Evaluating Impacts of Chashma Right Bank Irrigation Project on the Cropping Intensity of District D.I.Khan

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Abstract

This paper assesses the impacts of Chashma Right Bank Irrigation Project (CRBIP) on the cropping intensity in D.I.Khan district, Pakistan. To enhance agricultural productivity, the Chashma Right Bank Canal (CRBC) project was launched in 1984, which brought vast Gomal plains under the irrigation network. With the command area of 250,000 hectares, the project spreads over two provinces of Khyber Pakhtunkhwa and Punjab. Besides, drastic changes in the arid environment of D.I.Khan district, the project has brought large scale cultivable waste under cultivation. This study is based on evaluating cropping intensity to measure the land use efficiency of agriculture in the study area. The results show that due to canal irrigation, the cropping intensity has overall increased; while in some areas exceeded the proposed targets of the project. However, outside the CRBC command area, no significant change in the cropping intensity has occurred. The study suggests that cropping intensity could further be enhanced with the extension of canal irrigation to the remaining un-served parts of the district and multiple cropping patterns.

Keywords: Chashma Right Bank, Irrigation, Cropping intensity, D.I.Khan

Introduction

D.I.Khan is the southernmost district of Khyber Pakhtunkhwa (KPK), Pakistan. Geographically, D.I.Khan district stretches between 31^0 15' to 32^0 32' North latitude and 70^0 11' to 71^0 20' East longitude (Map 1). Here, water is one of the most valuable natural resources. There is a great

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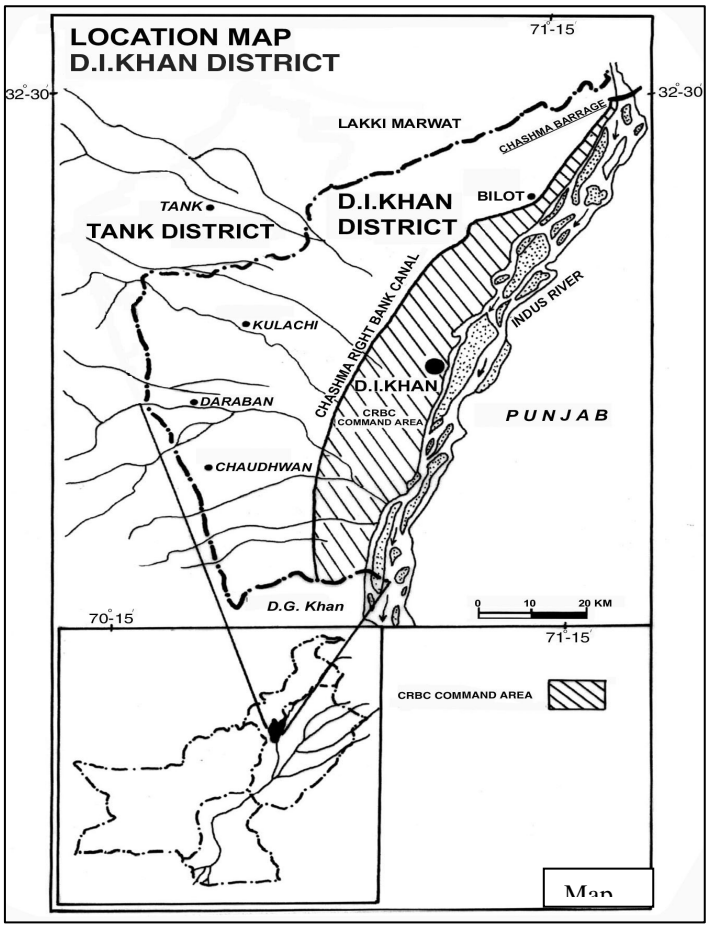
potential for water resource development in general and irrigation development in particular. Nevertheless, so far very little progress has been made in this respect. Likewise, in D.I.Khan uncertain climatic factors also become barriers in the development process, including arid to semi-arid climatic condition. In the study area Rod Kohi (hill torrent irrigation), lift irrigation, flood irrigation and canal irrigation are the major form of irrigation. However, Rainfed *(Barani*) farming dominates the land use. However, erratic rainfall largely results in crop failure before ripening. Therefore the yields are comparatively low. Contrary to this, irrigation has the potential to bring large scale transformation in the land use, cropping pattern and cropping intensity (Ali, et al., 2004). Historically, it had been a human effort to bring water through canal irrigation systems in the arid and semi-arid area.



