

**Enhancing Water Productivity and Cropping
Intensity in Right Bank Canal Command
Area of Samrat Ashok Sagar Project of
Vidisha District (MP)**

THESIS

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Jawaharlal Nehru KrishiVishwaVidyalaya, Jabalpur

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In

**AGRICULTURAL ENGINEERING
(SOIL AND WATER ENGINEERING)**

By

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2018

CERTIFICATE-I

*This is to certify that the thesis entitled “**Enhancing Water Productivity and Cropping Intensity in Right Bank Canal Command Area of Samrat Ashok Sagar Project of Vidisha District (MP)**” submitted in partial fulfillment of the requirement for the degree of **DOCTOR OF PHILOSOPHY in Agricultural Engineering (Soil and Water Engineering)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by*

***Mr. Shiv Singh Basediya** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instructions.*

All the assistance and help received during the course of the investigation has been acknowledged by him.

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ABBREVIATIONS

Abbreviations	Description
%	Percentage
Σ	Summation
()	Parenthesis
et al.	And others
Deptt.	Department
&	And
Df	Degree of freedom
Km	Kilometre
H	Horizontal
V	Vertical
Fig.	Figure
$m\ s^{-1}$	Meter per second
$m^3\ s^{-1}$	Cubic meter per second
hr.	Hours
i.e.	That is
MS	Mean Sum of square
CCA	Culturable Command Area
Ha	Hectare
$M\ m^3$	Million Cubic meter
WUA	Water User Association
J.N.K.V.V.	JawaharlalNehruKrishiVishwaVidyalaya
CAE	College of Agricultural Engineering
CD	Critical Difference
$kg\ m^{-3}$	Kilogram per cubic meter
$q\ ha^{-1}$	quintal per hectare

S.No.		Serial number
Cm		Centimeter
	Govt.	Government
	Agril.	Agricultural
	BCM	Billion CubicMeter
	CWC	CentralWaterCommission
	RBC	Right Bank Canal
	D ₁	Distributary one
	D ₂	Distributary two
	D ₃	Distributary three
	CD	Critical Difference
	SAS	Samrat Ashok Sagar
	SV	Sum of Variance
	SS	Sum of Square
<	Less than	
	>	More than
	lps	Liter per second
	MILP	Mixed-Integer Linear Programming
	LP	Linear Programming
	OFD	On-Farm Demonstration
	RWS	Rotational Water Supply
	RFP	Recommended Farmer Practice

INTRODUCTION

Water is the most precious natural resource and a universal asset. Water is scarce and it has several characteristics that make the role of its development and management more essential than other goods available for mankind. The World's total irrigated area is 311 M ha out of which 21.7% irrigated area exist in India. On an average, the global consumption of water in agriculture is around 71% of the total water use (FAO, 2013). India has 17% of global population, and only 4% of global freshwater supply. Irrigated agriculture has a predominant role in India's food production. During the post-independence period, the country has invested huge amount of capital in the major and the medium irrigation projects. The average annual water availability of the country is assessed as 1869 billion cubic meters (BCM). Of this, total utilizable water resources are assessed as 1123 BCM, surface water 690 BCM and ground water as 433 BCM. At present, India has the ultimate irrigation potential of 140 M ha and the total area equipped for irrigation is 66.3 M ha (FAO, 2013).

In India, most of the irrigation networks are unlined and huge amount of the irrigation water is lost in main canal, distributaries, minors and field channels. Navalwala (1991) found that about 71% of the irrigation water is lost in the whole process of its conveyance from head works and application in the field. The breakup of the losses in main and branch canal (15%), distributaries (7%), water courses (22%) and field losses of (27%). The situation is particularly bad in minor irrigation systems of plateau areas of eastern India, where the overall irrigation efficiency varies between 20% to 35%. These systems are located in coarse soil area and have rolling topography. Due to this, the conveyance losses are high and the system suffers from inadequate supply and poor water availability especially during lean season. Therefore, the need of the hour is to increase irrigation efficiency of existing projects and use saved water for irrigating new areas or reducing the gap between potential and actual irrigated areas. Shifting to

pressurized irrigation can be an option for increasing this irrigation efficiency.

Modernization of the irrigation system is required for improving the overall project efficiency of irrigation projects and increasing the water productivity. Modernization and optimization of irrigation systems have often been promoted in public and private agendas as tools to improve irrigation efficiency and producing more agricultural goods with less water input. Playan and Maetos (2006) Shifting from surface irrigation to pressurized irrigation system to increase water use efficiency is an important component of the modernization process. Water is the most critical input for agriculture. The availability of adequate water for irrigation is a key factor in achieving higher productivity. However, poor efficiency of conventional irrigation systems has not only reduced the anticipated outcome of investments towards water resource development, but has also resulted in environmental problems viz., water logging and soil salinity, thereby adversely affecting crop yields. Management of the water resources for diverse uses should incorporate a participatory approach: by involving not only the various governmental agencies but also the users' and other stakeholders, in an effective and decisive manner, in various aspects of planning, design, development and management of the water resources schemes. Water User's Association and local bodies such as municipalities and Gram-Panchayats should particularly be involved in the operation, maintenance and management of water infrastructures/facilities at appropriate levels progressively, with a view to eventually transfer the management of such facilities to the user groups/ local bodies studies by Kathpalia and Kapoor (2002). Command area development program (CADP) was launched exclusively to reduce the physical and time gap between irrigation potential created and its actual utilization through systematic land development, scientific water management and appropriate extension methods (Rathod, 2013).

Madhya Pradesh, with a geographic area of about 30.8 M ha is the second largest state of India. The major land use in Madhya Pradesh is under agriculture (49.5% of geographic area) followed by forest (30.88%). The state has a sub-tropical climate and the average annual rainfall is 1160 mm (with regional variation from below 800 mm to above 1600 mm). The state has sufficient water resources and it is estimated that about 70% of water resources can be harnessed for irrigation purpose. It is possible to irrigate about 60.90 lakh ha from surface water, while 52 lakh ha can be irrigated through ground water. Thus the state has an ultimate irrigation potential of about 121.74 lakh ha. The net irrigated area in the state including all resources of irrigation in the year 2011-2012 was 78.80 lakh ha, which was 52.47% of the net sown area. When the above potential is harnessed, the percentage of irrigation to net sown area would be 76.80% (State Focus Paper 2015, NABARD (MP)).

Agriculture is still the mainstay of the state's economy, as about 71% of the population is still dependent on agriculture. Agriculture in the state is still traditional and mostly rainfed. There is high proportion of low value crops with low productivity. There are large area of cultivable wastes and fallow lands. Agricultural holding are fragmented. Net area sown in the state in 2015 was 150.44 lakh ha of which 57.16 lakh ha was double crop area. At present, about 60% of gross cropped area is under food crops and remaining 41% area under non-food crops. Wheat and rice contribute about 59% of the total food grain production. A number of major, medium and minor schemes have been develop for irrigation in the state through massive investment under successive five-year plans to build on a long history of water management. Major irrigation schemes are those which have cultivable command area (CCA) more than 10,000 ha. Irrigation schemes having CCA between 2,000 to 10,000 ha are classed as medium irrigation schemes. Before the first five-year plan (1950-51) the state was having 2 major irrigation projects, 18 medium irrigation projects and 618 minor irrigation schemes having irrigation potential of 4.69 lakh ha. At the

re-organization of the state in 1956, the state had 4.84 lakh ha irrigation potential with 3 major, 37 medium and 948 minor irrigation schemes. In the year 1997-98 the state had 22 major, 134 medium and 6910 minor irrigation schemes having irrigation potential of 33.04 lakh ha. The irrigation potential in the year 2014-15 has become 112.9 lakh ha. In Madhya Pradesh 22 major, 90 medium and 4804 minor irrigation schemes have been completed (CWC, <http://www.india-wris.nrsc.gov.in>, 2016). Shifting from surface irrigation to pressurized irrigation system requires changing the supply of water from on-off mode to continuous, reduction of turbidity to desirable level and modifying system to provide surface irrigation to rice crop in monsoon and different types of pressurized irrigation to suit different crops of the command in post monsoon season. The technical and economic feasibility of these interventions require studying the real field conditions. The modernization program of the canal irrigation system in Madhya Pradesh is going on in different commands with the help of various funding agencies as well as from national funds. The improvement and interventions to enhance the water use efficiency have been concentrated on renovating the canal network and not much emphasis was on below the outlet thus a need is being felt for identifying the interventions to be done below the outlet level which will provide significant improvement in water use efficiency as well as water productivity the interventions design should not only improve water productivity but also should increase cropping intensity which is important in improving the condition of farmers with this in view Samrat Ashok Sagar irrigation project of Vidisha district Madhya Pradesh is being selected as study area.

Samrat Ashok Sagar Project is a major irrigation project located in Vidisha district of Madhya Pradesh (India). The gross command area of the Samrat Ashok Sagar (SAS) project is 37,419 ha, cultivable command area is 32,292 ha and canal irrigated area is 30,151 ha. The total irrigated area of SAS project is about 44,000 ha, including irrigation through other sources. 2,141 ha area out of total irrigated area is being irrigated through pumping

from canal. The cultivable command area of Right Bank Canal is 14,836 ha and irrigated area of RBC command is 9,503 ha. Out of this 2,436 ha area is being irrigated through pumping from canals as water is not reaching through gravity. The supply of canal water is stopped in the month of February to meet to increasing demand of drinking water for Vidisha Township. So in peak maturity period of crops farmers do not get water. The tail end farmers do not get water during supply period because of seepage losses, over irrigation and poor maintenance of system. This all result in low water productivity, "Pressurized irrigation in command area" is emerging as a solution of these problems as reported by Shrivastava et al. (2010), Nema and Shrivastava (2012), Rathod and Shah (2013), with these facts in mind about water distribution system of right bank canal command area, a detailed study with following objectives was planned.

1. To assess existing cropping intensity and water productivity.
2. To assess techno-economic feasibility of pressurized irrigation in the study area and to prepare conjunctive plan for surface and pressurized irrigation.
3. To implement and evaluate the proposed plan at farmers' fields of right bank canal command area of Samrat Ashok Sagar Project.

REVIEW OF LITERATURE

2.1 General

This chapter deals with a brief review of the work done by several research workers in the country and abroad related to methods of surface and micro irrigation flood, border and sprinkler according to water productivity, cropping intensity, irrigation efficiency along with critical comments. An account of work is taken for the role of Water User Association in command area, water distribution, crop production and water resource utilization, use of ground water and behavior of farmers in command area in respect of improvement of water productivity and cropping intensity.

2.2 Canal Irrigation

Irrigation has been practiced throughout the world since the early days of civilization. In India too, water conservation for irrigation has received much attention since the beginning of civilization. The grand amicus across the river Cauvery existed in the second century. At the beginning of the 19th century, there were large number of water tanks in peninsular India and several inundation canals in northern India. The upper Ganga canal, the upper Bari Doab canal and the Krishna and Godavari delta systems were constructed between 1836 and 1866. The famines of 1876-78, 1897-98 1899-1900 led to the setting up of the first irrigation commission in 1901 to ascertain the usefulness of irrigation as a means of protection against famine and to assess the extent of irrigation development required and the scope for further irrigation work. In 1901 the total irrigated area was only 13.3 M ha which increased to 22.6 M ha 1950 as a result of spurt in protective irrigation schemes. After independence, the country began an era of planned development starting with the first five-year plan in 1951. (Shah T 2011).

Rana and Raman (1999) studied the irrigation arrangements in the Indian North West region of Gujarat. Approximately, 2.5 million ha of the 10.9 million ha cultivated area was irrigated. Arrangements differed in the eight agro-

climatic zones. North Gujarat and the saurashtra peninsula were generally irrigated with ground water, while South and Central Gujarat area were predominantly irrigated by canal water. In the canal irrigated areas, the major problems were water logging, secondary salinization, higher incidence of pest and diseases and tail end problems. These were mainly due to: (i) Poor drainage, especially in heavy textured soils with low outfall conditions; (ii) Unscientific water management practices; (iii) Preference for high water consuming crops; (iv) Over use by head-reach farmers; (v) Aquatic weeds; (vi) High conveyance losses; (vii) Slow uptake of conjunctive use. Fast receding water tables combined with the poor quality waters were the major constraints.

India is among the foremost countries in the world practicing large scale irrigation. During the post-independence period, the country has invested huge amount of capital in the major and the medium irrigation projects. The performance of major and medium irrigation schemes was examined by the National Irrigation Commission (1972), the National Commission on Agriculture (1976) and several other committees. However the gap between the potential created and utilized has been increasing over the years. It was found that the available irrigation potential was not fully utilized. The difference between the available and utilized irrigation potential exceeds 4.0 M ha. Among the states, three have already achieved 70% or more of the ultimate irrigation potential with Tamilnadu recording 100% achievement, followed by the Punjab and Rajasthan 84% and 74% respectively. 53% of the net sown area in the country is rain-fed as of 2012-13. 47% (66.1 million hectares) of the net sown area is irrigated by ground water sources such as wells and tube-wells, and surface water sources such as canals and tanks, as of 2013-14. Irrigated area constituted 18% (20.9 million hectares) of the sown area in 1950-51. In Madhya Pradesh, long term planning has been done to develop irrigation and all possible efforts are being made to execute such plans. 22 major, 90 medium and 4804 minor schemes have completed till 2015. (Anonymous Annual plan WRD Govt. of M.P 2015).

2.3 Evaluating System Performance

Performance evaluation parameters of irrigation canal systems should involve factors such as command area, canal network, control structures, cropping patterns, weather conditions as well as human factors. An integrated simulation and optimization approach is proposed to improve the irrigation delivery system operation and management strategy. Providing optimal water levels in the main system will guarantee proper flow diversion to laterals and farm turnouts. Research work was conducted to evaluate irrigation project performance at different locations by taking different parameters.

Hart et al. (1979) described performance of an irrigation system in terms of four parameters, i.e. the fraction of the observed water stored in the root zone, the fraction of the requirement fulfilled, the fraction of the delivered water absorbed and the fraction of the infiltration water that percolated below the mean infiltration depth. Most of the efficiencies including storage, application, delivery and distribution were derived from these parameters.

The performance of an irrigation project was studied by Reddy (1986) in terms of technical efficiencies with which the water was provided to the crop root zone, total agricultural production from the project and the equity. Performance of an irrigated agricultural production system is dependent upon technical, economical, institutional and organizational support to the system under a given set of constraints.

Sharma and Rao (1997) evaluated Paladugu major distributary in the Nagarjuna Sagar Right Bank Canal Command Area in Andhra Pradesh, in terms of water supply requirement ratio and other indices such as irrigation intensity, crop productivity and cropping pattern. A comparison with the performance of the system in the year before the scheme was introduced revealed that the scheme effectively led to a sustained increase in the irrigated area and irrigation intensity (by >25) resulting in increased crop production. Yield of paddy and cotton went up by more than 100%.

Nelson (2000) studied the socio-economic and delivery aspect of the system. Key delivery system indicators, suggested were area uniformity, carrying capacity and sustainability of irrigated area with set of potential benefits of irrigation, which could be measured as response capacity, farmer's satisfaction, knowledge of farmers and house hold income.

Wahaj (2001) studied the performance of irrigation system in Fordwah Irrigation system in Pakistan. Six water courses along the two distributaries at the tail of the system were selected for in depth study. Collective and individual water management actions were studied to understand their dynamics and their impact on improving water delivery to the farm. The study suggested that there was neither a standard set of water management activities nor there was strict plan. Farmer's actions were mostly subjected to their desires to match water demand with supply. However, one could still see some of the water management activities that were inevitable to operate the system. Collective action was undertaken more at the watercourse or higher level in the irrigation system, whereas individual actions were mainly undertaken at the farm level. The study indicates that farmers were knowledgeable and capable actors who took actions that improved water supply and compensated for dysfunctional delivery; farmer's actions were not only technical and economically sound but also motivated other than just economic benefit; farmer's management could be classified as contingent management and rather it was performance oriented; and performance indicators, which were not able to show realities of social relations shaping water availability could be improved by including criteria to performance of irrigation system from the perspectives of different actors. Patterns of conjunctive water use at the farm level suggested that in the future groundwater must continue to provide significant amount of water for crop production.

Singh and Kothari (2006) examined water delivery performance of the Amarpura minor, in the command area of left main canal of Som-kagdar irrigation project, of Rajasthan, India. Outlet wise performance was evaluated, using the adequacy, equity, dependability and relative water supply indicators.

The outlet wise water delivery performance indicators have shown poor performance of the system. Considering the irrigation season and system as a whole, the calculated indicator's average values were found as "poor" for adequacy, equity and dependability. These results have also shown that there is a systemic water delivery problem.

The performance of minor irrigation project of Mehgawn tola command area had been evaluated by Patidar et al. (2007). It was reported that overall project irrigation efficiency decreased from head to tail reach of the command area. Irrigation efficiency was obtained as 75.36%, 69.80% and 62.59% at head middle and tail reach respectively. Performance of irrigation system at farm as well as water course level was evaluated by Tyagi (1998) showed that equity of water distribution decreased with the size of water course (flow rate). The average relative water supply was observed to be in (m³/sec) 0.72 in summer and 0.65 in winter at the head reach and 0.52 in summer and 0.50 in winter at the tail reach of water course.

Checkol and Alamirew (2008) made technical and institutional performance evaluation of Geray Irrigation Scheme in order to identify management practices for implementation to improve the system operation and the performance of the irrigation system. The evaluation was made based on the selected performance indicators such as conveyance efficiency, application efficiency, water delivery performance and maintenance indicators. The availability of institutional and support services were also investigated through a questionnaire administered to beneficiary farmers and other stakeholders. Results showed that proper institutional setup need to be in place and WUA needs to be more empowered in order to enforce its by-laws.

Korkmaz and Avci (2012) evaluated water delivery and irrigation performances in the Menemen Left Bank irrigation district at field level on the basis of farmers' irrigations. Water delivery performance was determined by the indicators of adequacy, efficiency, dependability equity and irrigation performance was determined according to the indicators of water application,

water storage, uniformity coefficient, and distribution uniformity. These indicators were evaluated from the amount of water which was actually applied and which should have been applied and from soil moisture values for the irrigation seasons of 2005 and 2006. Two-year average varied between 50% and 80% for water application efficiency, 54% and 97% for water storage efficiency, 73% and 88% for uniformity coefficient and 68% and 82% for distribution uniformity. These result showed that irrigation efficiency and uniformity are generally at attainable levels for surface irrigation.

Asaana and Sadick (2016) found that irrigation performance of the command areas studied was poor. Due to operational and physical deficiencies in the system. The indicators, namely Overall Consumed Ratio (OCR), Relative Water Supply (RWS), Relative Evapotranspiration (RET), Depleted Fraction (DF) and Crop Water Deficit (CWD) were used at 3 command areas, Bonia, Korania and Chuchuliga. Potential evapotranspiration and actual evapotranspiration were estimated with Penman Monteith method and Surface Energy Balance System (SEBS) using Aster Satellite image, respectively. Most of the canals and laterals leading to the command areas were broken down and this has become difficult to assess irrigation performance. Data for estimating most of the indicators were missing at the time of visit. There was no data on groundwater supply which play important role when considering the amount of water supply to the system.

2.4 Performance Parameters

Biswas (1984) described a list of parameters monitored in relation to the operation and maintenance of irrigation projects. Table 2.1 shows the factors that influence performance of the irrigation delivery system.

Table 2.1 Factors Influencing Performance of Delivery System

Process	Influence on the performance
Planning	Cropping pattern (crop water requirements) equity, Layout of command area, Channel design, Rotation, continuous or on-demand
Design	Seepage losses, design discharge, depth of flow, Location, type and size of structures, section parameters (shape, size, roughness, slope)
Operation	Timing of operation, skills of the operator, communication related to supply and demand
Maintenance	Structure

Tripathi (1984) suggested the principal objectives of (i) increasing the utilization of irrigation potential in selected major and medium projects (ii) raising productivity per unit of irrigated land through adoption of proper land, water and crop management; and (iii) making an equitable distribution of irrigation water between different size holding classes of farmers in various districts of the command areas. Analyses made both before and after and using with and without approaches indicate substantial changes in productivity, specifically in cereal crops.

Bos and Nugteren (1990) presented the most widely used concepts and definitions of irrigation efficiencies. Overall project efficiency was divided into various components so that the efficiencies associated with different components of the water delivery system-conveyance, distribution, and field application can be separately stated. The performance of warabandi system and illustrated some of the practical aspect of carrying out a rapid performance assessment had been described by Goldsmith and Makin (1991).

Conveyance efficiency was improved to 53% at time of study 42% without improved maintenance. The efficiency of canal water in a monsoon climate is generally low, unless conjunctive use of other water resources (i.e. groundwater) is possible has been calculated by Tyagi et al. (1992). A demand/supply decision model was formulated to aid in planning the optimal use of canal and groundwater with a view to improve this efficiency. The model was applied to a typical, watercourse command in the Bhakra canal project. It indicated that the canal water utilization efficiency could be improved from the existing level of 72% to 95%, if 70% of the groundwater potential were developed. Nearly 98% utilization efficiency could be achieved at 85% development of groundwater potential.

Kaushal et al. (1992) considered equity (uniformity of water distribution), adequacy (ratio of seasonal supply and demand) and productivity (timing and quantity of water) as the criteria parameters of irrigation system performance, diagnostic analyses were performed for unit command areas of the Bhakra canal system in Haryana. Low values of performance indices were due to improper unit command area and stream sizes, temporal mismatch between demand and supply and the rigid frequency schedules. Introduction of auxiliary storage, intra and inter-seasonal changes in fixed frequency schedules to reduce the mismatch and improved design of unit command area size with consideration for soil characteristics would improve performance.

The Bardenas district Canal surface irrigation had been studied by Lecina et al. (2004) alternatives were assessed to improve on-farm irrigation performance. Field work consisted of a soil survey and a campaign of irrigation evaluation. Shallow soils, a limited conveyance network and poor irrigation management practices resulted average application efficiency in the district as 49%. The district wide irrigation efficiency only reaches reasonable values of 66% when the system operates under water scarcity.

Chandra et al. (2008) worked on variations in groundwater use, water productivity and profitability across a canal command in the Indo- Gangetic

basin, at the farmer field level in the command area of Pabnawa minor (tertiary canal) of Bhakra irrigation system. The groundwater contribution in the canal command was very high. Water productivity increased from head to tail due to wastage of canal water upstream and judicious use of groundwater at the tail end. Farmers practicing conjunctive use have higher profitability than tube-well irrigators and canal irrigators. The cost of water increases from head to tail, but because of the flat rate charge for electricity there was only a small difference in the costs of water for paddy and wheat.

.Productivity of water is sum of the net multi-sectorial benefits per unit of water used in the river basin. Three basic thrust area addressed for improving the productivity of water are improving the institutional landscape, ensuring the efficient delivery system and following the management techniques. At system and river basin level, options for improving water productivity includes better land use planning, use of medium term weather forecast, improved irrigation system and scheduling and use of various source of water Tiwari (2008).

2.5 Farmers Participation in Water Management

Svendsen et al. (1990) studied farmer perspective on irrigation performance. The paper attempts to explore the meaning of irrigation performance from their perspective, highlighting at the outset basic difference between this perspective and that of system manager. Discuss a set of twelve parameters of irrigation service were judged as adequacy, timeliness, equity, tractability, convenience, predictability temperature, sediment content, salt content, nutrient content, toxics and pathogens.

Parker (1992) summarized findings from several different studies in Bangladesh focused on command area utilization, yield, and equity under various irrigation systems or management changes and on irrigation fees in all of the systems. Role of farmers and farm managers (or owners) in making decisions, in cooperating (or not), or in just reacting to the opportunities created by the action of others has been included. Farmers were Involved in the operation of the Ganges-Kobadak rotation scheme to contribute to the success

of the program. In the Rajshahi area, most well are dominated not by the irrigation agency but by one farmer or a group of farmers, who are de facto owners. It again seems to have been farmers involvement in fee setting and collecting that has helped determine success or failure.

Chandran et al. (2001) quantified the farmers' participation through Water Users' Associations (WUAs) under Command Area Development Program (CADP) in Malampuzha Irrigation Project, Kerala State. The study has shown that only about 30 percent of participatory activities envisaged for WUAs were being undertaken by farmers and hence participation is low. Most of the activities undertaken were related to irrigation water management. Activities such as consolidation of landholdings, group farming, adoption of suitable cropping pattern etc., were not carried out most of the WUAs. Farmers were found to contribute money labor for maintenance field channels constructed by CADA in order to ensure water availability. However, a system of farm channels for carrying out scientific on-farm water management through channel to field irrigation and Rotational Water Supply (RWS) does not exist for majority of the WUAs. Location (reach) of WUAs on the canal network was not found to influence farmer participation since water scarcity was not a problem in the different reaches. However, landholding size was found to influence participation.

Satyal et al. (2006) evaluated the dynamics of water scheduling in a farmer managed irrigation system in a small mountain watershed (Tharigad) of the central Himalaya. Despite being ancient, these systems perform at high project irrigation efficiencies because of the proper water scheduling managed by the local community. These water distribution schedules functioned smoothly until recent times and helped the farmers to meet irrigation needs during the crucial period of crop germination when other areas of the region suffered water crises. The distribution of water was decided by an irrigation committee on the basis of the area to be irrigated and the distance of the village from the source. The studies revealed that with public participation, the performance of irrigation system can be improved.

2.6 Problems in Command Area

Singh (1978) suggested that the latest practice for the approximation of absorption losses in unlined channels was to assume a loss varying from 1.83 cumec/M sq.m of wetted area for a channel with a discharge upto 3.36 cumec for a channel upto 56 cumec discharge.

Abassi (1991) studied the environmental impact in some of the major irrigation projects of Karnataka. The study offers, some useful insights on the causal factors of waterlogging and salinity. In the Upper Krishna project, nearly 1,000 ha of area has been affected due to waterlogging and about 500 ha are prey to salinity and solicit. Improper leveling of irrigated land, absence of field drains, silting up of natural drains along with weed growth, non-exploitation of groundwater and adoption of a cropping pattern not best suited to the specific soil has led to adverse effects. Natural factors like the heterogeneity of geology and landscapes further contributed to the problem. In the Malaprabha project, more than 2,460 ha have become waterlogged or saline because of the adoption of a cropping pattern not suitable to the soil apart from improper water management practices. Furthermore, field canals were not maintained properly and the lands were not leveled as required. Similarly, in projects like Ghata Prabha, an area of about 2,000 ha is estimated to have been affected by waterlogging.

In last two decades, the may researchers investigated the hazards of over irrigation and its impact on large and small farmers head been highlighted by Das (1991). This study was undertaken in the Ajoy-Kopai inter riverine tract in western West Bengal to analyzed the nature and extent of loss incurred by farmers due to uncontrolled canal irrigation. Large areas have been degraded. It was noted that, there was no cause and effect relationship between elevation, socio-economic groups of farmers and the amount of degraded land. Both the rich and the poor farmers have fallen prey to land degradation. The author has attributed improper provision and unscientific distribution of irrigation water, lack of proper coordination and communication between various organizations.

Environmental problems in the major irrigation projects as defined by Reddy (1991) for the potential catchment and command area. In his study on Ghata Prabha irrigation project, in the northern part of Karnataka, it was observed that 96 villages were affected by salinity, waterlogging and alkalinity. The areas affected by waterlogging constitute about 3% of the command area brought under irrigation. It was further noted that in the villages located at the head and middle reaches of canals, the adverse effects on soil were more when compared to the tail end. The reasons for adverse effects in the upper reaches were over irrigation and violation of cropping pattern, and also non-lining of canals. Lack of proper drainage, encroachment of natural drains, non-practicing of night irrigation, lack of scientific on-farm development and high intensity of cropping seem to have compounded the problems. The study has also highlighted some of the positive effects of canal irrigation on the social environment.

Pramanick (1996) studied the Damodar Valley Irrigation Command in West Bengal, India to understand the existing water utilization pattern below an outlet and to optimize the available water resources through farmers' participatory approach. Significant amount of canal water wastage due to untimely release, a lack of regulatory measure at the outlet, free flooding and a lack of field channels results in low water use efficiency of the canal irrigation System. Considering the existing situation, an on-farm research project was conducted on a large number of farmers' fields. As a result of these trials, through farmers' participatory activity, it was revealed that out of the total number of farmers in the minor followed the proven irrigation management methods to achieve higher water use efficiency. The effects of major irrigation projects in Puri and Balasore was investigated by Atibudhi (1997) for every 100 ha that were under irrigation eight ha have gone out of cultivation due to waterlogging. The resource use in the problem area is seriously affected. Policy measures suggested to tackle the problem included conjunctive use of water in command area, drainage and supply of rotational irrigation water, changing the cropping pattern and more light duty crops.

Reddy (1998) was made a comprehensive attempt to understand the problems and prospects of irrigation development in canal commands. The approach and thrust given in the study is a longitudinal study and the focus is on farmers' understanding of the various irrigation related factors and its impact on the implementation of CAD programme. The study identifies perceptible gap between area notified for irrigation and the area actually irrigated and this has been on account of a host of factors as reported by the farmers including non-leveling of land before the actual release of water (40.7%), followed by lack of adequate water in the canal (32.2%), undependable and untimely supply (27.1%) and non-availability of labour (24.7%). The impact of OFD on water use efficiency in terms of value of crop output per unit of water used and productivity of crops have also been examined. The productivity of crops grown in the plots where OFD is done scientifically is invariably higher than those grown in undeveloped plots.

A study was conducted by Choudary (2007) for it is important to know at the outset how the farmers' perceive the current irrigation service delivery system to provide a superior irrigation service to the farmers. The results show that only 69 per cent reported canal irrigation as the dominant source of irrigation. Only 56 per cent of the total irrigation needs of an individual farmer come from the canals. Accountability of the service providers towards the farmers is currently lacking and needs major attention in the future. Quality of the service delivery varied across different sections of the command of a system, with the tail reaches receiving the worst service, effectively shrinking the actual command.

2.7 Causes of Poor Performance

Tom et al. (1999) discussed on irrigation efficiencies and identified that inefficient use of water, leakage from unlined canals or breakage in the canal systems and faulty use of irrigation water (overflowing in flood irrigation regimes) are some of the causes of irrigation inefficiencies in the canal command areas.

Vaidyanathan (1999) considered capacity under-utilisation in irrigation projects as an outcome of the lack of complementarity between the state initiatives in constructing the main reservoir, main and branch canals and distributaries up to outlets as well as the beneficiary efforts in constructing field channels in their own fields' necessary for irrigation.

Padaria et al. (2000) pointed out in the study of Tawa irrigation project that an area of 335.20 ha has been affected by waterlogging and these areas were spread over 25 villages. Severely waterlogged areas became unsuitable for cultivation and remained as marshy barren lands. The study has attributed a number of reasons for such adverse effects, like faulty on-farm development works carried out by the government, careless and excess irrigation by the farmers, and lack of farmers' cooperation and participation in the operation and maintenance of canals. Seepage coupled with high rainfall and moisture retentive deep black cotton soil further aggravated the problem of waterlogging. The study emphasizes the need for training of farmers to ensure a proper utilization of water and also to form farmers' cooperatives for proper operation and maintenance of canals.

Styles and Marino (2017) utilized and refined a set of evaluation indicators to describe the irrigation performance for 16 international irrigation projects in less developed countries and found that performance of many projects was poor. The causes behind the poor performance of these projects were due to technical, financial, managerial, social, or institutional causes. They concluded that modernized irrigation delivery service index can be used as a determinant of an economic irrigation project performance indicator.

Ahmad (2017) claimed that water scarcity, degradation of water and land and lack of funds to maintain and develop irrigation and drainage systems are symptoms of deeper problems of policy and institutional and market failure. Irrigation and drainage reforms should be integrated in a way that ensures that the policies are technically sound, economically viable, socially acceptable and environmentally sustainable. Drainage user associations should be introduced

to promote the participation of beneficiaries in subsurface-drain operation and maintenance in coordination with WUAs.

2.8 WUAs and Their Role in Command Area

Participatory Irrigation Management (PIM) or Irrigation Management Transfer (IMT) is an approach of surface irrigation management wherein the management of the canal system is gradually handed over to the farmers in the command area. This approach is based on the belief that farmers have most to gain from improved irrigation services and hence, if they govern the irrigation systems, then the irrigation institutions would be more accountable. Water User Associations are promoted and facilitated to take over the management of canal systems. Notable success has been achieved in many places (Joshi, 1997). However, many researchers feel that despite being tried out for so long, the results are not substantial. In India, Andhra Pradesh was the first state to pass a PIM Act, i.e. an Act by which all irrigation systems were to shift to a PIM approach. Under the Act of Madhya Pradesh *Sinchai Prabandhan Me Krishakon Ki Bhagidari Adhinyam*, 1999, the Farmers' Organization was formed under which the District Collector delineate every command area under each of the irrigation systems on a hydraulic basis which may be administratively viable; and declare it to be a water users area for the purpose of this Act; Provided that in respect of the command area under the minor and lift irrigation systems, the entire command area may, as far as possible form a single water users' area. "Water User" means and includes any individual or body corporate or a society using water for agriculture domestic, power, non-domestic, commercial or industrial or any other purpose from a Government source of irrigation.

The objects of the farmers' organization shall be to promote and secure distribution of water among its users; adequate maintenance of the irrigation system, efficient and economical utilization of water to optimized agricultural production, to protect the environment, and to ensure ecological balance by involving the farmers, inculcating a sense of ownership of the irrigation system in accordance with the water budget and the operational plan.

Pant (1999) showed that the management transfer to the WUAs in Maharashtra is effective in terms of area expansion under irrigation as well as water use efficiency. The WUAs have considerably improved the recovery of water charges thereby bringing revenue to the government. Moreover, by charging much higher amount from the water users, the WUAs have accumulated funds for the maintenance of their microstructures and continue to survive and thrive even after management subsidy of the government has ceased to exist.

Sinha (2000) discussed farmers' participation In the Partapgarh sub-project of the Uttar Pradesh Sodic Land Reclamation Project in India. The project aims to developed appropriate water-management strategies, including drainage infrastructure, with farmer's participation. The survey confirmed that because the farmers' association would not be able to sustain drainage activity alone, farmers in the pilot sub-project should be organized under canal water management, with drainage as an additional function.

Mollinga et al. (2001) studied the implementation of participatory irrigation management in Andhra Pradesh. He reported on the impact of the introduction of participatory irrigation management in two secondary canals in the Tungabhadra right bank low level canal irrigation system. The empirical findings revealed that the rural elite captured most of the seats in the Water Users Associations managing committees, committee membership was strongly linked to party politics. A significant amount of physical rehabilitation works had been undertaken resulting in a technically improved canal system; the reform had no significant impact on water distribution so far as it did not lead to increase in irrigated area. It was suggested that the lack of 'demand' for policy reform was a feature not exclusive to Andhra Pradesh.

Chandrasekharan et al. (2004) studied participatory irrigation management for efficient water use and enhanced rice productivity in Tamil Nadu. They reported the result of community based on-farm irrigation management trials. Experiments were conducted during 1992-97 at two

different sites of the Cauvery delta zone, to determine the requirements and benefits of improved irrigation management. Intermittent imitation reduced water use at the head and middle reaches and spared more water for farmers at the tail-end compared with the control. Under the control treatment, an inadequate water supply at the tail-end area led to low rice yield, whereas the improved irrigation management permitted judicious use of water by the farmers and resulted in increased rice yield by 40% at the head, middle and tail-end areas. Results indicated that farmers in an irrigation system could increase crop productivity through the judicious management if irrigation water and equal sharing of water from the head to tail-end area.

In India WUA's functions include preparing and implementing a warabandi scheduling, planning and implementing the maintenance of irrigation system, regulating the use of water and water budgeting. WUA's main aim is to increase water productivity in command area development. Water user association described as a parallel or lower than panchayati raj which is considered as third tier of India's federation, which has to operate, manage and maintain the canal system (Hooja 2005).

Reddy and Reddy (2005) reported the water management in production of rice in Balipatna command area of Orissa indicated that irrigation through field channels had positive impact on the yield of *Kharif* paddy. The variables like application of fertilizers, irrigation cost, seed and labor cost had significant positive impact on the paddy yields. The marginal productivity of inputs indicated fertilizers and seeds are not efficiently utilized as compared to other inputs. WUAs were being undertaken by farmers but participation is low. Most of the activities undertaken were related to irrigation water management. Activities such as consolidation of landholdings, group farming, adoption of suitable cropping pattern etc., were not carried out in most of the WUAs. Farmers were found to contribute money/labor for maintenance field channels constructed by CADA in order to ensure water availability. However, a system of farm channels for carrying out scientific on-farm water management through channel to field irrigation and Rotational Water Supply (RWS) does not exist for

majority of the WUAs. Location (reach) of WUAs on the canal network was not found to influence farmer participation since water scarcity was not a problem in the different reaches. However, landholding size was found to influence participation.

Koc et al. (2006) assessed the impact of water users related to management, operation and maintenance services carried out by Water Users Associations in Great Menderes basin irrigation schemes. Survey was carried out using the random sampling methodology in order to investigate the opinion of water users. A questionnaire considering five different topics was used to analyze the management, operation and maintenance performance of the WUA's. The water user's general opinion was that the turnover of the irrigation infrastructure to the WUAs has had a very positive impact.

Namboodiri et al. (2006) studied Surface Water institutions in India. He analyzed the performance of the local level water user associations and irrigation co-operatives. The study covered 150 farmer respondents under the canal co-operatives, 100 from Gujarat and 50 from Maharashtra and 100 WUAs from Andhra Pradesh. Tobit Model was adopted to study the impact of the institutions on maintenance, equity within the structure of the institution and the rules followed for equitable water distribution. The study showed that the role of government dominated as regards to pricing of water and actual release of water for irrigation. On the other hand the institutions played a major role with respect to planning for capital investments, actual release of water for irrigation, collection of dues from farmer members and monitoring the use of water. The respondents partially agree or disagreed that those institutions had rigid rules or regular review of the rules. The respondents strongly agreed that they were aware of the rules and the management had enough power to bring compliance to the institutional objectives as well as the ability of the institutions to ensure fairness and justice to its members.

Karatas et al. (2007) determined the irrigation performance of Sarigol, and Uzum WUAs in the vicinity of Sarigol and Alaflehir using remote sensing techniques. For this purpose, the performance of the irrigation system for the 2004 irrigation season (May to September) was determined according to 5 indicators, namely overall consumed ratio (ep), relative water supply (RWS), depleted fraction (DF), crop water deficit (CWD), and relative evapotranspiration (RET). According to the seasonal average values of all the performance indicators, the irrigation performance of all WUAs was usually poor, and only the depleted fraction indicator for Uzum WUA was within the range of acceptability. Thus, performance indicators showed that less irrigation water was supplied to WUAs than was needed.

Cakmak et al. (2009) evaluated the irrigation system performances of the Water User Associations in Asartepe irrigation scheme in Turkey. Financial performance, productive performance and water delivery performance were determined. From the result, it was concluded that Asartepe irrigation association is successful in decision making on system development.

Ghosh et al. (2011) assessed the performance of WUA from the farmers' perspective through a questionnaire survey of 75 farmers (15 farmers selected as respondents from each of the five WUAs vis. WUA1, WUA2 and WUA4 under left distributary and WUA6 and WUA7 under right distributary) taking farmers' responses on a total of 20 parameters related to issues like participation, operation and management, financial management and organizational linkage on 5 point continuum scale. WUAs performance with respect to operation and a management and organizational linkage is found better (score >3.0) as participation and financial management. Water management by the compared to WUAs (WUA1 and WUA6) in head reach is found to be poor with score <2.0 especially with respect to the efforts to save water. It is interesting to note that performance of WUAs in head reach is relatively less effective as compared to middle and tail reach as head reach always faces fewer problems related to irrigation service to the farmers. Assessed irrigation performance important tools that irrigation service providers

at various levels of the water management hierarchy can use for monitoring, benchmarking and self-improvement by Yakubov (2012). He attempted to explore and sensitizing farmers' views about irrigation service and related performance dimensions using qualitative research methods. Based on focus group discussions with a purposive sample of farmers from a range of water users' associations in Central Asia and a grounded theory approach the study lays a conceptual foundation for future practical applications.

Phadnis and Kulshrestha (2012) evaluate the efficiency, for WUAs of irrigation project Samrat Ashok Sagar (Halali) in India, using benchmarking by data envelopment analysis as the performance evaluation tool and to integrate the outcome of the benchmarking process for planning, design and effective management of available water resources. In the analysis, the gap was compared with the scheme. The performance gap and the action required for closing the performance gap were explored. It is evident that considerable variations occur amongst the various WUAs in terms of the operational characteristics reflected by the independent variables.

Sreehari et al (2012) studied evaluation of Water User Associations functioning along Pyderu canal, Pennar delta, Nellore District, Andhra Pradesh, India. The strength and weaknesses of the functioning of WUA'S have been analyzed. Partial functioning of WUA'S in the study area has been observed from this study and many constraints have been found in effective mobilization of resources.

Sangle (2016) found that the project level associations of Waghad saved about one-third water supplied for irrigation apart from increasing productivity. This water has been used for additional area under irrigation. Waghad project has developed good rapport and coordination between various institutions involving in irrigation management.

2.9 Planning in Canal Command Area

Canal command area planning plays important role on efficient water resource management as well as socio-economic development of society. The irrigation water requirements of major crops and the total available water through canal and ground water in the command of Shahi distributary had been estimated by Singh et al. (2001). A linear programming model was formulated to suggest the optimal cropping pattern giving the maximum net return at different water availability levels. The objective function of the model was subject to the following constraints: total available water and land during different seasons, the minimum area under wheat and rice for local food requirements, farmer's socio-economic conditions, and preference to grow a particular crop in a specific area.

Reca et al. (2001) developed a model to determine optimal irrigation strategies for a single season that had been achieved by using a simple relation between yield and amount of irrigation water which takes into account the effect of uniformity of water application. The main objective of the model was to provide a procedure by which farms can evaluate and compare alternative assumptions on expected water regimes for the following year in order to optimize crop rotations, crop production and farm incomes and to attain the optimum use of irrigation works, farmland and other resources. The data that are readily available to the farmer are used for this method.

