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Diagnostic analysis of right main canal command of West Banas irrigation project

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Abstract
In this study, a diagnostic analysis was carried out to study the operational problems in the West Banas Right Main Canal Irrigation Project. The study concluded that damaged lining or broken wall was found at 24 locations in the Right Main Canal. Two control gates were found tempered or damaged on the starboard main channel. The Kyaria distributary needs to be walled in such a way that farmers in the end parts of the Kyaria distributary can get enough water. A high growth of vegetation was found in the canal at 19 places and on both sides of the canal throughout the network and is damaging the canal lining. The average traffic efficiency of the head, middle and tail sections of the Baroda branch canal was found to be 76.02 percent. Barley with maximum crop water use efficiency values among Rabi crops reaching 62.93 kg/ha-cm. Average values of crop water use efficiency for wheat, gram and mustard were obtained as 44.85 kg/ha-cm, 40.53 kg/ha-cm and 33.90 kg/ha-cm for the period 2013-2018. Field water use efficiency was calculated for Rabi crops from 2013-14 to 2017-18. In 2013-14, barley achieved the highest field water use efficiency value of 41.07 kg/ha-cm followed by wheat (40.81 kg/ha-cm), gram (31.54 kg/ha-cm) and mustard (23, 32a kg/ha). -cm). Garlic has a maximum field water use efficiency value set for all crops in 2014-15 (51.45 kg/ha-cm). In 2015-16, barley used water efficiently and provided the highest field water use efficiency, while mustard achieved the lowest water use capacity.

Keywords: Diagnostic analysis, transport efficiency, water use efficiency, crop water use efficiency, field water use efficiency

1. Introduction
Irrigated agriculture represents the largest demand for water in the world. Irrigation consumes over 70 percent of the world's total water supply for development. Increased demand for water from non-agricultural sectors requires effective planning and management of water resources. Effective operation and management of an irrigation system plays an important role in the sustainability of irrigated agriculture (Mishra *et al*., 2001) [1]. In the past, considerable efforts have been made to improve the efficiency of irrigation systems through physical/structural development and effective operation and management.
The performance of irrigation systems is reported to be better through effective management than through structural development (Santhi and Pundarikanthan, 1997) [8]. This finding appears to be particularly true for developing countries such as India, where lack of financial resources and infrastructure are the main constraints.
India's population is estimated to reach 1.5 to 1.8 billion by 2050. UN agencies put the figure at 1.64 billion. It is now widely accepted that countries with annual per capita water availability of less than 1,700 cubic meters of water are water stressed. If India's population increases to 1.64 billion, per capita water availability will fall below 1000 cubic meters, which is far below the norm. Earth will be short of water even when total available water is taken into account. To feed a population of 1.64 billion, nearly 450 million tonnes of food grains would be required in 2050, the production of which would be a mammoth task given the constraints faced by the irrigation sector (Mishra, 2009) [4].
Rajasthan is one of the states in India which has barely 1.04 percent water resources. Precipitation behavior generally remains abnormal, being erratic, sparse, premature, unevenly distributed with prolonged dry spells and occasional localized flooding. The irrigation facilities that are available are neither evenly distributed nor fully reliable in the state. This is due to the uneven distribution of rainfall coupled with the reliability of the irrigation infrastructure. On the right, the Aravallis and the eastern and southeastern parts of the state are comparatively better situated and fertile. Chambal, Banas, Mahi and all other rivers and tributaries add prosperity to this region (Bhalla, 2010) [1].

The West Banas Irrigation Scheme is an important irrigation scheme in the state of Rajasthan. It was approved by the planning commission in 1958. A total of 36 municipalities benefit from this project. These 36 villages are located in Pindwara and Abu road tehsil of sirohi district. Now, in the West Banas irrigation system, the overall operating system is not up to the marks. Therefore, this study focused on the diagnostic analysis of the project's right main channel through two performance indicators (i.e., physical/structural condition and irrigation efficiency).

2. Materials and Methods

2.1 Description of the Study Area

The West Banas Dam was constructed on West Banas River. The river Originated from eastern side of Sirohi town and flows in South west direction through Sirohi district of Rajasthan and Banas Katha District of Gujarat state and ultimately flows in to the run of Kuchha. The dam is situated near village Dhanari about 3.0 km north west to Swarupganj Railway station of Northern-Western Railway on Delhi-Ahmedabad main rail line and of its co-ordinates are Latitudes 24˚ 41'N Longitudes 72˚ 56'E.