In district D.I.Khan, dry conditions remained the major limiting factor in changing land use and cropping system. Therefore, an intervention was made in the form of Chashma Right Bank Canal (CRBC) during 1987. The Chashma Right Bank Irrigation Scheme is a large irrigation network spread over the two provinces i.e. KPK and Punjab. The total canal command area is 250,000 ha, out of which 152,500 ha is in D.I.Khan district (Ahmad, 1993; WAPDA, 1995). The ultimate goal of the Chashma Right Bank Irrigation Project (CRBIP) was to increase agricultural productivity and strengthening institutional support in the agriculture sector (WAPDA, 2002). All these goals were aimed to alleviate poverty in the area (ADB, 1987). Availability of water through large-scale surface irrigation in this arid tract has brought revolutionary changes in both physical and cultural environment.

Prior to the construction of CRBIP, the cropping intensity of D.I.Khan district was 28%. One of the objectives of CRBIP was to raise cropping intensity from mere 28% to 143% in the CRBC command area. This paper is aimed to investigate the ex post impacts evaluation of CRBIP on the cropping intensity of D.I.Khan district. This is a sort of pioneering study of its nature in evaluating irrigation projects in Pakistan. In this paper analysis has been made at two levels i.e. micro and macro. This study may be used as a guideline for decision makers, planners to assess land use efficiency of irrigation projects in future.

This paper is divided into four sections. Section one of the paper deals with the detailed introduction of the study, while section two describes the methods and material used for this research. The following section gives analysis, results and discussion. The paper is concluded in the final section.

Materials and Methods

Conceptual framework

The world's population continues to grow progressively. Therefore, dams and irrigation projects are required to be built, particularly in the developing countries to cater the food requirements of the growing population (Stockle, 2001). However, it is important to ensure that such projects must be built to higher standards and with due accountability to local people and their environment than in the past (Singh, 1991; Stockle, 2001; Government of India, 2002).

Increasing expansion in the irrigated area is possible mainly due to large-scale irrigation projects involving enormous capital expenditure (Cantor, 1967; Garg, 1987). Irrigation projects are usually associated with its positive impacts on human life. However, ill planned projects

and unwise irrigation practices are always associated with adverse impacts on environment. These impacts may eventually curtail the sustainability of irrigation projects (Dalua, 1993). Hence, all the irrigation projects cause both positive and adverse impacts on the environment. However, the positive impacts of irrigation projects do not need any emphasis particularly during the times of acute food shortages and growing population. The spread of irrigation has been a key factor behind the near tripling of global grain production, since 1950. However, it is very unfortunate that about one-third of the world's irrigated lands have reduced productivity because of poorly managed irrigation system (Sadhukhan, 1990; Khan and Ali, 1998; Hussain, 2004; Khan, et al., 2006). Literatures on irrigation sector have already focused attention on socio-economic aspects, but impacts on the physical environment have not been properly considered (Amarasekara, 1993).

The concept of impact evaluation has been variously defined, because it conveys different meaning to different people (Havens, 1981; Hussain, 1991; Baker, 2000; Maredia, et al., 2000). The evaluation may be described as a systematic process of collecting and analysing data to measure pre-determined objectives and targets of a project within a specified time period (Hussain, 1991). A more specific definition is put forward by Rutman (1982) that evaluation deals with the use of scientific method to measure the implementation and out-come of the project for decision-making. The project evaluation is a process to analyse the achievements and results of the completed projects (Hussain, 1991). Evaluation actually measures the effects of the outcome against the specified goal of a project (Havens, 1981). Ex post evaluation is an applied and interdisciplinary science activity (Hussain, 1991; ADB, 1993; Baker, 2000; Maredia, et al., 2000). It is a type of evaluation that is intended to determine the consequences of an intervention. This analysis can be either ex ante or ex post, which measures the outcomes that have actually resulted from the intervention to date (Baker, 2000; Maredia, et al., 2000). Ex post evaluation provides feedback for future irrigation projects (Hussain, 1991).

Cropping intensity refers to the number of crops grown on the same area in any one year (Gajja, 1991). Cropping intensity indicates the extent to which cultivated area was used for cropping. It is also expressed statistically e.g. total cropped area as a percentage of the total cultivated land (GoP, 2004). Thus, higher would be the intensity of cropping higher is the agricultural land use efficiency and vice versa (Hirashima and Gooneratne, 1990; Gajja, 1991; GoP, 2004). Various studies on the irrigation projects indicate that with the availability of assured canal irrigation the cropping intensity has improved (Hirashima

and Gooneratne, 1990; Khan and Ali, 1998; Ahmed, 2000; Osman, 2003). The study on Fertility Impact of the Rahad Irrigation Project, Sudan found that irrigation project has influenced the income level, labour force participation and economic productivity due to higher cropping intensity (Osman, 2003). The study on role of Aswan high dam, Egypt indicates that cropping intensity was greatly enhanced after commissioning of canal irrigation (Ahmed, 2000). After the inception of Warsak Right Bank Canal, the cropping intensity has increased from average 20% to 110%. The cropping intensity is comparatively high at head reaches than the tail one (Khan and Ali, 1998). The irrigation and water management in Asia indicates that application of irrigation has increased the cropping intensity and is one of the positive impacts of irrigation projects (Hirashima and Gooneratne, 1990).