Jalal et al. (2007) developed a mathematical model for the optimal multi-crop irrigation areas associated with reservoir operation policies in a reservoir-irrigation system. Optimal area allocations are considered by addressing an appropriate mathematical model. The reservoir operations are related to releases policy, monthly water allocations, and occasional reservoir spills in a monthly operating time. The objective is to maximize the annual benefit of the system by supplying irrigation water for a proposed multi-crop pattern over the planning period. Herein, three sets of constraints are applied to the system: achieving monthly balance in the reservoir, covering water demand for crop

production, considering evaporation loss from the reservoir and governing equations for reservoir release and operations. The provided model is formulated with these constraints linked together by appropriate additional constraints as a linear programming model. Sensitivity analysis of inflow and alternative irrigation policies is conducted to investigate their effect on the final results.

Sudha et al. (2008) discussed about the methods for increasing productivity of water consumed in agriculture is improved by water supply management. They presented that the results from an optimization study of the Malampuzha irrigation project of the Bharathapuzha river basin of Kerala in India. The objective of this study was to determine whether significant improvements might be realized from optimization of operation of the reservoir system. To do this a MILP model was developed and five different management strategies were tested. The result indicated that a management strategy with deficit irrigation by supplying less water in non-critical growth period and maximum water during stress sensitive periods was a best viable solution for better performance. A MILP Model, rather than a LP model, was used to ensure that the reservoir did not spill before reaching its capacity.

Sivanpheng et al. (2009) found an optimal crop pattern for irrigation planning in a varied-utilized area of the Van being Phi irrigation project, Khammouan province, Central Region of Lao PDR. An allocation Linear Programming (LP) model was applied to find the optimal crop pattern in dry-season (November-April). The considered irrigation project was divided into several sub-areas, based on suitable soil type of each crop representing the varied-utilized character. The existing suitable soil type of each crop was used to represent the vanned-utilized in term of water requirement and crop yield for each sub-area. The records of seasonal flow from pump station, requested and actual implementation of irrigation area. Crop water requirements, evaporation, percolation and effective rainfall were used for this illustrative application. The results have shown that the net benefit of vanned-utilized character and unvaried utilized character (existing consideration) were obvious difference. The

obtained crop pattern of the proposed model corresponded to the suitable soil type for cultivation. Furthermore, the results presented that the proposed model gave higher net benefit than the existing unvaried-utilized character.

Ayare et al. (2010) estimated the irrigation water requirement of major crops and total water available in the Natuwadi dam located in Konkan region of Maharashtra. A linear programming model was formulated to suggest optimal cropping pattern giving the maximum return at different water availability levels. The objective function of the model was subject to following constraints: total water available and land during Rabi season, minimum area under rice and sugarcane for local food requirement and preference to grow particular crop in a specific area. This model has given the optimal cropping pattern for a command area of 2050 ha at water availability levels of 100, 90, 80 and 70% and net returns of 120,109.50, 99.10 and 88.64 million rupees, respectively. It is found that, the water available in the command area may support optimally 36.50, 1018, 50, 273, 45, 98 and 127 ha of rice, banana, sugarcane groundnut, chilli, brinjal and maize for fodder, respectively, to get maximum returns of 120 million rupees at 100% water availability levels. Banana appears to provide the most consistent profit in the command area.

Bhuvandas et al. (2011) used a Linear Programming (LP) model for obtaining optimized cropping area in the command of Ukai reservoir, with the objective of maximizing the sum of the relative yields from all crops in the irrigated area for specific range of water availability like 100%, 90%, 80% and 70%. The net revenue from agricultural production were maximized for available irrigation water taking into account the sets of constraints like crop area, cropping pattern and water requirement. The model is applied to a part of Ukai reservoir system namely Ukai Right Bank Main Canal (URBMC), in Gujarat, India.

Gadge et al. (2011) found that the currently micro irrigation methods are mainly adopted on farms with irrigation from tube wells or dug wells. However, in view of increasing scarcity of water for irrigation and need to increase food

production, it is important to adopt these methods in canal command area. A linear programming model was formulated to suggest the optimal cropping pattern under micro irrigation method in canal command areas. The objective was to achieve the maximum such as net returns. The objective function of the model was subjected to the constraints such as total available water and land during different irrigation periods, crop area restrictions, and system reutilization constraints. The system reutilization constraint facilitated utilization of micro irrigation system among the different short duration seasonal crops having similar system geometry requirement. The model was applied to command area of direct minor no. 3 of the Mula Irrigation Project, Ahmednagar and Maharashtra. The model gave optimal cropping pattern for 431.7 ha of command area having water availability of 1,71,280 m³ during the "ON" period (7 days) of canal rotation. The net returns from the optimal cropping plan were Rs.186 million. The optimal cropping pattern allocated 43.17 ha area for papaya, 43.17 ha for sugarcane, 86.35 ha for *Kharif* brinjal, 259.04 ha for cabbage, 85.35 ha for summer onion and 259.04 ha for summer brinjal. It was found that 6% increase in net benefit could be achieved through reutilization of the micro irrigation systems among the seasonal crops having similar system requirements.

Kumar et al. (2016) stated that the strategy needs to be developed ensuring an equal distribution of water per unit area to all the farmers being provided irrigation from a common watercourse irrespective of the location of their land holding from the watercourse inlet. Considering limited availability of surface water and ground water, conjunctive use of these water resources should ensure adequate irrigation to the crops to maximize the crop production and net annual return. Taking this into consideration, the most beneficial crops with comparatively lower water requirements, such as pulses and vegetables, should be given priority and the present practice of extensive rice cultivation should be limited to the minimum possible extent, which will be helpful for the protection of the environment because of reduction in greenhouse gas emissions.

2.10 Improving Cropping Intensity and Water Productivity

We are interested in measuring water productivity with respect to the amount of water directly consumed by the cropping system (evaporation and transpiration) as well as relative to the amount of water supplied from different sources. As we move upscale from field to farm to basin, we wish to know how much water has been depleted in agricultural production, which accounts for actual evapotranspiration (Et) by the crop, evapotranspiration losses from return or “unused” flows and losses to sinks, such as saline groundwater (Molden 1997).

Molden et al. (2003) carried out a study on water productivity framework for understanding and action. Water productivity depends on several factors like crop genetic material, water management practices and agronomic practices. There are two way for increasing the productivity of water, deplete more available water supply for beneficial purpose and produce more output per unit of water deplete (kg/m^3). Three types of scenarios were reported to maximize the productivity of water, reducing in overall water supply, change in incentives associated with farm level water management and desire to increase farm level profitability.

Trivedi and Singh (2004) worked on impact of quality and reliability of irrigation in field and farm level water production of crops The irrigation quality index was higher for well irrigated field as compared to canal irrigated fields and field irrigated by both wells and canals in Skohpur and canal irrigated fields for most crop in Changrwan the which received irrigation water of higher quality and reliability got higher water productivity in rupee terms.

Zwart and Bastiaanssen (2004) compared measured water productivity values (in terms of marketable crop yield over actual evapotranspiration) of major crops. They find wide ranges, amounting to 0.6-1.7 kg/m^3 for wheat, 0.6-1.6 kg/m^3 for rice, and 1.1-2.7 kg/m^3 for maize, and interpret these to indicate "tremendous opportunities for maintaining or increasing agricultural production with 20-40% less water resources". Without more in-depth analysis, they

discuss three factors that influence the soil-plant-water relationship as key for explaining the large variations, including climate, irrigation water management, and soil management.

Khataniar and Benazir (2013) found that out of total operated land of 498 ha, irrigation services were extended to 195 ha of land only. That is the irrigation service could cover only 39.21% of the total operated land in the surveyed area. The available sources of irrigation were only minor irrigation schemes; particularly Deep Tube well (DTW), Shallow Tube well (STW) and other conventional mode of irrigation which includes check bundh, galley control, agribundh, etc. However, irrigation ratio and cropping intensity are very poor in the surveyed area. Thus the study advocates a strategic policy formulation for a radical increase in cropping intensity, supported by commensurate irrigation facilities along with required (and feasible) increase in productivity levels of food grains especially rice and wheat.

The composite timing system in north Gujarat, to analyze the applied water productivity in daily production analyzed by Kumar (2014). It also analyzed the extent to which groundwater use in the region can be reduced without compromising on the farm economy and milk production through efficient irrigation water use technologies using a simulation model based on linear programming. To summarize, past research on water productivity were on analyzing average physical productivity of water for select crops, including variation according to climate. There is limited analysis of marginal water productivity (kg/ET) in response to supplementary irrigation and change in depleted water. However, the economic dimensions of water productivity were not analyzed.

Sethi et al. (2014) the water harvesting structures, during the experimentation, the water use efficiency and water productivity of different vegetable crops, paddy crops grown under open well command and bore well command has been analyzed based on crop yield data and irrigation water used by the crops and crop ET for the growing season. Conjunctive use

planning of irrigation through bore well, dug wells and ponds on farmers' participatory approach in tail reach of the canal command areas could increase cropping intensity from 151% to 300% with high value and less water requirement crops. Interventions showed that during long dry spell period in *Kharif* season and non-availability of canal water, use of groundwater up to 20% of the crop water demand could enhance crop yield up to 21%. Utilizing water from dug well, for three crops (short duration rice- potato/ radish bitter gourd) in a year recorded highest net return of Rs 87368/ha against Rs 90,031/ha for two crops (rice - brinjal) without depletion of groundwater level.

Mondal et al. (2015) found that T. aman rice (var: Binadhan7) – Mustard (var: BARISarisha-15) – Mungbean (var:BARIMung-6)–T. aus rice (var: Parija) cropping pattern gave higher benefit with less cost of production and could be easily fitted in the existing pattern. T. aman rice (var: Binadhan7)–Potato (var:Diamont)–Boro rice (var:BRRIdhan-28) –T. aus rice (var: Parija) also showed reasonable benefit and added higher organic matter than the former one. Short duration of mustard, mungbean, potato and aus rice variety could be easily fitted in the existing pattern without deteriorating soil nutrient system. Due to growing four crops in year in the same piece of land more employment opportunity for male and female laboures could be created and at the same time due to increased production of rice, potato, mustard and mungbean, the food security and nutritional security could be ascertained for the farmers at same time cropping intensity and productivity could be increased.

2.11 Water Productivity of Wheat Crop

Timsina et al. (2008) introduced dry seeding to the rice—wheat system brings with it the potential to adopt conservation agriculture (CA), with reduced or zero tillage for all crops, and surface residue retention. This would further reduce fuel and labor costs for crop establishment, and air and also bring benefits for soil structure and nutrient cycling. However whether conversion to CA rice. Wheat system would help solve the problem of groundwater depletion is less well-understood. In this region evapotranspiration (ET) must be reduced

to reduce groundwater depletion. We used the APSIM cropping system model to examine whether conversion from recommended farmer practice (RFP) comprising puddle transplanted rice, alternate wetting and drying rice water management, rice straw removal. Tillage for wheat) to a CA rice-wheat system would reduce ET in Punjab, northwest India. We also used the model to identify the optimum system management taking into account effects on total cropping system rice equivalent yield (REY), components of the water balance and water productivity. Maximum REY (mean 14.6 t ha⁻¹) occurred in systems with 5 June sowing of a popular long duration rice variety, with similar yield for RFP and CA. Irrigation input with CA was much lower (by 390 mm) than with RFP, resulting in slightly higher irrigation water productivity (increased from 11.3 to 11.7 kg/ha/mm). However, changing to CA only reduce to ET of the highest yielding system by 4% (55 mm) and of other current practices (let May and early June sowing of medium and long duration varieties) by less than this. The only way to achieve a substantial reduction in ET was by growing short duration rice varieties in both the RFP and CA systems. However, with current short duration varieties, this came at the cost of both rice and system yields (system yield reduced by an average of about 1.8 t ha⁻¹). This could be overcome by intensification to 3 crops per year in a CA rice-wheat-mung system (with short duration rice varieties), while still providing a substantial but smaller decrease in ET. This system also had considerable flexibility in rice sowing date, with similar system yields for sowings from 5 June to 15 July. These findings suggest that greater effort to increase the yield potential of short duration rice varieties is warranted. Field experimentation is needed to test the improved systems as suggested by the model simulations, particularly in terms of cropping system yield and ET, and alternatives to rice and wheat should also be evaluated.

Faramarzi et al. (2010) modeled irrigated and rain fed wheat yield (Y) and consumptive water use (ET) with uncertainty analysis at a sub basin level in Iran based on a previously calibrated hydrologic model. Simulated Y and ET were used to calculate crop water productivity (CWP). The model was then used to analyze the impact of several stated policies to improve the agricultural

system in Iran. These included: increasing the quantity of cereal production through more efficient use of land and water resources, improving activities related to soil moisture conservation and retention, and optimizing fertilizer application. Our analysis of the ratio of water use to internal renewable water resources revealed that 23 out of 30 provinces were using more than 40% of their water resources for agriculture. Twelve provinces reached a ratio of 100% and even greater, indicating severe water scarcity and groundwater resource depletion. An analysis of Y-CWP relationship showed that one unit increase in rain fed wheat yield resulted in a lesser additional water requirement than irrigated wheat, leading to a larger improvement in CWP. The inference is that a better water management in rain fed wheat, where yield is currently small, will lead to a larger marginal return in the consumed water. An assessment of improvement in soil available water capacity (AWC) showed that 18 out of 30 provinces are more certain to save water while increasing AWC through proper soil management practices. As wheat self-sufficiency is a desired national objective, we estimated the Water requirement of the year 2020 (keeping all factors except population constant) to fulfill the wheat demand. The results showed that 88% of the additional wheat production would need to be produced in the water scarce provinces. Therefore, a strategic planning in the national agricultural production and food trade to ensure sustainable water use is needed. This study lays the basis for a systematic analysis the potentials for improving regional and national water use efficiency. The methodology used in this research, could be applied to other water scarce countries for policy impact analysis and the adoption of a sustainable agricultural strategy.

Araki et al. (2012) carried out over two consecutive cropping seasons (2009/10 and 2010/11), examines whether or not wheat plants exposed to waterlogging at jointing exhibit early leaf senescence during grain filling. The effects of a single waterlogging at jointing (WLjoint) or after anthesis (WLANthe), and of a double waterlogging at the same two stages (WW) were compared in three Japanese wheat cultivars. Waterlogging for 21 days was imposed in all cases except for after anthesis in 2010/11 when the treatment was for only 11

days. In both cropping seasons, grain yield in the WL joint plants was 10-15% lower than that in the well-drained plants. The lower yields were due to smaller grain weights, rather than to decreases in spike number or grain number per spike. The WL_{anthe} treatment also reduced yield by 15%, although the duration of stress in the WL_{anthe} plots was 10 days shorter than in the WL_{joint} plots. This indicates that the WL_{anthe} treatment had a more negative impact on yield. Plants in the WW plots exhibited reductions in grain yield of from 22 to 35% depending on the cultivar. The smaller grain weights of waterlogged plants was a result of both a 1-5 days shorter grain-filling period and also lower grain growth rates in the later stages of filling. Plants in the WL_{joint} and WW plots did not show reductions in leaf greenness, stomatal conductance or leaf water content during or after waterlogging at jointing. However, the plants in the WL_{joint} and WW plots and also in the WL_{anthe} plots, suffered reductions in these parameters about 14 days after anthesis. At the same time, the plants in the WW plots showed the most marked leaf senescence and the lowest leaf water contents (0.39 g g⁻¹ in the WW plots vs. 0.85 g g⁻¹ in the well-drained plots). At maturity concentrations of water-soluble carbohydrates (WSCs) in culms were highest in the WW plots; probably indicating that remobilization of the WSCs from the culms to the grains was reduced. These results indicate that root injury by water logging at jointing induces rapid leaf senescence in the grain filling period.

2.12 Feasibility of Pressurized Irrigation in Command Area

Shrivastava et al. (2010) evaluated feasibility of pressurized irrigation by initiating a pilot study at Water Technology Centre for Eastern Region, Bhubaneswar, on one outlet of a minor irrigation command. The system has been designed in such a way that it provides pipe conveyance and surface irrigation for rice cultivation during monsoon season and pressurized irrigation during post monsoon period through a hybrid system of sprinkler and drip irrigation system with four outlets for sprinkler irrigating irrigation system 2.8 ha area and two outlets for drip irrigating system 1.9 ha area. The system is also capable of providing irrigation through drip to part of a command during summer

for third crop using water stored in service reservoir after the canal is closed in first week of April. To take care of sediment in the canal water, there are three stages of filtration: first by hydro cyclone filter which filters heavy suspended materials viz. sand, silt, etc., then by the sand filter and finally by the screen filter. The filtration at three stages reduces the turbidity to the desired level. It has been found that three-stage filtration reduced the turbidity to two NTU which is within permissible limit. Considering the cost of water saved, a benefit-cost ratio of the system was found out to be 1.126. This B:C ratio can be further increased by increasing the productivity of the fish and papaya in service reservoir area and better crop management during summer season.

Phadnis and Kulsrestha (2010) studied water delivery performances through various indicators for Samrat Ashok Sagar Major Irrigation Project for the period 2000-01 to 2007-08. Irrigation ratios ranged satisfactory for system level evaluation as for as *Rabi* irrigation but it is also inclusive of area irrigated by pumps in command. It was also observed that entire area cannot be irrigated due to deficiency of irrigation facilities, poor practices of irrigation by flooding method and socioeconomic factors in the irrigation scheme. The demand of water supply for drinking purpose put additional stress on existing distribution network, especially main canal and Right Bank Canal and its Distributary No. 2 and create conflict situation in *Rabi* season. In large public irrigation schemes in Asia, the main problems of irrigation service delivery faced by the farmers were usually erratic delivery and inequity between the heads and tail ends of the canals, resulting in low cropping intensities, in a poor proportion of the systems' command area being irrigated, and poor yields.

Nema and Shrivastava (2012) reported that of Rani Avanti Bai Sagar Project only 105 ha, out of 210 ha was receiving proper irrigation and rest of the area was almost unirrigated. After intervention of sprinkler irrigation system, area increased by 90 ha towards the tail end and efficiency and water productivity increased as compared to head reach.

Rathod and Shah (2013) found in their study that there is no alternatives

but to adopt a modern irrigation technology which saves water, double the area under irrigation, improve yields and quality as well as saves on labour, energy and crop production costs. In this study area included provision of irrigation facility to the command area adjacent to the canal where irrigation by canal is practically not possible because farmers not acquired land for construct minor canal. By using Pressurized Irrigation Network System in terms of degree of adoption of water saving and yield enhancing. Shifting to pressurized irrigation system in commands of flow based minor irrigation systems in plateau areas is feasible both from technical and financial point of view.

Surwase (2015) studied in Satara district; the principle sources of irrigation were rivers, lakes, wells, tube-wells, canals and lift irrigation projects. In the last 2-3 decades, the lift irrigation projects have played a vital role in the agricultural development of Satara district. Therefore, an attempt has been made here to assess the status of lift irrigation in Satara district. The total area under lift irrigation is 65,248 ha. In 2011, the total area under irrigation accounted to 28.27% in Satara district. The Arphal canal project covers the major of the irrigated area 31,005 ha i.e. 47.52%. There is a scope for further augmentation of the existing projects for better utilization of lift irrigation and also construction of new projects in the district. The lift irrigation projects should be based on sound technical and economic feasibility. The geographical aspects of the area should be studied in detail and this study should be carefully scrutinized and incorporated while preparing the technical proposal.

MATERIAL AND METHODS

3.1 General

Performance assessment of a command area has been focused to understand internal processes of irrigation methods. Application of suitable methods, materials used including instruments and appropriate observations are considered as the key points for the success of an experiment. This chapter deals with the details of the study area, soil, crop and resource status, data collected from various sources, methodology adopted to analyses the information collected and planning a system of pressurized irrigation during the course of the present study. It also presents the process of survey of farmers for the response on intervention suggested for improvement and to prepare a final plan to implement.

3.2 Description of the Study Area

The study was conducted in the command area of Right Bank Canal of Samrat Ashok Sagar Irrigation Project located in Vidisha district, Madhya Pradesh (India). The Samrat Ashok Sagar Project is a major irrigation project located in Vidisha district of Madhya Pradesh (India). Its command area falls in parts of Vidisha and Raisen districts. The dam is constructed on the Halali river, which is a tributary of Betwa river about 40 km from Bhopal. Command area of Samrat Ashok Sagar lies between Longitude 77°33' E and Latitude 23°30' N, at an altitude of 426 m respectively, as shown in Fig 3.1. The project is based on catchment and gravity flow. The problems of farmer at tail end canal command area, because optimum water is not available. However, individual farmers use diesel and/or electric pump sets to lift water out of the canals. This project was commenced in year 1977 to irrigate 25,091 ha in *Rabi* season. Table 3.1 presents the general features of the project.

Table 3.1 Salient Features of Right Bank Canal (RBC) of SAS Project

S. No.	RBC data	
1	Longitude	77° 33' 00"
2	Latitude	23° 30' 00"
3	Altitude	426 m
4	Length	23.43 km
5	Lining length	10.8 km
6	Discharge	6.41 Cumecs
7	Bed width at head	3.9 m
8	Full supply depth at head	2.1 m
9	Free board at head	0.65 m
10	Bed width at tail	2.9 m
11	Full supply depth at tail	1.02 m
12	Free board at tail	0.65 m
13	Cultivable command area	7261 ha
14	Canal irrigated area	7067 ha

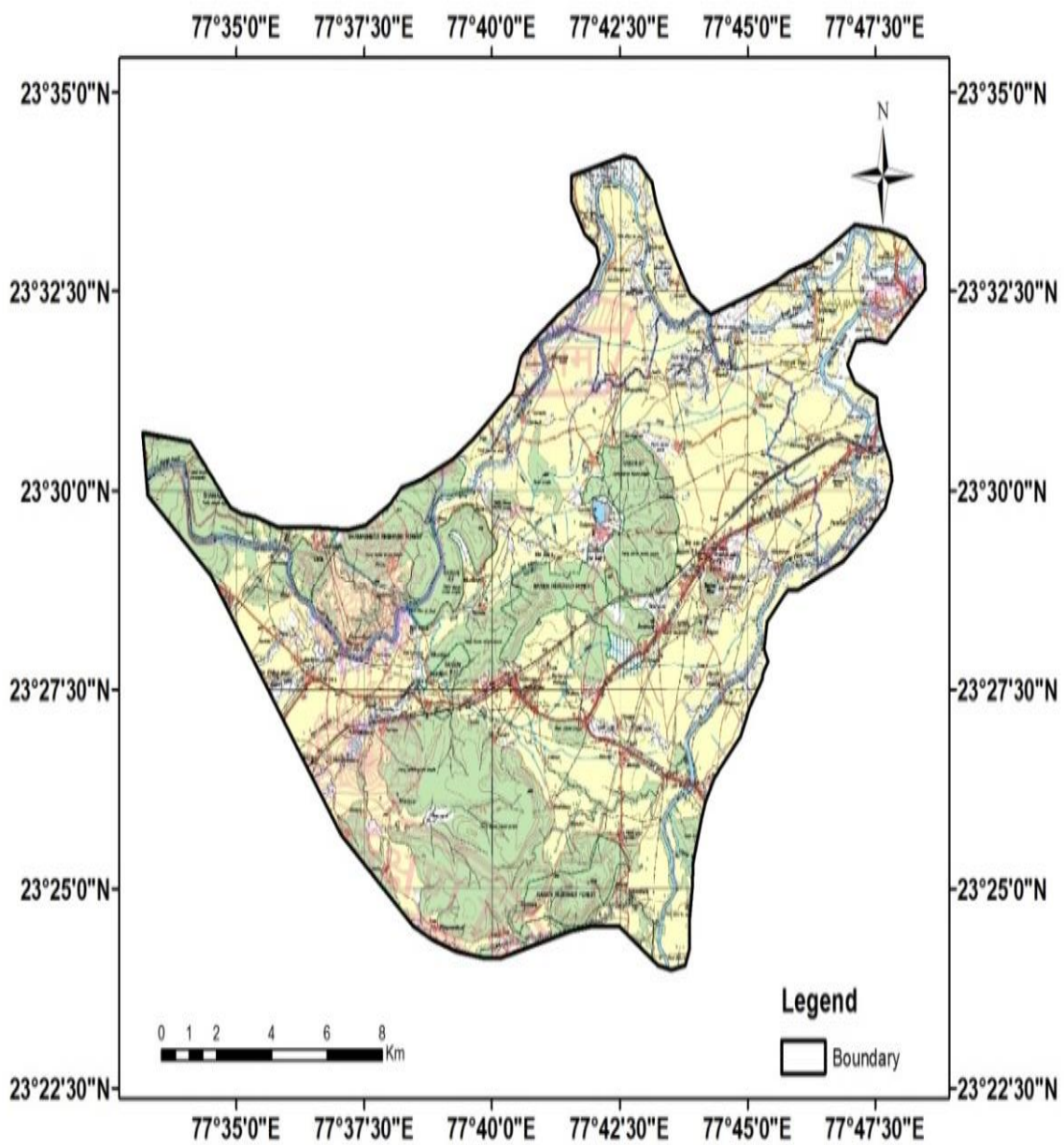


Fig.3.1: Topographic Map of the Study Area

3.2.1 Climate and Weather Condition

The climate of study area is characterized as typically semi-humid and tropical which is featured by hot dry summer and cool dry winter. It is classified as “Vindhya Plateau” agro climatic zone as per norms of National Agriculture Research Project and is known as wheat crop zone of M.P. As per classification of National Bureau of Soil Survey and Land Use Planning this area belongs to agro ecological region no.10 named as hot sub humid (dry) ecological (Malwas, Budelkhand, and Eastern Satpura). The maximum temperature received during the month of May is 45.29°C and minimum during the month of December is 7.13°C. The relative humidity generally exceeds 91% (August month). The wind velocity is higher during the pre-monsoon period as compare to post monsoon period. The maximum wind velocity is 14.21 km hr⁻¹ as observed during the month of May and is minimum of 5.10 km hr⁻¹ during the month of December. Average annual normal wind velocity of study area is 221.90 km day⁻¹. The average annual rainfall of Vidisha district is 1225.13 mm.

3.2.2 Cropping Pattern

The major crops grown in the command area during *Rabi* season is wheat, and gram, Wheat crop is the major crop in *Rabi* season of command area. It is covered about 74.33% of cultivated area compare to other crops. In *Kharif* season the main crop is paddy, soybean, black gram and Maize are presented below in the table 3.2 Information of sowing and harvesting of different crops, their duration, crop stage which need irrigation, root zone depth of crop of the study area were collected from the different source including contacts with the local farmers and revenue records of the village.

Table 3.2 Cropping Pattern in the Study Area

Season	Crop	Cultivated area (ha)	% of cultivated area (ha)
<i>Rabi</i>	Wheat	11028.61	74.33
	Gram	653.885	4.41
	Pea	102.523	0.69
	Lentil	111.604	0.75
	Other	2939.81	19.81
<i>Kharif</i>	Paddy	1591.22	10.73
	Soybean	8871.994	59.80
	Maize	88.492	0.60
	Black gram	180.614	1.22
	Other	4104.11	27.66

3.2.3 Soil Type

The command area has black soil with high clay content with patches of loam near streams.

3.3 Characterization of Study Area

With the help of the information collected from secondary sources, field visits were planned to conduct interviews with key informants and observations of the irrigation systems. The advices of an interdisciplinary team with backgrounds in soil science, agricultural engineering, agricultural economics, and agricultural extension were considered for further processes in the data collection and analysis.

To characterize the command area information was collected from various sources regarding present irrigation system of command area, basic data related to crop, soil type, soil properties, irrigation water availability and rainfall. Assessment of water requirement of crops, discharge in head, middle and tail reach of canal and its distributaries irrigation methods and irrigation schedule followed. Farmer's survey was conducted to understand their opinion regarding the irrigation system at present.

3.3.1 Water Resources

Daily records of supply head in RBC canal were obtained from the Halali office Vidisha district in Madhya Pradesh and presented in monthly basis in table 4.4 under result and discussion section. Based on cross sectional area and outlet conditions, the discharge delivered to the command area was estimated. Operating hours of selected minor and the schedule of operation of the RBC canal during the irrigation season were obtained to estimate the volume of water delivered to study area. Location of different fields with respect to water user association, field channels and area irrigated was obtained from the records of the local irrigation authorities. Open wells and tube-wells are other source of irrigation during *Rabi* season. Pumps and motor are used for lifting water for irrigation as shown in Plate 3.1.



Plate 3.1 Lift of Water in Right Bank Canal Command

3.3.2 Irrigation Water Availability

The possibility of supplying as much water to the irrigation area as is needed during each period of the irrigation season depends primarily on the availability of the water at its source. Availability may vary a lot over the year, or even between one year and another. Secondary, the supply depends on the capacity of the facility installed to withdraw the water from the water source. Further, technicians should be aware that water must be available during each week or month of the growing season. Presents the position of distributary and minors on the right bank canal and command area covered from each distributary. After the outlet water was conveyed from field to field to the desired location as shown in Table 3.3.

Irrigation water availability at canal was determined by multiplying measured discharge in lps of canal at head, middle and tail reach to operating hours of canal and no. of days canal operates. Volume of water available at head, middle and tail reach of canal was computed. Availability of water through well was determined by multiplying measured discharge of pump to operating hours and days of irrigation.

Table 3.3 Canal Water Irrigation in Command Area

Descriptions	Name of WUAs					
	Sarchampa	Ucher	Medaki	Sayar	Neemkheda	Total
Canal irrigated area (ha)	910	2040	1506	1250	1361	7067
Pump irrigated area (ha)	177	1170	105	645	339	2436
Total	1087	3210	1611	1895	1700	9503

3.3.3 Irrigation Method

Irrigation in almost entire command is done by the surface method. Irrigation water is applied by flooding from a channel located at the upper reach of a field. Farmers of RBC command used free flooding surface irrigation method. No specific design criterion is followed in this method of water application. This method results wasteful losses and many times results in soil erosion and non-uniform application of water in a field as shown in Plate 3.2.



Plate 3.2 Free Flooding Surface Irrigation in the RBC Command

3.3.4 Farmers and Land Holdings

The list of farmers or water users was collected from irrigation department of Vidisha district. The president of WUAs was helpful for collecting information about farmer's namely, location of farm, land holding, power source, irrigation method etc. Farmers were categorized according to their land holding. Area less than 1 ha under marginal category, 1-2 ha in small category, 2-4 ha in medium category and more than 4 ha was categorized in large category. Table 3.4 given below.

Table 3.4 Farmers and Land Holdings

S. No.	Category of farmers	No. of farmers	% of farmers	Area (ha)	% of Area (ha)
1	Marginal farmers	1743	35.51	1224	12.88
2	Small farmers	1546	31.49	2554	26.88
3	medium farmers	1124	22.90	3079	32.40
4	Large farmers	496	10.10	2646	27.84
Total		4909	100.00	9503	100.00

Fig. 3.2 shows distribution of farmers and area under categories in Sarchampa WUA. Total number of farmers highest in small categories is 34% of the total farmers but maximum area covered by medium categories farmers is 39% in Sarchampa WUA.

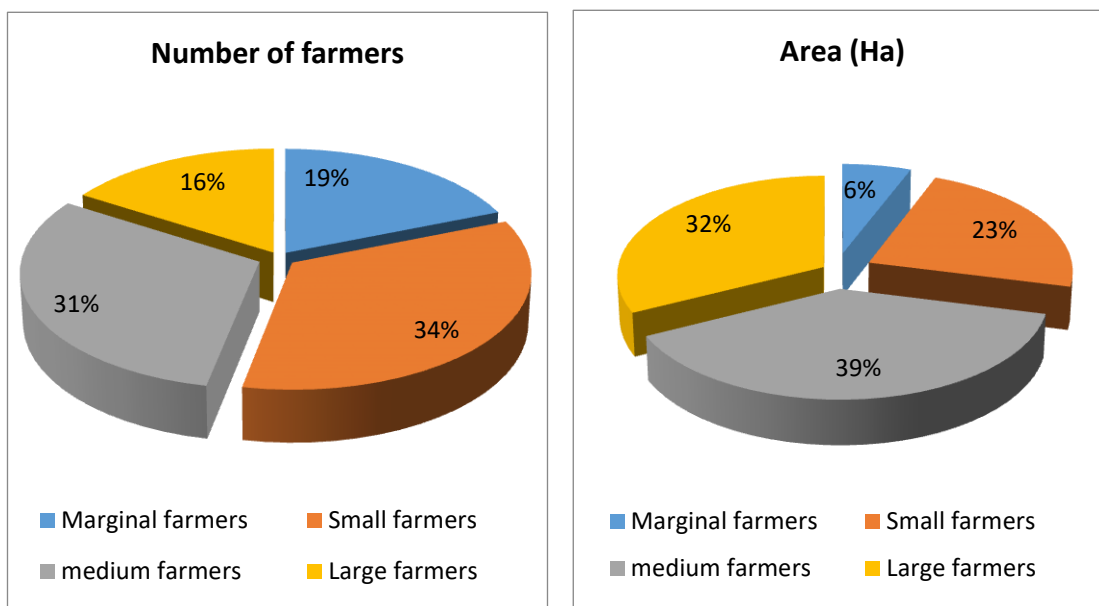


Fig.3.2 Land Holding in Sarchampa WUA

Fig. 3.3 shows distribution of farmers and area under categories in Ucher WUA. Total number of farmers highest in small categories is 33% of the total farmers but maximum area covered by medium categories farmers is 35% in Ucher WUA.

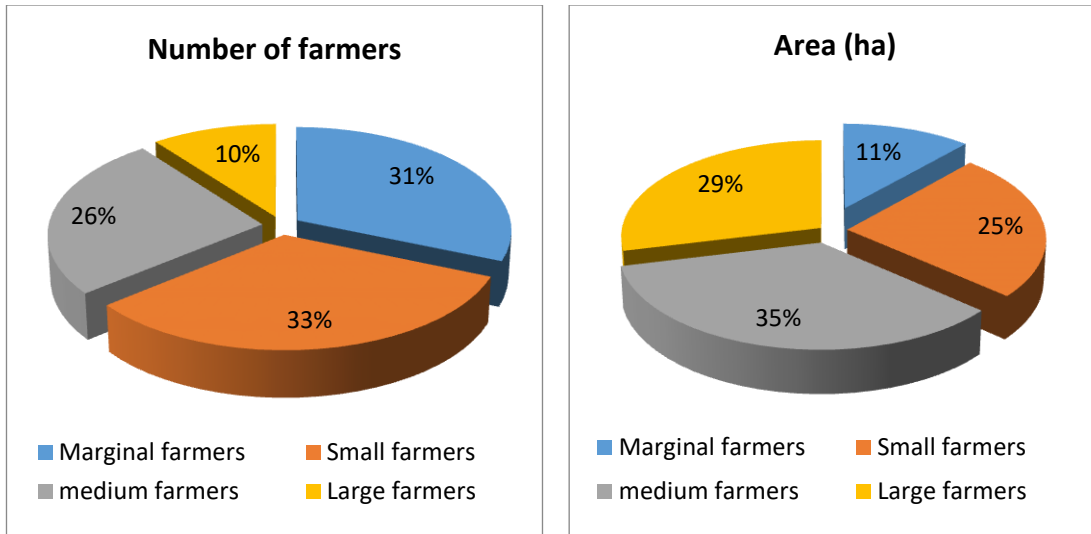


Fig. 3.3 Land Holding in Ucher WUA

Fig. 3.4 shows distribution of farmers and area under categories in Medaki WUA. Total number of farmers highest in marginal categories is 38% of the total farmers but maximum area covered by medium categories farmers is 34% in Medaki WUA.

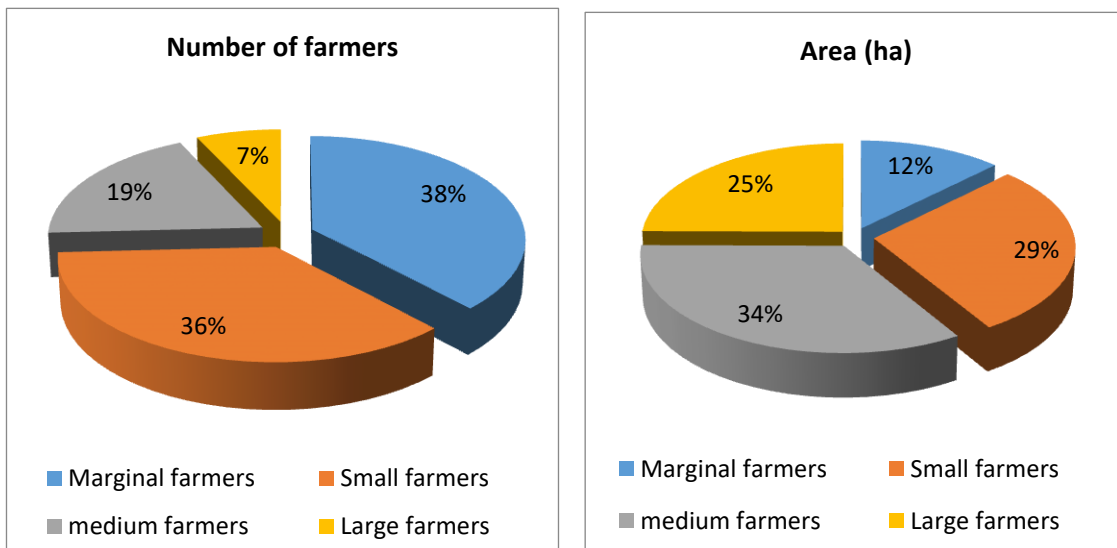
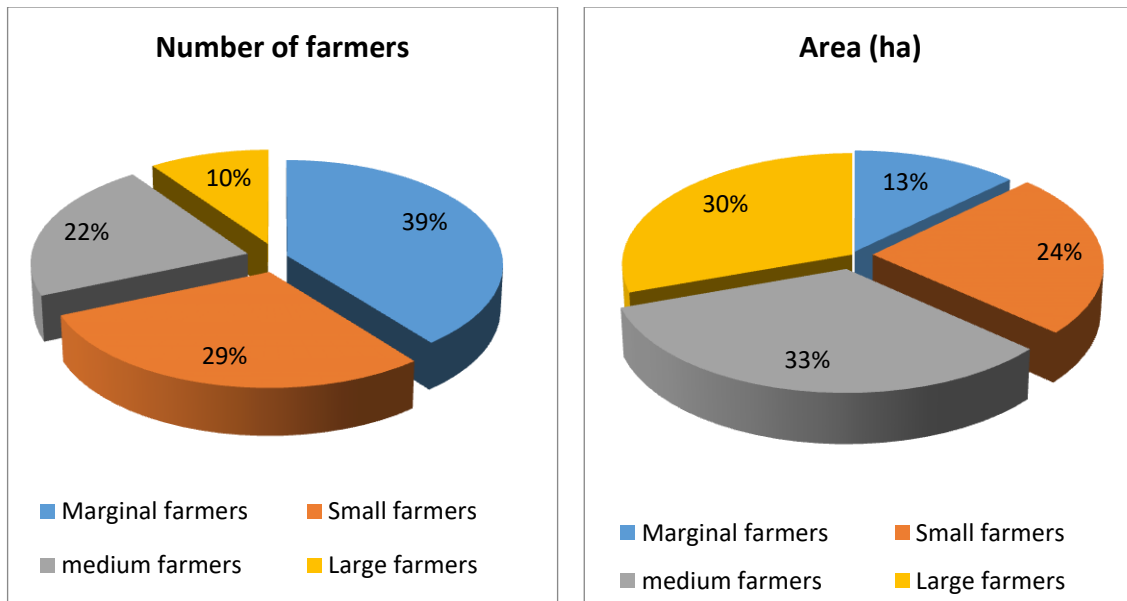


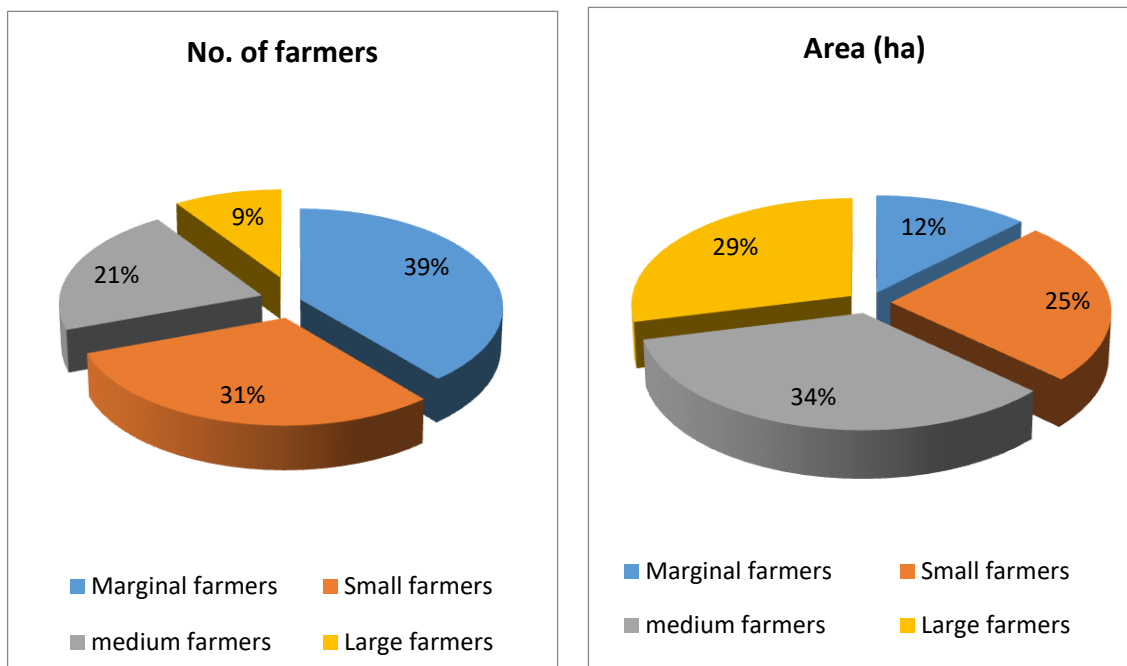
Fig. 3.4 Land Holding in Medaki WUA

Fig. 3.5 shows distribution of farmers and area under categories in Sayar WUA. Total number of farmers highest in marginal categories is 39% of the total farmers but maximum area covered by medium categories farmers is 33% in Sayar WUA.



