



सत्यमेव जयते

National Mission for Clean Ganga

Ministry of Jal Shakti

Department of Water Resources, River Development & Ganga Rejuvenation
Government of India



JOJARI

Revival and Protection

River Focused - Integrated and Composite Water Resources Management



cGanga

Centre for Ganga River Basin Management and Studies

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National Mission for Clean Ganga (NMCG)

NMCG is the implementation wing of National Ganga Council which was setup in October 2016 under the River Ganga Authority order 2016. Initially NMCG was registered as a society on 12th August 2011 under the Societies Registration Act 1860. It acted as implementation arm of National Ganga River Basin Authority (NGRBA) which was constituted under the provisions of the Environment (Protection) Act (EPA) 1986. NGRBA has since been dissolved with effect from the 7th October 2016, consequent to constitution of National Council for Restoration, Protection and Management of River Ganga (referred to as National Ganga Council).

www.nmcg.in

Centre for Ganga River Basin Management and Studies (cGanga)

cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga's mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this it is also responsible for introducing new technologies, innovations and solutions into India.

www.cganga.org

Local Executive Bodies, Jodhpur

The Jodhpur Municipal Corporation is the official body of the Jodhpur city located in the western region of Rajasthan. The democratically elected members, through this body, undertake the management of the city's infrastructure and public services under the leadership of the Mayor. At present, the municipal area of Jodhpur is divided into Jodhpur South (80 wards) and Jodhpur North (80 wards). The Jodhpur Municipal Corporation was established in 1992, which is spread over 3 assembly constituencies. In addition to the Municipal Corporation, the development works in Jodhpur are done through the Jodhpur Development Authority, enacted under the Jodhpur Development Authority, Authority Act, 2009 (Act No. 2 of 2009), under the Urban Development and Housing Department, Government of Rajasthan. The Jodhpur Development Authority was set up to plan, coordinate and oversee the proper, orderly and rapid development of the Jodhpur region and to implement plans, projects and plans for development. The Department of Water Supply, Government of Rajasthan is responsible for the water supply in the Jodhpur region and later on, through the Rajiv Gandhi lift canal brought up to Jodhpur, the water supply from the Sutlej river for drinking water and other needs.

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Acknowledgment

This document is a collective effort of many experts, institutes, and organizations of the country and the state, we thank them for their cooperation and guidance with the dedicated members of cGanga. We especially express our gratitude to the people who contributed the necessary data, photographs, and pictures for this document.

Suggested Citation

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Preface

NATIONAL RIVER Ganga has been at the center of the government's multi-decadal efforts to restore and conserve degraded Indian rivers. The Ganga River Basin Management Plan (GRBMP) submitted to the National Mission for Clean Ganga (NMCG), Government of India in the year 2015 by a Consortium of 7 IITs ("Indian Institute of Technology"s) set a clear direction and action-framework for this purpose, but progress on its implementation was tardy, partly due to the GRBMP recommendations being broad-based strategic measures to some extent. Therefore, after the Centre for Ganga River Basin Management and Studies ("cGanga") was created through a Memorandum of Understanding between MoWR, RD&GR (now Ministry of Jal Shakti), the Government of India, and IIT Kanpur in April 2016, cGanga conducted many field and in-house studies as well as workshops and consultations with stakeholders, executive bodies, monitoring agencies and experts on various components of GRBMP and its implementation. Based on these activities over the past few years, a clearer understanding emerged on some of the major implementation challenges of GRBMP, especially the difficulty in restoring a very large and complex river system like River Ganga. This led to a more refined and detailed strategic implementation procedure that combines robust scientific methods with a socio-economically, culturally, and administratively aligned policy framework.

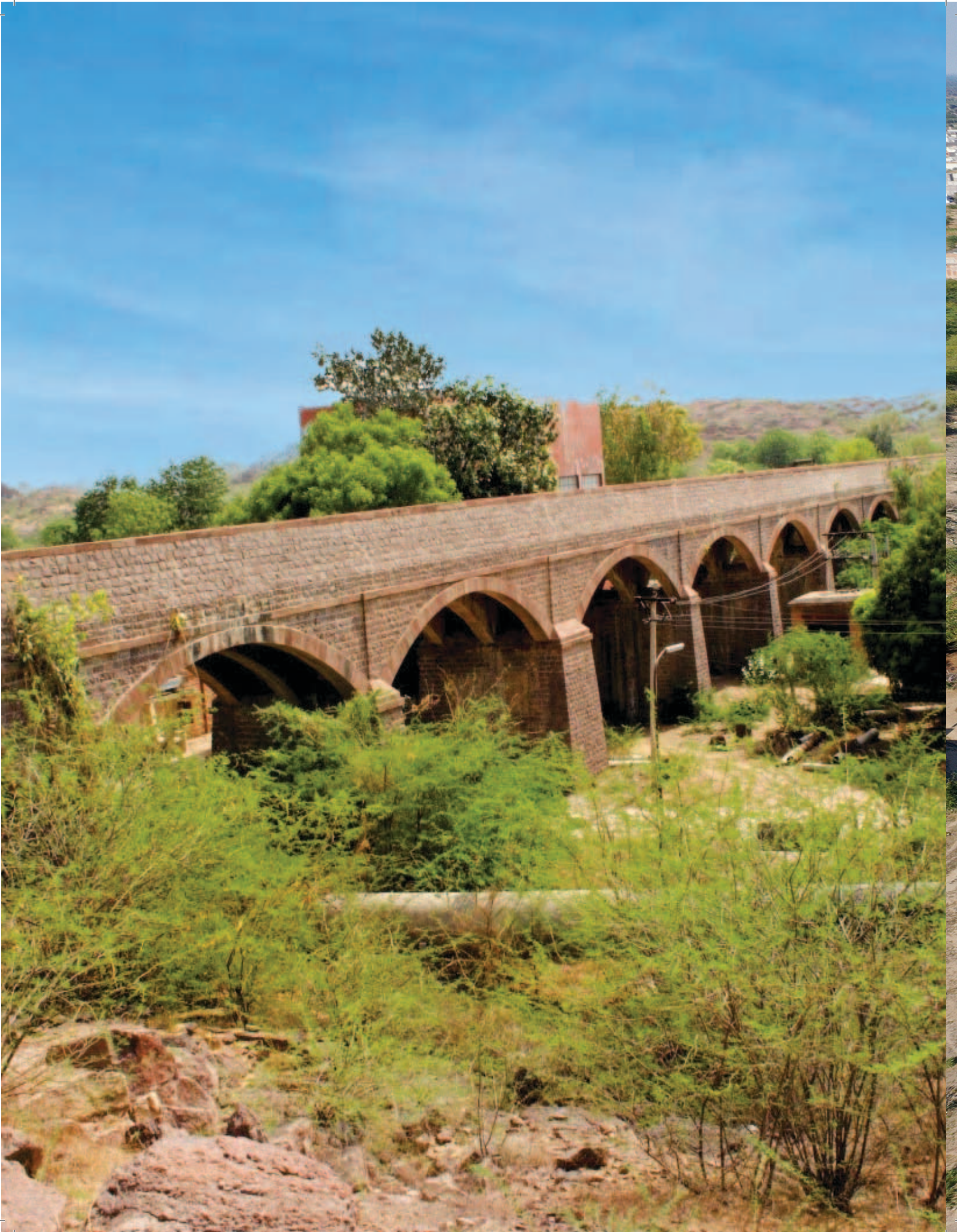
The revised strategy that evolved was essentially a bottom-up approach to Ganga river conservation where relatively small, low-order streams that comprise the main source streams of the Ganga

river system were brought into focus for restorative action because they could be restored and conserved independently and cohesively in the entire Ganga basin, thereby leading to a cascading impact on River Ganga as a whole. This approach was embodied in the Concise Manual and Guide for River Restoration presented by cGanga and NMCG during the India Water Impact Summit (IWIS) in 2019. Adopting the strategy outlined in the manual, the present Vision Document for River Jojari lays down the restoration needs and strategy for the river given its socio-cultural and ecological status – both historical and modern– and the urban and rural socio-economic needs of present times. The document does not lay down the nuts and bolts of the restoration plan but is a first step at defining them by taking cognizance of the physical, social, and management status of the Jojari river.

This document was prepared by dedicated members of cGanga through the gathering of information, analyses, and discussions with various agencies and individuals. Key stakeholders, experts, and community representatives of the Jojari river basin also interacted with cGanga members and gave their valuable inputs unreservedly on many aspects of the document. This document is, therefore, the outcome of a joint effort of Team cGanga with dedicated members of the Jojari river basin.

VINOD TARE

Professor & Founding Head, cGanga
IIT Kanpur





Aerial view of Feeder Canal (used for rainwater harvesting) and Jojari River

1. River Jojari – A key tributary of the “Desert Ganga” Luni River

Rivers in India originate from and traverse a variety of landscapes like mountains, plateaus, plains, and even deserts. Most large rivers like the Ganga, Yamuna, Brahmaputra, Narmada, Godavari and Kaveri originate as small source streams in mountain ranges and flow down the plains towards the sea as they join several tributaries on the way. Many small rivers,

however, originate at lower elevations such as the desert rivers of Rajasthan. Prominent among these is the Luni river, often referred to as the “Maru Ganga” (i.e. “Desert Ganga”) on account of its vital life-giving importance in the arid regions of Rajasthan. Originating near Ajmer in the Aravalli Range, Luni ends in the Rann of Kutch. Though is a saltwater river and a seasonal one that, River Luni fulfils vital domestic and irrigation water needs, and is thus the lifeline of arid water-starved regions of Rajasthan – just as the perennial freshwater Ganga serves as the lifeline of water-rich states of North India. Notable among the tributaries of the Luni is the Jojari river, which flows through the districts of Jodhpur and Barmer before draining into Luni.

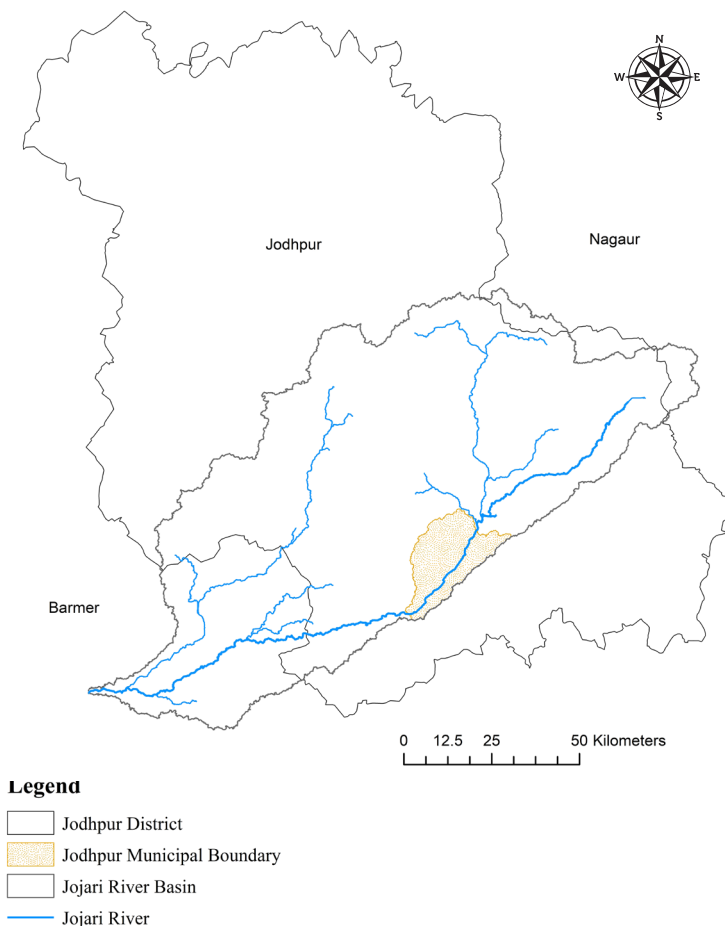


Figure 1: River Jojari and its catchment covering three districts of Rajasthan

The catchment area of Jojari River is spread over three of the driest districts of Rajasthan, namely, Nagaur, Jodhpur and Barmer (**Figure 1**). The headwaters of Jojari river originate from the Ustara and Birai areas of Jodhpur district. It enters Jodhpur city through Banad in the north-eastern part of the city and flows for about 35 km southward till Salawas, where it exits the city limits. Traditionally a seasonal river, the present flow in the river in Jodhpur is, however, depleted and severely polluted by sewage and effluent inflows caused by unplanned population growth, inadequate sewage collection and treatment facilities, and unregulated industrialization. Moreover, due to construction of a national highway from Araba located below Jodhpur, the path of the river has been disrupted at

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many places, and the flow is eventually obstructed, with the river ceasing to exist beyond this point with waters spilling over onto low-lying lands. On the other hand, the polluted waters from industrial and residential areas affect not only the river, but also the productivity of the surrounding lands and groundwater quality. The present-day Jojari river is,

thus, in dire need of systematic revival. A brief overview of the Jojari river basin is presented in **Table 1**.

