Research Article

Impacts of Palai Dam on Land use and Cropping Pattern of Mouza Qilla, District Charsadda, Khyber Pakhtunkhwa, Pakistan

Muhammad Jamal Nasir*, Anwar Saeed Khan, Said Alam and Saeed Akhtar

Department of Geography, University of Peshawar, Peshawar, Khyber Pakhtunkhwa, Pakistan.

Abstract | Palai dam is a small irrigation dam located on the northern border of district Charsadda, adjacent to Mohmand agency. The construction of dam was started in 2009 and was completed in 2011. It is claimed that dam will irrigate 5000 acre of land in four mouza's of district Charsadda. Present study is an attempt to determine the impact of Palai dam on the land use and cropping pattern, crop production and revenue of mouza Qilla, Tehsil Tangi, district Charsadda in Khyber Pakhtunkhwa province, Pakistan. Secondary data was collected from revenue office Tangi, and was geospatially analyzed in ARC GIS 10.1. Geographic information system (GIS) is a computer-based set of procedures used to store and analyze geographically-referenced data. Primary data about crop yield and per acre production, new seed and crop varieties etc. was collected with the help of a questionnaire survey. A total of 50 household were surveyed which make 45 percent of the total (114 households). The analysis of acquired data reveals that in 2008-09 tube well irrigated land account for 81.67 acre which decreased to 37.46 acre in 2013-14, after the dam construction. The number of parcels irrigated by tube well decreased from 158 to 75 in 2013-14. Today canal irrigation is the largest source of irrigation in the Mouza, which accounts for 56.09 acre. The analysis also reveals that the centuries old conventional subsistence agriculture is changed to market farming i.e. from wheat to vegetable and sugarcane. The yield per acre of almost every crop grown has been increased, which considerably increased the crop revenue. Due to availability of irrigation water, the current fallow in both the Rabi (winter cropping) and Kharif (summer cropping) has decreased with matching increase in area net sown. The study suggests that mouza has capacity for further increase in cropping intensity and cultivated land, if innovatory irrigation and agriculture practices were adopted which can surely raise the agricultural productivity and socio economic condition of the residents.

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Correspondence | Muhammad Jamal Nasir, Department of Geography, University of Peshawar, Khyber Pakhtunkhwa, Pakistan; **Email:** drjamal_n@yahoo.com

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Keywords | Land use, Cropping Pattern, Yield, Revenue Record, Palai Dam, Geographic information system

Introduction

The principal and known inputs for agriculture are land and water. Water and energy can boost the yield of any crop (Khan et al., 2007). Water is conceived as the major determining factor for the improvement of agriculture (Troeh et al., 1999). In developing countries agricultural water use accounts for 90% of global water consumption. Water management is a key requirement of sustainable agricultural practices (Tess et al., 2014). The management and development of water resources is considered important for the growth of agriculture sector in arid and semi-arid areas (Ashraf et al., 1999). According to land utilization statistics of Khyber Pakhtunkhwa (KP) 2013-2014, out of the total area of the province 18.4 million acre, only 28.86 percent is cultivated and rest 71.14 percent is uncultivated land. The total irrigated area of Khyber Pakhtunkhwa (KP) province is 2.02 million acre, out of which 71 percent area is classified as arid

which have no assured irrigation water for agriculture. Here the rainfall is sporadic which threatens the agriculture sector and hence causes wide spread food insecurity. In arid and semi-arid areas agricultural production can be increased by either bringing more area under plough or increasing the yield per hectare. In both cases the water seem to be the most important limiting factor (Ashraf et al., 1999).

The per capita water availability in Khyber Pakhtunkhwa is 513.44 cubic meter, which is far less compared to national and international standard *i.e.* 1000 and 1200 cubic meter, respectively (Govt. KP, 2010). Thus the province is facing a high water stress situation.

The impact analysis of thirteen small irrigation schemes in Gilgit-Baltistan and Chitral area suggests that as a whole 35 percent additional area was brought under plough as a result of these irrigation schemes. The study further reveals that the crop intensity was also increased (AKRSP, 2000). Similar study of the impact of Idgaon and Bakkhali dams in Bangladesh determined the increase yield and found the ameliorated socio economic indicators (Saleh and Mondal, 2001). Another study carried out by Pender and Berhanu (2002), on the impact of irrigation scheme in Northern Ethiopia suggests substantial improvement in agriculture due to considerable increase in the use of water and inputs. The crop production was 18 percent higher than in the rain fed irrigated land of Northern Ethiopia.

