Flowing The Magnificent River Of Sambalpur: The Mahanadi

Giving life to the life-giver

Ar. SHREYA SINGH

Introduction

River Mahanadi, the 6th largest river in the peninsular river frameworks of India, charitably streams 494 km in the North-Eastern portion of Odisha. The distance spans 851 km from its root to the outfall point at the Bay of Bengal. In the early fifties of the twentieth century, the Union government took a giant leap to develop the Hirakud dam venture over river Mahanadi in the Sambalpur locale of Odisha state. Hirakud dam, the biggest ever earthen dam, became operative in 1957.

The Union Government arranged the development of Hirakud Dam in 1948 after considering the obliterating impacts of a few chronicled surge occasions in the Mahanadi River, with its foremost objective as flood retention by controlled discharge through the spillways of sluice gates. But over this long time of compelling flood control management, there were a few events of security concern during heavy monsoon within the upper catchment. The Hirakud supply got diverted to the sudden encroachment of floods while it stood at its greatest outlined water level.

Concrete dams have an average life expectancy of 100 years, but Hirakud Dam is an earthen dam with an average life expectancy of 50 years. The Hirakud Dam has already crossed its life expectancy of life, and there is a lot of pressure on the dam due to the siltation and the increased water volume during monsoons. Concrete dams are gravity dams usually built in large blocks divided by joints to make the construction more convenient, while Earthen dams are constructed of soil pounded and compacted in areas where the foundation is not strong enough to bear the weight of a concrete dam and where the land is easily available.

While the water assets of the Hirakud Dam proceed to stay the pillar of Odisha's rural success and hydropower possibility, in the past two decades, there has been developing concern in working out the choices for overseeing the flood occasions when the reservoir is kept up at its greatest holding capacity. Thus, it becomes imperative to develop feasible arrangements and provide sustainable solutions for managing this weight and pressure discharge to guarantee the security of Hirakud Dam.

This case study aims to create solutions for an alternate reality of dams and revive the Mahanadi River flow through resilient landscape design. Firstly, an analysis of predicted and unforeseen problems that could arise with large dams was studied and then a watershed management system involving soil conservation and catchment restoration within the larger context of the Mahanadi basin was made to design a resilient sustainable landscape management plan for restoration of rivers lost due to dams.

Methodology

Understanding dams- through its history, objectives of construction and impact of dam

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Analysis of condition of dams in India

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Understanding the ramification of dams through case examples in India

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Taking case example of Hirakud dam as a prototype for study

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Site analysis of Hirakud dam and its entire catchment

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Identification of major issues pertaining to dam- Sedimentation and River fragmentation

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Landscape management plan of Catchment of Hirakud dam to address the issues

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Proposing alternate strategies for the safety and existence of dams

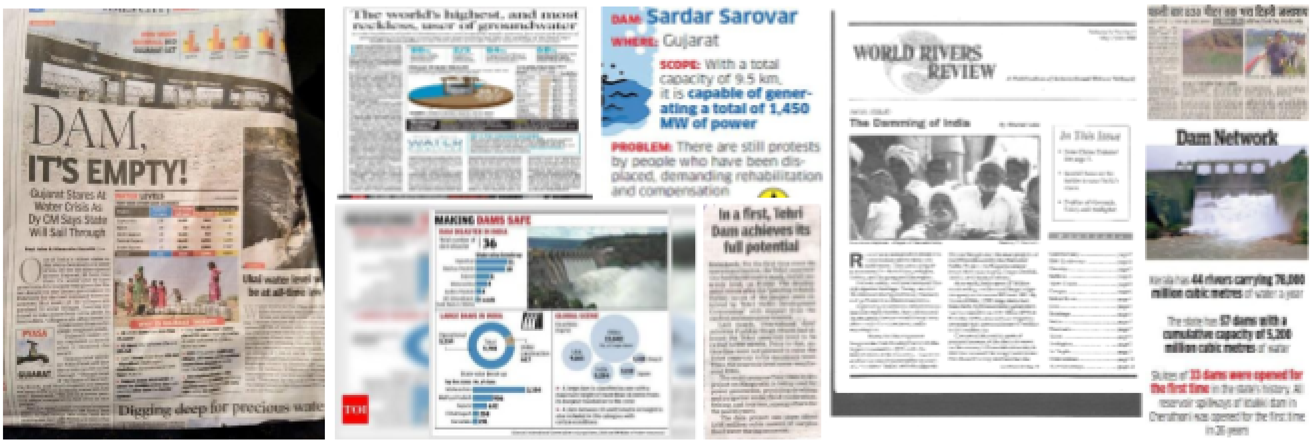
↓

Quantitative analysis to verify the implementation goals

ANALYIS OF DAMS IN INDIA

According to ICOLD (International Commission of Large Dams), India is ranked 3rd in the world for having a larger number of dams. According to ICOLD, India has 5701 large dams and 1000 medium and small dams.