2. Desert Rivers – In a class of their own

Rivers, large and small, flowing through different geographical areas, have unique characteristics that set them apart from

TABLE 1: BRIEF INFORMATION ABOUT THE JOJARI RIVER BASIN

Basin Area	Length of Main Stream	Catchment Area Spread	River Segments	Shrinkage of Basin Area
				
INCLUDES , hills, alluvial soil, agricultural land, urban and rural centers and industrial areas.	FROM THE place of origin Ustara to Banad (76 km), Banad to Salavas (35 km), Salavas to Doli Rajguron (43 km), Doli Rajguron to Luni to Sangam (85 km) having a total length of 239 km.	THE TOTAL catchment area of 10222 sq.km is spread over 254 sq. Km in Nagaur district, 7846 sq. Km in Jodhpur district and 1922 sq. Km. in Barmer district.	THE RIVER can be divided into 5 segments based on the changes in hydrology, water quality and topography. 1. Banad from the point of origin (entering Jodhpur city) 2. Salavas from Banad (exit from Jodhpur's urban area) 3. Saliwas to Doli Rajguron (NH 25 ends the river) 4. Doli Rajguron to Pachapadra 5. Lunar to Pachapadra	THE LENGTH and catchment area of the river has been reduced by 92 km and about 50 percent respectively. The Jojari River lost its right to meet with the Luni River at Blotra.

one another. Ancient Indian scriptures also allude to different rivers having different significances thus:

What the above verse suggests is that all rivers may be important and sacred for humans, but different rivers should be approached differently and treated differently because each

**त्रिभिः सारस्वतं तोयं सप्ताहेन तु यामुनम्।
सद्यः पुनाति गांगेय दर्शनादेव नामर्दम्**

(मतस्य पुराण १८५६१०-११)

सरस्वती नदी में तीन दिन स्नान करने से, यमुना में सात दिन स्नान करके एवं गंगा में केवल एक स्नान से पवित्रता प्राप्त होती है परन्तु नर्मदा के दर्शन मात्र से मनुष्य पवित्र हो जाता है।

[Bathing for three days in River Saraswati, seven days in River Yamuna, and only one day in River Ganga bestows sacredness, but humans become sacred merely by the sight of River Narmada.]

Matsya Purana, 185/10-11]

river has its unique characteristics in terms of topography, catchment characteristics, geomorphology and geochemistry, hydrology and hydraulics, water quality, and ecology. Thus, the restoration and conservation of different rivers should be addressed with differentiation commensurate with their different characteristics.

In desert areas with low rainfall and rare surface storages or soil moisture, the groundwater table is often far below ground level. Hence, there is virtually no contribution of groundwater to river baseflows. Thus desert rivers, unless fed by perennial water sources like perennial lakes, are often seasonal or ephemeral, flowing only or mainly during in the monsoon season. Some rivers

may even flow only once in several years when monsoon rainfall is plenty. At the same time, even such monsoonal rivers may flood the surrounding lands when heavy showers occur. A second distinguishing feature of desert rivers is that, due to the high amount of salt in their catchment soils, saline water flows are common in such rivers, due to which the river ecosystem is characteristically different from those of freshwater rivers. Despite these differences and apparent shortcomings, however, desert rivers are a unique source of vitality for local habitations and the ecology.

3. Historical Significance of River Jojari

The Jojari river flows through some of the driest areas of the country. About

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78% of its total basin area of about 10 thousand sq. Km lies in Jodhpur district. Currently it drains into River Luni, but some archaeologists consider Jojari to be a tributary of the extinct Saraswati river (India Water Portal, Hindi). Since the establishment of Jodhpur city and until the 19th century, many harvesting and water storage structures were built from time to time in the Jojari catchment to meet the water needs of the ruling family and residents of the central region of Jodhpur city. These water harvesting structures were a great boon for the city's growth and, indirectly, also a partial source of flow in the Jojari river. But the state and utility of these structures have changed over time, thereby affecting River Jojari and its catchment conditions.

4. Current Water Problems in the Jojari River Basin

At present, the major problems of River Jojari are directly related to unplanned

and disjointed water management practices of Jodhpur in the backdrop of its previous water resource development and the geology of the region. For instance, a survey conducted by the School of Desert Science (1989) found that Jodhpur has many Bere (wells), 8 Jhalare (step-wells), 48 Bawdi (pools) 46 ponds (only 40 found in existence at present. 25 naadis (dug-out ponds), many tanks, and 5 lakes (**Figure 2**) which have been used as water sources from time to time. These distributed water storage devices remain largely outside the fold of water resource planning.

Western Rajasthan generally lies in low rainfall area, due to which water for domestic, agricultural (irrigation) and industrial use is supplied with the help of canals connected to water sources in other parts of the country. Of the total 595 groundwater-zones (regions/ divisions) of Rajasthan, 268 zones have been identified as gray or dark zones, and only 3516.9 MCM groundwater is available in the desert region of Rajasthan. From 1870 to 1936, the water supply of Jodhpur city was met from the rainwater harvested in hilly areas around Jodhpur city. Construction of 27 small dams spread over 92 sq. Km., feeder canals of 80 km length, and construction of Balsamand, Kayalana and Ummed Sagar dams and other water storage structures took place during this period. These structures are estimated to store about 3.4 MCM (120 MCFT) and 8.16 MCM (288 MCFT) of water during an average annual rainfall of 35 cm (14 in) and above-average rainfall of 50 cm (20 in), respectively. This

Jodhpur has many distributed water storage devices, but these remain largely outside the fold of water resource management.

Legend

- Water Harvesting Structures
- Jojari River
- JMC Boundary
- Jojari Catchment Jodhpur

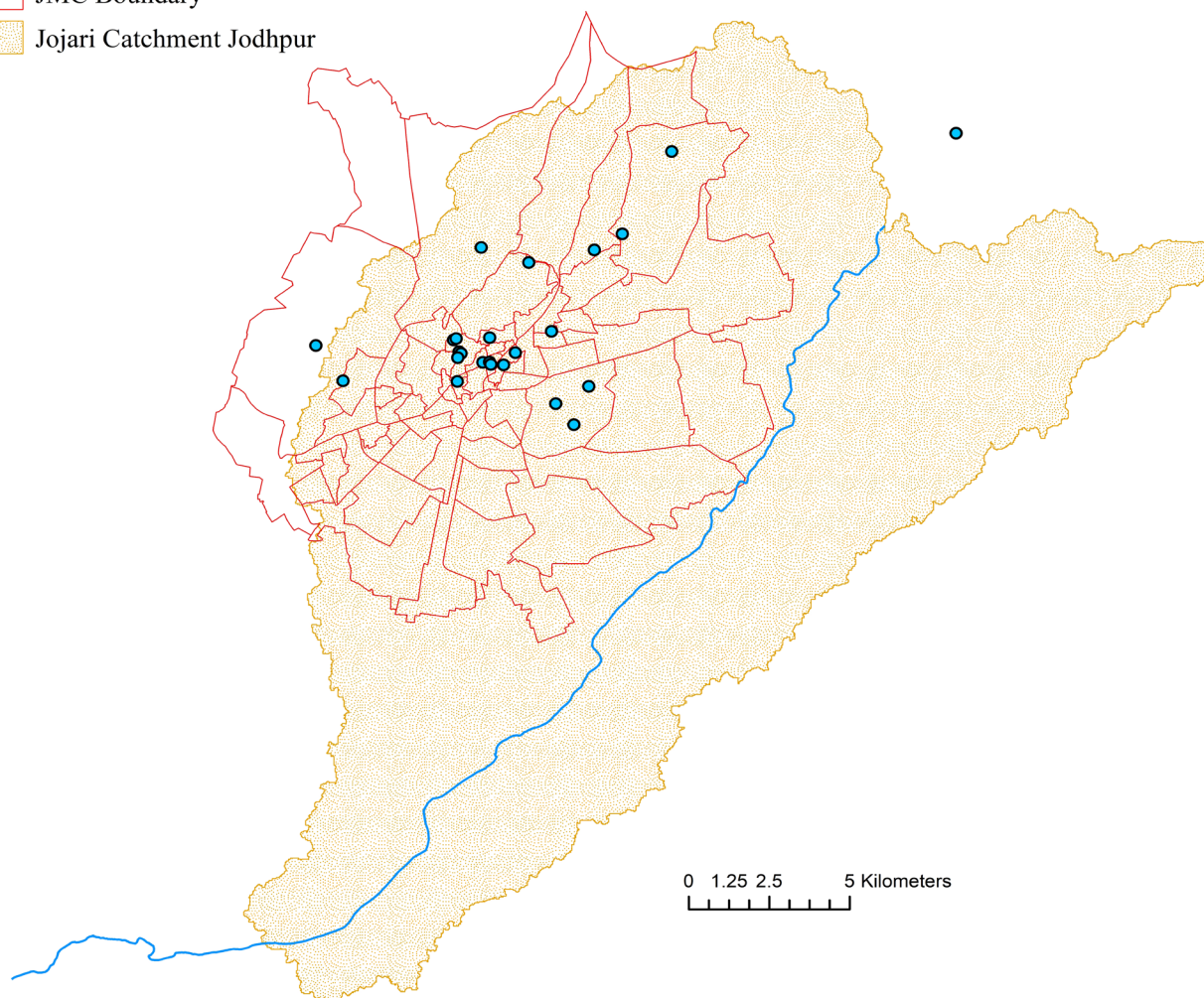


Figure 2: Existing water harvesting structures of the historical water harvesting system in Jodhpur

rainwater harvesting system has been considered to be one of the best water harvesting systems in the world.

During the 1970s, mining activities in the catchment areas of the canals converted large swathes of the present hill

catchment into mining pits that capture runoff which may have otherwise run into the existing water harvesting structures. Along with this, the feeder canals have also got damaged. Thus, every year during the rainy season, rainwater collects in the mining pits, which is

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mostly pumped out onto nearby roads by the mine owners. Between 1996 and 2000, a plan of new feeder canals by way of small drains was being implemented for pumping water from the mining pits to water storage structures, but it did not prove very useful due to being limited to small areas. Moreover, due to the altered land use of residential colonies coming up in the catchments of the dams, the rainwater coming from urban parts of the city is mixed with untreated sewage and solid wastes, and is unsuitable for the water harvesting system. Thus, the city's rainwater has to be disposed of in the wastewater drains.