The impact study of irrigation schemes/dams suggests that beside irrigation they have a number of economic benefits including additional agricultural outputs, fishing, hydropower, navigation, increase of water table, recreation, flood control and prevention of drought etc. (Mugabe et al., 2003; Tortajada et al., 2012). The evaluation and monitoring of irrigation schemes play an important role the sustainable water management in water scarce areas (Thawale, 2012). Today in many developing countries irrigation is the largest public investment to combat the domestic demand of food crops (Ashraf et al., 2004; Hillel, 2005). Construction of dams for hydro power and irrigation is an urging requirement to deal with rising need for food and energy in Pakistan (Ashraf at al., 2007; Rahim et al., 2007).

Qilla is a small Mouza of tehsil Tangi, district Charsadda which came under the command of Palai dam irrigation canal. (*Mouza* is locally used term for the smallest unit in the hierarchy of settlements in Pakistan, for which a separate revenue record is maintained). It is situated at a distance of six km from Shakor bazzar, at 34° 15' 30" N to 34° 16' 25" N latitude and 71° 39' 05" to 71° 39' 45" E longitude at an altitude of 465 meters above sea level (Figure 1). Mouza Qilla is an agricultural village where almost every household possess a piece of land. Palai dam is a small dam which is located on the north border of district Charsadda, adjacent to the historic area of Mohmand agency. The construction of dam was started in 2009 by Niamatulla Construction Company (pvt.), but the 2010 Flood drastically damaged the project. For construction a sum of Rs. 998 million, was provided by Federal Government. The dam was completed in 2011. Government of KP claims that it will irrigate about 5000 acers of land in four *Mouzas*. Keeping in view the importance of irrigation in the development of agriculture, the present study was designed with the objective to determine the impact of Palai dam on the land use and cropping pattern of mouza Qilla.

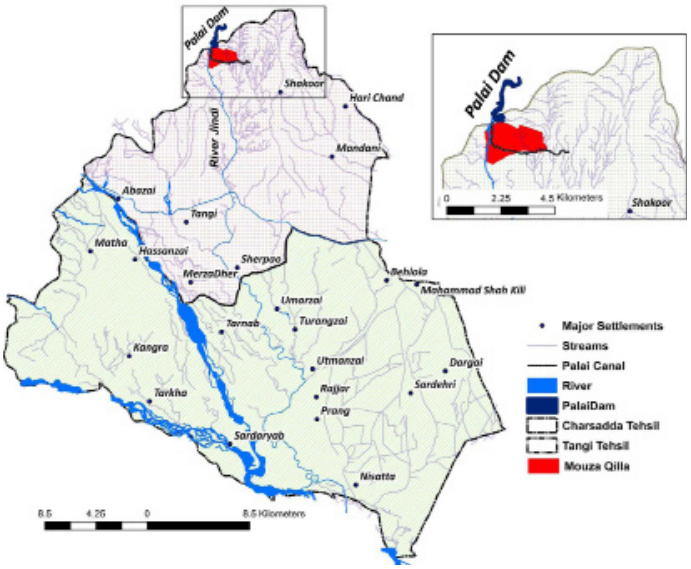

Figure 1: *Mouza Qilla, (study area) Khyber Pakhtunkhwa, Pakistan*

Materials and Methods

Data collection

The study was based mainly on secondary data collected from the Revenue office Tangi, district Charsadda. The record was available and collected for 2008-09 and 2013-14 representing the before and after dam situation. The data collected include the following:

- Area under different crops and the type of crops

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sown in winter and summer.
- *Khasra Number* of the parcel, name of owner/cultivator, area of the *parcel,* type of land/land use, irrigation type and crop grown in *Rabi* and *Kharif.*
- Cadastral maps showing the boundaries of the property (*Parcels*) along with the ownership.

Primary data regarding crop yield before and after the dam construction, per acre production before and after dam, new crops and crop varieties introduced after dam construction, change in household income after dam construction, change in cropping pattern *etc.* was collected with the help of questionnaire survey. A household survey was conducted and a total of 50 questionnaire were filled covering 45% of the universe. Besides the GPS way points were collected for the control points, which were used for georefrencing of cadastral map.

Data analysis

The collected data was geo-spatially analyzed in Arc GIS (10.1 Registered version) with the help of Core i7 Dell Computer, with Inspiron version using window-10 of Microsoft. Geographic Information System is an automated system for creating, editing, analyzing and displaying spatially referenced data. GISspatial analysis is a rapidly changing field, and GIS packages are increasingly including analytical tools. It integrates spatial and non-spatial information from divergent sources within a single system, it offers a consistent framework for analyzing geographical data and in turn enhance the decision making. The study used an integrated approach including simple descriptive statistical analysis and temporal spatial correlation analysis linked to GIS.