The West Banas irrigation project was sanctioned by Govt. of Rajasthan vide letter No.F-2(42)/Irrigation/156 dated22/05/1958 for Rs.4800300/-only. The Dam was proposed on West Banas River near village Dhanari. This Project is medium irrigation project with CCA of 7952 Ha. And Commissioned during the year1962-63 originally irrigation project was envisaged an area of 5566 Ha. To be irrigated with irrigation intensity of 70%. The Dam gives irrigation benefits to the 36 villages of Pindwara and Abu road Tehsils. Construction of dam was started in the year 1958 and was completed in year 1963. The irrigation project was revised for 64.21 Lacks. On its completion.

West Banas Irrigation project was completed during the year 1962-63 is a medium irrigation project, planned to store 39.05 Mcum of water and to provide irrigation facilities to an area 7952 ha. CCA, ICA 5200.00 ha (Revised 5566.00 ha.) of land. The dam consist of 4.00 km. Long embankment with 472 meter long masonry waste weir &198.0 m. long bye wash.

West Banas dam is a homogeneous earthen dam. The top width of bank is 3.65 m. The total length of dam is 4.00 km. Out of which 472 m. is masonry overflow portion and bye wash length is 198.0 m. It has two sluice gates for Right and Left Main canal. The Gross storage capacity at FTL is 37.526 Mcum. Out of which 35.801 Mcum. Is live storage. The maximum height of dam is 16.75 m. in river portion. The TBL, MWL, &FTL are 337.04, 335.54 &334.45m respectively. The sill level of both canals is 327.13m. It has two main canal namely RMC as 34.75 km.in length and LMC as 22.32 km in length. The discharge at head of RMC and LMC are 3.259 cumecs and 0.635 cumecs respectively.

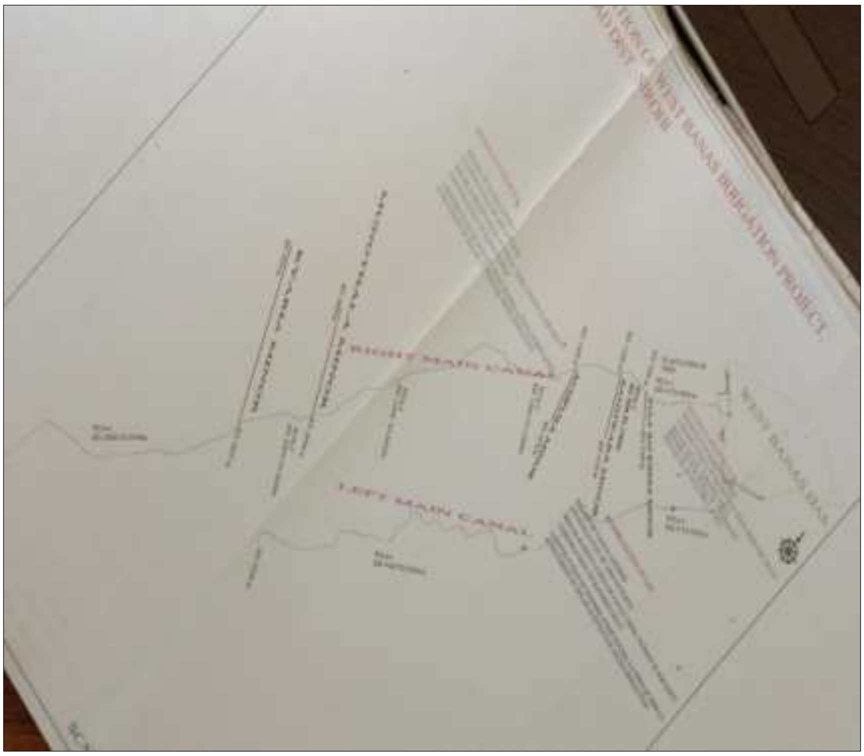

Fig 2: Location of study area

2.2 Performance Evaluation of Baroda Branch Canal Command

Many studies (e.g. Molden and Gates, 1990; Molden *et al*., 1998; Mishra, 2009) [4] have addressed criteria and indicators for quantifying water supply performance to identify the reasons for poor performance and its corrective measures and physical interventions for improvement. performance. Many factors such as real-time data, canal system, hydraulic unit withdrawals from the field, inflow and farmer access affect timely irrigation and its proper distribution in the project (Rowshon *et al*., 2004). Therefore, in this study, two indicators (i.e., physical/structural condition and irrigation efficiency) are selected to be used to evaluate system performance.