With the abundance of water brought by the Rajiv Gandhi Lift Canal from stored waters of Punjab rivers to Jodhpur city, the water consumption of Jodhpur-dwellers have also become excessive, with 17-60% more water supply than national standards (NIH 2011). Increased water usage has also increased the amount of polluted water generation. Due to the lack of a proper sewerage system in the city and the geological substrate of Jodhpur, a significant part of the wastewater probably seeps into the groundwater, resulting in groundwater pollution and rising groundwater levels. In addition, the rainwater harvested or flowing in natural drains also mixes with industrial effluents before discharging into River Jojari. Due to these multiple reasons, Jodhpur, which was once known for the importance given to water, development of local water storage facilities, and judicious water

management, faces formidable water-related problem as discussed below.

4.1 Pollution from Industrial and Residential areas in Jojari river

There are more than 400 industrial units in Jodhpur region, which include more than 300 textile mills and 90 steel re-rolling mills located in the industrial area of Jodhpur. A CETP was constructed for the treatment of industrial effluents, but most of the effluent remains untreated in the absence of a proper collection and treatment system, and it flows via the RIICO drain into the Jojari river (Singh, 2018).

The sewerage network of Jodhpur is also grossly inadequate. Thus, due to limited sewage collection, only a part (75-80 MLD) of the sewage coming from the residential areas of Jodhpur city reaches STP, while a large portion of the sewage directly flows through various drains into River Jojari (Singh, 2018). **Table 2** lists the main drains of Jodhpur, and some of the main drains which run through Jodhpur city and discharge into Jojari are shown in **Figure 3**. A proposal to link the thirteen main drains of Jodhpur with Jojari by means of six drainage channels has been made. Recently, it was also proposed to connect two nalas (Bhairav Nala and Mata Ka Than Nalla) with Jojari. Though all these drains are important for drainage during the rainy season, in the remaining part of the year it is sewage that mainly flows in these drains and reaches River Jojari. Thus, since Jojari is not a perennial river, untreated and semi-treated municipal sewage flows comprise the main flow of River Jojari except during the rainy season.

Table 2 : Information related to main drains for the drainage of Jodhpur city

S. No.	Drain Route	Total Length (Km)
1-1	Sojati Gate - Anand Cinema - Old Power House - Central Jail - Shiva temple - Ratanada	2.2
2-2	Diagnostic Center (Rog Nidan Kendra) Jalori Gate - Jalori Bari - MG Hospital - Jaswant Sarai - Railway Reservation Office - Anand Cinema	1.2
3-3	From Bamba Mohalla (Old Stadium) - Darpan Cinema - Gaushala Ground - Ajit Colony - Shiva Temple - Ratanada	2.6
4-4	From Ratanada Junction Point - Engineering College - Sansi Colony - Civil Airport Pabupura	6.8
5-5	Nakati Pulia - MDM Circle - Pal Road - Khema Kuan	3.7
6-6	From Sur Sagar - Chandana Bhakar - Kamla Nehru Nagar - Lal Pulia - Chopasini Housing Board - Khema Kuan - Ambika Nagar - Sobhavat ki Dhani	18.5
7-7	From Udaya Mandir - Baldev Mirdha Circle - Paota Circle - Rasala Road - Prithvipura - Jaipur Road Cantonment - Digri Saran Village - Army Area - Jojari River	9.7
8-8	From Krishi Mandi Nala - Bhadwasia - Vishwakarma Nagar - Vidya Nagar - RTO Office - Gulab Nagar - Sirkaria Beri	8.0
9-9	From Balsamand Overflow - Sanghvi School (Mandore Road) - School of Mandavato - Phool Bagh to Surpura Tank - Jojari	6.4
10-10	Bhakat Sagar - Nehru Park - Medical College - MDM Hospital - Section 7 - Bhagat Ki Kothi - Mahaveer Nagar - Polytechnic College - Golf Course - Air Force Area	10.9
11-11	Basni Bandh - Mata Ka Than - Central Academy - Khokharia - Jojari	10.1
12-12	Ummed Sagar - Meera Colony - Gaurav Pond - Joshi Colony - Chandna Bhakar - Suthala Village - Jwala Vihar - Ummed Sagar	5.8
13-13	Balsamand - Janta Colony - Indira Colony - Mirasi Colony - Bagar - Gulab Sagar	9.7

4.2 Obstructed River Flow

The construction of National Highway 25 passing near Araba blocked the route of Jojari river at this point, and

all its sewage-contaminated waters accumulate in low-lying areas near Doli Rajaguran. Due to this inflowing sewage, not only have the river and surrounding

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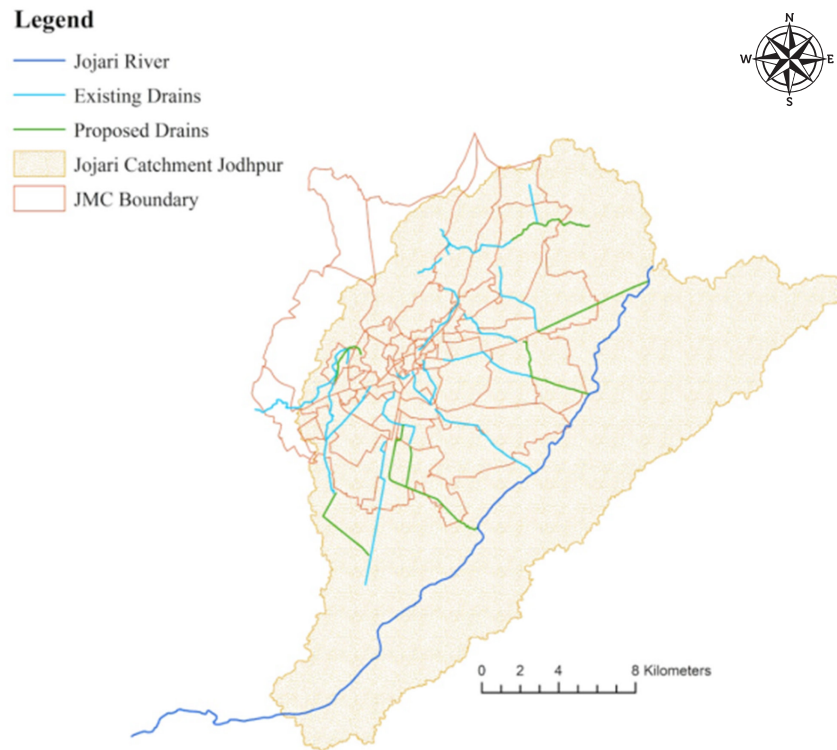
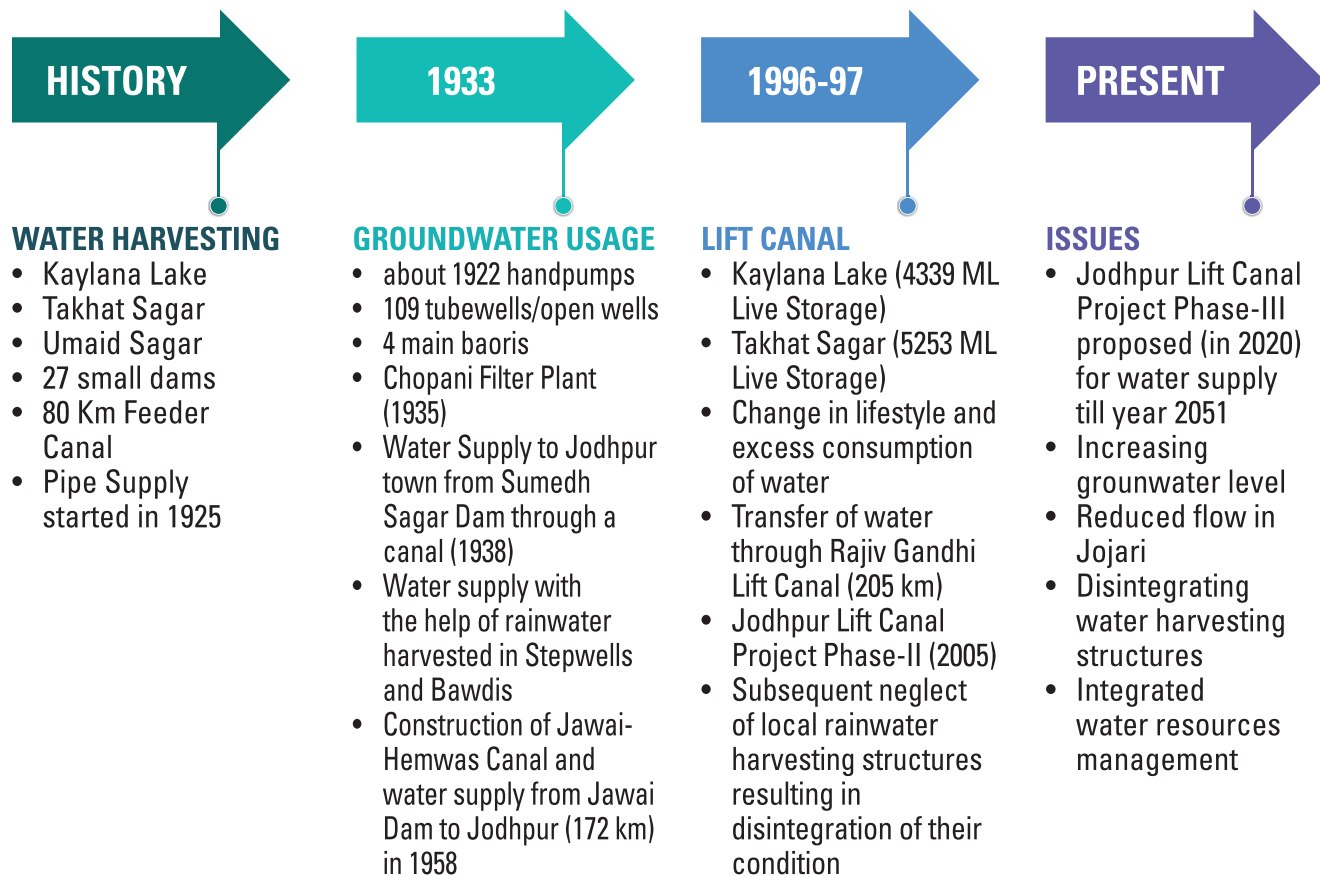


Fig 3: Proposed and Existing Drains flowing through Jodhpur City



ecosystem changed, but the use of this ponded water in downstream areas has affected the quality of soil and agricultural products there, a likely hazard for human health.

4.3 Rising Groundwater Levels and Groundwater Pollution

The groundwater level has been steadily increasing in some areas of Jodhpur city in recent times. About 40 percent of the urban area is affected by this fast-growing problem, due to which water has been seeping into the basements of houses and shops since the late 1990s, with the building foundations becoming weak and increasing possibility of building collapses. As a result there is greater likelihood of weakening of foundations and building collapses, and hence their construction and maintenance expenses have increased. Besides, the seepage of polluted waters creates undesirable humidity and poses the threat of spread of water-borne diseases.

The problem of rising groundwater levels in Jodhpur city was observed to happen with the increase in water supply to Jodhpur region after commissioning of the Rajiv Gandhi lift canal. Groundwater seepage in basements was first detected between 1998–2000 in some areas of the old city such as New Road, Hathi Ram Ka Oda, Tripolia, Public Park, Ship House, Laxmi Nagar, and Fatehsagar area. The problem has now spread to areas outside the city limits, such as Ajit Colony, Raatanada, Panchvati Colony,

High Court Colony, Outer Chand Pol area, and Bhadasia. Increased groundwater levels have escalated water logging in the basements, added to moisture in buildings, reduced the capacity of sanitation pits, deep drains and septic tanks, and caused an upsurge in pollution in open wells, step-wells, and ponds. Since the 1960s, the water of about 60 wells in Salavas village has also become polluted and no longer potable due to the flow of industrial and residential waste into the Jojari River (CAZRI, 2016).

While rising groundwater table can be generally attributed to increased water/wastewater discharges, some specific causes of increasing groundwater levels and pollution in the inner areas of the city have been attributed to the following factors (NGRI, 2010, NIH, 2011 and CGWB, 2015):

1. Increased leakages from the water supply system, as indicated by high amounts of chlorine found in groundwater.
2. Increased leakage from sewerage system as indicated by high nitrate levels in groundwater.
3. Possible leakage from the Kaylana-Takhtasagar lakes though so far studies have not found any direct correlation of the increased water level of the city with the lakes.