DAMS IN DISTRESS



CASE EXAMPLE OF HIRAKUD DAM

As the **HIRAKUD DAM** is the oldest surviving dam in India post-independence and has crossed its life expectancy, a prototype watershed management plan and river restoration needs to be done so that an example can be set for other older dams in India that need recovery.

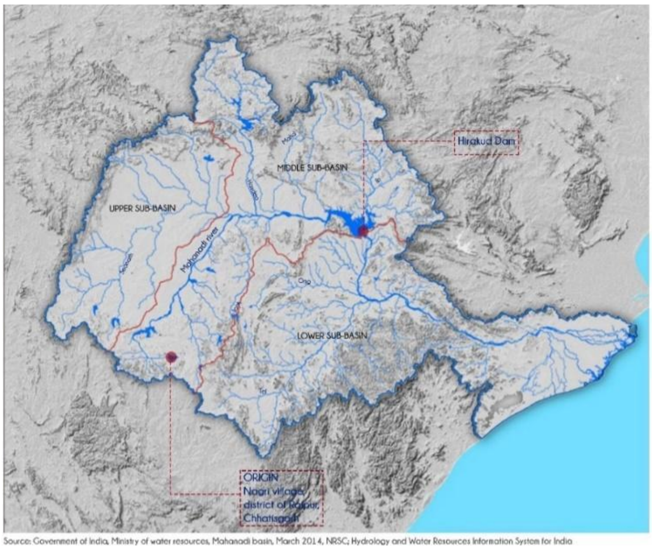


Figure 1 Upper and middle sub-basin of Mahanadi basin, the catchment of Hirakud dam reservoir.

Source: Government of India, Ministry of water resources, Mahanadi basin, March 2014, NRSC; Hydrology & Water Resources Information System for India

Figure 2 The Hirakud reservoir is a stunning sight, with its vast expanse of water and surrounding hill

Source: Author

Figure 3 Hirakud dam and reservoir visuals

Source: Author

UNDERSTANDING THE IMPORTANCE OF RESERVOIR ON THE LIVES OF PEOPLE THROUGH PRIMARY CASE STUDY

Figure 4 The dependency of people on Hirakud reservoir water.

Source: Author

MAJOR ISSUE FACED BY THE DAM

Sedimentation in the reservoir.

Due to variations in the incoming discharge and sediment load, the bed level does not change uniformly but rather varies alternatively between erosion and deposition according to the water and sediment load fluctuations. This results in different deposition patterns throughout the reservoir. During extreme events (e.g., high floods), the flow velocity increases, causing erosion as well as an increased sediment transport rate along the reservoir in the form of bed load and suspended sediment load.

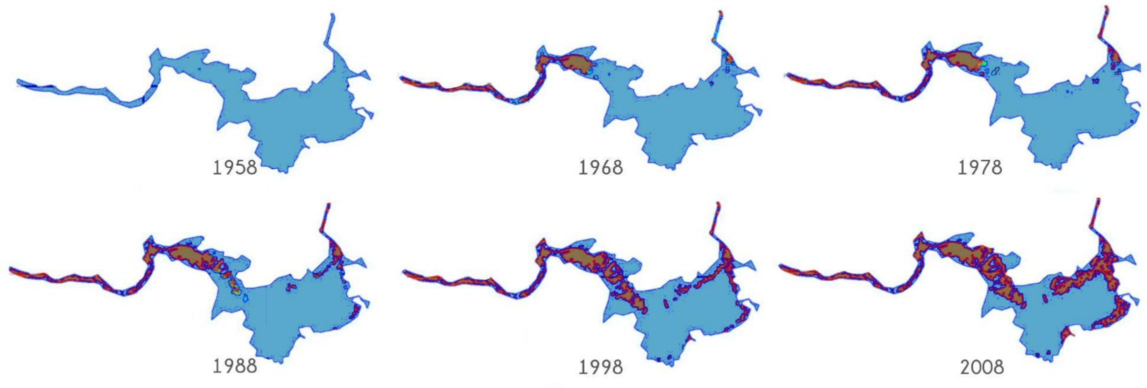


Figure 5 Major issue of Changing sediment deposition over the years in the reservoir of the dam was found in the reservoir over a period of time.