Cadastral map locally known as *SHAJRA* or *LATTHA* is a large scale map on which Patwaries (The official of revenue department responsible to keep the revenue record) show the boundaries of the property (Parcels) along with the ownership. Khasra number is the primary field and all other records *i.e.* Land use, Cropping Pattern, Irrigation type *etc.* are linked with it. The Cadastral map was scanned and import to GIS environment where it was georeferenced with the help of ground control point. Than every parcel was digitized and all the other information related to that parcel were entered in the attribute table linked to that parcel. Figure 2, explains the methodology followed to achieve the objectives

Table 1: *Mouza Qilla, change in area under different landuse categories acreage before and after the construction of Pallai dam*

Lands classification	Before the dam 2008-09		After the dam 2013-14		Change (area in acres)
	2009 (area in acres)	%age of Total area	2013 (area in acres)	%age of Total area	
Cultivated land					
Area net sown	63.37	11.52	68.99	12.55 4.46	+7.08
Current fallow	30.16	5.48	24.55	12.55 4.46	-5.61
Total cultivated area (a+b)	93.54		93.54		
Uncultivated land					
Cultivable waste land	2.57	0.46	2.57	0.46	0
Culturable waste land					
Graveyard	0.59	0.10	0.59	0.10	0
Path	0.31	0.05	0.31	0.05	0
Road	1.54	0.28	1.54	0.28	0
Settlement	7.01	1.27	7.01	1.27	0
Not available for cultivation					
Natural drainage	1.62	0.29		0.29	0
Mountains	409.09	74.43		74.43	0
River Jindi	33.34	6.06		6.06	0
Total uncultivated (c+d+e)	456.07		456.07		
Total area (1+2)	549.61		549.61		

Source: *Revenue Record*

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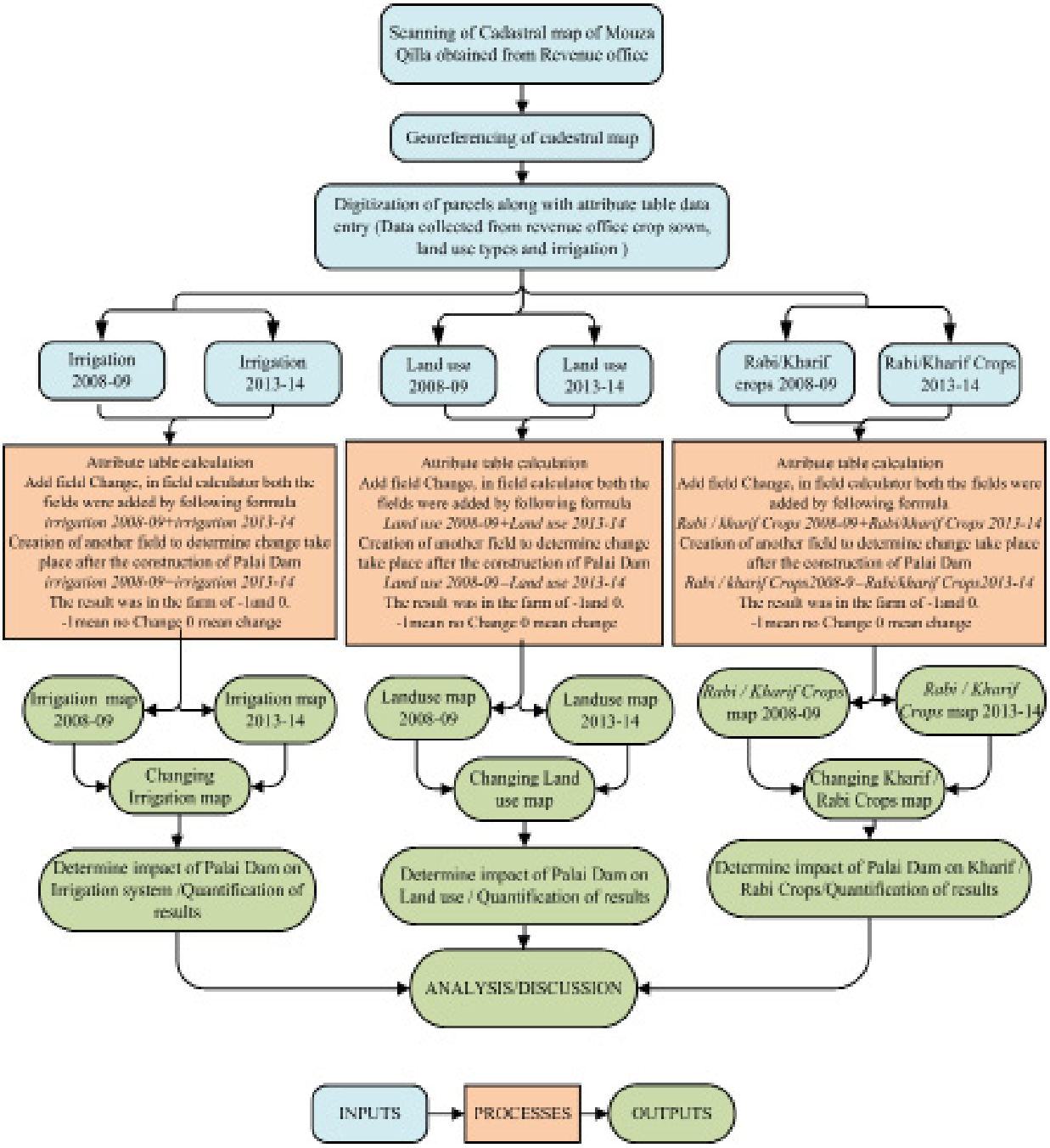