Fis.3.5 Land Holding in Sayar WUA

Fig. 3.6 shows distribution of farmers and area under categories in Neemkheda WUA. Total number of farmers highest in marginal categories is 39% of the total farmers but maximum area covered by medium categories farmers is 34% in Neemkheda WUA.



Fis.3.6 Land Holding in Neemkheda WUA

3.4 Assessment of Cropping Intensity in Command Area

Data of gross cultivated area and net sown area (*rabi* and *kharif* season) of 55 villages of RBC command were collected from Tehsil office (Revenue Department), Vidisha district. Cropping intensity is defined as the ratio of total cropped area in year to total cultivated area. This is also expressed in percentage.

S. No.	Name of WUAs	Name of village	CCA	Rabi area (ha)	Kharif area (ha)	Rabi + Kharif Area (ha)
1.						
2.						
3.						
4.						
5.						
6.						

3.5 Assessment of Water Productivity

Agricultural water productivity can be expressed either as a physical productivity in terms of yield per unit quantity of water consumed (tones per ha m of water or yield in kg per m³ water consumed) in accordance with the scale of reference that includes or excludes the losses of water or an economic productivity replacing the yield term by the gross or net present value of the crop yield for the same water consumption. Water productivity is defined as crop production per unit amount of water used. Concept of water productivity in agricultural production system is focused on producing more food with the same water resources or producing the same amount of food with less water resources

$$\text{Water productivity} = \text{Actual Yield} / \text{actual water use.}$$

3.6 Discharge Measurement

Field observations were recorded to determine the discharge of main canal and field channel at different reaches. Discharge of canal was estimated by velocity area method. Cross sectional area, velocity of flow and depth of flow were measured at head, middle and tail reach. Velocity of flow was measured with the help of current meter in main canal, whereas float area method was applied in field channels. Digital current meter was used for measurement of velocity. Recording was made by current meter in unit cm/sec and converted into m/sec. Rotating head of the current meter was submerged in canal at 1/3 rd position. Velocity was measured at different depth and different section of main canal, distributary and minors.

3.7 Evaluation of Performance of Irrigation Project

Performance indicators as proposed by Nelson (2000) were used for evaluating the irrigation project commanded by WUA. These indicators were grouped into four categories namely, Water deliveries, Maintenance, Financial and Sustainability indicator. Water users were surveyed in right bank canal of SAS project. Information was collected on gross command area, cultivable command area, total number of structures, total number of damaged structures, water charges collection, expected water charges collection, total length of canal, total number of day water available in canal, total number of staff working, canal irrigated area and tube well irrigated area. This information was tabulated and analyzed to characterize the WUA .All the information was collected with the help of questionnaire.

3.7.1 Water Deliveries Status

Quality of water deliveries is evaluated in terms of tail-end supply ratio, area uniformity and delivery timeliness ratio.

3.7.1.1 Tail-End Supply Ratio (TSR)

The simplest indicator of water delivery performance is whether adequate water is reaching the farmers at the end of the canal system. The

Tail-end Supply Ratio is the number of days that sufficient water reaches the end of the canal system, divided by the total number of days as shown in equation 3.1. Ideally, this ratio should be close to one. TSR is simple and inexpensive, but is only a qualitative indicator. It is based on the common situation that irrigators at the end of the canal are usually the ones shorted.

$$\text{Tail - end Supply Ratio} = N_s/N_t \quad \text{----- 3.1}$$

Where,

N_s = The number of days that sufficient water reached the end of the Canal system

N_t = The total number of days the canal system was delivering water.

This information of canal running days and number of days of sufficient supply to tail end was collected through Performa.

3.7.1.2 Delivery Timeliness Ratio (DTR)

If water is delivered on request, an analysis of timeliness may be possible from the individual water order records. The Delivery Timeliness Ratio is the number of orders where water was delivered within the target time of the requested date, divided by the total number of orders as shown in equation 3.2. Ideally, this ratio would equal one. If there is a difference in DTR between the upper part of the canal system and the lower end or DTR is low, or lower than normal, this may be occur due to reasons like, if demand exceed the canal capacities, if demand exceed the available water supply, or the water supply itself mismanaged or it could also be caused by poor maintenance or management of the diversion dam, pump stations, or canals.

$$\text{Delivery Timeliness Ratio} = N_t/NT \quad \text{----- 3.2}$$

Where,

N_t = Number of orders where water was delivered within the target time. It was assumed that all the farmers have ordered for three irrigation in wheat, one in gram etc.

NT = Total number of orders (from the individual water order records).180 farmers were considered for total number of orders.

3.7.2 Maintenance Status

Maintenance work in WUA is evaluated through carrying capacity ratio and poor structure ratio.

3.7.2.1 Carrying Capacity Ratio (CCR)

Canal capacity can indicate problems related to sediment deposits, erosion, vegetation, or possibly inadequate capacity of some structures. The CCR is the actual capacity for the selected canal, divided by its designed capacity as shown in equation 3.3. The ideal ratio would be one. In applying this indicator, flow is measured at the designed water level or head.

$$\text{Carrying capacity ratio} = Ca/Cd \quad \text{-----} \quad 3.3$$

Where,

Ca = actual canal capacity for the selected canal during observations.

Cd = designed canal capacity for the selected canal.

3.7.2.2 Poor Structure Ratio (PSR)

The Poor Structure Ratio is the number of structures in poor condition, divided by the total number of structures as shown in equation 3.4. Poor can be defined as a structure not functioning adequately, or at risk of failing during the coming year. Ideally, this ratio should be zero.

$$\text{Poor structure ratio} = Np/Nt \quad \text{-----} \quad 3.4$$

Where,

NP = Number of structures in poor condition (not functioning Adequately or at risk of failure) as per observation during survey.

NT = Total number of structures on the system.

3.7.3 Financial Status

Financial indicators namely, Fee collection performance was used to evaluate financial status of WUA.

3.7.3.1 Fee Collection Performance

Fee Collection Performance is the annual irrigation fees collected, divided by the total annual fees assessed as shown in equation 3.5. This indicates the effectiveness of the collection program, but it can also be affected by the economic condition of the irrigators and the degree to which the irrigators feel the system is worth supporting. Values greater than 1 are possible if some delinquent assessments from previous years are collected.

$$\text{Fee collection performance} = F_c / F_a \quad \text{-----} \quad 3.5$$

Where,

F_c = annual amount of water charges collected as per WUA records

F_a = annual amount of water charges assessed as per WUA records.

3.7.3.2 Manpower Number Ratio

The manpower number ratio, which is the number of staff (full time equivalent), divided by the total irrigated area as shown in equation 3.6. The optimum value for this indicator may vary widely among different regions of the world, because of differences in labor productivity and irrigation intensity.

$$\text{Manpower Number Ratio} = N_s / A_t \quad \text{-----} \quad 3.6$$

Where,

N_s = is number of staff (full time equivalent)

A_t = is total irrigated area.

3.7.4 Sustainability

3.7.4.1 Sustainability of Irrigated Area

Sustainability of irrigated area is the current irrigated area divided by the initial irrigated area when the system was first fully developed as shown in

equation 3.7. A trend towards reduced area generally indicates that the system is not sustainable (for water supply, environmental, or economic reasons). If area has increased significantly from the designed area, it may indicate the water supply is now distributed over too much land, or delivery capacities are being exceeded.

$$\text{Sustainability of irrigated area} = A_c/A_t \quad \text{----- 3.7}$$

Where,

A_c = is current total irrigated area

A_t = is total irrigated area when the system developed was completed.

3.7.4.2 Area/Infrastructure Ratio

A key variable affecting the economic sustainability of a system is the Area/Infrastructure Ratio which can be roughly defined as the irrigated area divided by the total length of canals and laterals as shown in equation 3.8. The critical value for this variable is determined by the economics of the region.

$$\text{Area/Infrastructure Ratio} = A_t/L_c \quad \text{----- 3.8}$$

Where,

A_t = is the total irrigated area.

L_c = is the total length of canals and laterals on the system.

3.8 Farmers Survey

In order to assess the present irrigation system of a minor command and its diagnostic study, farmers were contacted personally to collect the desired information in performa prepared for survey (Appendix A). The survey of Right Bank Canal (RBC) command farmers on the basis of their size of land holding, awareness of the farmers for new irrigation technologies, source of irrigation and type of crop taken in *rabi* season and *kharif* season, water availability from all sources working of WUA in there command, feasibility of adoption of pressurized irrigation and willingness to do according to the new concept and plan.

3.8.1 Survey of Villages Farmers and Rural People for Present Status

Representative farmers from within the WUA command area as well as in the immediate vicinity were selected using stratified random sampling technique. Farmers were contacted personally (Plate 3.3) to collect the desired information in Performa prepared for survey (A copy is presented in Appendix A). Mainly five water users associations are working in RBC command. Three farmers in each of four categorized were selected in head, middle and tail reach of RBC command. Thus total 36 farmers were selected in each WUA. The selected farmers were interviewed and the information on their present irrigation system of RBC command area, cropping pattern, land use, irrigation method, irrigation source, location of farm were obtained. This information was tabulated and analyzed to determine the status of canal water use.



Plate 3.3 Collection of Farmer Information in Command Area

3.8.2 Techno-Socio Characters Regarding Pressurized Irrigation in RBC

S. No.	Characters	Nil	Poor	Medium	High
1	Awareness				
2	Knowledge (Perception)				
3	Attitude				
4	Willingness of adoption				
5	Purchase capacity				

3.8.3 Scoring to Characteristics of Technology

S. No.	Scoring to characteristics	Sprinkler	Border	Flood
1	Cost			
2	Labour required			
3	Suitability of soil/field			
4	Control and management of water			
5	Availability in nearly city			
6	Time saving			
7	Ease of operation			
8	Water saving			
9	High income			

3.9 Finalization of Plan

After the analysis of farmers view about irrigation methods used in canal command area, plan for the improvement of water productivity and cropping intensity of canal command area was prepared on the basis of problems identified in command area. More critical problems induced in that area were studied separately for solution and to arrive at the final plan. Irrigation Water Management plans (IWM) specify the system components and operation needed to achieve the water user's objectives were prepared. The size of land owned and cultivated by the owned respondent categorized as marginal, small, medium and large farmers as indicated in Table 3.4. The categories were assigned score 1 to 4 from marginal to large. Fields nearby head of the canal are kept into head reach on the basis of location of their field with respect to canal and likewise middle into middle category and tail into tail category.

3.10 Analysis of Variance

Randomized complete block design with many observations was applied to conduct the experiment with six treatments under pressurized irrigation and surface irrigation was grouped as 0-100, 20-80, 40-60, 60-40, 80-20, and 100-0 category of land, and 15 replication namely number of farmers are experimented in field as shown in Table 3.5.

Number of treatment "T" = 6,

Number of Replication "R" = 15

T = Number of treatment

R = Number of replication

$$\text{Coefficient factor (CF)} = (GT)^2 / RT \quad \text{-----}3.9$$

$$\text{Total sum of square (TSS)} = \sum \sum Y_{ij}^2 - CF \quad \text{-----}3.10$$

Table 3.5 Structure of ANOVA

Source of variation due to	Degree of freedom (df)	Sum of square (SS)	Mean sum of square (MS)
Replication, r, (Reaches)	(r - 1)	Replication SS = $\sum_j 1 \frac{R_j^2}{ts} - CF$	$S_r^2 = \frac{Rep.SS}{dfr}$
Treatment, t, (Group categories)	(t - 1)	Treatment error SS = $\sum_i \frac{t_i^2}{rs} - CF$	$S_t^2 = \frac{Tr.SS}{dft}$
Experimental error	(r - 1) x (t - 1)	Experimental error SS= Total SS – Tr. SS- Rep. SS	$S_e^2 = \frac{ERROR SS}{df(error)}$
Total	(r x t x s) - 1	Total SS = Rep. SS + Tr. SS + Error SS	

RESULTS AND DISCUSSION

The study was undertaken in right bank canal command area of Samrat Ashok Sagar irrigation project of Vidisha district, Madhya Pradesh for evaluating the present irrigation system and to plan improvements for enhancing water productivity and cropping intensity of the project. The due emphasis was given to the view of farmers to adopt the technical improvement suggested and finally a prepared plan was implemented and evaluated at the farmers' fields. The study area is comprises of five water user association (WUA) namely Sayar, Sarchampa, Ucher, Medaki and Neemkheda. There are 55 villages under these WUA covering total area of 14836.43 ha out of this 9503 ha area is within the study command area. This chapter presents the results obtained during the study in form of characteristics of present irrigation system including the water users, irrigation scenario, production and productivity of crops, water productivity in different reaches of canal and farmers or water user's attitude toward farming practices. The chapter also presents the result of experiment conducted in the farmer's field to evaluate the pressurized irrigation in command area.

4.1 Basic Information of the Study Area

4.1.1 Study Area

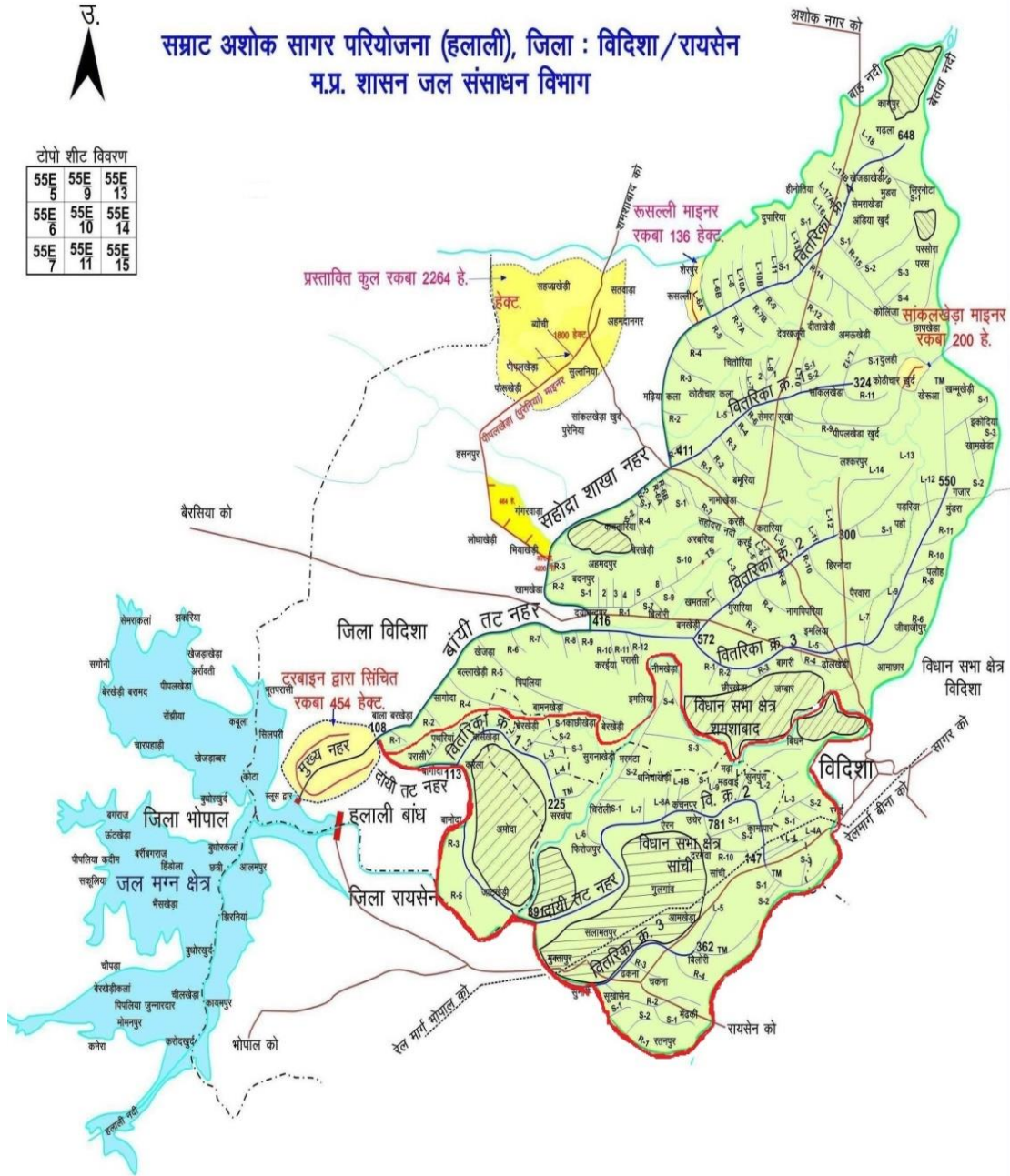
The study was conducted in command area of right bank canal of Samrat Ashok Sagar irrigation project located 27 km away from Vidisha district of Madhya Pradesh. The dam water spread area is 44510 ha. The dam has one main canal. The main canal is divided into two branch canals, left bank canal and right bank canal. The command area of dam 32292 ha is under wheat as major *Rabi* crop. Fig 4.1 shows the entire canal command area including main canal, branch canals, distributaries, river, field road and seasonal nalla which is tributary to Betwa river, right bank canal is having a command area of 7261 ha and were divided into three distributaries i.e. D₁, D₂ and D₃ having command area of 1100 ha, 1000 ha and 1434 ha respectively.



सम्राट अशोक सागर परियोजना (हलाली), जिला : विदिशा / रायसेन
म.प्र. शासन जल संसाधन विभाग

टोपो शीट विवरण

55E 5	55E 9	55E 13
55E 6	55E 10	55E 14
55E 7	55E 11	55E 15



4.1.2 Water Users

The right bank canal command area has 4909 farmers having total area 9503 ha. The land size of farmer's holdings varies between 0.2 ha to 20 ha. Details of water users, size of holding, water availability in different fields, crop grown, water resource and pumping facility in all three reaches i.e. head, middle and tail was collected through survey of farmers. The farmers were grouped into different categories as shown in table 4.1. Table 4.1 presents that maximum farmer's belong to marginal category having land holding of size 0.2 ha to 1 ha. There are 436 marginal holdings in head reach, 624 holdings in middle reach and 683 in tail reach.

Table 4.1 Details of Water Users in RBC Command Area

Farmers group	Number of farmer's in different reach			Total farmer	% of farmers	Area (ha)	% of Area (ha)
	Head	Middle	Tail				
Land holding							
Marginal farmers	436	624	683	1743	36	1224	12.88
Small farmers	422	613	511	1546	31	2554	26.88
medium farmers	336	414	374	1124	23	3079	32.40
Large farmers	164	155	177	496	10	2646	27.84
Total	1358	1806	1745	4909	100	9503	100

4.1.3 Soil Characteristics

Soil characteristics such as soil texture and bulk density were determined for the command of right bank canal. Soil sample were collected from three locations situated at head, middle and tail reach of command area. Mechanical analysis was performed for textural classification. The surface texture of soil in the area varies from clay to clay loam. The analysis showed that the clay content of the soils ranged from 39.52 to 43.25% (Table 4.2).

Table 4.2 Soil Texture in Command Area

S. No.	Location	Clay (%)	Silt (%)	Sand (%)	Classification	Bulk density (g cm ⁻³)
1.	Head reach	39.52	27.82	32.65	Sand clay loam	1.25
2.	Middle reach	40.82	35.21	28.35	Silt clay loam	1.19
3.	Tail reach	43.25	25.32	33.21	Clay loam	1.23

The values of bulk density obtained at different reaches as presented in Table 4.2 shows the maximum values of bulk density is 1.25 g cm⁻³ at head reach and the minimum of 1.19 g cm⁻³ at middle reach and as shown in Plate 4.1



Plate 4.1 Calculate the Bulk Density in RBC Command Area

4.2 Water Availability of RBC

The velocity of flowing water was measured with the help of current meter and discharge was calculated at head, middle and tail reach of the main canal and in its distributaries namely D_1 , D_2 and D_3 as shown in Plate 4.2. The discharge $5.93 \text{ m}^3 \text{ sec}^{-1}$ was found in head reach of RBC $4.36 \text{ m}^3 \text{ sec}^{-1}$ in middle reach and $2.95 \text{ m}^3 \text{ sec}^{-1}$ in tail reach. The discharge calculated in head, middle and tail reach of distributaries D_1 , D_2 and D_3 is also presented in Table 4.3.

Table 4.3 Discharge in Different Reach of RBC and its Distributary

RBC	Designed discharge ($\text{m}^3\text{sec}^{-1}$)	Measured discharge ($\text{m}^3\text{sec}^{-1}$) at different reaches		
		Head	Middle	Tail
RBC	6.41	5.93	4.36	2.95
D_1 /RBC	0.85	0.71	0.33	0.15
D_2 /RBC	1.26	0.88	0.52	0.20
D_3 /RBC	1.20	0.66	0.31	0.12



Plate 4.2 Measurement of Canal Water Flow Velocity in Middle Reach RBC

The canal was in operation for 24 hours for 112 days. It was observed that the water availability through main canal decreases in tail reaches. The deficit of irrigation water was supplemented by the tube well water at head, middle and tail end. The farmers were using tube well water mainly in the *Rabi* season. Monthly water releases are presented in Table 4.4

Table 4.4 Monthly Water Releases to RBC

S. No.	Month	Volume of Water Released (M m³)
1	November	11.051942
2	December	10.912571
3	January	11.726796
4	February	9.282985
Total		42.974294

4.3 Survey of the Command Area

In order to assess the existing impact of canal irrigation on cropping pattern, cropping intensity, land use and agricultural production, farmers were contacted personally to collect the desired information in Performa (Appendix A). Representative farmers from WUA as well as from immediate vicinity were selected under different categories namely marginal, small, medium and large. Plate 4.3 shows the collection of information from farmers. Farmers were selected using stratified random sampling technique. Three farmers in each of four categories were selected in head; middle and tail reach of RBC. Thus total 36 farmers were surveyed in each WUA area. The selected farmers were interviewed and the information on their agricultural practices, land use, crops grown, irrigation sources, irrigation practices were obtained. The information so collected was compiled and presented in Table 4.5



Plate 4.3 Farmers Survey at Head Reach of RBC

Table 4.5 Farmer's Information in Command Area

S. No.	Name of WUA	Farmer Name	Area (ha)	Irrigation Method	Rabi crop	Kharif crop
1	Sayar	Shakti Singh	5.00	Flood	Wheat	Soybean
2	Sayar	Imarat Singh	7.00	Flood	Wheat	Soybean
3	Sayar	Gainda Lal	2.50	Flood	Wheat	Soybean
4	Sayar	Ajab Singh	5.00	Flood	Wheat	Soybean
5	Sayar	Ganeshram	2.61	Flood	Wheat	Paddy
6	Sayar	Nandram	0.72	Flood	Wheat	Soybean
7	Sayar	Vishal Singh	2.53	Flood	Wheat	Soybean
8	Sayar	Sangram Singh	5.17	Flood	Wheat	Paddy

9	Sayar	Tularam	0.81	Flood	Wheat	Soybean
10	Sayar	Dasharth Singh	1.97	Flood	Wheat	Soybean
11	Sayar	Deewan Singh	0.50	Flood	Wheat	Paddy
12	Sayar	Harinarayan	6.56	Flood	Wheat	Soybean
13	Sayar	Bhairo Singh	1.44	Flood	Wheat	Paddy
14	Sayar	Shyamlal	0.43	Flood	Wheat	Paddy
15	Sayar	Rupsingh	0.50	Flood	Wheat	Paddy
16	Sayar	Dhannalal	3.91	Flood	Wheat	Soybean
17	Sayar	Anar Singh	3.35	Flood	Wheat	Soybean
18	Sayar	Gajraj Singh	2.02	Flood	Wheat	Paddy
19	Sayar	Harprasad	0.69	Flood	Wheat	Soybean
20	Sayar	Maharaj Singh	3.62	Flood	Wheat	Soybean
21	Sayar	Shakti Singh	5.00	Flood	Wheat	Soybean
22	Sayar	Kamala Bai	4.75	Flood	Wheat	Paddy
23	Sayar	Raghuveer Singh	5.07	Flood	Wheat	Soybean
24	Sayar	Vipin Singh	1.13	Flood	Wheat	Soybean
25	Sayar	Ashok	0.60	Flood	Wheat	Soybean
26	Sayar	Bharat Singh	7.27	Flood	Wheat	Paddy
27	Sayar	Baboo Lal	1.11	Flood	Wheat	Soybean
28	Sayar	Parsuram	3.59	Flood	Wheat	Soybean
29	Sayar	Bhagawan Singh	0.78	Flood	Wheat	Soybean
30	Sayar	Hariram	1.34	Flood	Wheat	Soybean
31	Sayar	Bhairo Singh	1.72	Flood	Wheat	Soybean
32	Sayar	Radheshyam	1.00	Flood	Wheat	Soybean
33	Sayar	Saitan Singh	3.72	Flood	Wheat	Soybean
34	Sayar	Lakshminarayan	1.20	Flood	Wheat	Paddy
35	Sayar	Maharaj Singh	1.34	Flood	Wheat	Soybean
36	Sayar	Jagannath	0.61	Flood	Wheat	Soybean
37	Ucher	Mahendra Singh	6.98	Flood	Wheat	Soybean

38	Ucher	Badam Singh	2.35	Flood	Wheat	Soybean
39	Ucher	Ramprasad	0.92	Flood	Wheat	Paddy
40	Ucher	Sarvan Kumar	1.67	Flood	Wheat	Soybean
41	Ucher	Bainiprasad	3.14	Flood	Wheat	Soybean
42	Ucher	Atmaram	2.33	Flood	Wheat	Soybean
43	Ucher	Rakesh Kumar	6.16	Flood	Wheat	Soybean
44	Ucher	Shriram	0.33	Flood	Wheat	Soybean
45	Ucher	Dharmendra Singh	0.31	Flood	Wheat	Soybean
46	Ucher	Ramgopal	3.12	Flood	Wheat	Soybean
47	Ucher	Karan Singh	4.03	Flood	Wheat	Paddy
48	Ucher	Shalendra Kumar	3.25	Flood	Wheat	Soybean
49	Ucher	Rajkumar	1.82	Flood	Wheat	Soybean
50	Ucher	Ganeshram	3.99	Flood	Wheat	Paddy
51	Ucher	Seetaram	0.50	Flood	Wheat	Soybean
52	Ucher	Dileep	1.34	Flood	Wheat	Paddy
53	Ucher	Kishor Kapoor	2.06	Flood	Wheat	Soybean
54	Ucher	Halkooram	4.00	Flood	Wheat	Soybean
55	Ucher	Abhinash Singh	0.46	Flood	Wheat	Paddy
56	Ucher	Jashodi Bai	1.80	Flood	Wheat	Paddy
57	Ucher	Jagannath Singh	8.96	Flood	Wheat	Paddy
58	Ucher	Rajendra Singh	1.96	Flood	Wheat	Soybean
59	Ucher	Ajab Singh	2.86	Flood	Wheat	Paddy
60	Ucher	Beersingh	0.89	Flood	Wheat	Soybean
61	Ucher	jasabant Singh	0.56	Flood	Wheat	Soybean
62	Ucher	Karan Singh	0.40	Flood	Wheat	Soybean
63	Ucher	Ganeshram	4.08	Flood	Wheat	Soybean
64	Ucher	Babulal	1.51	Flood	Wheat	Soybean
65	Ucher	Tulsiram	0.41	Flood	Wheat	Soybean
66	Ucher	Sarswati Bai	1.82	Flood	Wheat	Soybean

67	Ucher	Gulav Singh	4.04	Flood	Wheat	Soybean
68	Ucher	Jagadish	1.08	Flood	Wheat	Soybean
69	Ucher	Meharwan Singh	3.83	Flood	Wheat	Paddy
70	Ucher	Than Singh	4.57	Flood	Wheat	Soybean
71	Ucher	Gaurav Yadav	1.60	Flood	Wheat	Soybean
72	Ucher	Narendra Kumar	6.88	Flood	Wheat	Soybean
73	Neemkheda	Rajesh Dubey	2.35	Flood	Wheat	Soybean
74	Neemkheda	Ramesh Chandra	1.87	Flood	Wheat	Paddy
75	Neemkheda	Prakash Chandra	1.87	Flood	Wheat	Soybean
76	Neemkheda	Abadhnarayan	0.20	Flood	Wheat	Soybean
77	Neemkheda	Renu Tiwari	1.36	Flood	Wheat	Paddy
78	Neemkheda	Hukam Singh	3.05	Flood	Wheat	Soybean
79	Neemkheda	Komal Singh	5.09	Flood	Wheat	Soybean
80	Neemkheda	Shivcharan	2.67	Flood	Wheat	Soybean
81	Neemkheda	Rambabu	0.50	Flood	Wheat	Paddy
82	Neemkheda	Ramkali	0.50	Flood	Wheat	Soybean
83	Neemkheda	Rajendra Kumar	2.09	Flood	Wheat	Soybean
84	Neemkheda	Ram Manohar	1.42	Flood	Wheat	Soybean
85	Neemkheda	Pawan Kumar	1.17	Flood	Wheat	Soybean
86	Neemkheda	Uttam Rao	1.00	Flood	Wheat	Soybean
87	Neemkheda	susheel Kumar	0.33	Flood	Wheat	Soybean
88	Neemkheda	Mahendra Singh	1.92	Flood	Wheat	Soybean
89	Neemkheda	Bhaver Lal	0.05	Flood	Wheat	Soybean
90	Neemkheda	Yogendra Singh	7.24	Flood	Wheat	Soybean
91	Neemkheda	Sakti Singh	6.08	Flood	Wheat	Soybean
92	Neemkheda	Aditya Singh	1.04	Flood	Wheat	Paddy
93	Neemkheda	Nirmala Bai	1.48	Flood	Wheat	Soybean
94	Neemkheda	Kamal Singh	0.07	Flood	Wheat	Soybean
95	Neemkheda	Ganeshram	9.89	Flood	Wheat	Soybean

96	Neemkheda	pooran Chandra	0.98	Flood	Wheat	Paddy
97	Neemkheda	Dhanna Lal	5.17	Flood	Wheat	Soybean
98	Neemkheda	Bhaiya Lal	5.27	Flood	Wheat	Soybean
99	Neemkheda	Harish Chandra	5.86	Flood	Wheat	Soybean
100	Neemkheda	Pushpendra	0.69	Flood	Wheat	Soybean
101	Neemkheda	Madan Singh	3.54	Flood	Wheat	Soybean
102	Neemkheda	Bhairo Singh	2.41	Flood	Wheat	Soybean
103	Neemkheda	Mohan Singh	3.53	Flood	Wheat	Soybean
104	Neemkheda	Karan Singh	2.88	Flood	Wheat	Soybean
105	Neemkheda	Malkhan Singh	0.81	Flood	Wheat	Soybean
106	Neemkheda	Akhalesh	3.02	Flood	Wheat	Paddy
107	Neemkheda	Amit Kumar	5.96	Flood	Wheat	Soybean
108	Neemkheda	Gopal Rao	4.81	Flood	Wheat	Soybean
109	Sarchampa	Sajid Moh.	1.19	Flood	Wheat	Soybean
110	Sarchampa	Mokhtayar Moh.	2.27	Flood	Wheat	Soybean
111	Sarchampa	Maskoor Bag	5.26	Flood	Wheat	Soybean
112	Sarchampa	Shyamlal	0.56	Flood	Wheat	Soybean
113	Sarchampa	Musarf Bag	2.00	Flood	Wheat	Soybean
114	Sarchampa	Manseer moh.	1.26	Flood	Wheat	Soybean
115	Sarchampa	Dharu Singh	1.11	Flood	Wheat	Soybean
116	Sarchampa	Suraj Singh	0.59	Flood	Wheat	Paddy
117	Sarchampa	Gayatri Bai	1.00	Flood	Wheat	Soybean
118	Sarchampa	Ameena Bi	3.31	Flood	Wheat	Soybean
119	Sarchampa	Balram	8.56	Flood	Wheat	Soybean
120	Sarchampa	Sardar Singh	3.26	Flood	Wheat	Soybean
121	Sarchampa	Nijay ulla	1.22	Flood	Wheat	Soybean
122	Sarchampa	Nosambabi	2.00	Flood	Wheat	Soybean
123	Sarchampa	Prayag Singh	2.72	Flood	Wheat	Soybean
124	Sarchampa	Samad Khan	5.49	Flood	Wheat	Soybean

125	Sarchampa	Yunish Khan	0.31	Flood	Wheat	Soybean
126	Sarchampa	Prem Bai	0.4	Flood	Wheat	Soybean
127	Sarchampa	Ratan Singh	0.80	Flood	Wheat	Soybean
128	Sarchampa	Sagir Moh.	1.41	Flood	Wheat	Soybean
129	Sarchampa	Anveri Bi	5.43	Flood	Wheat	Paddy
130	Sarchampa	Imnaj Moh.	2.10	Flood	Wheat	Soybean
131	Sarchampa	Majid Moh	4.04	Flood	Wheat	Soybean
132	Sarchampa	Ganeshram	1.88	Flood	Wheat	Soybean
133	Sarchampa	Sardar Singh	5.88	Flood	Wheat	Paddy
134	Sarchampa	Sandeep Kumar	3.10	Flood	Wheat	Soybean
135	Sarchampa	Hari Singh	2.94	Flood	Wheat	Soybean
136	Sarchampa	Yusuf Khan	6.32	Flood	Wheat	Soybean
137	Sarchampa	Insaf Moh	0.60	Flood	Wheat	Soybean
138	Sarchampa	Suleman Moh	0.52	Flood	Wheat	Paddy
139	Sarchampa	Amar Chandra	3.04	Flood	Wheat	Soybean
140	Sarchampa	Bhagawan Singh	1.06	Flood	Wheat	Paddy
141	Sarchampa	Sarjan Singh	0.59	Flood	Wheat	Soybean
142	Sarchampa	Gulav Singh	0.59	Flood	Wheat	Soybean
143	Sarchampa	Ramesh Chandra	4.20	Flood	Wheat	Soybean
144	Sarchampa	Ramcharan	6.3	Flood	Wheat	Soybean
145	Medaki	Sadhana Singh	3.74	Flood	Wheat	Soybean
146	Medaki	Anil kumar	5.66	Flood	Wheat	Soybean
147	Medaki	Mukesh Kumar	4.64	Flood	Wheat	Soybean
148	Medaki	Vatee Bai	3.5	Flood	Wheat	Paddy
149	Medaki	Lakshminarayan	1.18	Flood	Wheat	Soybean
150	Medaki	Randheer Singh	3.14	Flood	Wheat	Soybean
151	Medaki	Amar Singh	1.06	Flood	Wheat	Soybean
152	Medaki	Karan Singh	1.21	Flood	Wheat	Soybean
153	Medaki	Badri Prasad	0.78	Flood	Wheat	Paddy

154	Medaki	Jain Raid	3.23	Flood	Wheat	Soybean
155	Medaki	Pyare Lal	2.02	Flood	Wheat	Soybean
156	Medaki	Fatama Bi	1.61	Flood	Wheat	Paddy
157	Medaki	Prabhoodayal	1.61	Flood	Wheat	Soybean
158	Medaki	Ramkishan	0.49	Flood	Wheat	Soybean
159	Medaki	Hiralal	2.02	Flood	Wheat	Paddy
160	Medaki	Saroj Bai	1.51	Flood	Wheat	Soybean
161	Medaki	Vineet Kumar	2.02	Flood	Wheat	Soybean
162	Medaki	Balbant Singh	3.10	Flood	Wheat	Paddy
163	Medaki	Baboo Singh	1.63	Flood	Wheat	Soybean
164	Medaki	Dileep Singh	2.33	Flood	Wheat	Soybean
165	Medaki	Bharat Singh	4.23	Flood	Wheat	Soybean
166	Medaki	Phool Bai	4.47	Flood	Wheat	Soybean
167	Medaki	Javed haidar ali	7.62	Flood	Wheat	Soybean
168	Medaki	Lal Singh	0.49	Flood	Wheat	Soybean
169	Medaki	Mishri Lal	0.60	Flood	Wheat	Paddy
170	Medaki	Dasharth Singh	0.36	Flood	Wheat	Soybean
171	Medaki	Ashish Tripathi	1.92	Flood	Wheat	Soybean
172	Medaki	Devendra Singh	1.31	Flood	Wheat	Paddy
173	Medaki	Malekhan	0.30	Flood	Wheat	Soybean
174	Medaki	Mrs. Sushama	0.80	Flood	Wheat	Soybean
175	Medaki	Veer Singh	4.53	Flood	Wheat	Paddy
176	Medaki	Hardev Singh	5.03	Flood	Wheat	Soybean
177	Medaki	Phool Singh	5.98	Flood	Wheat	Soybean
178	Medaki	mrs. Kiran	0.40	Flood	Wheat	Soybean
179	Medaki	Nihal Singh	0.60	Flood	Wheat	Paddy
180	Medaki	Kanika Sharma	10.25	Flood	Wheat	Soybean

4.4 Performance Evaluation

The existing irrigation system including the canal water distribution, irrigation supplied, crop yield, water used and water productivity was evaluated on the basis on Nelson (2000) parameters. The Nelson parameters include water delivery, maintenance of canal and financial indicators as described in section 3.7. The performance indicators calculated were tail-end supply ratio, area uniformity ratio and delivery timeliness ratio to identify the problem in water delivery and are presented in Table 4.6. Data collected through farmer's survey as described in section 3.8 is compiled and analyzed. Performance of water user associations was evaluated using performance indicators i.e. physical indicators, bio-economic indicators and social indicators in head, middle and tail reaches.

Table 4.6: Water Delivery Indicators for RBC Command of SAS Irrigation Project

Parameters	Performance Indicator	Basic Input	Input Value	Value	Reference range
Water Deliveries	Tail-end Supply Ratio	Ns/Nt	80/112	0.714	0.50-0.70
	Delivery timeliness Ratio	Nt/NT	¾	0.750	0.70-0.90
Maintenance	Carrying Capacity Ratio	Ca/Cd	5.097/6.4	0.796	0.60-1.26
	Poor Structure Ratio	Np/Nt	0/9	0	0.01-0.20
Financial	Fee Collection Performance	Fc/Fa	3427513531/ 1199629736	0.350	0.62-1.0
	Manpower Numbers Ratio	Ns/At	33/9503	0.003	0.0004-0.001
Sustainability	Sustainability of Irrigated Area	Ac/Ai	27924/24000	1.16	0.5-1.0
	Area Infrastructure Ratio	At/Lc	7067/23.34	301.62	350

Tail end ratio value 0.714 indicates that water supply in the head and tail is almost in satisfactory range. It was also observed that tail end water supply was sufficient for 80 days only out of 112 days of canal operation. Delivery timeliness ratio (0.750), carrying capacity ratio (0.796), poor structure ratio (0.000), fee collection(0.350), Manpower Numbers Ratio (0.003), sustainability of irrigated area ratio (1.160) and area infrastructure ratio (301.620) were calculated tail end supply ratio was not found within the preference range this indicates that amount water reaching to tail end is not satisfactory and requires proper planning. Similarly fee collection ratio was also found poor and needs improvement. The values of other water delivery indicators was found within reference range and hence declared satisfactory.

4.5 Existing Cropping Intensity

To determine the cropping intensity of canal command area covering all 55 villages, information of total area, area under different crops in *rabi* and *kharif* season was collected from revenue department and presented in Table 4.7. It can be seen from the Table 4.7 that the cropping intensity of command area varies from 115% to 196%.