Among the three points mentioned above, the 2nd point is probably the main reason for higher and more polluted groundwater levels in Jodhpur city.

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5. Importance of Restoration and Conservation of River Jojari

The Centre for Ganga River Basin Management and Studies (cGanga), based on its expertise gained through the preparation of GRBMP and extensive research, had formulated a reliable method to revive and preserve degraded rivers, expressed through its documents such as "Vision Ganga" and "A Concise Manual and Guide for Restoration and Conservation of Rivers (RRC Manual)". In consonance with its mandate, cGanga – with the assistance of NMCG – selected some degraded rivers flowing in different geographical areas in the country as priority projects for demonstrating river restoration and conservation. These rivers have lost their natural pristine forms in various ways but had a significant role in the aquatic environment and water wealth of the region earlier. River Jojari, a major tributary of the Desert Ganga (Maru Ganga) Luni river, is one such river that was identified for applying the

restoration strategy.. The pertinent location of the River Jojari and its usefulness (for agriculture, ecosystems, water resources, etc.) of western Rajasthan makes it an important desert river that needs speedy revival. In line with the criteria outlined in the RRC Manual, the main reasons for selecting the Jojari river for restoration and conservation are the following:

5.1 Low-Order River

Before entering the urban area of Jodhpur, the Jojari river transforms from a second order to a third order river above Banad. Near Charlai Khurd, it joins the Luni River to form a fourth-order river (**Figure 4**). Since River Jojari itself is a relatively low-order river with few large tributaries, its restoration and conservation can be done independently and comprehensively, which will also have a cascading positive effect on River Luni.

5.2 Perennial Stream

As mentioned earlier, according to some archaeologists, the river Jojari was a tributary of Saraswati that may have been a perennial river. The Jojari river itself, flowing in arid regions, may not itself be naturally perennial; however, about 180 MLD of water (wastewater) coming from industrial and residential areas of Jodhpur city effectively convert it into a perennial river, albeit a polluted one. If the polluted waters presently reaching Jojari are subjected to proper collection and treatment before entering the river, they have the potential to convert Jojari into a perennial clean water river by maintaining a minimum flow of unpolluted water in the river during the dry season. This minimal

The strategic and location of River Jojari and its usefulness for agriculture, ecosystems, water resources, etc. makes it an important desert river that needs speedy revival.

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Legend

 Jojari River Basin

Stream Order

 1

 2

 3

 4

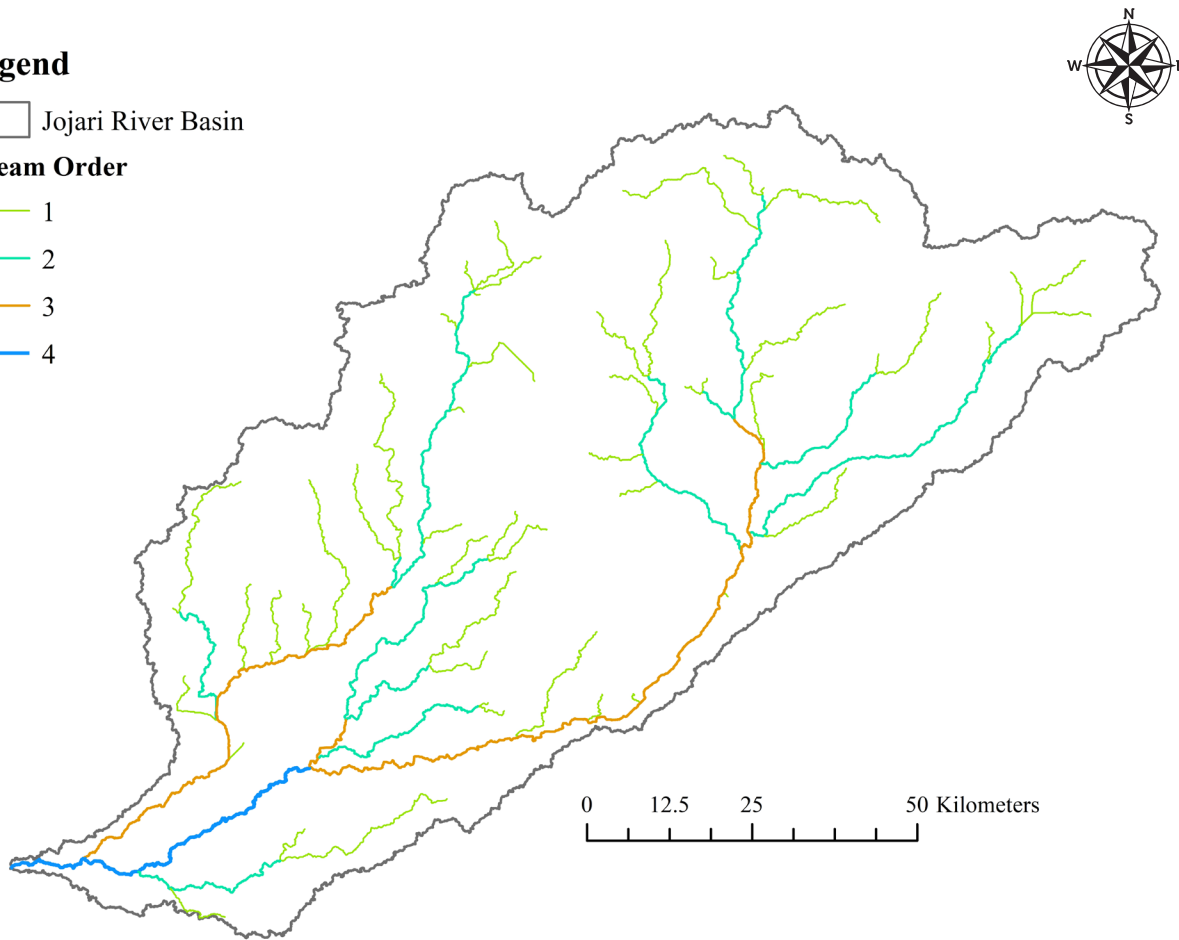


Figure 4: The third-order River Jojari that drains into the higher order River Luni

dry season flow can not only prove beneficial for the Jojhari river ecosystem, but can also be utilized for other tasks like irrigation, rejuvenation of nearby water sources, etc. It may be noted that the fragmented water storage structures of Jodhpur can also play a paramount role in this transformation.

5.3 Urban Setting

Jodhpur, the second-largest city of the rapidly developing Rajasthan State, is known for its historical heritage, healthy

environment, harmonious social life, and generally well-managed civic facilities. However, wastewater from industrial units and the changing trend of water use of its residents in this growing city has led to the degradation of River Jojari and imparted adverse consequences on groundwater in this region. If the wastewater generated by the city is properly treated before discharge, then it can be a valuable source of freshwater in Jojari river. As shown in **Figure 5**, the Jojari river presently flows partly

Legend

- Jojari River
- Tributary Rivers of Jojari
- Jojari River Basin
- Jodhpur Development Authority Boundary
- Jodhpur Municipal Corporation Boundary

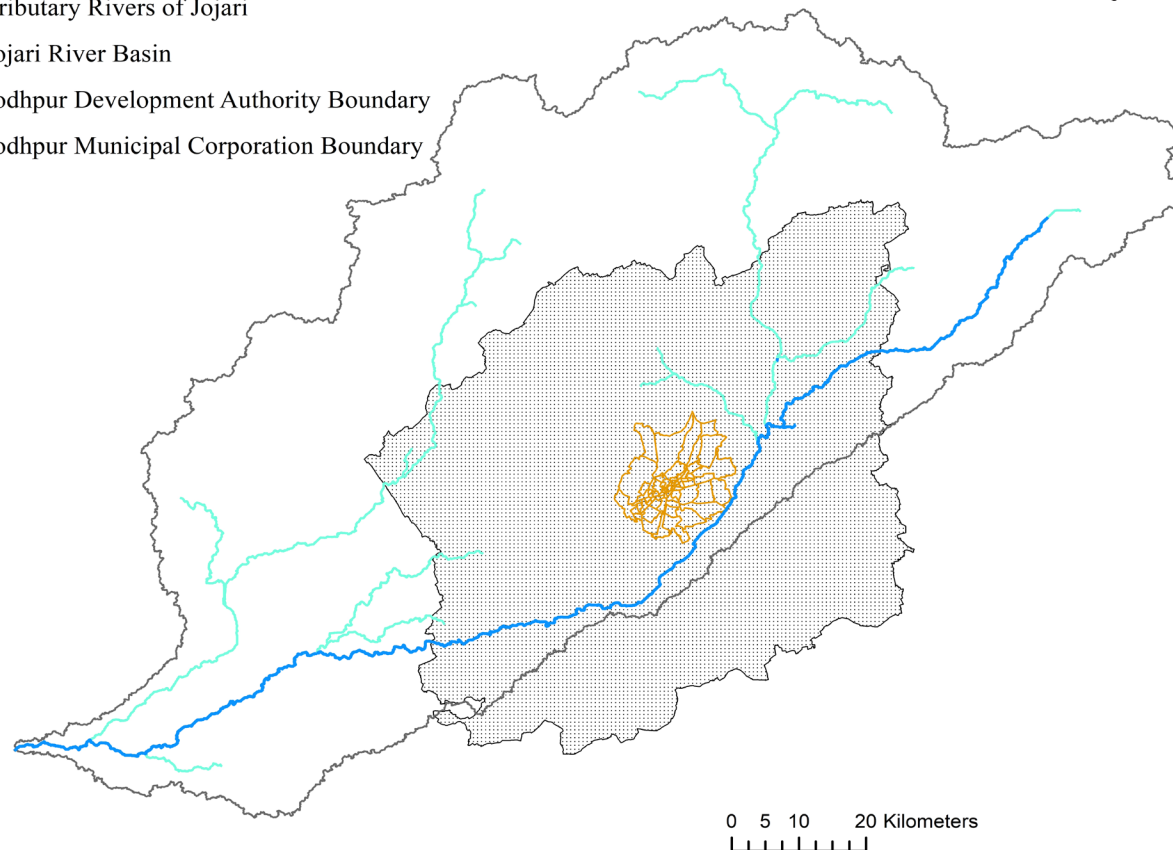


Figure 5: Jojari river and its natural catchment area along with Jodhpur Development Authority and Jodhpur Municipal Corporation areas.

outside the municipal area of Jodhpur. But according to Jodhpur Development Authority's extension plan, the major part of Jojari river will pass through the middle of the residential/ urban areas of Jodhpur in future. Given the likely expansion of Jodhpur, early restoration and conservation of the Jojari river are very much needed for the city's water self-sufficiency and wholesome needs. Protecting the Jojari river and Jodhpur's heritage water conservation structures together are therefore vital.

5.4 River of Prominence

River Jojari is the most prominent river of Jodhpur and surrounding regions. It flows for a length of about 35 km through Jodhpur city, and about 450 sq km area of its drainage area from Banad to Salawas lies in urban Jodhpur. Besides, there are several small and big towns as well as rural habitats lying the river in its basin that are dependent on or associated with the river in some way or the other. The obstruction to the current river flow below Araba, Doli Rajaguran, due to the

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construction of National Highway 25 has decreased the basin area by about 50 percent. The restoration and conservation of Jojari river will undoubtedly contribute to the overall development of the area. It will also be a major step to preserve the beauty of the outer Jodhpur city and in maintaining the water and rainwater drains for agriculture in the lower and southern parts of the basin. The river can also be used to drain out the surplus groundwater in Jodhpur, and the economic, social and cultural benefits resulting from it can mobilize its citizens and stakeholders to work together concert for River Jojari's revival and conservation. The river's regional importance and prominence, and its potentially enormous contribution to regional development and welfare, are thus major factors for its restoration priority.