Figure 2: *Flow diagram showing methodology for analysis in ARC GIS*

of the study in GIS environment.

Results and Discussion

Impact of Palai dam on land use pattern

Mouza Qilla is a small agriculture village which exhibits a very simple land use pattern. According to revenue record the total numbers of parcels (fields) in Mouza Qilla are 219 with a total area of 549.61 acre. Land use is dominated by features like mountain, river Jindi and natural drainage, which account for 456.97 acre (83.14% of total area). According to revenue record, the cultivated land in 2008-2009 was 93.54 acre (17.01% of total area) which remains the same after the construction of Palai dam in 2013-14. The cultivated land is further divided into current fallow and area net sown (area net sown is the area which is cropped during the census year). According to revenue record area net sown has increased from 63.37acre in 2008-09 to 68.99 acre in 2013-14. Similarly, the current fallow (current fallow is the area

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Table 2: *Mouza Qilla, change in crop acreage before and after the Pallai dam.*

Cropping season and crops	Before the dam 2008-09		After the dam 2013-14		Change (area in acres)
	Area in acre	%age of cultivated land	Area in acre	%age of cultivated land	
Rabi crops					
Wheat	58.45	62.48	64.80	69.27	+6.35
Onion	04.92	5.25	04.19	4.47	-0.73
Current fallow	30.89	33.02	24.55	26.24	-5.61
Total	93.54	100	93.54	100	
Kharif crops					
Tomato	43.62	46.63	72.75	77.77	+29.13
Vegetables	1.40	1.49	4.04	4.31	+2.64
Sugarcane	0	0	5.93	6.3	+5.93
Current fallow	48.51	51.86	10.82	11.56	-37.69
Total	93.54	100	93.54	100	

Source: *Revenue Record*

which is not cropped during the census year to retain its fertility or because of lack of inputs) records a decrease from 30.16 acre in 2008-09 to 24.55 acre in 2013-14, after the construction of dam. As for as uncultivated land is concerned there is no significant changes take place in any categories of uncultivated land. Table 1, shows the area under different land use categories before and after the construction of Palai dam.

Impact on cropping pattern

The cropping pattern of an area is influenced by both natural and cultural factors. The main factors are climatic, soil conditions, water availability and prevailing land tenure system etc. In those villages which are located very close to urban areas or on major high ways, market may be another factor for crops selection. The study area features two cropping season known as the *Rabi* or winter cropping and *Kharif* or summer cropping. Being a small agriculture village, the Mouza Qilla has a very simple cropping pattern dominated by wheat and onion in *Rabi* while tomato and sugarcane in *Kharif*. Table 2 is showing the change in crop acreage before and after the Palai dam.

Rabi cropping pattern

Rabi crops are sown in October/November and harvested in April and May. The most important *Rabi* crop of the Mouza in 2008-09 was wheat followed by onions. Wheat records an increase from 58.45 acre in 2008-09 to 64.80 acres in 2013-14. This increase in area under wheat is the result of canal construction. The area under onion decrease from 4.92 acre to 4.19 acre. Table 3 and Figure 3 are showing the impact of Palai dam on *Rabi* crops.