Data collection and analysis

To evaluate the ex post impacts of CRBIP and achieve the study objectives, both primary and secondary sources were used. Such data and information were obtained both from inside and outside the CRBC command area. In D.I.Khan district, there are a total of 384 villages (GoP, 1999). Data about cropping intensity before and after CRBC of entire district were collected, in order to get clear picture of CRBC impacts on the cropping intensity of D.I.Khan district. Ideally, the entire villages should have been surveyed for in-depth study. However, due to time and resource constraint, sampling technique was applied. Hence, for micro level analysis four villages were randomly selected from the CRBC command area namely: Jarra, Gomal, Buchari and Chera. Likewise, one village i.e. Khudaka was also randomly selected from outside the CRBC command area. The sample sites were selected from all the three stages of CRBC.

Initially, a series of reconnaissance visits were made to grasp an idea of positive and adverse impacts of CRBC on the cropping intensity. After the observations several field visits were made. For collection of primary data, four different types of questionnaires were designed i.e. for individual household, Focused Group Discussions (FGD's), the line agencies and *Patwari* (in-charge revenue record) of the study area. Questionnaire for the individual households were administered to the general public. Similarly, for every sample village two to three questionnaires for the whole village were filled during FGD's with the community leaders and elderly people. Group discussion with the community leaders, local organizations and farmers were the landmark feature for cross checking the individual data. Questionnaire for the line

agencies were filled-up by interviewing officials of the concerned line agencies.

Secondary data was obtained from the offices of related line agencies, NGO's, reports, journals, maps and electronic database searches etc. Data regarding each and every plot of sample villages, before and after the CRBC were obtained from the revenue records of D.I.Khan district. The collected data was then analysed, using GIS and statistical techniques. Finally, the data was presented in the form of maps, tables and statistical diagrams.

Results and Discussion

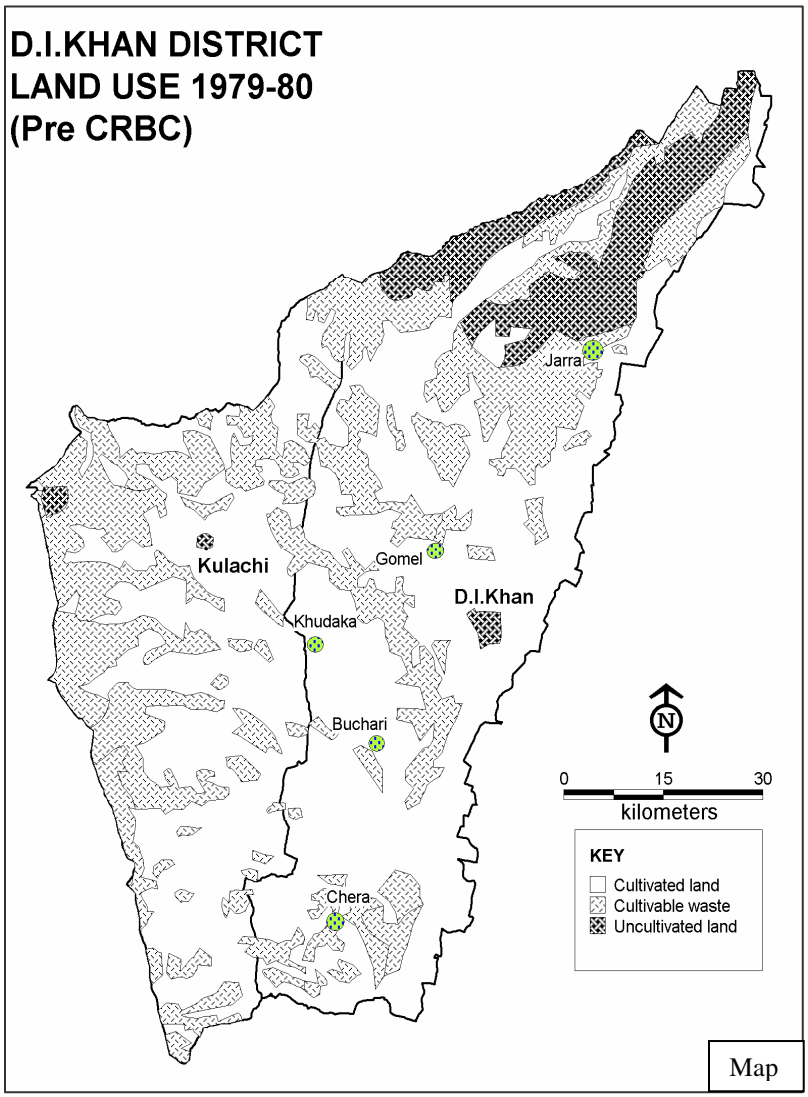
This section presents an analysis of the data at two levels i.e. macro and micro. At macro level, focus has been on the entire district, whereas at micro level five sample villages selected randomly from different environmental settings have been assessed.