Table 4.7 Existing Cropping Intensity of Command Area

S. No.	Name of village	CCA	Rabi season area (ha)	Kharif season area (ha)	Total cropped area (ha)	Cropping Intensity (%)	Irrigated area (ha) by different sources	
							Canal	Tube well
1	Sunari	285.56	245.52	84.39	329.91	115.53	25	220.52
2	Anauriberkhedi	455.12	264.00	272.71	536.71	117.93	200.99	63.00
3	Kanakheda kalan	312.31	300.70	102.19	402.89	129.00	243.50	57.20
4	Ratanpurgirdhari	214.36	168.50	104.81	273.31	127.50	126.50	42.00
5	Manchi	171.15	150.73	71.43	222.16	129.81	110.73	40.00
6	Suganakhedi	292.10	178.43	179.02	357.45	122.37	170.00	8.43
7	Nagori	124.24	110.43	54.83	165.26	133.02	66.43	44.00
8	Naranda	102.26	68.47	71.37	139.84	136.74	0.00	68.47

9	Firojpur	338.58	250.00	210.92	460.92	136.14	119.87	130.13
10	Uneeda	79.83	51.62	62.60	114.22	143.09	22.00	29.62
11	Airan	264.07	203.00	169.95	372.95	141.23	140.00	63.00
12	Rataltai	352.97	297.61	224.73	522.33	147.98	20.00	277.61
13	Sanchi	186.36	144.98	129.03	274.01	147.03	37.57	107.41
14	Medaki	463.92	418.70	257.90	676.60	145.85	349.00	69.70
15	Sookhansen	104.13	85.62	68.43	154.04	147.93	60.00	25.62
16	Kamapar	266.96	233.56	155.41	388.97	145.70	200.56	33.00
17	Dargava	123.19	118.58	61.39	179.97	146.08	80.39	38.19
18	Moralikhedi	336.26	270.10	265.95	536.05	159.41	0.00	270.10
19	Chiroli	247.24	183.41	191.60	375.00	151.68	175.00	8.41
20	Fatehpur	314.74	282.00	215.62	497.62	158.11	159.33	122.67
21	Ucher	276.80	219.69	196.30	415.99	150.29	214.00	5.69
22	Nonakhedi	127.77	99.96	104.41	204.37	159.96	80.00	19.96
23	Khamkheda	251.44	233.56	155.41	388.97	154.70	15.00	218.56
24	Bansakheda	491.19	475.94	354.88	830.82	169.14	310.94	165.00
25	Gulgaonv	312.53	224.03	291.60	515.63	164.99	24.00	200.03
26	Madvai	415.97	352.23	328.76	681.00	163.71	300.00	52.23
27	Kachhikanakheda	236.36	196.75	203.50	400.25	169.34	106.75	90.00
28	Pipariakhurd	96.51	78.94	84.74	163.68	169.60	40.98	37.96
29	Madaiyakhurd	87.09	82.18	60.70	142.88	164.06	25.23	56.95
30	Bamora	327.57	300.32	233.69	534.01	163.02	114.34	185.98
31	Neemkheda	775.21	689.06	631.52	1320.58	170.35	625.66	63.40
32	Sunpura	309.12	285.10	235.95	521.05	168.56	6.98	278.12
33	Karaiyahaveli	200.35	191.70	147.51	339.21	169.31	123.00	68.69
34	Padariyamaphi	89.14	85.92	65.00	150.92	169.32	19.00	66.92
35	Base	468.12	405.06	367.52	772.56	165.03	300.93	104.12
36	Udaygiry	151.77	139.30	120.23	259.53	171.00	59.99	79.30

37	Rangai	131.44	120.50	114.00	234.50	178.41	70.00	50.50
38	Dhaniyakhedi	172.59	164.40	141.80	306.20	177.41	4.00	160.40
39	Mada	173.83	129.42	168.11	297.53	171.16	100.00	29.42
40	Bagaud	359.85	325.32	312.10	637.41	177.13	311.20	14.11
41	Bala barkheda	583.23	546.99	500.50	1047.49	179.60	464.01	82.98
42	Berkhedi	242.20	229.54	216.17	445.71	184.03	116.54	113.00
43	Vighan	100.65	96.60	94.00	190.60	189.36	53.60	43.00
44	Dakana chapana	277.67	252.71	255.25	507.96	182.94	100.00	152.71
45	Vilori	203.81	181.69	196.24	377.93	185.43	40.00	141.69
46	Mudiakheda	228.07	200.40	219.10	419.50	183.94	0.00	200.40
47	Muktapur	80.98	74.89	75.55	150.44	185.77	0.00	74.89
48	Parasi khurd	141.23	134.93	131.03	265.97	188.32	50.28	84.65
49	Patharia	234.13	221.87	208.16	430.03	183.68	106.33	115.54
50	Karela	377.94	350.70	340.99	691.69	183.02	212.00	138.70
51	Silwaha	249.31	246.00	243.50	489.50	196.34	225.75	20.25
52	Sarchampa	369.98	395.59	324.36	719.95	194.60	302.11	93.48
53	Suakhedi	236.88	229.14	223.41	452.55	191.05	129.00	100.14
54	Aamkheda	183.58	178.80	182.33	361.13	196.72	100.00	78.80
55	Sayar	836.80	811.26	807.47	1618.73	193.44	620.00	191.26

4.6 Frequency Distribution of Cropping Intensity in Command Area

In order to obtain frequency distribution pattern the cropping intensity was divided into ranges 110-200%. It is also clear from Fig.4.2 that the cropping intensity of villages under study varies between 110% to 200%. It is also depicted from the figure that only nine villages out of 55 villages were having cropping intensity less than 140%. On the higher side, only five villages were having cropping intensity more than 190%. The lowest cropping intensity 115% was found in Sunari village of Medaki WUA. This village is having 245 ha net sown area in rabi season but very less net sown

area (84 ha) in kharif season due to unavailability of water. Similarly less cropping intensity 118% was found in Anouri berkhedi village. This village is having 264 ha net sown area out of 455 ha in Rabi season and 272 ha net sown area out of 455 ha in kharif season.

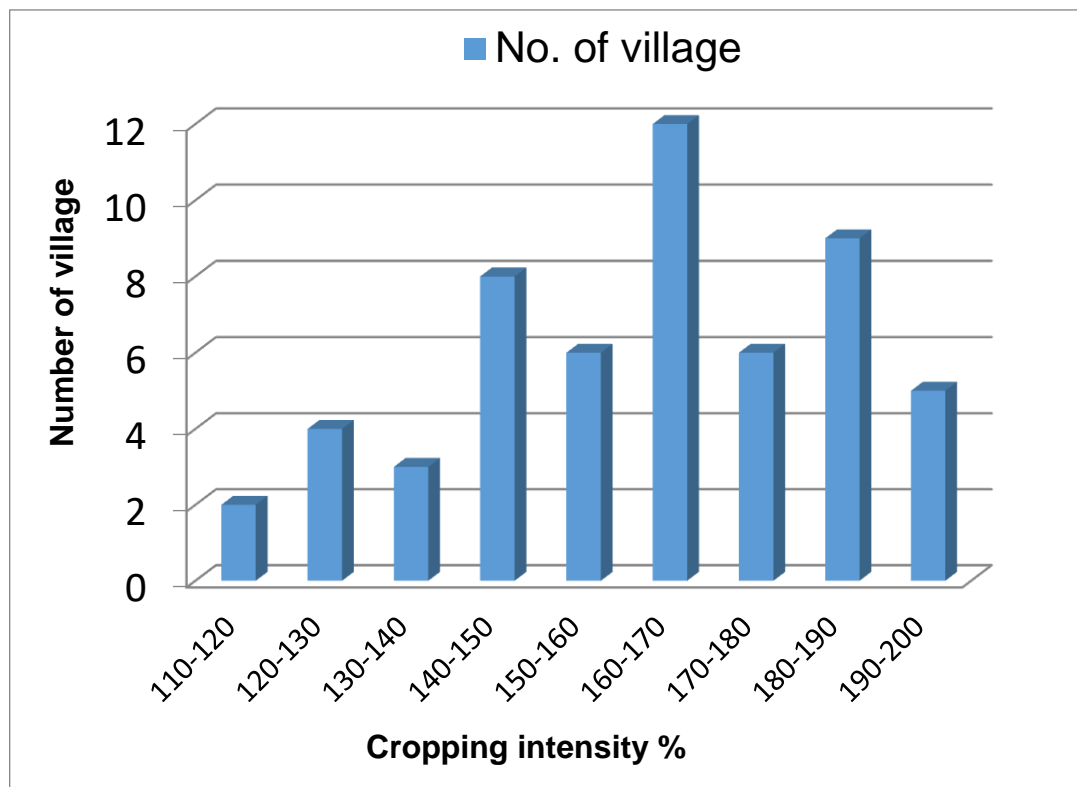


Fig 4.2 Frequency of Cropping Intensity of Command Area

The cropping intensity of four villages namely Sugnakhedi Ratanpur girdhari, Kanakheda kalan and Manchi fall in range of 120- 130 % cropping intensity. All four villages have very less sown area in kharif that is ie. 61 %, 49%, 33 and 42%, respectively, on the other side the net sown area in *Rabi* season is 78%, 79%, 96% and 88% for Sugnakhedi Ratanpur girdhari, Kanakheda kalan and Manchi villages respectively. In village Kanakheda kalan 99 % area is under irrigation which results in 300 ha net sown area out of 312 ha cultural command area in *Rabi* season.

The cropping intensity of three villages namely Sugnakhedi, Ratanpur girdhari and Manchi was found very poor as shown in Table 4.7 due to rocky area, unavailability of canal water and tubewells are not successful. These results should the poor cropping intensity in two villages as mentioned.

The cropping intensity of three villages namely Nagori, Naroda and Firozpur falls in 130%-140% cropping intensity range. Village Nagori is having only 54.83 ha net sown area in kharif season out of 124 ha and net sown area in rabi season is 110 ha (Table 4.7). Out of 110 ha net sown area 44 ha is irrigated from tubewell. In village Naroda net sown area in *Rabi* season 68 ha and 71 ha is the net sown area in *Kharif* season against the total cultural command area of 102 ha.

The cropping intensity of eight villages namely Uneeda, Airan, Rataltai, Sanchi, Medaki, Sookhansen, Kamapar and Dargava out of surveyed 55 villages were found in the range of 140-150%. The villages namely Uneeda Airan, Rataltai, Sanchi, Medaki, Sookhansen, Kamapar and Dargava having canal irrigated area 22 ha, 140 ha, 20 ha, 37.57 ha and 349 ha, 60 ha, 200.55 ha and 80.39 ha, respectively and tubewell irrigated area was found to be 29.619 ha, 63 ha, 277.60 ha, 107.408 ha, 69.7 ha, 25.61ha, 33 ha and 38.19 ha, respectively. The kharif sown area in these villages was 50%-78%. While the *Rabi* sown area in these villages varies from 65%-96%.

The cropping intensity of six villages namely Moralikhedi, Chiroli, Fatehpur, Ucher, Nonakhed and Khamkheda was found in the range of 150-160%. All these villages are having canal irrigated area, 175 ha, 159.33 ha, 214 ha, 80 ha, 15 ha, respectively except Moralikhedi village and tubewell irrigated area was found 270.10 ha, 8.40 ha, 122.66 ha, 5.69 ha, 19.96 ha and 218.55 ha area respectively. The irrigated area in these villages varies from 64-100%.

The cropping intensity of twelve villages namely Bansakheda, Gulgaonv, Madvai, Kachhi kanakheda, Pipariakhurd, Madaiyakhurd, Bamora, Neemkheda, Sunpura, Karaiyahaveli, Padariyamaphi and Baise was found in the range from 160-170%. All these villages are having canal irrigated area of 310.93 ha, 24 ha, 300 ha, 106.75 ha, 40.98 ha, 25.23 ha, 114.34 ha, 625.65 ha, 6.98 ha, 123 ha, 19 ha, and 300.93 ha, respectively and tube well irrigated area was found 165 ha, 200.03 ha, 52.23 ha, 90 ha, 37.96 ha, 56.95 ha, 185.98 ha, 63.40 ha, 278.12 ha, 68.69 ha, 66.92 ha and 104.12 ha, respectively.

The cropping intensity of six villages namely Udaygiry, Rangai, Dhaniyakhedi, Mada, Bagaud and Bala barkheda was found range from 170-180%. All these villages are having canal irrigated area that is 59.99 ha, 70 ha, 4 ha, 100 ha, 311.20 ha and 464.01 ha, respectively and tube well irrigated area was found 79.29 ha, 50.5 ha, 160.4 ha, 29.42 ha, 14.11 ha and 82.98 ha, respectively. Irrigated area in these villages varies from 74-100%.

The cropping intensity of Nine villages namely Berkhedi, Vighan, Dakana chapana, Vilori, Mudiakheda, Muktapur, Parasikhurd, Patharia and Karela, are having from 182-189%. All these villages are having canal irrigated 116.54 ha, 53.6 ha, 100 ha, 40 ha, 0 ha, 0 ha, 50.28 ha, 106.33 ha and 212 ha, respectively except Vilori, Mudiakheda villages and tubewell irrigated area was found 113 ha, 43 ha, 152.71 ha, 141.69 ha, 200.4 ha, 74.89 ha, 84.65 ha, 115.54 ha and 138.7 ha, respectively.

The cropping intensity of five villages namely Silwaha, Sarchampa , Suakhedi, Aamkheda and Sayar. Which have exceptionally very high cropping intensity ie 191-196%. All these villages namely are having canal irrigated area 225.74 ha, 302.11 ha, 129 ha, 100 ha and 620 ha, respectively villages and tubewell irrigated area was found 20.253 ha, 93.479 ha, 100.13 ha, 78.8 ha and 191.26 ha, respectively.

It is difficult to increase kharif sown area due to uncertainty of monsoon, excess of deficit rain fall, but it is easy to manage to take third crop as summer crop provided that there is assured irrigation. If considerable amount of water is saved, than summer cropping is easily feasible.

4.7 Existing Cropping Intensity in Command Area WUA Wise

The existing cropping intensity of right bank canal command area was found 163%. The right bank canal comprises of five water user association namely Sarchampa, Ucher, Medaki, Sayar and Neemkheda whose existing cropping intensity was found 181%, 149%, 158% 177% and 172%, respectively as shown in table 4.8

Table 4.8 Existing Cropping Intensity in Command Area WUA Wise

Area (ha)	Name of Water User Association					Total
	Sarchampa	Ucher	Medaki	Sayar	Neemkheda	
Culturable command area(CCA) of WUA (ha)	1110	4320	3698	3240	2468	14836
Rabi crop season area (ha)	1087	3380	3249	2952	2243	12911
Kharif crop season area (ha)	923	3046	2591	2774	1992	11326
Total cropped area (ha)	2010	6426	5840	5726	4235	24237
Cropping intensity (%)	181	149	158	177	172	163

4.8 Existing Water Productivity in Command Area

The total water supplied in $M\ m^3$ excluding losses from RBC was collected from water resources department and the data on total production of wheat was collected from revenue record of Vidisha district to assess the existing water productivity. The existing water productivity of the command area was found to be $0.60\ kg\ m^{-3}$ for *Rabi* season as shown in Table 4.9

Table 4.9: Wheat Crop Yield and Productivity in RBC Command Area

Name of WUAs	Cropped area (ha) in rabi season	Production (q ha-1)	Total Production (q)	Total water released from RBC (M m ³)	Water productivity (kg m ⁻³)
Sarchampa	1087	27.66	29959	42.974294	0.60
Ucher	3210	28	89687		
Medaki	1611	28	44959		
Sayar	1895	27	52299		
Neemkheda	1700	26	44261		
Total	9503		261165		

4.9 Assessment of Techno-Economic Feasibility of Pressurized Irrigation System Namely Sprinkler Irrigation System in the Study Area

Feasibility of pressurized irrigation technically was judged through an interview schedule and score matrix as suggested and adopted by Nema and Shrivastva (2012). To conduct this interview the study area was divided in three reach that is head, middle and tail reach. Total 45 farmers were selected, surveyed and interviewed from each category of farmers. In this way 180 farmers of all the five WUA were considered for analysis through Chi-square test.

Information given by the farmers was compiled and the Chi-square test was applied as presented in Table 4.10. The contingency table of (4x4) regarding awareness of farmers about pressurized irrigation system was prepared under the farmer's category marginal, small, medium large and their response was recorded as nil, poor, medium and high as shown in table 4.10. The Chi-square test was applied as per the contingency table.

The null hypothesis was postulated as below.

H_0 : Type of farmers and their awareness are independent.

H_1 : Type of farmers and their awareness are dependent.

The calculated Chi-square test value was 20.72 which was larger than the tabulated value 16.919 at 9 degree of freedom. Thus the null hypothesis is rejected and it was concluded that the type of farmers and their awareness dependent on each other that is the large farmer could have the different awareness than marginal, small and medium farmers.

Table 4.10 Awareness of Farmer about Pressurized Irrigation System

Farmers Category	Nil (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Poor (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Medium (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	High (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Total (O _i)	Total $\frac{(O_i - E_i)^2}{E_i}$
Marginal	12	6.25	5.29	11	9.25	0.33	12	13.75	0.22	10	15.75	2.10	45	7.94
Small	8	6.25	0.49	13	9.25	1.52	12	13.75	0.22	12	15.75	0.89	45	3.13
Medium	3	6.25	1.69	7	9.25	0.55	15	13.75	0.11	20	15.75	1.15	45	3.50
Large	2	6.25	2.89	6	9.25	1.14	16	13.75	0.37	21	15.75	1.75	45	6.15
Total	25	25	10.36	37	37	3.54	55	55	0.93	63	63	5.89	180	20.72

Note:- O_i- Observed value and E_i. Expected value.

$E_i = (R_i \times C_j) / N$, where R_i and C_j are the total of ith row and C_j colume, respectively. N is total number of farmers.

Information given by the farmers was compiled and the Chi-square test is applied as presented in Table 4.11. The contingency table of (4x4) regarding awareness of farmers about pressurized irrigation system was prepared under the farmer's category marginal, small, medium large and their response was recorded as nil, poor, medium and high as shown in Table 4.11. The Chi-square test was applied as per the contingency table.

The null hypothesis is postulated as below.

H_0 : Type of farmers and their Technical knowledge are independent.

H_1 : Type of farmers and their Technical knowledge are dependent.

The calculated Chi-square test value was 27.46 which was larger than the tabulated value 16.919 at 9 degree of freedom. Thus the null hypothesis is rejected and it was concluded that the type of farmers and their technical knowledge dependent on each other that is the large farmer could have the different technical knowledge than marginal, small and medium farmers. The small farmers could have the different technical knowledge than large and medium farmers.

Table 4.11 Technical Knowledge of Farmer about Pressurized Irrigation System

Farmers Category	Nil (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Poor (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Medium (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	High (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Total (O _i)	Total $\frac{(O_i - E_i)^2}{E_i}$
Marginal	17	10.5	4.02	12	10.5	0.21	9	11.25	0.45	7	12.75	2.59	45	7.28
Small	15	10.5	1.93	14	10.5	1.17	8	11.25	0.94	8	12.75	1.77	45	5.80
Medium	7	10.5	1.17	9	10.5	0.21	13	11.25	0.27	16	12.75	0.83	45	2.48
Large	3	10.5	5.36	7	10.5	1.17	15	11.25	1.25	20	12.75	4.12	45	11.90
Total	42	42	12.48	42	42	2.76	45	45	2.91	51	51	9.31	180	27.46

Note:- O_i- Observed value and E_i- Expected value.

$E_i = (R_i \times C_j) / N$, where R_i and C_j are the total of ith row and C_j column, respectively. N is total number of farmers.

Information given by the farmers was compiled and the Chi-square test is applied as presented in Table 4.12. The contingency table of (4x4) regarding awareness of farmers about pressurized irrigation system was prepared under the farmer's category marginal, small, medium large and their response was recorded as nil, poor, medium and high as shown in Table 4.12. The Chi-square test was applied as per the contingency table.

The null hypothesis is postulated as below.

H_0 : Type of farmers and their attitude are independent.

H_1 : Type of farmers and their attitude are dependent.

The calculated Chi-square test value was 24.83 which was larger than the tabulated value 16.919 at 9 degree of freedom. Thus the null hypothesis is rejected and it was concluded that the type of farmers and their attitude dependent on each other that is the large farmer could have the different attitude than marginal, small and medium farmers and vice-versa

Table 4.12 Attitude of Farmer about Pressurized Irrigation System

Farmers Category	Nil (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Poor (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Medium (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	High (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Total (O _i)	Total $\frac{(O_i - E_i)^2}{E_i}$
Marginal	14	8	4.50	16	13.5	0.46	9	12.5	0.98	6	11	2.27	45	8.22
Small	10	8	0.50	17	13.5	0.91	11	12.5	0.18	7	11	1.45	45	3.04
Medium	6	8	0.50	12	13.5	0.17	15	12.5	0.50	12	11	0.09	45	1.26
Large	2	8	4.50	9	13.5	1.50	15	12.5	0.50	19	11	5.82	45	12.32
Total	32	32	10.00	54	54	3.04	50	50	2.16	44	44	9.64	180	24.83

Note:- O_i- Observed value and E_i- Expected value.

$E_i = (R_i \times C_j) / N$, where R_i and C_j are the total of ith row and C_j column, respectively. N is total number of farmers.

Information given by the farmers was compiled and the Chi-square test is applied as presented in Table 4.13. The contingency table of (4x4) regarding awareness of farmers about pressurized irrigation system is prepared under the farmer's category marginal, small, medium large and their response was recorded as nil, poor, medium and high as shown in Table 4.13. The Chi-square test was applied as per the contingency table.

The null hypothesis is postulated as below.

H_0 : Type of farmers and their Purchasing capacity are independent.

H_1 : Type of farmers and their Purchasing capacity are dependent.

The calculated Chi-square test value was 24.28 which was larger than the tabulated value 16.919 at 9 degree of freedom. Thus the null hypothesis is rejected and it was concluded that the type of farmers and their purchasing capacity dependent on each other that is the large farmer could have the different purchasing capacity than marginal, small and medium farmers.

Table 4.13 Purchasing Capacity of Farmer about Pressurized Irrigation System

Farmers Category	Nil (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Poor (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Medium (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	High (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Total (O _i)	Total $\frac{(O_i - E_i)^2}{E_i}$
Marginal	17	10.25	4.45	12	11.25	0.05	9	13.25	1.36	7	10.25	1.03	45	6.89
Small	12	10.25	0.30	11	11.25	0.01	16	13.25	0.57	6	10.25	1.76	45	2.64
Medium	9	10.25	0.15	14	11.25	0.67	13	13.25	0.00	9	10.25	0.15	45	0.98
Large	3	10.25	5.13	8	11.25	0.94	15	13.25	0.23	19	10.25	7.47	45	13.77
Total	41	41	10.02	45	45	1.67	53	53	2.17	41	41	10.41	180	24.28

Note:- O_i- Observed value and E_i- Expected value.

$E_i = (R_i \times C_j) / N$, where R_i and C_j are the total of ith row and C_j column, respectively. N is total number of farmers.

Information given by the farmers was compiled and the Chi-square test is applied as presented in Table 4.14. The contingency table of (4x4) regarding awareness of farmers about pressurized irrigation system was prepared under the farmer's category marginal, small, medium large and their response was recorded as nil, poor, medium and high as shown in Table 4.14. The Chi-square test was applied as per the contingency table.

The null hypothesis is postulated as below.

H_0 : Type of farmers and their Willingness of adoption are independent.

H_1 : Type of farmers and their Willingness of adoption are dependent.

The calculated Chi-square test value was 37.75 which was larger than the tabulated value 16.919 at 9 degree of freedom. Thus the null hypothesis is rejected and it is concluded that the type of farmers and their willingness of adoption dependent on each other that is the large farmer could have the different willingness of adoption than marginal, small and medium farmers.

Table 4.14 Willingness of Adoption of Pressurized Irrigation System

Farmers Category	Nil (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Poor (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Medium (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	High (O _i)	E _i	$\frac{(O_i - E_i)^2}{E_i}$	Total (O _i)	Total $\frac{(O_i - E_i)^2}{E_i}$
Marginal	17	10.5	4.02	16	12.25	1.15	8	12.25	1.47	4	10	3.60	45	10.25
Small	15	10.5	1.93	14	12.25	0.25	11	12.25	0.13	5	10	2.50	45	4.81
Medium	8	10.5	0.60	13	12.25	0.05	13	12.25	0.05	11	10	0.10	45	0.79
Large	2	10.5	6.88	6	12.25	3.19	17	12.25	1.84	20	10	10.00	45	21.91
Total	42	42	13.43	49	49	4.63	49	49	3.490	40	40	16.20	180	37.75

Note:- O_i- Observed value and E_i- Expected value.

$E_i = (R_i \times C_j) / N$, where R_i and C_j are the total of ith row and C_j column, respectively. N is total number of farmers.

4.9.1 Scoring Matrix for Characteristics of Technology

To study the characteristics of technology score matrix tables were prepared and the area was divided in to three reaches that is head, middle and tail reach. Total 36 farmers from each water user association were selected, surveyed and interviewed. Their response was obtained for each characters of technology and was recorded in respective tables i. e. Table 4.15 to Table 4.59.

The tabulated data gives the scores given by the farmers of right bank canal command area of Samrat Ashok Sagar project Vidisha regarding the test of irrigation methods. The maximum score that could be awarded by a person was 10. Test whether judges could be formed irrespective of group.

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

Table 4.15: Score Matrix for Labour Requirement of Different Irrigation Methods in Sayar WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Shakti singh	7	3	5	2	13.5	1	4.5	3	27.5
Imarat singh	4	2	5	3	27.5	1	4.5	3	27.5
Gainda lal	7	3	6	3	27.5	1	4.5	4	45.5
Ajab singh	5	4	6	3	27.5	1	4.5	4	45.5
Ganeshram	8	1	5	4	45.5	1	4.5	4	45.5
Nandram	7	3	6	4	45.5	1	4.5	4	45.5
Vishal singh	7	5	3	4	45.5	1	4.5	4	45.5
Sangram singh	6	2	6	4	45.5	2	13.5	4	45.5
Tularam	9	3	5	5	63.5	2	13.5	4	45.5
Dasharth singh	7	1	6	5	63.5	2	13.5	4	45.5
Deewan singh	5	1	4	5	63.5	2	13.5	5	63.5
Harinarayan	2	3	4	5	63.5	2	13.5	5	63.5
Bhairo singh	8	3	7	5	63.5	2	13.5	5	63.5
Shyamlal	9	1	5	6	79	2	13.5	5	63.5
Rupsingh	5	3	5	6	79	2	13.5	5	63.5
Dhannalal	7	5	7	6	79	3	27.5	5	63.5
Anar singh	8	2	5	7	92	3	27.5	5	63.5
Gajraj singh	4	3	4	7	92	3	27.5	5	63.5
Harprasad	9	1	7	7	92	3	27.5	5	63.5
Maharaj singh	3	3	4	7	92	3	27.5	5	63.5
Shakti singh	8	4	4	2	13.5	1	4.5	3	27.5
Kamala bai	4	4	6	7	92	3	27.5	5	63.5
Raghuveer	8	3	5	7	92	3	27.5	6	79
Vipin singh	6	1	7	7	92	3	27.5	6	79
Ashok	7	2	4	7	92	3	27.5	6	79
Bharat singh	2	4	5	7	92	3	27.5	6	79
Baboo lal	8	2	3	8	101.5	3	27.5	6	79
Parsuram	7	2	6	8	101.5	3	27.5	6	79
Bhagawan	3	3	5	8	101.5	4	45.5	6	79
Hariram	5	3	6	8	101.5	4	45.5	6	79
Bhairo singh	9	2	3	8	101.5	4	45.5	6	79
Radheshyam	3	4	4	8	101.5	4	45.5	6	79
Saitan singh	4	2	6	9	106.5	4	45.5	7	92
Lakshminaraya	6	1	5	9	106.5	4	45.5	7	92
Maharaj singh	5	4	6	9	106.5	5	63.5	7	92
Jagannath	7	1	4	9	106.5	5	63.5	7	92
Average	-				75.25	-	24.27	-	63.97

T₁- Sprinkler irrigation methods, T₂- Border irrigation methods, T₃- Flood irrigation methods and Obs- is Observations.

	Mean
$T_1 = 874$	$= 75.25$
$T_2 = 2303$	$= 24.27$
$T_3 = 2709$	$= 63.97$

$$\text{Sum of Square (SS)} = (T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N \quad \text{----- 4.1}$$

$$SS = (874^2 + 2303^2 + 2709^2)/36 - (874 + 2303 + 2709)^2/108$$

$$SS = 51612.05$$

$$\text{Chi square test} = 12 \times (SS)/N(N+1) \quad \text{----- 4.2}$$

$$= 12 \times 51612.05/108(109)$$

$$= 52.62$$

The mean values of specific irrigation that is sprinkler irrigation; border irrigation and flood irrigation were 75.25, 24.27 and 63.97 as shown Table 4.15. The data was analyzed using nonparametric approach. The Kruskal-Wallis test is a completely randomize design when the observations were rank by the farmers for the specify method of irrigation.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in labour requirement.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in labour requirement.

The Chi-square test value was 52.62 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods.

Table 4.16 Scoring for Cost in Sayar WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Shakti singh	2	5	9	1	4	4	40.5	7	77
Imarat singh	3	5	8	1	4	4	40.5	7	77
Gainda lal	3	5	9	1	4	4	40.5	7	77
Ajab singh	3	6	9	1	4	4	40.5	7	77
Ganeshram	1	5	7	1	4	4	40.5	7	77
Nandram	2	6	7	1	4	4	40.5	7	77
Vishal singh	1	4	9	2	15	4	40.5	7	77
Sangram singh	3	4	9	2	15	5	50.50	7	77
Tularam	1	6	9	2	15	5	50.50	8	88
Dasharth singh	3	5	7	2	15	5	50.50	8	88
Deewan singh	2	6	8	2	15	5	50.50	8	88
Harinarayan	3	6	9	2	15	5	50.50	8	88
Bhairo singh	3	6	8	2	15	5	50.50	8	88
Shyاملal	3	5	8	2	15	5	50.50	8	88
Rupsingh	3	6	7	2	15	5	50.50	8	88
Dhannalal	2	5	8	2	15	5	50.50	8	88
Anar singh	1	6	8	2	15	5	50.50	8	88
Gajraj singh	2	6	7	2	15	5	50.50	8	88
Harprasad	2	5	9	2	15	5	50.50	8	88
Maharaj singh	2	6	8	2	15	6	64.50	8	88
Shakti singh	2	6	7	1	4	4	40.5	7	77
Kamala bai	3	4	8	2	15	6	64.50	8	88
Raghuveer singh	2	4	9	3	29.50	6	64.50	9	101.50
Vipin singh	3	6	7	3	29.50	6	64.50	9	101.50
Ashok	3	4	8	3	29.50	6	64.50	9	101.50
Bharat singh	2	4	8	3	29.50	6	64.50	9	101.50
Baboo lal	3	5	8	3	29.50	6	64.50	9	101.50
Parsuram	2	4	9	3	29.50	6	64.50	9	101.50
Bhagawan singh	3	5	9	3	29.50	6	64.50	9	101.50
Hariram	2	6	9	3	29.50	6	64.50	9	101.50
Bhairo singh	2	6	8	3	29.50	6	64.50	9	101.50
Radheshyam	1	6	7	3	29.50	6	64.50	9	101.50
Saitan singh	2	4	7	3	29.50	6	64.50	9	101.50
Lakshminarayan	1	5	8	3	29.50	6	64.50	9	101.50
Maharaj singh	1	6	9	3	29.50	6	64.50	9	101.50
Jagannath	2	5	9	3	29.50	6	64.50	9	101.50
Average	-	-	-	-	18.50	-	54.50	-	90.50

	Mean	
$T_1 = 666$	=	18.50
$T_2 = 1962$	=	54.50
$T_3 = 3258$	=	90.50

$$\text{Sum of Square (SS)} = (T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N \quad \text{----- 4.3}$$

$$\text{SS} = (666^2 + 1962^2 + 3258^2)/36 - (666 + 1962 + 3258)^2/108$$

$$\text{SS} = 93312$$

$$\text{Chi square test} = 12 \times (\text{SS})/N(N+1) \quad \text{----- 4.4}$$

$$= 12 \times 93312/108(109)$$

$$= 95.12$$

The mean values of treatment T_1 , T_2 and T_3 was found 18.50, 54.50 and 90.50, respectively, as shown in Table 4.16. The data was analyzed using nonparametric approach. The Kruskal-Wallis test is a completely randomize design when the observations were rank by the farmers for the specify method of irrigation.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in cost requirement.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in cost requirement.

The Chi-square test value was found 95.12 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods of irrigation as for as suitability for purchasing and cost involved in application of water through these methods.

Table 4.17 Scoring for Suitability of Irrigation Method Sayar WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Shakti singh	8	7	5	6	60	4	30.5	2	5
Imarat singh	8	4	4	6	60	4	30.5	2	5
Gainda lal	6	6	3	6	60	4	30.5	2	5
Ajab singh	9	5	2	6	60	4	30.5	2	5
Ganeshram	7	4	4	6	60	4	30.5	2	5
Nandram	8	6	3	7	79	5	45	2	5
Vishal singh	8	6	5	7	79	5	45	2	5
Sangram singh	6	7	5	7	79	5	45	2	5
Tularam	9	4	2	7	79	5	45	3	16.5
Dasharth singh	7	7	3	7	79	5	45	3	16.5
Deewan singh	7	5	3	7	79	5	45	3	16.5
Harinarayan	8	5	2	7	79	5	45	3	16.5
Bhairo singh	9	6	4	7	79	5	45	3	16.5
Shyamlal	6	4	5	7	79	5	45	3	16.5
Rupsingh	8	7	3	7	79	5	45	3	16.5
Dhannalal	7	6	2	7	79	6	60	3	16.5
Anar singh	7	6	4	7	79	6	60	3	16.5
Gajraj singh	9	5	4	8	96.5	6	60	3	16.5
Harprasad	6	5	3	8	96.5	6	60	3	16.5
Maharaj singh	8	7	2	8	96.5	6	60	3	16.5
Shakti singh	7	5	2	6	60	4	30.5	2	5
Kamala bai	8	7	4	8	96.5	6	60	3	16.5
Raghuveer singh	7	4	3	8	96.5	6	60	3	16.5
Vipin singh	9	6	2	8	96.5	6	60	4	30.5
Ashok	7	5	3	8	96.5	6	60	4	30.5
Bharat singh	8	5	3	8	96.5	7	79	4	30.5
Baboo lal	6	6	2	8	96.5	7	79	4	30.5
Parsuram	7	7	4	8	96.5	7	79	4	30.5
Bhagawan singh	9	7	3	8	96.5	7	79	4	30.5
Hariram	7	4	4	8	96.5	7	79	4	30.5
Bhairo singh	8	7	3	9	105.	7	79	4	30.5
Radheshyam	6	5	3	9	105.	7	79	5	45
Saitan singh	7	6	2	9	105.	7	79	5	45
Lakshminarayan	7	5	3	9	105.	7	79	5	45
Maharaj singh	8	7	5	9	105.	7	79	5	45
Jagannath	8	7	3	9	105.	7	79	5	45
Average	-			-	86.08	-	56.72	-	20.69

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3099$	= 86.08
$T_2 = 2042$	= 56.72
$T_3 = 745$	= 20.69

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.5

$$SS = (3099^2 + 2042^2 + 745^2)/36 - (3099 + 2042 + 745)^2/108$$

$$SS = 77229.38$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.6

$$= 12 \times 77229.38 / 108(109)$$

$$= 78.72$$

The average values for suitability of irrigation method in command area of Sayar WUA that is sprinkler irrigation system, border irrigation system and flood irrigation system was found to be 86.08, 56.72 and 20.69, respectively as shown in Table 4.17. The data was analyzed using nonparametric approach. The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in suitability of irrigation.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in suitability of irrigation.

The Chi-square test value was 78.72 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and found that there is significant difference in values was observed among sprinkler irrigation, border irrigation and flood irrigation methods.

Table 4.18 Scoring for Control and Management of Water in Command

Area in Sayar WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Shakti singh	7	6	4	6	61.5	32	34	1	4
Imarat singh	9	6	3	6	61.5	32	36	1	4
Gainda lal	7	5	1	6	61.5	32	37	1	4
Ajab singh	8	5	4	6	61.5	5	45.5	1	4
Ganeshram	8	7	5	6	61.5	5	45.5	1	4
Nandram	9	6	1	7	79	5	45.5	1	4
Vishal singh	7	4	2	7	79	5	45.5	2	12
Sangram singh	9	5	2	7	79	5	45.5	2	12
Tularam	8	7	4	7	79	5	45.5	2	12
Dasharth singh	8	5	3	7	79	5	45.5	2	12
Deewan singh	6	6	3	7	79	5	45.5	2	12
Harinarayan	9	7	1	7	79	5	45.5	2	12
Bhairo singh	7	6	1	7	79	5	45.5	2	12
Shyamlal	8	7	4	7	79	5	45.5	2	12
Rupsingh	6	4	4	7	79	5	45.5	2	12
Dhannalal	9	5	2	8	93	5	45.5	3	21.5
Anar singh	7	5	2	8	93	6	61.5	3	21.5
Gajraj singh	7	7	1	8	93	6	61.5	3	21.5
Harprasad	9	6	5	8	93	6	61.5	3	21.5
Maharaj singh	6	6	3	8	93	6	61.5	3	21.5
Shakti singh	6	4	2	6	61.5	32	35	1	4
Kamala bai	9	7	2	8	93	6	61.5	3	21.5
Raghuveer singh	9	5	5	8	93	6	61.5	3	21.5
Vipin singh	7	5	3	8	93	6	61.5	3	21.5
Ashok	8	7	1	8	93	6	61.5	3	21.5
Bharat singh	8	6	3	9	103	6	61.5	3	21.5
Baboo lal	9	4	2	9	103	6	61.5	4	32
Parsuram	9	7	4	9	103	7	79	4	32
Bhagawan singh	6	5	4	9	103	7	79	4	32
Hariram	7	7	3	9	103	7	79	4	32
Bhairo singh	8	5	1	9	103	7	79	4	32
Radheshyam	8	5	3	9	103	7	79	4	32
Saitan singh	9	6	2	9	103	7	79	4	32
Lakshminarayan	6	5	2	9	103	7	79	5	45.5
Maharaj singh	7	6	3	9	103	7	79	5	45.5
Jagannath	7	5	3	9	103	7	79	5	45.5
Average		-		-	86.92	-	57.21	-	19.76

	Mean	
$T_1 = 3129$	=	86.92
$T_2 = 2059$	=	57.21
$T_3 = 711$	=	19.76
Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.7		
$SS = (3129^2 + 2059^2 + 711^2)/36 - (3129 + 2059 + 711)^2/108$		
$SS = 81530$		
Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.8		
$= 12 \times 81530/108(109)$		
$= 83.11$		

The mean values of ranking allotted to sprinkler irrigation, border irrigation and flood irrigation system was found to be 86.92, 57.21 and 19.76, respectively as shown in Table 4.18. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in control and management of water.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in control and management of water.

The Chi-square test value was 83.11 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods as for as scoring for control and management of water in command area of Sayar water user association was concerned.

Table 4.19 Scoring for Availability of Nearby City in Sayar WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Shakti singh	5	5	9	2	4	4	27	7	77.5
Imarat singh	3	5	9	2	4	4	27	7	77.5
Gainda lal	4	4	9	2	4	4	27	7	77.5
Ajab singh	2	5	8	2	4	4	27	7	77.5
Ganeshram	5	5	7	2	4	4	27	7	77.5
Nandram	4	6	7	2	4	4	27	7	77.5
Vishal singh	4	6	9	3	11.5	4	27	7	77.5
Sangram singh	2	4	8	3	11.5	4	27	7	77.5
Tularam	5	4	8	3	11.5	4	27	7	77.5
Dasharth singh	3	5	9	3	11.5	4	27	8	89
Deewan singh	5	6	7	3	11.5	4	27	8	89
Harinarayan	2	5	9	3	11.5	5	51	8	89
Bhairo singh	5	6	7	3	11.5	5	51	8	89
Shyاملal	4	4	9	3	11.5	5	51	8	89
Rupsingh	4	4	9	4	27	5	51	8	89
Dhannalal	2	6	8	4	27	5	51	8	89
Anar singh	3	5	7	4	27	5	51	8	89
Gajraj singh	3	5	7	4	27	5	51	8	89
Harprasad	4	4	8	4	27	5	51	8	89
Maharaj singh	4	5	7	4	27	5	51	8	89
Shakti singh	2	4	8	2	4	4	27	7	77.5
Kamala bai	5	6	9	4	27	5	51	8	89
Raghuveer singh	2	5	9	4	27	5	51	8	89
Vipin singh	3	4	8	4	27	5	51	9	102
Ashok	3	5	8	4	27	5	51	9	102
Bharat singh	4	5	7	4	27	5	51	9	102
Baboo lal	4	6	9	5	51	5	51	9	102
Parsuram	2	4	9	5	51	6	68	9	102
Bhagawan singh	5	5	8	5	51	6	68	9	102
Hariram	3	6	8	5	51	6	68	9	102
Bhairo singh	3	4	7	5	51	6	68	9	102
Radheshyam	5	5	7	5	51	6	68	9	102
Saitan singh	4	4	8	5	51	6	68	9	102
Lakshminarayan	4	4	8	5	51	6	68	9	102
Maharaj singh	5	5	8	5	51	6	68	9	102
Jagannath	5	6	9	5	51	6	68	9	102
Average	-	-	-	-	25.75	-	47.25	-	90.50

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 927$	= 25.75
$T_2 = 1701$	= 47.25
$T_3 = 3258$	= 90.50

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.9

$$SS = (927^2 + 1701^2 + 3258^2)/36 - (927 + 1701 + 3258)^2/108$$

$$SS = 78304.5$$

Chi square test = $12 \times (SS) / N(N+1)$ ----- 4.10

$$= 12 \times 85472 / 108(109)$$

$$= 79.82$$

The mean of rank values of score matrix for availability of nearby city location of Sayar WUA for adopting sprinkler irrigation, border irrigation and flood irrigation system was found to be 25.75, 47.25 and 90.50, respectively as shown in Table 4.19. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in availability of nearby city.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in availability of nearby city.

The calculated Chi-square test value was 79.82 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected.

Table 4.20 Scoring for Time Saving of Irrigation Method in Command Area in Sayar WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
	Shakti singh	6	3	3	5	66.5	2	5	3
Imarat singh	9	5	5	5	66.5	2	5	3	22
Gainda lal	8	3	5	5	66.5	2	5	3	22
Ajab singh	9	4	3	5	66.5	2	5	3	22
Ganeshram	9	2	6	5	66.5	2	5	3	22
Nandram	9	5	3	5	66.5	2	5	3	22
Vishal singh	5	3	3	6	81.5	2	5	3	22
Sangram singh	7	3	4	6	81.5	2	5	3	22
Tularam	5	2	4	6	81.5	3	22	3	22
Dasharth singh	8	4	5	6	81.5	3	22	3	22
Deewan singh	5	4	5	6	81.5	3	22	3	22
Harinarayan	9	2	4	6	81.5	3	22	3	22
Bhairo singh	7	2	4	6	81.5	3	22	4	45.5
Shyamlal	9	4	5	7	89	3	22	4	45.5
Rupsingh	5	3	6	7	89	3	22	4	45.5
Dhannalal	6	3	3	7	89	3	22	4	45.5
Anar singh	6	5	3	7	89	3	22	4	45.5
Gajraj singh	8	4	4	7	89	3	22	4	45.5
Harprasad	9	4	5	8	94	3	22	4	45.5
Maharaj singh	7	2	6	8	94	3	22	4	45.5
Shakti singh	9	2	4	5	66.5	2	5	3	22
Kamala bai	9	3	3	8	94	4	45.5	4	45.5
Raghuveer singh	6	5	3	8	94	4	45.5	4	45.5
Vipin singh	5	3	3	8	94	4	45.5	4	45.5
Ashok	9	2	4	9	102.	4	45.5	4	45.5
Bharat singh	5	3	5	9	102.	4	45.5	5	66.5
Baboo lal	9	4	4	9	102.	4	45.5	5	66.5
Parsuram	8	2	5	9	102.	4	45.5	5	66.5
Bhagawan singh	5	4	3	9	102.	4	45.5	5	66.5
Hariram	6	3	4	9	102.	4	45.5	5	66.5
Bhairo singh	7	4	3	9	102.	4	45.5	5	66.5
Radheshyam	6	3	4	9	102.	5	66.5	5	66.5
Saitan singh	6	3	3	9	102.	5	66.5	5	66.5
Lakshminarayan	8	2	3	9	102.	5	66.5	6	81.5
Maharaj singh	9	5	4	9	102.	5	66.5	6	81.5
Jagannath	7	4	4	9	102.	5	66.5	6	81.5
Average	-			-	88.36	-	30.46	-	44.68

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3181$	= 88.36
$T_2 = 1096$	= 30.46
$T_3 = 1608$	= 44.68

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.11

$$SS = (3181^2 + 1096^2 + 1608^2)/36 - (3181 + 1096 + 1608)^2/108$$

$$SS = 65555.93$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.12

$$= 12 \times 65555.93/108(109)$$

$$= 66.82$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 88.36, 30.46 and 44.68, respectively as shown in Table 4.20. The data was analyzed using nonparametric approach. The Kruskal-Wallis test is a completely randomize design when the observations were rank by the farmers for the specify method of irrigation. The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in time saving of irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in time saving of irrigation method.

