of water facilities in the village (Installations d'eau Gestion des dans le village)

Stakeholder	Contribution
Government	1. Provides about 90% of share of capital for improving the irrigation facilities(IIS) 2. Provides workers for the repair and maintenance of IIS 3. For IIS and TIS damaged due to flood and landslides, provide assistance for restoration
WUAs	1. WUAs play important role in water distribution from main to secondary channels 2. WUA collects money from the non-participating farmers to maintain channels 3. Organize farmers to clean water channels in order to maintain continuous water flow
Sub WUAs	1. Ensure water distribution from secondary channel to the farmer's field 2. Organize farmers for maintenance and cleaning of sub channel 3. To help the water user association in different aspects
Farmers	1. Abide by rules of water user associations 2. Contribute to operation and maintenance cost 3. Co-operate with officials for establishing and expending of improved irrigation system

4. CONCLUSIONS

This study was aimed at assessing the benefits of improved irrigation system in Northern Areas of Pakistan. The results reveal that the improved irrigation system enabled to bring more land area under cultivation as well as facilitate farmers to cultivate more crops in the same area due to availability of irrigation water throughout the year. The improved irrigation system has significantly contributed to increase agriculture production and productivity. Improved irrigation facilities enabled to bring more area under cultivation, increase cropping intensity and encouraged farmers to use more agro chemicals particularly in the dry season. Better management of IIS enabled extended use of water, especially during dry season when there is no more flow in the stream. Increased agriculture production enhanced household food security and made food affordable to poorer households.

It is also concluded from the study that water user associations (WUAs) in the study area are very strong and viable. The water user associations (WUAs) play a crucial role in water management, maintenance of channel, water distribution and channel cleaning. The study highlights the significance of improved irrigation system and the role water user associations in enhancing agriculture production in Northern Areas of Pakistan. It is imperative to further focus on both qualitative and quantitative data to better understand and resolve issues in irrigation improvement and economic wellbeing of rural communities in Northern Areas of Pakistan.

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