Impacts on cropping intensity (Macro-level analysis)

Cropping intensity is directly influenced by certain factors such as land use, availability of water and cropping pattern etc. Before discussing macro level cropping intensity, it is essential to provide background information about the ex post conditions of land use, irrigation and cropping pattern. These indicators will however provide firm foundation to ex post impact evaluation of CRBC on the cropping intensity.

In D.I.Khan district, land use has been classified into cultivated, uncultivated and cultivable waste land (Map 2 and 3). In D.I.Khan district, cultivated area is the second largest land use category after cultivable waste (GoNWFP, 1975; 1980; 1991; 2000 and 2004). The total reported area of D.I.Khan district is 730,575 ha, out of which 232,036 ha was cultivated pre construction of CRBC in 1969-70. The Table 1 reveals that after inception of CRBC, area under cultivation has increased to 238,678 ha in 1989-90, which in 1999-2000 reduced to 233,100 ha. The increase in the cultivated area during 1989-90 was due to the inception of canal irrigation in the form of CRBC, whereas reduction in the cultivated area during 1999-2000 is attributed to the drought spell (1997 to 2003) in Pakistan (Sheikh, 2004). Subsequently, in 2003-04, the cultivated area once again increased and marked the figure of 236,371 ha, which is approximately 32% of the total reported area. Thus increase in the cultivated area has been recorded after the lapse of drought condition. It causes a positive change of about 0.58% of the total reported area. Hence, there has been gradual increase in the cultivated area particularly after the inception of canal irrigation in the form of CRBC.

In D.I.Khan district, large tract is uncultivated and hence agriculturally unproductive. The analysis reveals that before the construction of CRBC (1969-70), the uncultivated land was 132,408 ha, which after advent of CRBC gradually increased to 132,428 ha (1989-1990). This figure has further increased to 132,487 ha in 2003-04. Field survey together with the secondary data also reveals that both cultivated and cultivable waste has been gradually consumed by the built-up area (uncultivated area). This alarming change has been attributed to the increase in the district population and socio-economic development in the area in the post CRBC scenario.