2.2.1 Physical/structural status

A water distribution system consisting of a main canal, minors and outlets in minors at each end of the canal was investigated. Silt deposition was investigated at selected locations in the canal network before and after irrigation was applied. Silt was measured as the height of the sludge deposit on the bottom of the channel.

2.2.2 Irrigation efficiencies

Irrigation efficiency indicates how effectively the available water resource is used based on various assessment methods. In this study, transport and water use efficiencies are calculated to evaluate system performance.

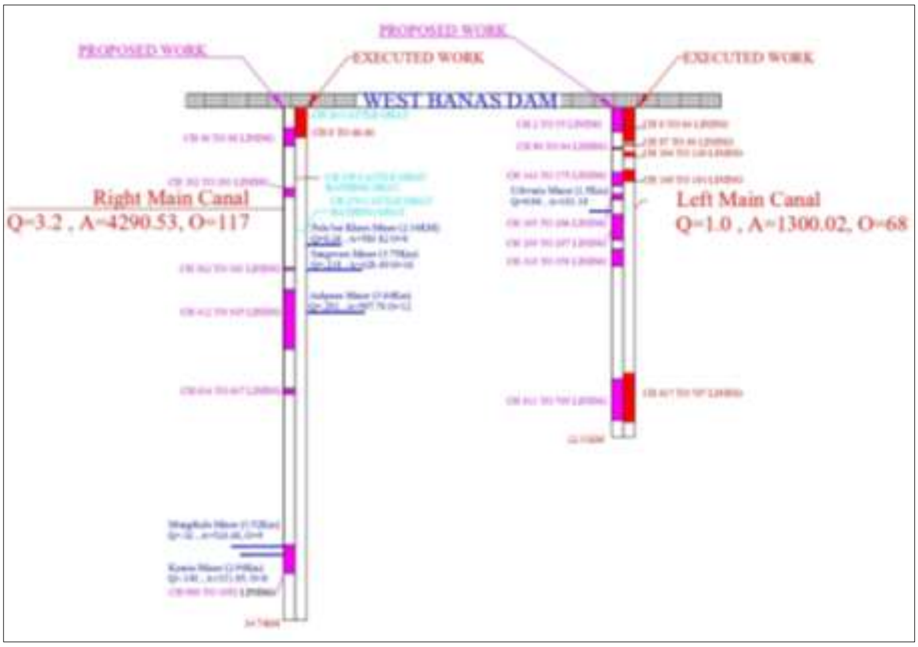

Fig 3: Tree Chart Canal System of West Banas Irrigation Project

(a) Water Conveyance Efficiency (Ec)

It is estimated by

$$\text{Conveyance Efficiency (Ec)} = \frac{\text{Water flowing in the canal}}{\text{Water flowing out of canal}} \quad .....(1)$$

(b) Water Use Efficiency of Project

Crop water use is generally described in terms of water use efficiency (kg/ha-cm). It can be defined in the following ways:-

i. Crop water use efficiency

It is the ratio of crop yield (Y) to the amount of water used by the crop in the process of evapotranspiration (ET).

Water use efficiency = Y/ ET .....(2)

ii. Field water use efficiency

It is the ratio of crop yield (Y) to the total amount of water used in the field (WR).

Field water use efficiency (kg/ha-cm) =Y/WR .....(3)

3. Results and Discussion

Performance of Right main canal of west banas Irrigation project is evaluated by two indicators. Results are presented and discussed in following sections.

Generally, head reach farmers enjoy supplies of irrigation water in excess to their actual requirement. This results in either very low or no supplies of irrigation water at tail reach of the Baroda Branch Canal. Therefore, tail reach farmers suffer with reduced yield in their commands.

