IMPACT OF RANBIR CANAL CLOSURE ON WHEAT PRODUCTIVITY

By

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(J-17-M-527)

Thesis submitted to Faculty of Postgraduate Studies
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MASTER OF TECHNOLOGY
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IN
SOIL AND WATER ENGINEERING

Division of Agricultural Engineering
Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu
Main Campus, Chatha, Jammu 180009

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CERTIFICATE-I

This is to certify that the thesis entitled "**Impact of Ranbir Canal Closure on Wheat Productivity**" submitted in partial fulfillment of the requirements for the degree of **Master of Technology (Agricultural Engineering) in Soil and Water Engineering** to the Faculty of Post Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, is a record of bonafide research carried out by **Ms. Mubina Banoo,** Registration No. **J-17-M-527** under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma. It is further certified that help and assistance received during the course of thesis investigation have been duly acknowledged.

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ABBREVIATIONS

&	:	And
º	:	Centigrade
′	:	Minutes
J&K	:	Jammu and Kashmir
ha	:	Hectare
%	:	Percentage
/	:	Per
-	:	Hyphen
v/s	:	Verses
C	:	Canal
C + T	:	Canal plus tube well
g	:	Gram
km	:	Kilometer
cm	:	Centimeter
mm	:	Millimeter
F.A.O	:	Food and Agriculture Organization
SKUAST-J	:	Sheri Kashmir University of Agriculture Science and technology - Jammu
AICRP	:	All India Coordinated Research Project
ASCE	:	American Society of Civil Engineers
EWRI	:	Environmental and Water Resources Institute
PMKSY	:	Pradhan Mantri Krishi Sinchaye Yojana
CRI	:	Crown root initiation
LT	:	Late tillering
LJ	:	Late jointing
F	:	Flowering
M	:	Milking

I.W	:	Irrigation Water
C.P.E	:	Cumulative Pan Evaporation
WUE	:	Water use efficiency
etc	:	Et-cetra
et al	:	et-alibi
q/ha	:	Quintal per hectare
MJ/ha	:	Mega joule per hectare
MJ/t	:	Mega joule per tonne
T	:	Treatment
V	:	Variety
t ha^{-1}	:	Tones per hectare
kg $ha^{-1}cm^{-1}$	:	Kilogram per hectare per centimeter
viz.	:	Videlicet
I	:	Irrigation
i.e.	:	That is
S	:	Sowing
t	:	Tonnes
g/m^2	:	Gram per square meter
DAS	:	Days after Sowing
+	:	Plus
g m^{-1}	:	gram per meter
ET	:	Evapotranspiration
CU	:	Consumptive use
K_c	:	Crop coefficient
sq. kms	:	Square kilometers
NIR	:	Net irrigation required
FIR	:	Field irrigation required
GIR	:	Gross irrigation required
w.e.f	:	with effect from
w.r.t	:	with respect to

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Place: Jammu

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ABSTRACT

Title of thesis	:	"Impact of Ranbir Canal Closure on Wheat Productivity"
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In Irrigated belt of Jammu district of J&K state, Ranbir canal is the major source of irrigation. The canal takes its origins from River Chenab at Akhnoor, flows with gravity force and cover 60 km length within Jammu district and irrigate approximate 27,548 ha area under wheat crop. The canal opens from mid-April to end of December and remains closed from January to mid-April for de-siltation. Due to climate change in recent years, the farmers in the command areas are raising hue and cry even going to the extent of blockage of roads to open canal early as the productivity of wheat crop is declining by 10 to 40% due to the change in rainfall pattern as per their perception. The irrigation regimes affect the wheat crop productivity and non-availability of water at crucial stages in command area due to the closure of Ranbir canal system is one of the major factors for the decline in the crop productivity. In this study, rainfall data of 30 years on decadal basis of Jammu district was analyzed. The effect of rainfall v/s crop consumptive use of wheat crop calculated by modified penman method (crop coefficient and pan evaporation data) was compared. In the month of March, when the crop is at milky and later at dough stages, in the Ist decade rainfall is above the demand whereas it is almost same in second decade but it is only 49% in third decade clearly indicating that a deficiency of 51% which forced the farmers to cry for opening of canal at the earliest. In the month of April, the crop water demand is 94.5mm which was sufficiently met in the 1stand 2nddecade but it remains only 12% in 3rd decade showing a deficiency of 88%. Both these deficiency in March and April, makes the grain shrewled (undersize) hence decline in crop productivity as claimed by the farmers. Results further revealed that due to this shortage of water the farming community is suffering a huge loss of amounting to Rs. 17.7 crores. It is suggested that department of irrigation who is maintaining 60 Km main canal system should review the canal closure time for desiltation and repair work in January and February and water should be made available to farmers under each circumstances in month of March and onwards so that the productivity of wheat can be increased.

Key words: Consumptive use, crop productivity, rainfall frequency.

Signature of Major Advisor

Mubina-Banoo
Signature of Student

Introduction

CHAPTER–1

INTRODUCTION

The Government of India is committed to accord high priority to water security and has conceived the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) with the objective of extending the coverage of irrigation in a focused manner, with end-to-end solution on source creation, distribution, management, field application and extension activities. The share of water use other than for agriculture was only 13 % in 1985, which is likely to become 27% by the year 2025 (SKUAST- J ,2009).The fast growth of water need in the face of emerging supply constraints is likely to result in a wide supply gap for irrigation water in near future. The scope of expanding water supplies through development of new water resources is limited as suitable sites are fewer development costs are too high and environmental concerns are too strong.

The crisis about water resources development and management thus arises due to the limited availability of water at the actual place of utilization, as water is very unevenly distributed over place and time, stressing its random and stochastic characteristics. The scarcity of water is mainly due to the following reasons: increase in water requirements due to increase in population, easily available sources of water tapped already, contamination of available water sources due to increase in human activities, industrial development, human needs and desire for higher standards of living, delay in project initiation due to increasing social and environmental concerns.

The Indian sub-continent was blessed with verdant forest, water stocked mountain ranges, grassy pasture, rich soils and a bountiful river system with abundant rain and fertile soils added to this. But years of mismanagement have led to our forest being degraded and water resources diminishing. The rainfall is one of the important parameters of the environment beside air, food & sunlight and it is influenced by various factors like ocean currents, trade winds, air mass movement, orographic effect and the location of the place with respect to the physical barrier. The annual precipitation including snowfall which is the main source of water in India is estimated to be of the order of 4000 km^3 (1200 mm) (SKUAST- J,2009).The rainfall in the country is highly variable, irregular and undependable with wide-spread variations among various meteorological sub-stations in terms of rainfall distribution and amount. Its spatial distribution varies from 100 mm in Rajasthan to about 11000 mm in Cherrapunji in Meghalaya (SKUAST- J, 2009) and because of its wide spatial and seasonal variations, agricultural production is affected greatly by the recurrent floods and droughts of high magnitude in absence of effective water conservation measures. In order to mitigate the harmful effects of weather adversities on agricultural production, country has to conserve maximum available water, and focus on most effective and economic utilization of all water sources (rain, surface and ground water) for sustained higher production without any negative effect in soil health and environmental safety. To overcome these trends in irrigated areas one should irrigate the fields as per its crop water requirements so as to use water judiciously and effectively. As stated earlier rainfall is an important parameter of the environment and its distribution with respect to time and space is not a good situation hence it has given a setback to rice-wheat cropping system being followed in northern India.

Wheat (*Triticum aestivum*) is the major source of fiber, protein and energy in human diet and is second most important cereal crop in the world after rice. Globally, it is cultivated in an area of 225.62 million ha with a production and productivity of 749.50 million tonnes and 3.3 tonnes/ha respectively (www.fao.org).In India, the wheat crop is cultivated in about 30.6 million ha with a production and productivity of 98.38 million tonnes and 3.2 tonnes/ha, respectively (Anonymous, 2018a) and occupying second place in wheat production after China.

In J&K state, the wheat crop is grown in an area of about 290.30 thousand hectares with production and productivity of 5485 thousand quintals and 1890 kg/ha respectively (Anonymous, 2018b). In Jammu division, the area under wheat crop is 282.53 thousand hectares with a production and productivity of 5422 thousand quintals and 1919 kg/ha (Anonymous, 2018b).It is quite less as compared to the national (31.3%) and world (37.1%) productivities. In irrigated belt of Jammu district, rice-wheat is the major cropping pattern being followed from time in memorial. The farmers in the irrigated belt normally grow wheat in the month of November and harvest the same in the month of April whereas the farmers of Kandi belt usually depend on the rainfall pattern and cultivate the same depending on the availability of moisture through rains. The major source of irrigation to wheat crop is through Ranbir canal system and the canal opens from mid-April to end of December and remains closed from January to mid-April for desiltation purposes.

Due to the closure of the Ranbir canal system from January to mid-April, the condition of both rainfed and irrigated belt are the same as both depend on natural rainfall for irrigation of wheat crop. The farmers in the command areas are raising hue and cry even going to the extent of blockage of roads to open canal early as the productivity of wheat crop is declining by 10 to 40% due to the change in rainfall pattern as per their perception. In an experiment conducted at Research Station Vijapur Junagadh, Gujarat, (Package of Practices, 2017), it clearly indicates that the irrigation regimes effect wheat productivity and the yield reduces substantially. If irrigation is not given at critical stages. The yield reduces 35 percent if not given at CRI stage, 20 percent if not given at tillering stage, 20 percent if not given at jointing stage, 25 percent if not given at booting stage, 17 percent at milk stage and 10 percent at dough stage.

From the above discussions, it is clear that the irrigation regimes affect the wheat crop productivity and non-availability of water at crucial stages in command area due to the closure of Ranbir canal system is one of the major factors for the decline in the crop productivity in Jammu region.

The present study entitled “Impact of Ranbir Canal Closure on Wheat Productivity” shall be undertaken with the following objectives:

1. Analysis of rainfall data (*Rabi Season*) of 30 years on decadal basis.
2. Estimation of excess / deficit rainfall based on consumptive use of wheat crop.
3. Estimation of wheat productivity reduction due to closure of Ranbir canal.

Review of Literature

CHAPTER-2

REVIEW OF LITERATURE

Water is a prime source essential for human, animal and plant growth. The major part of water resources is used for the purpose of irrigating the crops to meet the evapotranspiration requirement. The availability of water in any region depends upon the annual rainfall, surface water stored in the reservoirs of dams or supplied by rivers and the ground water reserve.

Improved soil and water management holds the key for increasing agricultural production. Although water is manageable resource yet it is often used in crop production quite wastefully. Injudicious irrigation practice not only results in wasteful expenses of costly and scarce water and energy resources but it also causes salt accumulation, water logging and low productivity of soil.

In irrigated agriculture, water management must aim at providing suitable environment for obtaining optimum yield of crops which should commensurate with maximum economy in water use and maintenance of soil productivity. Various on farm water management technologies/ practices such as altering crop evapotranspiration of crops, depth of ponding, puddling / tillage operation to reduce percolation losses, scheduling irrigation at different stages of crop growth on the basis of irrigation water to cumulative pan evaporation (I.W./ C.P.E.) ratio, size of plot and method of water application, conveyance losses, conjunctive use of saline ground water and fresh canal water, multiple-well point skimming technology etc. for rice and wheat crops were developed and demonstrated to the farmers, extension workers and planners. There is voluminous literature documenting the extensive research efforts of scientist worldwide on the topic concerned. Only the salient concepts and literature of direct relevance to the present investigations are reviewed in this chapter.

A brief review related to the research work entitled as “Impact of Ranbir Canal Closure on Wheat Productivity” is mentioned in this chapter which mainly consist of two parts. The first part mainly emphasis on the various relationship between yield, irrigation scheduling and its effect on crop at various stages of the growth. The reviews are mainly about wheat crop and are presented in this chapter under following headings.

2.1 Relationship between Yield, Irrigation Scheduling and Effect on Crop at various Stages of Growth

2.1.1 Effect of Irrigation Scheduling on Yield.

2.1.2 Effect of Irrigation Scheduling on Crop Growth Parameters.

2.1.3 Effect of Irrigation Scheduling with Respect to Crop Growth Stages.

2.1.4 Crop Requirement and Moisture Stress Studies.

The second part of this chapter mainly comprises of review related todifferent methods for estimation of consumptive use of water and are presented under following sub headings.

2.2 Methods of Determining Consumptive use of Water.

2.2.1 Direct Measurement of Consumptive use of Water.

2.2.2 By using Emperical formula.

2.1 Relationship between Yield, Irrigation Scheduling and Effect on Crop at various Stages of Growth

2.1.1 Effect of Irrigation Scheduling on Yield

Tiwari and Singh (1969) studied the application of irrigation water at various frequencies to observe the effect on any character of the plant. The study revealed that by increasing the irrigation frequencies there is a positive effect on 1000 grain weight, but does not significantly affect the character of plant.

Parihar *et al.* (1974) carried a study by the approach of amount of irrigation water applied to the cumulative pan evaporation i.e. IW/CPE. The study included the scheduling irrigation with concept of IW/CPE on a wheat crop and it was observed that scheduling irrigation with IW/CPE of 1.0 gave maximum grain and straw yield for the entire season.

Singh *et al.* (1980) studied the effect of frequency of irrigation on the yield of wheat crop. It was observed that the yield increased by the 40 and 67.6% with one and two irrigations respectively including no post sowing irrigation.

Patra (1990) observed the effect on yield with respect to varying levels of fertilizers and irrigation. The study concluded that a significantly higher yield of 29.5q/ha was recorded with four irrigation at four stages of growth i.e. crown root initiation, panicle initiate, flowering and soft drought as compared to three irrigations at CRI, panicle initiate and milk stage and two irrigations at CRI and flowering with grain yield of 26.5q/ha and 23.7q/ha for three irrigation and two irrigation respectively.

Pandey *et al.* (1997) observed an adverse effect on yield attributes and finally on yield with delaying or withholding first irrigation. First irrigation at 20 days gave a yield of 56.1 q/ha, at 30 days 51.6 q/ha and at 40 days gave 50.5 q/ha.

Jana *et al.* (2001) carried a field study for two years in wheat recorded highest average yield of 29.97 q/ha and highest average consumptive use of water (424.49mm) for 4 irrigations (CRI, tillering, flowering and dough stages) which subsequently fell down with 3 and 2 irrigations and lowest for rainfed wheat (14.70 q/ha and 306.42 mm respectively).

Singh *et al*. (2012) conducted an experiment during winter season 2007-08, to evaluate the performance of wheat under different moisture regimes, water use and its efficiency. It was found that irrigation supplementation at 1.0 Irrigation water/Cumulative Pan Evaporation (IW/CPE) ratio significantly influenced the growth and yield of wheat crop. The study revealed that under4.0 cm irrigation, the highest water use efficiency was found at 1.0 IW/CPE ratio.