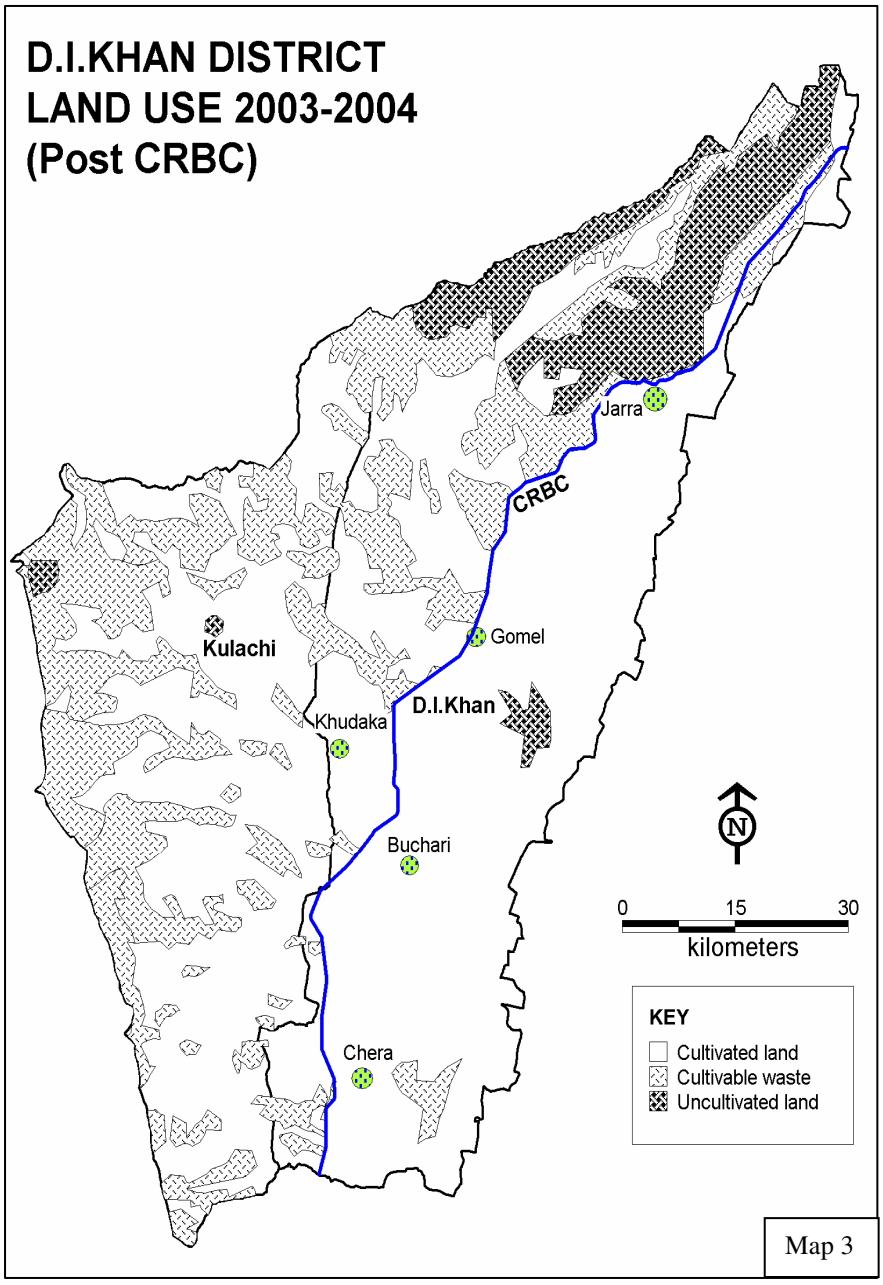

D.I.KHAN DISTRICT
LAND USE 2003-2004
(Post CRBC)
Jarra
CRBC
Gomel
Kulachi
D.I.Khan
Khudaka
Buchari
Chera
N
0
15
30
kilometers
KEY
Cultivated land
Cultivable waste
Uncultivated land
Map 3

Table 1
D.I.Khan district, pre and post CRBC land utilization, 1969-70 to 2003-2004 (Area in ha)

Year	Total Area	Cultivated Area			Area not available for cultivating		
		Total	Net Sown	Current fallow	Cultivable waste	Uncultivated area	Forest
1969-70	730,575	232,036	113,292	118,744	366,132	366,047	4,048
1979-80	730,575	232,108	DNA	DNA	366,047	132,420	4,048
Post CRBC							
1989-90	730,575	238,678	131,688	106,990	355,561	132,428	3,908
1999-2000	730,575	233,100	89,339	143,761	361,116	132,451	3,908
2003-2004	730,575	236,371	104,512	131,859	357,809	132,487	3,908

Source: Go NWFP, 1975; 1980; 1991; 2000 and 2004
DNA- Data Not Available

In D.I.Khan district, cultivable waste has been the largest land use category. This large tract of land under cultivable waste is mainly due to shortage of irrigation water. Nevertheless, cultivable waste has been gradually reduced after the advent of CRBC, but this category is still at number one in the land use classes. During the study period a negative change in the cultivable waste has been recorded, after inception of CRBC. The analysis found that cultivable waste has inverse relation with the cultivated area. As the cultivated land increases, the cultivable waste decreases and vice versa.

In D.I.Khan district, there has been constant increase in the total irrigated area, since 1969-70. In the pre CBRC (1969-70) scenario, the total irrigated land was 52,023 ha, which increased to 145,798 ha (2002-03) due to introduction of CRBC. After CRBC, a net positive change of 10.77% has been recorded in the irrigated area. This increase in the irrigated area is attributed to the CRBC. Therefore, after the inception of CRBC, canal irrigated area has been considerably increased. Presently, the share of canal irrigated area is more than all the other categories. Prior to the construction of CRBC (1969-70), the canal-irrigated area was only 16,517 ha, which is 6.5% of the cultivated area. During the stated period, Paharpur canal was the major source of canal irrigation. After CRBC, the share of canal irrigated area was constantly improved and marked the figure of 127,498 ha in 2002-03.

The cropping pattern is a dynamic phenomenon. It is because of the fact that all the impact factors vital for cropping pattern is consistently changing. Availability of water in the form of irrigation is an important factor, which influence the cropping pattern of any region.

Therefore, irrigation in the form of CRBC has resulted enormous changes in the cropping pattern of D.I.Khan district. In D.I.Khan district, wide variety of crops ranging from arid to humid is cultivated. In D.I.Khan district both Kharif (summer crops) and Rabi (winter crops) are cultivated. Variety of Kharif crops are grown, but the most important are rice, sugarcane, cotton, maize, millet, sorghum, pulses, oilseed, vegetables and fruits. Prior to the inception of CRBC, sorghum and millet were the major crops grown in the district. These crops respond better even if little water is applied. However, after CRBC sugarcane, rice and orchards took the lead and were largely introduced in the Kharif (summer) season. Similarly, important Rabi (winter) crops are wheat, barley, pulse, oilseed, and fruits. The analysis reveals that there has been constant increase in Kharif (summer) and Rabi (winter) acreage particularly after the inception of CRBC. With the advent of CRBC, new water loving crops have been introduced. As a result, water-table is inclining at a rapid pace leading into the problem of waterlogging and salinity in the CRBC command area.