Table 3: *Mouza Qilla, impact of Palai dam on rabbi cropping pattern*

Change in rabi cropping pattern	No of parcels	Area in acre
Current fallow in 2009-10 cropped with wheat in 2013-14	15	6.98
Current fallow in 2009-10 cropped with onion in 2013-14	02	1.34
Onion in 2009-10 cropped with wheat in 2013-14	02	2.08
Wheat in 2009-10 become current fallow in 2013-14	04	2.71
Total	23	13.13

Source: *Revenue Record, Analysis in GIS*

Kharif crops

Kharif crops are sown in May/June and harvested in September. Some of the important *Kharif* crops of the mouza are tomato, sugar cane and vegetables. Sugarcane is being introduced in 2013, after the construction of Palai dam. The analysis reveals that in 2008 the area under tomato was 43.6 acre which increased to 72.75acre in 2013. Tomato and sugar cane are emerged as most important cash crops of the area after the construction of dam. Vegetable in 2008

were cultivated on 1.40 acre of the total cultivated land which increased to 4.04 acre in 2013. Table 4 and Figure 4 are showing the impact of Palai dam on *Kharif* crops. After the construction of Palai dam Kharif vegetables were cultivated on 4.31 percent of the total cropped area. Tomato, which were grown on 46.64% of the net sown area, increased to 77.77% of the total net sown area after the dam. Sugarcane was absent before dam is gaining importance and now is grown on 6.3% of the area. The yield of various crops also recorded a gradual increase.

Impact on cropping intensity

Cropping intensity is the ratio between cropped area and area net sown. It is therefore, refers to producing a number of crops from the same field during the same agricultural year. The cropping intensity of the mouza was calculated by the following formula (after the Bureau of Statistics, Government Khyber Pakhtunkhwa, 2014; Sakila Haque, 2015). The most obvious and immediate impact of the Palai dam and canal would be

Table 4: *Mouza Qilla, impact of Palai dam on kharif cropping pattern*

Change in cropping pattern	No of parcels record change	area in acre	% of total area record change
Current fallow in 2009-10 cropped with tomato in 2013-14	64	32.85	76.46
Current fallow in 2009-10 cropped with sugar cane in 2013-14	04	3.64	8.47
Current fallow in 2009-10 cropped with vegetable in 2013-14	06	2.09	4.86
Tomato in 2009-10 converted to current fallow in 2013-14	01	0.25	0.85
Tomato in 2009-10 cropped with Sugar cane in 2013-14	03	2.28	5.30
Tomato in 2009-10 cropped with vegetables in 2013-14	03	1.89	4.39
Vegetables in 2009-10 become current fallow in 2013-14	01	0.64	1.48
Total	82	42.96	

