

Diagnostic analysis of Baroda branch canal of Som Kamla Amba irrigation project, Rajasthan, India

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ARTICLE INFO	ABSTRACT
<p>Received : 10 May 2021 Revised : 22 June 2021 Accepted : 20 June 2021</p> <p>Published online: 22 February 2022</p> <p>Key Words: Baroda branch canal Command area Diagnostic analysis Irrigation Irrigation efficiency</p>	<p>Irrigation projects are of paramount importance in meeting the water demand of agriculture sector. Therefore, evaluating the performance of irrigation systems makes it possible to improve agricultural water management and consequently enhances irrigation efficiency. In this perspective, the present study focuses on diagnostic analysis of the Baroda branch canal of the Som Kamla Amba irrigation project, Rajasthan, India. This study attempts to identify constraints attributed to poor irrigation efficiency and remedial strategies to improve irrigation management. Results revealed that poor maintenance and lacking immediate action of damaged water distribution network were culprits resulting in silting and vegetation infestation. Poor structures viz., tempered pipe outlets and gates, blockage of minors, unauthorized pumping, and poor operations of water distribution systems resulted in poor performance of Baroda branch canal. The performance of Baroda branch canal system can be improved by adoption of appropriate strategies.</p>

Introduction

The land and water available for agriculture are limited in most of the countries in world and therefore their efficient utilization ensures the sustainable development of the nations. In many developing countries, on account of the growth of cities and industries, available land for agriculture is shrinking rapidly. As water is a scarce resource worldwide, efforts should be made to improve the effective utilization of this limited resource for irrigating agricultural land. Irrigated area utilizing surface and groundwater sources is about 308 million ha hectares (ha) of the total land is irrigated worldwide (ICID, 2018). Most of these projects have low productivity (30-50%) and cannot meet their design objectives (Arya et al., 2017) In India & South Asia, the number of irrigation schemes has a

low overall efficiency of the performance at different levels of complex hydraulic systems (physical/structural and operational/management) (Sakthivadivel et al., 1999). Therefore, the only viable solution is the effective operation and management of the irrigation system to enhance irrigation efficiency and subsequently food production. In India, irrigation infrastructures were created but it has been seen that created irrigation capacity is not entirely exploited, and there is a difference between the created potential and the used potential. This realization has changed the attention of policymakers and researchers to improve the efficiency of canal irrigation by main system management. Rajasthan state has only 1.04 percent of India's water resources (GOI, 2004). The

rainfall behavior generally remains abnormal, scanty, untimely, unevenly distributed with prolonged drought periods and mostly local floods. The available irrigation facilities in the state are neither distributed fairly nor completely dependable. This is due to irregular rain distribution and the efficiency of the irrigation infrastructure. On the right side of the Aravallis, the east and southeastern parts of the state are comparatively better placed and fertile. Chambal, Banas, Mahi, and other rivers and tributaries add prosperity to this region (Bhalla, 2010). To address the issues of low overall project performance and insufficient water supply, irrigation system preparation, service, and management must be improved. Monitoring, assessment, and diagnostic status (physical condition of canal system, check gates, cross drainage works, outlets etc.) of irrigation scheme are crucial to appreciate the increase in productivity in irrigation projects. Irrigation and drainage performance assessment can be characterized as the systematic observation, recording, and analysis of irrigated agriculture activities with a view to quality improvement (Molden *et al.*, 2007).

The overall goal of performance evaluation is to ensure efficient and effective use of resources by providing management at all levels with accurate input. The successful functioning and maintenance of the irrigation system play a significant role in the sustainability of irrigated agriculture (Unal *et al.*, 2004). For this purpose, irrigation project success studies are being used to support this aim with increasing frequency (Bos *et al.*, 2005). Diagnostic evaluations are performed to better understand how irrigation works, diagnose issues, and identify opportunities for improving efficiency so that measures could be taken to enhance irrigation water management. Diagnostic evaluations are to be carried out when complex issues are found by regular testing or when stakeholders are dissatisfied with the current performance levels and want improvements in system activity. Mishra (2009) had done the diagnostic analysis of the Rajsam and canal network and in the command room, it was discovered that there is no proper water distribution system. The canal lining exists in the entire canal network. The majority of pipe outlets and gates were found tampered, and numbers of oversized outlets were observed in the canal network.