Hossain*et al.* (2015) investigated the possible effects of four different level of irrigation on two modern varieties i.e. rainfed (T_1), one irrigation at CRI stage (T_2), two irrigation at CRI and Booting(T_3) and three irrigation at CRI, Booting and Grain filling stages(T_4) and BARI Gom-21 (V_1) and BARI Gom-24 (V_2) respectively. Maximum grain yield was found for the variety BARI Gom-24 which was 4.51 t ha^{-1} followed by 4.07 t ha^{-1} for BARI Gom-21. It also showed that though the highest grain yield (4.59

tha-^{1}) was found in treatment T_4, its water productivity was the lowest (479 kg ha-^{1}cm-^{1}) of all. On the contrary, treatment T_3, gave a yield of 4.55 t ha-1 having the highest water productivity of (630 kg ha-^{1}cm-^{1}). The highest irrigation requirement (5.48 cm) was found in the treatment T_4, while treatment T_3 needed only 3.23 cm of water. It was observed (V_2) T_3 would be the best choice for the wheat cultivation.

Nayak *et al.* (2015) studied five levels of irrigation schedule Viz., I_1 (crown root initiation, late tillering, boot tillering, late flowering, late milking and dough stage), I_2 (0.4 IW: CPE ratio), I_3 (0.6 IW: CPE ratio), I_4 (0.8 IW: CPE ratio) and I_5 (1.0 IW: CPE ratio)and reported significant increase in yield attributes and yield viz. number of tillers per plant, test weight, ear length, grain weight per ear, grain and straw yield of wheat due to irrigation at critical stages and remained at par with irrigation at 0.8 IW/CPE over rest of the treatments. The highest grain and straw yield (4380 and 4538 kg/ha) was recorded under treatment I_1 (crown root initiation, late tillering, boot tillering, late flowering, late milking and dough stage) followed by I_4 (0.8 IW/CPE ratio) and I_5 (1.0 IW/CPE) treatment.

Verma (2017) carried a field experiment under loamy sand soil during two consecutive *Rabi* seasons to study the effect of irrigation scheduling on growth, yield and quality of wheat. The treatments consisted of five irrigation scheduling i.e. I_1 (irrigation at critical stages), I_2 (0.9 IW/CPE ratio), I_3 (0.6 IW/CPE ratio at vegetative phase + 0.8 IW/CPE ratio at reproductive phase), I_4 (0.6 IW/CPE ratio at vegetative phase + 1.0 IW/CPE ratio at reproductive phase) and I_5 (0.8 IW/CPE ratio at vegetative phase + 1.0 IW/CPE ratio at reproductive phase). The main findings of the result showed that irrigation applied at 0.9 IW/CPE ratio (I_2) recorded the maximum values of yield attributes (number of effective tillers per metre row length, number of grains per ear, ear length and test weight) and yield (grain, straw, biological) proved significantly superior over I_1, I_4 and I_3 except treatment I_5.

Singh *et al.* (2017)conducted a field experiment during two consecutive *Rabi* seasons of 2014-15 and 2015-16 to evaluate the effect of different tillage practices and irrigation scheduling in wheat (Triticum aestivum L.). The treatment consisted of five irrigation scheduling viz. Irrigation at CRI- I_1, CRI+50 mm CPE- I_2, CRI+100 mm CPE-

I_3, CRI+150 mm CPE- I_4 and CRI+200 mm CPE- I_5. The result showed that furrow irrigated raised beds increased the mean grain yield of wheat significantly over rest of the plots and grain yield increased by and 38.4% over I_1 and 6.4 % over I_4 irrigation schedule.

Deo *et al.* (2017) conducted field experiment during *Rabi* seasons of 2014-2015 and 2015-2016.The treatments comprised of four levels of irrigation schedule Viz., I_1 (critical stages), I_2 (0.6 IW: CPE ratio), I_3 (0.8 IW: CPE ratio), and I_4 (1:0 IW: CPE ratio). The findings of the investigation indicated that the grain and straw yields as well as most of the growth and yield attributes of wheat were significantly influenced due to different irrigation schedules. The results, further revealed that growth attributes such as plant height (cm), number of shoots $m^{-2}$and Leaf area index were found significantly higher under I_1 (critical stages) treatment during both years 2014-15 and 2015-16.

Sarkar *et al.* (2017) studied the effect of irrigation under varying sowing times on yield performance of wheat. The experiment comprised of two factors; Factors A: Irrigation (3 levels) i.e. I_1: Irrigation up to field capacity; I_2: Irrigation upto 1/2 of field capacity and I_3: Irrigation upto1/4th of field capacity (at crown root initiation, flowering and grain filling stage); Factor B: Sowing time (4 levels at 10 days interval) i.e. S_1, S_2, S_3 and S_4. The experiment was laid out in Split Plot Design with three replications. The highest grain yield ha^{-1} (3.380t) and highest straw yield ha^{-1} (3.787t) were obtained by the treatment I_1 and the respective lowest grain yield ha^{-1} (2.858t) and straw yield ha^{-1} (3.402t) were obtained by the treatment I_3. In case of biological yield I_1 obtained the highest value of 7.168tha^{-1}which was significantly higher than each of the respective values obtained by the rest irrigation treatments and highest harvest index (47.09%) was obtained from I_1 compared to other irrigation treatments. The highest grain yield (3.607tha^{-1}), straw yield (4.027tha^{-1}) and biological yield (7.633tha^{-1}) and harvest index (47.21%) were also recorded in sowing (S_2) and all the lowest values of all these parameters were recorded on sowing (S_1). Irrigation upto field capacity (I_1) in combination with sowing (I_1S_2) recorded the highest grain yield (3.97tha^{-1}), straw yield (4.310tha^{-1}) and biological yield (8.280tha^{-1}) and harvest index (47.93%) respectively. The respective lowest yield 2.300tha^{-1}, 2.867tha^{-1}, 5.167tha^{-1} 44.66% were obtained in the treatment combination of I_3S_1. It may be concluded that yield attributes and yield of wheat were significantly affected with irrigation and sowing time.

Sagar *et al*. (2018) conducted a field study during 2014-15 and 2015-16 in a split plot design having three replications. The treatments consisted of three irrigation schedule practices such as 4 cm irrigation at IW/CPE 0.8; 5 cm irrigation at IW/CPE 1.0; 6 cm irrigation at IW/CPE 1.2. The objective of the study was to examine the treatment effects on water productivity, yield and profitability of wheat crop. The results showed that the grain yield (46.52; 47.63 and 44.01 and 44.88 q ha^{-1}), were significantly higher in 4cm irrigation at IW/CPE 0.8 during both the years of study.

2.1.2 Effect of Irrigation Scheduling on Crop Growth Parameters

Mastsunaka *et al.* (1992) reported that the increase in the number of spikes per unit area was more affected by irrigation. Irrigation from beginning to tillering and finally to heading resulted in the production of larger number of effective spikes and higher grain yield than irrigation during any other growth stages.

Kotwal (2000) revealed that the plant height and ear length was not significantly influenced by different irrigation levels (1.0, 0.8 and 0.6) however it significantly affected the number of effective tillers per meter row of length.

Dhaka *et al.* (2006)observed in a field experiment the significant influence in yield attributing characters and grain yield viz. number of tillers per plant, number of grains per spike, test weight and grain yield of wheat. The yield attributes and yield were maximum when six irrigations were applied and it decreased, respectively when three irrigations were applied at vegetative phase or reproductive phase.

Khan *et al.* (2007) carried a study to evaluate the effect of different irrigation schedules on water use and yield of wheat. The results of yield and its components indicated that there was significant effect of irrigation intervals on grain yield, number of grain per spike, grain weight per spike, number of tillers per plant and visual lodging percentage. The maximum yield of4017 kg ha-^{1}was obtained when plots were irrigated after five weeks interval.

Khokhar *et al.* (2010) while working on two year field experiments revealed that number of irrigation did not have any significant effect on plant height, whereas plant height was affected significantly in different cultivars. The application of five irrigations (irrigation at crown root, tillering, booting, anthesis and soft dough stage)at different wheat growth stages resulted in higher spike length, higher number of grains and wheat grain yield of 5089 kg ha^{-1}.

Vishuddha *et al.* (2014) informed significant increases in growth parameters due to various moisture regimes and nutrient sources. The growth parameters, like plant height, number of shoots, LAI and dry matter accumulation (g/m^2) were significantly increased fewer than 5 irrigations over control.

2.1.3 Effect of Irrigation Scheduling with Respect to Crop Growth Stages

Telgote and Nalamwar (1989) reported a grain yield of 2.51t/ha with irrigation frequency of two, when applied on wheat crop at the crown root initiation and flowering stage. The study also concluded that the production increased from 2.67 to 2.86t/ha with three to four irrigation at different stages of growth.

Pratibha *et al.* (1994) conducted a field study in wheat and observed highest yield (34.23 q/ ha) with eight irrigation (10 DAS, CRI, tillering, late tillering, late jointing, flowering, milking and dough stages) followed by six and four irrigations (28.62 q/ha and 20.02 q/ha respectively). The consumptive use of water increased whereas water use efficiency increased up to six irrigations and decreased thereafter with eight irrigations.

Shivani *et al.* (2003) reported that grain yield as well as straw yield of wheat cultivars significantly increased with increasing irrigation levels. The crop which received four irrigations each at CRI, maximum tillering, boot and milk stages gave 13.7 and 29.1% more grain yield than the crop grown with two or three irrigations, respectively. Further, they found that crop receiving irrigation at CRI, tillering, boot and milk stages produced significantly more spike bearing tillers per square metre, number of grains per spike and 1000-grain weight than those which received two and three irrigations only.

Saren *et al.* (2001) reported that four irrigations applied at crown root initiation, tillering, flowering and grain development stages resulted in maximum plant height, dry matter accumulation, leaf area index and crop growth rate of wheat on sandy loam soil.

Sharma *et al.* (2007) in a field experiment conducted during 2000-01 and 2001-02 observed significantly higher number of spikes per meter row length, number of grains per spike and test weight. The wheat crop under adequate irrigation one each at crown-root initiation, late tillering, late jointing, flowering and milk stages recorded better growth, yield attributes, grain and straw yields and nutrient uptake.

Sarwar *et al.* (2010) carried out a field experiment and reported that wheat crop supplied with five irrigations at crown root + tillering + booting + earing + milking recorded the highest grain yield (5696 kg/ha) which was significantly higher with wheat cultivar viz. AS-2002 than all the other irrigation levels and cultivars.

Rahim *et al.* (2010)studied theeffect of irrigation scheduling on wheat yield. Four irrigations were applied at critical stages of wheat and reported that three irrigations at crown roots, booting, and grain development stages were sufficient to get maximum yield.

Ahmad and Kumar(2015) conducted a field experiment in the year 2001-02 to study the effect of irrigation scheduling on the growth and yield of wheat. The findings revealed that irrigation at crown root initiation + tillering + jointing + flowering + milky + dough stages recorded maximum effective tillers at harvest (94.66), total dry matter production (217.58 g m^{-1} row length), leaf area (49.31 dm^2 m^{-1} row length), leaf area index (2.18), the mean ear length (6.89 cm), number of grains per ear (34.58) and 1000 grain weight (39.83 g).

Mishra and Kushwaha(2016)conducted a field experiment and reported significant increase in the seed yield of wheat due to the application of irrigation at crown root initiation (CRI), late tillering(LT), late jointing(LJ), flowering(F) and milking(M) stages over control. The highest grain and straw yield of wheat in treatment I_5 (CRI, LT, LJ, F and M) being at par with I_4 (CRI, LT, LJ and F) proved superior over rest of the irrigation scheduling treatments.

Bian *et al.* (2016) evaluated the impact of planting pattern and irrigation frequency on grain yield and WUE (water use efficiency) of winter wheat. The effects of planting pattern and irrigation frequencies were determined on tiller number, grain yield and WUE. The irrigation regimes include: irrigation (120mm) at jointing stage, irrigation (60mm) at both jointing and heading stage, and irrigation (40mm) at jointing, heading and milking stages. The highest grain yields and WUE were observed when irrigation was applied at jointing stage (120mm) or at the jointing and heading stages (60mm).

Meena *et al.* (2017) conducted a field experiment during two consecutive years from 2014-15 and 2015-16.In this experiment, treatments comprised combinations of five irrigation schedule (early milk, late milk, early soft dough, late soft dough and IW/CPE 0.8 control).The pooled data showed that under last irrigation at late milk stage recorded significantly highest grain yield of (5.3 t/ha) and straw yield of (7.0 t/ha) as compared to the early milk, late soft dough stage and control but at par with early soft dough stage.

Bashir *et al.* (2017) carried a study on irrigation scheduling of wheat and observed that wheat development, growth and yield, based on critical growth stages responded significantly to the irrigation scheduling at tillering, stem elongation, booting and grain formation.

Shabnam *et al.* (2018) studied the effect of seeding time and irrigation on growth development productivity of wheat. The results revealed that when five irrigations were applied at crown root initiation, maximum tillering, late jointing, flowering and milking produced higher grain of 3.76t/ha and straw of 5.91 t/ha yield, harvest index of 38.9, gross energy output of 10291 MJ/ha, net energy output of 87223 MJ/ha, energy use efficiency of 6.56 and lower specific energy of 4395 MJ/t as compared to three irrigations at crown root initiation, boot and milk stages. It was revealed irrigation applied to wheat at five critical growth stages reduced the loss in yield and energy uses caused by delay in sowing.

2.1.4 Crop Requirement and Moisture Stress Studies

Sharma and Prasad(1986) studied the relationship between moisture stress with the different stages of growth and it was observed that a moisture stress is maximum during flowering and grain filling stages.

Wang(1992)observed that the rate of irrigation was clearly related to the yield of wheat crop. It was further observed that water requirement for wheat crop was higher during the month of January and February as compared to the month March and April.

Patel and Upadhyaya(1993) reported that the wheat crop when irrigated at irrigation water/consumptive pan evaporation of 0.8 and 1.6, the yield increased significantly with increasing irrigation up to 1.2 cumulative pan evaporation.

Bandyopadhyay (1997) reported in wheat that irrigation of 50mm depth applied at 1.2 depth of IW: CPE gave the maximum grain yield (3111 kg/ha) and yield attributes and showed highest water use efficiency (12.93 kg/ha/mm) and actual evapotranspiration (239.08mm).The water uptake was found maximum (56.5%) from the 0-15cm layer and it gradually changed with soil depths.

Abbate *et al.* (2004) conducted an experiment in wheat and concluded that with high water availability, day time vapour pressure deficit was better related to water use efficiency than with Pan evaporation, Relative air dryness or Potential evaporation. Water use efficiency was greater for experiment with water limitation probably because stomatal closure to restrict transpiration rate occurred around mid-day when vapour pressure deficit was highest.