Source: *Revenue Record, Analysis in GIS*

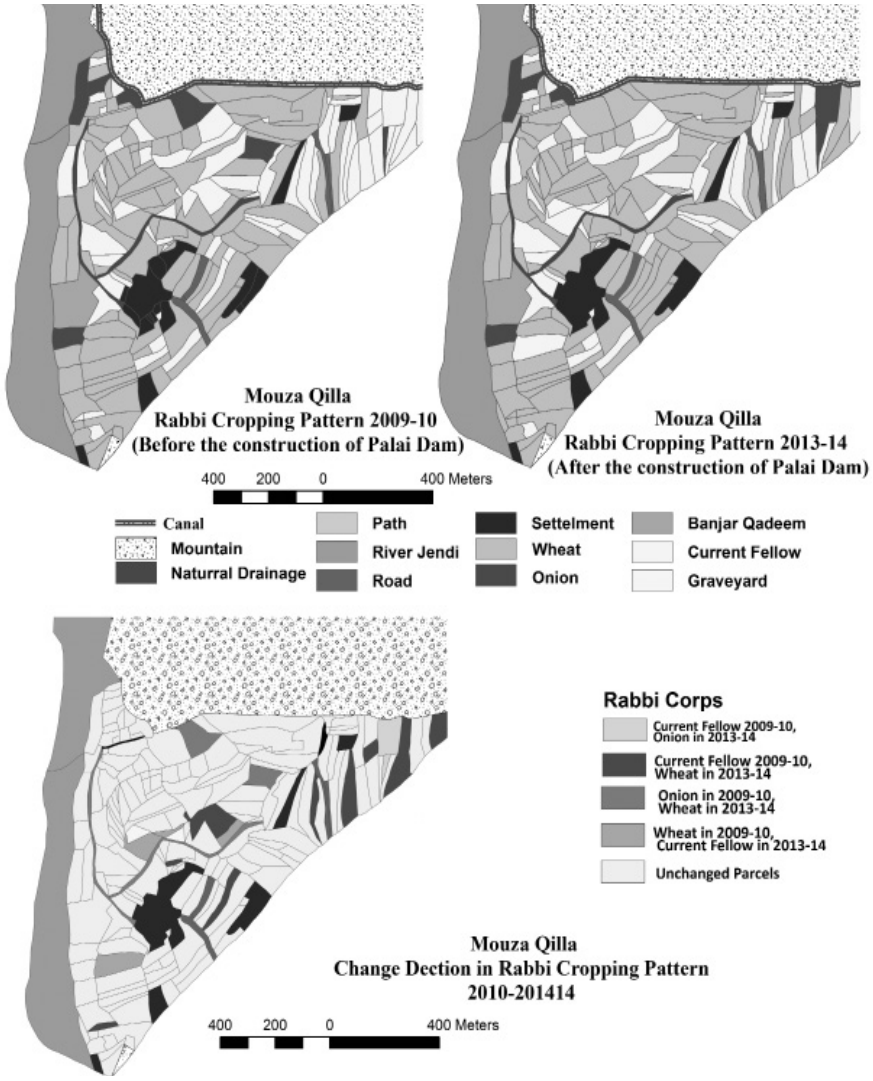

Figure 3: *Impact of Palai dam on Rabi cropping pattern of Mouza Qilla 2010-14*

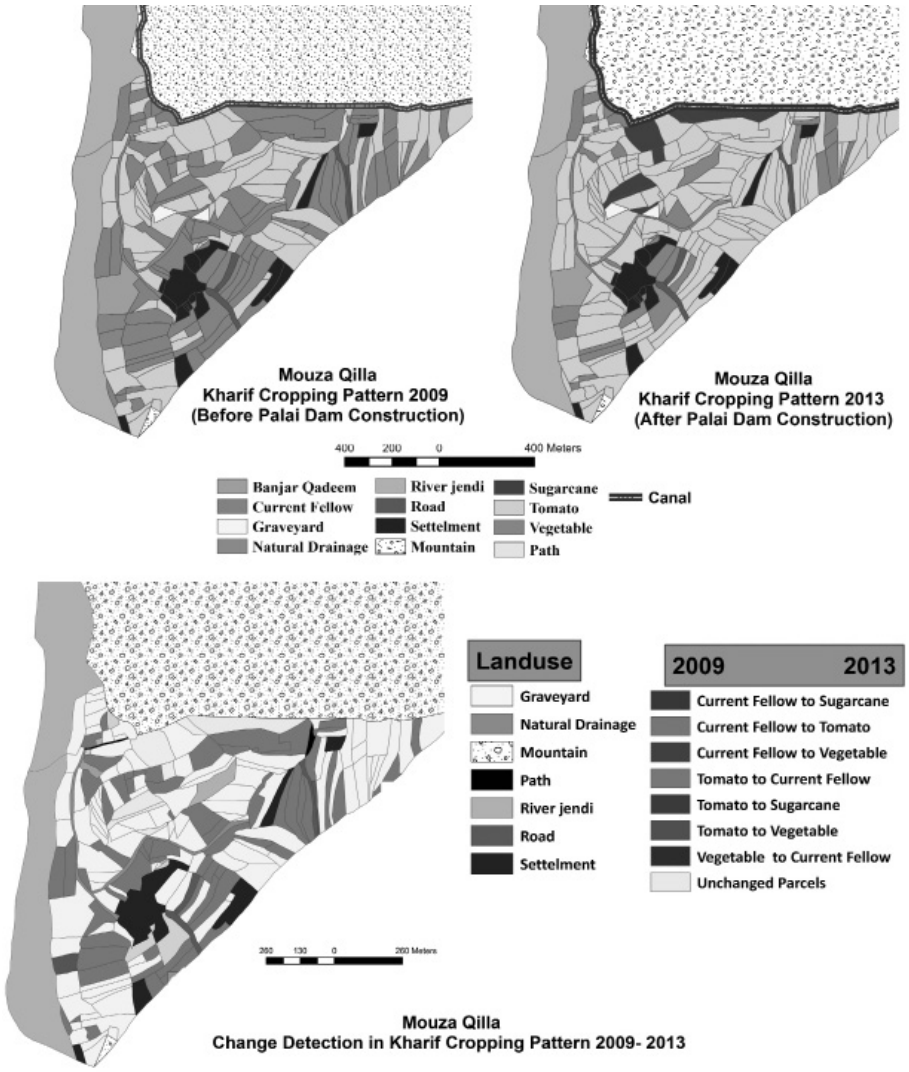

Figure 4: *Impact of Palai dam on Kharif cropping pattern of Mouza Qilla*

Table 5: *Mouza Qilla, impact of Palai dam on cropping intensity and revenue*

Season	Crops	Rs kg^{-1} 2014	Before dam			After dam			Increase in revenue (after dam-before dam)
			Area in acre	Yield kg acre^{-1}	Revenue in PKR	Area in acre	Yield kg acre^{-1}	Revenue in PKR	
Rabbi	Wheat	35	58.45	1000	2045750	64.80	1900	4309200	2263450
	Onion	40	4.92	1850	364080	4.19	3800	636880	272800
Kharif	Tomato	60	43.62	2600	6804720	77.77	3800	17731560	10926840
	Vegetables	30	1.40	1800	75600	4.31	2700	349110	273510
	Sugarcane	50	0.0	0		6.3	1600	504000	504000
Total			108.39	7250	9290150	157.37		23530750	14240600