Siltation and overtopping were the two major problems in command of Dhoinda minor because of improper bed slope. Water use efficiencies in command of the head, mid, and tail end minors for the wheat crop were 44.3, 49.4, and 48.2 kg/ha-cm, respectively, and for barley 60.12, 62.6 and 67.94 kg/ha-cm, respectively. Shah and Dalwadi (2012) carried out the diagnostic analysis of Mehasana district command of Sabarmati right bank main canal (North Gujarat, India) by satellite Remote Sensing. To research crop growth stages and determine the time of full canopy, ERDAS imagine software was used to process multi-temporal, multirate remote sensing data (harvest season). Over the study region, vegetation spectral index and crop evapotranspiration were produced for the full canopy stage of the Rabi season (February month). The reference crop evapotranspiration was estimated at 5.65 mm/day. The distributaries within the command called M3LA and M5L were adequate. The land patches growing wheat were classified using supervised classification, dividing them into three parts: head, middle section, and tail end.

Many authors have noted that in the domain of irrigation system management, there is a notable lack of analytical frameworks to assist irrigation managers and auditors in assessing performance achievements and finding feasible ways to improve performance in the future (Burt and Styles, 2004; Luquet *et al.*, 2002; FAO, 2012; Pereira *et al.*, 2012 and Levidow *et al.*, 2014). Optimum irrigation schedule and rotational water allocations aid in improving the irrigation system performance to achieve the desired goal of the project (Rajput *et al.*, 2018). Technical, maintenance, and comparative performance indicators are essential to assess the performance of canal irrigation schemes globally (Rajput *et al.*, 2017a; 2017b; 2017c). These performance indicators are limited to canal systems and equally applicable in tube well/ community tube well irrigation systems for improving system performance (Rajput *et al.*, 2020). As a result, diagnostic methodologies are required to evaluate system actions, assess current and future results, and identify critical aspects and weaknesses in existing irrigation systems' operation. The current investigation used diagnostic analysis to determine the general health of the water distribution network.

of the Baroda branch canal of the Som Kamla irrigation project.

Material and Methods

Description of Baroda Branch Canal

The planning commission approved the Som Kamla Amba irrigation project in the year 1975. The scheme envisaged construction of storage dam of 83.10 M Cum capacity with surplus arrangements for 3.72 lacs cusecs, across river Som and canal

system for providing irrigation facilities to culturable command area of 13878 ha of land in

Aspur and Salumbar tehsil of district Dungarpur and Udaipur respectively in the state of Rajasthan as shown in Table 1. The scheme was intended to benefit tribal areas, irrigating 5714 ha of land annually with a BC ratio of 1.63:1 and financial return of 0.19 %. The project has seen several changes in its perspective since its inception, as shown in table 1.

Table 1: Changes in the scope of the project at various stages

SN	Particulars	1975	1978	1982	1985	1994
1	C.C.A. (ha)	13870	13940	13989	17724	17724
2	Annual Irrigation (ha)	5714	8364	12975	18788	18788
3	Gross storage (Mcum.)	83.1	83.1	118.65	172.8	172.8
4	Probable Max Flood (PMF) lacs cusec	3.72	4.8	8.0	10.63	7.24
5	F.R.L. (m)	209	209	211	213.5	213.5
6	M.W.L. (m)	209	209	213	215.5	215.5
7	T.B.L. (m)	212	212	215	217.5	217.5
8	Types of canals	Partially lined	Partially lined	Fully lined	Fully lined	Fully lined

A detailed study of the Baroda Branch Canal (BBC) of the Som Kamla Amba irrigation project has been done in this paper. This canal consists of 15 distributary, minors, and sub minors with the length of canal 23.19 Km. The canal is off taking directly from the dam site with a CCA of 4832 ha. Discharge of canal at head is 2.71 cumec. Maximum bed width and free board is 1.85 m and 0.60 m respectively. Maximum side slope is ¼:1 and maximum bed slope is 1:2500. Cross regulators are provided across the main canals/branch canals little downstream of each major off taking branch/minor for creation of necessary head to deliver the required discharge. Particulars and Details of structures on Baroda Branch Canal are given in Table 2 and 3, respectively. Figure 1 shows the location map of the Som Kamla Amba irrigation project dam and figure 2 shows the line diagram of Baroda Branch Canal of Som Kamla Amba Irrigation Project. Diagnostic analysis is one of the tools through which scientific management can be accomplished in best manner. Diagnostic analysis is a form of inquiry that tests whether or not an irrigation system is working as it should be.