Bikrmaditya *et al.* (2011) recorded significantly higher grain yield of wheat due to the application of irrigation @ 1.0 IW/CPE ratio and it remained at par with the application of irrigation @ 0.8 IW/CPE ratio during vegetative phase and 1.0 IW/CPE ratio at the reproductive phase.

2.2 Methods of Determining Consumptive use (CU) of Water

Various methods adopted for determining the consumptive use of water may be broadly classified under following two categories.

2.2.1 Direct Measurement of CU of Water:

The principal methods for direct measurement of Consumptive Use / Evapotranspiration are:

1. Lysimeter Method
2. Field Experiment Techniques
3. Soil Moisture Depletion.
4. Water Balance Method.

2.2.1.1 Lysimeter Method

Lysimeter method is the direct method for the calculation of evapotranspiration in which set of field plants with soil are grown in the special water tight tank. Evapotranspiration is estimated in terms of the amount of water required to maintain constant moisture conditions within the tank measured either volumetrically or gravimetrically through an arrangement made in the lysimeter. A special care should be taken that the plants grown in the lysimeter are same as in the surroundings. Lysimeter studies are time consuming and expensive.

2.2.1.2 Field Experiment Techniques

In this method measurement of water supplies to the field and changes in soil moisture content of the field plots are used to calculate water change due to evapotranspiration. The measurement of water supplies to the field and changes in soil moisture content of the field plots are sometime more dependable for computing seasonal water requirement of crops than measurement with lysimeters which do not simulate field conditions. It is given by following relationship.

$$WR = IR + ER + \sum_{i=1}^{n} \frac{M_{bi} - M_{ei}}{100} A_i D_i$$

Where,

WR: is seasonal water requirement (mm)

IR: is total water applied (mm),

ER: is seasonal effective rainfall (mm).

M_{bi} and M_{ei}: the moisture percentage at the beginning and end of the season in the i_{th}layer of soil

$A_{i:}$ apparent specific gravity of the i^{th}layer of soil

D_i: depth of the i^{th}layer of soil within the root zone (mm).

n: number of soil layer in the root zone D.

2.2.1.3 Soil Moisture Depletion

The soil moisture depletion method is usually employed to determine the consumptive use of irrigated field crops grown on fairly uniform soils when the depth to the ground water is such that it will not influence the soil moisture fluctuation within the root zone.

2.2.1.4 Water Balance Method

Water balance method is also called the inflow-outflow method, is suitable for large areas (watersheds) over long period. It may be represented by the following hydrological equation

Precipitation = Evapotranspiration + Surface Runoff + Sub-surface drainage + change in soil water content

These methods are laborious, costly and time consuming. Hence normally where more accuracy is needed these methods are preferred.

2.2.2 By Using Empirical Formula.

Following are some of the methods for determining the consumptive use (CU) or evapotranspiration (ET) with the help emperical formulas

2.2.2.1 Blaney-Criddle Method

The Blaney-Criddle method was first developed in 1942. Blaney Criddle also in (1950) observed that amount of water consumptively used by crops doing their growing season was closely co-related with mean monthly temperature and day night hours.It is an empirical equation and very simple to use. Mathematical model given by Blaney & Criddle, 1962 in an form of Equation is as follows (Abhinaya and Jose L, 2015)

$$u = kf$$

$$U = \sum kf = KF$$

Where,

u = monthly consumptive use, in inches

f = TF × p / 100 is the monthly consumptive use factor;

TF = mean monthly temperature, in degrees Fahrenheit (ºF);

p = monthly percentage of daytime hours of the year;

k = empirical consumptive use crop coefficient for monthly period;

U = seasonal consumptive use (or evapotranspiration), in inches;

F = sum of the monthly consumptive use factors for the period (sum of the products of mean monthly temperature and monthly percentage of daytime hours of the year)

K = empirical consumptive use crop coefficient for irrigation season or growing period.

In metric units,

$$u = kp(\frac{45.7Ta + 813}{100})$$

Where,

u = monthly consumptive use, in millimetres;

Ta = mean monthly temperature, in degrees Centigrade/Celsius (ºC).

Although the method was originally developed to compute ET on a monthly basis, it can be modified to estimate daily values of ET with mean daily temperature (ASCE, 1990). As temperature methods tend to under estimate ET in arid regions while overestimating ET in humid regions, local calibration of the empirical coefficients is required to produce reliable estimates of ET (ASCE, 1990). The advantage of this method is the simplicity and disadvantage is that it underestimates ET grossly compared to the measured ET values (*Sammis et al*., 2011).

2.2.2.2 Class A Pan Evaporation Method

In this method, Evapotranspiration (ET) is given by the formula E_T = k x (E_p) Pan evaporation(Abhinaya and Jose L, 2015)

Where;

k = consumptive use coefficient

E_p = Pan Evaporation can be calculated by Christianson method where

Ep = 0.459 x R x C_t x C_w x Ch x Cs x Ce

R = Extra – terrestrial radiation in mm.

C_t = Co-efficient of temperature= 0.393 +0.02796 Tc +0.0001189 Tc^2

T_c = Mean temperature in ^oC.

C_w = Co-efficient of wind velocity = 0.708 +0.0034W + 0.000003W^2

W = Mean wind velocity at 0.1m height above ground level inKm/day

Ch = Co-efficient of relative humidity = 1.25-0.0087H+0.75x$10^{-4}H^2$-

0.85x$10^{-8}H^4$

H= Mean % of R.H.

Cs = Co-efficient of % sunshine hours = 0.542+0.0085-0.78x10^{-4}

S^2+0.62x$10^{-6}S^3$

S= Mean Sunshine percentage

Ce = Co-efficient of elevation = 0.97 + 0.00984E

Where;

E= Elevation in 100m

Due to lack of the data like R, Tc, W, H, S and E, it is not possible to adopt this method.

2.2.2.3 Thornthwaite Method

In 1948, Thornthwaite and Penman both developed potential Evapotranspiration equation independently. Penman's equation was more mechanistic while Thornthwaite's equation was more empirical. It is an empirical study between mean air temperature and evapotranspiration. Thornthwaite's equation is as follows (Abhinaya and Jose L, 2015)

$$PET = 16(10T\mathrm{a}/I)^a$$

Where;

PET = potential evapotranspiration rate, in mm per month;

T_a = mean monthly air temperature, in degrees Celsius (ºC);

I = summation of the 12 monthly heat index i, where i = (Ta / 5)1.514;

ɑ = an empirical coefficient,

This is calculated using the following equation:

$$a = 0.675 * 10^{-6} * I^3 - 77.1 * 10^{-6} I^2 + 0.01792 I + 0.49239$$

This method is not based on strong mathematical and physical principles as it is purely empirical. However, as it is simple to use and gives acceptable result, in many parts of the world the method is still used to estimate irrigation water requirement.

2.2.2.4 Hargreaves Equation

Hargreaves (1975) developed an equation for estimating evapotranspiration (ET) which doesn't require wind speed data. His equation is as follows (Abhinaya and Jose L, 2015):

$$ET_0 = 0.0075 R_S T_F$$

Where,

ET_0 = potential ET for a grass reference surface in the same units as R_S

R_S = global solar radiation at the surface in equivalent water evaporation, usually mm of evaporation;

T_F = mean air temperature in degrees Fahrenheit (ºF).

For degrees Celsius, the equation is modified as:

$$ET_0 = 0.0135 R_S (T_a + 17.8)$$

2.2.2.5 Christiansen Method

Christiansen (1968) developed a simple method to estimate pan evaporation and crop evapotranspiration. According to Christiansen, the reasons for using pan evaporation data were: they were more consistent, already considerable work had been done to relate pan evaporation data with crop consumptive use and the pan evaporation data were readily available. The mathematical model that he developed was as follows (Abhinaya and Jose L, 2015):

$$E = KR_aC$$

Where;

E is used in a general sense to apply to evaporation or evapotranspiration.

K is a dimensionless constant developed empirically from data analysis

C is a dimensionless coefficient related to climatic parameters

R_a is the extra-terrestrial radiation, expressed as equivalent depth of evaporation.

The coefficient C is expressed as the product of any number of sub coefficients that are functions of specific climatic parameters that are found to have a significant effect on the evaporation or evapotranspiration.

Mathematically,

$$C = C_T C_W C_H C_S C_E$$

Where, C_T, C_W, C_H, C_S and C_E represent the coefficients for air temperature, wind speed, relative humidity, sunshine percentage and elevation, respectively.

2.2.2.6 Modified Penman Equation

This method is easily accepted as it provides more satisfactory result where measured data on temperature, humidity, wind, sunshine hours are available. This method gives most satisfactory result as compared to other methods (Abhinaya and Jose L, 2015).

$$ET_0 = c[(W * R_n) + (1 - W)f(u)(ea - ed)]$$

Where,

ET_0= Reference crop evapotranspiration in mm/day

C = Adjustment factor for day and night wind velocity and humidity

W = Weighing factor for altitude and temperature effect on radiation

R_n = Net radiation in equivalent evaporation in mm/day

f(u) = Wind function expressed in terms of equivalent evaporation in mm/day

(e_a-e_d) = Vapour pressure deficit expressed in millibar

e_a = Saturation water vapour pressure of the air

e_d = Saturation vapour pressure at mean air

2.2.2.7 ASCE-EWRI Standardized Penman Monteith Evapotranspiration Equation

The ASCE Standardized Reference Evapotranspiration Equation (ASCE EWRI, 2005) is based on the Penman-Monteith equation, with some simplification and standardization on the aerodynamic and surface resistances. This equation is applicable for both tall (alfalfa) and short (grass) reference surfaces. A grass reference crop is defined as an extensive, uniform surface of dense, actively growing, cool-season grass with a height of 0.12 m, and not short of soil water; whereas a full cover alfalfa reference crop is defined as an extensive, uniform surface of dense, actively growing alfalfa with a height of 0.50 m, and not short of soil water (ASCE-EWRI, 2005)

The equation is as follows:

$$ET_{SZ} = \frac{0.408\Delta(R_n - G) + \gamma C_n u_2 \frac{e_s - e_a}{T_a + 273}}{\Delta + \gamma(1 + C_d U_2)}$$

Where,

ET_{sz} = standardized reference crop evapotranspiration for short crop.

R_n = calculated net radiation at the crop surface (MJ/m2/d for daily time steps or MJ/m2/h for hourly time steps);

G = soil heat flux density at the soil surface (MJ/m2/d for daily time steps or MJ/m2/h for hourly time steps) (Abhinaya and Jose L, 2015).

Materials and Methods

CHAPTER- 3

MATERIALS AND METHODS

This chapter gives information regarding the materials and methods used in the study and are presented under the following headings which also includes the survey to know the effect of Ranbir canal closure on wheat productivity.

3.1 Profile of Jammu and Kashmir

3.2 Profile of the Study area.

3.3 Collection of Rainfall Data.

3.4 Estimation of Excess or Deficit Rainfall with respect to Consumptive use (CU)/Evapotranspiration (ET) value of Wheat crop.

3.5 Survey to Estimate the Wheat Productivity Reduction due to Closure of Ranbir Canal.

3.6 Estimation of Financial Losses incurred by Farmers due to the Closure of Canal System.

3.1 Profile of Jammu and Kashmir

3.1.1 Geographical location

The state of Jammu and Kashmir is one of the states of India and is situated in extreme north of India between 32° 15' to 37° 05' N latitude and 72° 35' to 80°20' E longitude . As the state is situated at the extreme of the country, it is also referred as crown on the head of the Indian sub-continent. The state has a total geographical area of 2,22,236 sq. kms which includes 37,555sq. kms under illegal occupation of China in Leh (Ladakh district), 78114sq. km sunder illegal occupation of Pakistan and 5180sq. kms illegally hand over by Pakistan to China. Thus total geographical area under its territory is 101387sq. kms (DES, 2015-16) comprising three regions viz. Jammu, Kashmir and Ladakh .The state consists of alluvial plains of the Chenab, Tawi and Ravi rivers and their tributaries. The outer plain of Jammu division is highly fertile and the temperature permits the cultivation of crops throughout the year. To the north of the Jammu plains between Ravi and Jhelum rivers stretch the youngest mountain of the sub-continent i.e.

the Siwaliks which are covered with the deciduous forest, shrubs and grasses. The geographical map of J&K state is presented in Fig 3.1.

Fig 3.1Geographical map of Jammu and Kashmir state

3.1.2 Soil of the district

The soils of the districts are variable in their colour, texture, structure, pH, water holding capacity and organic carbon content. The salinity, sodicity and calcareousness are the main soil problems in the district. The soils of Kandi-belt are characterized by low water holding capacity, organic carbon, total N and cation exchange capacity. Most of the soils of this zone are deficient in available zinc. Due to the lack of vegetative cover and cultivation of crops in hilly slopes, the Kandi belt poses a serious problem of soil erosion. Moreover, there is scarcity of water in the area especially during the months of May, June, October and November. The soil and water conservation measures are the prime necessities of this region (SKUAST-J, 1997)

3.1.3 Climate

The state of Jammu and Kashmir possess a diversification in terms of climate as the state is divided in three divisions. They differ in their latitude, longitude and altitude and because of the differences in their altitude the climate of the all the three divisions is different. The climate of Jammu is mainly sub-tropical, temperate climate for Kashmir and semi- arctic or cold arid for Ladakh division. Since, there are the difference in the climate, so all the three divisions have different cropping patterns. The major predominant crops of all the three divisions is as per details in Table 3.1 below

Table 3.1 Major crops in three divisions of Jammu and Kashmir state

Division	**Major crops**
Jammu	Wheat, Maize, Paddy, Pulses, Fodder and Oilseeds.
Kashmir	Paddy, Maize, Orchards and Saffron.
Ladakh	Barley, Wheat, Maize, Vegetables, Barssem and Fodder.

Source: (DES, 2015-16).

3.2 Profile of the Study Area

The present study was confined to Jammu district of the state of Jammu and Kashmir (India). The Jammu district which besides being the winter capital of the state, is known as the city of temples. Jammu district is spread over an area of 2342 sq. kms and is located 74° 24' and 75° 18', East longitude and 32° 50' and 33° 30' North latitude with an elevation of 300 metre above the sea level. The temperature varies from 0.9 degree celsius to maximum up to 46 degree celsius. The annual precipitation is 1200 mm with the bulk of the rainfall in the months from June to September, although the winters also receives rains. In terms of population, Jammu had a population, of 15,29,958 of which male and female were 8,13,821 and 7,16,137 respectively while as in previous reports Jammu had a population of 13,57,077 of which males were 7,27,738 and remaining 6,29,339 were females. The district has been divided into 5tehsils, 14 towns, 12 blocks, 1162 villages and 396 panchayats administratively (DES, 2015-16).The geographical map of Jammu district is presented in Fig 3.2.