Source: *Field Survey 2014, Revenue record*

increased in cropping intensity. The cropping intensity of the Mouza in 2008-09 was 170.80%, which increase to 261.28% after the construction of Palai dam in 2013-14. Table 5 is showing the impact of Palai Dam on the cropping intensity and revenue.

$$\text{Cropping Intensity} = \frac{\text{Total cropped area}}{\text{Area net sown}} \times 100$$

(Cropped area include the area which is fit for cultivation and include both the area net sown and current fallow. Net sown area is the area actually cropped during the census year)

$$\text{Cropping Intensity before Dam} = \frac{108.39}{63.46} \times 100 = 170.80\ \%$$

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$$\text{Cropping intensity after Dam} = \frac{180.26}{68.99.74} \times 100 = 261.28\%$$

Provision of irrigation water after the construction of dam not only increase the cropping intensity, but the level of crop failure also decrease and that's the real difference-making factor. Before dam construction the probability of the crops reaching full maturity was low as tube-well irrigation and rainfall are insufficient. This problem was mostly overcome with canal irrigation. Higher cropping intensity implies that a larger part of the area net sown is cultivated more than once during a revenue year. Which also mean higher production during one revenue year.

Impact on crop revenues

The statistical analysis of the revenue generated before and after the dam of individual respondents was carried out. The price of 2014 were used to avoid inflation. The total revenue generated before the construction of dam was Pakistani Rupees 9.29 million which increased to Pakistani Rupees 23.53 million after the dam. The net increase is Pakistani Rupees 1.42 million. The average household revenue before construction of dam was 81492.00 PKR, which increased to 2,064,10.00 (According to 1998 census the total households in Mouza Qilla are 114).

It was concluded that a significant increase in the revenue from increase crop production and shifting from wheat to sugarcane as a result of dam construction.

Impact on irrigation system

Mouza Qilla is located in a semi-arid area, therefore both *Kharif* and *Rabi* crops are dependent on irrigation. Mouza Qilla though located on the left bank of Jindi River, never being irrigated by river. Before the construction of Palai dam and canal in 2008-09 the major source of irrigation was tube wells, which accounts for 81.67 acre. A total of 158 *parcels* were irrigated by tube wells. Rain fed irrigation was the second largest source of irrigation. A total of 25 *parcels* were dependent on rainfall which accounts 11.88 acre of cultivated land. There was no canal irrigated land in the Mouza before the construction of dam and canal. the completion of Palai dam and irrigation canal in 2011 brought far-reaching change in the irrigation system of the Mouza. In 2013-14 the tube well irrigated land decrease from 81.67 acre in 2008-09 to 37.46 acre. The number of *parcels* irrigated by tube well decreased from 158 to 75 in 2013-14. Today canal irrigation is the largest source of irrigation in the Mouza, which accounts for 56.09 acre. Table 6 is showing the source of irrigation before and after the construction of dam, while Table 7 and Figure 5 is showing the impact of Palai dam on source of irrigation.

Table 6: *Mouza Qilla, source of irrigation 2009-14*

Source	2008-09		2013-14	
	Area in acre	No. of parcels	Area in acre	No. of parcels
Tube well	81.67	158	37.46	75
Rain fed	11.88	25	0.00	00
Canal	0.00	00	56.09	108
Total	93.55	183	93.55	183

Source: *Revenue Record, Tangi Tehsil*

Table 7: *Mouza Qilla, impact of Palai Dam on source of irrigation 2009-14*

Change in source of irrigation	No of parcels	Area in acre
Rain fed irrigation in 2009-10, canal irrigated in 2013-14	25	11.88
Tube well irrigated in 2009-10, canal irrigated in 2013-14	83	44.20
Total	108	56.09

Source: *Revenue Record, Tangi Tehsil, Geo-Spatial analysis*

Conclusion

The geospatial analysis of the revenue record reveals that overall impact of the Palai Dam is extremely significant. Before the construction of Palai Dam and irrigation canal in 2008-09, the major source of irrigation in the mouza was tube wells, which accounts for 81.67 acre of total area. (A total of 158 *parcels* were irrigated by tube wells). Rain fed irrigation was the second largest source of irrigation which accounts for 11.88 acre of cultivated land. The completion of Palai Dam and irrigation canal in 2011 brought significant change in the irrigation system of the Mouza. In 2013-14 the tube well irrigated land decrease from 81.67 acre in 2008-09 to 37.46 acre. The number of *parcels* irrigated by tube well decreased from 158 to 75 in 2013-14. As a result the century old traditional cropping pattern has went under worthy and yielding changes. The emphasis of farmers is shifted from subsistence to commercial farming. The cropping intensity increased from 170.80 before dam construction to 261.28 after the dam. The yield of all the crops grown are substantially increased, which in turn boost