The Chi-square test value was 66.82 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. It was concluded that time of saving matters among sprinkler irrigation, border irrigation and flood irrigation system.

Table 4.21 Scoring for Ease Operation of Various Irrigation Methods in Sayar WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood			
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank		
	Shakti singh	6	5	2	6	76.5	2	8	2	8	
Imarat singh	8	2	3	6	76.5	2	8	2	8		
Gainda lal	9	3	4	6	76.5	2	8	2	8		
Ajab singh	9	5	2	6	76.5	2	8	2	8		
Ganeshram	6	2	4	6	76.5	2	8	2	8		
Nandram	9	3	3	6	76.5	3	23	2	8		
Vishal singh	6	4	3	6	76.5	3	23	2	8		
Sangram singh	9	2	4	6	76.5	3	23	2	8		
Tularam	7	4	2	6	76.5	3	23	3	23		
Dasharth singh	6	4	4	6	76.5	3	23	3	23		
Deewan singh	8	3	4	6	76.5	3	23	3	23		
Harinarayan	9	3	5	6	76.5	3	23	3	23		
Bhairo singh	7	2	2	7	90.5	4	41.5	3	23		
Shyamlal	7	4	3	7	90.5	4	41.5	3	23		
Rupsingh	6	6	4	7	90.5	4	41.5	3	23		
Dhannalal	8	3	4	7	90.5	4	41.5	3	23		
Anar singh	6	5	2	7	90.5	4	41.5	4	41.5		
Gajraj singh	6	2	5	7	90.5	4	41.5	4	41.5		
Harprasad	7	4	3	7	90.5	4	41.5	4	41.5		
Maharaj singh	7	4	3	7	90.5	4	41.5	4	41.5		
Shakti singh	7	3	5	6	76.5	2	8	2	8		
Kamala bai	9	5	2	7	90.5	4	41.5	4	41.5		
Raghuveer singh	9	3	4	7	90.5	4	41.5	4	41.5		
Vipin singh	6	6	5	8	98	4	41.5	4	41.5		
Ashok	8	2	2	8	98	5	60	4	41.5		
Bharat singh	7	5	4	8	98	5	60	4	41.5		
Baboo lal	6	4	2	8	98	5	60	4	41.5		
Parsuram	6	6	3	8	98	5	60	4	41.5		
Bhagawan singh	7	4	5	9	104.	5	60	5	60		
Hariram	9	4	5	9	104.	5	60	5	60		
Bhairo singh	6	5	2	9	104.	5	60	5	60		
Radheshyam	7	4	5	9	104.	6	76.5	5	60		
Saitan singh	6	5	3	9	104.	6	76.5	5	60		
Lakshminarayan	6	6	4	9	104.	6	76.5	5	60		
Maharaj singh	8	6	5	9	104.	6	76.5	5	60		
Jagannath	7	4	4	9	104.	6	76.5	5	60		
Average	-				89.60	-		40.78	-		33.13

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3225$	= 89.60
$T_2 = 1468$	= 40.78
$T_3 = 1192$	= 33.13

$$\text{Sum of Square (SS)} = (T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N \quad \text{-----4.13}$$

$$SS = (3225^2 + 1468^2 + 1192^2)/36 - (3225 + 1468 + 1192)^2/108$$

$$SS = 67572.18$$

$$\text{Chi square test} = 12 \times (SS)/N(N+1) \quad \text{----- 4.14}$$

$$= 12 \times 67572.18 / 108(109)$$

$$= 68.88$$

The score matrix for ease operation of various irrigation methods was prepared as shown in Table 4.21. The mean values of treatment T_1, T_2 and T_3 was found to be 89.60, 40.78 and 33.13, respectively. The data was analyzed using nonparametric approach. The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for ease operation of various irrigation methods.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for ease operation of various irrigation methods. The Chi-square test value was 68.88 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that ease of operation of irrigation methods is very important for farmers of Sayar water user association.

Table 4.22 Scoring for Water Saving in Irrigation Methods of Sayar

WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Shakti singh	8	6	4	6	62	4	32	2	8
Imarat singh	6	4	2	6	62	4	32	2	8
Gainda lal	8	6	2	6	62	4	32	2	8
Ajab singh	7	6	3	6	62	4	32	2	8
Ganeshram	9	5	4	7	80	4	32	2	8
Nandram	9	4	3	7	80	5	45.5	2	8
Vishal singh	6	7	4	7	80	5	45.5	2	8
Sangram singh	7	7	3	7	80	5	45.5	2	8
Tularam	8	5	2	7	80	5	45.5	2	8
Dasharth singh	7	4	2	7	80	5	45.5	2	8
Deewan singh	9	7	3	7	80	5	45.5	2	8
Harinarayan	7	5	2	7	80	5	45.5	2	8
Bhairo singh	9	6	3	7	80	5	45.5	2	8
Shyamlal	6	6	4	7	80	5	45.5	2	8
Rupsingh	9	7	3	7	80	5	45.5	3	20.5
Dhannalal	9	5	2	8	93.5	6	62	3	20.5
Anar singh	7	7	2	8	93.5	6	62	3	20.5
Gajraj singh	9	5	2	8	93.5	6	62	3	20.5
Harprasad	8	4	4	8	93.5	6	62	3	20.5
Maharaj singh	8	6	5	8	93.5	6	62	3	20.5
Shakti singh	7	5	5	6	62	4	32	2	8
Kamala bai	6	7	4	8	93.5	6	62	3	20.5
Raghuveer singh	9	5	2	8	93.5	6	62	3	20.5
Vipin singh	7	6	2	8	93.5	6	62	3	20.5
Ashok	8	6	3	8	93.5	6	62	3	20.5
Bharat singh	7	6	2	8	93.5	6	62	4	32
Baboo lal	7	5	3	9	103.	6	62	4	32
Parsuram	9	5	2	9	103.	6	62	4	32
Bhagawan singh	8	6	4	9	103.	6	62	4	32
Hariram	8	4	2	9	103.	6	62	4	32
Bhairo singh	6	6	3	9	103.	7	70	4	32
Radheshyam	7	5	2	9	103.	7	70	4	32
Saitan singh	8	6	2	9	103.	7	70	5	45.5
Lakshminarayan	7	4	5	9	103.	7	70	5	45.5
Maharaj singh	9	6	3	9	103.	7	70	5	45.5
Jagannath	8	6	5	9	103.	7	70	5	45.5
Average	-			-	87.78	-	53.75	-	20.31

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3160$	= 87.78
$T_2 = 1935$	= 53.75
$T_3 = 731$	= 20.31

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.15

$$SS = (3160^2 + 1935^2 + 731^2)/36 - (3160 + 1935 + 731)^2/108$$

$$SS = 81947.05$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.16

$$= 12 \times 81947.05 / 108(109)$$

$$= 83.53$$

The mean values of specific irrigation that is sprinkler irrigation; border irrigation and flood irrigation were 87.78, 53.75 and 20.31, respectively as shown in Table 4.22. The data was analyzed using nonparametric approach. The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for water saving in irrigation methods.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for water saving in irrigation methods.

The Chi-square test value was 83.53 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods as for as water saving in irrigation methods of Sayar WUA is concerned.

Table 4.23 Scoring for High Income Irrigation Method in Command

Area in Sayar WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Shakti singh	8	5	2	5	61.5	3	17.5	2	4
Imarat singh	7	4	3	5	61.5	3	17.5	2	4
Gainda lal	6	3	4	5	61.5	3	17.5	2	4
Ajab singh	7	5	2	5	61.5	3	17.5	2	4
Ganeshram	5	4	5	5	61.5	3	17.5	2	4
Nandram	6	3	5	5	61.5	3	17.5	2	4
Vishal singh	7	5	3	5	61.5	3	17.5	3	17.5
Sangram singh	8	4	4	5	61.5	3	17.5	3	17.5
Tularam	5	3	3	5	61.5	3	17.5	3	17.5
Dasharth singh	6	6	4	6	82.5	4	38	3	17.5
Deewan singh	7	3	2	6	82.5	4	38	3	17.5
Harinarayan	8	6	5	6	82.5	4	38	3	17.5
Bhairo singh	5	4	4	6	82.5	4	38	3	17.5
Shyamlal	6	6	4	6	82.5	4	38	3	17.5
Rupsingh	7	3	3	6	82.5	4	38	3	17.5
Dhannalal	7	4	3	6	82.5	4	38	3	17.5
Anar singh	5	6	5	6	82.5	4	38	4	38
Gajraj singh	8	3	2	7	95	4	38	4	38
Harprasad	6	5	4	7	95	5	61.5	4	38
Maharaj singh	7	6	5	7	95	5	61.5	4	38
Shakti singh	5	3	4	5	61.5	3	17.5	2	4
Kamala bai	5	4	3	7	95	5	61.5	4	38
Raghuveer singh	7	6	4	7	95	5	61.5	4	38
Vipin singh	6	4	2	7	95	5	61.5	4	38
Ashok	5	3	5	7	95	5	61.5	4	38
Bharat singh	8	5	3	7	95	5	61.5	4	38
Baboo lal	6	5	4	7	95	5	61.5	4	38
Parsuram	5	3	3	8	104	5	61.5	4	38
Bhagawan singh	8	5	5	8	104	6	82.5	4	38
Hariram	6	4	2	8	104	6	82.5	5	61.5
Bhairo singh	7	6	3	8	104	6	82.5	5	61.5
Radheshyam	5	3	4	8	104	6	82.5	5	61.5
Saitan singh	8	4	2	8	104	6	82.5	5	61.5
Lakshminarayan	8	5	4	8	104	6	82.5	5	61.5
Maharaj singh	5	6	3	8	104	6	82.5	5	61.5
Jagannath	8	5	4	8	104	6	82.5	5	61.5
Average		-		-	85.17	-	48.07		30.26

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3066$	= 85.17
$T_2 = 1730$	= 48.07
$T_3 = 1090$	= 30.26

$$\text{Sum of Square (SS)} = (T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N \quad \text{-----4.17}$$

$$SS = (3066^2 + 1730^2 + 1090^2)/36 - (3066 + 1730 + 1090)^2/108$$

$$SS = 56490.68$$

$$\text{Chi square test} = 12 \times (SS)/N(N+1) \quad \text{----- 4.18}$$

$$= 12 \times 56490.68 / 108(109)$$

$$= 57.58$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 85.17, 48.07 and 30.26, respectively as shown in Table 4.23. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for high income irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for high income irrigation method.

The Chi-square test value was 57.58 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods.

Table 4.24 Scoring Matrix for Labour Requirement of Different Irrigation Method in Sarchampa WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
	Sajid Mohmmad	9	4	3	6	65	4	27.5	2
Mokhtayar Moh.	7	5	4	6	65	4	27.5	2	5
Maskoor Bag	8	4	2	6	65	4	27.5	2	5
Shyamlal	6	3	3	6	65	4	27.5	2	5
Musarf bag	9	4	2	6	65	4	27.5	2	5
Manseer moh.	7	3	5	6	65	4	27.5	2	5
Dharu singh	7	6	2	6	65	4	27.5	2	5
Suraj singh	7	4	4	6	65	4	27.5	2	5
Gayatri bai	8	4	2	6	65	4	27.5	2	5
Ameena bi	7	3	3	6	65	4	27.5	3	13.5
Balram	6	5	3	7	85	4	27.5	3	13.5
Sardar singh	9	6	5	7	85	4	27.5	3	13.5
Nijay ulla	7	3	2	7	85	5	46.5	3	13.5
Nosambabi	6	6	5	7	85	5	46.5	3	13.5
Prayag singh	6	4	3	7	85	5	46.5	3	13.5
Samad khan	8	4	6	7	85	5	46.5	3	13.5
Yunish khan	7	3	4	7	85	5	46.5	3	13.5
Prem bai	7	5	5	7	85	5	46.5	4	27.5
Ratan singh	9	3	4	7	85	5	46.5	4	27.5
Sagir Moh.	6	5	2	7	85	65	45	4	27.5
Anveri bi	6	4	5	7	85	65	57	4	27.5
Imnaj moh.	8	6	3	7	85	65	58	4	27.5
Majid moh	7	4	6	7	85	65	59	4	27.5
Ganeshram	7	4	2	8	99	65	60	4	27.5
Sardar singh	6	5	5	8	99	65	61	4	27.5
Sandeep kumar	9	3	5	8	99	65	62	5	46.5
Hari singh	6	6	2	8	99	65	63	5	46.5
Yusuf khan	8	7	5	8	99	65	64	5	46.5
Insaf moh	7	4	2	8	99	7	85	5	46.5
Suleman moh	7	7	5	8	99	7	85	5	46.5
Amar Chandra	8	5	4	9	105.	7	85	5	46.5
Bhagawan singh	6	4	5	9	105.	7	85	5	46.5
Sarjan singh	9	6	4	9	105.	7	85	5	46.5
Gulav singh	6	6	4	9	105.	7	85	5	46.5
Ramesh chandra	8	5	5	9	105.	7	85	5	46.5
Ramcharan	7	7	4	9	105.	7	85	5	46.5
Average	-	-	-	-	85.58	-	51.79	-	24.57

The tabulated data gives the scores given by the farmers of right bank canal command area of Samrat Ashok Sagar project Vidisha regarding the test of irrigation methods. The maximum score that could be awarded by a person was 10.

	Mean
T ₁ = 3081	= 85.58
T ₂ = 1864	= 51.79
T ₃ = 884	= 24.57

$$\text{Sum of Square (SS)} = (T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N \quad \text{----- 4.19}$$

$$SS = (3081^2 + 1864^2 + 884^2)/36 - (3081 + 1864 + 884)^2/108$$

$$SS = 67267.47$$

$$\text{Chi square test} = 12 \times (SS)/N(N+1) \quad \text{----- 4.20}$$

$$= 12 \times 67267.47/108(109)$$

$$= 68.57$$

The mean values of specific irrigation that is sprinkler irrigation; border irrigation and flood irrigation were 85.58, 51.79 and 24.57, respectively as shown in Table 4.24. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H₀: There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in labour requirement.

H₁: There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in labour requirement.

The Chi-square test value was found 68.57 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and significant difference in labour requirement ranking awarded by the farmers was found among sprinkler irrigation, border irrigation and flood irrigation.

Table 4.25 Scoring for Cost in Sarchampa WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
	Sajid Mohmmad	2	5	8	1	4.5	4	41	7
Mokhtayar Moh.	3	6	9	1	4.5	4	41	7	77
Maskoor Bag	3	6	7	1	4.5	4	41	7	77
Shyamlal	3	4	8	1	4.5	4	41	7	77
Musarf bag	3	6	8	1	4.5	4	41	7	77
Manseer moh.	2	4	8	1	4.5	4	41	7	77
Dharu singh	1	4	9	1	4.5	4	41	7	77
Suraj singh	2	6	9	1	4.5	4	41	7	77
Gayatri bai	2	4	9	2	16	4	41	7	77
Ameena bi	1	4	8	2	16	5	51.5	8	88.5
Balram	3	5	7	2	16	5	51.5	8	88.5
Sardar singh	2	4	7	2	16	5	51.5	8	88.5
Nijay ulla	2	5	8	2	16	5	51.5	8	88.5
Nosambabi	3	6	9	2	16	5	51.5	8	88.5
Prayag singh	2	6	9	2	16	5	51.5	8	88.5
Samad khan	3	6	9	2	16	5	51.5	8	88.5
Yunish khan	2	4	8	2	16	5	51.5	8	88.5
Prem bai	3	5	8	2	16	5	51.5	8	88.5
Ratan singh	2	6	9	2	16	5	51.5	8	88.5
Sagir Moh.	2	5	9	2	16	5	51.5	8	88.5
Anveri bi	1	5	7	2	16	5	51.5	8	88.5
Imnaj moh.	2	6	7	2	16	6	65	8	88.5
Majid moh	1	5	9	2	16	6	65	8	88.5
Ganeshram	1	5	8	3	30	6	65	9	102
Sardar singh	2	6	9	3	30	6	65	9	102
Sandeep kumar	2	5	7	3	30	6	65	9	102
Hari singh	2	6	8	3	30	6	65	9	102
Yusuf khan	3	4	9	3	30	6	65	9	102
Insaf moh	3	4	7	3	30	6	65	9	102
Suleman moh	3	6	8	3	30	6	65	9	102
Amar Chandra	1	5	7	3	30	6	65	9	102
Bhagawan singh	2	6	8	3	30	6	65	9	102
Sarjan singh	1	6	8	3	30	6	65	9	102
Gulav singh	3	6	7	3	30	6	65	9	102
Ramesh chandra	1	5	9	3	30	6	65	9	102
Ramcharan	3	6	8	3	30	6	65	9	102
Average	-			-	18.50	-	54.50	-	90.50

	Mean	
$T_1 = 666$	= 18.50	
$T_2 = 1962$	= 54.50	
$T_3 = 3258$	= 90.50	
Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.21		
SS = $(666^2 + 1962^2 + 3258^2)/36 - (666 + 1962 + 3258)^2/108$		
SS = 414099 - 320787		
SS = 93312		
Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.22		
= $12 \times 93312 / 108(109)$		
= 95.12		

The mean values of treatment T1, T2 and T3 was found 18.50 54.50 and 90.50, respectively as shown in Table 4.25. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in cost requirement.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in cost requirement.

The Chi-square test value was 95.12 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods of irrigation at least when cost was concern.

Table 4.26 Scoring for Suitability of Irrigation Method in Command Area in Sarchampa WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Sajid Mohmmad	7	5	3	6	71.5	3	23.5	1	4
Mokhtayar Moh.	9	3	1	6	71.5	3	23.5	1	4
Maskoor Bag	8	5	2	6	71.5	3	23.5	1	4
Shyamlal	6	6	1	6	71.5	3	23.5	1	4
Musarf bag	9	3	4	6	71.5	3	23.5	1	4
Manseer moh.	9	6	4	6	71.5	3	23.5	1	4
Dharu singh	9	4	3	6	71.5	3	23.5	1	4
Suraj singh	6	6	4	6	71.5	4	41.5	2	11.5
Gayatri bai	7	4	2	6	71.5	4	41.5	2	11.5
Ameena bi	9	3	4	7	85.5	4	41.5	2	11.5
Balram	6	5	1	7	85.5	4	41.5	2	11.5
Sardar singh	9	5	4	7	85.5	4	41.5	2	11.5
Nijay ulla	7	4	3	7	85.5	4	41.5	2	11.5
Nosambabi	7	4	3	7	85.5	4	41.5	2	11.5
Prayag singh	6	6	2	7	85.5	4	41.5	2	11.5
Samad khan	9	5	2	7	85.5	5	56.5	3	23.5
Yunish khan	8	3	1	7	85.5	5	56.5	3	23.5
Prem bai	6	6	4	8	92.5	5	56.5	3	23.5
Ratan singh	7	4	4	8	92.5	5	56.5	3	23.5
Sagir Moh.	6	4	3	8	92.5	5	56.5	3	23.5
Anveri bi	9	4	2	8	92.5	5	56.5	3	23.5
Imnaj moh.	8	3	4	8	92.5	5	56.5	3	23.5
Majid moh	9	6	2	8	92.5	5	56.5	3	23.5
Ganeshram	6	5	1	9	102	5	56.5	3	23.5
Sardar singh	6	4	3	9	102	5	56.5	4	41.5
Sandeep kumar	8	3	3	9	102	6	71.5	4	41.5
Hari singh	9	3	4	9	102	6	71.5	4	41.5
Yusuf khan	8	6	2	9	102	6	71.5	4	41.5
Insaf moh	7	5	4	9	102	6	71.5	4	41.5
Suleman moh	6	6	1	9	102	6	71.5	4	41.5
Amar Chandra	9	6	3	9	102	6	71.5	4	41.5
Bhagawan singh	8	5	4	9	102	6	71.5	4	41.5
Sarjan singh	7	6	2	9	102	6	71.5	4	41.5
Gulav singh	9	6	1	9	102	6	71.5	4	41.5
Ramesh chandra	9	5	4	9	102	6	71.5	4	41.5
Ramcharan	7	5	3	9	102	6	71.5	4	41.5
Average	-			-	89.13	-	51.33	-	23.04

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3208$	= 89.13
$T_2 = 1848$	= 51.33
$T_3 = 830$	= 23.04

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.23

$$SS = (3208^2 + 1848^2 + 830^2)/36 - (3208 + 1848 + 830)^2/108$$

$$SS = 79147.63$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.24

$$= 12 \times 79147.63 / 108(109)$$

$$= 80.68$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 89.13, 51.33 and 23.04, respectively as shown in Table 4.26. The data was analyzed using nonparametric approach. The Kruskal-Wallis test is a completely randomize design when the observations were rank by the farmers for the specify method of irrigation.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for suitability of irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for suitability of irrigation method.

The tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance was found less than the Chi-square test value 80.68. Thus the null hypothesis is rejected which clearly showed that suitability of irrigation methods matters for the farmers.

Table 4.27 Scoring for Control and Management of Water in Command Area in Sarchampa WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Sajid Mohmmad	8	6	4	6	68	3	23	1	1
Mokhtayar Moh.	8	4	1	6	69	3	24	1	2
Maskoor Bag	6	3	5	6	70	3	25	1	3
Shyamlal	8	6	2	6	71	3	26	1	4
Musarf bag	7	3	5	6	72	3	27	1	5
Manseer moh.	6	7	1	6	73	3	28	1	6
Dharu singh	9	7	5	6	74	3	29	1	7
Suraj singh	8	4	3	6	75	4	38	1	8
Gayatri bai	6	3	2	6	76	4	39	1	9
Ameena bi	9	5	2	7	82	4	40	2	10
Balram	7	4	1	7	83	4	41	2	11
Sardar singh	6	4	3	7	84	4	42	2	12
Nijay ulla	9	3	4	7	85	4	43	2	13
Nosambabi	8	6	4	7	86	4	44	2	14
Prayag singh	6	7	1	7	87	4	45	2	15
Samad khan	8	4	5	7	88	4	46	2	16
Yunish khan	7	6	3	7	89	4	47	3	17
Prem bai	6	5	1	7	90	5	54	3	18
Ratan singh	9	3	4	8	91	5	55	3	19
Sagir Moh.	7	6	2	8	92	5	56	3	20
Anveri bi	6	5	4	8	93	5	57	3	21
Imnaj moh.	6	4	1	8	94	5	58	3	22
Majid moh	8	3	4	8	95	5	59	4	30
Ganeshram	6	5	2	8	96	5	60	4	31
Sardar singh	9	7	1	8	97	6	61	4	32
Sandeep kumar	7	3	5	8	98	6	62	4	33
Hari singh	7	6	3	8	99	6	63	4	34
Yusuf khan	9	5	4	8	100	6	64	4	35
Insaf moh	9	4	3	9	101	6	65	4	36
Suleman moh	7	4	3	9	102	6	66	4	37
Amar Chandra	9	6	2	9	103	6	67	5	48
Bhagawan singh	8	5	1	9	104	7	77	5	49
Sarjan singh	7	7	5	9	105	7	78	5	50
Gulav singh	8	4	4	9	106	7	79	5	51
Ramesh chandra	7	5	1	9	107	7	80	5	52
Ramcharan	8	4	2	9	108	7	81	5	53
Average	-	-	-	-	89.25	-	51.36	-	22.89

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3213$	= 89.25
$T_2 = 1849$	= 51.36
$T_3 = 824$	= 22.89

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.25

$$SS = (3213^2 + 1849^2 + 824^2)/36 - (3213 + 1849 + 824)^2/108$$

$$SS = 79800.39$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.26

$$= 12 \times 79800.39/108(109)$$

$$= 81.35$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 89.25, 51.36 and 22.89, respectively as shown in Table 4.27. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for control and management of water.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for control and management of water.

The Chi-square test value was 81.35 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and it was concluded that control and management of irrigation water in sprinkler irrigation, border irrigation and flood irrigation methods was an important issue for the farmers of Sarchampa water user association.

Table 4.28 Scoring for Availability of Nearby City in Sarchampa WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Sajid Mohmmad	5	4	8	2	4.5	4	23.5	7	75.5
Mokhtayar Moh.	3	6	9	2	4.5	4	23.5	7	75.5
Maskoor Bag	2	5	7	2	4.5	4	23.5	7	75.5
Shyamlal	5	7	9	2	4.5	4	23.5	7	75.5
Musarf bag	4	6	8	2	4.5	4	23.5	7	75.5
Manseer moh.	2	4	7	2	4.5	4	23.5	7	75.5
Dharu singh	5	7	9	2	4.5	4	23.5	7	75.5
Suraj singh	3	5	9	2	4.5	4	23.5	7	75.5
Gayatri bai	4	7	7	3	11.5	4	23.5	7	75.5
Ameena bi	5	5	9	3	11.5	4	23.5	7	75.5
Balram	5	4	8	3	11.5	5	44	7	75.5
Sardar singh	2	7	7	3	11.5	5	44	7	75.5
Nijay ulla	5	5	7	3	11.5	5	44	7	75.5
Nosambabi	4	6	9	3	11.5	5	44	7	75.5
Prayag singh	3	7	8	4	23.5	5	44	7	75.5
Samad khan	2	4	7	4	23.5	5	44	8	92.5
Yunish khan	5	5	9	4	23.5	5	44	8	92.5
Prem bai	4	5	9	4	23.5	5	44	8	92.5
Ratan singh	5	6	7	4	23.5	5	44	8	92.5
Sagir Moh.	2	4	8	4	23.5	6	59.5	8	92.5
Anveri bi	3	7	7	4	23.5	6	59.5	8	92.5
Imnaj moh.	3	6	9	4	23.5	6	59.5	8	92.5
Majid moh	2	4	7	5	44	6	59.5	8	92.5
Ganeshram	4	7	9	5	44	6	59.5	8	92.5
Sardar singh	2	4	7	5	44	6	59.5	8	92.5
Sandeep kumar	2	7	8	5	44	6	59.5	9	103
Hari singh	5	6	7	5	44	6	59.5	9	103
Yusuf khan	4	5	8	5	44	7	75.5	9	103
Insaf moh	3	4	7	5	44	7	75.5	9	103
Suleman moh	5	6	9	5	44	7	75.5	9	103
Amar Chandra	4	5	7	5	44	7	75.5	9	103
Bhagawan singh	5	6	7	5	44	7	75.5	9	103
Sarjan singh	5	4	8	5	44	7	75.5	9	103
Gulav singh	4	7	8	5	44	7	75.5	9	103
Ramesh chandra	5	5	8	5	44	7	75.5	9	103
Ramcharan	5	4	7	5	44	7	75.5	9	103
Average	-	-	-	-	25.25	-	49.63	-	88.63

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 909$	= 25.25
$T_2 = 1787$	= 49.63
$T_3 = 3191$	= 88.63

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.27

$$SS = (909^2 + 1787^2 + 3191^2)/36 - (909 + 1787 + 3191)^2/108$$

$$SS = 73578.38$$

Chi square test = $12 \times (SS) / N(N+1)$ ----- 4.28

$$= 12 \times 73578.38 / 108(109)$$

$$= 75.00$$

The calculated mean values of ranking awarded by farmers for sprinkler irrigation; border irrigation and flood irrigation system was found to be 25.25, 49.63 and 88.63, respectively as shown in Table 4.28. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for availability of nearby city.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for availability of nearby city.

The Chi-square test value was 75.00 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected which indicated that availability of nearby city for the farmers of this water user association was important.

Table 4.29 Scoring for Time Saving of Irrigation Method in Command Area in Sarchampa WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Sajid Mohmmad	10	4	4	7	76.5	3	26.5	1	4
Mokhtayar Moh.	7	3	1	7	76.5	3	26.5	1	4
Maskoor Bag	8	5	4	7	76.5	3	26.5	1	4
Shyamlal	9	4	2	7	76.5	3	26.5	1	4
Musarf bag	7	3	4	7	76.5	3	26.5	1	4
Manseer moh.	9	5	1	7	76.5	3	26.5	1	4
Dharu singh	10	6	4	7	76.5	3	26.5	1	4
Suraj singh	9	4	4	7	76.5	3	26.5	2	12.5
Gayatri bai	8	6	2	8	86.5	4	45	2	12.5
Ameena bi	10	3	4	8	86.5	4	45	2	12.5
Balram	8	6	1	8	86.5	4	45	2	12.5
Sardar singh	7	4	4	8	86.5	4	45	2	12.5
Nijay ulla	9	5	2	8	86.5	4	45	2	12.5
Nosambabi	8	3	4	8	86.5	4	45	2	12.5
Prayag singh	7	6	2	8	86.5	4	45	2	12.5
Samad khan	10	6	2	8	86.5	4	45	2	12.5
Yunish khan	8	4	1	8	86.5	4	45	2	12.5
Prem bai	7	3	3	8	86.5	4	45	3	26.5
Ratan singh	10	6	4	8	86.5	5	59	3	26.5
Sagir Moh.	10	5	2	8	86.5	5	59	3	26.5
Anveri bi	8	4	3	9	96	5	59	3	26.5
Imnaj moh.	7	3	2	9	96	5	59	3	26.5
Majid moh	9	5	1	9	96	5	59	3	26.5
Ganeshram	10	3	3	9	96	5	59	3	26.5
Sardar singh	7	6	1	9	96	5	59	3	26.5
Sandeep kumar	7	3	3	9	96	5	59	3	26.5
Hari singh	8	5	2	9	96	5	59	3	26.5
Yusuf khan	8	5	3	10	104	6	68	4	45
Insaf moh	8	4	1	10	104	6	68	4	45
Suleman moh	10	6	2	10	104	6	68	4	45
Amar Chandra	8	5	2	10	104	6	68	4	45
Bhagawan singh	9	4	3	10	104	6	68	4	45
Sarjan singh	8	6	3	10	104	6	68	4	45
Gulav singh	10	4	3	10	104	6	68	4	45
Ramesh chandra	9	5	3	10	104	6	68	4	45
Ramcharan	8	4	3	10	104	6	68	4	45
Average	-			-	90.50	-	50.14	-	22.86

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3258$	= 90.50
$T_2 = 1805$	= 50.14
$T_3 = 823$	= 22.86

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.29

$$SS = (3258^2 + 1805^2 + 823^2)/36 - (3258 + 1805 + 823)^2/108$$

$$SS = 83377.39$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.30

$$= 12 \times 83377.39/108(109)$$

$$= 84.99$$

The mean ranking values for specific irrigation methods that is sprinkler irrigation, border irrigation and flood irrigation was found to be 90.50, 50.14 and 22.86, respectively as shown in Table 4.29. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for time saving of irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for time saving of irrigation method.

The Chi-square test value was larger than the tabulated value at 5% and 1% level of significance, respectively. Which clearly indicated that time saving in application of water by irrigation methods is very much important for the farmers.

Table 4.30 Scoring for Ease Operation of Various Irrigation Methods in Sarchampa WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
	Sajid Mohmmad	9	4	3	7	76.5	2	4	3
Mokhtayar Moh.	7	2	3	7	76.5	2	4	3	18.5
Maskoor Bag	8	5	4	7	76.5	2	4	3	18.5
Shyamlal	9	4	5	7	76.5	2	4	3	18.5
Musarf bag	8	2	3	7	76.5	2	4	3	18.5
Manseer moh.	7	5	4	7	76.5	2	4	3	18.5
Dharu singh	9	3	6	7	76.5	2	4	3	18.5
Suraj singh	10	5	5	7	76.5	3	18.5	3	18.5
Gayatri bai	9	2	4	8	85.5	3	18.5	3	18.5
Ameena bi	8	5	3	8	85.5	3	18.5	3	18.5
Balram	7	3	5	8	85.5	3	18.5	3	18.5
Sardar singh	9	5	6	8	85.5	3	18.5	4	37.5
Nijay ulla	8	4	3	8	85.5	3	18.5	4	37.5
Nosambabi	7	3	4	8	85.5	3	18.5	4	37.5
Prayag singh	10	5	5	8	85.5	3	18.5	4	37.5
Samad khan	8	2	3	8	85.5	3	18.5	4	37.5
Yunish khan	9	3	4	8	85.5	3	18.5	4	37.5
Prem bai	7	5	5	8	85.5	3	18.5	4	37.5
Ratan singh	10	3	3	9	96	4	37.5	4	37.5
Sagir Moh.	8	3	6	9	96	4	37.5	4	37.5
Anveri bi	7	4	5	9	96	4	37.5	5	56
Imnaj moh.	10	5	3	9	96	4	37.5	5	56
Majid moh	8	2	4	9	96	4	37.5	5	56
Ganeshram	7	3	5	9	96	4	37.5	5	56
Sardar singh	8	2	3	9	96	4	37.5	5	56
Sandeep kumar	7	2	3	9	96	5	56	5	56
Hari singh	10	5	4	9	96	5	56	5	56
Yusuf khan	10	3	5	9	96	5	56	5	56
Insaf moh	9	4	4	9	96	5	56	5	56
Suleman moh	8	3	6	10	105	5	56	5	56
Amar Chandra	9	4	5	10	105	5	56	6	69.5
Bhagawan singh	8	3	6	10	105	5	56	6	69.5
Sarjan singh	10	5	3	10	105	5	56	6	69.5
Gulav singh	9	4	4	10	105	5	56	6	69.5
Ramesh chandra	9	3	5	10	105	5	56	6	69.5
Ramcharan	9	5	6	10	105	5	56	6	69.5
Average	-			-	90.50	-	30.83	-	42.17

	Mean	
$T_1 = 3258$	=	90.50
$T_2 = 1110$	=	30.83
$T_3 = 1518$	=	42.17

$$\text{Sum of Square (SS)} = (T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N \quad \text{-----} \quad 4.31$$

$$SS = (3258^2 + 1110^2 + 1518^2)/36 - (3258 + 1110 + 1518)^2/108$$

$$SS = 72296.00$$

$$\text{Chi square test} = 12 \times (SS)/N(N+1) \quad \text{-----} \quad 4.32$$

$$= 12 \times 72296.00 / 108(109)$$

$$= 73.70$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 90.50, 30.83 and 42.17, respectively as shown in Table 4.30. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for ease operation of various irrigation methods.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for ease operation of various irrigation methods.

The Chi-square test value was 73.70 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that ease operations among sprinkler irrigation, border irrigation and flood irrigation methods play an important role for farmers.

Table 4.31 Scoring for Water Saving of Irrigation Method in Command Area in Sarchampa WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Sajid Mohmmad	7	5	3	6	66.5	4	29.5	2	5
Mokhtayar Moh.	6	4	2	6	66.5	4	29.5	2	5
Maskoor Bag	9	6	4	6	66.5	4	29.5	2	5
Shyamlal	9	5	2	6	66.5	4	29.5	2	5
Musarf bag	6	6	3	6	66.5	4	29.5	2	5
Manseer moh.	9	4	5	6	66.5	4	29.5	2	5
Dharu singh	7	7	2	6	66.5	4	29.5	2	5
Suraj singh	8	6	4	6	66.5	4	29.5	2	5
Gayatri bai	7	4	3	7	83.5	4	29.5	2	5
Ameena bi	6	6	2	7	83.5	4	29.5	3	14
Balram	9	7	5	7	83.5	4	29.5	3	14
Sardar singh	8	4	3	7	83.5	4	29.5	3	14
Nijay ulla	7	4	3	7	83.5	5	49	3	14
Nosambabi	6	6	4	7	83.5	5	49	3	14
Prayag singh	8	7	2	7	83.5	5	49	3	14
Samad khan	7	5	5	7	83.5	5	49	3	14
Yunish khan	7	5	4	7	83.5	5	49	3	14
Prem bai	6	4	3	7	83.5	5	49	3	14
Ratan singh	8	4	4	7	83.5	5	49	4	29.5
Sagir Moh.	8	6	2	8	96.5	5	49	4	29.5
Anveri bi	6	5	3	8	96.5	5	49	4	29.5
Imnaj moh.	9	5	3	8	96.5	6	66.5	4	29.5
Majid moh	6	6	2	8	96.5	6	66.5	4	29.5
Ganeshram	8	4	4	8	96.5	6	66.5	4	29.5
Sardar singh	7	6	2	8	96.5	6	66.5	4	29.5
Sandeep kumar	6	5	2	8	96.5	6	66.5	4	29.5
Hari singh	8	4	3	8	96.5	6	66.5	4	29.5
Yusuf khan	7	6	5	8	96.5	6	66.5	4	29.5
Insaf moh	8	4	5	8	96.5	6	66.5	5	49
Suleman moh	8	7	4	9	105	6	66.5	5	49
Amar Chandra	7	5	5	9	105	6	66.5	5	49
Bhagawan singh	9	7	4	9	105	7	83.5	5	49
Sarjan singh	8	5	4	9	105	7	83.5	5	49
Gulav singh	7	4	5	9	105	7	83.5	5	49
Ramesh chandra	9	6	4	9	105	7	83.5	5	49
Ramcharan	7	4	5	9	105	7	83.5	5	49
Average	-			-	87.51	-	52.15	-	23.83

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3151$	= 87.51
$T_2 = 1878$	= 52.15
$T_3 = 858$	= 23.83

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.33

$$SS = (3151^2 + 1878^2 + 858^2)/36 - (3151 + 1878 + 858)^2/108$$

$$SS = 73291.35$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.34

$$= 12 \times 73291.35 / 108(109)$$

$$= 74.71$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 87.51, 52.15, and 23.83, respectively as shown in Table 4.31. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for water saving of irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for water saving of irrigation method.

The Chi-square test value was 74.71 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods as for as water saving is concerned.

Table 4.32 Scoring for High Income Irrigation Method in Command Area in Sarchampa WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Sajid Mohmmad	8	5	4	6	63.5	4	25.5	2	4
Mokhtayar Moh.	8	5	3	6	63.5	4	25.5	2	4
Maskoor Bag	9	6	4	6	63.5	4	25.5	2	4
Shyamlal	9	5	2	6	63.5	4	25.5	2	4
Musarf bag	7	6	4	6	63.5	4	25.5	2	4
Manseer moh.	9	5	5	6	63.5	4	25.5	2	4
Dharu singh	7	7	4	7	79	4	25.5	2	4
Suraj singh	8	6	4	7	79	4	25.5	3	12
Gayatri bai	7	5	3	7	79	4	25.5	3	12
Ameena bi	6	7	2	7	79	4	25.5	3	12
Balram	9	7	5	7	79	5	46	3	12
Sardar singh	8	5	4	7	79	5	46	3	12
Nijay ulla	7	5	3	7	79	5	46	3	12
Nosambabi	6	6	5	7	79	5	46	3	12
Prayag singh	8	7	4	7	79	5	46	3	12
Samad khan	7	4	5	7	79	5	46	3	12
Yunish khan	8	5	4	8	93.5	5	46	4	25.5
Prem bai	6	4	3	8	93.5	5	46	4	25.5
Ratan singh	8	5	4	8	93.5	5	46	4	25.5
Sagir Moh.	8	6	2	8	93.5	5	46	4	25.5
Anveri bi	6	6	4	8	93.5	5	46	4	25.5
Imnaj moh.	9	5	3	8	93.5	6	63.5	4	25.5
Majid moh	6	7	2	8	93.5	6	63.5	4	25.5
Ganeshram	9	4	3	8	93.5	6	63.5	4	25.5
Sardar singh	7	5	2	8	93.5	6	63.5	5	46
Sandeep kumar	6	5	2	8	93.5	6	63.5	5	46
Hari singh	9	5	3	9	103.	6	63.5	5	46
Yusuf khan	7	7	5	9	103.	7	79	5	46
Insaf moh	9	4	3	9	103.	7	79	5	46
Suleman moh	8	7	3	9	103.	7	79	5	46
Amar Chandra	7	5	5	9	103.	7	79	5	46
Bhagawan singh	9	7	3	9	103.	7	79	5	46
Sarjan singh	8	5	5	9	103.	7	79	5	46
Gulav singh	7	4	5	9	103.	7	79	5	46
Ramesh chandra	9	7	4	9	103.	7	79	5	46
Ramcharan	7	4	4	9	103.	7	79	5	46
Average	-	-	-	-	87.25	-	51.47	-	24.78

	Mean	
$T_1 = 3141$	=	87.25
$T_2 = 1853$	=	51.47
$T_3 = 892$	=	24.78

$$\text{Sum of Square (SS)} = (T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N \quad \text{----- 4.35}$$

$$SS = (3141^2 + 1853^2 + 892^2)/36 - (3141 + 1853 + 892)^2/108$$

$$SS = 70745.06$$

$$\text{Chi square test} = 12 \times (SS)/N(N+1) \quad \text{----- 4.36}$$

$$= 12 \times 70745.06/108(109)$$

$$= 72.11$$

The mean values of ranking awarded by farmers for getting higher income by adoption of sprinkler irrigation, border irrigation and flood irrigation system was found to be 87.25, 51.47 and 24.78, respectively as shown in Table 4.32. The data was analyzed using nonparametric approach. The Kruskal-Wallis test is a completely randomize design when the observations were rank by the farmers for the specify method of irrigation.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for high income irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for high income irrigation method..

The Chi-square test value was 72.11 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods.