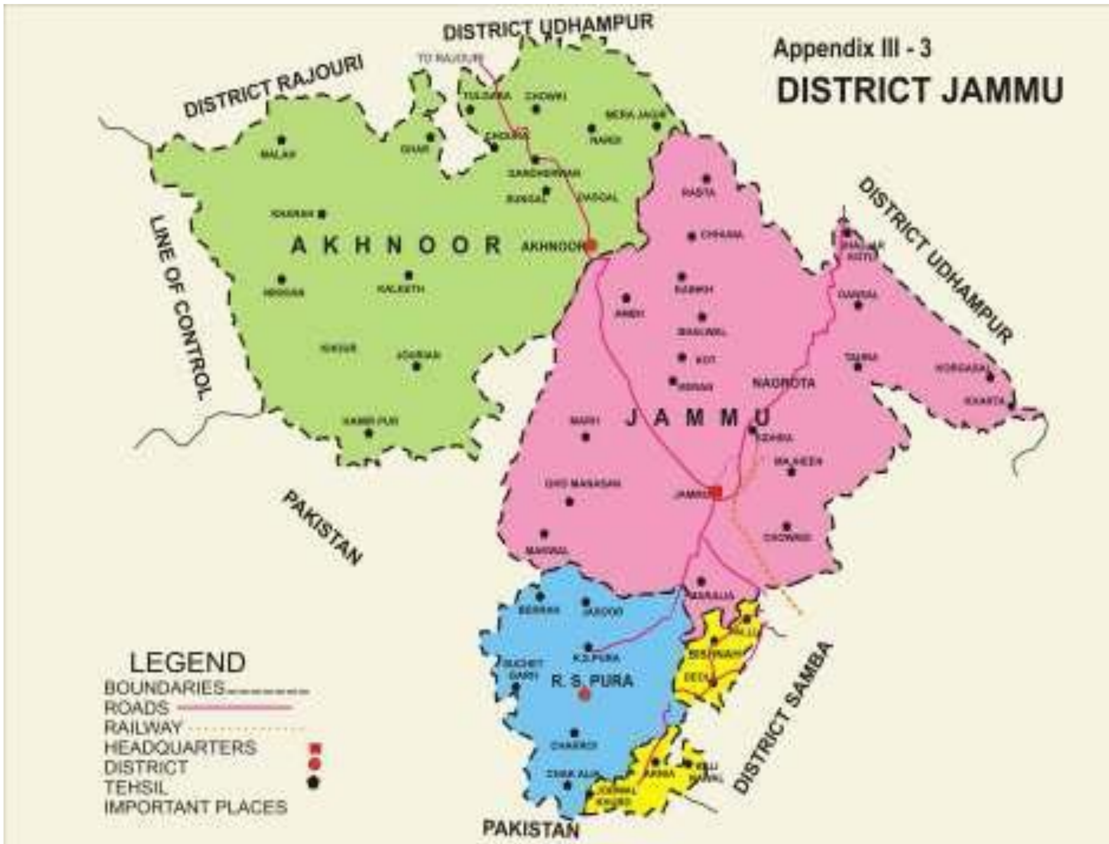

Fig 3.2 Geographical map of Jammu district

3.2.1 Agriculture condition of Jammu district

The total geographical area of Jammu district is 2342 Sq. Km with forest covering of 297 Sq. Km which forms 12.7% of the total area of the district (DES, 2015-16).The source of water with respect to the crop grown in our study area is represented in the Table 3.2 below

Table 3.2 Source of water w.r.t crop grown

S. No	Farming system	
1	Irrigated (bore well)	Paddy, Berseem, Vegetables and Wheat
2	Irrigated (canal)	Paddy, Berseem, Wheat, Vegetables, Sarson, Gobisarson
3	Rainfed	Paddy, Wheat, Gram, Mash moong, Sarson, Gobisarson

The district comes under subtropical zone of the state having paddy and wheat as principal crops in this area. The area under different crops is presented in the Table 3.3 below

Table 3.3: Area under different crops

S. No	Crop	Area (ha)
1	Paddy	79153
2	Wheat	80204
3	Maize	24213
4	Bajra	5465
5	Millets	2261
6	Barley	392

Source: (DES, 2015-16)

3.2.2 Irrigation in Jammu district

The main rivers of Jammu district are Chenab and Tawi and the water of these rivers have been utilized for irrigation and hydro power generation purposes. In addition to it some of the important canals of Jammu district are as Ranbir canal, Pratap canal and Ravi-Tawi irrigation complex. The respective canals with their command areas are represented in the Table 3.4 below.

Table 3.4: Command area of various canals

S.No	Name of canal	Command area or irrigation area
1.	Ranbir Canal	38800 ha
2.	Pratap canal	5400ha
3	Ravi- Tawi complex (Ravi Canal and Tawi lift irrigation)	66850ha

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3.2.2.1 Ranbir Canal System

In Jammu district, the main source of irrigation is Ranbir canal and it takes off from left bank of river Chenab up stream of Akhnoor bridge, which is 25km North East of Jammu city and passes through four tehsils of the district viz. Jammu, Akhnoor, R.S.Pura, and Bishnah. This canal was completed in the year 1905 with the length of the main canal system as 60 km and that of its distribution system as 400 kms. The canal system has a gross command area of 67000 ha and culturable command area of 38800 ha covering 489 villages. (Malhotra, 2018)

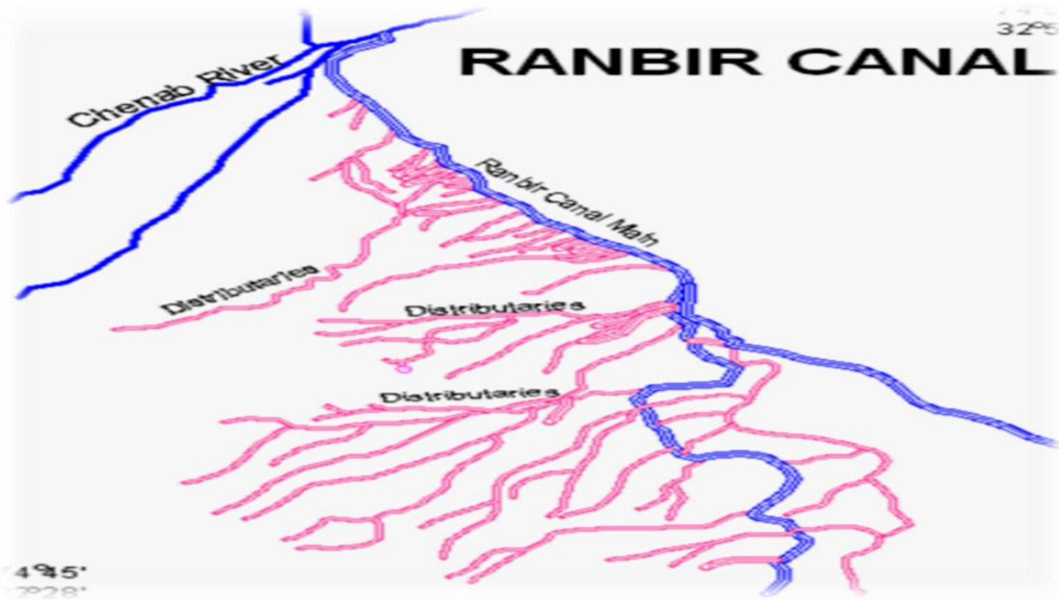


Fig 3.3 Map of Ranbir canal

Cropping pattern

The soil in the areas fed by the Ranbir canal system is predominantly clayey and is most suitable for raising the principal crops viz. Rice and Wheat. At present, in this canal command, seventy six percent (76%) of the area in *Kharif* is occupied by Rice and seventy one percent (71%) by Wheat in *Rabi* for which irrigation water is being used. (SKUAST-J, 2010)

***Kharif* season**

1.	Paddy	76 %
2.	Maize	5.0%
3.	Vegetables	2.5%
4.	Other crops	16.5%

***Rabi* season**

1.	Wheat	71.0%

2.	Barssem	16.0%
3.	Vegetables	5.0%
4.	Other crops	8.0%

Functioning of the Ranbir canal system

The schedule of the Ranbir canal system followed by the state is given here under:

Canal opens : Mid-April to end of December.

Canal closure : January to mid-April for de-siltation purpose.

In irrigated belt of Jammu district, rice-wheat is the major cropping pattern being followed from time immemorial. The farmers in the irrigated belt normally grow wheat in the month of November and harvest the same in the month of April, whereas the farmers of Kandi belt usually depend on the rainfall pattern and cultivate the same depending on the availability of moisture through rains. The major source of irrigation for wheat crop in Jammu district is through Ranbir canal system and the canal opens from mid-April to end of December and remains closed from January to mid-April for de-siltation purposes.

3.3 Collection of Rainfall Data

The Rainfall data of the district was collected for a period of 30 years (1980-2010) from All India Coordinated Research Project (AICRP) on Irrigation Water Management, SKUAST-J- Chatha Jammu and the data was analyzed for ten years interval period for *Rabi* season so as to find trend in changing rainfall pattern.

3.4 Estimation of Excess or Deficit Rainfall with respect to Consumptive Use (CU)/ Evapotranspiration (ET) value of Wheat Crop

For the estimation of excess/ deficit rainfall pattern in comparison with the consumptive use (CU) of wheat crop, water requirement values of wheat crop generally grown in *Rabi* season was calculated. The step wise procedures and various terminologies being used in these calculations are discussed as below.

3.4.1 Crop water requirement

The water requirement is the total quantity of water required by the crop from the time it is sown to the time it is harvested including application losses.

Water Requirement (WR) =Evapotranspiration (ET) + Efficiencies + Water used for other purposes.

The water used for other purpose includes water for leaching down of salts or any other special treatments.

3.4.2 Consumptive use (CU)

The consumptive use is defined as the total quantity of water used in the vegetative growth of a given area in transpiration and building up plant tissues and that being evaporated from, the adjacent soils in the area in any specified time period. Hence, it includes the water removed from soil by transpiration and evaporation plus water used by plant for maintenance of its tissue system. Since, the quantity of water required by plants to maintain its tissue system is generally one percent of evapotranspiration, hence generally we take consumptive use approximately equal to the evapotranspiration. Hence, all those methods used for calculating evapotranspiration are used for calculating consumptive use. The consumptive use values are low during the early stages of growth and increases as the plant approaches maturity. There is a general decline during the later period.

The consumptive use is expressed in ha/m or depth of water for specified period such as days, month or crop growing season. The consumptive use varies from crop to crop and for the same crop, it varies with time and space. The various factors affecting the consumptive use are:

Evaporation from adjacent soil

1. Temperature
2. Wind velocity

3. Relative humidity
4. Precipitation
5. Day time hours
6. Intensity of solar radiation
7. Type of soil and topography
8. Type of crop
9. Cropping pattern
10. Length of growing season
11. Growing stage of plant
12. Amount of foliage of plant
13. Forest stand
14. Nature of leaves of plant
15. Method of irrigation
16. Quantity of irrigation water applied
17. Depth of soil
18. Quantity of readily available soil moisture

3.4.3 Crop growing season

The time taken by the crop from the time it is sown till harvesting is known as crop growing season i.e., time taken by the crop from seed to seed.

3.4.4 Effective rainfall (R_e)

The precipitation falling during the growing season of the crops required to meet the evapotranspiration needs of the plant, is called effective rainfall (R_e).It does not include the precipitation lost through deep percolation or water lost as surface run-off. The term effective rainfall has been interpreted differently not only by specialists in different fields but also by different workers in the same field:

(i) To a canal irrigation engineer, the rainfall which reaches the storage reservoir directly and by surface run-off from the surrounding area indirectly is the effective portion.

(ii) To a hydro-electric engineer, the rainfall which is useful for running the turbines that generate electricity is the effective portion of the total received.

(iii) Geo-hydrologist would define as effective rainfall that portion of rainfall which contributes to groundwater storage. The extent of the rise in the water table level would be the effective rainfall.

(iv) An agriculturists consider as effective that portion of the total rainfall which directly satisfies crop water needs and also the surface runoff which can be used for crop production on their farms by being pumped from ponds or well.

(v) For a dry land agriculturist when the land is left fallow, effective rainfall is that which can be conserved for the following crop.

(vi) An individual farmer considers that effective rainfall is that quantity which is useful in raising crops planted on his land under his management

Thus it may be seen that even though the concept is the same in all the above cases, the values of effective rainfall are different for different agencies for the same total rainfall. From the point of view of the water requirement of crops, the Food and Agricultural Organization of the United Nations has defined the annual or seasonal effective rainfall as that part of the total annual or seasonal rainfall which is useful directly or indirectly for crop production at the site where it falls, but without pumping. The above concept of effective rainfall is suggested for use in planning and operation of the irrigation projects. The irrigation water supply in a given year should be planned to complement rainfall. Since, annual rainfall varies from year to year, an irrigation project cannot be planned on one year data; reports are needed over a long period to calculate effective rainfall on the basis of probability of occurrence. For calculating effective rainfall following formula has been used. (SKUAST-J, 2018)

$$R_e = 0.0011x^2 + 0.4422x$$

Where;

$$x = \text{Normal Rainfall (mm)}$$

3.4.5 Net irrigation requirement (N.I.R)

It is the amount of irrigation water required to bring the soil moisture level in the effective root zone to field capacity or it is defined as the amount of irrigation water required in order to meet the evapotranspiration needs of the crop

$$N.I.R = CU - R_e$$

Thus it is the difference between the field capacity and soil moisture content in the root zone before starting irrigation.

3.4.6 Field irrigation requirement (F.I.R)

It is the ratio of net irrigation requirement (N.I.R) to the water application efficiency (η_a).For our calculation we have taken η_a=0.8.Most of the farmers in the command area of Ranbir canal have almost leveled their land and as such application losses have been taken as 20% with application efficiency η_a of 0.8

$$F.I.R = \frac{N.I.R}{0.8}$$

In general it gives an idea that how effectively we are using water in the field.

3.4.7 Gross irrigation requirement (G.I.R)

It is the ratio of the Field irrigation requirement (F.I.R) to the water conveyance efficiency (η_c). For our, calculation purposes we have taken η_c = 0.7.Most of the soil of Jammu region are sandy loam soil and in general the conveyance losses varies between 30 to 40%, hence average value of 35% conveyance losses have been taken with conveyance efficiency (η_c) It gives an idea, that how effectively the water is being conveyed from source to the field.

$$G.I.R = \frac{F.I.R}{\eta c}$$

In general, the various methods as listed below are used for estimating consumptive use or evapotranspiration

1. Blaney - Criddle Method.

2. Class A Pan evaporation Method.
3. Thornth Waite Method.
4. Hargreaves Equation.
5. Christiansen Method.
6. Modified Penman Method.