The analysis reveals that since the inception of CRBC, there has been constant increase in the cropping intensity particularly in the CRBC command area. Before the introduction of canal irrigation, the cropping intensity in D.I.Khan district was very low. This was mainly due to limited supply of water for agricultural land. Rod Kohi (hill torrent irrigation) and rainfed cultivation was largely practiced, but with uncertainty in maturity of crops. Pre CRBC, small area was under irrigation, but after CRBC, rapid increase in the canal irrigated area occurred mainly due to the inception of CRBC. However, CRBC has brought an immense change in the cropping intensity.

The Table 2 indicates that before CRBC (1969-70), total cultivated land in D.I.Khan district was 232,036 ha. Out of this cultivated land, area under Kharif (summer) crops was 20,864 ha, making Kharif (summer) cropping intensity of only 9.0%. Similarly, area under Rabi (winter) crops in 1969-70 was 58,375 ha, which has resulted Rabi (winter) cropping intensity of 25.15% (Table 2). The overall picture suggests that the annual cropping intensity was 34.15% during 1969-70.

The analysis further indicates that after the construction of CRBC in 1989-90, total cultivated area has increased to 238,678 ha. Out of this cultivated land, 47,724 ha were under Kharif (summer) crop, making cropping intensity of only 20%. However, during the same year, Rabi (winter) crops were grown over 93,879 ha, giving Rabi cropping intensity of 39%. It means that after the inception of CRBC in 1989-1990, the annual cropping intensity of D.I.Khan district has increased to 49% (Table 2).

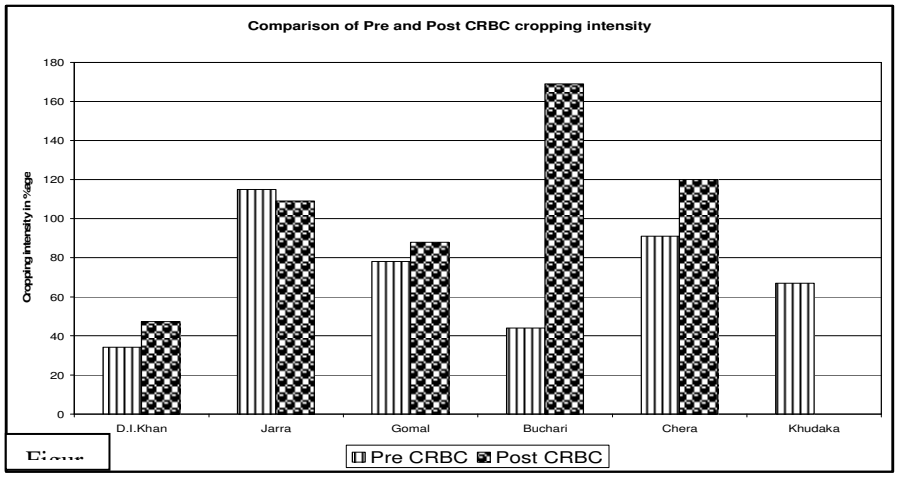
Table 2
D.I.Khan district, Pre and post CRBC cropping intensity, 1969-70 to 2003-2004

Type of area	*Pre CRBC*		*Post CRBC*		
	1969-70	*1979-80*	*1989-90*	*1999-2000*	*2003-2004*
Cropping intensity	34.15%	DNA	49%	46%	47.2%
Cultivated land	232,036	232,108	238,678	233,100	236,371
Kharif (summer) cropped area	20,864 (9.0%)	DNA	47,724 (20%)	42,150 (18%)	40,807 (17.2%)
Rabi (winter) cropped area	58,375 (25.15%)	DNA	93,879 (39%)	65,407 (28%)	70,878 (30%)

Source: GoNWFP, 1975; 1980; 1991; 2000 and 2004
DNA- Data Not Available

In 1999-2000, total cultivated area of D.I.Khan district was 233,100 ha. It is 31.9% of the total reported area. Out of this cultivated area 42,150 ha were under Kharif (summer) crop, making Kharif cropping intensity of only 18% and that of Rabi (65,407 ha) 28% (Table 2). Hence, the annual cropping intensity of D.I.Khan district during 1999-2000 has reduced to 46% as against 49% in 1989-90. The prevailing low cropping intensity was mainly due to dependence on uncertain rainfall and Rod Kohi irrigation together with the drought period (1997 to 2003). Nevertheless, as a whole in D.I.Khan district, the cropping intensity has gradually increased mainly due to the extension of CRBC.

In D.I.Khan district, during 2003-2004, the total cultivated area was 236,371 ha. Out of this cultivated land, 40,807 ha were under Kharif (summer) crops, which has resulted Kharif cropping intensity of 17.2%. Similarly, Rabi (winter) crops were grown on 70,878 ha, which shows cropping intensity of 30%. Hence, the annual cropping intensity of D.I.Khan district was 47.2% during 2003-2004 as against 46%, during 1999-2000 (Table 2). The Figure 1 shows comparison of pre and post CRBC cropping intensity. It reveals that during the study period a positive change has occurred in the cropping intensity. It indicates that after CRBC the land use efficiency has been improved to a greater extent. Field survey together with the secondary data reveals that increase in the cropping intensity has positively affected the socio-economic condition of the study area. Hence, the evidences support that after CRBC the cropping intensity has gradually increased.