Table 4.33 Scoring Matrix for Labour Requirement of Different Irrigation Method in Ucher WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
	Mahendra singh	8	4	3	6	72.5	3	16.5	2
Badam singh	10	4	2	6	72.5	3	16.5	2	4
Ramprasad	6	3	4	6	72.5	3	16.5	2	4
Sarvan kumar	7	5	5	6	72.5	3	16.5	2	4
Bainiprasad	10	3	2	6	72.5	3	16.5	2	4
Atmaram	7	6	3	6	72.5	3	16.5	2	4
Rakesh kumar	6	4	4	6	72.5	3	16.5	2	4
Shriram	8	5	4	6	72.5	3	16.5	3	16.5
Dharmendra singh	7	3	5	7	85	3	16.5	3	16.5
Ramgopal	8	6	2	7	85	4	34	3	16.5
Karan singh	10	4	5	7	85	4	34	3	16.5
Shalendra kumar	8	5	3	7	85	4	34	3	16.5
Rajkumar	6	3	4	7	85	4	34	3	16.5
Ganeshram	9	6	2	7	85	4	34	3	16.5
Seetaram	7	4	5	7	85	4	34	3	16.5
Dileep	8	5	3	7	85	4	34	3	16.5
Kishor Kapoor	7	3	5	7	85	4	34	4	34
Halkooram	10	4	5	8	94.5	4	34	4	34
Abhinash singh	8	5	3	8	94.5	5	53.5	4	34
Jashodi bai	8	3	2	8	94.5	5	53.5	4	34
Jagannath singh	6	6	5	8	94.5	5	53.5	4	34
Rajendra singh	8	4	3	8	94.5	5	53.5	4	34
Ajab singh	7	3	4	8	94.5	5	53.5	4	34
Beersingh	6	5	2	8	94.5	5	53.5	4	34
jasabant singh	10	3	5	8	94.5	5	53.5	5	53.5
Karan singh	10	4	2	8	94.5	5	53.5	5	53.5
Ganeshram	7	5	5	8	94.5	5	53.5	5	53.5
Babulal	6	6	3	9	101	5	53.5	5	53.5
Tulsiram	8	3	5	9	101	6	72.5	5	53.5
Sarwati bai	9	5	4	9	101	6	72.5	5	53.5
Gulav singh	6	4	5	10	105.	6	72.5	5	53.5
Jagadish	9	6	3	10	105.	6	72.5	5	53.5
Meharwan singh	7	5	4	10	105.	6	72.5	5	53.5
Than singh	8	6	5	10	105.	6	72.5	5	53.5
Gaurav yadav	7	5	3	10	105.	6	72.5	5	53.5
Narendra kumar	6	6	4	10	105.	6	72.5	5	53.5
Average	-			-	89.61	-	43.60	-	30.29

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3226$	= 89.61
$T_2 = 1570$	= 43.60
$T_3 = 1091$	= 30.29

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.37

$$SS = (3226^2 + 1570^2 + 1091^2)/36 - (3226 + 1570 + 1091)^2/108$$

$$SS = 69757.35$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.38

$$= 12 \times 69757.35 / 108(109)$$

$$= 71.10$$

The mean values of specific irrigation that is sprinkler irrigation; border irrigation and flood irrigation were 89.61, 43.60 and 30.29, respectively as shown in Table 4.33. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in labour requirement.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in labour requirement.

The Chi-square test value was 71.10 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there was significant difference among sprinkler irrigation, border irrigation and flood irrigation methods.

Table 4.34 Scoring for Cost in Ucher WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mahendra singh	2	6	9	1	4	4	40.5	7	76.5
Badam singh	2	5	7	1	4	4	40.5	7	76.5
Ramprasad	2	6	8	1	4	4	40.5	7	76.5
Sarvan kumar	3	4	9	1	4	4	40.5	7	76.5
Bainiprasad	3	4	8	1	4	4	40.5	7	76.5
Atmaram	3	6	8	1	4	4	40.5	7	76.5
Rakesh kumar	1	5	7	1	4	4	40.5	7	76.5
Shriram	2	6	8	2	15	4	40.5	7	76.5
Dharmendra singh	1	6	8	2	15	5	50.5	8	87.5
Ramgopal	3	6	7	2	15	5	50.5	8	87.5
Karan singh	1	5	9	2	15	5	50.5	8	87.5
Shalendra kumar	3	6	8	2	15	5	50.5	8	87.5
Rajkumar	3	5	8	2	15	5	50.5	8	87.5
Ganeshram	3	6	9	2	15	5	50.5	8	87.5
Seetaram	2	6	9	2	15	5	50.5	8	87.5
Dileep	3	6	9	2	15	5	50.5	8	87.5
Kishor kapoor	2	4	8	2	15	5	50.5	8	87.5
Halkooram	3	5	8	2	15	5	50.5	8	87.5
Abhinash singh	2	6	9	2	15	5	50.5	8	87.5
Jashodi bai	2	5	9	2	15	5	50.5	8	87.5
Jagannath singh	1	5	7	2	15	6	64.5	8	87.5
Rajendra singh	2	6	7	2	15	6	64.5	8	87.5
Ajab singh	1	5	9	3	29.5	6	64.5	9	101.
Beersingh	1	5	9	3	29.5	6	64.5	9	101.
jasabant singh	2	5	8	3	29.5	6	64.5	9	101.
Karan singh	3	6	9	3	29.5	6	64.5	9	101.
Ganeshram	3	6	7	3	29.5	6	64.5	9	101.
Babulal	3	5	8	3	29.5	6	64.5	9	101.
Tulsiram	3	6	8	3	29.5	6	64.5	9	101.
Sarswati bai	2	4	8	3	29.5	6	64.5	9	101.
Gulav singh	1	4	9	3	29.5	6	64.5	9	101.
Jagadish	2	6	9	3	29.5	6	64.5	9	101.
Meharwan singh	2	4	9	3	29.5	6	64.5	9	101.
Than singh	2	4	8	3	29.5	6	64.5	9	101.
Gaurav yadav	3	5	7	3	29.5	6	64.5	9	101.
Narendra kumar	2	4	7	3	29.5	6	64.5	9	101.
Average	-	-	-	-	18.50	-	54.50	-	90.50

	Mean	
$T_1 = 666$	=	18.50
$T_2 = 1962$	=	54.50
$T_3 = 3258$	=	90.50

$$\text{Sum of Square (SS)} = (T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N \quad \text{-----} \quad 4.39$$

$$SS = (666^2 + 1962^2 + 3258^2)/36 - (666 + 1962 + 3258)^2/108$$

$$SS = 93312$$

$$\text{Chi square test} = 12 \times (SS) / N(N+1) \quad \text{-----} \quad 4.40$$

$$= 12 \times 93312 / 108(109)$$

$$= 95.12$$

The mean values of treatment T1, T2 and T3 was found 18.50 54.50 and 90.50, respectively as shown in Table 4.34. The data was analyzed using nonparametric approach. The Kruskal-Wallis test is a completely randomize design when the observations were rank by the farmers for the specify method of irrigation.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in cost requirement.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in cost requirement.

The Chi-square test value was found 95.12 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there was significant difference among sprinkler irrigation, border irrigation and flood irrigation methods of irrigation as for as suitability for purchasing and cost involved in application of water through these methods.

Table 4.35 Scoring for Suitability of Irrigation Method in Command

Area in Ucher WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mahendra singh	9	4	3	6	73	3	27	1	5.5
Badam singh	10	3	1	6	73	3	27	1	5.5
Ramprasad	6	5	3	6	73	3	27	1	5.5
Sarvan kumar	7	4	4	6	73	3	27	1	5.5
Bainiprasad	6	3	1	6	73	3	27	1	5.5
Atmaram	8	5	4	6	73	3	27	1	5.5
Rakesh kumar	10	5	3	6	73	4	42.5	1	5.5
Shriram	7	3	1	6	73	4	42.5	1	5.5
Dharmendra singh	8	4	4	6	73	4	42.5	1	5.5
Ramgopal	9	6	4	7	86.5	4	42.5	1	5.5
Karan singh	6	5	1	7	86.5	4	42.5	2	15.5
Shalendra kumar	10	4	2	7	86.5	4	42.5	2	15.5
Rajkumar	8	5	3	7	86.5	4	42.5	2	15.5
Ganeshram	9	3	1	7	86.5	4	42.5	2	15.5
Seetaram	8	6	4	7	86.5	4	42.5	2	15.5
Dileep	7	5	2	7	86.5	5	52	2	15.5
Kishor kapoor	6	4	3	7	86.5	5	58	2	15.5
Halkooram	10	6	2	7	86.5	5	58	2	15.5
Abhinash singh	8	5	1	7	86.5	5	58	2	15.5
Jashodi bai	7	5	4	8	95	5	58	2	15.5
Jagannath singh	9	3	2	8	95	5	58	3	27
Rajendra singh	6	6	4	8	95	5	58	3	27
Ajab singh	7	4	2	8	95	5	58	3	27
Beersingh	6	5	1	8	95	5	58	3	27
jasabant singh	10	4	2	8	95	5	58	3	27
Karan singh	7	3	1	8	95	5	58	3	27
Ganeshram	8	6	3	9	101	5	58	3	27
Babulal	6	6	2	9	101	5	58	4	42.5
Tulsiram	7	5	4	9	101	6	73	4	42.5
Sarswati bai	8	5	2	9	101	6	73	4	42.5
Gulav singh	6	6	1	9	101	6	73	4	42.5
Jagadish	7	5	4	10	106	6	73	4	42.5
Meharwan singh	9	4	3	10	106	6	73	4	42.5
Than singh	7	6	2	10	106	6	73	4	42.5
Gaurav yadav	6	4	1	10	106	6	73	4	42.5
Narendra kumar	7	5	2	10	106	6	73	4	42.5
Average	-	-	-	-	89.50	-	52.13	-	21.71

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3222$	= 89.50
$T_2 = 1877$	= 52.13
$T_3 = 782$	= 21.71

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.41

$$SS = (3222^2 + 1877^2 + 782^2)/36 - (3222 + 1877 + 782)^2/108$$

$$SS = 83013.29$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.42

$$= 12 \times 83013.29 / 108(109)$$

$$= 84.62$$

The average values for suitability of irrigation method in command area of Sayar WUA that is sprinkler irrigation system, border irrigation system and flood irrigation system was found to be 89.50, 52.13 and 21.71, respectively as shown in Table 4.35. The data was analyzed using nonparametric approach. The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in suitability of irrigation.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in suitability of irrigation.

The Chi-square test value was 84.62 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and found that there was significant difference in values was observed among sprinkler irrigation, border irrigation and flood irrigation methods.

Table 4.36 Scoring for Control and Management of Water in Command Area in Ucher WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
	Mahendra singh	10	3	2	6	73.5	3	30.5	1
Badam singh	7	4	1	6	73.5	3	30.5	1	4.5
Ramprasad	10	6	2	6	73.5	3	30.5	1	4.5
Sarvan kumar	8	3	1	6	73.5	3	30.5	1	4.5
Bainiprasad	6	4	4	6	73.5	3	30.5	1	4.5
Atmaram	10	5	2	6	73.5	3	30.5	1	4.5
Rakesh kumar	8	4	3	6	73.5	3	30.5	1	4.5
Shriram	7	3	1	6	73.5	3	30.5	1	4.5
Dharmendra singh	6	5	2	6	73.5	3	30.5	2	15
Ramgopal	9	4	3	7	84.5	4	48.5	2	15
Karan singh	6	4	1	7	84.5	4	48.5	2	15
Shalendra kumar	10	3	4	7	84.5	4	48.5	2	15
Rajkumar	9	5	2	7	84.5	4	48.5	2	15
Ganeshram	7	4	2	7	84.5	4	48.5	2	15
Seetaram	6	4	3	7	84.5	4	48.5	2	15
Dileep	8	5	3	7	84.5	4	48.5	2	15
Kishor Kapoor	7	3	1	7	84.5	4	48.5	2	15
Halkooram	7	6	2	8	92	4	48.5	2	15
Abhinash singh	10	4	4	8	92	4	48.5	2	15
Jashodi bai	9	4	2	8	92	4	48.5	2	15
Jagannath singh	6	6	3	8	92	4	48.5	2	15
Rajendra singh	8	5	1	8	92	4	48.5	3	30.5
Ajab singh	7	3	3	8	92	5	62	3	30.5
Beersingh	6	4	2	8	92	5	62	3	30.5
jasabant singh	10	5	1	9	98	5	62	3	30.5
Karan singh	7	3	1	9	98	5	62	3	30.5
Ganeshram	6	5	3	9	98	5	62	3	30.5
Babulal	10	5	4	9	98	5	62	3	30.5
Tulsiram	8	4	2	9	98	5	62	3	30.5
Sarwati bai	9	3	3	10	104	5	62	3	30.5
Gulav singh	8	6	4	10	104	5	62	4	48.5
Jagadish	7	4	2	10	104	6	73.5	4	48.5
Meharwan singh	6	3	3	10	104	6	73.5	4	48.5
Than singh	9	6	2	10	104	6	73.5	4	48.5
Gaurav yadav	6	4	4	10	104	6	73.5	4	48.5
Narendra kumar	8	5	2	10	104	6	73.5	4	48.5
Average	-			-	88.88	-	50.85	-	22.13

	Mean	
$T_1 = 3199$	=	88.88
$T_2 = 1831$	=	50.85
$T_3 = 797$	=	22.13
Sum of Square (SS) = $(T_1^2+T_2^2+T_3^2)/r - (T_1+T_2+T_3)^2/N$ ----- 4.43		
$SS = (3199^2+1831^2+797^2)/36-(3199+1831+797)^2/108$		
$SS = 80719.69$		
Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.44		
$= 12 \times 80719.69/108(109)$		
$= 82.28$		

The mean values of ranking allotted to sprinkler irrigation, border irrigation and flood irrigation system was found to be 88.88, 50.85 and 22.13, respectively as shown in Table 4.36. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in control and management of water.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in control and management of water.

The Chi-square test value was 82.28 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods as for as scoring for control and management of water in command area of Ucher water user association.

Table 4.37 Scoring for Availability of Nearby City in Ucher WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mahendra singh	4	4	8	2	5	4	28	7	75
Badam singh	3	6	9	2	5	4	28	7	75
Ramprasad	2	5	7	2	5	4	28	7	75
Sarvan kumar	5	7	9	2	5	4	28	7	75
Bainiprasad	4	6	8	2	5	4	28	7	75
Atmaram	2	4	8	2	5	4	28	7	75
Rakesh kumar	4	7	9	2	5	4	28	7	75
Shriram	2	5	9	2	5	4	28	7	75
Dharmendra singh	4	7	7	2	5	4	28	7	75
Ramgopal	4	5	9	3	13.5	5	46	7	75
Karan singh	5	5	9	3	13.5	5	47.5	7	75
Shalendra kumar	2	7	8	3	13.5	5	47.5	7	75
Rajkumar	5	5	7	3	13.5	5	47.5	8	89.5
Ganeshram	3	6	10	3	13.5	5	47.5	8	89.5
Seetaram	3	7	10	3	13.5	5	47.5	8	89.5
Dileep	2	4	5	3	13.5	5	47.5	8	89.5
Kishor Kapoor	4	5	9	3	13.5	5	47.5	8	89.5
Halkooram	4	5	10	4	28	5	47.5	8	89.5
Abhinash singh	3	6	7	4	28	5	47.5	8	89.5
Jashodi bai	2	4	8	4	28	5	47.5	8	89.5
Jagannath singh	3	7	7	4	28	6	61	8	89.5
Rajendra singh	3	6	10	4	28	6	61	8	89.5
Ajab singh	2	4	7	4	28	6	61	9	99
Beersingh	4	7	9	4	28	6	61	9	99
jasabant singh	2	4	7	4	28	6	61	9	99
Karan singh	2	7	8	4	28	6	61	9	99
Ganeshram	5	6	7	4	28	6	61	9	99
Babulal	4	5	8	4	28	6	61	9	99
Tulsiram	3	4	8	4	28	6	61	9	99
Sarswati bai	4	6	10	5	47.5	7	75	9	99
Gulav singh	3	5	7	5	47.5	7	75	9	99
Jagadish	5	6	6	5	47.5	7	75	10	106
Meharwan singh	4	4	8	5	47.5	7	75	10	106
Than singh	4	7	9	5	47.5	7	75	10	106
Gaurav yadav	5	5	8	5	47.5	7	75	10	106
Narendra kumar	5	4	7	5	47.5	7	75	10	106
Average	-	-	-	-	22.82	-	51.31	-	89.33

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 822$	=	22.82
$T_2 = 1847$	=	51.31
$T_3 = 3216$	=	89.33

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.45

$$SS = (822^2 + 1847^2 + 3216^2)/36 - (822 + 1847 + 3216)^2/108$$

$$SS = 80180$$

Chi square test = $12 \times (SS) / N(N+1)$ ----- 4.46

$$= 12 \times 80180 / 108(109)$$

$$= 81.73$$

The mean of rank values of score matrix for availability of nearby city location of Ucher water user association for adopting sprinkler irrigation, border irrigation and flood irrigation system was found to be 22.82, 51.31 and 89.33, respectively as shown in Table 4.37. The data was analyzed using nonparametric approach. The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in availability of nearby city.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in availability of nearby city.

The calculated Chi-square test value was 81.73 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that availability of nearby city nearer to Ucher is important for farmers.

Table 4.38 Scoring for Time Saving of Irrigation Method in Command Area in Ucher WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
	Mahendra singh	8	7	5	7	74	4	30	2
Badam singh	7	5	2	7	74	4	30	2	6
Ramprasad	8	4	4	7	74	4	30	2	6
Sarvan kumar	10	6	3	7	74	4	30	2	6
Bainiprasad	9	4	2	7	74	4	30	2	6
Atmaram	7	4	4	7	74	4	30	2	6
Rakesh kumar	8	6	2	7	74	4	30	2	6
Shriram	8	6	5	7	74	4	30	2	6
Dharmendra singh	10	7	5	7	74	4	30	2	6
Ramgopal	9	4	2	7	74	4	30	2	6
Karan singh	10	7	3	7	74	5	47.5	2	6
Shalendra kumar	7	4	2	7	74	5	47.5	3	16
Rajkumar	8	5	2	8	89.5	5	47.5	3	16
Ganeshram	9	4	4	8	89.5	5	47.5	3	16
Seetaram	10	4	5	8	89.5	5	47.5	3	16
Dileep	8	7	3	8	89.5	5	47.5	3	16
Kishor kapoor	10	5	2	8	89.5	5	47.5	3	16
Halkooram	7	6	4	8	89.5	5	47.5	3	16
Abhinash singh	9	4	4	8	89.5	5	47.5	3	16
Jashodi bai	10	5	4	8	89.5	6	59.5	3	16
Jagannath singh	8	7	2	8	89.5	6	59.5	4	30
Rajendra singh	7	7	4	8	89.5	6	59.5	4	30
Ajab singh	7	4	3	9	97.5	6	59.5	4	30
Beersingh	9	6	2	9	97.5	6	59.5	4	30
jasabant singh	7	4	4	9	97.5	6	59.5	4	30
Karan singh	8	5	3	9	97.5	6	59.5	4	30
Ganeshram	10	5	2	9	97.5	6	59.5	4	30
Babulal	7	6	4	9	97.5	7	74	4	30
Tulsiram	9	6	5	10	104.	7	74	4	30
Sarswati bai	7	4	5	10	104.	7	74	5	47.5
Gulav singh	7	7	3	10	104.	7	74	5	47.5
Jagadish	10	5	3	10	104.	7	74	5	47.5
Meharwan singh	7	6	2	10	104.	7	74	5	47.5
Than singh	7	5	3	10	104.	7	74	5	47.5
Gaurav yadav	8	7	5	10	104.	7	74	5	47.5
Narendra kumar	8	7	3	10	104.	7	74	5	47.5
Average	-			-	89.00	-	51.93	-	22.57

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 3204$	=	89.00
$T_2 = 1870$	=	51.93
$T_3 = 813$	=	22.57

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.47

$$SS = (3204^2 + 1870^2 + 813^2)/36 - (3204 + 1870 + 813)^2/108$$
$$SS = 79790.85$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.48

$$= 12 \times 79790.85/108(109)$$
$$= 81.33$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 89.00, 51.93 and 22.57, respectively as shown in Table 4.38. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in time saving of irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in time saving of irrigation method.

The Chi-square test value was 81.33 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. It was concluded that time of saving matters among sprinkler irrigation, border irrigation and flood irrigation system.

Table 4.39 Scoring for Ease Operation of Various Irrigation Methods in Ucher WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mahendra singh	9	5	2	7	77.5	3	21.5	2	6.5
Badam singh	7	6	5	7	77.5	3	21.5	2	6.5
Ramprasad	8	3	2	7	77.5	3	21.5	2	6.5
Sarvan kumar	9	3	4	7	77.5	3	21.5	2	6.5
Bainiprasad	8	5	2	7	77.5	3	21.5	2	6.5
Atmaram	8	6	4	7	77.5	3	21.5	2	6.5
Rakesh kumar	9	6	3	7	77.5	3	21.5	2	6.5
Shriram	10	3	2	7	77.5	3	21.5	2	6.5
Dharmendra singh	9	6	4	7	77.5	3	21.5	2	6.5
Ramgopal	7	4	2	7	77.5	4	40	2	6.5
Karan singh	10	3	4	8	86.5	4	40	2	6.5
Shalendra kumar	8	3	4	8	86.5	4	40	2	6.5
Rajkumar	9	3	5	8	86.5	4	40	3	21.5
Ganeshram	7	6	2	8	86.5	4	40	3	21.5
Seetaram	7	4	3	8	86.5	4	40	3	21.5
Dileep	10	6	4	8	86.5	4	40	3	21.5
Kishor Kapoor	8	3	3	8	86.5	4	40	3	21.5
Halkooram	7	5	2	8	86.5	4	40	3	21.5
Abhinash singh	10	3	5	9	94.5	4	40	3	21.5
Jashodi bai	7	4	3	9	94.5	5	56	3	21.5
Jagannath singh	7	3	2	9	94.5	5	56	3	21.5
Rajendra singh	9	5	2	9	94.5	5	56	4	40
Ajab singh	9	3	4	9	94.5	5	56	4	40
Beersingh	10	6	5	9	94.5	5	56	4	40
jasabant singh	8	6	2	9	94.5	5	56	4	40
Karan singh	8	4	4	9	94.5	5	56	4	40
Ganeshram	10	4	2	10	103.	6	67.5	4	40
Babulal	10	6	3	10	103.	6	67.5	4	40
Tulsiram	7	4	5	10	103.	6	67.5	4	40
Sarswati bai	9	3	4	10	103.	6	67.5	4	40
Gulav singh	10	5	2	10	103.	6	67.5	5	56
Jagadish	7	4	4	10	103.	6	67.5	5	56
Meharwan singh	10	5	3	10	103.	6	67.5	5	56
Than singh	10	5	3	10	103.	6	67.5	5	56
Gaurav yadav	8	6	5	10	103.	6	67.5	5	56
Narendra kumar	7	4	4	10	103.	6	67.5	5	56
Average	-			-	90.50	-	46.13	-	26.88

	Mean	
$T_1 = 3258$	=	90.50
$T_2 = 1661$	=	46.13
$T_3 = 968$	=	26.88
Sum of Square (SS) = $(T_1^2+T_2^2+T_3^2)/r - (T_1+T_2+T_3)^2/N$ ----- 4.49		
$SS = (3258^2+1661^2+968^2)/36-(3258+1661+968)^2/108$		
$SS = 76654.13$		
Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.50		
$= 12 \times 76654.13/ 108(109)$		
$= 78.14$		

The score matrix for ease operation of various irrigation methods was prepared as shown in table 4.21. The mean values of treatment T1, T2 and T3 was found to be 90.50, 46.13 and 26.88, respectively as shown in Table 4.39. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for ease operation of various irrigation methods.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for ease operation of various irrigation methods.

The Chi-square test value was 78.14 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that ease of operation of irrigation methods is very important for farmers of Ucher water user association.

Table 4.40 Scoring for Water Saving of Irrigation Method in Command Area in Ucher WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
	Mahendra singh	7	5	2	7	75	4	33	2
Badam singh	10	4	2	7	75	4	33	2	7
Ramprasad	9	6	4	7	75	4	33	2	7
Sarvan kumar	9	5	2	7	75	4	33	2	7
Bainiprasad	10	6	3	7	75	4	33	2	7
Atmaram	9	4	5	7	75	4	33	2	7
Rakesh kumar	7	7	2	7	75	4	33	2	7
Shriram	8	6	4	7	75	4	33	2	7
Dharmendra singh	7	5	2	7	75	4	33	2	7
Ramgopal	10	6	2	7	75	4	33	2	7
Karan singh	9	7	5	7	75	5	50	2	7
Shalendra kumar	8	4	3	7	75	5	50	2	7
Rajkumar	7	5	3	8	88	5	50	2	7
Ganeshram	7	6	4	8	88	5	50	3	19
Seetaram	8	7	2	8	88	5	50	3	19
Dileep	7	5	3	8	88	5	50	3	19
Kishor Kapoor	7	5	3	8	88	5	50	3	19
Halkooram	10	4	3	8	88	5	50	3	19
Abhinash singh	8	4	4	8	88	5	50	3	19
Jashodi bai	8	6	2	8	88	5	50	3	19
Jagannath singh	10	5	3	8	88	5	50	3	19
Rajendra singh	9	5	2	9	94	5	50	3	19
Ajab singh	10	6	2	9	96.5	6	62.5	3	19
Beersingh	8	4	3	9	96.5	6	62.5	3	19
jasabant singh	7	5	2	9	96.5	6	62.5	4	33
Karan singh	10	5	2	9	96.5	6	62.5	4	33
Ganeshram	8	4	3	9	96.5	6	62.5	4	33
Babulal	7	6	5	9	96.5	6	62.5	4	33
Tulsiram	9	4	4	9	96.5	6	62.5	4	33
Sarswati bai	8	7	3	10	105	6	62.5	4	33
Gulav singh	7	5	5	10	105	6	62.5	4	33
Jagadish	9	7	3	10	105	7	75	5	50
Meharwan singh	8	5	4	10	105	7	75	5	50
Than singh	7	4	5	10	105	7	75	5	50
Gaurav yadav	9	6	4	10	105	7	75	5	50
Narendra kumar	7	4	3	10	105	7	75	5	50
Average	-			-	88.79	-	51.88	-	21.69

	Mean	
$T_1 = 3197$	=	88.79
$T_2 = 1868$	=	51.88
$T_3 = 781$	=	21.69
Sum of Square (SS) = $(T_1^2+T_2^2+T_3^2)/r - (T_1+T_2+T_3)^2/N$ ----- 4.51		
$SS = (3197^2+1868^2+781^2)/36-(3197+1868+781)^2/108$		
$SS = 81308.92$		
Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.52		
$= 12 \times 81308.92/ 108(109)$		
$= 82.88$		

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 88.79, 51.88, and 21.69, respectively as shown in Table 4.40. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for water saving in irrigation methods.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for water saving in irrigation methods.

The Chi-square test value was 82.88 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there was significant difference among sprinkler irrigation, border irrigation and flood irrigation methods as for as water saving in irrigation methods of Ucher water user association is concerned.

Table 4.41 Scoring for High Income Irrigation Method in Command Area in Ucher WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mahendra singh	7	5	2	7	73.5	4	32	2	5.5
Badam singh	10	4	2	7	73.5	4	32	2	5.5
Ramprasad	9	6	4	7	73.5	4	32	2	5.5
Sarvan kumar	9	5	2	7	73.5	4	32	2	5.5
Bainiprasad	10	6	3	7	73.5	4	32	2	5.5
Atmaram	9	4	5	7	73.5	4	32	2	5.5
Rakesh kumar	7	7	2	7	73.5	4	32	2	5.5
Shriram	8	6	4	7	73.5	4	32	2	5.5
Dharmendra singh	10	5	3	7	73.5	4	32	2	5.5
Ramgopal	10	6	2	8	86.5	4	32	2	5.5
Karan singh	9	7	5	8	86.5	4	32	3	16.5
Shalendra kumar	8	4	3	8	86.5	5	49.5	3	16.5
Rajkumar	7	4	3	8	86.5	5	49.5	3	16.5
Ganeshram	10	6	4	8	86.5	5	49.5	3	16.5
Seetaram	8	7	3	8	86.5	5	49.5	3	16.5
Dileep	7	5	4	8	86.5	5	49.5	3	16.5
Kishor Kapoor	8	5	4	8	86.5	5	49.5	3	16.5
Halkooram	10	4	3	8	86.5	5	49.5	3	16.5
Abhinash singh	8	4	4	8	86.5	5	49.5	3	16.5
Jashodi bai	8	6	2	9	95.5	5	49.5	3	16.5
Jagannath singh	10	6	3	9	95.5	5	49.5	3	16.5
Rajendra singh	9	5	3	9	95.5	6	61.5	3	16.5
Ajab singh	10	6	2	9	95.5	6	61.5	4	32
Beersingh	8	4	3	9	95.5	6	61.5	4	32
jasabant singh	7	5	2	9	95.5	6	61.5	4	32
Karan singh	10	5	2	9	95.5	6	61.5	4	32
Ganeshram	8	4	3	9	95.5	6	61.5	4	32
Babulal	7	7	5	10	104	6	61.5	4	32
Tulsiram	9	4	3	10	104	6	61.5	4	32
Sarwati bai	8	7	3	10	104	7	73.5	4	32
Gulav singh	7	5	5	10	104	7	73.5	5	49.5
Jagadish	9	7	3	10	104	7	73.5	5	49.5
Meharwan singh	8	5	5	10	104	7	73.5	5	49.5
Than singh	7	4	5	10	104	7	73.5	5	49.5
Gaurav yadav	9	7	4	10	104	7	73.5	5	49.5
Narendra kumar	7	4	4	10	104	7	73.5	5	49.5
Average	-			-	89.63	-	51.49	-	22.39

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 3227$	=	89.63
$T_2 = 1854$	=	51.49
$T_3 = 806$	=	22.39

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.53

$$SS = (3227^2 + 1854^2 + 806^2)/36 - (3227 + 1854 + 806)^2/108$$
$$SS = 81863$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.54

$$= 12 \times 81863 / 108(109)$$
$$= 83.44$$

The mean values of specific irrigation that is sprinkler irrigation; border irrigation and flood irrigation were 89.63, 51.49 and 22.39, respectively as shown in Table 4.41. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for high income irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for high income irrigation method.

The Chi-square test value was 83.44 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods.

Table 4.42 Scoring Matrix for Labour Requirement of Different Irrigation Method in Medaki Wua

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
	Mis Sadhana singh	9	3	2	6	73.5	3	20	2
Anil kumar	6	3	2	6	73.5	3	20	2	5.5
Mukesh kumar	6	3	4	6	73.5	3	20	2	5.5
Vatee bai	8	3	5	6	73.5	3	20	2	5.5
Lakshminarayan	9	3	2	6	73.5	3	20	2	5.5
Randheer singh	7	6	2	6	73.5	3	20	2	5.5
Amar singh	6	3	4	6	73.5	3	20	2	5.5
Karan singh	8	4	4	6	73.5	3	20	2	5.5
Badri Prasad	7	3	5	6	73.5	3	20	2	5.5
Jain Raid	8	6	2	7	85.5	3	20	2	5.5
Pyare lal	9	4	5	7	85.5	3	20	3	20
Fatama bi	8	4	2	7	85.5	4	39	3	20
Prabhoodayal	6	3	4	7	85.5	4	39	3	20
Ramkishan	9	6	2	7	85.5	4	39	3	20
Hiralal	7	4	5	7	85.5	4	39	3	20
Saroj bai	8	5	3	7	85.5	4	39	3	20
Vineet kumar	7	3	5	7	85.5	4	39	3	20
Balbant singh	9	4	5	8	94.5	4	39	3	20
Baboo singh	8	4	3	8	94.5	4	39	4	39
Dileep singh	8	3	2	8	94.5	4	39	4	39
Bharat singh	6	6	5	8	94.5	4	39	4	39
Phool bai	8	4	3	8	94.5	5	57	4	39
Javed haidar ali	7	3	4	8	94.5	5	57	4	39
Lal singh	6	4	2	8	94.5	5	57	4	39
Mishri lal	9	3	5	8	94.5	5	57	4	39
Dasharth singh	9	4	2	8	94.5	5	57	4	39
Ashish Tripathi	7	4	5	8	94.5	5	57	4	39
Devendra singh	6	6	3	9	104	5	57	5	57
Malekhan	8	3	5	9	104	5	57	5	57
mrs. Sushama	9	5	4	9	104	6	73.5	5	57
Veer singh	6	4	5	9	104	6	73.5	5	57
Hardev singh	9	5	3	9	104	6	73.5	5	57
Phool singh	7	5	4	9	104	6	73.5	5	57
mrs. Kiran	8	6	5	9	104	6	73.5	5	57
Nihal singh	7	5	3	9	104	6	73.5	5	57
Kanika sharma	6	6	4	9	104	6	73.5	5	57
Average	-			-	89.63	-	43.90	-	29.97

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3227$	= 89.63
$T_2 = 1581$	= 43.90
$T_3 = 1079$	= 29.97

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2) / r - (T_1 + T_2 + T_3)^2 / N$ ----- 4.55

$$SS = (3227^2 + 1581^2 + 1079^2) / 36 - (3227 + 1581 + 1079)^2 / 108$$

$$SS = 70116.43$$

Chi square test = $12 \times (SS) / N(N+1)$ ----- 4.56

$$= 12 \times 70116.43 / 108(109)$$

$$= 71.47$$

The mean values of specific irrigation that is sprinkler irrigation; border irrigation and flood irrigation was found to be 89.63, 43.90 and 29.97, respectively as shown in Table 4.42. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in labour requirement.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in labour requirement.

The Chi-square test value was found 71.47 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and significant difference in labour requirement ranking awarded by the farmers was found among sprinkler irrigation, border irrigation and flood irrigation.

Table 4.43 Scoring for Cost in Medaki WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mis Sadhana singh	3	5	8	1	4	4	40.5	7	76.5
Anil kumar	3	6	9	1	4	4	40.5	7	76.5
Mukesh kumar	2	6	9	1	4	4	40.5	7	76.5
Vatee bai	3	6	9	1	4	4	40.5	7	76.5
Lakshminarayan	2	4	8	1	4	4	40.5	7	76.5
Randheer singh	3	5	8	1	4	4	40.5	7	76.5
Amar singh	2	6	9	1	4	4	40.5	7	76.5
Karan singh	2	5	9	2	15	4	40.5	7	76.5
Badri Prasad	1	5	7	2	15	5	50.5	8	87.5
Jain Raid	2	6	7	2	15	5	50.5	8	87.5
Pyare lal	1	5	9	2	15	5	50.5	8	87.5
Fatama bi	1	5	9	2	15	5	50.5	8	87.5
Prabhoodayal	2	5	8	2	15	5	50.5	8	87.5
Ramkishan	3	6	9	2	15	5	50.5	8	87.5
Hiralal	3	6	7	2	15	5	50.5	8	87.5
Saroj bai	3	5	8	2	15	5	50.5	8	87.5
Vineet kumar	3	6	8	2	15	5	50.5	8	87.5
Balbant singh	2	4	8	2	15	5	50.5	8	87.5
Baboo singh	1	4	9	2	15	5	50.5	8	87.5
Dileep singh	2	6	9	2	15	5	50.5	8	87.5
Bharat singh	2	4	9	2	15	6	64.5	8	87.5
Phool bai	2	4	8	2	15	6	64.5	8	87.5
Javed haidar ali	3	5	7	3	29.5	6	64.5	9	101.
Lal singh	2	4	7	3	29.5	6	64.5	9	101.
Mishri lal	2	6	8	3	29.5	6	64.5	9	101.
Dasharth singh	1	6	8	3	29.5	6	64.5	9	101.
Ashish Tripathi	3	6	7	3	29.5	6	64.5	9	101.
Devendra singh	1	5	9	3	29.5	6	64.5	9	101.
Malekhan	3	6	8	3	29.5	6	64.5	9	101.
mrs. Sushama	2	6	9	3	29.5	6	64.5	9	101.
Veer singh	2	5	7	3	29.5	6	64.5	9	101.
Hardev singh	2	6	8	3	29.5	6	64.5	9	101.
Phool singh	3	4	9	3	29.5	6	64.5	9	101.
mrs. Kiran	3	4	8	3	29.5	6	64.5	9	101.
Nihal singh	3	6	8	3	29.5	6	64.5	9	101.
Kanika sharma	1	5	7	3	29.5	6	64.5	9	101.
Average	-	-	-	-	18.50	-	54.50	-	90.50

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 666$	=	18.50
$T_2 = 1962$	=	54.50
$T_3 = 3258$	=	90.50

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.57

$$SS = (666^2 + 1962^2 + 3258^2)/36 - (666 + 1962 + 3258)^2/108$$
$$SS = 93312$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.58

$$= 12 \times 93312/108(109)$$
$$= 95.12$$

The mean values of treatment T1, T2 and T3 was found 18.50, 54.50 and 90.50, respectively as shown in Table 4.43. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in cost requirement.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in cost requirement.

The Chi-square test value was 95.12 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods of irrigation at least when cost was concern

Table 4.44 Scoring for Suitability of Irrigation Method in Command Area in Medaki WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mis Sadhana singh	7	4	4	7	73.5	4	31.5	1	3
Anil kumar	9	9	4	7	73.5	4	31.5	1	3
Mukesh kumar	8	7	3	7	73.5	4	31.5	1	3
Vatee bai	7	4	3	7	73.5	4	31.5	1	3
Lakshminarayan	9	6	4	7	73.5	4	31.5	1	3
Randheer singh	10	4	5	7	73.5	4	31.5	2	9
Amar singh	9	6	3	7	73.5	4	31.5	2	9
Karan singh	7	9	5	7	73.5	4	31.5	2	9
Badri Prasad	8	7	2	7	73.5	5	47	2	9
Jain Raid	10	4	4	7	73.5	5	47	2	9
Pyare lal	8	5	1	7	73.5	5	47	2	9
Fatama bi	10	4	5	8	88	5	47	2	9
Prabhoodayal	7	5	3	8	88	5	47	3	17.5
Ramkishan	7	4	3	8	88	5	47	3	17.5
Hiralal	9	7	2	8	88	5	47	3	17.5
Saroj bai	10	6	2	8	88	5	47	3	17.5
Vineet kumar	8	5	1	8	88	5	47	3	17.5
Balbant singh	8	7	4	8	88	6	58.5	3	17.5
Baboo singh	7	5	4	8	88	6	58.5	3	17.5
Dileep singh	7	4	3	8	88	6	58.5	3	17.5
Bharat singh	10	6	2	9	97	6	58.5	3	17.5
Phool bai	8	9	4	9	97	6	58.5	3	17.5
Javed haidar ali	10	4	2	9	97	6	58.5	4	31.5
Lal singh	7	5	1	9	97	6	58.5	4	31.5
Mishri lal	9	7	3	9	97	6	58.5	4	31.5
Dasharth singh	8	7	3	9	97	6	58.5	4	31.5
Ashish Tripathi	9	9	5	9	97	6	58.5	4	31.5
Devendra singh	8	7	2	9	97	7	73.5	4	31.5
Malekhan	7	5	4	9	97	7	73.5	4	31.5
mrs. Sushama	9	6	1	10	105	7	73.5	4	31.5
Veer singh	9	7	3	10	105	7	73.5	4	31.5
Hardev singh	8	6	4	10	105	7	73.5	4	31.5
Phool singh	7	5	2	10	105	7	73.5	5	47
mrs. Kiran	10	6	1	10	105	7	73.5	5	47
Nihal singh	9	5	4	10	105	7	73.5	5	47
Kanika sharma	7	7	3	10	105	7	73.5	5	47
Average	-			-	89.13	-	53.38	-	21.00

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3209$	= 89.13
$T_2 = 1922$	= 53.38
$T_3 = 756$	= 21.00

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.59

$$SS = (3209^2 + 1922^2 + 756^2)/36 - (3209 + 1922 + 756)^2/108$$

$$SS = 83606.63$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.60

$$= 12 \times 83606.63 / 108(109)$$

$$= 85.22$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 89.13, 53.38 and 21.00, respectively as shown in Table 4.44. The data was analyzed using nonparametric approach. The Kruskal-Wallis test is a completely randomize design when the observations were rank by the farmers for the specify method of irrigation.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for suitability of irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for suitability of irrigation method.

The tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance was found less than the Chi-square test value 85.22. Thus the null hypothesis is rejected which clearly showed that suitability of irrigation methods matters for the farmer

Table 4.45 Scoring for Control and Management of Water in Command Area in Medaki WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mis Sadhana singh	10	4	1	6	73	3	30.5	1	5.5
Anil kumar	8	4	1	6	73	3	30.5	1	5.5
Mukesh kumar	10	6	1	6	73	3	30.5	1	5.5
Vatee bai	8	3	1	6	73	3	30.5	1	5.5
Lakshminarayan	10	4	4	6	73	3	30.5	1	5.5
Randheer singh	10	5	2	6	73	3	30.5	1	5.5
Amar singh	8	4	3	6	73	3	30.5	1	5.5
Karan singh	7	3	1	6	73	3	30.5	1	5.5
Badri Prasad	6	5	2	7	83	4	49	1	5.5
Jain Raid	9	4	3	7	83	4	49	1	5.5
Pyare lal	6	4	1	7	83	4	49	2	16
Fatama bi	10	3	4	7	83	4	49	2	16
Prabhoodayal	9	5	2	7	83	4	49	2	16
Ramkishan	7	4	2	7	83	4	49	2	16
Hiralal	6	4	3	7	83	4	49	2	16
Saroj bai	8	5	3	8	90.5	4	49	2	16
Vineet kumar	7	3	1	8	90.5	4	49	2	16
Balbant singh	7	6	2	8	90.5	4	49	2	16
Baboo singh	10	4	4	8	90.5	4	49	2	16
Dileep singh	9	4	2	8	90.5	4	49	2	16
Bharat singh	6	6	3	8	90.5	4	49	2	16
Phool bai	8	5	1	8	90.5	4	49	3	30.5
Javed haidar ali	7	3	3	8	90.5	5	62.5	3	30.5
Lal singh	6	4	2	9	97.5	5	62.5	3	30.5
Mishri lal	10	5	1	9	97.5	5	62.5	3	30.5
Dasharth singh	7	3	1	9	97.5	5	62.5	3	30.5
Ashish Tripathi	6	6	3	9	97.5	5	62.5	3	30.5
Devendra singh	9	5	4	9	97.5	5	62.5	3	30.5
Malekhan	8	4	2	9	97.5	5	62.5	3	30.5
mrs. Sushama	9	3	3	10	104	5	62.5	3	30.5
Veer singh	8	6	3	10	104	6	73	3	30.5
Hardev singh	7	4	2	10	104	6	73	4	49
Phool singh	6	3	3	10	104	6	73	4	49
mrs. Kiran	9	6	2	10	104	6	73	4	49
Nihal singh	6	4	4	10	104	6	73	4	49
Kanika sharma	8	5	2	10	104	6	73	4	49
Average	-			-	88.94	-	51.89	-	21.69

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3202$	= 88.94
$T_2 = 1868$	= 51.89
$T_3 = 781$	= 21.69

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.61

$$SS = (3202^2 + 1868^2 + 781^2)/36 - (3202 + 1868 + 781)^2/108$$

$$SS = 81688.57$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.62

$$= 12 \times 81688.57/108(109)$$

$$= 83.27$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 88.94, 51.89 and 21.69, respectively as shown in Table 4.45. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for control and management of water.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for control and management of water.