Existing Physical Status

The physical state of the water distribution system is also influenced by farmers' awareness of how much water should be applied for proper plant

growth in the command area. The water distribution system in this area was surveyed by walk along the canals /minors to determine the current physical state of the main channel, minors, and outlets i.e., status of lining, gates and outlets, vegetation infestation, blockage, unauthorized pumping and so on. A variety of locations in the canal network had damaged canal lining, gates, and outlets.

Table 2:Particulars of Baroda branch canal

S.No	Particulars of Baroda Branch Canal	
1.	Length, Km	23.19
2.	Discharge, Cumec	2.7076
3.	Bed Width (max.), m	2.20
4.	Side Slopes (max.)	¼:1
5.	Free Board (max.), m	0.60
6.	Coefficient of Rugosity (N)	0.018
7.	CCA, ha	4832
8.	No. of Minors	15

Silt Deposition in Canals/Minors

Silt deposition was investigated at number of locations in entire canal network before irrigation

and after irrigation. The depth of silt deposition expressed in cm unit. Only thickness of silt measured using scale and the silt deposition was deposition was measured. The weed growth /

Table 3: Basic details of Baroda branch canal minors

SN	Minor	Off take	CCA (ha)	Discharge (cumec)
1	Tonkwasa minor	ch 137+20 L	61	0.033
2	Vasunder minor	ch 236 L	135	0.0729
3	Baroda minor I	ch 318 L	461	0.2475
4	Baroda minor II	ch 322 L	66	0.0289
5	Bhatwara minor	ch 370+20 L	145	0.0783
6	Punjpur minor	ch 416+15 L	521	0.3507
7	Chundiyawara minor I	ch 432 R	307	0.0693
8	Chundiyawara minor II	ch 487 R	76	0.0425
9	Jaspur minor	ch 523 L	103	0.056
10	Katisor distributory	ch 637 L	1953	1.081
11	Gada siyalia minor	ch 726 L	75	0.041
12	Badliya mnor	ch 735 L	170	0.097
13	Bankora minor II	ch 750 L	44	0.03
14	Galiyana distributory	ch 769 L	626	0.338
15	Bankora minor	ch 773	89	0.049