3.1 Physical/Structural Status

3.1.1 Canal lining

The canal lining was observed to be damaged at 25 locations on the Right Main Canal (Plate-1 & 2) and at a number of locations throughout the canal network. Knowledge of how and how much water should be applied to the field for effective crop yield is lacking among farmers in the command area. They damage the canal lining or minor children because they get excessive water and avoid other labor staff to irrigate the fields which they have to do because the drains are far away from their fields. This causes large losses of water through seepage from the damaged section and subsequently affects the designed discharge in the canal section. Cracks in the canal lining were also observed at a number of locations in the canal network, which requires maintenance to prevent water wastage through seepage from the cracks. Most farmers irrigate their fields until; the water does not stop in the channels.

Fig 4: Damaged lining of RMC

3.1.1 Water courses

Watercourses, which are the responsibility of farmers, have not been regularly maintained, particularly by farmers, as a result of which almost all watercourses in a number of locations have been damaged and weeded. Due to unprofessional maintenance and tempering of the networks by the farmers, the water flows were not taken even from the leading distributor or the minors in a condition to supply a sufficient amount of water to its end fields.

3.1.2 Gates and pipe outlets

Most of the gates were found tempered or damaged throughout the canal network and at 2 locations on the Baroda branch canal. So no flow control or regulation (opening or closing) can be practiced. Tempered or oversized pipe outlets were also found in the channel network. Observations were also made at other unauthorized outlets and were found to be nine outlets at RMC, many outlets at minors.

3.1.3 Siltation / weed infection in canals

Alluvium carried by the river is not significant. However, canal water is generally silt-free, but clogging occurs in the canal due to run-off water entering the canal at many places. Sections of the channel were found with silt and debris deposits. In many places it reaches a height of up to 15 cm. Weed growth/vegetative growth is also found at a number of locations throughout the canal network. Maintenance activities were not carried out by the department due to lack of personnel. Clogging also affects flow in canals and the number of times water flows out of the canal and accumulates in low-lying areas.

3.2 Irrigation Efficiencies

(a) Conveyance efficiency

The transport efficiency of the right main channel (RMC) was measured at three locations selected in the head, middle and tail sections, each 200 m long. Inflow and outflow were measured for these sections. Several times throughout the irrigation season. For the right main channel in the head section, the achieved transport efficiency was 85.80 percent.

73.04 percent and 69.24 percent were observed in the middle and tail reaches. An average transport efficiency of 76.02 percent was found for the entire right main channel, which is within an acceptable range for the distribution systems.

Table 1: Conveyance efficiencies of the water distribution system at head, middle and tail of RMC

Location	Length of Reach (m)	Inflow (cumec)	Outflow (cumec)	Conveyance losses/Km	Conveyance Efficiency (%)
Head	200	4.625	4.501	14.17	85.80
Middle	200	2.874	2.689	23.65	73.04
Tail	200	1.351	1.236	35.47	69.24
Average					76.02

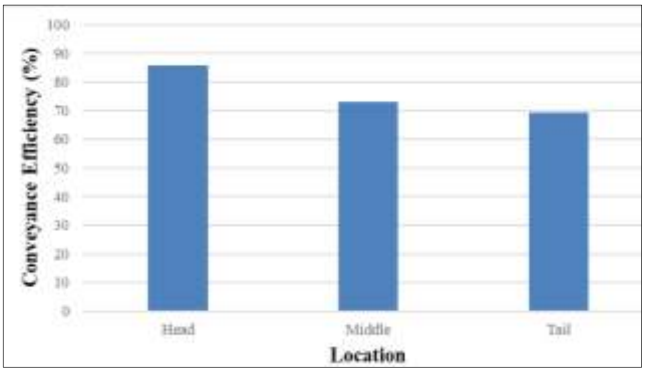

Fig 5: conveyance efficiency of RMC

Fig 6: Damaged gate of RMC

(b) Water use efficiency

Water use efficiency of Wheat, Barley, Gram and Mustard were measured for year 2013-14. Crop and Field Water Use Efficiencies values were measured for evaluation of performance of various crops grown in Right Main Canal command area so that problems causing low yield, less production in command area can be identified like inept cropping pattern, incorrect crop selection, lack of knowledge about modern agricultural practices etc.

i. Crop water use efficiency (CWUE)

Average of five-year CWUE values for Rabi crops was computed and presented in Table 2 Barley having maximum values of CWUE among *Rabi* crops attaining value 62.93 Kg/ha-cm. Average CWUE values for Wheat, Gram and Mustard were obtained as 44.85 Kg/ha-cm, 40.53 Kg/ha-cm and 33.90 Kg/ha-cm respectively.