The Chi-square test value was 83.27 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and it was concluded that control and management of irrigation water in sprinkler irrigation, border irrigation and flood irrigation methods was an important issue for the farmers of Medaki water user association.

Table 4.46 Scoring for Availability of Nearby City in Medaki WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mis Sadhana singh	4	5	8	2	3	4	24.5	7	75
Anil kumar	3	6	8	2	3	4	24.5	7	75
Mukesh kumar	3	5	8	2	3	4	24.5	7	75
Vatee bai	4	7	9	2	3	4	24.5	7	75
Lakshminarayan	4	6	8	2	3	4	24.5	7	75
Randheer singh	2	4	7	3	10	4	24.5	7	75
Amar singh	5	7	9	3	10	4	24.5	7	75
Karan singh	3	5	9	3	10	4	24.5	7	75
Badri Prasad	4	7	7	3	10	4	24.5	7	75
Jain Raid	4	5	9	3	10	5	45	7	75
Pyare lal	5	4	8	3	10	5	45	7	75
Fatama bi	3	7	7	3	10	5	45	7	75
Prabhoodayal	5	5	7	3	10	5	45	7	75
Ramkishan	4	6	9	3	10	5	45	7	75
Hiralal	3	7	8	4	24.5	5	45	8	92.5
Saroj bai	2	4	7	4	24.5	5	45	8	92.5
Vineet kumar	5	5	9	4	24.5	5	45	8	92.5
Balbant singh	4	5	9	4	24.5	5	45	8	92.5
Baboo singh	5	6	7	4	24.5	5	45	8	92.5
Dileep singh	2	4	8	4	24.5	6	59.5	8	92.5
Bharat singh	3	7	7	4	24.5	6	59.5	8	92.5
Phool bai	3	6	9	4	24.5	6	59.5	8	92.5
Javed haidar ali	2	4	7	4	24.5	6	59.5	8	92.5
Lal singh	4	7	9	4	24.5	6	59.5	8	92.5
Mishri lal	2	4	7	4	24.5	6	59.5	8	92.5
Dasharth singh	3	7	8	5	45	6	59.5	8	92.5
Ashish Tripathi	5	6	7	5	45	6	59.5	9	103.
Devendra singh	4	5	8	5	45	7	75	9	103.
Malekhan	3	4	7	5	45	7	75	9	103.
mrs. Sushama	5	6	9	5	45	7	75	9	103.
Veer singh	4	5	7	5	45	7	75	9	103.
Hardev singh	5	6	7	5	45	7	75	9	103.
Phool singh	5	4	8	5	45	7	75	9	103.
mrs. Kiran	4	7	8	5	45	7	75	9	103.
Nihal singh	5	5	8	5	45	7	75	9	103.
Kanika sharma	5	4	7	5	45	7	75	9	103.
Average	-	-	-	-	25.15	-	50.60	-	88.75

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 870$	=	25.15
$T_2 = 1822$	=	50.60
$T_3 = 3195$	=	88.75

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.63

$$SS = (870^2 + 1822^2 + 3195^2)/36 - (870 + 1822 + 3195)^2/108$$
$$SS = 75932.93$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.64

$$= 12 \times 75932.93 / 108(109)$$
$$= 77.40$$

The calculated mean values of ranking awarded by farmers for sprinkler irrigation; border irrigation and flood irrigation system was found to be 25.15, 50.60 and 88.75, respectively as shown in Table 4.46. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for availability of nearby city.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for availability of nearby city.

The Chi-square test value was 77.40 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected which indicated that availability of nearby city for the farmers of this water user association was important.

Table 4.47 Scoring for Time Saving of Irrigation Method in Command Area in Medaki WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mis Sadhana singh	10	3	2	6	69.5	3	13	2	3.5
Anil kumar	6	4	4	6	69.5	3	13	2	3.5
Mukesh kumar	8	6	3	6	69.5	3	13	2	3.5
Vatee bai	6	3	5	6	69.5	3	13	2	3.5
Lakshminarayan	9	6	4	6	69.5	3	13	2	3.5
Randheer singh	10	3	2	6	69.5	3	13	2	3.5
Amar singh	6	6	4	6	69.5	3	13	3	13
Karan singh	8	3	5	7	84	3	13	3	13
Badri Prasad	9	4	3	7	84	4	30	3	13
Jain Raid	10	3	4	7	84	4	30	3	13
Pyare lal	6	6	2	7	84	4	30	3	13
Fatama bi	8	4	4	7	84	4	30	4	30
Prabhoodayal	10	3	3	7	84	4	30	4	30
Ramkishan	9	6	2	7	84	4	30	4	30
Hiralal	7	5	4	7	84	4	30	4	30
Saroj bai	9	6	5	7	84	4	30	4	30
Vineet kumar	7	6	4	8	92.5	5	50	4	30
Balbant singh	9	6	2	8	92.5	5	50	4	30
Baboo singh	7	6	4	8	92.5	5	50	4	30
Dileep singh	8	3	5	8	92.5	5	50	4	30
Bharat singh	7	6	4	8	92.5	5	50	4	30
Phool bai	9	6	5	8	92.5	5	50	4	30
Javed haidar ali	8	3	4	8	92.5	5	50	4	30
Lal singh	7	4	4	8	92.5	6	69.5	4	30
Mishri lal	8	6	5	9	99.5	6	69.5	5	50
Dasharth singh	7	5	2	9	99.5	6	69.5	5	50
Ashish Tripathi	6	4	5	9	99.5	6	69.5	5	50
Devendra singh	8	5	4	9	99.5	6	69.5	5	50
Malekhan	7	4	5	9	99.5	6	69.5	5	50
mrs. Sushama	10	5	4	9	99.5	6	69.5	5	50
Veer singh	8	4	5	10	105.	6	69.5	5	50
Hardev singh	7	5	5	10	105.	6	69.5	5	50
Phool singh	6	4	3	10	105.	6	69.5	5	50
mrs. Kiran	10	5	5	10	105.	6	69.5	5	50
Nihal singh	7	6	5	10	105.	6	69.5	5	50
Kanika sharma	6	5	3	10	105.	6	69.5	5	50
Average	-			-	89.24	-	44.38	-	29.89

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 3213$	=	89.24
$T_2 = 1598$	=	44.38
$T_3 = 1076$	=	29.89

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.65

$$SS = (3213^2 + 1598^2 + 1076^2)/36 - (3213 + 1598 + 1076)^2/108$$
$$SS = 68933.51$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.66

$$= 12 \times 68933.51/108(109)$$
$$= 70.26$$

The mean ranking values for specific irrigation methods that is sprinkler irrigation, border irrigation and flood irrigation was found to be 89.24, 44.38 and 29.89, respectively as shown in Table 4.47. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for time saving of irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for time saving of irrigation method.

The Chi-square test value was larger than the tabulated value at 5% and 1% level of significance, respectively. Which clearly indicated that time saving in application of water by irrigation methods is very much important for the farmers.

Table 4.48 Scoring for Ease Operation of Various Irrigation Methods in Medaki WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mis Sadhana singh	10	5	3	6	73	3	17	2	4
Anil kumar	8	3	5	6	73	3	17	2	4
Mukesh kumar	8	3	3	6	73	3	17	2	4
Vatee bai	10	3	4	6	73	3	17	2	4
Lakshminarayan	9	5	2	6	73	3	17	2	4
Randheer singh	6	6	4	6	73	3	17	2	4
Amar singh	9	3	3	6	73	3	17	2	4
Karan singh	6	4	3	6	73	3	17	3	17
Badri Prasad	10	3	4	6	73	3	17	3	17
Jain Raid	8	4	3	6	73	4	35	3	17
Pyare lal	6	4	4	6	73	4	35	3	17
Fatama bi	8	3	4	7	87.5	4	35	3	17
Prabhoodayal	10	3	5	7	87.5	4	35	3	17
Ramkishan	7	6	2	7	87.5	4	35	3	17
Hiralal	7	4	3	7	87.5	4	35	3	17
Saroj bai	6	6	4	7	87.5	4	35	3	17
Vineet kumar	8	3	4	7	87.5	4	35	3	17
Balbant singh	6	5	2	7	87.5	5	53	4	35
Baboo singh	7	6	5	7	87.5	5	53	4	35
Dileep singh	7	5	3	8	94.5	5	53	4	35
Bharat singh	7	4	3	8	94.5	5	53	4	35
Phool bai	10	5	2	8	94.5	5	53	4	35
Javed haidar ali	9	3	4	8	94.5	5	53	4	35
Lal singh	6	6	5	8	94.5	5	53	4	35
Mishri lal	9	6	2	8	94.5	5	53	4	35
Dasharth singh	7	5	5	9	100	5	53	4	35
Ashish Tripathi	6	5	2	9	100	6	73	5	53
Devendra singh	6	6	3	9	100	6	73	5	53
Malekhan	7	4	5	9	100	6	73	5	53
mrs. Sushama	10	5	5	9	100	6	73	5	53
Veer singh	6	5	2	10	105.	6	73	5	53
Hardev singh	9	4	5	10	105.	6	73	5	53
Phool singh	6	6	3	10	105.	6	73	5	53
mrs. Kiran	6	6	5	10	105.	6	73	5	53
Nihal singh	8	6	5	10	105.	6	73	5	53
Kanika sharma	7	4	4	10	105.	6	73	5	53
Average	-	-	-	-	88.97	-	45.56	-	28.97

	Mean	
$T_1 = 3203$	=	88.97
$T_2 = 1640$	=	45.56
$T_3 = 1043$	=	28.97
Sum of Square (SS) = $(T_1^2+T_2^2+T_3^2)/r - (T_1+T_2+T_3)^2/N$ ----- 4.67		
$SS = (3203^2+1640^2+1043^2)/36-(3203+1640+1043)^2/108$		
$SS = 69120.17$		
Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.68		
$= 12 \times 69120.17/ 108(109)$		
$= 70.45$		

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 88.97, 45.56 and 28.97, respectively as shown in Table 4.48. The data was analysis using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for ease operation of various irrigation methods.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for ease operation of various irrigation methods.

The Chi-square test value was 70.45 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that ease operations among sprinkler irrigation, border irrigation and flood irrigation methods play an important role for farmers.

Table 4.49 Scoring for Water Saving of Irrigation Method in Command Area in Medaki WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mis Sadhana singh	5	4	3	5	67	3	21	2	4.5
Anil kumar	6	4	3	5	67	3	21	2	4.5
Mukesh kumar	5	5	5	5	67	3	21	2	4.5
Vatee bai	7	5	3	5	67	3	21	2	4.5
Lakshminarayan	6	3	4	5	67	3	21	2	4.5
Randheer singh	5	6	2	5	67	3	21	2	4.5
Amar singh	7	3	5	5	67	3	21	2	4.5
Karan singh	5	3	3	5	67	3	21	2	4.5
Badri Prasad	7	4	3	6	82.5	3	21	3	21
Jain Raid	5	4	2	6	82.5	3	21	3	21
Pyare lal	8	5	4	6	82.5	3	21	3	21
Fatama bi	5	5	4	6	82.5	3	21	3	21
Prabhoodayal	7	4	2	6	82.5	4	45	3	21
Ramkishan	5	4	2	6	82.5	4	45	3	21
Hiralal	9	5	4	6	82.5	4	45	3	21
Saroj bai	7	6	3	7	91	4	45	3	21
Vineet kumar	7	3	3	7	91	4	45	3	21
Balbant singh	8	3	5	7	91	4	45	3	21
Baboo singh	7	4	4	7	91	4	45	3	21
Dileep singh	8	5	4	7	91	4	45	3	21
Bharat singh	8	6	2	7	91	4	45	3	21
Phool bai	9	3	3	7	91	4	45	4	45
Javed haidar ali	8	3	5	8	98.5	4	45	4	45
Lal singh	5	3	3	8	98.5	4	45	4	45
Mishri lal	6	4	2	8	98.5	4	45	4	45
Dasharth singh	9	5	3	8	98.5	5	67	4	45
Ashish Tripathi	6	4	4	8	98.5	5	67	4	45
Devendra singh	8	5	2	8	98.5	5	67	4	45
Malekhan	9	3	4	8	98.5	5	67	4	45
mrs. Sushama	6	4	3	8	98.5	5	67	4	45
Veer singh	9	3	4	9	105.	5	67	4	45
Hardev singh	8	4	3	9	105.	5	67	5	67
Phool singh	6	3	3	9	105.	5	67	5	67
mrs. Kiran	9	3	2	9	105.	6	82.5	5	67
Nihal singh	6	4	5	9	105.	6	82.5	5	67
Kanika sharma	8	4	4	9	105.	6	82.5	5	67
Average	-			-	88.10	-	45.01	-	30.39

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 3172$	=	88.10
$T_2 = 1621$	=	45.01
$T_3 = 1094$	=	30.39

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.69

$$SS = (3172^2 + 1621^2 + 1094^2)/36 - (3172 + 1621 + 1094)^2/108$$

$$SS = 64803.79$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.70

$$= 12 \times 64803.79/108(109)$$

$$= 66.05$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 88.10, 45.01, and 30.39, respectively as shown in Table 4.49. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for water saving of irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for water saving of irrigation method.

The Chi-square test value was 66.05 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods as for as water saving is concerned.

Table 4.50 Scoring for High Income Irrigation Method in Command Area in Medaki WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Mis Sadhana singh	7	6	3	6	62.5	4	27	2	4
Anil kumar	7	6	3	6	62.5	4	27	2	4
Mukesh kumar	9	7	4	6	62.5	4	27	2	4
Vatee bai	9	5	2	6	62.5	4	27	2	4
Lakshminarayan	6	6	4	6	62.5	4	27	2	4
Randheer singh	9	5	5	6	62.5	4	27	2	4
Amar singh	7	7	4	6	62.5	4	27	2	4
Karan singh	8	6	4	7	80	4	27	3	13.5
Badri Prasad	7	5	3	7	80	5	45	3	13.5
Jain Raid	6	7	2	7	80	5	45	3	13.5
Pyare lal	9	7	5	7	80	5	45	3	13.5
Fatama bi	8	5	4	7	80	5	45	3	13.5
Prabhoodayal	7	5	3	7	80	5	45	3	13.5
Ramkishan	6	6	4	7	80	5	45	3	13.5
Hiralal	8	7	3	7	80	5	45	3	13.5
Saroj bai	7	5	4	7	80	5	45	3	13.5
Vineet kumar	8	5	4	7	80	5	45	3	13.5
Balbant singh	6	5	3	7	80	5	45	3	13.5
Baboo singh	8	5	4	8	94.5	5	45	3	13.5
Dileep singh	8	6	2	8	94.5	6	62.5	4	27
Bharat singh	6	6	3	8	94.5	6	62.5	4	27
Phool bai	9	5	3	8	94.5	6	62.5	4	27
Javed haidar ali	6	7	2	8	94.5	6	62.5	4	27
Lal singh	9	4	3	8	94.5	6	62.5	4	27
Mishri lal	7	5	2	8	94.5	6	62.5	4	27
Dasharth singh	6	5	2	8	94.5	6	62.5	4	27
Ashish Tripathi	9	5	3	9	103.	7	80	5	45
Devendra singh	7	7	5	9	103.	7	80	5	45
Malekhan	9	4	3	9	103.	7	80	5	45
mrs. Sushama	8	7	3	9	103.	7	80	5	45
Veer singh	7	5	5	9	103.	7	80	5	45
Hardev singh	9	7	3	9	103.	7	80	5	45
Phool singh	8	5	5	9	103.	7	80	5	45
mrs. Kiran	7	4	5	9	103.	7	80	5	45
Nihal singh	9	7	4	9	103.	7	80	5	45
Kanika sharma	7	4	4	9	103.	7	80	5	45
Average	-			-	86.35	-	54.13	-	23.03

	Mean	
$T_1 = 3109$	= 86.35	
$T_2 = 1949$	= 54.13	
$T_3 = 829$	= 23.03	
Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.71		
$SS = (3109^2 + 1949^2 + 829^2)/36 - (3109 + 1949 + 829)^2/108$		
$SS = 72175.93$		
Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.72		
$= 12 \times 72175.93/108(109)$		
$= 73.57$		

The mean values of ranking awarded by farmers for getting higher income by adoption of sprinkler irrigation, border irrigation and flood irrigation system was found to be 86.35, 54.13 and 23.03, respectively as shown in Table 4.50. The data was analyzed using nonparametric approach. The Kruskal-Wallis test is a completely randomize design when the observations were rank by the farmers for the specify method of irrigation. The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for high income irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for high income irrigation method..

The Chi-square test value was 73.57 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in respect of high income.

Table 4.51 Scoring Matrix for Labour Requirement of Different Irrigation Method in Neemkheda WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Rajesh dubey	9	4	2	6	71.5	3	16.5	2	5
Ramesh chandra	10	4	2	6	71.5	3	16.5	2	5
Prakash chandra	6	3	4	6	71.5	3	16.5	2	5
Abadhnarayan	8	5	5	6	71.5	3	16.5	2	5
Renu tiwari	10	4	2	6	71.5	3	16.5	2	5
Hukam singh	7	6	2	6	71.5	3	16.5	2	5
Komal singh	6	4	4	6	71.5	3	16.5	2	5
Shivcharan	8	5	4	6	71.5	4	32	2	5
Rambabu	8	4	5	7	83.5	4	32	2	5
Ramkali	8	6	2	7	83.5	4	32	3	16.5
Rajendra kumar	10	4	5	7	83.5	4	32	3	16.5
Ram manohar	8	5	3	7	83.5	4	32	3	16.5
Pawan kumar	6	3	4	7	83.5	4	32	3	16.5
Uttam rao	9	6	2	7	83.5	4	32	3	16.5
susheel kumar	7	4	5	8	92	4	32	3	16.5
Mahendra singh	8	5	3	8	92	4	32	3	16.5
Bhaver lal	7	3	5	8	92	4	32	4	32
Yogendra singh	10	4	5	8	92	4	32	4	32
Sakti singh	8	5	3	8	92	5	51.5	4	32
Aditya singh	8	3	2	8	92	5	51.5	4	32
Nirmala bai	6	6	5	8	92	5	51.5	4	32
Kamal singh	8	4	3	8	92	5	51.5	4	32
Ganeshram	8	3	5	8	92	5	51.5	5	51.5
pooran chandra	6	5	2	8	92	5	51.5	5	51.5
Dhanna lal	10	3	5	8	92	5	51.5	5	51.5
Bhaiya lal	10	4	2	9	100	5	51.5	5	51.5
Harish chandra	7	6	5	9	100	6	71.5	5	51.5
Pushpendra	6	6	3	9	100	6	71.5	5	51.5
Madan singh	9	3	5	9	100	6	71.5	5	51.5
Bhairo singh	9	5	5	9	100	6	71.5	5	51.5
Mohan singh	6	4	5	10	105.	6	71.5	5	51.5
Karan singh	9	6	3	10	105.	6	71.5	5	51.5
Malkhan singh	7	5	4	10	105.	6	71.5	5	51.5
Akhalesh	8	6	5	10	105.	6	71.5	5	51.5
Amit kumar	7	6	3	10	105.	6	71.5	5	51.5
Gopal rao	6	6	4	10	105.	6	71.5	5	51.5
Average	-			-	89.39	-	44.29	-	29.82

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 3218$	=	89.39
$T_2 = 1595$	=	44.29
$T_3 = 1074$	=	29.82

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.73

$$SS = (3218^2 + 1595^2 + 1074^2)/36 - (3218 + 1595 + 1074)^2/108$$
$$SS = 69500.68$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.74

$$= 12 \times 69500.68/108(109)$$
$$= 70.84$$

The mean values of specific irrigation that is sprinkler irrigation; border irrigation and flood irrigation were 89.39, 44.29 and 29.82, respectively as shown in Table 4.51. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in labour requirement.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in labour requirement.

The Chi-square test value was 70.84 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there was significant difference among sprinkler irrigation, border irrigation and flood irrigation methods.

Table 4.52 Scoring for Cost in Neemkheda WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Rajesh dubey	2	5	9	1	4	4	40.5	7	76.5
Ramesh chandra	1	5	7	1	4	4	38	7	76.5
Prakash chandra	2	6	7	1	4	4	39	7	76.5
Abadh narayan	1	5	9	1	4	4	40	7	76.5
Renu tiwari	1	5	9	1	4	4	41	7	76.5
Hukam singh	2	5	8	1	4	4	42	7	76.5
Komal singh	3	6	9	1	4	4	43	7	76.5
Shivcharan	3	5	8	2	15	4	44	7	76.5
Rambabu	3	6	9	2	15	5	50.5	8	87.5
Ramkali	2	6	9	2	15	5	50.5	8	87.5
Rajendra kumar	3	6	9	2	15	5	50.5	8	87.5
Ram manohar	2	4	8	2	15	5	50.5	8	87.5
Pawan kumar	3	5	8	2	15	5	50.5	8	87.5
Uttam rao	2	6	9	2	15	5	50.5	8	87.5
susheel kumar	1	6	8	2	15	5	50.5	8	87.5
Mahendra singh	3	6	7	2	15	5	50.5	8	87.5
Bhaver lal	1	5	9	2	15	5	50.5	8	87.5
Yogendra singh	3	6	8	2	15	5	50.5	8	87.5
Sakti singh	2	6	9	2	15	5	50.5	8	87.5
Aditya singh	2	5	7	2	15	5	50.5	8	87.5
Nirmala bai	2	6	8	2	15	6	64.5	8	87.5
Kamal singh	3	4	9	2	15	6	64.5	8	87.5
Ganeshram	3	4	8	3	29.5	6	64.5	9	101.
pooran chandra	3	6	8	3	29.5	6	64.5	9	101.
Dhanna lal	1	5	7	3	29.5	6	64.5	9	101.
Bhaiya lal	3	6	7	3	29.5	6	64.5	9	101.
Harish chandra	3	5	8	3	29.5	6	64.5	9	101.
Pushpendra	3	6	8	3	29.5	6	64.5	9	101.
Madan singh	2	4	8	3	29.5	6	64.5	9	101.
Bhairo singh	1	4	9	3	29.5	6	64.5	9	101.
Mohan singh	2	6	9	3	29.5	6	64.5	9	101.
Karan singh	2	4	9	3	29.5	6	64.5	9	101.
Malkhan singh	2	4	8	3	29.5	6	64.5	9	101.
Akhalesh	3	5	7	3	29.5	6	64.5	9	101.
Amit kumar	2	4	7	3	29.5	6	64.5	9	101.
Gopal rao	2	6	8	3	29.5	6	64.5	9	101.
Average	-			-	18.50	-	54.60	-	90.50

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 666$	=	18.50
$T_2 = 1966$	=	54.60
$T_3 = 3258$	=	90.50

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.75

$$SS = (666^2 + 1966^2 + 3258^2)/36 - (666 + 1966 + 3258)^2/108$$
$$SS = 93312.23$$

Chi square test = $12 \times (SS) / N(N+1)$ ----- 4.76

$$= 12 \times 93312.23 / 108(109)$$
$$= 95.12$$

The mean values of treatment T_1, T_2 and T_3 was found 18.50 54.50 and 90.50, respectively as shown in Table 4.52. The data was analyzed using nonparametric approach. The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in cost requirement.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in cost requirement.

The Chi-square test value was found 95.12 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there was significant difference among sprinkler irrigation, border irrigation and flood irrigation methods of irrigation as for as suitability for purchasing and cost involved in application of water through these methods.

Table 4.53 Scoring for Suitability of Irrigation Method in Command Area in Neemkheda WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Rajesh dubey	8	6	3	5	59	3	21	1	2.5
Ramesh chandra	6	4	3	5	59	3	21	1	2.5
Prakash chandra	8	6	2	5	59	3	21	1	2.5
Abadhnarayan	6	6	1	5	59	3	21	1	2.5
Renu tiwari	9	3	4	5	59	3	21	2	9.5
Hukam singh	5	6	4	5	59	3	21	2	9.5
Komal singh		4	3	5	59	4	39.5	2	9.5
Shivcharan	6	6	4	6	78	4	39.5	2	9.5
Rambabu	7	4	2	6	78	4	39.5	2	9.5
Ramkali	5	3	4	6	78	4	39.5	2	9.5
Rajendra kumar	6	5	2	6	78	4	39.5	2	9.5
Ram manohar	5	5	4	6	78	4	39.5	2	9.5
Pawan kumar	7	4	3	6	78	4	39.5	2	9.5
Uttam rao	7	4	4	6	78	4	39.5	2	9.5
susheel kumar	6	6	2	6	78	4	39.5	3	21
Mahendra singh	5	5	2	6	78	5	59	3	21
Bhaver lal	8	3	1	6	78	5	59	3	21
Yogendra singh	6	6	4	7	93	5	59	3	21
Sakti singh	7	4	4	7	93	5	59	3	21
Aditya singh	6	4	3	7	93	5	59	3	21
Nirmala bai	5	4	2	7	93	5	59	3	21
Kamal singh	8	3	4	7	93	5	59	4	39.5
Ganeshram	5	6	2	7	93	5	59	4	39.5
pooran chandra	6	5	1	7	93	6	78	4	39.5
Dhanna lal	6	4	4	8	99.5	6	78	4	39.5
Bhaiya lal	8	3	4	8	99.5	6	78	4	39.5
Harish chandra	9	3	4	8	99.5	6	78	4	39.5
Pushpendra	9	6	2	8	99.5	6	78	4	39.5
Madan singh	7	5	4	8	99.5	6	78	4	39.5
Bhairo singh	6	6	1	8	99.5	6	78	4	39.5
Mohan singh		6	3	9	105.	6	78	4	39.5
Karan singh	8	5	4	9	105.	6	78	4	39.5
Malkhan singh	7	6	2	9	105.	6	78	4	39.5
Akhalesh	5	6	2	9	105.	6	78	4	39.5
Amit kumar	9	5	4	9	105.	6	78	4	39.5
Gopal rao	7	5	3	9	105.	6	78	4	39.5
Average		-		-	85.39	-	54.65	-	23.46

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3074$	= 85.39
$T_2 = 1968$	= 54.65
$T_3 = 845$	= 23.46

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.77

$$SS = (3074^2 + 1968^2 + 845^2)/36 - (3074 + 1968 + 845)^2/108$$

$$SS = 69038.35$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.78

$$= 12 \times 69038.35/108(109)$$

$$= 70.37$$

The average values for suitability of irrigation method in command area of Sayar WUA that is sprinkler irrigation system, border irrigation system and flood irrigation system was found to be 85.39, 54.65 and 23.46, respectively as shown in Table 4.53. The data was analyzed using nonparametric approach. The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in suitability of irrigation.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in suitability of irrigation.

The Chi-square test value was 70.37 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and found that there was significant difference in values was observed among sprinkler irrigation, border irrigation and flood irrigation methods.

Table 4.54 Scoring for Control and Management of Water in Command Area in Neemkheda WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
	Rajesh dubey	7	5	5	7	70.5	4	28	1
Ramesh chandra	8	7	5	7	70.5	4	28	1	3.5
Prakash chandra	8	7	3	7	70.5	4	28	1	3.5
Abadhnarayan	7	4	4	7	70.5	4	28	1	3.5
Renu tiwari	9	6	4	7	70.5	4	28	1	3.5
Hukam singh	10	4	5	7	70.5	4	28	1	3.5
Komal singh	9	6	3	7	70.5	4	28	2	9.5
Shivcharan	9	6	5	7	70.5	5	44.5	2	9.5
Rambabu	7	7	1	7	70.5	5	44.5	2	9.5
Ramkali	10	4	5	8	86.5	5	44.5	2	9.5
Rajendra kumar	8	5	1	8	86.5	5	44.5	2	9.5
Ram manohar	10	4	5	8	86.5	5	44.5	2	9.5
Pawan kumar	7	5	4	8	86.5	5	44.5	3	16.5
Uttam rao	7	4	3	8	86.5	5	44.5	3	16.5
susheel kumar	9	7	2	8	86.5	5	44.5	3	16.5
Mahendra singh	10	7	2	8	86.5	5	44.5	3	16.5
Bhaver lal	8	5	1	8	86.5	5	44.5	3	16.5
Yogendra singh	9	7	5	8	86.5	6	56.5	3	16.5
Sakti singh	7	5	4	8	86.5	6	56.5	3	16.5
Aditya singh	8	4	3	9	96	6	56.5	3	16.5
Nirmala bai	10	7	2	9	96	6	56.5	4	28
Kamal singh	8	5	4	9	96	6	56.5	4	28
Ganeshram	10	4	2	9	96	6	56.5	4	28
pooran chandra	8	5	1	9	96	7	78	4	28
Dhanna lal	9	7	3	9	96	7	79	4	28
Bhaiya lal	8	7	3	9	96	7	80	4	28
Harish chandra	9	7	5	9	96	7	81	4	28
Pushpendra	8	7	2	9	96	7	82	4	28
Madan singh	7	5	4	10	104.	7	83	5	44.5
Bhairo singh	10	6	1	10	104.	7	84	5	44.5
Mohan singh	9	7	3	10	104.	7	85	5	44.5
Karan singh	8	6	4	10	104.	7	86	5	44.5
Malkhan singh	7	5	2	10	104.	7	87	5	44.5
Akhalesh	10	6	1	10	104.	7	88	5	44.5
Amit kumar	9	5	4	10	104.	7	89	5	44.5
Gopal rao	7	7	3	10	104.	7	90	5	44.5
Average	-			-	88.88	-	57.56	-	21.94

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 3200$	=	88.88
$T_2 = 2072$	=	57.56
$T_3 = 790$	=	21.94

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.79

$$SS = (3200^2 + 2072^2 + 790^2)/36 - (3200 + 2072 + 790)^2/108$$
$$SS = 80745.1$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.80

$$= 12 \times 80745.1 / 108(109)$$
$$= 82.30$$

The mean values of ranking allotted to sprinkler irrigation, border irrigation and flood irrigation system was found to be 88.88, 57.56 and 21.94, respectively as shown in Table 4.54. The data was analyzed using nonparametric approach. The null hypothesis was postulated as below

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in control and management of water.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in control and management of water.

The Chi-square test value was 82.30 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods as for as scoring for control and management of water in command area of Neemkheda water user association.

Table 4.55 Scoring for Availability of Nearby City in Neemkheda WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Rajesh dubey	3	6	9	2	4.5	4	25	7	73
Ramesh chandra	2	7	9	2	4.5	4	25	7	73
Prakash chandra	2	5	8	2	4.5	4	25	7	73
Abadhnarayan	3	7	9	2	4.5	4	25	7	73
Renu tiwari	4	7	8	2	4.5	4	25	7	73
Hukam singh	2	5	8	2	4.5	4	25	7	73
Komal singh	4	7	9	2	4.5	4	25	7	73
Shivcharan	3	5	9	2	4.5	5	44	7	73
Rambabu	4	7	8	3	12.5	5	44	7	73
Ramkali	4	5	9	3	12.5	5	44	7	73
Rajendra kumar	5	5	9	3	12.5	5	44	7	73
Ram manohar	2	7	7	3	12.5	5	44	7	73
Pawan kumar	5	5	7	3	12.5	5	44	8	90
Uttam rao	4	6	9	3	12.5	5	44	8	90
susheel kumar	3	7	8	3	12.5	5	44	8	90
Mahendra singh	2	4	7	3	12.5	5	44	8	90
Bhaver lal	5	5	9	4	25	5	44	8	90
Yogendra singh	4	5	9	4	25	5	44	8	90
Sakti singh	5	6	7	4	25	6	58	8	90
Aditya singh	2	4	8	4	25	6	58	8	90
Nirmala bai	3	7	7	4	25	6	58	8	90
Kamal singh	3	6	9	4	25	6	58	8	90
Ganeshram	2	4	7	4	25	6	58	8	90
pooran chandra	4	7	9	4	25	6	58	9	102
Dhanna lal	2	4	7	4	25	6	58	9	102
Bhaiya lal	3	7	8	4	25	7	73	9	102
Harish chandra	5	6	7	5	44	7	73	9	102
Pushpendra	4	5	8	5	44	7	73	9	102
Madan singh	3	4	7	5	44	7	73	9	102
Bhairo singh	5	6	9	5	44	7	73	9	102
Mohan singh	4	5	7	5	44	7	73	9	102
Karan singh	5	6	7	5	44	7	73	9	102
Malkhan singh	5	4	8	5	44	7	73	9	102
Akhalesh	4	7	8	5	44	7	73	9	102
Amit kumar	5	5	8	5	44	7	73	9	102
Gopal rao	5	4	7	5	44	7	73	9	102
Average	-	-	-	-	22.94	-	51.89	-	88.67

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 826$	=	22.94
$T_2 = 1868$	=	51.89
$T_3 = 3192$	=	88.67

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.81

$$SS = (826^2 + 1868^2 + 3192^2)/36 - (826 + 1868 + 3192)^2/108$$
$$SS = 78117.56$$

Chi square test = $12 \times (SS) / N(N+1)$ ----- 4.82

$$= 12 \times 78117.56 / 108(109)$$
$$= 79.63$$

The mean of rank values of score matrix for availability of nearby city location of Ucher water user association for adopting sprinkler irrigation, border irrigation and flood irrigation system was found to be 22.94, 51.89 and 88.67, respectively as shown in Table 4.55. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in availability of nearby city.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in availability of nearby city.

The calculated Chi-square test value was 79.63 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis was rejected.

Table 4.56 Scoring for Time Saving of Irrigation Method in Command Area in Neemkheda WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Rajesh dubey	10	4	2	6	70	3	15.5	2	4.5
Ramesh chandra	10	4	3	6	70	3	15.5	2	4.5
Prakash chandra	8	5	2	6	70	3	15.5	2	4.5
Abadh narayan	6	3	5	6	70	3	15.5	2	4.5
Renu tiwari	9	6	4	6	70	3	15.5	2	4.5
Hukam singh	10	3	2	6	70	3	15.5	2	4.5
Komal singh	6	5	3	7	83	3	15.5	2	4.5
Shivcharan	8	3	5	7	83	4	32.5	2	4.5
Rambabu	9	4	3	7	83	4	32.5	3	15.5
Ramkali	10	3	3	7	83	4	32.5	3	15.5
Rajendra kumar	6	6	2	7	83	4	32.5	3	15.5
Ram manohar	8	4	3	7	83	4	32.5	3	15.5
Pawan kumar	10	3	2	7	83	4	32.5	3	15.5
Uttam rao	9	6	2	7	83	4	32.5	3	15.5
susheel kumar	7	5	4	7	83	4	32.5	3	15.5
Mahendra singh	9	6	5	8	91.5	4	32.5	4	32.5
Bhaver lal	7	6	4	8	91.5	5	52	4	32.5
Yogendra singh	9	6	2	8	91.5	5	52	4	32.5
Sakti singh	7	6	4	8	91.5	5	52	4	32.5
Aditya singh	8	3	5	8	91.5	5	52	4	32.5
Nirmala bai	7	6	4	8	91.5	5	52	4	32.5
Kamal singh	9	6	5	8	91.5	5	52	4	32.5
Ganeshram	8	3	4	8	91.5	5	52	4	32.5
pooran chandra	7	4	4	9	98.5	5	52	4	32.5
Dhanna lal	8	6	4	9	98.5	5	52	4	32.5
Bhaiya lal	7	5	2	9	98.5	6	70	4	32.5
Harish chandra	6	4	5	9	98.5	6	70	5	52
Pushpendra	8	5	4	9	98.5	6	70	5	52
Madan singh	7	4	5	9	98.5	6	70	5	52
Bhairo singh	10	5	4	10	105	6	70	5	52
Mohan singh	8	4	4	10	105	6	70	5	52
Karan singh	7	5	5	10	105	6	70	5	52
Malkhan singh	6	4	3	10	105	6	70	5	52
Akhalesh	10	5	5	10	105	6	70	5	52
Amit kumar	7	6	5	10	105	6	70	5	52
Gopal rao	6	5	3	10	105	6	70	5	52
Average	-			-	89.58	-	45.53	-	28.39

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 3225$	=	89.58
$T_2 = 1639$	=	45.53
$T_3 = 1022$	=	28.39

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.83

$$SS = (3225^2 + 1639^2 + 1022^2)/36 - (3225 + 1639 + 1022)^2/108$$

$$SS = 71752.72$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.84

$$= 12 \times 71752.72/108(109)$$

$$= 73.14$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 89.58, 45.53 and 28.39, respectively as shown in Table 4.56. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in time saving of irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods in time saving of irrigation method.

The Chi-square test value was 73.14 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. It was concluded that time of saving matters among sprinkler irrigation, border irrigation and flood irrigation system.

Table 4.57 Scoring for Ease Operation of Various Irrigation Methods in Neemkheda WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Rajesh dubey	6	6	2	6	74	3	18.5	2	5
Ramesh chandra	8	4	5	6	74	3	18.5	2	5
Prakash chandra	8	3	2	6	74	3	18.5	2	5
Abadhnarayan	7	5	5	6	74	3	18.5	2	5
Renu tiwari	9	6	2	6	74	3	18.5	2	5
Hukam singh	6	3	4	6	74	3	18.5	2	5
Komal singh	9	3	3	6	74	3	18.5	2	5
Shivcharan	6	4	3	6	74	3	18.5	2	5
Rambabu	8	4	4	6	74	3	18.5	2	5
Ramkali	8	4	3	6	74	3	18.5	3	18.5
Rajendra kumar	6	4	4	6	74	4	37	3	18.5
Ram manohar	8	3	4	6	74	4	37	3	18.5
Pawan kumar	9	3	5	7	87.5	4	37	3	18.5
Uttam rao	7	3	2	7	87.5	4	37	3	18.5
susheel kumar	7	4	3	7	87.5	4	37	3	18.5
Mahendra singh	6	6	4	7	87.5	4	37	3	18.5
Bhaver lal	8	3	4	7	87.5	4	37	3	18.5
Yogendra singh	6	5	2	7	87.5	4	37	4	37
Sakti singh	7	3	5	7	87.5	4	37	4	37
Aditya singh	7	5	3	7	87.5	4	37	4	37
Nirmala bai	7	4	3	8	95.5	4	37	4	37
Kamal singh	8	5	2	8	95.5	5	55.5	4	37
Ganeshram	9	3	4	8	95.5	5	55.5	4	37
pooran chandra	6	6	5	8	95.5	5	55.5	4	37
Dhanna lal	9	3	2	8	95.5	5	55.5	4	37
Bhaiya lal	8	5	5	8	95.5	5	55.5	5	55.5
Harish chandra	6	5	2	8	95.5	5	55.5	5	55.5
Pushpendra	6	6	3	8	95.5	5	55.5	5	55.5
Madan singh	7	4	5	9	103.	6	74	5	55.5
Bhairo singh	9	5	5	9	103.	6	74	5	55.5
Mohan singh	6	5	2	9	103.	6	74	5	55.5
Karan singh	9	4	5	9	103.	6	74	5	55.5
Malkhan singh	6	6	3	9	103.	6	74	5	55.5
Akhalesh	6	6	5	9	103.	6	74	5	55.5
Amit kumar	9	6	5	9	103.	6	74	5	55.5
Gopal rao	7	4	4	9	103.	6	74	5	55.5
Average	-			-	88.33	-	43.68	-	30.54

	Mean	
$T_1 = 3180$	=	88.33
$T_2 = 1573$	=	43.68
$T_3 = 1100$	=	30.54

$$\text{Sum of Square (SS)} = (T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N \quad \text{-----} \quad 4.85$$

$$SS = (3180^2 + 1573^2 + 1100^2)/36 - (3180 + 1573 + 1100)^2/108$$

$$SS = 66076.53$$

$$\text{Chi square test} = 12 \times (SS)/N(N+1) \quad \text{-----} \quad 4.86$$

$$= 12 \times 66076.53 / 108(109)$$

$$= 67.35$$

The score matrix for ease operation of various irrigation methods was prepared as shown in table 4.21. The mean values of treatment T_1 , T_2 and T_3 was found to be 88.33, 43.68 and 30.54, respectively as shown in Table 4.57. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for ease operation of various irrigation methods.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for ease operation of various irrigation methods.

The Chi-square test value was 67.35 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that ease of operation of irrigation methods is very important for farmers of Neemkheda water user association.

Table 4.58 Scoring for Water Saving of Irrigation Method in Command Area in Neemkheda WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Rajesh dubey	6	4	1	6	72	3	20.5	1	3
Ramesh chandra	8	5	2	6	72	3	20.5	1	3
Prakash chandra	9	4	3	6	72	3	20.5	1	3
Abadhnarayan	6	5	2	6	72	3	20.5	1	3
Renu tiwari	9	4	1	6	72	3	20.5	1	3
Hukam singh	6	5	4	6	72	3	20.5	2	8.5
Komal singh	8	4	3	6	72	3	20.5	2	8.5
Shivcharan	6	5	2	6	72	4	38	2	8.5
Rambabu	8	4	3	7	85	4	38	2	8.5
Ramkali	9	5	1	7	85	4	38	2	8.5
Rajendra kumar	6	4	3	7	85	4	38	2	8.5
Ram manohar	8	4	2	7	85	4	38	3	20.5
Pawan kumar	6	5	1	7	85	4	38	3	20.5
Uttam rao	9	6	1	7	85	4	38	3	20.5
susheel kumar	8	4	4	7	85	4	38	3	20.5
Mahendra singh	8	4	7	7	85	4	38	3	20.5
Bhaver lal	9	4	4	7	85	4	38	3	20.5
Yogendra singh	8	3	3	8	93.5	5	55	3	20.5
Sakti singh	9	6	4	8	93.5	5	55	3	20.5
Aditya singh	7	3	3	8	93.5	5	55	3	20.5
Nirmala bai	8	6	5	8	93.5	5	55	3	20.5
Kamal singh	7	3	3	8	93.5	5	55	3	20.5
Ganeshram	9	6	2	8	93.5	5	55	4	38
pooran chandra	7	3	4	8	93.5	5	55	4	38
Dhanna lal	9	6	5	8	93.5	5	55	4	38
Bhaiya lal	7	3	4	9	103	5	55	4	38
Harish chandra	9	6	2	9	103	5	55	4	38
Pushpendra	9	5	3	9	103	6	72	4	38
Madan singh	7	6	5	9	103	6	72	4	38
Bhairo singh	9	3	4	9	103	6	72	5	55
Mohan singh	7	5	3	9	103	6	72	5	55
Karan singh	6	6	5	9	103	6	72	5	55
Malkhan singh	9	3	5	9	103	6	72	5	55
Akhalesh	7	5	3	9	103	6	72	5	55
Amit kumar	6	6	5	9	103	6	72	5	55
Gopal rao	7	5	3	9	103	6	72	5	55
Average	-			-	89.50	-	47.82	-	26.18

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean
$T_1 = 3222$	= 89.50
$T_2 = 1722$	= 47.82
$T_3 = 943$	= 26.18

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.87

$$SS = (3222^2 + 1722^2 + 943^2)/36 - (3222 + 1722 + 943)^2/108$$

$$SS = 74578.35$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.88

$$= 12 \times 74578.35 / 108(109)$$

$$= 76.02$$

The mean values of specific irrigation that is sprinkler irrigation; border irrigation and flood irrigation were 89.50, 47.82, and 26.18, respectively as shown in Table 4.58. The data was analyzed using nonparametric approach. The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for water saving in irrigation methods.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for water saving in irrigation methods.