Source: Subhasri Dutta and Dhrubajyoti Sen, Sediment distribution and its impacts on Hirakud Reservoir (India) storage capacity, School of Water Resources, IIT Kharagpur

RISK IMPOSED BY THE HIRAKUD DAM DUE TO THE ISSUE

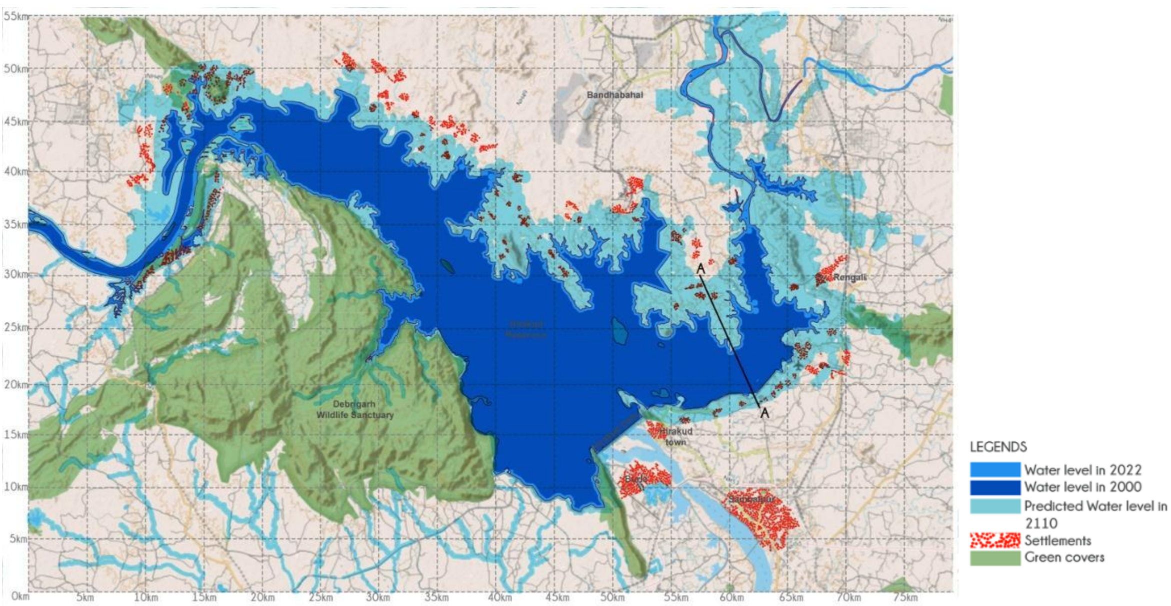


Figure 6 Sedimentation can have negative impacts on the reservoir, as it can reduce the storage capacity and lead to flooding in the vicinity.

Source: Author

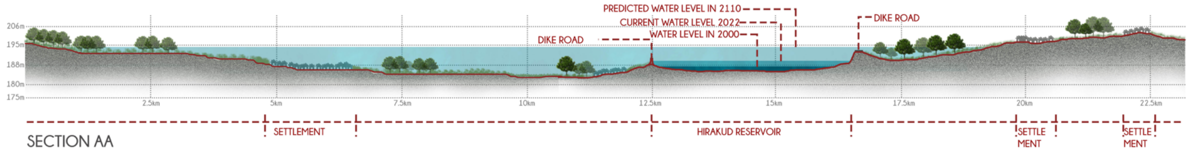


Figure 7 Conceptual Section through the reservoir showing the past and present scenario along with future risk

Source: Author

At present, the water level of the reservoir stands at 629.52 ft against the maximum storage capacity of 630 ft. The inflow capacity has increased by over 1 lakh cusec. (Mohanty, 2020). Considering the reservoir sedimentation, we can conclude that the loss in live storage over the past 50 years was around 20.1%. This map shows the predictable future scenario that not addressing the sedimentation will lead to flooding in the reservoir surrounding, submerging various habitable and agricultural lands and leading to its destruction. The sediment load and increased inflow of water may also lead to dam failure.

LONG TERM GOALS: SOLUTIONS FOR ADDRESSING THE ISSUE OF SEDIMENTATION

To reduce the inflow of sediments, the landscape management of the entire watershed of the dam must be done. This can be done by incorporating better water management practices along with sediment management techniques to reduce the sedimentation rate into Hirakud Reservoir, by implementation of alternate strategies and techniques at the catchment level.

