Plant Archives Vol. 22, No. 1, 2022 pp. 203-210 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2022.v22.no1.032

WATER MANAGEMENT IN GHATERA BABAJI MINOR IRRIGATION PROJECT, MADHYA PRADESH, INDIA

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(Date of Receiving : 30-10-2021; Date of Acceptance : 16-02-2022)

ABSTRACT

Water is a vital component of nature, which brings life in land; therefore the judicious utilization of water is needed for all types of human advancement. India is a monsoon dependent country for its water resources. Irrigation sector has been fundamental to India's economic development and poverty alleviation, since 25% of India's Gross Domestic Product (GDP) and 65% of employment are based on agriculture (MOWR GOI, 2006). The world's total irrigated area was 249.5 M ha in 2011 in which India has 21.7% share in irrigated area in the world. The global consumption of water in agriculture is around 71% of the total water use (FAO, 2008). Considering the importance of irrigation management and the water user's participation in increasing water productivity and the development of existing irrigation command area, this study was carried out to assess the present irrigation system of command area and to perform diagnostic study for the possible improvement in command area of Ghatera Babaji tank canal situated in Betwa River basin.

The study area has a gross command area of 147 ha out of which cultivable area are 127 ha. Irrigation is supplied during Rabi season in about 121 ha. Main canal is 1360 m long with a slope of 1 in 1000. The command area has 101 land holdings ranging from 0.23 ha to 6.32 ha belonging to 87 farmers. Majority of farmers have small and marginal holdings (up to 2 ha), middle age (> 39 yrs) and with low income (< Rs 50,000 per annum) and have education up to primary or middle school level. The basic infiltration rate varies from 0.2 cm/hr to 2.4 cm/hr. The major crop of the area is Wheat followed by small area under Gram and Vegetable during Rabi, whereas, Soybean is grown during Kharif season. Discharge measured in main canal varies from 0.066 m^3/sec at head reach to 0.013 m^3/sec at tail reach. Discharge reaching to farmer's field is changing from 3.82 to 5.36 lps. Seepage losses in main canal are measured to be 38.83 m^3/ Mm^2 to 16.04 m^3/ Mm^2 wetted area. Overall irrigation efficiency is computed to be 35 per cent. Productivity of Wheat crop varies from 4.5 to 35.1 q/ha which when converted to water productivity ranges from 0.33 to 1.55 kg/m^3. Water productivity for Gram varies from 0.97 kg/m^3 to 1.86 kg/m^3.

Keywords: Water resources, participatory approach, canal command

Introduction

The ultimate irrigation potentiality of the country has been assessed as 139.9 M ha. At the beginning of plan era, the total irrigation potential created was of the order of 22.6 M ha. Irrigated agricultural land reportedly increased yield of most of the crops by 100 to 400% (FAO). A large number of irrigation projects were therefore taken up with the objective to further increase agricultural production in the country. To achieve food security for the growing population the country's focus is on to bring more and more area under irrigation, reducing gap between potential created and utilized as well as efficient water management. Most of the major irrigation command areas in India suffer from problems of inadequate and unreliable water supply. This leads to temporal imbalance of water demand and supplies, excessive seepage losses and rise of ground water table, resulting in problems of water-logging & salinity. The problem of water loss and insufficient water use in irrigation schemes cannot be attributed to canal control and operation only. Institutional and socio-economic factors also contribute to the problem. An integrated approach should be adopted to improve water use efficiency. The main areas for improvement are management of water course, feeling of ownership among water users, appropriate methods for conveyance through canal and its application on field.

In spite of sincere efforts, the water use efficiency in most irrigation system is low especially in surface irrigation system ranges from 35 to 40 per cent. The main causes of low efficiency as observed by Indian institute of management (IIMs) are: deficiencies' in water delivery system, inequitable delivery of water to the field and inefficient management. The reasons of present low efficiencies also include delay in construction large projects resulting in shift towards high water consuming crops, wasteful use of water by head reach farmers, excessive seepage and evaporation as well as percolation below the root zone.

Efforts made so for are from institutional side and farmers were not given due consideration in improving

situation. Therefore a need was felt to include farmers view to finalize the water management plan in an adaptive mode. Adaptive management is defined as a framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management, planning and implementation of a project to achieve specified objectives. An adaptive management approach provides a structured process that allows for taking action under uncertain conditions based on the best available science; close monitoring, evaluating outcomes, re-evaluating and adjusting decisions.