Impacts on cropping intensity (Micro-level analysis)

The study also presents the cropping intensity at the micro level. It was found that the cropping intensity of the sample villages varies from one another. The analysis reveals that after CRBC the cropping intensity of CRBC command sample villages have increased, whereas off the commands area no impacts of CRBC on the cropping intensity was detected. The following discussion covers the micro level study of sample villages as discussed below:

Jarra

Jarra, one of the sample villages falls in CRBC stage I and received water from CRBC in 1988-89. Before the construction of CRBC, Jarra was under the command of old Paharpur canal. It has a total area of about 518 ha. In Jarra, two major sources of water were found including canal and rainfall. In Jarra, canal irrigation remained a predominant source of irrigation throughout the study period. In the sample village, canal irrigation is reported, since 1902, when old Paharpur canal was constructed. The analysis reveals that in Jarra, land utilization has been greatly changed after the construction of CRBC. During Kharif (summer), sugarcane, rice, maize, sorghum, fodder, pulses, vegetables and fruits are grown. However, during the study period, the dominant Kharif crops were sugarcane and rice, which hold maximum land cover. Maize, sorghum and fodder were also grown, but due to competition with more productive crops, these were found on relatively limited area. Similarly, wheat, barley, pulses, oilseed, fodder and fruits were grown during Rabi (winter) cropping season. Jarra is also famous for orchard

farming. As a result of these developments, the population of Jarra has comparatively better socio-economic condition.

In Jarra, prior to CRBC (1987-88), the total cultivated land was 389 ha. Out of total cultivated area, 147 ha were under Kharif crop making cropping intensity of 38%. During the same year, area under Rabi crops was 300 ha, which gives cropping intensity of 77% in Rabi. The Figure 1 reveals that in the pre CRBC, the annual cropping intensity was 115%. However, after the inception of CRBC this intensity has been reduced to 109%. This high intensity during pre CRBC is mainly because of the fact that Jarra was under the command of old Paharpur canal. However, after CRBC, the annual cropping intensity was reduced to 55% during 1999-2000. After the advent of CRBC, water loving crops such as rice and sugarcane were largely introduced. Field survey together with the revenue records reveal that after CRBC unwise irrigation practices had severely affected the productive agricultural land by the twin problem of waterlogging and salinity. The analysis further reveals that in 2003-04 once again, the annual cropping intensity was improved to a level of 109%. This increase in the cropping intensity is attributed to the reclamation of waterlogged and saline area.

Gomal

With a total area of about 3,661 ha, Gomal is one of the biggest villages in terms of area in district D.I.Khan. Gomal falls in CRBC stage II and canal irrigation through CRBC started in 1988-89. Prior to CRBC, wells and Rod Kohi were the dominant sources of irrigation, while small area was also found under rainfed cultivation. Therefore, numerous crops are grown since long. The revenue record reveals that in Gomal, prior to CRBC, there were 13 tube wells, out of which, 7 were in government control, while 6 were privately managed. In this village, CRBC passes through the western part of the village. About two third land of the village is under the direct command of CRBC.

Important Kharif (summer) crops are sugarcane, cotton, rice, maize, sorghum, millet, fodder, oilseed, vegetables and pulses. Before CRBC, sugarcane, sorghum and millet dominated the Kharif (summer) cropping season but after CRBC the two water loving crops i.e. rice and sugarcane remained the principal contributors in Kharif (summer) season. Similarly wheat, barley, pulse, oilseed, fodder and fruits are important Rabi crops.

In Gomal, prior to CRBC, the cropping intensity was 42% (1969-70), which after CRBC increased to 88%. The data reveals that before CRBC in 1969-70, Kharif cropping intensity was 6% and that of Rabi 36%. Hence, the annual cropping intensity has marked 42%, which

further increased to 95% during 1979-80. This increase was due to large-scale availability of water from Rod Kohi that has accelerated the Rabi cropping intensity. Before CRBC, the cropping intensity was varied mainly due to its dependence on uncertain Rod Kohi system. However, after CRBC, the annual cropping intensity has shown a consistent increase i.e. 51% in 1989-90, 66% in 1999-2000 and 88% during 2003-04. The analysis further indicates that after CRBC, both cultivated land and cropped area is gradually increasing due to availability of assured canal irrigation. It is expected that if this trend continues, the cropping intensity will further enhance in the future.