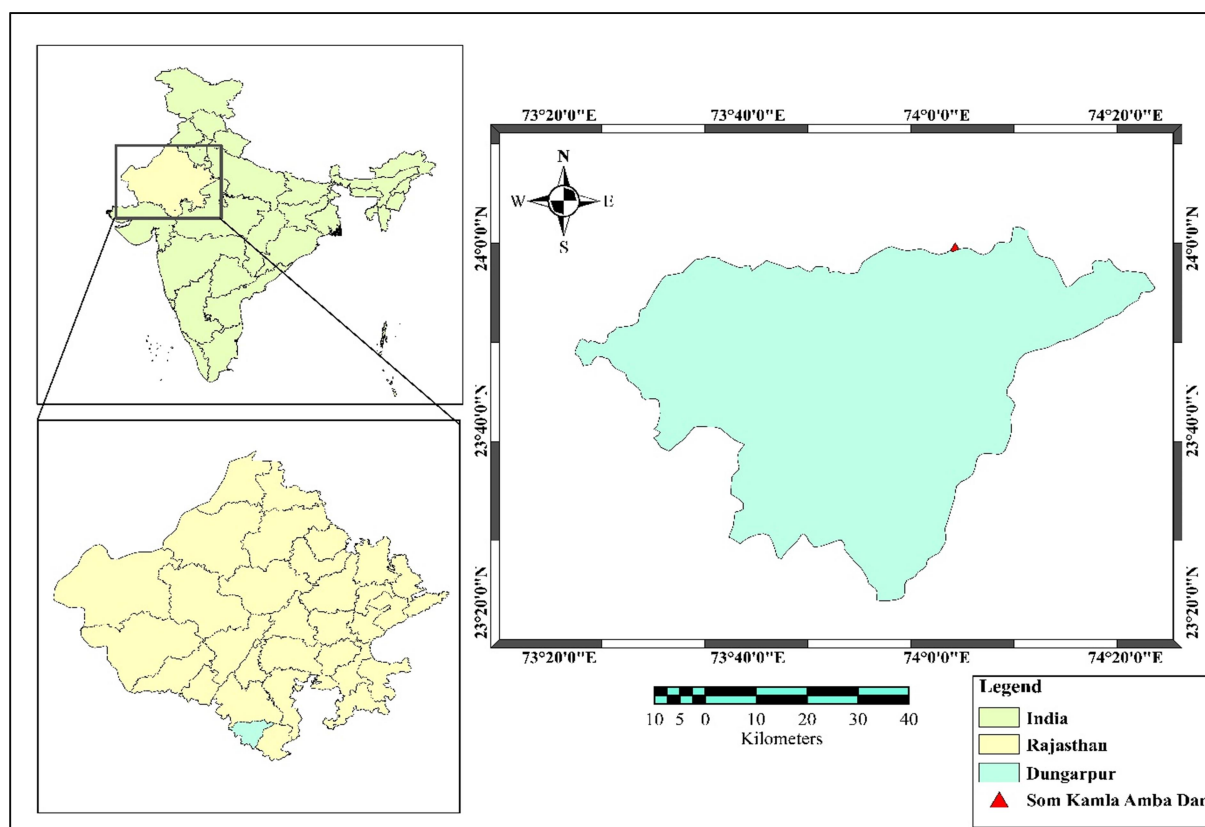


Figure 1: Location map of Som Kamla Amba irrigation dam

vegetative growth were also observed in main canals and minors. Siltation in canals/minors increases the likelihood of overtopping, resulting in

water waste. As a result, farmers must deal with

water logging in low-lying areas, necessitating the investigation of siltation in canals and minors. The height of silt accumulated from the canal's bottom was used to determine siltation.

Results and Discussion

Under diagnostic analysis, physical status of water distribution system and siltation of minors was studied. Physical status in terms of general health of the water distribution network, condition of lining, gates and outlets, vegetation infestation, unauthorized pumping etc., were evaluated. Siltation results in reduction in the carrying capacity of canal/minor, therefore, silt deposit was measured in the water distribution network.

Seepage and overtopping were the two major problems in the command area because of blockage of canal water due to sliding of sides of valley (figure 2) and damaged lining (figure 3) therefore maintenance is requiring, but no action is taken on behalf of Irrigation Department due to unavailability of maintenance funds. The second problem is siltation. The depth of silt is ranging between 35-40 cm. The vegetative growth was found at both bank of canal which is also one major problem which covers the canal at many locations.

The trees like babul, neem, khajur, etc. also grown both the sides, which results in damaged lining and also covers canal at both sides (figure 4 & 5). To maintain and preserve ditch and canal banks, vegetative growth, particularly grasses such as Bermuda, Bahia, or St. Augustinegrass, can be employed. The plant species should have broad root systems capable of retaining soil and be robust enough to supply sufficient hydration to the plants throughout the dry spring season, i.e., vegetation should maintain good cover and growth throughout the year to successfully safeguard the banks from eroding (Diaz *et al.*, 2014). However, mismanagement of vegetation can result in restricted access and inspecting capabilities, root damage, operational disruptions, obstructions, and habitat for burrowing animals, all of which increase the probability of canals deteriorating. Each year, a number of canals collapse, which are frequently due to poor vegetation upkeep. These failures can result in major economic losses, loss of project benefits, personal injury, and even death (Reclamation, 2017). The control gates were found

improperly working or damaged at 6 places, and damaged lining or broken wall was found at 22 places on the Baroda Branch Canal. Based on verbal enquire from the farmers, it is reported that many times, water is not ending at the tail end of BBC at that time, farmers in these areas irrigate their fields from wells or keep their fields uncultivated during rabi season. Rajput *et al.* (2021) reported that poor up keep of canal water system and lack of appropriate repair and maintenance activities were the main reasons for the poor performance of Bhimsagar irrigation project. They have also reported poor physical condition of the water distribution network and siltation hampering the optimal operation of the irrigation system. The diagnostic analysis of all the minors of Baroda branch canal have been described.