Table 2: Average values of Crop Water Use Efficiencies of Rabi crops for year 2013-17

Crops	CWUE (Kg/ha-cm)
Wheat	44.85
Barley	62.93
Gram	40.53
Mustard	33.90

ii. Field water use efficiency (FWUE)

Field water use efficiency is the ratio of crop yield to gross crop irrigation demand. FWUE was calculated for Rabi crops from 2013-14 to 2017-18. In 2013-14, barley achieved the highest FWUE of 41.07 kg/ha-cm followed by wheat (40.81 kg/ha-cm), gram (31.54 kg/ha-cm) and mustard (23.32a kg/ha -cm). Garlic gives the maximum FWUE value (51.45 kg/ha-cm) among all crops in 2014-15. In 2015-16, barley used water efficiently and provided the highest FWUE, while mustard achieved the minimum water use ability. Wheat achieved the highest FWUE of 42.87 (kg/ha-cm) while mustard achieved the lowest FWUE of 23.07 (kg/ha-cm) in 2016-17. Barley achieved higher FWUE values while mustard failed to use water efficiently in 2017-18. Table 3 shows the field water use efficiency of Rabi crops for the period 2013-14 to 2017-18.

Table 3: Values of Field Water Use Efficiency for Year 2013-17

Crops	Field Water Use Efficiency (Kg/ha-cm)				
	2013-14	2014-15	2015-16	2016-17	2017-18
Wheat	40.81	37.17	38.37	42.87	34.84
Barley	41.07	51.45	51.54	40.47	36.54
Gram	31.54	25.62	27.25	28.09	27.31
Mustard	23.32	25.06	25.94	23.07	20.94

Conclusions

In this study, a diagnostic analysis is carried out to study the operational problems in the entire network of the Right Main Canal (RMC) of the West Banas Irrigation Project. A proper water distribution system is missing from this order. Farmers in the lead use more water than their actual need by placing obstructions in canals. Farmers at the end of the canal are not getting enough water for irrigation. Therefore, they irrigate their fields from wells or keep their fields uncultivated during the Rabi season. Irrigation problem was observed in low-lying areas during irrigation due to seepage from canals. Canal lining damage was observed at 25 RMC locations and at several locations throughout the RMC network. Most pipe outlets and inlets were found to be tempered (2 inlets in RMC) along with a few oversized outlets in the channel network. Seepage and overflow are identified as the two main problems at the top of the RMC command due to cracks in the lining and improper bed inclination of the minor. Based on staff communication with farmers, it was found that approximately 25 percent of the area at the tail end of the Kayaria distribution network does not receive any irrigation water. A big problem is the lack of water in the smaller reach of the tail due to its location at the end of the tail and seepage through cracks in the smaller. The canal water is generally free of silt, but clogging occurs in the canal due to run-off water entering the canal at several places. The depth of the mud is up to 15 cm in many places. Lesser head range carrying efficiency was found to be maximum (ie 85.80 percent) among all selected juveniles and was 76.02 percent for RMC. Crop water use efficiency of wheat, barley, gram and mustard was found to be 44.85, 62.93, 40.53 and 33.90 kg/ha-cm, respectively and field water use efficiency of wheat, barley, gram and mustard was found to be 38.14, 44.52 and 2 24.32 kg/ha-cm respectively in RMC command.

Based on the results of the present study, the following major conclusions are drawn:

1) Damaged lining or broken wall was found at 25 places of Baroda branch canal.
2) Two control gates were found tempered or damaged on Baroda Branch Canal.
3) The Kyaria distributory needs to be lined so that farmers of tail reaches of Kyaria distributory can get sufficient amount of water.
4) High growth of vegetation has been found in the canal at 16 places and on both sides of the canal in the entire network and is damaging the lining of the canal, but no action is being taken by the irrigation department due to non-availability of funds for maintenance and also lack of staff.
5) Barley (62.93 kg/ha-cm) is the most efficient crop in water use, followed by Wheat (44.85 kg/ha-cm), Gram (40.53 kg/ha-cm) and Mustard (33.90 kg/ha-cm).

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