The Chi-square test value was 76.02 which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there was significant difference among sprinkler irrigation, border irrigation and flood irrigation methods as for as water saving in irrigation methods of Neemkheda water user association is concerned.

Table 4.59 Scoring for High income Irrigation Method in Command Area in Neemkheda WUA

Farmers name	Marks given by the farmers, for different Irrigation methods			Sprinkler		Border		Flood	
	Sprinkler	Border	Flood	Obs	Rank	Obs	Rank	Obs	Rank
Rajesh dubey	7	6	3	7	72.5	4	28	3	10
Ramesh chandra	7	6	4	7	72.5	4	28	3	10
Prakash chandra	9	7	4	7	72.5	4	28	3	10
Abadhnarayan	9	5	3	7	72.5	4	28	3	10
Renu tiwari	10	6	4	7	72.5	4	28	3	10
Hukam singh	9	5	5	7	72.5	4	28	3	10
Komal singh	7	7	4	7	72.5	4	28	3	10
Shivcharan	8	6	4	7	72.5	4	28	3	10
Rambabu	7	5	4	7	72.5	5	46	3	10
Ramkali	10	7	3	7	72.5	5	46	3	10
Rajendra kumar	9	7	5	7	72.5	5	46	3	10
Ram manohar	8	5	4	8	87.5	5	46	3	10
Pawan kumar	7	5	4	8	87.5	5	46	3	10
Uttam rao	10	6	4	8	87.5	5	46	3	10
susheel kumar	8	7	3	8	87.5	5	46	3	10
Mahendra singh	7	5	4	8	87.5	5	46	3	10
Bhaver lal	8	5	4	8	87.5	5	46	3	10
Yogendra singh	10	5	3	8	87.5	5	46	3	10
Sakti singh	8	5	4	8	87.5	5	46	3	10
Aditya singh	8	6	3	9	96.5	6	58.5	4	28
Nirmala bai	10	6	3	9	96.5	6	58.5	4	28
Kamal singh	9	5	4	9	96.5	6	58.5	4	28
Ganeshram	7	7	3	9	96.5	6	58.5	4	28
pooran chandra	9	4	3	9	96.5	6	58.5	4	28
Dhanna lal	7	5	3	9	96.5	6	58.5	4	28
Bhaiya lal	10	5	3	9	96.5	7	72.5	4	28
Harish chandra	9	5	3	9	96.5	7	72.5	4	28
Pushpendra	7	7	5	9	96.5	7	72.5	4	28
Madan singh	9	4	3	9	96.5	7	72.5	5	46
Bhairo singh	8	7	3	10	105	7	72.5	5	46
Mohan singh	7	5	5	10	105	7	72.5	5	46
Karan singh	9	7	3	10	105	7	72.5	5	46
Malkhan singh	8	5	5	10	105	7	72.5	5	46
Akhalesh	7	4	5	10	105	7	72.5	5	46
Amit kumar	9	7	4	10	105	7	72.5	5	46
Gopal rao	7	4	4	10	105	7	72.5	5	46
Average	-			-	88.82	-	52.18	-	22.50

Number of treatment (T) = 3

Number of replication $R_1 = 36, R_2 = 36, R_3 = 36$

Total number of replication (N) = $R_1 + R_2 + R_3 = 36 + 36 + 36 = 108$

	Mean	
$T_1 = 3198$	=	88.82
$T_2 = 1879$	=	52.18
$T_3 = 810$	=	22.50

Sum of Square (SS) = $(T_1^2 + T_2^2 + T_3^2)/r - (T_1 + T_2 + T_3)^2/N$ ----- 4.89

$$SS = (3198^2 + 1879^2 + 810^2)/36 - (3198 + 1879 + 810)^2/108$$
$$SS = 79459.35$$

Chi square test = $12 \times (SS)/N(N+1)$ ----- 4.90

$$= 12 \times 77787/108(109)$$
$$= 80.99$$

The mean values of specific irrigation that is sprinkler irrigation, border irrigation and flood irrigation were 88.82, 52.18 and 22.50, respectively as shown in Table 4.59. The data was analyzed using nonparametric approach.

The null hypothesis was postulated as below.

H_0 : There is no significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for high income irrigation method.

H_1 : There is significant difference among sprinkler irrigation, border irrigation and flood irrigation methods for high income irrigation method.

The Chi-square test value was 80.99, which was larger than the tabulated value 5.99 and 9.21 on 2 degree of freedom at 5% and 1% level of significance, respectively. Thus the null hypothesis is rejected and concluded that there were significant difference among sprinkler irrigation, border irrigation and flood irrigation methods.

4.10 Conjunctive Plan for Surface and Pressurized Irrigation System

It was found from the survey of the study area that about 60% of the land is owned by medium and large farmers and about 40% of the land is owned by small and marginal farmers as shown in table 4.1. At the same time, the fact emerged from the feasibility analysis that medium and large farmers were showing willingness and having purchase capacity also and feels no problem in handling and management of sprinkler irrigation system. On the other side small and medium farmers was not agreed fully for adoption and they have few problems along with low investment capacity. It was also reported by many researchers that flood irrigation is mainly responsible for low water productivity and it must be replaced by pressurized irrigation system and improved surface method of irrigation. Looking to these facts a plan was prepared taking a hypothesis that about 60% area should be brought under sprinkler irrigation system and about 40% area under border irrigation system and no flood irrigation system should be practiced.

4.10.1 Planning for the Entire RBC Command

It is clear that a combination of sprinkler and border irrigation system in a ratio of 60:40 is best suitable for entire RBC command area. So the irrigation planning for the entire area was made accordingly. Based on the topography and distance from the RBC area at higher elevation undulating area and nearer to RBC was found suitable for sprinkler irrigation system while the rest of the area that is flat area was found suitable for border irrigation system. It is also recommended that flood irrigation should not be practiced. A map showing all the villages with elevation (in parentheses) is given in Fig 4.3. Villages having area recommended under sprinkler irrigation are marked red. Village wise area as recommended under sprinkler irrigation system (60%) and area should be covered by border irrigation system (40%) is presented in Table 4.60.

Table 4.60 Area Proposed Under Sprinkler and Border Irrigation Methods

Name of WUA	Name of village	Canal irrigated area (ha)	Area proposed under irrigation methods	
			Border (40%)	Sprinkler (60%)
Sarchampa	Bansakheda	477	152	325
	Silwaha	245	122	123
	Sarchampa	365	225	140
Ucher	Moralikhedi	184	-	184
	Naranda	65	-	65
	Gulgaonv	140	25	115
	Firojpur	240	40	200
	Chiroli	177	175	2
	Fatehpur	262	100	160
	Uneeda	52	22	30
	Airan	188	40	148
	Dhaniyakhedi	138	130	8
	Anauri berkhedi	360	48	312
	Ucher	257	98	159
	Dargava	50	30	20
	Kanakhedakalan	195	50	145
	Mada	170	48	122
	Madvai	400	104	296
	Kamapar	243	38	205
Nonakhedi	89	15	74	
Medaki	Dakana chapana	220	15	205
	Medaki	354	249	105
	Suakhedi	130	130	0
	Sookhansen	50	40	10
	Aamkheda	102	102	0

	Ratanpur girdhari	155	145	10
	Kachhikanakheda	180	180	-
	Vilori	145	145	-
	Nagori	105	105	-
	Piparia khurd	80	80	-
	Mudiakheda	5	-	5
	Muktapur	25	-	25
	Sunari	25	-	25
	Rataltai	20	-	20
	Khamkheda	15	15	-
Sayar	Sayar	660	72	588
	Bagaud	291	99	192
	Parasi khurd	122	122	-
	Patharia	12	12	-
	Karela	256	72	184
	Madaiya khurd	78	73	5
	Suganakhedi	258	70	188
	Bala barkheda	35	-	35
	Bamora	183	-	183
Neemkheda	Neemkheda	684	180	504
	Sunpura	289	54	235
	Karaiya haveli	172	52	120
	Rangai	75	70	5
	Berkhedi	85	27	60
	Padariya maphi	75	70	5
	Udaygiry	90	90	-
	Base	132	32	100
	Vighan	98	38	60
Total	-	9503	3801	5702

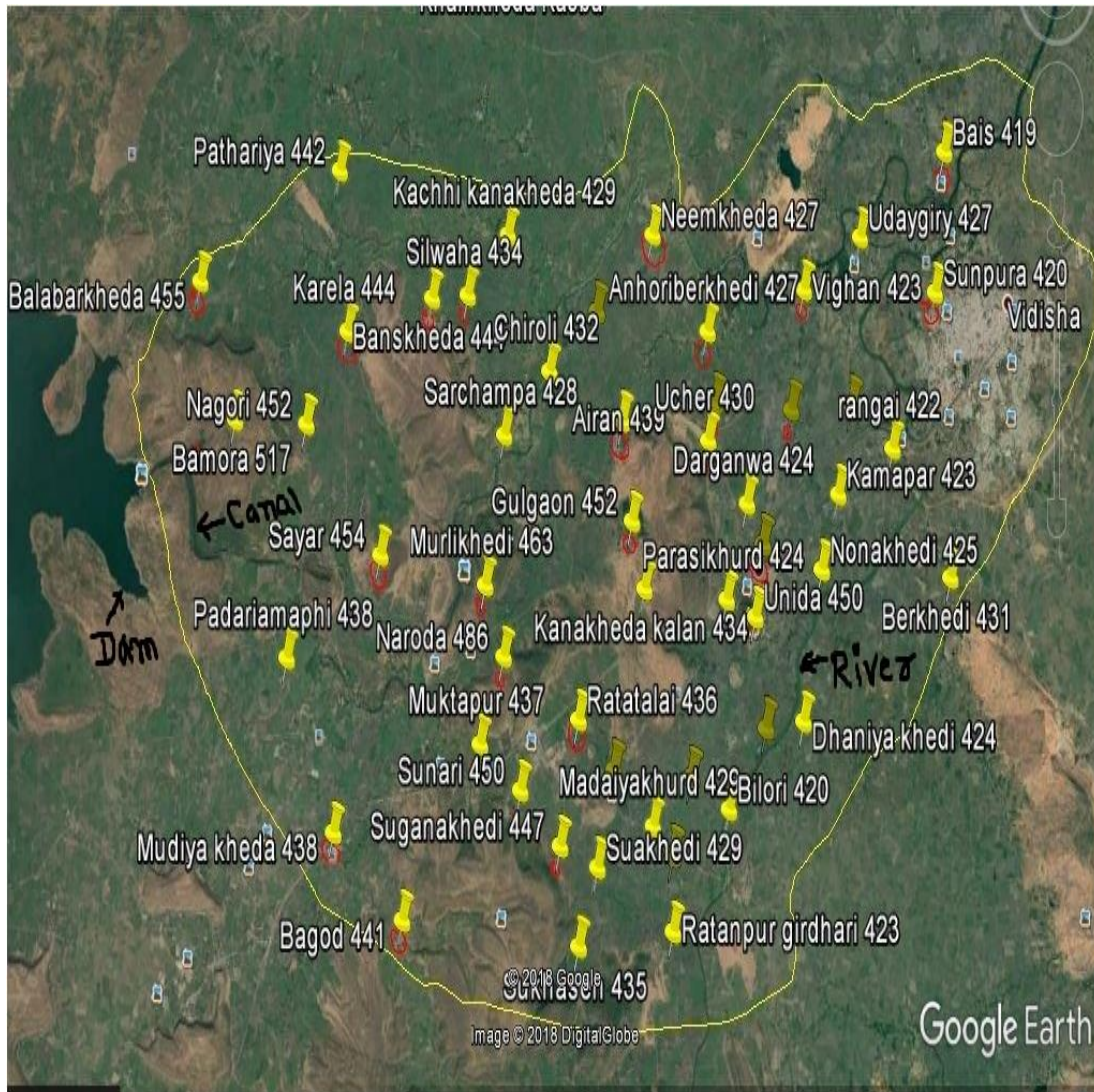


Fig. 4.3 Planning in RBC Command Area

4.11 Implementation and Evaluation at Farmer's Field

In order to implement and evaluate the plan at farmers field 15th farmers (5 head, 5 middle and 5 tail reach) were selected from the farmers list using random number technique. To fit the experiment in statistical design six levels of sprinkler irrigation system and border irrigation system combination at a width of 10 and 20 intervals were tried. The level 0-100, 10-90, 20-80, 30-70, 40-60, 50-50, 60-40, 70-30, 80-20, 90-10 and 100-0 (sprinkler irrigation - border irrigation system) was found non significant in the analysis of variance table because the critical difference among the various levels of the sprinkler irrigation and border irrigation system, whereas the levels (sprinkler- border irrigation system) 0-100, 20-80, 40-60, 60-40, 80-20 and 100-0 was found significant in the analysis of variance

table because the critical difference among the various levels of the sprinkler irrigation and border irrigation system was found to be at for implementation in the command area. Experiment was laid down having all these levels of irrigation at each farmer's field. Thus a total of six treatments were taken at each field. Crop variety and other crop management was kept same for all replications. Observations were recorded for each level and have been presented in Table 4.61, Table 4.62 and 4.63 reveals about the impact of pressurized irrigation method and border irrigation method at various levels through the technique of ANOVA. The sprinkler irrigation method and border irrigation method was taken to at width of 20 interval considering over all 100 at each level of irrigation including sprinkler irrigation method and border irrigation method. Significant difference in the yield was found and it was concluded that sprinkler irrigation method was having more yield than border irrigation method. The ANOVA table indicated that the irrigation method differing at an interval of 20% was found to be significant at 5% and 1% level of significance. When the data were analyzed using the same technique taking concentration at 10 percent interval, they were not found to significant. It concluded that the irrigation method differed significantly when the concentration different were more than 10%. The null hypothesis was postulated as below.

H_0 : There is no significant difference among all the level of the combination of sprinkler irrigation method and border irrigation method.

H_1 : There is significant difference among all the level of the combination of sprinkler irrigation method and border irrigation method.

Table 4.61 Impact of Sprinkler Irrigation System and Surface Irrigation System on the Yield of Wheat Crop

Name of farmers			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Max. yield (q ha ⁻¹)	Mean
Tm	Sprinkler area %	Bor der area %	yield (q ha-1)	Yield (q ha-1)	Yield (q ha ⁻¹)	yield (q ha ⁻¹)	Yield (q ha ⁻¹)	yield (q ha ⁻¹)	yield (q ha ⁻¹)	yield (q ha ⁻¹)	yield (q ha ⁻¹)	yield (q ha ⁻¹)	yield (q ha ⁻¹)	yield (q ha ⁻¹)	yield (q ha ⁻¹)	yield (q ha ⁻¹)	yield (q ha ⁻¹)		
T ₁	0	100	32.0	35.0	34.00	32.00	33.00	33.00	35.00	36.00	31.00	32.00	32.00	34.00	35.00	35.00	36.00	36.00	33.67
T ₂	20	80	36.0	34.8	33.40	37.40	36.20	35.00	36.20	37.20	36.80	35.40	36.80	36.00	34.80	35.00	36.00	37.40	35.80
T ₃	40	60	37.0	36.4	36.60	38.40	38.60	38.40	39.40	39.40	36.80	36.40	36.00	38.60	37.60	38.60	37.20	39.40	37.69
T ₄	60	40	40.4	40.4	39.60	40.00	39.00	39.80	40.20	41.00	40.00	40.40	40.00	39.60	40.20	38.60	40.60	41.00	39.99
T ₅	80	20	41.0	42.0	40.80	41.00	41.00	41.00	41.80	42.00	41.00	40.80	43.00	42.80	43.00	41.20	42.00	43.00	41.63
T ₆	100	0	44.0	45.0	46.00	45.00	42.00	43.00	42.00	46.00	44.00	45.00	44.00	44.00	45.00	44.00	43.00	46.00	44.13
Average			-															38.8	

Not: 1, 2, 3,.....15 are name of the farmers given appendix B and **Tm** is treatment

Table 4.62 Difference Among all the Level of the Combination of Sprinkler Irrigation and Border Irrigation Method.

Treatment	Mean	T ₁ -T ₁ -T ₆	T ₂ -T ₁ -....T ₆	T ₃ -T ₁ -....T ₆	T ₄ -T ₁ -....T ₆	T ₅ -T ₁ -....T ₆	T ₆ -T ₁ -....T ₆
T ₁	33.67	0.00	2.13	4.03	6.32	7.96	10.47
T ₂	35.80	-2.13	0.00	1.89	4.19	5.83	8.33
T ₃	37.69	-4.03	-1.89	0.00	2.29	3.93	6.44
T ₄	39.99	-6.32	-4.19	-2.29	0.00	1.64	4.15
T ₅	41.63	-7.96	-5.83	-3.93	-1.64	0.00	2.51
T ₆	44.13	-10.47	-8.33	-6.44	-4.15	-2.51	0.00

Table 4.63 Structure of ANOVA Table

S. No.	S.V.	D.F.	S.S.	M.S.	F. cal.	F.tab.
1	Replication	14	22.93	151.04	183.07	5%= 2.35
2	Treatment	5	755.20			t = 2
3	Error	70	57.76	0.825		C.D=0.65

To arrive an optimum ratio of border irrigation method and sprinkler irrigation method. The percent area ratio for adoption of sprinkler irrigation method and border irrigation method was grouped as 0-100%, 20-80%, 40-60%, 60-40%, 80-20% and 100-0%. The experiment was planned in 15 farmers' fields having percent area distribution under border irrigation system and sprinkler irrigation system as shown in Table 4.61. The yield of wheat was obtained in each treatment and it was found that maximum yield 46 q ha^{-1} was found under treatment T_6 (100-0) that is 100% sprinkler and 0% border followed by T_5 (43 q ha^{-1}), T_4 (41 q ha^{-1}), T_3 (39 q ha^{-1}), T_2 (37 q ha^{-1}) and T_1 (36 q ha^{-1}). The overall average yield of wheat was found $38.82 \text{ (q ha}^{-1}\text{)}$. In present situation the entire area under experiment could not be replaced by either sprinkler irrigation system or border irrigation system as far as feasibility of adoption and economics of farmers is concerned. Wheat yield 39.99 q ha^{-1} under the treatment T_4 (60:40) is almost nearest to average yield $38.82 \text{ (q ha}^{-1}\text{)}$. Hence, it is recommended that in first phase 60% of total RBC command area must be replaced by sprinkler irrigation system and 40% area must be replaced by border irrigation system in place of flood irrigation system to enhance the water productivity and water use efficiency.

4.12 Enhancing Water Productivity

It was found that average water productivity in case of sprinkler irrigation system, border irrigation system and flood irrigation system was recorded as 1.32 kg m^{-3} , 0.75 kg m^{-3} and 0.61 kg m^{-3} , respectively as shown in Table 4.64. An increase of 76% in the water productivity was observed, if border irrigation system is replaced by sprinkler irrigation system. Similarly 116% increase in water productivity was found if flood irrigation system is replaced by sprinkler irrigation system and about 23% increase in water productivity was found if flood irrigation system is replaced by border irrigation system.

Table 4.64: Average Wheat Crop Yield and Water Productivity for Three Irrigation Method in Command Area

S. No.	Irrigation Method	Average Water Productivity (kg m ⁻³)	Average Yield (t ha ⁻¹)
1	Sprinkler	1.32	4.40
2	Border	0.75	3.36
3	Flood	0.61	2.88

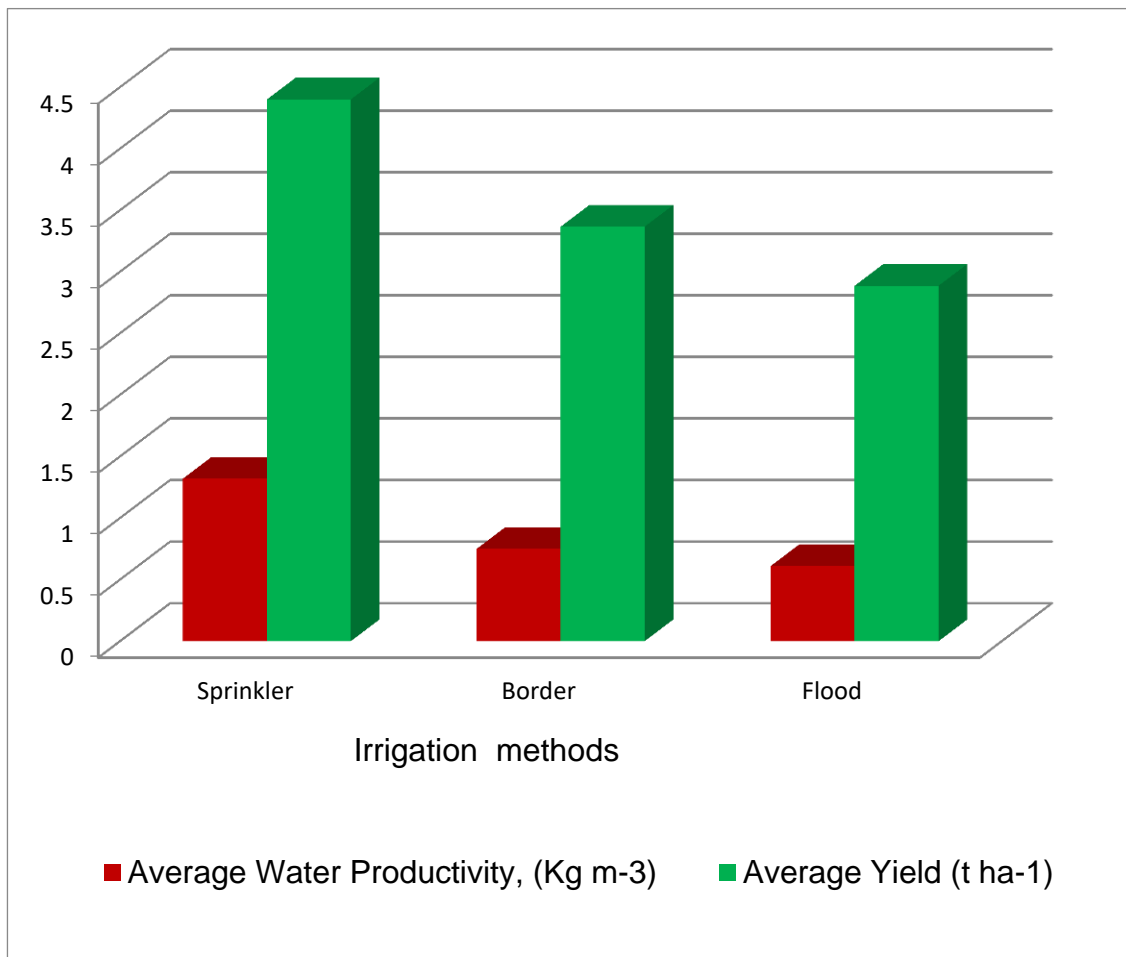


Fig 4.4: Wheat Crop Yield and Water Productivity for Three Irrigation Methods

4.13 Irrigation Area Increased through Adoption of Technology

Combination of recommended irrigation methods that is 60% area was covered by sprinkler irrigation system and 40% area was covered by border irrigation system was adopted for irrigating the wheat crop in the entire command area of RBC. Table 4.65 reveals that 20% saving in water is obtained and consequent upon it 2016 ha additional area may be brought under irrigation and thus increasing the cropping intensity by 8.60%.

Table 4.65 Increase in Irrigated Area through Adoption of Technology

Irrigation method	% Area covered (ha)	Total water required (m ³)	Water requirement (m ³ ha ⁻¹)	% Saving of water as compared to flood	Irrigated area increased (ha)
Flood	100% (9503 ha)	45349494	4772.12	Nil	Nil
Sprinkler	60% (5702 ha)	19122113.2	3353.58	29.72	2995
Border	40% (3801 ha)	17155950.3	4513.53	5.42	546
Sprinkler (60%) + Border (40%)	100% (9503 ha)	36278063.5	3817.53	20.00	2016

SUMMARY, CONCLUSIONS AND SUGGESTIONS

FOR FURTHER WORK

This study was planned to assess the present irrigation system, water productivity and cropping intensity of the right bank canal command area of Samrat Ashok Sagar project. The techno-economic feasibility of pressurized irrigation system was also assessed in view of conjunctive plan preparation for surface and pressurized irrigation system as well as implementation of plan at farmer's field.

5.1 Summary

The primary data were collected personally by interviewing the water users with the help of structured and pre-tested interview perform. The secondary data was collected from various government agencies and literature. The results were summarized as characteristics of present irrigation system, preparing improvement plan and evaluation of proposed plan at farmers' fields of right bank canal command area of Samrat Ashok Sagar Project. The study area is 9503 ha which is irrigated from canal system of RBC. Main canal is 23.43 km long with a slope of 1 in 1000. The command area has 984 ha land holding ranging from 0.25 ha to 1 ha belonging to 1743 farmers. Majority of farmers were marginal and small (up to 2 ha). The soils in the command have the texture from clay loam to sandy clay loam with clay varying from 43.25 to 39.52%. The major crop of the area is wheat during rabi, whereas, soybean is grown during kharif season. Discharge measured in main canal varies from $5.93 \text{ m}^3 \text{ sec}^{-1}$ at head reach to $2.92 \text{ m}^3 \text{ sec}^{-1}$ at tail reach. A detailed survey was conducted in order to know the existing condition and performance of the system. In RBC command WUA, middle reach has highest area followed by head and tail reach. Highest total number of farmers present in marginal category was 1743 and lowest 496 was found in large category. Highest total area 3417 ha was covered by middle reach in medium category and lowest 2982 ha was covered in head reach in marginal category. The cropping

intensity of the area was worked out and ranges from 115% to 196%. Similarly existing water productivity was found to be 0.60 kg m^{-3} . Performance of the project was judged through Nelson's indicators. These indicators were found as tail end supply ratio: 0.71, delivery timeliness ratio: 0.75 carrying capacity ratio: 0.79 and fee collection performance: 0.35. It was found that average water productivity in case of sprinkler irrigation system, border irrigation system and flood irrigation system was recorded as 1.32 kg m^{-3} , 0.75 kg m^{-3} and 0.61 kg m^{-3} , respectively. An increase of 76% in the water productivity was observed, if border irrigation system is replaced by sprinkler irrigation system. Similarly 116% increase in water productivity was found if flood irrigation system is replaced by sprinkler irrigation system and about 23% increase in water productivity was found if flood irrigation system is replaced by border irrigation system. In order to evaluate feasibility of the technology survey of the selected farmer was done using interview schedules. Data so obtained was analyzed statistically for all five Water Users Associations. It was clearly emerged from the analysis that the technology that is pressurized irrigation was found feasible for the study area. Based on the survey results and data of land holdings a ratio of 60:40 to sprinkler and border irrigation was found suitable to enhance water productivity. This concept was implemented and tested in farmer's field at 15 locations. It was found that the results agreed with planned irrigation methods level that is 60% area should come under sprinkler irrigation system and 40% area should come under border irrigation system. Combination of recommended irrigation methods that is 60% area was covered by sprinkler irrigation and 40% area was covered by border irrigation system was adopted for irrigating the wheat crop in the entire command area of RBC. It was found that 25% saving in water was obtained and consequent upon it 2016 ha additional area was brought under irrigation and thus increasing the cropping intensity by 8.60%.

5.2 Conclusions

1. Existing cropping intensity of RBC command area was found to be 163% and existing water productivity of RBC command area was 0.60 kg m^{-3} .
- 2(a). To assess techno-economic feasibility of pressurized irrigation system the characters like awareness of farmers, technical knowledge, attitude, willingness of adoption and purchasing capacity of farmers were considered and analyzed through Chi-square test and it was found that type of farmers and their awareness, technical knowledge, attitude, willingness of adoption and purchasing capacity of farmers dependent on each other that is the large farmer could have the different awareness, technical knowledge, attitude, willingness of adoption and purchasing capacity than marginal, small and medium farmers. On the basis of this, it is concluded that pressurized irrigation system is feasible for RBC command area of SAS Project Vidisha.
- 2(b). The ratio of 60:40 of sprinkler irrigation system and border irrigation system was found suitable for RBC command of Samrat Ashok Sagar project in view to enhance the water productivity, water use efficiency and cropping intensity in study area. The water saved through this level was found 9071431 m^3 (25%) and thus the additional area 2016 ha (21.21%) may be brought under irrigation through adoption of 60-40% irrigation level technology and increasing the cropping intensity by 8.59%.
3. Prepared conjunctive plan for surface and pressurized irrigation was implemented and evaluated in the 15 farmers field and was found suitable as per recommendations made under 2(b). A complete plan for entire RBC command area that is for 9503 ha was made and also recommended for implementation on the basis of results obtained in this study.

5.3 Suggestions for Future Work

1. Similar study for enhancing the water productivity and cropping intensity may also be done for left bank canal command area of Samrat Ashok Sagar project.
2. Computer based model for rotational water supply system may be developed for right bank canal and left bank canal command area.
3. Data Envelopment Analysis Technique may be used for evaluating the irrigation inefficiencies in a Samrat Ashok Sagar project.
4. A study for replacing the entire open surface water supply system by pipe flow may be done for 100% reduction in open surface water supply losses.

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Appendix- A

Performa for Survey of Farmers and Existing Cropping Pattern

1. Name of water user association-
2. Name of village
3. Name of farmer
4. Situation of farm at canal- Head reach, Middle reach, Tail reach
5. Size of land holding
6. Crops and cultivation practices:

Crop	Rabi crops	Kharif crops
Variety		
Date of sowing		
Seed rate		
Yield		
No. of irrigation		
Source of irrigation		
Method of irrigation		

6. Irrigation details

Irrigation	Day	Hours	discharge	Depth
First				
Second				
Third				
Fourth				

7. Power source for irrigation- Diesel / Electricity
8. How many HP (Electric moter/ Pump)
9. Source of water – Canal / Well / tube well
10. Distribution of water: - a) full b) half c) 1/3
11. In canal irrigation:

- a) Do you pay irrigation charges- yes/No
- b) How much amount paid per year -
- 12. Charge of electricity paid –
- 13. Do you collect canal water at different place- yes / no
If yes, so where Pond/ farm lower/ region
- 14. Khasra no. --

Techno-socio Characters Regarding Pressurized Irrigation in RBC

S. No.	Characters	Nil	Poor	Medium	High
1	Awareness				
2	Knowledge(Perception)				
3	Attitude				
4	willingness of adoption				
5	Purchase capacity				

Scoring to Characteristics of Technology

S. No.	Scoring to characteristics	Sprinkler	Border	Flood
1	Labour required			
2	Cost			
3	Suitability of soil/field			
4	Control and management of water			
5	Availability in nearby city			
6	Time saving			
7	Ease of operation			
8	Water saving			
9	High income			

Appendix- B

Implimentation and Evaluation of Plan at Farmers Field

S. No.	Farmers name	Reach	Area (ha)	Crop variety	Irrigation method	Discharge (lps)	Irrigation interval, days				No. of irrigation	Irrigation time (hr ha ⁻¹)	Water use (m ³ ha ⁻¹)	Yield (q ha ⁻¹)	Water Productivity (Kg m ⁻³)
1	Halkooram	M	0.05	GW 1544	Sprinkler	5.51	21	23	22	24	4	160	3352	44	1.31
2	Than singh	H	0.05	GW 1544	Sprinkler	5.01	24	22	24	25	4	160	3295	45	1.37
3	Jain Raid	M	0.05	GW 1544	Sprinkler	6.01	25	21	23	21	4	140	3407	46	1.35
4	Pyare lal	M	0.05	GW 1544	Sprinkler	6.01	26	23	24	20	4	140	3357	45	1.34
5	Ajab singh	T	0.05	GW 1544	Sprinkler	5.51	24	23	21	20	4	160	3364	42	1.25
6	Maharaj singh	T	0.05	GW 1544	Sprinkler	5.51	20	21	20	20	4	160	3300	43	1.30
7	Gulav singh	T	0.05	GW 1544	Sprinkler	6.01	20	21	21	22	4	140	3130	42	1.34
8	Meharwan singh	H	0.05	GW 1544	Sprinkler	5.01	23	24	20	21	4	180	3402	46	1.35
9	Narendra kumar	M	0.05	GW 1544	Sprinkler	6.01	22	25	20	22	4	140	3372	44	1.30
10	Mokhtayar Moh.	H	0.05	GW 1544	Sprinkler	5.01	21	21	21	20	4	180	3246	45	1.39
11	Sardar singh	H	0.05	GW 1544	Sprinkler	6.01	25	20	22	21	4	160	3750	44	1.17
12	Sardar singh	H	0.05	GW 1544	Sprinkler	6.01	22	21	20	23	4	140	3190	44	1.38
13	Balbant singh	M	0.05	GW 1544	Sprinkler	5.01	23	24	22	20	4	180	3246	45	1.39
14	Phool bai	T	0.05	GW 1544	Sprinkler	6.51	22	23	23	20	4	140	3281	44	1.34
15	Veer singh	T	0.05	GW 1544	Sprinkler	6.01	20	25	21	21	4	160	3502	43	1.23

S. No.	Farmers name	Reach	Area (ha)	Crop variety	Irrigation method	Discharge (lps)	Irrigation interval, days			No. of irrigation	Irrigation time (hr ha ⁻¹)	Water use (m ³ ha ⁻¹)	Yield (q ha ⁻¹)	Water Productivity (Kg m ⁻³)
1	Halkooram	M	0.05	GW 1544	Border	6.22	21	23	22	3	200	4478	32	0.71
2	Than singh	H	0.05	GW 1544	Border	5.91	24	22	24	3	200	4255	35	0.82
3	Jain Raid	M	0.05	GW 1544	Border	7.06	25	21	23	3	180	4575	34	0.74
4	Pyare lal	M	0.05	GW 1544	Border	6.16	26	23	24	3	200	4435	32	0.72
5	Ajab singh	T	0.05	GW 1544	Border	6.44	24	23	21	3	200	4637	33	0.71
6	Maharaj singh	T	0.05	GW 1544	Border	6.73	20	21	20	3	180	4361	33	0.76
7	Gulav singh	T	0.05	GW 1544	Border	6.41	20	21	21	3	200	4615	35	0.76
8	Meharwan singh	H	0.05	GW 1544	Border	7.25	23	24	20	3	160	4176	36	0.86
9	Narendra kumar	M	0.05	GW 1544	Border	6.93	22	25	20	3	180	4491	31	0.69
10	Mokhtayar Moh.	H	0.05	GW 1544	Border	5.19	21	21	21	3	220	4110	32	0.78
11	Sardar singh	H	0.05	GW 1544	Border	6.43	25	20	22	3	200	4630	32	0.69
12	Sardar singh	H	0.05	GW 1544	Border	7.53	22	21	20	3	160	4337	34	0.78
13	Balbant singh	M	0.05	GW 1544	Border	5.91	23	24	22	3	220	4681	35	0.75
14	Phool bai	T	0.05	GW 1544	Border	7.32	22	23	23	3	180	4743	35	0.74
15	Veer singh	T	0.05	GW 1544	Border	6.48	20	25	21	3	200	4666	36	0.77

S. No.	Farmers name	Reach	Area (ha)	Crop variety	Irrigation method	Discharge (lps)	Irrigation interval, days			No. of irrigation	Irrigation time (hr ha ⁻¹)	Water use (m ³ ha ⁻¹)	Yield (q ha ⁻¹)	Water Productivity (Kg m ⁻³)
1	Halkooram	M	0.05	GW 1544	Flood	6.22	23	22	21	3	220	4926	31	0.63
2	Than singh	H	0.05	GW 1544	flood	5.91	23	24	21	3	240	5106	32	0.63
3	Jain Raid	M	0.05	GW 1544	Flood	7.06	25	22	23	3	200	5083	30	0.59
4	Pyare lal	M	0.05	GW 1544	Flood	6.16	25	21	23	3	220	4879	27	0.55
5	Ajab singh	T	0.05	GW 1544	Flood	6.44	26	23	24	3	200	4637	28	0.60
6	Maharaj singh	T	0.05	GW 1544	Flood	6.73	25	20	21	3	180	4361	30	0.69
7	Gulav singh	T	0.05	GW 1544	Flood	6.41	24	26	24	2	200	4615	25	0.54
8	Meharwan singh	H	0.05	GW 1544	Flood	7.25	20	27	20	2	180	4698	24	0.51
9	Narendra kumar	M	0.05	GW 1544	Flood	6.93	26	23	26	2	180	4491	24	0.53
10	Mokhtayar Moh.	H	0.05	GW 1544	Flood	5.19	20	25	21	3	240	4484	33	0.74
11	Sardar singh	H	0.05	GW 1544	Flood	6.43	22	25	21	3	200	4630	32	0.69
12	Sardar singh	H	0.05	GW 1544	Flood	7.53	21	25	21	3	180	4879	34	0.70
13	Balbant singh	M	0.05	GW 1544	Flood	5.91	24	26	23	3	220	4681	27	0.58
14	Phool bai	T	0.05	GW 1544	Flood	7.32	26	20	23	3	180	4743	28	0.59
15	Veer singh	T	0.05	GW 1544	Flood	6.48	25	22	21	3	200	4666	28	0.60

Appendix- C

Release of Water from Right Bank Canal at Head Reach

Date	Discharge (Cusec)	Liter Sec ⁻¹
01-11-15	140	3962
02-11-15	140	3962
03-11-15	142	4018.6
04-11-15	142	4018.6
05-11-15	144	4075.2
06-11-15	144	4075.2
07-11-15	144	4075.2
08-11-15	146	4131.8
09-11-15	146	4131.8
10-11-15	152	4301.6
11-11-15	152	4301.6
12-11-15	152	4301.6
13-11-15	153	4329.9
14-11-15	155	4386.5
15-11-15	155	4386.5
16-11-15	155	4386.5
17-11-15	169	4782.7
18-11-15	169	4782.7
19-11-15	169	4782.7
20-11-15	169	4782.7
21-11-15	171	4839.3
22-11-15	171	4839.3
23-11-15	171	4839.3
24-11-15	171	4839.3
25-11-15	177	5009.1
26-11-15	177	5009.1
27-11-15	181	5122.3

28-11-15	181	5122.3
29-11-15	181	5122.3
30-11-15	181	5122.3
01-12-15	184	5207.2
02-12-15	184	5207.2
03-12-15	184	5207.2
04-12-15	75	2122.5
05-12-15	75	2122.5
06-12-15	75	2122.5
07-12-15	75	2122.5
08-12-15	80	2264
09-12-15	80	2264
10-12-15	143	4046.9
11-12-15	143	4046.9
12-12-15	143	4046.9
13-12-15	159	4499.7
14-12-15	159	4499.7
15-12-15	159	4499.7
16-12-15	159	4499.7
17-12-15	157	4443.1
18-12-15	157	4443.1
19-12-15	157	4443.1
20-12-15	157	4443.1
21-12-15	140	3962
22-12-15	140	3962
23-12-15	157	4443.1
24-12-15	157	4443.1
25-12-15	161	4556.3
26-12-15	161	4556.3
27-12-15	175	4952.5
28-12-15	175	4952.5

29-12-15	164	4641.2
30-12-15	164	4641.2
31-12-15	164	4641.2
01-01-16	164	4641.2
02-01-16	164	4641.2
03-01-16	154	4358.2
04-01-16	154	4358.2
05-01-16	154	4358.2
06-01-16	154	4358.2
07-01-16	154	4358.2
08-01-16	151	4273.3
09-01-16	151	4273.3
10-01-16	148	4188.4
11-01-16	148	4188.4
12-01-16	148	4188.4
13-01-16	144	4075.2
14-01-16	144	4075.2
15-01-16	144	4075.2
16-01-16	144	4075.2
17-01-16	144	4075.2
18-01-16	153	4329.9
19-01-16	153	4329.9
20-01-16	153	4329.9
21-01-16	155	4386.5
22-01-16	155	4386.5
23-01-16	155	4386.5
24-01-16	155	4386.5
25-01-16	163	4612.9
26-01-16	163	4612.9
27-01-16	163	4612.9
28-01-16	163	4612.9
29-01-16	167	4726.1

30-01-16	167	4726.1
31-01-16	167	4726.1
01-02-16	167	4726.1
02-02-16	167	4726.1
03-02-16	176	4980.8
04-02-16	176	4980.8
05-02-16	176	4980.8
06-02-16	176	4980.8
07-02-16	169	4782.7
08-02-16	169	4782.7
09-02-16	169	4782.7
10-02-16	169	4782.7
11-02-16	169	4782.7
12-02-16	169	4782.7
13-02-16	174	4924.2
14-02-16	174	4924.2
15-02-16	174	4924.2
16-02-16	174	4924.2
17-02-16	174	4924.2
18-02-16	156	4414.8
19-02-16	156	4414.8
20-02-16	141	3990.3
21-02-16	136	3848.8
22-02-16	130	3679
Average	159	4401.66

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