In our study, we have used modified Penman method for the estimation of the evapotranspiration as suggested by the F.A.O (Food and Agriculture Organization) which gives satisfactory results as compared to other methods, when data on temperature, humidity, wind, sunshine hours are available. The other methods give over estimated and under estimation values of evapotranspiration in humid and arid regions respectively.

This method is easily accepted and is calculated by the following equation (Hajare *et al.* 2008)

$$ET_0 = c[(W * R_n) + (1 - W)f(u)(e\mathrm{a} - ed)]$$

Where,

ET_0= Reference crop evapotranspiration in mm/day.

C = Adjustment factor for day and night wind velocity and humidity.

W = Weighing factor for altitude and temperature effect on radiation.

R_n = Net radiation in equivalent evaporation in mm/day.

f(u) = Wind function expressed in terms of equivalent evaporation in mm/day.

(e_a-e_d) = Vapour pressure deficit expressed in millibar.

e_a = Saturation water vapour pressure of the air.

e_d = Saturation vapour pressure at mean air.

Since, long term data on these parameters are not available so assuming the given Epan is equal to ET_0 as factor required for computing ET_0 from Epan not available and crop coefficient (K_c) from (FAO,1979),modified penman method has been selected for finding out crop evapotranspiration and the formula used is

$$ET_c = K_c \times ET_0$$

Where

ET_c = Crop Evapotranspiration (mm/day)

K_c = Crop Coefficient

ET_0= Reference crop evapotranspiration in mm/day.

The table used for K_c values from FAO manual is presented below as Table 3.5

The consumptive use value of wheat crop was matched with rainfall available in all the three decades in Table.

Table 3.5 Consumptive use and crop coefficient

Percent of Crop Growing Season	**Consumptive use (Evapo-transpiration) coefficients, k, to be Multiplied by Class A Pan Evaporation or Calculated**							
	Group A	**Group B**	**Group C**	**Group D***	**Group E**	**Group F**	**Group G**	**Rice**
0	0.20	0.15	0.12	0.08	0.90	0.60	0.50	0.80
5	0.20	0.15	0.12	0.08	0.90	0.60	0.55	0.90
10	0.36	0.27	0.22	0.15	0.90	0.60	0.60	0.95
15	0.50	0.38	0.30	0.19	0.90	0.60	0.65	1.00
20	0.64	0.48	0.38	0.27	0.90	0.60	0.70	1.05
25	0.75	0.56	0.45	0.33	0.90	0.60	0.75	1.10
30	0.84	0.63	0.50	0.40	0.90	0.60	0.80	1.14
35	0.92	0.69	0.55	0.46	0.90	0.60	0.86	1.17
40	0.97	0.73	0.58	0.52	0.90	0.60	0.90	1.21
45	0.99	0.74	0.60	0.58	0.90	0.60	0.95	1.25
50	1.00	0.75	0.60	0.65	0.90	0.60	1.00	1.30
55	1.00	0.75	0.60	0.71	0.90	0.60	1.00	1.30
60	0.99	0.74	0.60	0.77	0.90	0.60	1.00	1.30
65	0.96	0.72	0.58	0.82	0.90	0.60	0.95	1.25
70	0.91	0.68	0.55	0.88	0.90	0.60	0.90	1.20
75	0.85	0.64	0.51	0.90	0.90	0.60	0.85	1.15
80	0.75	0.56	0.45	0.90	0.90	0.60	0.80	1.10
85	0.60	0.45	0.36	0.80	0.90	0.60	0.75	1.00
90	0.46	0.35	0.28	0.70	0.90	0.60	0.70	0.90
95	0.28	0.21	0.17	0.60	0.90	0.60	0.55	0.80
100	0.20	0.20	0.17	0.20	0.90	0.60	0.50	0.20

*Wheat crop belong to the Group D

The respective values of pan evaporation for particular months of crop growing period was calculated by using table given below for evapotranspiration data of Jammu district. The data was taken from AICRP on irrigation water management, SKUAST-Jammu.

Table 3.6 Evaporation and rainfall data of Jammu district

S. No.	Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.	Rainfall (mm) 27 years	60.0	70	76.0	40.0	27.0	94.0	385	325	116	22.0	15.0	30
2.	Evaporation (10yr. Normal)	27	43	75	135	230	210	140	110	120	100	64	33

Source: AICRP on irrigation water management, SKUAST- Jammu

3.5 Survey to Estimate Wheat Productivity Reduction due to the closure of Ranbir Canal.

To ascertain the losses being incurred by the farmers of the command area, three villages Kalyanpur (upper section of Ranbir Canal), Rambagh (mid-section of Ranbir Canal) and Agwan/ Mussa Chak/ Sunder pur (tail end section of Ranbir Canal) were surveyed. A questionnaire was devised in consultation with the division of Extension Education, SKUAST-Jammu, which was pretested before the collection of actual data. In each village twenty farmers (10 with assured irrigation system and another 10 with unassured irrigation system i.e. totally dependent on rainfall) were provided with questionnaires (Annexure –I) pertaining to losses being incurred by the farmers, if any especially in wheat crop due to the closure of canal system.(Plate 3.1 and 3.2)

3.6 Estimation of Financial Losses incurred to Farmers due to the closure of Ranbir Canal System

To estimate the loss to farmers due to the closure of canal system, average yield of farmers having canal and canal + tube well as a source of irrigation was compared. The amount of yield in quintals by which the farmers having canal are deprived in comparison to the farmer having their own source of irrigation is multiplied with the procuring price of the wheat for an area of 27,548 ha thus gives the total loss due to the closure of canal system.

Plate 3.1: Survey in the selected villages

Plate 3.2: Survey in the selected villages

Results

CHAPTER-4

RESULTS

In this chapter, findings of the present investigation through rainfall data analysis of three decades and survey work carried in all the three villages located in the command of Ranbir canal in upper, mid and tail end section were depicted systematically.

The finding of the study is presented under the following major headings.

4.1 Rainfall Data Analysis.

4.2 Crop Water Requirement for Wheat Crop.

4.3 Consumptive Use or Evapotranspiration Value of Wheat Crop.

4.4 Comparison of Rainfall Data with Consumptive Use Values of Wheat Crop.

4.5 Financial Loss to Farming Community due to the closure of Ranbir Canal System.

4.6 Perception of Farmers Regarding closure of Ranbir Canal System.

4.1 Rainfall Data Analysis

In this study, rainfall data of 30 years on decadal basis of Jammu district was analysed to determine the trend in changing rainfall pattern so as to determine the dependency of farmers on canal water for the production of wheat. Table 4.1 revealed that average rainfall of *Rabi* season decreases on decadal basis. During *Rabi* season, average rainfall for 1980-90, 1991-2000 and 2001-2010 was 337.8mm, 296.1mm and 190.5mm respectively. The percentage decrease from 1980-90 to 1991-2000 is 12 percent, similarly percentage decrease from 1980-90 to 2001-10 is 43.6 percent and the same trend was observed in Figure 4.1.

Table 4.1Meteorological data of *Rabi* 1980-81 to 2009-10for Chatha, Jammu

Decade	Nov.	Dec.	Jan.	Feb.	Mar.	Apr	Total *Rabi*
Decade I 1981-1990	23.9	41.0	56.4	67.2	101.4	48.0	337.8
Decade II 1991 – 2000	11.6	34.3	70.3	83.8	52.8	43.5	296.1
Decade III 2001-2010	6.4	12.9	43.0	47.6	33.5	22.6	190.5
Avg 30 years	13.0	29.4	56.6	66.2	62.6	38.0	274.8

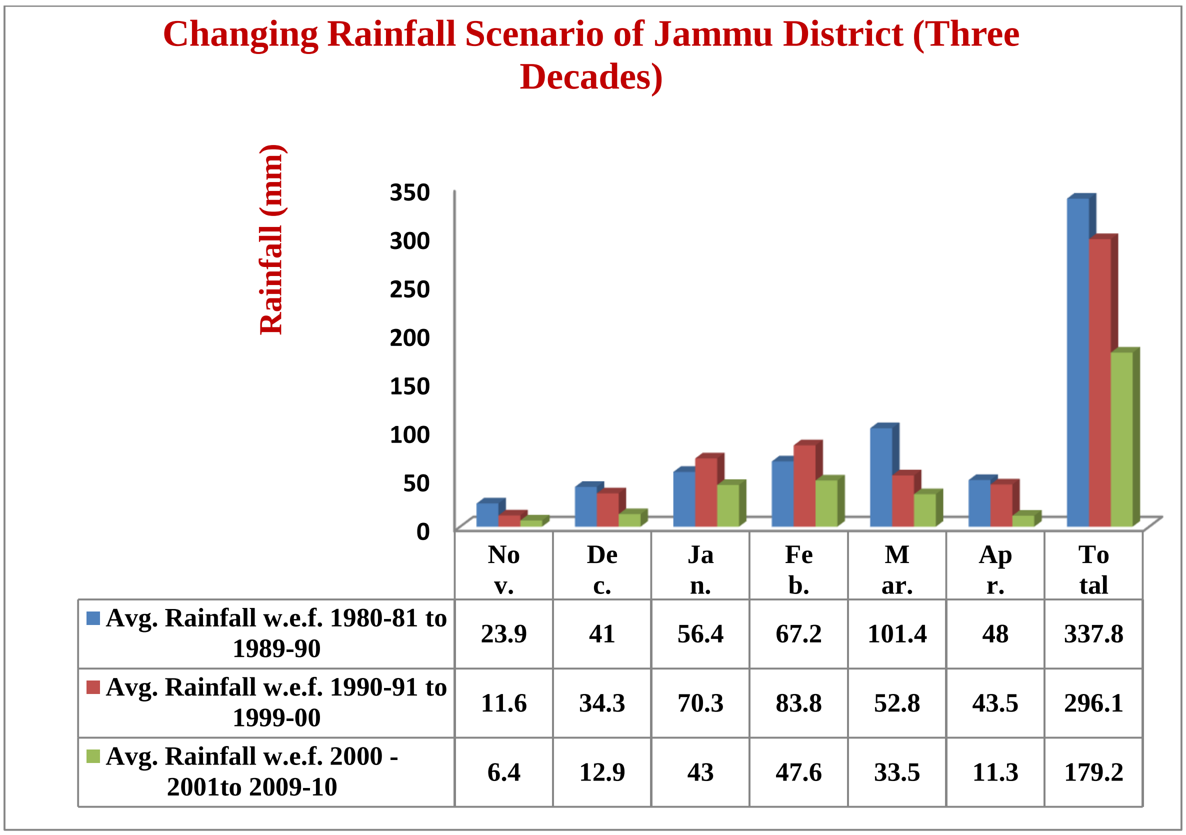


Fig 4.1Bar diagram of rainfall scenario of Jammu district

The above figures represent the rainfall data of three decades for the crop growing period of wheat crop. The figure shows the decreasing trend of rainfall from first decade to the third decade

4.2 Crop Water Requirement

The water requirement of wheat crop is calculated and presented in Table 4.2. The water requirement was estimated on monthly basis using modified penman method as mentioned in chapter 3.

4.2.1 Water requirement for wheat crop

The water requirement of wheat crop is given in the Table 4.2 with different crop growing periods.

Table 4.2 Crop water requirement of wheat crop for Jammu districtCrop growing period: Nov 1st to Apr 30th (181 Days)

Month	Mid-Point	% crop grown	K_C	EP (mm)	CU (mm)	Normal Rainfall (mm)	Effective Rainfall * Re (mm)	Probability of effective rainfall = 0.83x Re (mm)	NIR= CU-Prob rainfall (mm)	FIR= NIR/Application efficiency** (mm)	GIR= FIR/Conveyance efficiency*** (mm)
Nov 1st-30th	15.0	8.3	0.15	64.0	9.6	15.0	6.8	5.7	3.9	4.8	6.8
Dec 1st – 31st	45.5	25.1	0.33	33.0	10.8	30.0	14.2	11.8	-	-	-
Jan 1st – 31th	76.5	42.2	0.58	27.0	15.6	60.0	30.4	25.3	-	-	-
Feb 1st-28th	106.0	58.5	0.77	43.0	33.1	70.0	36.3	30.1	3.0	3.7	5.3
Mar 1st-31st	135.5	74.8	0.90	75.0	67.5	76.0	39.9	33.1	34.4	43.0	61.4
Apr 1st-30th	166.0	91.7	0.70	135.0	94.5	40.0	19.4	16.1	78.4	98.0	140.0
Total											213.5

Total water requirement for wheat crop= 213.5 mm

*Formulae used for calculating effective rainfall R_e= $0.0011x^2 + 0.4422x$ Where x is normal rainfall

**The value of application efficiency used in the calculation= 0.8

***The value of conveyance efficiency used in the calculation= 0.7

4.3 Consumptive Use (CU)/ Evapotranspiration (ET) Value of Wheat Crop

The consumptive use (CU) of the wheat crop is compared with the average rainfall of 30 years on decadal basis to analyse whether the water requirement of wheat crop are fulfilled or not by the rainfall on monthly basis of crop growing period as well as during the whole period.

Table 4.3Consumptive use of wheat crop for Jammu district

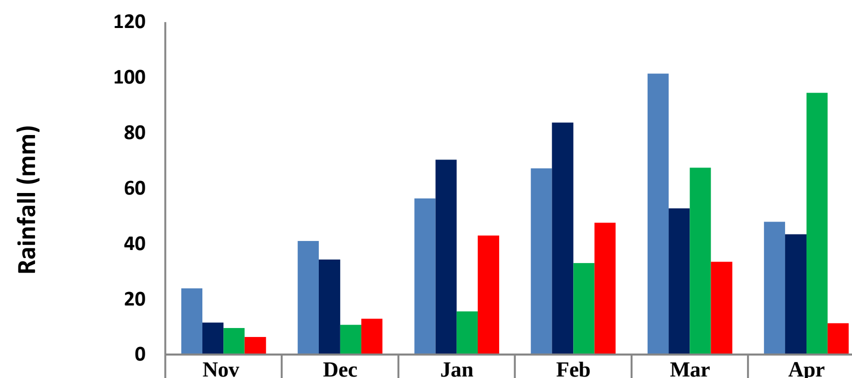
Month	Crop factor *k_c	Pan evaporation (mm)	CU/ET_c (mm)
1st-30th Nov	0.15	64.0	9.6
1st-31st Dec	0.33	33.0	10.8
1st-31th Jan	0.58	27.0	15.6
1st-28th Feb	0.77	43.0	33.1
1st-31stMar	0.90	75.0	67.5
1st-15th Apr	0.70	135.0	94.5

The above table shows the consumptive use with respective to pan evaporation for crop growing period of wheat crop i.e. from start of November to the mid of April which come under the group of *Rabi* season crop.