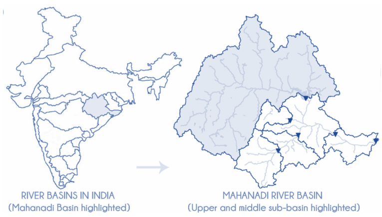


Figure 8 key map showing the area of study

Source: Author

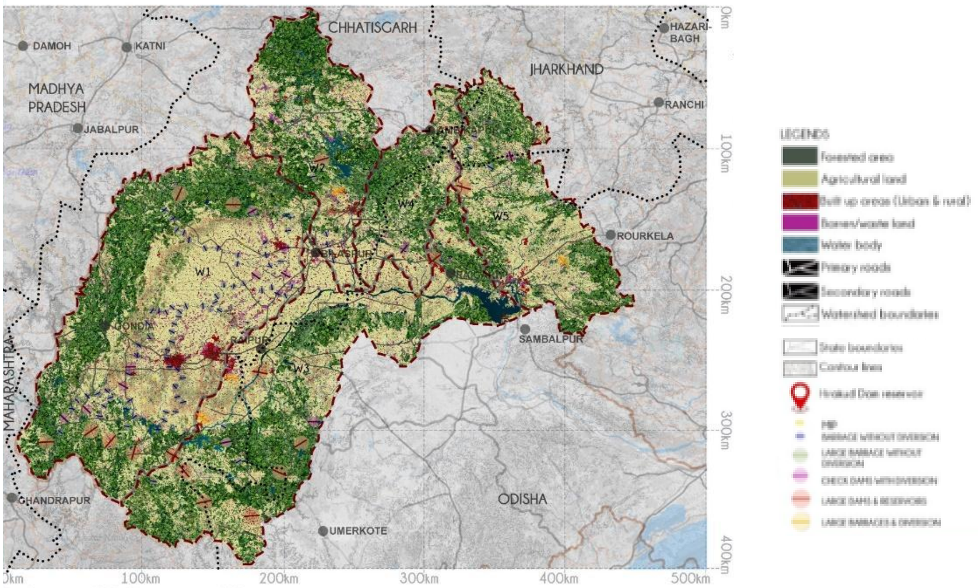


Figure 9 Landscape character plan of catchment of Hirakud reservoir; Source: Author

This map showcases the Upper & middle sub-basin of river Mahanadi which is the entire catchment area for Hirakud reservoir. While 53.1% of the catchment area of the Mahanadi falls in Chhattisgarh, it is almost 90% of the Hirakud Dam. Hence, the dam is completely dependent on the release of water from Chhattisgarh. The catchment area of the dam inside Odisha is only about 9.4%.

Area of Study = 92 lakh Hectares

The volume of water that flows to the reservoir = 81328 cubic metres (which has now reduced very significantly due to environmental issues).

SITE ANALYSIS AND SYNTHESIS

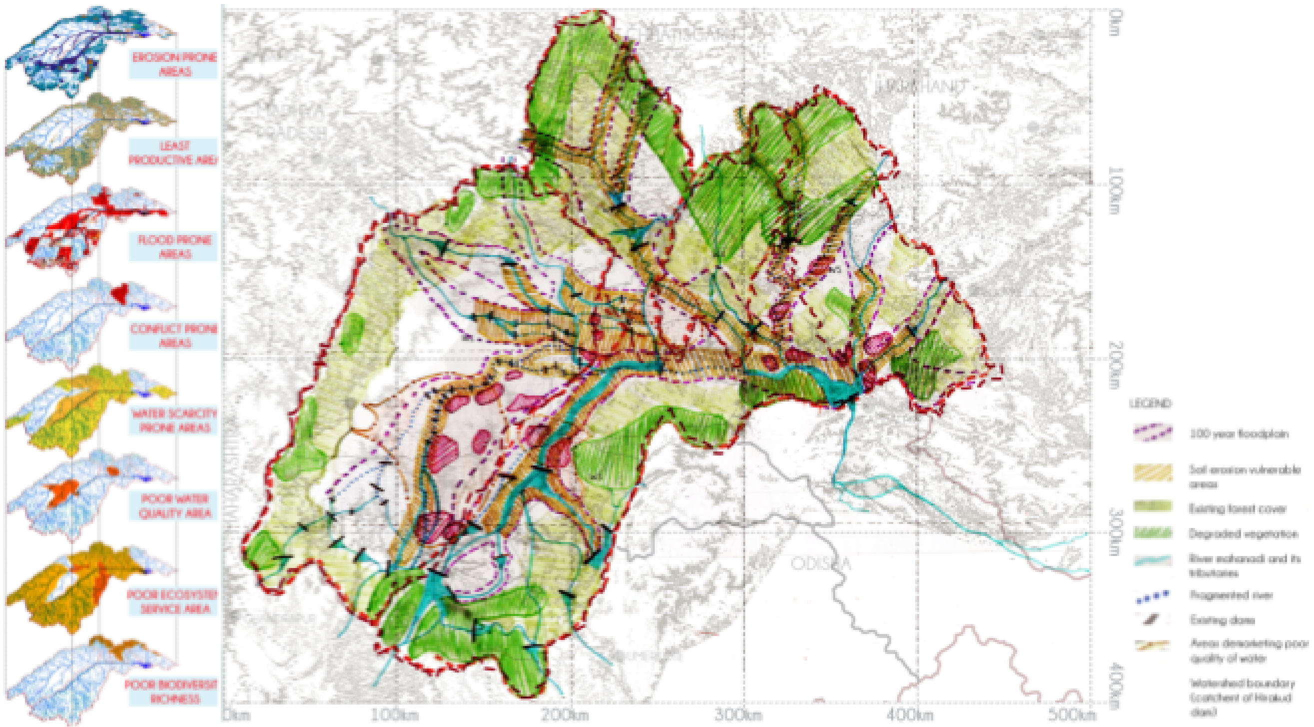


Figure 10 Site analysis synthesis map identifying the major issues in the catchment