6. Jojari River – Anthropogenic Changes and Their Demarcations

Along the 239 km length from its origin at Ujra (a tributary of Jojari that flows through Nagaur and joins the Jojari) and its confluence with the Luni river near Balotra, River Jojari can be divided along its length into the following five segments, keeping in view the various anthropogenic changes causing water-logged and ponded areas along the river's route (Figure 6), viz.:

1. From origin Ustara to Banad = 76 km
2. Banad to Salavas = 35 km
3. Salavas to Doli Raj Guran = 43 km
4. Doli Raj Guran to Pachpadra = 69 km
5. Pachpadra to Luni River = 16 km

“Length of the river has been estimated on the basis of DEM generated streams”

The basin area of the Jojari river, passing through a variety of geographical formations, ranges from sandy soils to rocky areas of rhyolite and sandstone from which rainwater flows into this river in different proportions. Similar to many other river basins of the country, the water usage and hydrological dynamics of the Jojari basin have also changed over time, largely due to anthropogenic factors. This is the main reason for demarcating

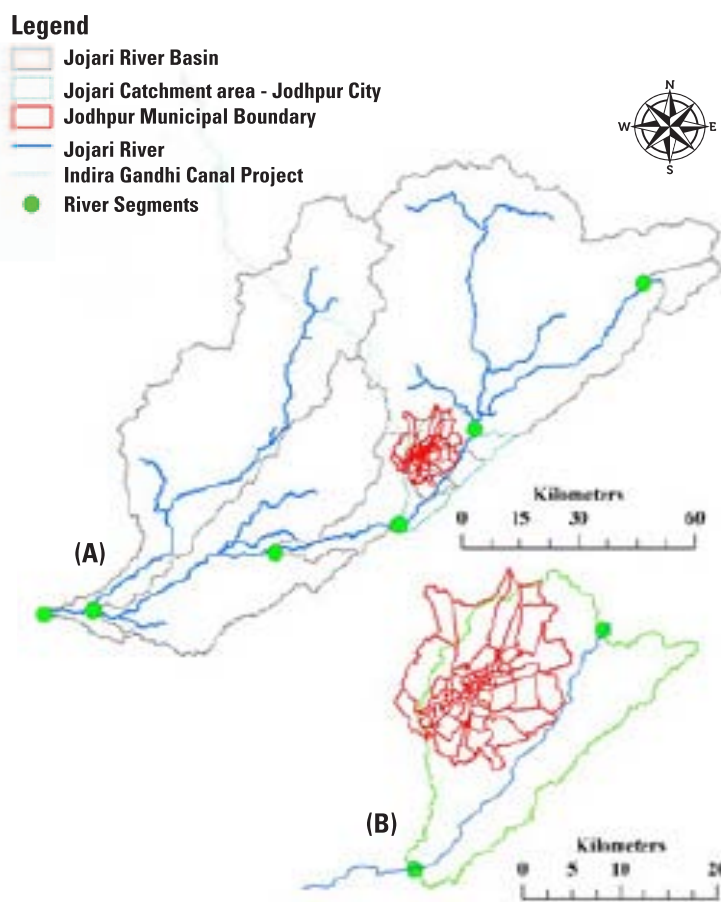


Figure 6: (a) Jojari River catchment and its boundary up to Salavas (downstream of Jodhpur) (b) Jojari River flowing through the Municipal Area of the Jodhpur Municipal Corporation

different segments of the river based on their many changes and the underlying factors in order to plan the river's revival and conservation efforts accordingly.

In each segment of the river, there have been significant changes over time, depending on its geographical location, land use, and soil and water properties. Unlike other segments, the stretch of Jojari that lies in Jodhpur city receives much contaminated water from industrial and domestic areas of Jodhpur. The channel width in this river segment is between 40 to 240 m. Some parts of the river have also been encroached in this segment, although the encroachment is less than in many other urban rivers of the country. Hence it should be relatively easy to clear the encroachments if steps are taken promptly. The Irrigation Department has constructed eight anicuts from Banad to Salavas in the urban part of Jojari with a one-time filling capacity of 450-500 million liters. Also, most natural drains that bring stormwater runoff from Jodhpur city to the river have been obstructed due

to encroachments or other reasons. The ones left unimpeded carry sludge round the year due to disposal of solid wastes and sewage from industrial and residential areas, increasing flood prospects in surrounding areas in the rainy season.

7. The Degraded Water Situation in Jojari River Basin

Although there are many small towns and villages in the Jojari river basin, it is primarily the major cities and towns of Jodhpur, Balotra, and Barmer districts that are responsible for the degradation of the Jojari river. Anthropogenic changes on its 35 km stretch flowing in Jodhpur have significantly disrupted the flows, structure, and management of the Jojari river. According to data received from various government institutions located in Jodhpur, the water distribution in Jodhpur and the corresponding estimated sewage generation is shown in **Figure 7**.

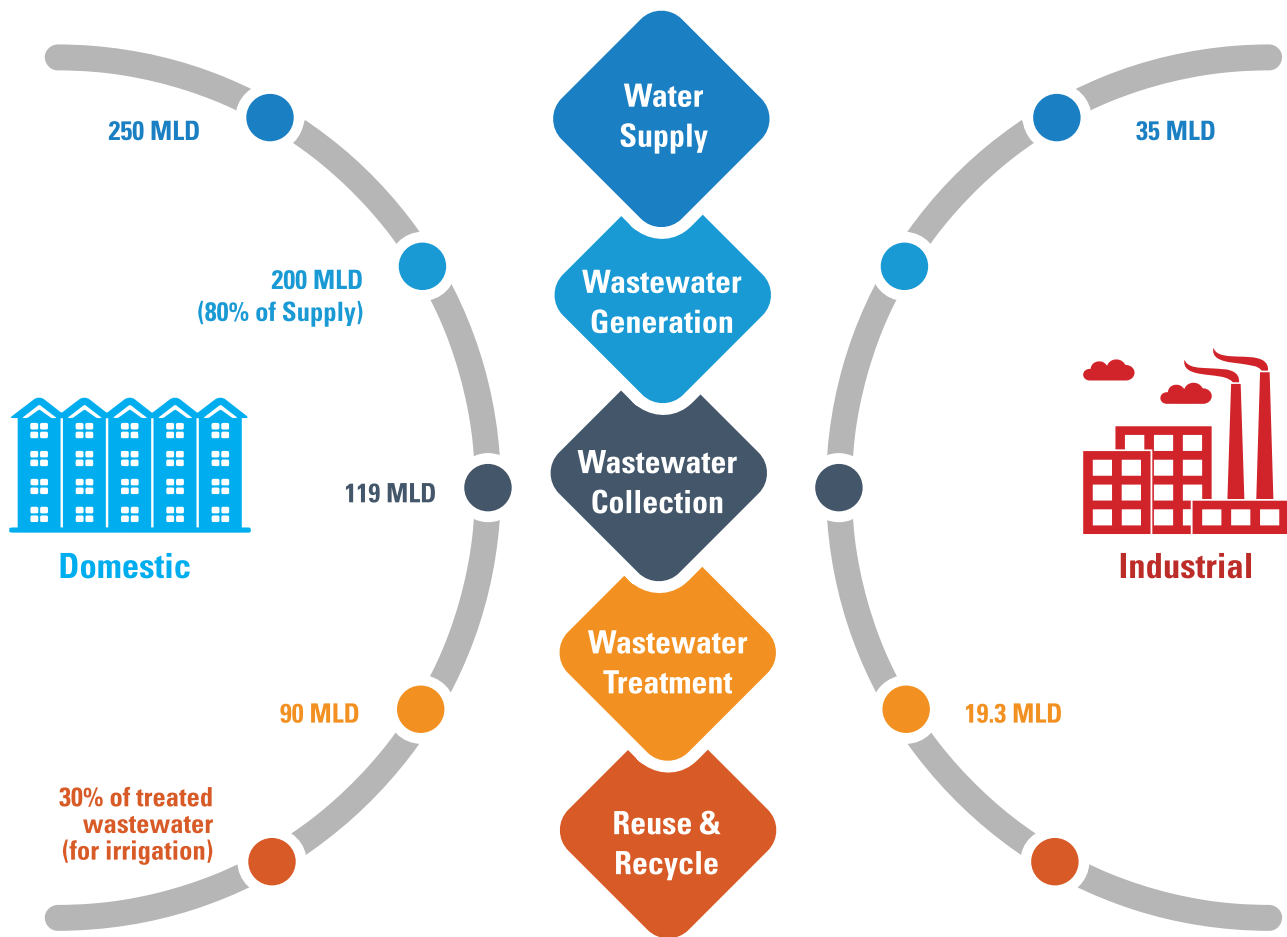
Historical water storage structures:

Historical water storage structures constructed to harvest rainwater include Fatehsagar, Gulab Sagar, and Umed Sagar. However, runoff water does not reach these structures any more due to encroachment on the river's floodplains and waste disposal into canals that convey water to the structures. Jodhpur's water-related problems can be partly resolved by restoring and conserving these structures. Many similar structures and reservoirs have been already restored through various schemes, but the remaining ones are yet to be revived.

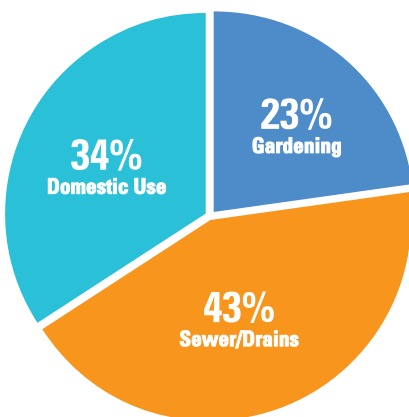
Jodhpur's water and related problems can be partly resolved by restoring and conserving its historical water storage structures.

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Water and Wastewater Scenario



Groundwater Abstraction (Present)



Current Abstraction

32-35 MLD for Domestic Use
12 MLD for Gardening Purposes
8 MLD into Sewers/Drains
12 MLD

Additional Proposed Abstraction

20-25 MLD for RIICO
18 MLD for Industrial Use

Figure 7: Overview of Water Supply and Wastewater Generation in Jodhpur



Natural River Path and Man-made

Disruption: The construction of National Highway 25 has blocked the passage of the Jojari river near Araba, and the river does not drain into the Luni River any more, spilling its contents into nearby low-lying lands and causing water-logging and ponding, and the quality of soil in the agricultural lands near Araba has degraded.

Figure 8 shows the entire natural basin of the Jojari river and the curtailed basin after the river path was blocked. It is essential to restore the river's path in this part of the river and reassign its right to union with the Luni river. This is not only necessary for the river's self-existence, but also to prevent the ill effects on land productivity, ecosystem health and human beings.

8. Jojari Restoration Strategy: River-centric Integrated Water Resource Management

River Jojari used to be a main water source for the city of Jodhpur but has

now become more of a wastewater drain carrying sewage and industrial effluents. The urbanization of Jodhpur has altered the physico-chemical characteristic of Jojari river and its basin. Thus, during the floods in 1979, a spread of about 200-300 m was observed on either side of the river (WRD, GoR). In the DPR prepared by WAPCOS for the riverfront development of the Jojari river, it is stated that in Jodhpur, there are 7 days in every 55 years when rainfall exceeds 100 mm. About 20 square km of the city is likely to be flood-affected by such rainfall events, but land encroachments and unplanned development has only accentuated the problem.

There is also a need to maintain the interrupted natural flow of the river from its origin to Banad. Hence, the flow obstruction due to the National Highway near Araba needs to be remedied by establishing the natural or a new alternate route of the river downstream of Araba.