Table 4.4: Month wise average rainfall with consumptive use of wheat crop(mm)

Average rainfall on decadal basis (mm)	Month						
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Avg. Rainfall w.e.f. 1980-81 to 1989-90(mm)I	23.9	41.0	56.4	67.2	101.4	48.0	337.8
Avg. Rainfall w.e.f. 1990-91 to 1999-00(mm)II	11.6	34.3	70.3	83.8	52.8	43.5	296.1
Avg. Rainfall w.e.f.2000-2001to 2009-2010III	6.4	12.9	43.0	47.6	33.5*	11.3*	179.2
Consumptive Use for Wheat crop (mm)	9.6	10.8	15.6	33.1	67.5	94.5	231.1

The above table shows the average rainfall of three decades i.e. from 1980-1990, 1991-2000 and 2001-2010 compared with consumptive use in the crop growing period of wheat crop. In the above, table it is observed that the consumptive use of wheat crop is met by the average rainfall of first decade in all months, while in second decade an average rainfall does not meet the requirement in the months of march and April lacking 14.7 and 51mmbut in overall the average rainfall (296.1mm) is exceeding the consumptive use of crop (231.1). In case of third decade, the water requirement of wheat crop is attained by the rainfall up to the month of Feb but after that there is immense scarcity of rainfall water in the months of March (33.5 against 67.5 mm) and April. In addition to scarcity of water through rainfall and canal closure and the crop being at very crucial stage i.e. milky stage the farmers suffers heavily both in productivity as well as financially and the same trend was observed in bar diagram 4.2



	Nov	Dec	Jan	Feb	Mar	Apr
Avg. Rainfall w.e.f 1980-81 to 1989-90	23.9	41	56.4	67.2	101.4	48
Avg. Rainfall w.e.f 1990-91 to 1999-00	11.6	34.3	70.3	83.8	52.8	43.5
Consumptive Use of Wheat Crop	9.6	10.8	15.6	33.1	67.5	94.5
Avg Rainfall w.e.f 2000 to 2009-10	6.4	12.9	43	47.6	33.5	11.3

Fig 4.2 Bar diagram of rainfall scenario of Jammu district (three decades) in comparison with consumptive use of wheat crop

4.4 Wheat Productivity Reduction

In order to determine effect of Ranbir canal closure on yield of wheat crop, a questionnaire was devised in consultation with Division of Extension Education, SKUAST-Jammu, which was pre tested before the collection of actual data. In all the three villagesi.e. Village Kalyanpur (upper section), Rambagh (mid-section) and Mussa Chak (tail end section), twenty farmers in each village (10 with assured irrigation system and another 10 with unassured irrigation system i.e. totally dependent on rainfall) were provided with questionnaires pertaining to losses being incurred by the farmers in wheat crop due to closure of canal system. Beside this perception of the farmers regarding closure of canal system was also the major part of the survey work. The various results of the survey works village wise depicted below.

4.4.1 Results of survey works of village Kalyanpur

The yield of wheat crop on decadal basis for village Kalyanpur is given in table 4.5

Table 4.5Yield of wheat crop for the farmers of Kalyanpur village (upper section)

S.No	Name of the farmer	Source of irrigation	Yield of Wheat crop (q/ha)		
			1980-81 to 1989-90	1990-91 to 1999-2000	2000-2001 to 2009-2010
1	Kuldeep Sharma	C+T	24.0	28.0	28.5
2	Pretam Bakshi	C+T	25.0	29.0	28.5
3	Satpal Sharma	C+T	26.0	29.0	27.5
4	Tarseem Lal	C+T	26.5	28.5	29.0
5	Lal Chand	C+T	23.5	27.0	27.5
6	Shri Suraj Prakash	C+T	22.5	26.5	27.0
7	Mohan Lal	C+T	26.0	29.5	28.0
8	Suraj Mani	C+T	24.5	27.5	27.0
9	Ashwani Sharma	C+T	24.0	28.0	27.0
10	Janak Raj Sharma	C+T	23.0	27.0	28.0
	Average	**C+T**	**24.5**	**28.0**	**27.8**
11	Sham Lal	C	23.0	26.5	21.0
12	Abishekh Sharma	C	24.5	26.0	22.5
13	Ratan Lal	C	24.0	26.5	20.0
14	Gyan Chand	C	24.0	27.5	21.0
15	Puran Chand	C	24.0	25.0.	22.5
16	Tilik Raj	C	22.5	28.5	22.0
17	Satpal Sharma	C	22.0	27.5	20.0
18	Raj Kumar Sharma	C	21.0	26.0	20.5
19	Satpal	C	22.0	26.5	22.5
20	Ramesh Chand	C	23.0	26.0	23.0
	Average	**C**	**23.0**	**26.0**	**21.5**

The above table gives the yield of wheat crop for 30 years period on decadal basis of village Kalyanpur. In general for all three decades the average yield of farmers having canal + tube well as a source of irrigation have more yield than the farmers which entirely depend on the canal only.

4.4.2 Results of survey works of village Rambagh

The yield of wheat crop for village Rambagh is given in Table 4.6

Table 4.6Yield of wheat crop for the farmers of Rambagh village (mid-section)

S.No	Name of the farmer	Source of irrigation	Yield of Wheat crop (q/ha)		
			1980-81 to 1989-90	1990-91 to 1999-2000	2000-2001 to 2009-2010
1	Natha Ram	C+T	24.0	28.0	28.5
2	Natha Ram	C+T	25.0	29.0	28.5
3	Sunita Ram	C+T	26.0	29.0	27.5
4	Koki Ram	C+T	26.5	28.5	29.0
5	Roop Lal	C+T	23.5	27.0	27.5
6	Balvinder	C+T	22.5	26.5	27.0
7	Madhan Singh	C+T	26.0	29.5	28.0
8	Betan Chand	C+T	24.5	27.5	27.0
9	Ram Singh	C+T	24.0	28.0	27.0
10	Raj Kumar	C+T	23.0	27.0	28.0
	Average	**C+T**	**24.5**	**28.0**	**27.8**
11	Rajinder Kumar	C	23.0	26.5	21.0
12	Sarpan Lal	C	24.5	26.0	22.5
13	Darshan Lal	C	24.0	26.5	20.0
14	Shri Bansal	C	24.0	27.5	21.0
15	Raj Kumar	C	24.0	25.0.	22.5
16	Raj Kumar	C	22.5	28.5	22.0
17	Kishore Kumar	C	22.0	27.5	20.0
18	Mohinder Kumar	C	21.0	26.0	20.5
19	Kuldeep Raj	C	22.0	26.5	22.5
20	Tara Chand	C	23.0	26.0	23.0
	Average	**C**	**23.0**	**26.0**	**21.5**

*C+T =Canal + Tube well,   C=Canal

The above table gives yield of wheat crop for 30 years period on decadal basis of village Rambagh for farmers having canal and canal + tube well as source of irrigation. In general for all three decades the average yield of farmers having canal + tube well as a source of irrigation have more yield than the farmers which entirely depend on the canal only.

4.4.3 Results of survey works of village Mussa Chak /Agwan /Sunderpur

The yield of wheat crop for village Mussa Chak is given in Table 4.7

Table 4.7Yield of wheat crop for the farmers of Mussa Chak (mid-section)

S.No	Name of the farmer	Source of irrigation	Yield of Wheat crop(q/ ha)		
			1980-81 to 1989-90	1990-91 to 1999-2000	2000-2001 to 2009-2010
1	Sardar Pyara Singh	C+T	23.8	28.5	27.8
2	Ravinder Singh	C+T	25.2	30.0	30.2
3	Rajinder Singh	C+T	25.0	29.0	28.3
4	Bhikam Singh	C+T	24.0	29.0	28.6
5	Tahir Choudary	C+T	24.8	30.0	29.5
6	Rattan Lal	C+T	24.9	29.0	28.3
7	Saindas	C+T	25.0	30.5	29.5
8	Ramesh Singh	C+T	24.6	28.5	28.0
9	Vipan Singh	C+T	24.9	29.0	27.8
10	Balbir Singh	C+T	24.8	28.5	27.0
	Average	**C+T**	**24.7**	**29.2**	**28.5**
11	Aya Singh	C	24.5	25.0	23.2
12	Gurmeet Singh	C	23.0	23.7	20.7
13	Swarn Singh	C	22.9	25.5	22.1
14	Harbhajan Singh	C	23.8	24.3	21.7
15	Manjit Singh	C	22.9	24.5	20.8
16	Amrik Singh	C	23.7	24.4	21.5
17	Raghbir Singh	C	24.6	25.5	22.0
18	Vijay Kumar	C	23.8	24.0	21.4
19	Hanas Raj	C	22.9	25.5	22.6
20	Sukhdev singh	C	22.9	25.6	21.0
	Average	**C**	**23.5**	**24.8**	**21.7**

*C+T =Canal + Tube well, C=Canal

The table shows yield of wheat crop for 30 years period on decadal basis of village Mussa Chak for farmers having canal and canal + tube wells as a source of irrigation. In general, for all three decades the average yield of farmers having canal +

tube well as source of irrigation have more yield than the farmers which entirely depend on the canal

4.4.4 Overall results of survey work of all the three villages

Table 4.8 gives the overall results of survey works of all the three villages surveyed

Table 4.8Yield trend of wheat crop in command area of Ranbir canal

S.No	Village	Source of irrigation	Average yield of Wheat crop (q/ ha)			Average of 30 years
			1980-81 to 1989-90	1990-91 to 1999-2000	2000-2001 to 2009-2010	
01	Kalyanpur	Avg (C+T)	24.5	28.0	27.8	26.8
02	Rambagh	Avg (C+T)	21.1	25.9	25.0	24.0
03	Agwan/Sunder Pur	Avg (C+T)	24.7	29.2	28.5	27.5
		Avg(C+T)	**23.4**	**27.7**	**27.1**	**26.1**
04	Kalyanpur	Avg (C)	23.0	26.0	21.5	23.5
05	Rambagh	Avg (C)	20.5	22.3	20.0	20.9
06	Agwan/Sunder Pur	Avg (C)	23.5	24.8	21.7	23.3
		Avg (C)	**22.3**	**24.4**	**21.1**	**22.6**

*C+T =Canal + Tube well, C=Canal

The above table shows the average yield of wheat crop for 30 years period on decadal basis for both category of farmers having canal + tube well and canal as a source of irrigation. The table also provides the yield trend on decadal basis and comparative average data of yield having canal + tube well and canal as a source of irrigation of all three villages surveyed.

4.4.5 Wheat productivity reduction due to closure of Ranbir canal system

Table 4.9 gives the overall wheat productivity reduction due to the closure of Ranbir canal system

Table 4.9Wheat productivity reduction due to closure of Ranbir canal system

S.No	Village	Source of irrigation	Average yield of Wheat crop (q/ ha)			Average of 30 years
			1980-81 to 1989-90	1990-91 to 1999-2000	2000-2001 to 2009-2010	
01	Kalyanpur	Avg (C+T)	24.5	28.0	27.8	26.8
		Avg (C)	23.0	26.0	21.5	23.5
	Loss %		**6.3**	**7.1**	**22.7**	**12.0**
02	Rambagh	Avg (C+T)	21.1	25.9	25.0	24.0
		Avg (C)	20.5	22.3	20.0	20.9
	Loss %		**2.9**	**13.9**	**20.0**	**12.3**
03	Agwan/Sunder Pur	Avg (C+T)	24.7	29.2	28.5	27.5
		Avg (C)	23.5	24.8	21.7	23.3
	Loss %		**4.9**	**15.1**	**23.9**	**14.6**
	Overall % Loss		4.7	12.0	22.2	**13.0**

*C+T =Canal + Tube well,   C=Canal

The above table assesses the loss of yield of each villages for farmers which entirely depend on the Ranbir canal as a source of irrigation in comparison with farmers having canal + tube well as a source of irrigation. On analysing, the data the losses were found in all the three decades for farmers depending on the canal, but comparatively the losses were less in early decades than that of the last decade. The table gives the overall loss of all the three villages in 30 years period with 12, 12.3and 14.6% for village Kalyanpur, village Rambagh and village Mussa Chak/Agwan/Sunder pur respectively. The overall loss for all three villages together was found to be 13.0%.

4.5 Estimation of Financial loss due to closure of Canal System

The financial losses to farmers due to the closure of Ranbir canal is represented in the table4.10

Table 4.10Estimation of financial loss due to closure of Ranbir canal

Crop	Losses percentage	Yield expected q/ha	Yield (q/ha)		Rate/q (Rs.)	Area (ha)	Losses (In crores)
			Obtained	Loss			
Wheat	13.0	26.1	22.6	3.5	1840	38800 (27,548)	17.7

From Table 4.10, it is clearly visiblethat the overall loss of 13.0 percent was obtained which accounts for 3.5 q/ha less as compared to the desired production. The cost of wheat procurement per quintal being Rs.1840. Thus the farming community suffered overall loss of Rs.17.7 crore.

4.6 Perception of the Farmers regarding closure of Ranbir Canal System

As per survey sheet, the perception of the farmers regarding closure of Ranbir canal system were also recorded so as to know the feeling of the farmers about effect of canal closure on wheat productivity. The survey works were carried on the same pattern as in wheat productivity analysis basis.

Table 4.11 Perception statements of farmers without pumpset

S. No	Perception statements (Canal) Without pumpset	Agree (2)	Neutral (1)	Disagree (0)	Weighted score	Weighted mean	Ranking
1	Closure of Ranbir Canal during Rabi Season directly affects the Wheat productivity.	30	0	0	60	2.00	I
2	Closure of Ranbir Canal mainly affect resource poor farmers.	30	0	0	60	2.00	I
3	Closure of Ranbir Canal is also affecting total wheat area.	27	3	0	57	1.90	IV
4	Farmers fail to apply irrigation to wheat crop at critical stages due to closure of Ranbir canal.	30	0	0	60	2.00	I
5	Closure of Ranbir Canal during Rabi season also affecting quality of wheat crop.	29	1	0	59	1.96	II
6	Closure of Ranbir Canal during Rabi season increases the vulnerability of farmers.	28	2	0	58	1.93	III
7	Desilting of Ranbir Canal should be seasonally executed for ensuring its perennial flow.	26	4	0	56	1.86	V
8	Closure of Ranbir Canal is also impacting ground water level due to installation of large number of shallow pump set.	24	5	1	49	1.63	VI
9	Government should think of opening of Ranbir Canal a bit earlier in an era of climate change.	30	0	0	60	2.00	I
10	Closure of Ranbir Canal also minimizes the efficiency of different fertilizers applied to wheat crop.	19	11	0	49	1.63	VI
11	Government should encourage Co-operative management of Ranbir Canal for its smooth Running throughout the year.	20	6	4	46	1.53	VII
12	Effective coordination with the irrigation staff is necessary.	17	9	4	43	1.43	VIII
13	Availability of green fodder (berseem) is also reducing due to non-availability of water through canal.	29	1	0	59	1.96	II

On the basis of weighted mean for thirty farmers owning pumpsets, it is concluded that perception statements numbered at s.no 1, 2, 4 and 9 are ranked first by respondents having no pumpset facility. The statement at s.no 5 and 13 are ranked second. The statement at s.no 6, 3 and 7 are ranked as third, fourth and fifth. The statements at s.no 8 and 10 are ranked by respondents at sixth position. The statement at s.no 11 and 12 is ranked as seventh and eighth by respondent farmers with respect to their perception on the effect of closure of Ranbir canal on the wheat productivity.