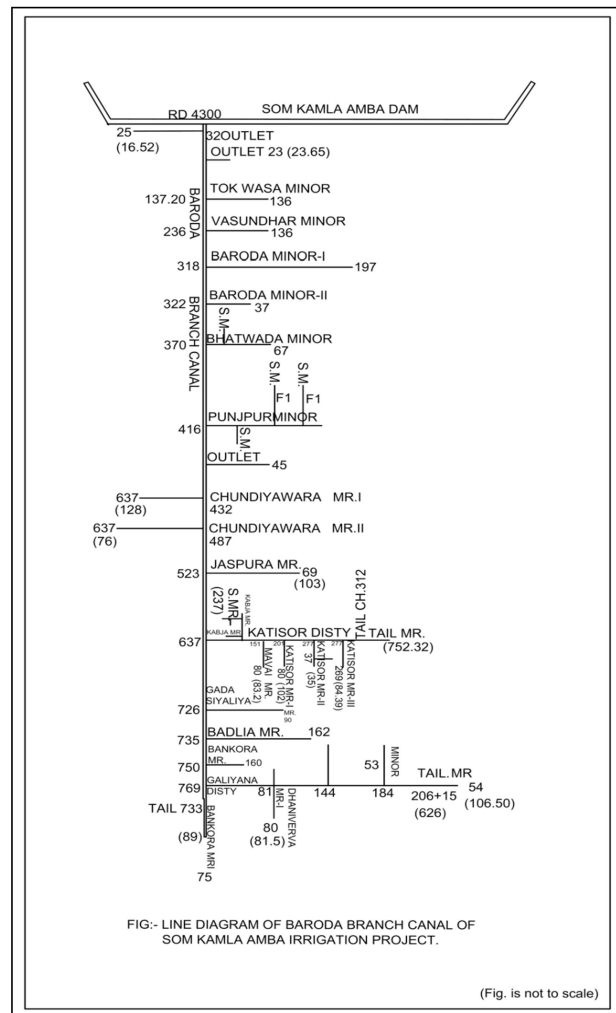


Figure 2: Line diagram of Baroda branch canal of Som kamla amba irrigation project



Figure 3: Blockage of canal water due to sliding of sides of valley in BBC at RD:187 chain



Figure 4: Damaged lining of BBC at RD:223 chain



Figure 5: Damaged lining of BBC due to Babul at RD:310 chain

Tokwasa minor

This minor off takes from head of BBC at RD 137+20 chainage and sluice gate was damaged resulting into uncontrolled flow in the minor. There is excess availability of water in this minor. Seepage and overtopping were the two major problems in the command because of cracks in the lining and improper beds slope. The vegetative growth was also found at both bank of minor which also results in the cracks in the lining. Irrigation is done by this minor in only Tokwasa village. Seepage is undesirable as it leads to ponding of the low lying area. Also, seepage causes a substantial amount of water lost which ultimately leads to unequitable water allocation among head and tail end commands.

Vasundhar minor

This minor off takes from head of BBC at RD 236 chainage. This minor has length of 136 chain. This minor has the culturable command area of 135.0 ha. There was a main problem of seepage in the command of vasundhar minor. Due to the seepage problem, minor had been blocked by villagers of vasundhar.

Baroda minor - I

This minor is situated on head of BBC and off takes at RD 318 chainage. This minor has maximum length 197 chain among all minors in the command with total culturable command area of 461.0 ha. There is a major problem of seepage in this minor. The vegetative growth was found at both banks of minor at many locations. Also, this minor is affected by the problem of siltation. The depth of silt ranges between 20-35 cm. The culturable command area of this minor mainly exists in Vasundhar chhoti and Baroda villages.