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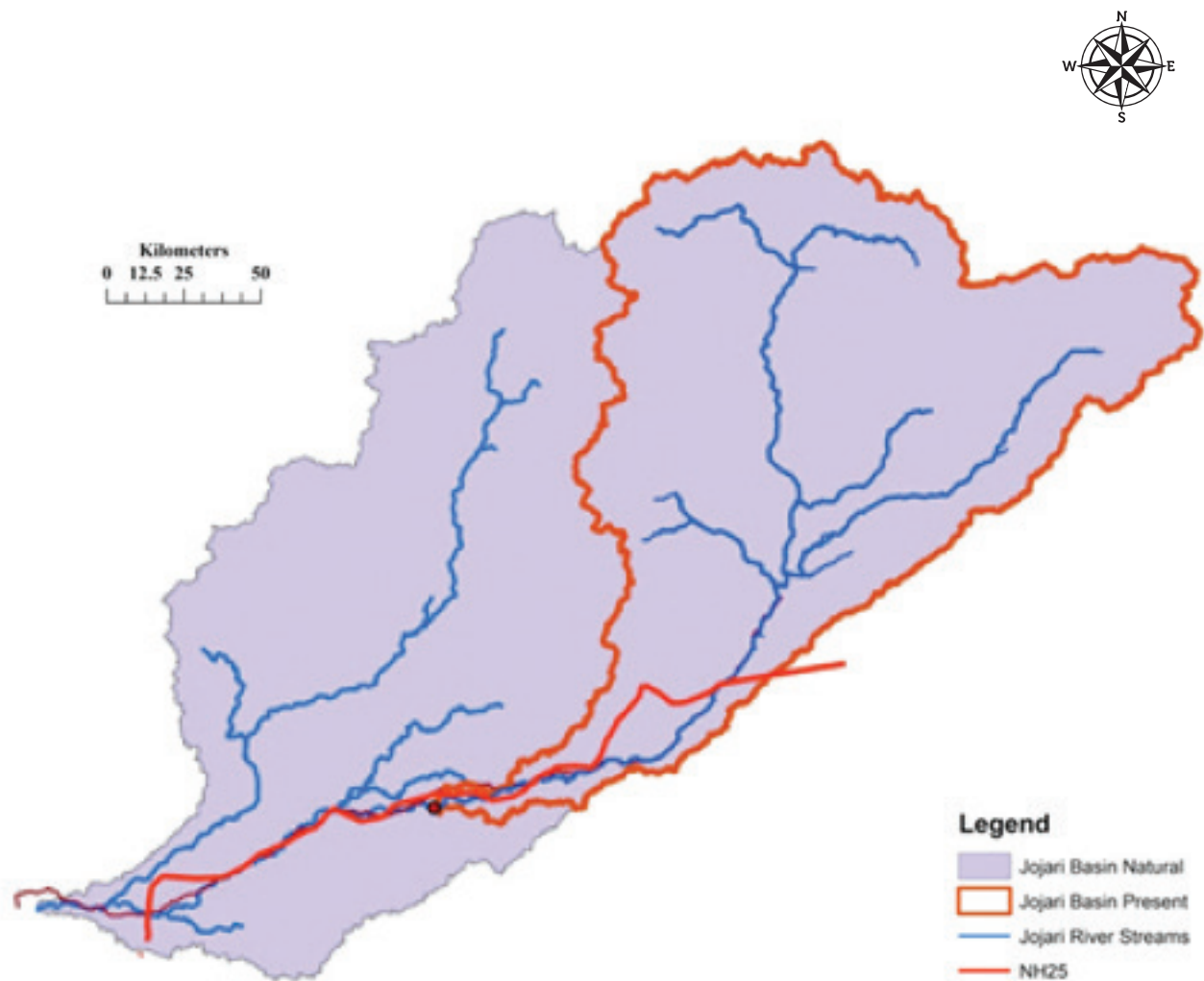


Figure 8: Natural (Previous) and Transformed (Present) Jojari River Basin

During the year 2012-14, efforts were made by the local Water Resources Department, Jodhpur Municipal Corporation, and Remote Sensing Department for this task, but it was aborted halfway due to various reasons. To take up this work again, a comprehensive action plan based on detailed land survey is needed.

Eight anicuts were built by Water Resources Department (Irrigation) between Banad and Nandwan (d/s of Salavas) on the Jojari River. The total catchment area of the river from Banad to Salawas is about 445 sq km, and some of the water coming from this area can be stored in the anicuts or similar harvesting

structures with a storage total capacity of about 0.5 MCM; which can be a good source of freshwater in future. The water can also be brought to the river through natural rainwater drains coming from Jodhpur city.

The above measures need to be formulated into a comprehensive plan for rejuvenation of Jojari and Jojari-centric water resources management plan for Jodhpur to mitigate the problems of water pollution and rising groundwater levels in the region. To achieve this, the following steps need to be taken:

8.1 Division of River into different Segments and Zones

Divide the river along its length into different segments based on factors like the quantity and quality of the river, water use, slope of the river, other hydrological parameters and physical structure of the river, ownership of the river and its riparian areas, principal land uses in the river basin area, etc. Thereafter, each segment should be divided into various zones based on the order of distance from the river, potential flood zone, land

jurisdiction, land use, environmental quality and sensitivity, cultural and economic importance, remedial works needed in each segment, etc. Figure 9 depicts an attempt at such segmentation and zonation for River Jojari. Such division requires a local river basin organization so that there is uniformity and completeness in the administrative, political and socially relevance of the work.

As shown in **Figure 9** and discussed in Section 6 earlier, the Jojari river is divided into five segments along its length based on the parameters mentioned above. Each segment can be further divided into sub-segments or sub-sections. Thus Segment 2, which is part of the river from Banad to Salawas, is divided into four sub-sections, namely: (1) Banad to Nandari; (2) Nandari to Basni Benda; (3) Basni Benda to Sangaria; and (4) Sangaria to Salawas. Each subdivision can be further divided into zones with its vertical part connected. The area falling on either side of the river near the stream banks or in the probable floodway of 50 or 100 year floods should be considered the core zone. The intermediate zone, beyond the core zone, may be defined based on other parameters, outside which lies the outermost zone or external zone. Figure 9 shows these zones in the vertical area of the subdivisions.

In the sub-segments of Segment 2, the river width varies between 40 m to 200 m, and the urban area is considered as the boundary for the intermediate section in the basin area bringing water to this

The area falling on either side of the river or in the probable 50 or 100 year floodway should be considered the core river zone.

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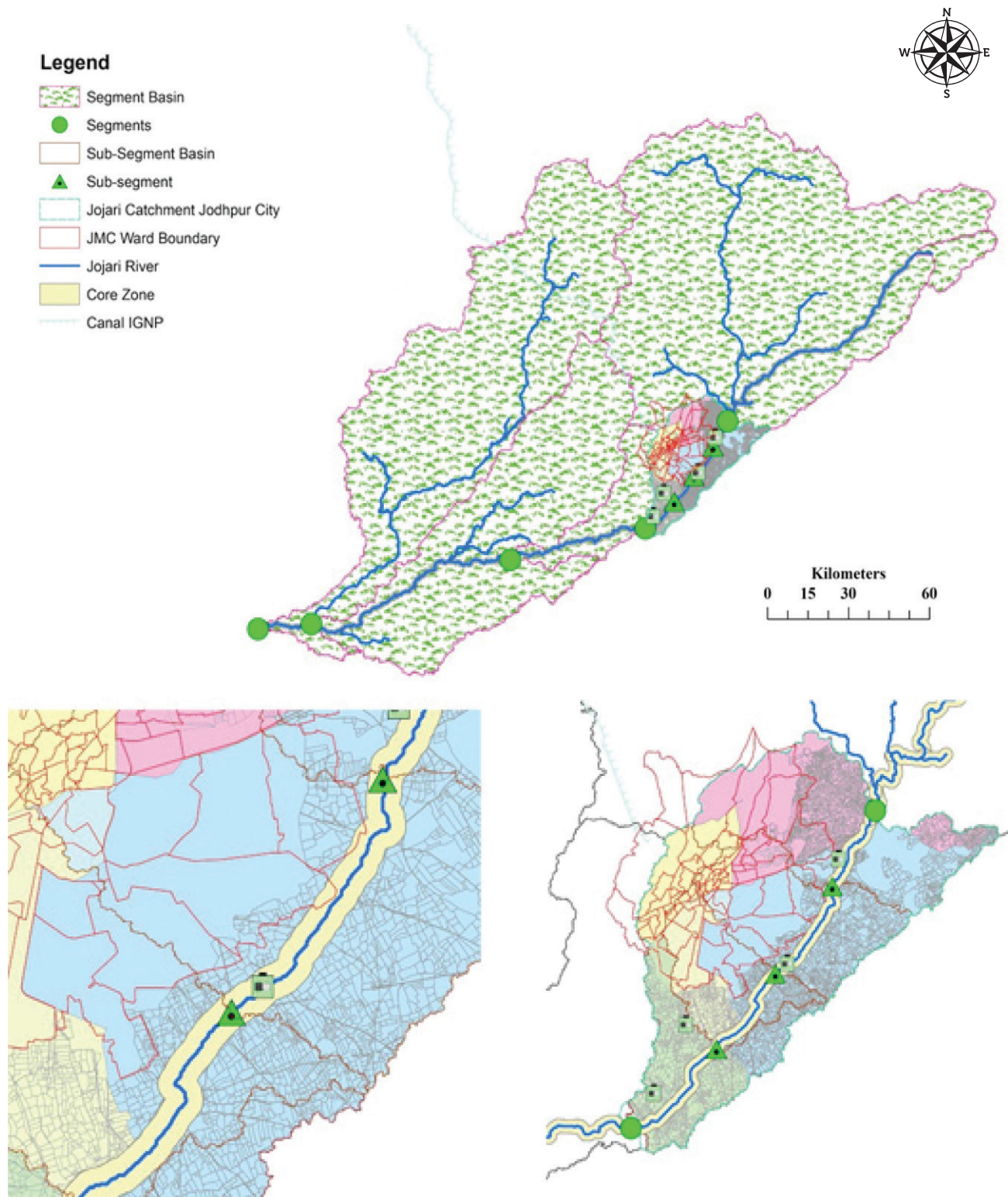


Figure 9: Segmentation and Zonation of Jojari river

part of the river. The basin area outside comprises the External Zone. With the help of segmentation and zonation of rivers, the priority of work to be carried out for restoration and conservation of rivers can be easily figured out, and cGanga is drafting a detailed document for this purpose to determine the zones and sections keeping in view the river's individuality.

8.2 Maintaining balance between Water Supply, Water Conservation and Groundwater Exploitation

For sustainable utilization of water resources, a balanced roadmap is needed to reduce canal water import, to rehabilitate water conservation structures, and to control groundwater rise in Jodhpur. Hence, feasible and acceptable solutions like regulation of per capita water supply, regulation of unbridled water use and wastewater generation by industries, use of surplus groundwater for irrigation and industry, restoration of dry reservoirs (optionally postponed till canals are revived), etc. need to be adopted.

In addition to the above, some immediate and temporary solutions and some long-term or permanent solutions may be adopted to address the current problems taking into consideration the need for economic progress and sustainable development in the Jojari river basin area. These are briefly described in **Table 3**.

As evident from Table 3, it is necessary to pay attention to the following aspects on priority basis:

8.2.1 Precise estimation of dry season flows in drains

At present, water from the Sutlej river is brought through Rajiv Gandhi Canal to supply drinking water to Jodhpur city. If the municipal wastewater generated is treated by the four-stage water recycling process, it can be utilized for the revival of Jojari as a perennial clean water river. The linking of rainwater drains of Jodhpur to Jojari is also indispensable for this. There are six such big nallas in Jodhpur that bring contaminated water from different areas of the city to Jojari river. Apart from rainwater, only treated wastewater should flow through these drains. As shown in **Figure 10**, through the four-stage treatment system and by connecting it to the local wetlands and reservoirs, the Jojari river can be thus transformed into a reliable round-the-year source of freshwater. The precise estimation/ measurement of wastewater and runoff discharges is a prerequisite for achieving this end. With the judicious management of water, the ecology and aesthetics of the drains, reservoirs and the Jojari river itself can be restored and enriched in an integrated manner.