Buchari

Buchari falls in CRBC stage III and received water through CRBC in 1994-95. In Buchari, before the inception of CRBC, the cultivated land was entirely dependent on rainfall and Rod Kohi. Field survey together with the FGD's reveals that in Buchari prior to CRBC farmers prefer to cultivate their land after rainfall. Before CRBC, during Kharif cropping season only sorghum and millet were grown but after CRBC area under new water loving crops, cereal crops and pulses has been largely increased. Similarly, major Rabi crops include wheat, barley, gram, oilseed, fodder and fruits.

Buchari has a total area of 550 ha. In Buchari, before CRBC (during 1969-1970), the total cultivated land was only 3 ha due to maximum dependence on uncertain rain and large area was under wasteland. Almost all this area was under Kharif crop, which makes cropping intensity of 100% as against zero in Rabi. Hence, before CRBC in 1969-70, the annual cropping intensity was 100%. Nevertheless, during 1979-80, the annual cropping intensity was reduced to 75% as against 15% during 1989-90. The analysis reveals that prior to CRBC several times even a single plot was not cultivated mainly due to non availability of water. The Figure 1 reveals that prior to CRBC cropping intensity was 44% in 1993-94, which after inception of CRBC has increased to 169%. It is the highest recorded cropping intensity amongst the sample villages. It is even higher than the proposed project cropping intensity of 143%. It is also expected that it will further increase in the preceding years. All this increase in the cropping intensity has been attributed to irrigation facility through CRBC.

Chera

Chera falls in CRBC stage III. This village received water from CRBC in 2000-2001. Before the inception of CRBC, rainfall and Rod Kohi were the two dominant sources of water. Prior to CRBC, important Kharif

crops were sorghum, millet, oilseed, fodder and fruit but after CRBC, sugarcane and pulses were also grown. In Chera, important Rabi crops include wheat, barley, pulse and oilseed.

Chera has a total area of 725 ha. The analysis reveals that in Chera, prior to CRBC in 1969-70, the cultivated area was 356 ha. Out of this cultivated area, 52 ha were under Kharif crops and only 2 ha under Rabi. It means that before CRBC the annual cropping intensity was 16% in 1969-70, 24% in 1979-80, 91% during 1989-90 and 50% in 1999-2000. The data indicates that after CRBC in 2003-2004, the annual cropping intensity increased to 120% with almost equal share from both Rabi and Kharif. This is the highest recorded cropping intensity during the study period and is expected to increase further in future. The analysis reveals that there has been constant increase in the cropping intensity as a result of CRBC. Subsequently, after CRBC both the cultivated area and cropped area were enhanced, which positively affected the cropping intensity.

Khudaka

Khudaka is one of the sample villages located outside the CRBC command area and falls in the command area of proposed Chashma Right Bank 1st Irrigation Project. This village lies right on the left bank of *Luni* hill torrent. In Khudaka, Rod Kohi is the only means of irrigation. Here groundwater is saline and is not fit both for drinking as well as irrigation purpose. Khudaka has a total area of about 320 ha. It lies off the CRBC command area and therefore presents quite a different picture as far as cropping intensity is concerned. The analysis reveals that during 1969-70, the annual cropping intensity was 45%, whereas 114% recorded in 1979-80. However, after 1979-80, even a single plot of land was not cultivated due to non-availability of water from Rod Kohi. Therefore, during the study period, no positive impact of CRBC was seen on the cropping intensity. As a result Khudaka demonstrates very low land use efficiency for agriculture.

Conclusion

The analysis revealed that in D.I.Khan district cropping intensity varies from area to area. Prior to CRBC, uncertain climatic conditions were the major limiting factors for prevailing low cropping intensity. It was found from the analysis that in the CRBC command area the cropping intensity has been increased due to introduction of canal irrigation, whereas low cropping intensity prevailed in the rainfed and Rod Kohi areas.

The district level analysis revealed that after CRBC, the cropping intensity was enhanced considerably. It was found that a positive change

of 13.05% of the total area has been recorded. The analysis of sample villages revealed that in Jarra, a negative change of 6% has occurred, which is mainly due to the problem of waterlogging and salinity. However, in rest of the CRBC command sample villages, the cropping intensity has been improved considerably. In Gomal, 10%, Buchari 125% and Chera 29% positive changes in the cropping intensity have been registered. This is clear indication that after the inception of CRBC, the cropping intensity was enhanced both at micro and macro level. It has registered a significant positive impact on the economic sector of D.I.Khan district. On the other hand, outside the CRBC command area (i.e. Khudaka), no impact of CRBC on the cropping intensity was detected.

The study found that in the CRBC command area, the cropping intensity has gradually increased, but still some land was found fallow. In order to further accelerate the cropping intensity, it is recommended that additional areas should be brought under canal irrigation. Similarly, better use of agricultural inputs and scientific farming technology need to be made available for the farmers. This will ultimately raise the cropping intensity and agricultural production several fold.

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