Baroda minor - II

This minor is situated on the head of BBC and off takes at RD 322 chainage. This minor has a length of 37 chains with a total culturable command area of 66.0 ha. There is a significant problem of seepage in this minor. Also, this minor is affected by the problem of siltation. The depth of silt ranges between 20-35 cm. Irrigation is done by this minor in only Vasundhar chhoti village.

Bhatwara minor

This minor off takes from the head of BBC at RD 370+20 chainage. The length and culturable command area of this minor is 62 chain and 145.0

ha, respectively. Seepage was the major problem in the command because there was an unlined minor and improper bed slope at many places. The vegetative growth was also found at both banks of minor, resulting in cracks in the lining. Due to improper bed slope and seepage loss due to unlined minors, tail end farmers were not getting enough water. A large area of the command of this minor mainly exists in Bhatwara village and some part in Baroda village.

Punjpur minor

This minor is situated in the middle of BBC and off takes at RD 416+15 chainage. This minor has a length of 131 chains and a maximum culturable command area of 521.0 ha among all minors in the command. The control gate was found damaged at Punjpur minor. The weed growth/vegetative growth are found at both banks of minor at many locations. Also, this minor is affected by the problem of siltation. The depth of silt ranges between 20-30 cm. A large area of the command of this minor mainly exists in Punjpur village and some parts in Nalva (Punjpur) and Talayfala (Punjpur) villages.

Chundiyawara minor - I

This minor is situated on the middle of BBC and off takes at RD 432 chainage. This minor has a length of 81 chains. The culturable command area of this minor is 129.0 ha. The sluice gate was found damaged (figure 6) of Chundiyawara minor-I. The vegetative growth was found at both banks of the minor, which covers the minor at many locations. The problem of seepage was also found, and also this minor is affected by the problem of siltation. The depth of silt ranges between 20-25 cm. The culturable command area of this minor mainly exists in Chundiyawara village.

Jaspur minor

This minor is situated on the middle of BBC and off takes at RD 523 chainage. This minor has a length of 69 chains. The culturable command area of this minor is 103.0 ha. The vegetative growth was found at one bank of the minor, which covers the minor at many locations. There is a significant problem of vegetative growth in the course of the minor. The culturable command area of this minor mainly exists in Jaspur village. The depth of silt ranges between 20-30 cm.

Katisor distributary

This distributary is situated on the middle of BBC and off takes at RD 637 chainage. This distributary

has a length of 312 chains. The culturable command area of this distributary is 1953.0 ha. This distributor has a fixed gate which cannot be opened or closed. Seepage and overtopping were the two major problems in the command because of cracks in the lining and improper bed slope and requiring maintenance. Still, no action was taken by Irrigation Department due to the unavailability of maintenance funds. Approximately 35 percent of the total area of a distributary is unlined, which results in the problem of seepage and siltation. The depth of silt ranges between 30-35 cm. The vegetative growth was found at both banks of the distributary, which covers the distributary at many locations. No control gate is found at off takes of Movai minor and Katisor minor - I, II, and III. Based on verbal enquire from the farmers, it is reported that water is not ending at the tail end of Katisor distributary. Approximately 25 percent of the area in the tail end of the Katisor distributary network is not getting any water for irrigation. Farmers in these areas irrigate their fields from wells or keep their fields uncultivated during the Rabi season. The culturable command area of this distributary mainly exists in Movai, Kabja, Antiya (punjapur), Lapiya, and Katisor villages.

Gada siyaliya minor

This minor is situated on the tail of BBC and off takes at RD 726 chainage. This minor has length of 90 chains. The culturable command area of this minor is 75.0 ha. The vegetative growth was found at both banks of minor, which covers the minor at many locations. This minor is having the problem of siltation. The depth of silt ranges between 10- 20 cm. The culturable command area of this minor mainly exists in Gada siyaliya village.