8.2.2 Planned utilization of water sources

In addition to the balanced use of water sources, to limit the rising groundwater level, the import and storage of water in the basin also need to be managed judiciously. In the ideal case, any leakage into groundwater should be stopped, but as an immediate solution, the abstraction of groundwater seems to be the only way out. A complete action plan should be chalked out to make good use of this water.

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Table 3: Temporary and long-term solutions suggested for River Centric - Integrated Water Resource Management

S. No.	Problems	Solution		
		Immediate/ temporary	Long-term/ permanent	Transit Route
1	Physical deformation of river	Jojari and its tributary rivers' right to union with Luni shall remain the ultimate solution to this problem		1. Re-creation of natural flow route through satellite images 2. Construction of the path of the river roughly parallel to the highway according to geographical conditions and keeping the highway as it is. 3. Balanced use of both above
2	Rising groundwater level and declining groundwater quality	Temporary system for abstraction of increased groundwater and road map for its overall use to achieve the long term goal	Complete check on contamination of groundwater	1. The contaminated water (on the surface) should be separated from rainwater drains and these drains should be used only for rainwater drainage; alternatively, selected drains from among these to be developed as perennial waterways. 2. The treated water from the decentralized purification facility can be discharged into rainwater drains or reused on site (after proper ground water leakage prevention system) 3. To find out other reasons for rising ground water level and constant research for its prevention
3	Pollution of waterbodies	Utilization of full capacity of STPs and ETPs	Complete prevention of all types of solid waste and contaminated water/ effluent discharge.	1. Improvement/ upgradation of the CETP or its reconstruction 2. Construction of proposed small treatment systems 3. Strengthening solid waste management 4. Construction of decentralized STPs for treatment of residential contaminated water



Figure 10: Four-layer Treatment Cycle

Treated water, coming from the treatment plants and stored in anicuts built in the river, may be released gradually to maintain the required flow rates in the dry season.

8.2.3 Unification and aesthetics of water resources

All the water sources, streams, and drains in the Jojari catchment area should be hydraulically and hydrologically interconnected. Especially, such links as existing earlier, should be restored and harmonized with the river. Also, the natural drains carrying monsoon runoffs should be beautified as a means to reach the river.

8.2.4 Structural changes to maintain water quantity and quality

To keep the Jojari flowing as a perennial river, it is necessary to maintain minimum water levels during the dry season. The treated water coming from the treatment plants and stored in some of the anicuts built in the river, may be released gradually to maintain the required flow rates, while they can dampen flood flows in the wet season. About eight such anicuts presently exist, but more anicuts and embankments can be constructed as per requirement to protect the river banks and riparian areas in times of high rainfall.

8.2.5 Healthy river ecology

Both aquatic and terrestrial vegetation are essential for the river and its catchment. Catchment vegetation is

directly helpful in the purification of runoff water, besides reducing runoff rates and soil erosion and promoting terrestrial fauna. Healthy river ecology also needs aquatic animals like fishes and macroinvertebrates. The abundance of indigenous aquatic animals thus reflects on the good quality of river waters. Hence, efforts should be made to reproduce suitable species of aquatic flora and fauna that existed naturally in River Jojari earlier or exist in other rivers and surface water bodies of the region.

8.3 Record Management and Choice of Technology

For restoration and conservation plans, it is essential to record all the works and interventions being carried out along with their timelines, and their possible effects should be evaluated. In Jodhpur, decentralized treatment plants are being set up by concerned institutions (**Table 4**), through which the contaminated water presently going to the drains will be brought to these treatment units located along the river. Some of these treatment plants are using wetlands as treatment systems. If some treatment plants, which make a balanced use of wetlands or electromagnetic treatment systems are to be installed on the banks of the drains

Table 4: Proposed Decentralized STPs in Jodhpur

Location	Capacity
Unchiar	10 MLD
Vivek Vihar	15 MLD
Jhalmand	10 MLD
Banad	2 MLD
Shobhovaton ki Dhani	2 MLD
Polytechnic College	2 MLD

and the treated water reaches the river flowing through these drains, they can be relatively easy to set up and inexpensive in the long run. Hence, preference should be given to such plants.

8.4 Establishment of Accounts and Information Centre

Due to inadequate information at present, the maintenance of various drains, reservoirs, and rivers are inefficient. Hence it is essential to establish a center that holds comprehensive information of all the water resource components present in the Jojari catchment, and from where relevant information about the historical and present water harvesting structures, natural drains and the river can be obtained by stakeholders, policymakers and executive agencies.

8.5 Some possible works for River-Centric Integrated Water Resource Management

8.5.1 Uninterrupted flow of Jojari

River flows that have been disrupted or obstructed by human interventions need to be corrected or compensated for this error. In the case of Jojari the

natural flow path of the river needs to be re-established if possible; if not, then an artificial new path (or a combination of partially new and partially old paths) for the river from near the National Highway at Araba to its confluence with the Luni is needed.

Impact: Fulfilling the right of the river to union with River Luni, remedying the inconveniences caused to Araba and its adjoining areas due to the river spill, preventing the degradation of quality agricultural land, and improving the water and environmental benefits in the Araba and its downstream regions.

Potential Expenditure: The expenditure of measures envisioned under this head will depend on the requirement and availability of land, river diversion route from the highway, research and field survey of land slope and other factors, etc. A provision of Rs 2 to 3 crores may be made for the survey and preparation of DPR to estimate the expenditure; however, as a rough estimate, about Rs 120 crores can be assigned for this work.

8.5.2 Prevention of industrial pollution coming into the river

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To prevent the river from the pollution influx from industrial areas, there is a need to create new CETPs and to improve or rebuild the existing CETPs in Jodhpur. Only the treated water remaining after reuse should be allowed to flow into the Jojari river.

Impact: Prevention of industrial pollutant discharges into the river will not only improve the the river water quality and its ecosystem, but the deterioration of groundwater quality due to industrial effluent in Salavas and the areas below will also be checked. Use of this contaminated water in agriculture will also stop, which will improve the soil and human health of the affected areas

Probable expenditure: A provision of about 150 crore rupees may be made for this work.

8.5.3 Improvement of Jodhpur drain water quality

Groundwater is also getting affected along with drains and rivers due to sewage coming through various city drains. Therefore, sewage going into the rainwater drains must be separated and treated, and only selected drains should be made perennial by feeding the treated wastewater. Boating along with walkway from the drain to the river should be also developed. For example, of about 50 MLD of sewage flows in the drains (Figure 3) passing through the engineering college near Ratanada, a part of it, say 15-20 MLD, can be diverted to the Polytechnic College drain through a Four Layer Treatment facilities (as shown in Figure 9) near the university. The treated water can be either reused locally or transported to

The natural flow path of Jojari river needs to be re-established, or an artificial new path for the river from Araba to its confluence with the Luni is needed.

River Jojari through the proposed drain through Jhalamand.

Impact: With the above measure, the Satluj-Jojari rivers can be indirectly linked along with the prevention of sewage pollution of groundwater. With a decentralized treatment facility, the treated water can be discharged into rainwater drains (after proper groundwater leakage prevention system). The treated water can be used by farmers, for city beautification works, and/ or also utilized at the Pachpadra Refinery.

Potential Expenditure: For this work, some small decentralized STPs can be constructed, and drains and rivers can be made perennial with the help of the treated water from these STPs. A provision of about 150 crore rupees can be made for this work.

8.5.4 Renovation and conservation of water harvesting structures

Feeder canals and their catchment areas that bring water to the storage structures of Jodhpur have been blocked or damaged by various anthropogenic activities and neglect. The restoration and utilization of these structures are

Table 5: Expected expense heads for Jojari River Restoration and Conservation and Revenue generation from the rejuvenated Jojari:

Expenses	Revenue
Withdrawal, treatment and disposal of surplus/ contaminated ground water by pumping (into river or nearest water body)	Improvement in ground water quality and public health; reduction in risk of structural damages/ strength of buildings;
Repair and maintenance of existing water and sewer network	Increase in freshwater availability with the help of RWH (Rain Water Harvesting) and minimum loss of municipal water and polluting leakages.
Restoration/ maintenance of existing step wells, jhalra, tanks, lakes and other similar water harvesting structures and installation of new RWH structures	Reduction in dependence and costs on transportation of water from distant sources for self-reliant ("atmanirbhar") Jodhpur.
Decentralized water treatment plants and wastewater treatment plants	Reduced treatment and transportation costs.
River floor/ surface cleaning and mud disposal	Promoted recreational activities like boating, fishing and riverside activities
Solid waste management plan for the city	Reduced public health expenses, and increased tourism revenues and employment opportunities for local people
Last stage of wastewater treatment by wetlands	Fuel, organic fertilizers and other value-added products from harvested wetland biomass
Improving drainage conditions by maintaining intermediation in the river and maintaining minimum water depth and reducing the risk of flooding	Beekeeping, floriculture, fisheries and commercial pisciculture
Removing encroachments from the river and its banks	Agriculture / Area specific commercial farming
Planting of trees and other vegetation in river floodplain and riparian areas.	Increased revenue generation through Pop-up Plazas, Shopping Malls, Commercial Establishments, Open Gymnasiums, Cycling Tracks, Sports, Children's Play Areas, Water Sports, Water Jet Landing/ Ports, Amphitheatres, Art Galleries, etc.
Connecting the river to nearby water sources/ water harvesting structures	Jal Vidya Mandir
Development of walkways, bathing ghats, crematoriums and other civic amenities along river / drains/ lakes	Crematorium usage and economically beneficial riparian activities.

possible with the help of the treated water. Treated water and the potential use of surplus groundwater can also help improve the water availability in the city. The restoration and conservation of other water storage structures/ reservoirs like Umed Sagar are, therefore, very essential.

Impact: After controlling the temporary problem of increasing groundwater of Jodhpur, the local water resources can be properly utilized by the balanced use of groundwater, imported water (brought by canal), and the harvested rainwater in these structures.

Expenditure: A provision of about 70 crore rupees can be made for this work.

8.6 Governance and Stakeholders

A dedicated Jojari River Basin Organization (JRBO) or equivalent body should be constituted to make the process of restoration and conservation effective and successful. According to the River Restoration and Conservation Manual (cGanga and NMCG, 2019), the principles and actions adopted by JRBO should be as follows:

- JRBO as a custodian of the Jojari river shall be its primary function
- Stakeholder-based participation and representation is a must in JRBO

- The JRBO's decisions must conform with State and Central laws
- JRBO must ensure comprehensive and continuous knowledge update.
- JRBO must establish a knowledge bank about the river, its water structures, reservoirs, groundwater and other water bodies, and their ecosystem characteristics.

In addition to government representatives and subject matter experts from executive institutions, a good representation of local people and common stakeholders should be included in the JRBO to enable mass participation and support. The potential role of various stakeholders has been discussed in detail in the RRC Manual (2019). **Figure 11** depicts the role of stakeholders along with the list of potential stakeholders to join the JRBO.