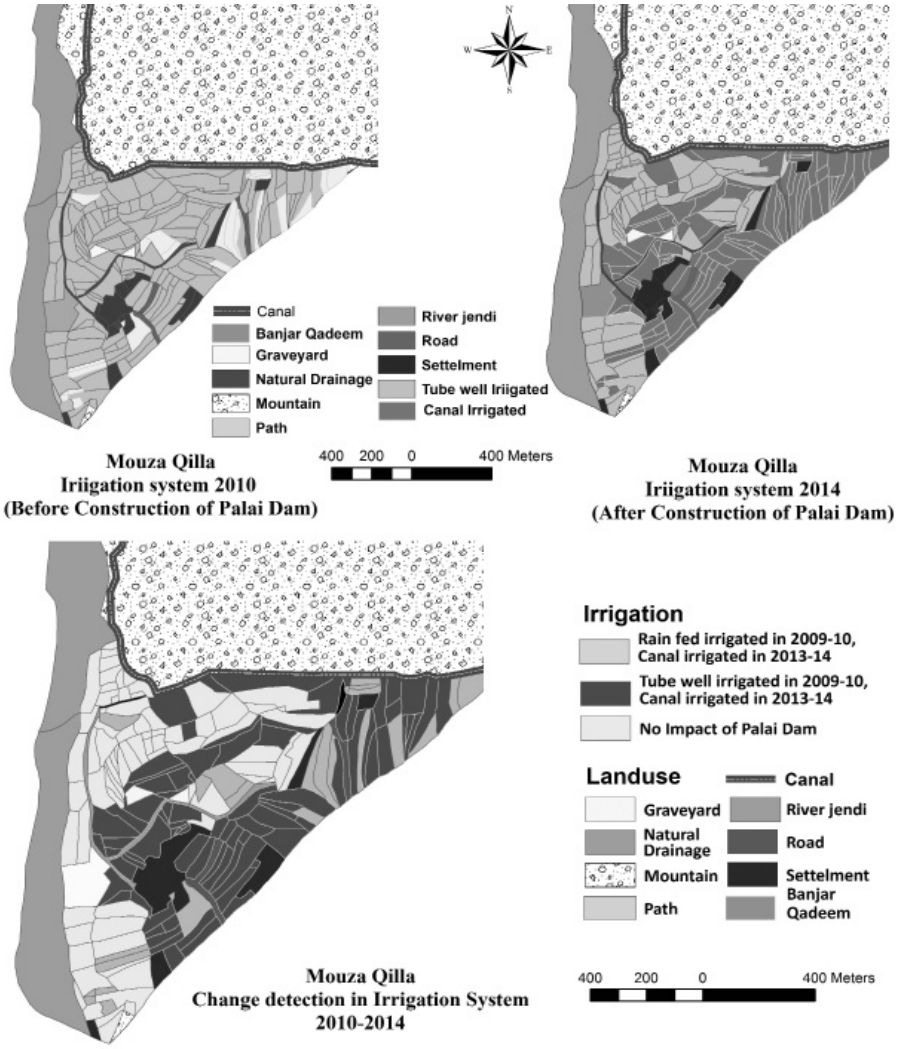

Figure 5: *Showing the impact of Palai dam on irrigation system of Mouza Qilla*

up the overall socio economic development of the study area.

It can be concluded that small dams like Palai dam are highly desirable and the construction of further small dams is strongly recommended in future, across the KP. However for maximum benefit, the proper management of water resources is highly recommended. Farmers whose land is located at the tail end of the command area of the dam, are facing acute shortages of water. The uneven water distribution causing conflicts among farmers. The whole channel should be lined in order to avoid water loss. There is a dire need to create farmers associations which not only can take care of irrigation infrastructure but also helpful in resolving conflicts by rationing of water and *warabandy* system (Rotational system with fixed time allocated on the basis of landholdings). The Mouza has potential for increasing crop production and land use intensity, but to get maximum benefits the agriculture extension services should be provided in the area.

Author's Contribution

Dr. M. Jamal Nasir analysed the data in GIS, mapped it and wrote the manuscript. Dr. Anwar Saeed Khan wrote and reviewed the manuscript. Said Alam and Saeed Akhtar collected the data from the revenue office Tangi, District Charsadda.

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