Table 4.12 Perception statements of farmers (canal + pump)with Pumpset

S. No	Perception statements (Canal+Pump) With pump set	Agree	Neutral	Disagree	Weighted score	Weighted mean	Ranking
1	Closure of Ranbir Canal during Rabi Season directly affects the Wheat productivity.	30	0	0	60	2.00	II
2	Closure of Ranbir Canal mainly affect resource poor farmers.	29	1	0	59	1.96	III
3	Closure of Ranbir Canal is also affecting total wheat area.	30	0	0	60	2.00	II
4	Farmers fails to apply irrigation to wheat crop at critical stages due to closure of Ranbir canal.	29	1	0	59	1.96	III
5	Closure of Ranbir Canal during Rabi season also affecting quality of wheat crop.	27	3	0	57	1.90	V
6	Closure of Ranbir Canal during Rabi season increases the vulnerability of farmers.	28	2	0	58	1.93	IV
7	Desilting of Ranbir Canal should be seasonally executed for ensuring its perennial flow.	27	3	0	57	1.90	V
8	Closure of Ranbir Canal is also impacting ground water level due to installation of large number of shallow pump set.	26	4	0	56	1.86	VI
9	Government should think of opening of Ranbir Canal a bit earlier in an era of climate change.	30	0	0	60	2.00	II
10	Closure of Ranbir Canal also minimizes the efficiency of different fertilizers applied to wheat crop.	25	5	0	55	1.83	VII
11	Government should encourage Co-operative management of Ranbir Canal for its smooth Running throughout the year.	23	7	0	61	2.03	I
12	Effective coordination with the irrigation staff is necessary.	18	5	7	41	1.36	VIII
13	Availability of green fodder (barseem) is also reducing due to non-availability of water through canal.	29	1	0	59	1.96	III

On the basis of weighted mean for thirty farmers owning pumpsets, it is concluded that perception statements numbered at s.no 11 is ranked first by respondents having pumpset facility. The statement at s.no 1, 3 and 9 are ranked second. The statement at s.no. 2, 4 and 13 are ranked as third. The statements at s.no 6 are ranked by respondents at fourth position. The statement at s.no 5 and 7 is ranked as fifth. The Statements at s.no 8, 10 and 12 is ranked by respondents at sixth, seventh and eighth position by respondent farmers with respect to their perception on the effect of closure of Ranbir canal on the wheat productivity.

Table 4.13 Significant difference of perception score between two groups of farmers

S. No	Perception statements (Canal+Pump)	Without pump perception score	With pump perception score	Difference	t and p-value
1	Closure of Ranbir Canal during Rabi Season directly affects the Wheat productivity.	60	60	0	**-.906 (.374)**
2	Closure of Ranbir Canal mainly affect resource poor farmers.	60	59	1	
3	Closure of Ranbir Canal is also affecting total wheat area.	57	60	-3	
4	Farmers fails to apply irrigation to wheat crop at critical stages due to closure of Ranbir canal.	60	59	1	
5	Closure of Ranbir Canal during Rabi season also affecting quality of wheat crop.	59	57	2	
6	Closure of Ranbir Canal during Rabi season increases the vulnerability of farmers.	58	58	0	
7	Desilting of Ranbir Canal should be seasonally executed for ensuring its perennial flow.	56	57	-1	
8	Closure of Ranbir Canal is also impacting ground water level due to installation of large number of shallow pump set.	49	56	-7	
9	Government should think of opening of Ranbir Canal a bit earlier in an era of climate change.	60	60	0	
10	Closure of Ranbir Canal also minimizes the efficiency of different fertilizers applied to wheat crop.	49	55	-6	
11	Government should encourage Co-operative management of Ranbir Canal for its smooth Running throughout the year.	46	61	-15	
12	Effective coordination with the irrigation staff is necessary.	43	41	2	
13	Availability of green fodder (berseem) is also reducing due to non-availability of water through canal.	59	59	0	

On the basis of p-value which is more than 5% level of significance it is concluded that there is no significant difference between perception score of two groups of farmers having no pump sets and owning pump sets. It is also concluded that there is no significant difference in different aspects of perception of two groups of farmers regarding effect of closure of Ranbir canal on the productivity of wheat crop.

Discussion

CHAPTER-5

DISCUSSION

The important findings of the research work entitled as "Impact of Ranbir Canal Closure on Wheat Productivity" embedded in the preceding chapters are being discussed in the present chapter, as per details below.

5.1 Changing Rainfall Pattern

The results obtained in Table 4.1 clearly indicates that the rainfall in the *Rabi* season in the 1st decade is 337.8 mm whereas, in the 2nd decade it remained only 296.1 mm and 190.5 mm in the 3rd decade clearly indicating a decrease in rainfall by 13% in 2nd decade and 44% in 3rd decade as compared to the 1st decade. The trend is clearly visible in Fig 4.1.Thus, farmer's perception/statement that changes in rainfall pattern have given a setback to wheat production holds true as the rainfall decreases on decadal basis.

5.2 Consumptive Use of Wheat Crop

The data from the Table 4.3 shows the consumptive use of wheat crop having crop growing period from the month of the November to the end of April. The table gives the consumptive use for respective months with peak values in the month of March and April i.e. 67.5 and 94.5 mm respectively when the crop is at a very crucial stage of wheat productivity i.e. milky and dough stages.

5.3 Consumptive Use of Wheat along with average Effective Rainfall

From the table 4.4, it is clearly visible that from sowing of wheat crop till CRI stage in the 1st, 2nd and 3rd decade, Ranbir canal system was functioning normally and farmers were irrigating their fields from gravity fed canal system. As crop reaches jointing and flowering i.e. January and February (when the canal system is closed) rainfall in command areas is sufficient to meet the consumptive use values of the wheat crop during 1st, 2nd and 3rddecade, but stress in later part (milky and dough stages) only in 3rd decade forced the farmers to cry regarding closure of canal system i.e. March and

April depriving them from good yield of wheat crop. The data also indicates that during the months of March and April the availability of rainfall is quite less as compared to the consumptive use demand. Moreover, the rainfall further reduced to 33.5 against 67.5 mm (49.6 % less in Mar) and 11.3 mm against 94.5 mm, which works out to be only 11.9% of demand in April. These shortages of rainfall overall shrewled the size of the wheat grain with the result the productivity reduced substansiouly and farming community in the command areas with any source of irrigation due to closure of canal system suffered huge losses.

5.4 Wheat Productivity Reduction in Ranbir Canal Command

Table 4.9 it clearly indicates that the losses in wheat crop productivity varies between 2.9 to maximum 23.9% with overall percentage loss of 13.0% in all these 30 years data. Thus the farmer's perception that changes in rainfall pattern have given a setback to wheat production holds true also scientifically.

5.5 Wheat Productivity Reduction in Ranbir Canal Command

The result in Table 4.10 indicates that the yield expected in the command area is 26.1 q/ha but the farmers without irrigation system are getting only 22.6 q/ha .Thus suffering an average loss of 3.5 q/ha. The overall loss workout to be Rs. 17.7 crores. Thus the farmer's thinking that changes in rainfall pattern have given a setback to wheat production holds true also scientifically.

5.6 Perception of the Farmers regarding Closure of Ranbir Canal System

From Table 4.11, 4.12 and 4.13 and on the basis of p-value which is more than 5% level of significance, it is concluded that there is no significant difference between perception score of two groups of farmers having no pump sets and the other one having pump sets. It is also concluded that there is no significant difference in different aspects of perception of two groups of farmers regarding effect of closure of Ranbir canal on the productivity of wheat crop, but the farmers without pump suffers huge financial losses as discussed in 5.5 above.

Summary and Conclusions

CHAPTER-6

SUMMARY AND CONCLUSIONS

6.1 Summary

Rain water is considered as one of the most ideal sources of irrigation in case it is timely & adequately received. But rainfall in India varies in different regions, it is uncertain, uneven & prominently seasonal and, long dry period in India also badly affects the agriculture.Irrigation are carried in three different ways according to their sources such as; canals, wells or tube wells and tanks. It is necessary to maintain soil moisture favorable for satisfactory growth and development of the plants. If irrigations are not given at required time then there is drastic reduction in yield. Therefore, it is always necessary to give water to wheat crop as and when needed. If irrigation is not given at different stages i.e. CRI, tillering stage, jointing stage, flowering stage, milking stage and dough stage the reduction in yield is 35, 20, 20, 25, 17 and 10% respectively. The Ranbir canal in Jammu district irrigates 38,800 hectares area out of which, 27,548 hectares (71%) is sown under wheat crop. The canal system from its inception is closed from Jan to mid Apr for desiltation purpose and opens from mid Apr to end of Dec. During canal closure, the major crop in the command area is wheat. Due to the non-availability of water at the critical stages especially during the months of March and Apr (milky and dough stage), the productivity of wheat crop is reduced and the farmers are raising hue and cry to reopen the canal at the earliest stage so that the productivity of wheat crop is maintained due to the change in rainfall pattern as per the perception of the farmers.

6.2 Conclusion

It is concluded that farmers in the command area are facing huge losses amounting to Rs.17.7crores from an area of 27,548 ha which is cultivated under wheat crop from the total of 38,800ha (71%) under Ranbir canal. These losses can be eliminated very easily provided the irrigation department who is maintaining the water distribution system reschedule the canal closure period. Since water deficiency is mainly experienced in Mar and April, thus by all means the water should be made available to the farmers in the month of March to enhance the wheat production and productivity in the areas irrigated by Ranbir canal.

6.3 Suggestion for Future Work

The following suggestion are recommended for future work

- Survey should be planned and started at the earliest of the research.
- Survey can include more villages for more precise results.

References

REFERENCES

Abbate, P.E. Dardanelli, J.L. Cantarero, M.G. Maturano, M. Melchiori, R.J.M and Suero, E.E. 2004. Climatic and Water availability effects on water use efficiency in wheat.*Crop Science,* **44**(2):474-483.

Abhinaya Subedi and Joss L.Chavez.2015.Crop Evapotranspiration (ET) Estimation Models: A Review and Discussion of the Applicability and Limitations of ET Methods. *Journal of Agricultural Science,***7**(6): 50-68.

Ahmad and Kumar.2015. Effect of irrigation scheduling on the growth and yield of wheat genotypes. *Agricultural Science Digest,***35**(3):199-202.

Ali Z.K. Irrigation in Jammu Kashmir and Ladakh, Articles based website, Available online at http://www.yourarticlelibrary.com/essay/irrigation–in-jammu-kashmir-and-ladakh-division

Annual Report of Agromet Advisory Services Unit. 1997. RARS, *Sher-e-Kashmir University of Agricultural Sciences and Technology Jammu.* PP 06

Annual report on Irrigation Water Management.2012. *Sher-e-Kashmir University of Agricultural Sciences and Technology Jammu.*

Anonymous (2018a). *Statistics at a glance.* Directorate of Economics and Statistics. Department of Agriculture and Cooperation, Government of India.

Anonymous (2018b). *Statistics at a glance.* Directorate of Economics and Statistics. Government of Jammu and Kashmir.

ASCE-EWRI.2005.American Society of Civil Engineers- Environmental and Water Resources Institute.2005. Retrieved from http://ascelibrary.org

Bashir, M. U. Wajid, S.A. Ahmad, A. Awais, M. Razd, M. A. S. Tahir, G. M. and Abbas.2017.Irrigation scheduling of Wheat at different nitrogen levels in semi-arid region. *Turkish journal of field crops,* **22**(1): 63-70.

Bandyopadhyay P.K.1997.Effect of irrigation schedule on evapo-transpiration and water use efficiency of winter wheat (Triticum aestivum). *Indian Journal of agronomy*,**42**(1):90-93

Belal hossain, Khandakar faisal ibn Murad, Sariful bin Ekram, Niaz Farhat Rahman, Mahbudur Rashid Talukar and Mesbauddin Ahmed.2015.Irrigation Scheduling of Wheat using Pan Evaporation Method. *International journal of innovative Research in Advanced Engineering*, **2**(10): 99-103.

Bikrmaditya. Verma, R., Ram, S. and Sharma, B. 2011. Effect of soil moisture regimes and fertility levels on growth, yield and water use efficiency of wheat (Triticum aestivum L.).*Progressive Agriculture*, **11**(1): 73-78.

Chengyue Bian, Changjian Ma, Xinhui Liu, Chao Gao, Quanru Liu, Zhenxing Yan, Yujie Ren and Quanqi Li.2016.Responses of Winter Wheat Yield and Water Use Efficiency to Irrigation Frequency and Planting Pattern, *PLoS ONE*,**11**(5):1-13.

Deo, K., Mishra, S. R., Singh, A. K., Mishra, A. N., Singh, A. and Kumar, S.2017. Determination of suitable irrigation schedule for optimum water use efficiency of wheat crop. *Journal of Medicinal Plants*, **5**(3): 343-347.

DES.2016.*Statistical Digest of Jammu and Kashmir*. Directorate of Economics &Statistics. Government of Jammu and Kashmir

Dhaka, A.K., Bangarwa, A.S., Pannu, R.K., Malik, R.K. and Garg, R.2006. Phenological development, yield and yield attributes of different wheat genotypes as influenced by sowing time and irrigation. *Agricultural Science Digest*, **26**(3): 174-177.

FAO.2019.(Food and Agriculture Organization of the United Nations).2019 Conservation Agriculture Website. Available online at http://www.fao.org/docrep

Hajare, H. V., Raman, N. S., & Dharkar, E. J. 2008. New Technique for Evaluation of Crop Water Requirement. *WSEAS Transactions on Environment and Development*, **4**(5): 436-446.

Jana, P.K., Bandyopadhyay, P., Ray, D. and Bhowmick, M.K.2001. Response of wheat to irrigation regimes in new alluvial zone of West Bengal. *Annals of Agricultural Research*, **22**(4): 498-502.

Kotwal, A.K.2000. "Influence of irrigation scheduling, phosphorus levels on yield and phosphorus uptake in wheat (Triticum aestivum L). M.Sc. Thesis, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu.

Khan, M. J., Sarwar, T., Shahzadi, A., and Malik, A. 2007. Effect of different irrigation schedules on water use and yield of wheat. *Sarhad Journal of Agriculture*, **23**(4), 1055.