Due to inadequate availability of irrigation water in the reservoir, most of the flow based minor irrigation projects suffer from poor irrigation intensity and cropping intensity. There is a need of proper crop planning especially during dry season taking into account the availability of irrigation water in the reservoir. Higher crop coverage sometimes leads to severe scarcity of irrigation water in the advanced crop growth stages thereby restricting the productivity of the crop significantly lower than the potential. The Water Users Association formed to look after the operation and maintenance of the system and collect water tax from the farmers still have several problems. Therefore, the challenges of water resource management in minor irrigation sector calls for immediate assessment of their performance to identify the gaps and development of suitable ways and means to bring improvement.

Materials and Method

Study area

The study has been undertaken in the command area of Ghatera Babaji tank canal, a tank irrigation project located at Ganjbasoda, Vidisha district, Madhya Pradesh.

Ghatera Babaji tank irrigation project is a minor irrigation project in Madhya Pradesh; the dam is situated on local nalla, a tributary to Betwa River. The Ghatera Babaji dam can be approached from Basoda city, a tehsil head quarter and is located about 22 km of Basoda town. The site is approachable from Basoda-Sagar road. The approach to dam site is a tar road. It is motarable during monsoon. Command area of Ghatera Babaji Tank canal lies between 23°48’00”N and 78°07’00”E respectively. (Fig. 3.1) Canal system of the Ghatera Babaji scheme consists of main canal 1360 m long.

Climate

The climate of study area is characterized by a hot summer and general dryness except during southwest monsoon season. The normal maximum temperature received during the month of May is 41.7°C and minimum during the month of December is 8.9°C. The relative humidity generally exceeds 94% (August month). The wind velocity is higher during the pre-monsoon period as compare to post monsoon period. The maximum wind velocity is 11.2 km/hr as observed during the month of June and is minimum of 1.5 km/hr during the month of December. The average annual rainfall of Vidisha district is 1375 mm.

Ghatera Babaji Tank

This project was constructed in year 1970 to irrigate 65 hectares of Rabi crop through unlined canal structure but it is providing irrigation to 110 ha of land with 100 ha during Rabi and 10 ha during kharif season. Table 3.1 presents the general features of the project.

Table 2.1 : Salient features of Ghatera Babaji minor tank project

S. No.	Features	
	Location of dam site	
1	Longitude	78°07’00”
2	Latitude	23°48’00”
	Reservoir data	
1	Catchment area	1.165 sq. km.
2	Gross storage capacity	0.650 M cum
3	Live storage capacity	0.605 M cum
4	Dead storage capacity	0.043 M cum
5	Full tank level	30.175 m
	Dam data	
1	Length	1380 m
2	Height	4.22 m
3	Top width	3.0 m
4	Length of waste-weir	74.5 m
5	Design discharge of waste-weir	21.7 cumec
	Canal data	
1	Length of main canal	1360 m
2	Highest elevation	440 m
3	Lowest elevation	431 m
4	Sluice gate type	well type sluice
	Area commanded	
1	Gross command area	147 ha
2	Culturable command area	120 ha
3	Forest area	7 ha