Source: Author

Issues identified after analysis of the entire catchment of Hirakud Dam are:

Fragmentation of the river affects soil health, vegetation, fauna, and risk of human life due to floods ultimately leading to soil erosion in the reservoir of dams, encroachment on floodplain, degraded vegetation, erosion susceptible areas, water quality risk and water scarcity

LANDSCAPE MANAGEMENT STRATEGY PLAN

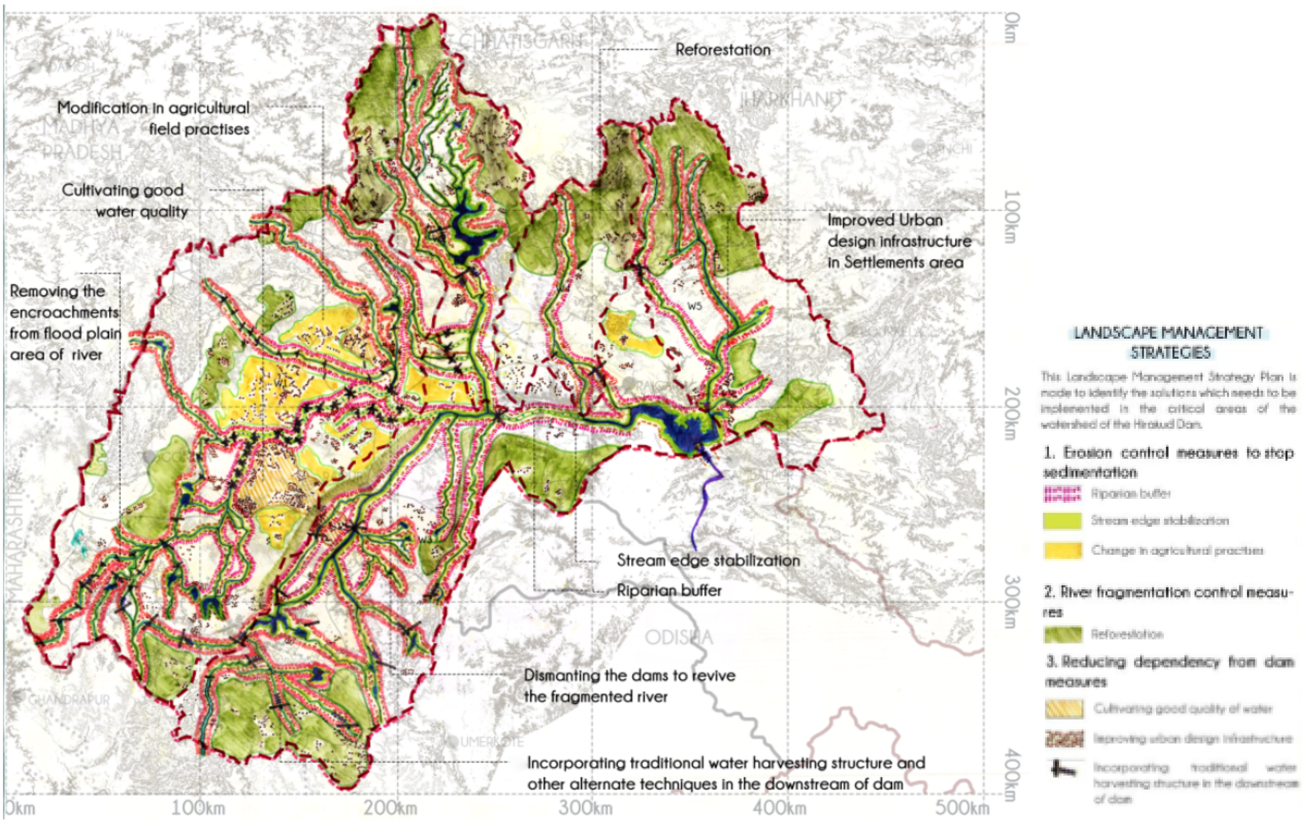


Figure 11 Long term Landscape management strategies plan to address the issues identified

Source: GIS, Author

This Landscape Management Strategy Plan identifies the solutions that need to be implemented in the critical areas of the watershed of the Hirakud Dam.