Badliya minor

This minor is situated on the tail of BBC and off takes at RD 735 chainage. This minor has a culturable command area of 170.0 ha with a minor length of 162 chains. There is a significant problem of vegetative growth in this minor. The vegetative growth was also found at both minor banks, which covers the minor at many locations. The problem of siltation was also one of the significant problems in this minor. The depth of silt ranges between 10-20 cm. Based on verbal enquire from the farmers, it is reported that water is often not ending at the tail end of the minor. Irrigation is done by this minor in only Badliya village.



Figure 6: Damaged lining and trees are grown on sides of BBC at RD:517 chain



Figure 7: Damaged sluice gate at the head of Chudiyawara minor-I in BBC at RD:432 chain

Bankora minor - II

This minor is situated on the tail of BBC and off takes at RD 750 chainage. This minor has a culturable command area of 44.0 ha with a minor length of 160 chains. There is a significant problem of vegetative growth in this minor. The weed growth was also found at both banks of minor, which covers the minor at many locations. Based on interaction with farmers, it is noted that most of the time, water is not ending at the tail end of the minor and sometimes even not ending the minor's head. The problem of siltation was also one of the significant problems in this minor. The depth of silt

ranges between 10-20 cm. Irrigation is done by this minor in only Bankora village.

Galiyana distributary

This distributary is situated on the tail of BBC and off takes at RD 769 chainage. This distributary has a length of 206+15 chain. The culturable command area of this distributary is 626.0 ha. Seepage and siltation were the two major problems in the command because of cracks in the lining. The depth of silt ranges between 10-25 cm. The vegetative growth was found at both banks of the distributary, covering the distributary at many locations. Based on verbal enquire from the farmers, it is reported that water is not ending at the tail end and sometimes even not ending the head of Galiyana distributary. Approximately 30 percent of the area in the tail end of the Galiyana distributary network is not getting any water for irrigation. Farmers in these areas irrigate their fields from wells or keep their fields uncultivated during the Rabi season. The culturable command area of this distributary mainly exists in, Galiyana, Dhaniverwa, Dhanibhevdi, and Dhanikateshvar villages.

Bankora minor - I

This minor is situated on the tail end of BBC and off takes at RD 773 chainage. This minor has the culturable command area of 89.0 ha with the minor length of 75 chains. There is a significant problem of vegetative growth in this minor. The weed growth was also found at both minor banks, which covers the minor at many locations. By the interaction with farmers, it is noted that most of the time, water is not ending the tail end of the minor and sometimes even not ending the minor's head. Most of the area in the tail end of Bankora minor - I network is not getting any water for irrigation. Farmers in these areas irrigate their fields from wells or keep their fields uncultivated during the Rabi season. Irrigation is done by this minor in only Bankora village.

A comparison of maintenance issues of minor/distributary located on Baroda branch canal is given in table 4. It is evident from the table that, the common issue of minor/distributary is seepage and vegetation growth which is due to neglected repair and maintenance of canal network system components. Minor/distributary located in the tail end of Baroda branch canal found were not getting adequate water and thus no assured irrigation water

in the tail end command system. The siltation problem is prominent due to irregular bed slope and poor maintenance of canal sidewalls. Many of the sluice gates were damaged, which resulted in the uncontrolled entry of water into the minor/distributary from the branch canal. It was observed that less attention was given to the mid and tail section of the Baroda branch canal than the head section, resulting in inequitable water distribution. Overtopping of water is due to reduced capacity of minor by silt deposition.

Physical / Structural lining of the canal

The lining of the canal was impaired at a variety of places in the entire network of canals. The farmers of the command area damage the lining of the canals or minors for getting the excess quantity of water and avoid an extra laborer in irrigating fields that have to do due to being outlets at significant distance from their fields. This is causing a large quantity of water loss through seepage from the damaged portion and affecting designed discharge in the canal section. Similar results were observed in the Bhimsagar irrigation system's water distribution network in Rajasthan state (Rajput *et al.*, 2017).

Water courses

Farmers' water courses were not maintained regularly, particularly by head end farmers. As a result, nearly all water courses were damaged and weed-infested in several locations. The water courses off taking even from the head of distributary or minor were not able to supply the sufficient quantity of water to its tail end fields due to improper maintenance and tempering of networks by the farmers.