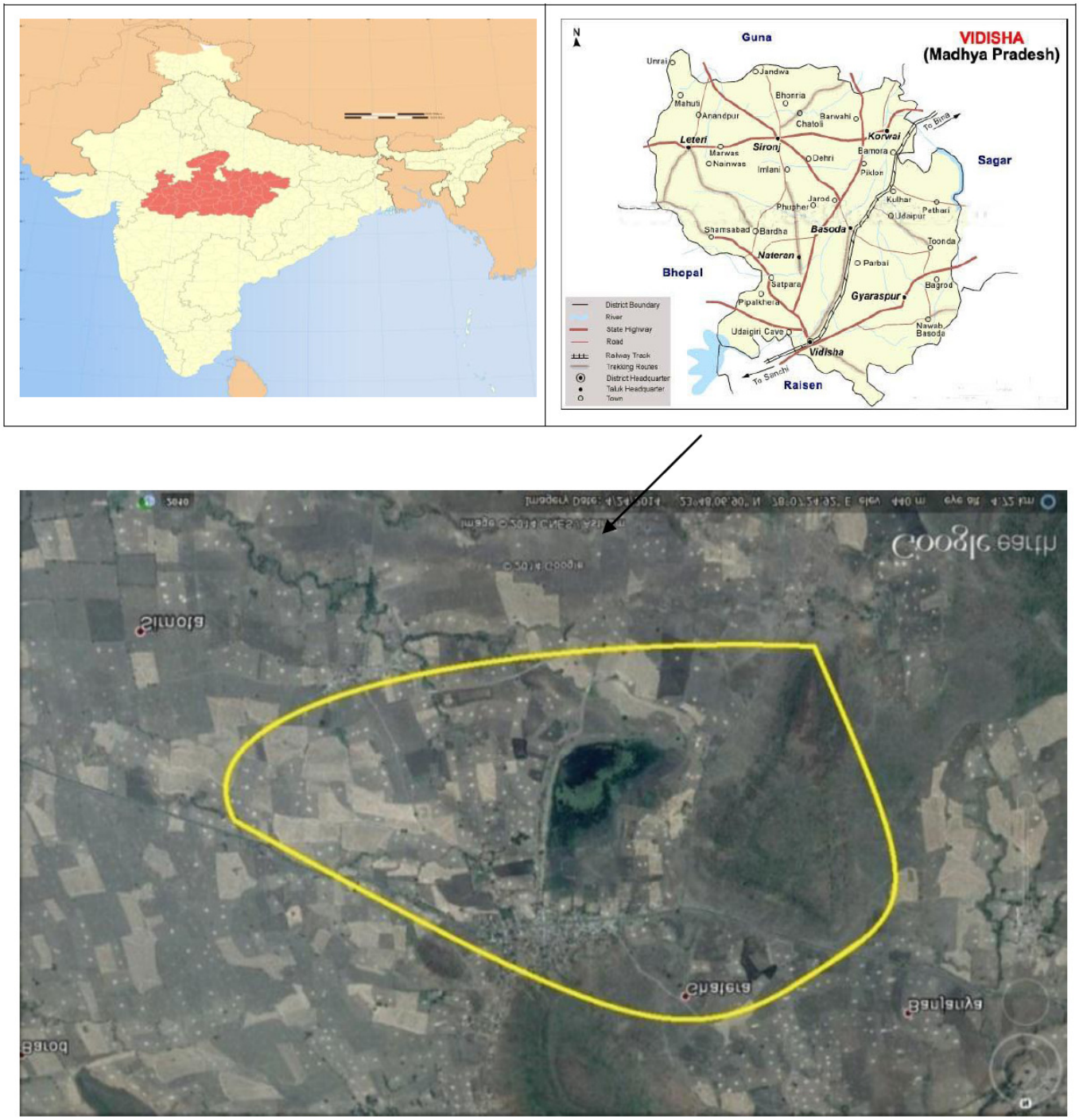

Fig. 2.1 : Location map of study area under Ghatera Babaji minor tank irrigation project

Crops

The major crops grown in the command area during Rabi season are wheat, gram, mustard and some vegetables. In Kharif season the main crop is soybean. 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.

Soils

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

Water resources

Daily records of supply head in main canal were obtained from the Water Resources Department, Government of Madhya Pradesh. Based on cross sectional area, slope and outlet conditions, the discharge delivered to the command area was estimated. Operating hours of selected minor and the schedule of operation of the main 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 courses, field channels and area irrigated was obtained from the records of the local irrigation authorities. Open wells are most important source of irrigation during Rabi season. Pumps and motor are used for lifting water for irrigation.

Tank or reservoir was designed to irrigate 65 ha command area of Ghatera Babaji. But at present 121 ha area is irrigated with 2-3 irrigation.

Soil properties

The common soil found in the area is clay loam (black cotton soil) with plots of loamy texture. Physical properties such as texture, bulk density, moisture status of the soil were determined by taking appropriate soil sample from the Ghatera Babaji minor command.

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. Secondly, 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. 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.

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 Ghatera Babaji minor 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.

Plate 2.1 : Free flooding surface irrigation in the GBT irrigation project

Discharge Measurement

Field observations were recorded to determine the discharge of main canal and field channel at different reach. 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.

Plate 2.2 : Measurement of canal water flow velocity in head reach

Estimation of irrigation efficiency

A number of efficiencies were suggested by researchers to evaluate performance of irrigation system (Boss and Nugteren, 1974). The present analysis considers system performance beyond the canal outlet. Therefore, only the conveyance efficiency of the canal and efficiencies at the field level were evaluated.