1. Erosion control measures to stop sedimentation

a. Stream edge stabilisation and riparian buffer

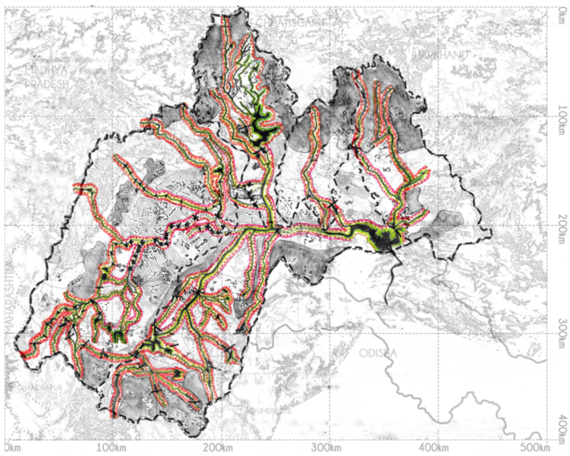
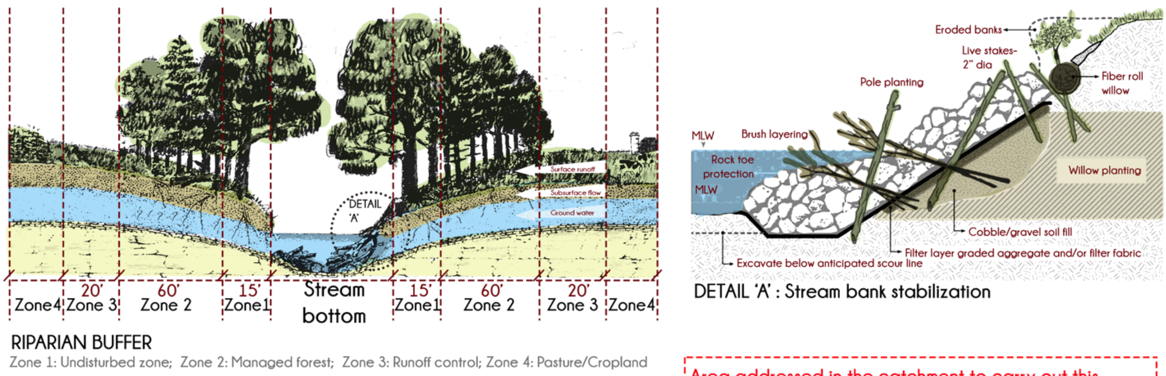
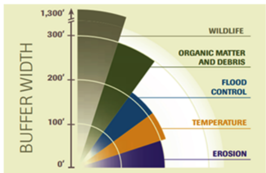


Figure 12 Areas to be implemented with the strategy of Riparian buffer and stream edge stabilisation;

Source: Author





STREAM ORDER	STREAM ORDER NUMBER	WIDTH OF RIPARIAN BUFFER
Upstream	1st to 5th	100ft on both sides
Midstream	6th to 10th	100ft-200ft on both sides
Large stream	11th to 16th	300ft or more on both sides

Area addressed in the catchment to carry out this measure = 3323 sq.km.
Time required for this measure to run efficiently = 5-10 yrs
Rate of sedimentation currently = 520 Cum/yr
Rate of sedimentation after implementing this strategy = 384.8 Cum/yr
Reduction % in sedimentation = 26.5%

Figure 13 Riparian buffer and stream edge stabilisation

Source: Author

b. Change in agricultural practises

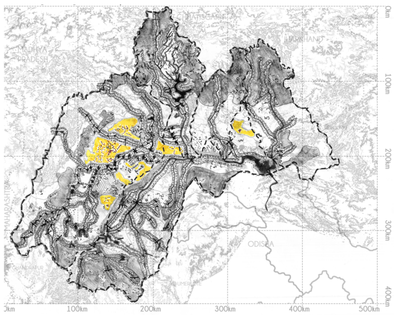
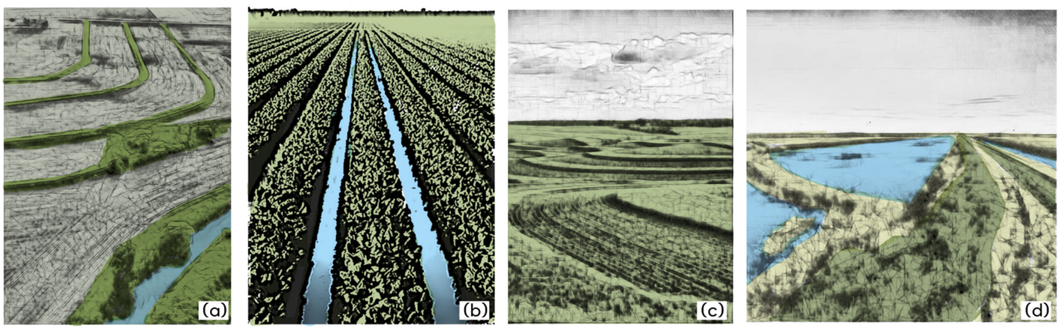


Figure 14 Areas where the strategy of change in agricultural practises will be implemented

Source: Author



CHANGE IN FIELD PRACTISE:
(a) Land has been tiled and terraced to better capture water.
(b) Land has been levelled and furrow irrigated.
These methods allow the land to absorb water efficiently & results in less waste.
(c) Creating vegetated buffer strips or wetlands between cultivated land and watercourses to slow surface water runoff and remove pollutants.
(d) Directing agricultural runoff to infiltration ponds, retention ponds and wetland areas to slow runoff and improve water quality.