Gates and pipe outlets

The majority of the gates are tempered or damaged. As a result, there is no flow or control (opening or closing) power available. In the canal network, the pipe outlets were often found tempered or oversized. The results for additional illegal outlets were also made and seen as nine outlets on BBC, several outlets on the minors.

Obstructions in the canals

Farmers block canals and do not allow water to pass down the stream. During the night time, this issue emerges more. In canals, stone barriers were placed to lift the head and increase the discharge at the outlets. At five BBC locations, obstructions to

reduce flow in canals and redirect further water in the water course were found.

Siltation / Weed infection in canals

The silt that is carried by the river is not significant. Nevertheless, canal water is generally silt-free, but silting in the canal takes place in certain areas due to the entry of run-off water into the channel. With the deposition of silt and debris, the canal parts were marked. At different places, it is as high as 40 cm. The growth/vegetative growth of weeds is also observed at a variety of canal network locations. The department did not carry out the maintenance operations due to a shortage of human resources. Siltation also affects river flow and the number of times water flows out of the canal and accumulates in low-lying areas. Similar work had been done by (Mishra 2009). She found that the canal lining exists in the entire Rajsam and Canal Network. The majority of gates were found tempered. The siltation and overtopping were the two significant problems in canal command. In the present study, approximately 35 % of the total area of Katisor distributary was unlined. The major problems were the vegetation growth and seepage in the entire canal network of the Baroda Branch Canal. The results found in the present study are in contrast with past research work because the Som Kamla Amba dam is too old, and the Rajsamand is comparatively new. To improve the overall functioning of the Baroda branch canal, the following measures should be adopted.

Measures to correct system deficiency and to improve the Baroda branch canal irrigation system performance

1. Inspection and repair & maintenance of canal water distribution network twice a year during the non-flowing season before Rabi crops are sown.
2. Formation of outlet water level monitoring committees comprises of irrigation department personal, water user associations (WUA), and irrigators for the judicious operation of the system.
3. Linkages and effective communication network between irrigators, WUA, and irrigation department to address issues related to the operation, monitoring, and maintenance of canal distribution network.
4. Development and effective implementation of water rostering system as per the crop water

the requirement in the different segments (head, mid, and tail end) of the canal system.

5. Training to irrigators on aspects such as water conservation and agronomical practices should be imparted to develop an understanding of water-saving.
6. Adoption of drip irrigation system and sprinkler/micro-sprinkler system to save water, energy and improve crop production.
7. Implementation of automatic sensor-based water delivery mechanism/check gates to tackle the tail end farmers problem by decreasing overuse of water in the head and middle sections of the canal network.
8. Conjunctive use of surface water and groundwater should be encouraged for sustainable crop production in the canal system.
9. Utilization of in-situ moisture for crop production in the tail end section to decrease gross water demand.

Conclusion

The diagnostic research was carried out to investigate the operational issues in the Som Kamla Amba irrigation project's Baroda Branch Canal network. In this command zone, there is no proper water delivery system. By inserting obstructions in canals, farmers at the head use more water than the

actual requirement and restrict water from ending to tail end farmers. Farmers were not getting enough water for irrigation at the tail end of the network. Therefore, they irrigate their fields from wells or keep their fields uncultivated during the Rabi season. The waterlogging problem is examined in low-lying areas during the irrigation season on account of seepage from the canals. The majority of pipe outlets and gates were tempered, and the number of oversized outlets was observed in the canal network. Seepage and overtopping were the two significant problems in command of minors at head end. This means Tokwasa minor, Baroda minor-I, Baroda minor-II, because of cracks in lining and improper beds slope of this minor. Based on verbal inquiry from the farmers, it is reported that approximately 25 % of total command of Katisor distributary is not getting any water for irrigation in the tail end for many years, and the command at tail end of Baroda Branch Canal also not getting the sufficient water. In Bankora minor-I, there is a significant issue of water scarcity because it is located on the tail end and water seeps through cracks formed in the minor.

Conflict of interest

The authors declare that they have no conflict of interest.

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