Conveyance efficiency

This term is used to measure the efficiency of water conveyance system associated with the canal network, watercourse and field channel. It is a measure of performance of the canal. The conveyance efficiency (Ec) was computed as

$$Ec = (Wf / Wd) \times 100$$

Where,

Wf = quantity of water delivered to the canal

Wd = quantity of water diverted to the outlets

Application efficiency

After the water reaches field supply channel, it is important to apply the water as efficiently as possible. It defined as

$$Ea = (Ws / Wf) \times 100$$

Where,

Ea = application efficiency, %,

Ws = water stored in the root zone of the plants, and

Wf = water delivered to the field.

Storage efficiency

It has been stated that small irrigation may lead to high water application efficiencies, yet the irrigation practice may be poor. The concept of water storage efficiencies is useful to evaluate this problem. This concept relates how completely the water needed prior to irrigation has been stored in the root zone during irrigation. It is defined as,

$$Es = (Ws / Wn) \times 100$$

In which,

Es = water storage efficiency,

Ws = water stored in the root zone during irrigation, and

Wn = water needed in the root zone prior to irrigation.

Overall efficiency was calculated by multiplying application, conveyance, and storage efficiency obtained above.

Results and Discussion

This chapter presents the results obtained during the study in form of characteristics of present irrigation system including the water users, irrigation demand and supply 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 possible improvements in the irrigation system to increase water productivity.

Soil characteristics

Soil characteristics, which greatly influence the seepage rate such as texture, bulk density and infiltration rate, were determined for the command of Ghatera Babaji minor tank canal.

Soil sample were collected from three locations situated at (head, middle and tail) reach of project area. Mechanical analysis was performed for textural classification. From the U.S.D.A. textural classification of the soil, the surface texture of majority of areas varied from clay to clay loam. The analysis showed that the clay content of the soils ranged from 39.52 to 43.25% (Table 3.1).

Crops grown

Wheat is the major Rabi crop grown in the command. It covered about 117.17 ha area during 2013-14. Table 4.3 gives the area under different crops, irrigated area and their coverages in the command of GBT project. All the cultivated area is under irrigation during Rabi season, whereas, only 8.3 percent of the Soybean area receives irrigation during Kharif season.

Table 3.1 : Soil Texture in command Area

S. No.	Location	% clay	% silt	% sand	Classification
1.	Head	39.52	27.82	32.65	Sandy clay loam
2.	Middle	40.82	35.21	28.65	Silty clay loam
3.	Tail	43.25	25.32	33.21	Clay loam

Table 3.2 : Crops in GBT irrigation project 2013-14

S. No.	Crops	Area cultivated, ha	% of cultivated area	Area irrigated, ha	% of cultivated area irrigated
1.	Wheat	117.1	79.7	117.1	100.0
2.	Gram	2.7	1.8	2.7	100.0
3.	Vegetables	1.0	0.6	1.0	100.0
4.	Soybean	119.2	0.8	10.0	8.3

Present irrigation system

Water resource assessment

The main source of irrigation is Ghatera Babaji tank storage. The tank canal irrigation area is higher than well irrigation. Numbers of wells were more in tail reaches compare to head and middle reach. There are 15 numbers of well in the command area of main canal, used to supplement the canal irrigation. One well command area is about 3 ha. When sufficient water is available in the tank, no irrigation is supplied through wells. In condition of lower amount available in tank, up to 45 ha area is irrigated by wells. Most of the farmers used 5 Hp diesel pumps for lifting water Fig 4.3 presents the tank command as well as location of wells.

Table shows the area capacity curve of Ghatera Babaji tank. Reduced level of lowest supply is 28.042 m with an area of water spread as 0.1231 M sq. m possesses a capacity of 0.0446 M cum. The capacity of the tank at full tank level of 30.178 m is 0.6503 M cum.

Fig. 3.1 : Tank command area with location of wells

Table 3.3 shows the cross section and velocity in main canal in the tank irrigated area. This is 1360 m long with a slope of 1 in 1000 and having a velocity of flow as 0.63 m/s on an average.

Table 3.3 : Details of main canal in Ghatera Babaji tank command area

Length, m	Bed Width, m	Slope	Side slope (H:V)	Depth of flow, m	Velocity of flow, m/s	Lowest Elevation, m	Highest Elevation, m
1360	0.30	1:1000	1.5:1	0.31	0.63	431	440

Water availability

Discharge was measured at different reach of the main canal and is presented in Table 3.4. Average discharge measured in head, middle and tail reach of Ghatera Babaji tank outlet main canal was observed as 0.066 m^3/s which decreases to 0.013 m^3/ sec in tail reach. It also presents the total volume of water available.