Area addressed in the catchment to carry out this measure = 5171.4sq.km.
Time required for this measure to run efficiently = 0-1yr
Rate of sedimentation currently = 520 Cum/yr
Rate of sedimentation after implementing this strategy = 436.8 Cum/yr
Reduction % in sedimentation = 16%

Figure 15 Details of change in agricultural practices to be carried out

Source: Author

2. River fragmentation control measures

a. Afforestation

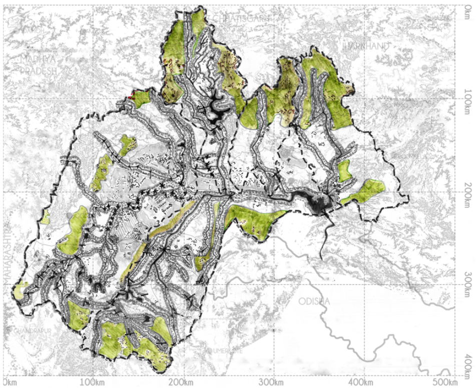


Figure 16 Areas where the strategy of Afforestation will be implemented

Source: Author

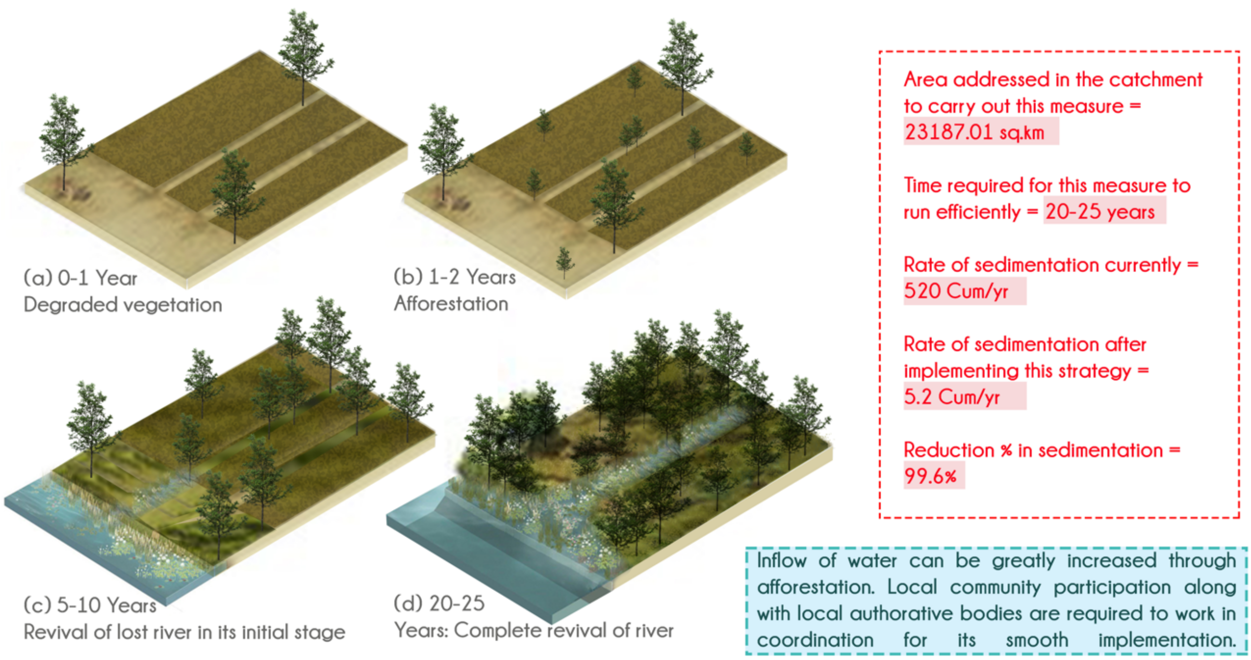


Figure 17 Afforestation strategy to revive the fragmented river

Source: Author

3. Reducing dependency from dam

a. Cultivating good quality of water

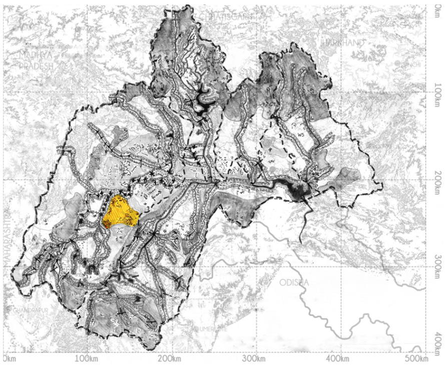


Figure 18 Areas where the strategy of cultivating good quality water will be implemented