Khokhar, B., Hussain, I., and Khokhar, Z. 2010. Effect of different irrigation frequencies on growth and yield of different wheat genotypes in Sindh. *Pakistan J. Agric. Res*, **23**(3-4).

Lakhapati, S., Singh, C. M. and Singh, G. R.2012. Response of bed planted wheat (Tritcum aestivum L.) under the different moisture regime on water use and its efficiency. *Journal of Chemical and Pharmaceutical Research*, **4**(11), 4941-4945.

Er. Vinod Malothra.2018. History of Ranbir Canal Jammu. *Daily Excelsior* PP 04 dated 27-05-2018.

Mastsunaka, T., Takeuchi, H and Miyawaki, T.1992. Optimum irrigation period for grain production in spring wheat. *Soil Sciences and Plant Nutrition*, **38**(2): 269-279.

Meena, H., Narolia, R. S., Singh, P., Meena, P. K. P. and Kumhar, B. L.2017. Effect of Last Irrigation Scheduling and Foliar Spray of Bio Regulators on the Productivity of Wheat (Triticum aestivum L.) In Context to the Changing on Climate under South East Rajasthan, India. *Int. J. Curr. Microbiol. App. Sci*, **6**(5): 1825-1830.

Mishra, Gaurav, and H. S. Kushwaha.2016. Winter wheat yield and soil physical properties responses to different tillage and irrigation. *European Journal of Biological Research*, **6**(1): 56-63.

National Training Programme on Watershed Management Strategies.2009.*Sher-e-*

Kashmir University of Agricultural Sciences and Technology Jammu. PP 01.

National Training Programme on Watershed Management Strategies.2010.*Sher-e-Kashmir University of Agricultural Sciences and Technology Jammu* PP 02

Nayak, M.K., Patel, H.R., Prakash, V. and Kumar, A. 2015. Influence of Irrigation scheduling on crop growth, yield and quality of Wheat. *Journal of Agriculture Research and Technology*, **2**(1): 65-68.

Package of Practices.2017.Research Station Vijapur Junagadh Gujarat

Pandey, D.S., Kumar, D., Misra, R.D., Prakash, A. and Gupta, V.K.1997. An integrated approach of irrigation and fertilizer management to reduce lodging in wheat (Triticum aestivum), *Indian Journal of Agronomy*, **42**(1): 86-89.

Parihar, S.S., Gajri, P.R. and Narang, R.S.1974. Scheduling Irrigation to wheat, using pan evaporation. *Indian Journal of Agricultural Sciences*, **44**(9): 567-571.

Patel, R.M. and Upadhyaya, P.N.1993. Response of wheat to irrigation under varying levels of nitrogen and phosphorus. *Indian Journal of Agronomy*, **38** (1): 113-115.

Patra, S.S.1990.Response of wheat varieties to fertilizer and irrigation. *Indian Journal of Agronomy*, **35** (3): 302-303.

Pratibha, G., Ramaiah, N.V., and Satya Narayana, V.1994. Studies on Consumptive Water Use, W.U.E., Soil Moisture Extraction Patterns by Wheat Genotypes under Varying Irrigations applied at Different Physiological stages, APAU. *Journal Research*, **22**(1&2): 33-34.

Rahim, A., Ranjha, A. M., and Waraich, E. A. 2010. Effect of phosphorus application and irrigation scheduling on wheat yield and phosphorus use efficiency. *Soil and Environment*, **29**(1): 15-22.

Sagar, V. K., Naresh, R. K., and Sagar, P. K. 2018. Water Productivity and Water Use Pattern in Bed Planted Wheat (Triticum aestivum L.) under Varying Irrigation Schedules. *Int. J. Curr. Microbiol. App. Sci*

Sammis, T.W., Wang, J. and Miller, B.R.2011. The transition of the Blaney- Criddle formulla to the Penman- Monteith equation in western United States. *Journal of Service Climatology,* **1**(5)**:** 1-11.

Sarwar, N., Mawqsood, M., Mubeen, K., Shehzad, M., Bhullar, M.S., Qamar, R. and Akbar, N. 2010. Effect of different levels of irrigation on yield and yield components of wheat cultivars. *Pakistan Journal of Agricultural Sciences*, **47**(3): 371-374.

Saren, B.K. and Jana, P.K. 2001. Effect of depth of irrigation level and time of nitrogen application on growth, yield and nutrient uptake by wheat (Triticum aestivum L.). *Indian Journal of Agronomy,* **46**(2):227-232.

Sarkar, S.A., Jafar Ullal, Shahriar, S.A, Shathi,. S.A., and Imrul Kaes.2017.Response of yield performance of wheat to irrigation regime and sowing time, *International Journal of Agronomy and Agricultural Research,* **10**(6):76-84.

Sharma, J.P and Rajendra Prasad, 1986. Response of wheat varieties to different levels of nitrogen and phosphorus. *Agriculture Science Digest* **2**(3/4): 157.

Singh, V., Naresh, R. K., Kumar, R., Singh, A., Shahi, U. P., Kumar, V. and Rana, N. S. 2017. Enhancing Yield and Water Productivity of Wheat (Triticum aestivum) through Sowing Methods and Irrigation Schedules under Light Textured Soil of Western Uttar Pradesh, India, *Int.J.Curr. Microbiol. App. Sci,* **6**(4): 1400-1411.

Singh, Paramjit; Singh, Nathu; Narang, R.S. and Sodhi, K.S.1992. Water use and yield of wheat as influenced by soil water regimes, Punjab Agriculture University. *Journal of Research,***29**(1): 17 – 22.

Singh. R.P., Dhiman, S.D. and Sharma, H.C.1980. Performance of wheat varieties under limited water supply. *Indian Journal of Agronomy,* **25**(2): 259 – 262.

Sharma, A., Singh, H. and Nanwal, R.K.2007. Effect of integrated nutrient management on productivity of wheat (Triticum aestivum) under limited and adequate irrigation supplies. *Indian Journal of Agronomy,* **52**(2): 120-123.

Shivani, Verma, V.N., Kumar, S., Pal, S.K. and Thakur, R.2003. Growth analysis of wheat (Triticum aestivum) cultivars under different seeding dates and irrigation levels in Jharkhand. *Indian Journal of Agronomy*, **48**(4): 282-286.

Swati Shabnam, Singh, M.K, Verma, U.N, Shushama Majhi and Abhay kumar.2018.Energetics of Wheat production under different Irrigation Schedules and Seeding Dates, *An international Refereed, Peer Reviewed and Indexed Quarterly Journal in Science, Agriculture and Engineering*, **8**(A): 58-60.

Tiwari, K.P and Singh, S.P.1969. Effect of nitrogen phosphorus and irrigation on yield attributes of wheat. *Indian Journal of Agronomy*, **14**(1): 1-7.

Training Manual of Five days on Mission Water Conservation, 2018*, Sher-e-Kashmir University of Agricultural Sciences and Technology Jammu.* PP 18

Training Manual of Fourteen days training programme on SWPA (Directorate of Research), 2010, *Sher-e-Kashmir University of Agricultural Sciences and Technology Jammu.* PP 69

Telgote, M.S and Nalamwar, R.V.1989.Effect of irrigation scheduling on growth, yield and consumptive use of late wheat variety AKW – 381. *Annals of Plant Physiology* **3**(2): 283 -287.

Verma, H.P.2017. Yield Attributes and Yield of Wheat (Triticum Aestivum L.) as influenced by Irrigation Scheduling and Organic Manures.

Vishuddha. N., Singh, G.R., Kumar, R., Raj, S. and Yadav, B.2014. Effect of irrigation levels and nutrient sources on growth and Yield of wheat (Triticum aestivum L.). *Annals of Agricultural Research*, **35**(1): 14-20.

Wang, Z.Y.1992. Water requirement, distribution and economic irrigation methods for wheat. *Shaannxi Journal of Agriculture Sciences* (1): 28 – 40.

Annexure

ANNEXURE I

Division of Agriculture Engineering
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Chatha Jammu Tawi

SURVEY SHEET FOR THE ANALYSIS OF IMPACT OF RANBIR CANAL CLOSURE ON WHEAT PRODUCTIVITY

1. **Name of the farmer :**
2. **Parentage :**
3. **Village :**
4. **Residential address :**
5. **Contact number :**
6. **Family status with age** **Male** **Female** **Children** **Total**

7. **Education**
   (i) Illiterate (0)
   (ii) Can read only (1)
   (iii) Can read and write (2)
   (iv) Primary (3)
   (v) Middle (4)
   (vi) High & (10 + 2) (5)
   (vii) Graduate and above (6)

8. **Land Holding (ha/Kanal)**

Particulars	Total	Irrigated	Unirrigated	Waste land	Any other
I. Owned					
ii. Leased in					
iii. Leased out					
Grand Total : (i + ii)-(ii)					

9. Occupation

(i)	Agriculture	(1)
(ii)	Agriculture + Business	(2)
(iii)	Agriculture + Business + Service	(3)
(iv)	Others	(4)

10. Area under different crops

S. No	Season	Crop	Variety	Area (ha)	Seed rate (q/ha)	Production (q/ha)			Reason for increase decrease in crop production
						1980-1990	1990-2000	2000-2010	
	Kharif								
	Rabi	Wheat							
		Mustard							

11. Problems mainly encountered with Rice-Wheat Cropping System

S.No	**Problem**	**Crops**	
		Wheat	**Rice**
01	Increase/ decrease in yield over the years if any		
02	Insect – Pest		
03	Weeds		
04	Labour Shortages		
05	Electricity for irrigation		
06	Change in water table Depth		
07	Use of Harvest Combine		
08	Burning of Straw		
09	Awareness regarding change in cropping pattern		
10	Are you ready to change the cropping pattern		
11	Any other information		

12. Source of Irrigation:

S.No	Source	Operating procedure	Consumption of electricity per Kanal (500m^2)	Cost	Cost of consumption for total area	Increase in yield	Reason for increase/ decrease
01	Canal						
02	Canal + Tube well						
03	Natural rainfall						
04	Any other						

13. Perception of farmers towards effect of Ranbir Canal Closure on Wheat Productivity

S.No	Perception State	Agree	Neutral	Disagree
01	Closure of Ranbir Canal during *Rabi* Season directly affects the Wheat productivity.			
02	Closure of Ranbir Canal mainly affect resource poor farmers.			
03	Closure of Ranbir Canal is also affecting total wheat area.			
04	Farmers fails to apply irrigation to wheat crop at critical stages due to closure of Ranbir canal.			
05	Closure of Ranbir Canal during *Rabi* season also affecting quality of wheat crop.			
06	Closure of Ranbir Canal during *Rabi* season increases the vulnerability of farmers.			
07	Desilting of Ranbir Canal should be seasonally executed for ensuring its perennial flow.			
08	Closure of Ranbir Canal is also impacting ground water level due to installation of large number of shallow pump set.			
09	Government should think of opening of Ranbir Canal a bit earlier in an era of climate change.			
10	Closure of Ranbir Canal also minimizes the efficiency of different fertilizers applied to wheat crop.			
11	Government should encourage Co-operative management of Ranbir Canal for its smooth Running throughout the year.			
12	Effective coordination with the irrigation staff is necessary.			
13	Availability of green fodder (barssem) is also reducing due to non-availability of water through canal.			

Signature of the Farmer

ANNEXURE II

Meteorological data of *Rabi* 1980-81 to 2009-100 Chatha, Jammu

Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr	Total *Rabi* *Rabi*
1980-81	48.4	30.5	181.5	58.9	164.1	20.2	503.6
1981-82	34.4	0.0	57.4	75.4	206.0	118.9	492.1
1982-83	45.0	44.9	88.2	58.3	118.8	190.9	546.1
1983-84	0.0	0.0	0.2	64.4	50.6	7.5	122.7
1984-85	9.5	38.4	35.3	5.1	4.8	35.2	128.3
1985-86	0.4	121.7	5.9	82.8	68.4	42.5	321.7
1986-87	90.0	63.2	11.3	66.5	39.7	30.7	301.4
1987-88	0.0	0.4	72.3	68.3	180.4	12.1	333.5
1988-89	3.6	61.5	73.6	22.0	61.0	17.5	239.2
1989-90	7.7	49.0	38.2	169.8	120.1	4.8	389.6
Avg	**23.9**	**41.0**	**56.4**	**67.2**	**101.4**	**48.0**	**337.8**
1990-91	0.8	249.8	2.0	171.7	55.5	140.0	619.8
1991-92	3.1	7.9	155.8	74.5	100.4	18.0	359.7
1992-93	17.9	4.3	37.6	71.0	104.0	33.0	267.8
1993-94	4.4	0.0	82.7	40.3	4.3	35.5	167.2
1994-95	0.0	67.8	96.5	156.1	25.6	28.3	374.3
1995-96	7.6	2.8	50.6	95.5	42.7	8.3	207.5
1996-97	0.0	0.2	57.4	7.8	67.7	99.7	232.8
1997-98	46.0	9.8	10.0	138.9	86.8	69.7	361.2
1998-99	0.0	0.0	82.8	20.0	20.3	0.0	123.1
1999-00	35.9	0.0	127.3	61.9	20.3	2.6	248.0
Avg	**11.6**	**34.3**	**70.3**	**83.8**	**52.8**	**43.5**	**296.1**
2000-01	2.6	0.2	13.9	7.6	30.0	34.3	88.6
2001-02	1.0	1.4	8.4	4.4	43.1	15.9	74.2

2002-03	0.0	7.1	9.1	147.5	74.1	10.1	247.9
2003-04	27.3	25.2	84.4	16.2	0.0	29.9	183.0
2004-05	3.6	28.4	105.7	139.7	90.2	9.9	377.5
2005-06	0.0	0.0	58.7	8.0	34.7	10.0	111.4
2006-07	13.0	32.8	0.0	71.0	278.2	2.6	397.6
2007-08	7.6	9.3	80.7	23.0	1.0	69.8	191.4
2008-09	0.0	24.2	60.8	37.6	22.4	42.4	187.4
2009-10	9.2	0.0	8.8	20.7	6.0	0.8	45.5
Avg	**6.4**	**12.9**	**43.0**	**47.6**	**58.0**	**22.6**	**190.5**
Avg 30 years	**13.0**	**29.4**	**56.6**	**66.2**	**62.6**	**38.0**	**274.8**

Vita

VITA

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CERTIFICATE-IV

Certified that all necessary corrections as suggested by external examiner and the advisory committee have been duly incorporated in the thesis entitled "**Impact of Ranbir Canal Closure on Wheat Productivity**" submitted by **Ms. Mubina Banoo,** Registration No. **J-17-M-527.**

Er. N.K. Gupta
(Major advisor)

Place : Jammu

Date : 22/10/2019

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