Table 3.4 : Water availability in different reach of main canal under Ghatera Babaji Tank command

Reach	Velocity of flow, m/sec	Measured discharge, m^3/s	Designed discharge, m^3/s	Volume available, m^3
Head	0.63	0.066	0.071	261360
Middle	0.60	0.041	0.043	162160
Tail	0.34	0.013	0.014	51480
Total				475200

Considering that canal is operating for 10 hr/day for 110 days. It was observed that the water availability through main canal decreases in tail reaches. The deficit of irrigation water is supplemented by the well water at tail end. The farmers are using well water mainly in the Rabi season. Total 475200 m^3 water is available at different reaches of canal. Canal operates 110 days in 4 month.

Seepage losses from main canal

A seepage loss from various section of canal was measured and is presented in Table 3.7. The observed seepage rate from main canal is 38.33 m^3/ M m^2 at head reach, 32.72 m^3/ M m^2 at middle reach and 16.04 m^3/ M m^2 wetted area at tail reach. The depth of flow varies from 0.28 to 0.32 m in different reach of main canal. The velocity of flow varies from 0.63 to 0.34 m/sec at various sections of main canal. (The wetted area varies from 498.57 to 652.15 m^2).

Table 3.5 : Measurement of seepage rate from various section of canal

S. No	Location	Bed width, m	Flow depth, m	Side slope H:V	Wetted area, sq. m.	Seepage rate, m^3/ M. sq. m.
1	Head	0.3	0.31	1.5:1	652.15	38.33
2	Middle	0.3	0.28	1.5:1	550.01	32.72
3	Tail	0.3	0.25	1.5:1	498.57	16.04

Irrigation efficiency

In order to assess the performance of irrigation system, conveyance efficiencies in the system right from the source to the field were taken into account. Water delivered to the field with discharge 57.5 lps and water diverted from the source with discharge of 66.8 lps. The conveyance efficiency was found to be 86 per cent at canal level.

Depth of water which may be stored in the root zone of the plant was computed to be 6 cm and water delivered to the field was 9 cm. The application efficiency was found to be 66 per cent. Considering the moisture content at time before irrigation, the amount of water which can be stored in root zone is 5.5 cm whereas water applied is 9 cm and storage depth is 6 cm thus storage efficiency was computed to be 61 per cent. The overall efficiency of the system has computed as multiple of all the computed efficiency, so overall efficiency of the system was found to be 35 per cent.

Water management

Water management is the process of determining and controlling the volume, frequency and application rate of irrigation water in a planned, efficient manner. Absence of proper water distribution system created problem to spread water efficiently.

Problem identified

- Out of 71 surveyed farmers 65 used free flooding method increases to water loss.
- Irrigation efficiency is poor as low as in 35% in present irrigation method.
- By use of free flooding method soil erosion problem has created.
- Absence of water distribution from field to field.
- Unlined water course responsible for losses of precious water resource.
- Moderate and seasonal problem in Kharif season due to lack of drainage system which causes water logging problem.

Suggestive irrigation plan for GBT irrigation project

There is need to improve the irrigation system of GBT command area by improving the physical status of system and crop water management. Following are the suggestive majors to improve the irrigation system.

- Compaction of earth work at optimum moisture content by light roller.
- Collection, stacking and spreading hard moorum on earth embankment.
- Increase reservoir storage capacity and decreased water logging problem near tank.
- Cleaning the silt for approach to sluice.
- Proper discharge of water from reservoir to canal and operation of gate in full mode.
- Adoption of border irrigation to get higher efficiency as compare to free flooding.
- Reducing loss of water through improved management.
- Decreased soil erosion problem by adopting proper practices.
- Increase water conveyance efficiency of canal.

Conclusions

Based on the diagnostic analysis of GBT irrigation project, possibility of improvements and adoptability of farmers following conclusions may be drawn for the study.

1. The overall irrigation efficiency of 35 per cent needs to be improved to enhance water productivity of Wheat from 0.89 to 1.16 and for Gram from 1.18 to 3.43.
2. Improved irrigation method namely border and sprinkler are to be adopted to improve application efficiency from 66% to 80%.
3. Total Water availability in canal at head, middle and tail reach was found to be 261360 m^3, 162160 m^3 and 51480 m^3 respectively. It is higher than the well water availability.
4. Seepage losses in main canal are measured to be 38.83 m^3/ Mm^2 to 16.04 m^3/M m^2 wetted area.

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