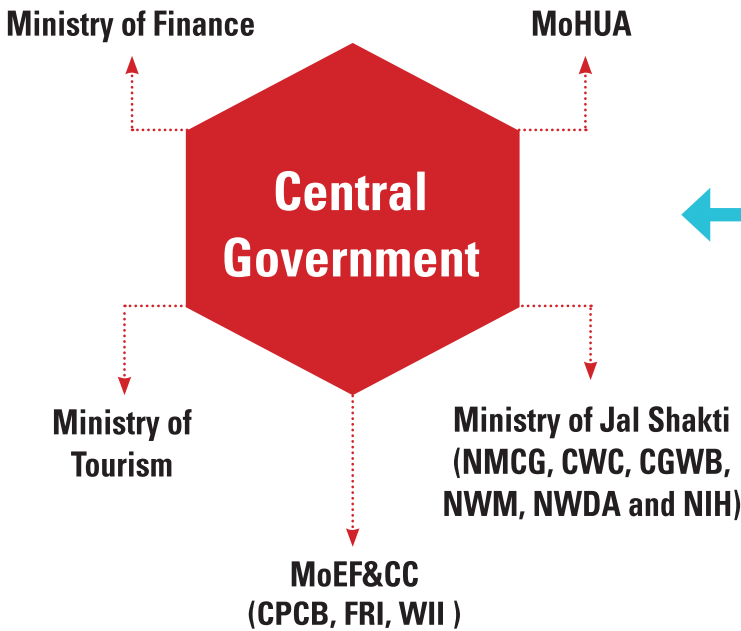
8.7 Knowledge and Information Gaps

Several important steps have been taken in the backdrop of the orders and guidelines of the Hon. National Green Tribunal (NGT) and the efforts of local administration and institutions with public awareness to resolve various water-related problems of Jodhpur. However, it is necessary to properly visualize the plan and gather and cross-check additional information

Apart from government representatives and institutional experts, local people and stakeholders should be well represented in the JRBO.

IMPLEMENTATION CHALLENGE: DE-ALIGNED INTERESTS COORDINATION

THE MAJOR IMPLEMENTATION CHALLENGE OF RIVER BASIN PLANS IS THE DIVERGENCE OF INTERESTS AND OUTLOOK OF DIFFERENT ACTORS AND THE SHORT AND VARIABLE RESIDENCE TIME OF THE AGENTS OF IMPLEMENTATION. HOW CAN THIS PROBLEM BE OVERCOME? APPROACH RIVER BASIN MANAGEMENT AS AN EMBEDDED CYCLIC PROCESS



**Politicians, Bureaucrats
& Technocrats**

LEGAL

Academics & Researchers

- cGanga
- IIT Jodhpur
- MBM Engineering College Jodhpur



**District Collector
Commissioner
Mayor**

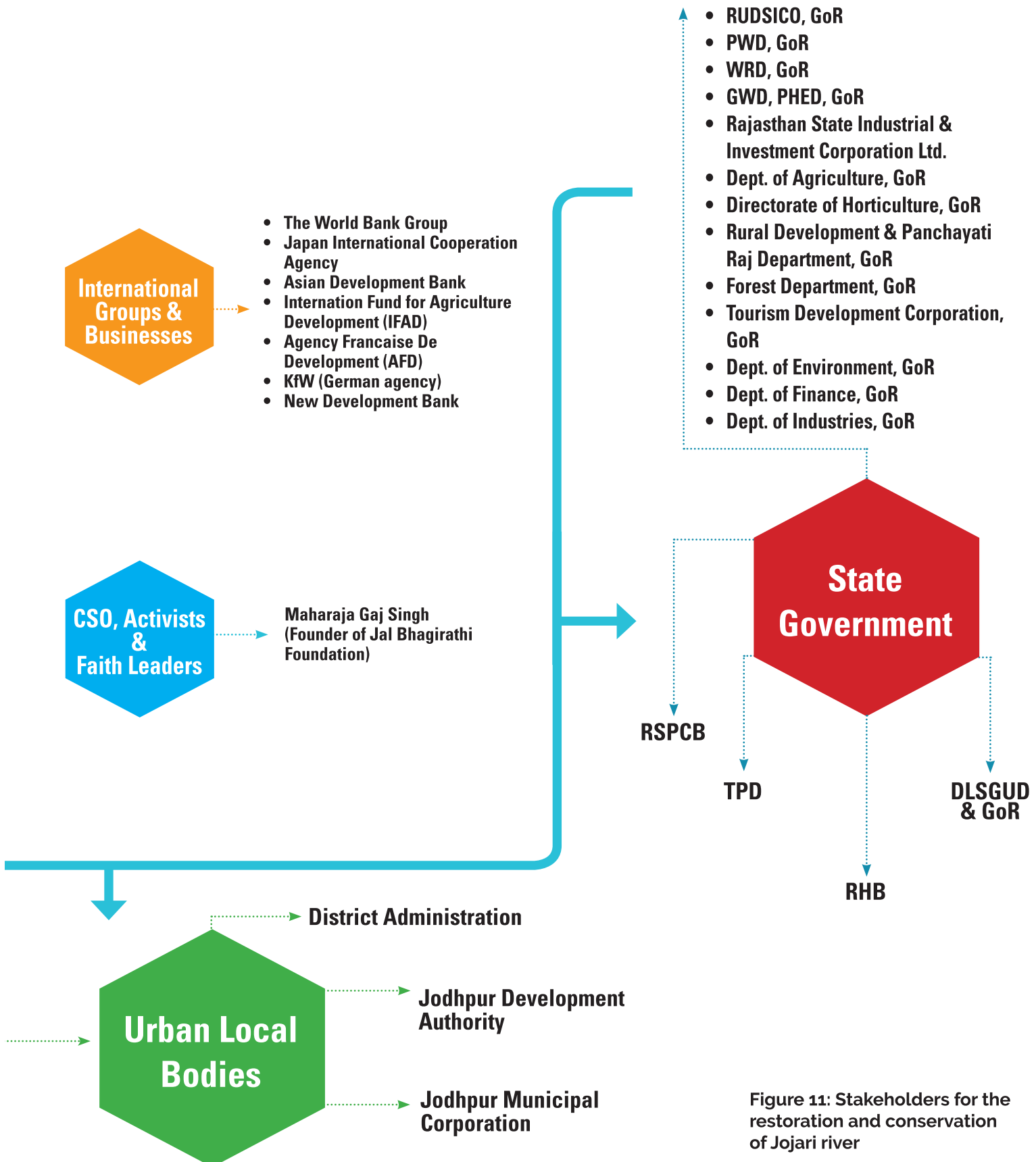
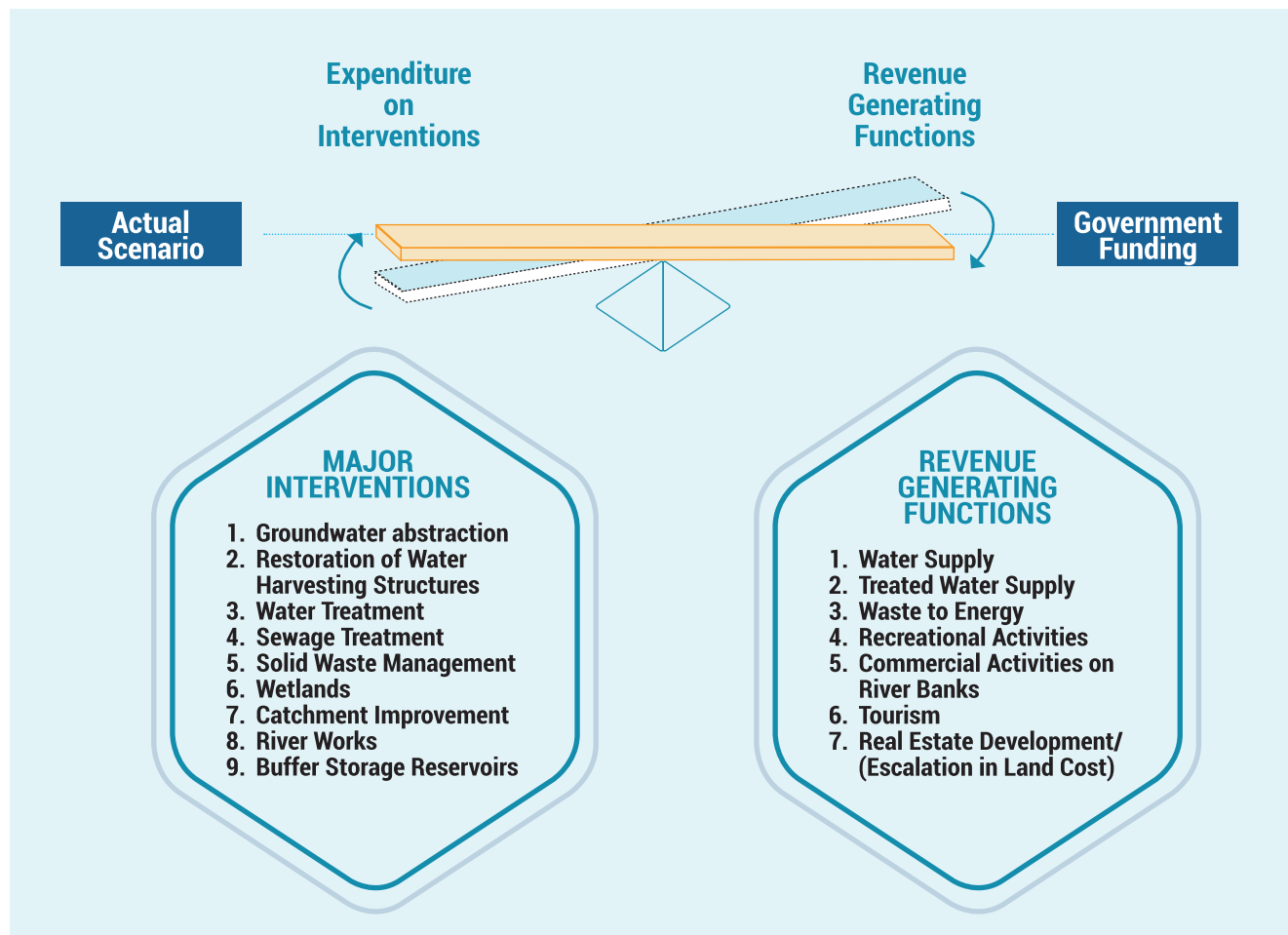


Figure 11: Stakeholders for the restoration and conservation of Jojari river



River Jojari is now indirectly linked to the distant Sutlej river, which enhances its importance and potentially transforms it into a perennial river.

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to effectively make the plan sound and easily implementable, such as (1) the actual natural form and local topography of the river below Araba; (2) a complete survey of the units present in the industrial area so that their present condition can be estimated (accurate knowledge of potential water use and quantity of effluent generated per unit); (3) estimation of the exact amount of water supply and sewage generated, its collection and treatment; (4) the amount of sewage flowing into rainwater drains and other open drains which discharge into the Jojari without any treatment; (5) capacity of water harvesting reservoirs water harvesting; (6) the state of fauna and flora in the river Jojari and its surrounding area; (7) Correct estimate of gauge-discharge relationship at suitable measuring sites in Jojari river; (8) Compilation and study of historical changes related to water sources of Jojari river and Jodhpur; (9) Rigorous scientific review of causes of rising groundwater of Jodhpur.

Conclusion

River Jojari is a relatively small and inherently ephemeral river of India, lying mostly in the state of Rajasthan. But its social, ecological and economic importance is on account of its strategic geographic location in the desert region of Rajasthan and its life-giving historical value in and around Jodhpur – enhanced by the water-harvesting schemes in the Jojari catchment that underpinned the development of Jodhpur city and agricultural activity over the past centuries. Though the river had degraded in recent decades due to adverse anthropogenic factors and mismanagement of the local water resources, River Jojari

is now indirectly linked to the distant Sutlej river, which further enhances its importance and potentially transforms it into a perennial clean-water river. This vision document outlines the basic framework for revitalizing the river as an important low-order perennial stream and its conservation at the focus of Jodhpur's water resources. The problems of rising groundwater table, surface water and groundwater pollution, water-logging in agricultural areas, unchecked monsoon runoff, water-related tourism and recreational bottlenecks, and regional ecological constraints can all be overcome by the holistic revival of the river proposed herein. In keeping with the aspirations of the people of Jodhpur, cGanga remains committed to help and advice local organisations and development agencies in to further develop and implement the proposed revival and conservation plan of Jojari river.

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