Source: Author

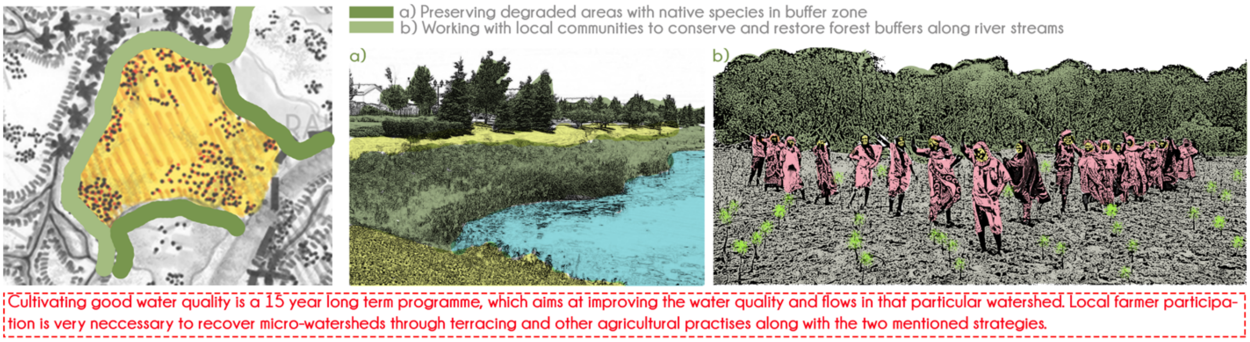


Figure 19 Cultivating good water quality for reducing dependency from dam

Source: Author

b. Improving urban design infrastructure

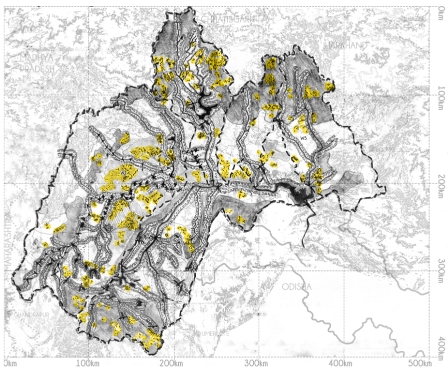
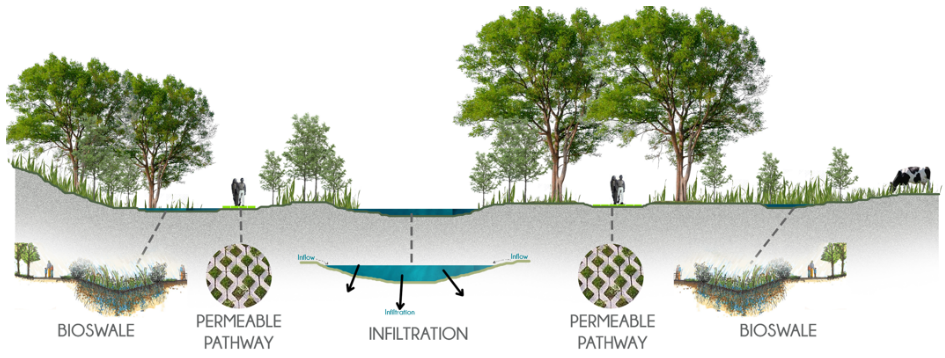


Figure 20 Areas where the strategy of improving the urban design infrastructure will be implemented;

Source: Author



IMMEDIATE IMPLEMENTATION CAN BE DONE: Rain is a vital resource that fills our rivers and replenishes our surface and groundwater supply. By carefully considering how to design communities sustainably and how to better plan for future growth and development, municipalities can implement innovative techniques that could extend the life of their water supply (i.e., sustain groundwater aquifers and steady base flows for rivers) and reduce their reliance on water supply dams and river diversions.

Figure 21 Improving urban design infrastructure;

Source: Author

c. Incorporating traditional water harvesting structure

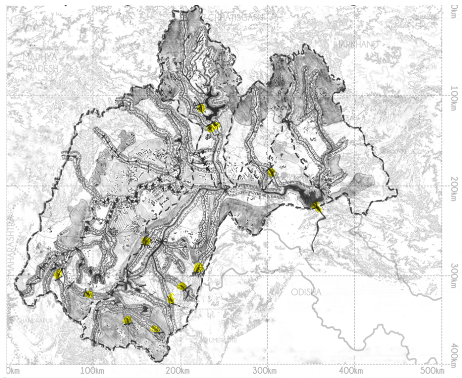


Figure 22 Areas where the strategy of incorporating traditional water harvesting structure will be implemented

Source: Author

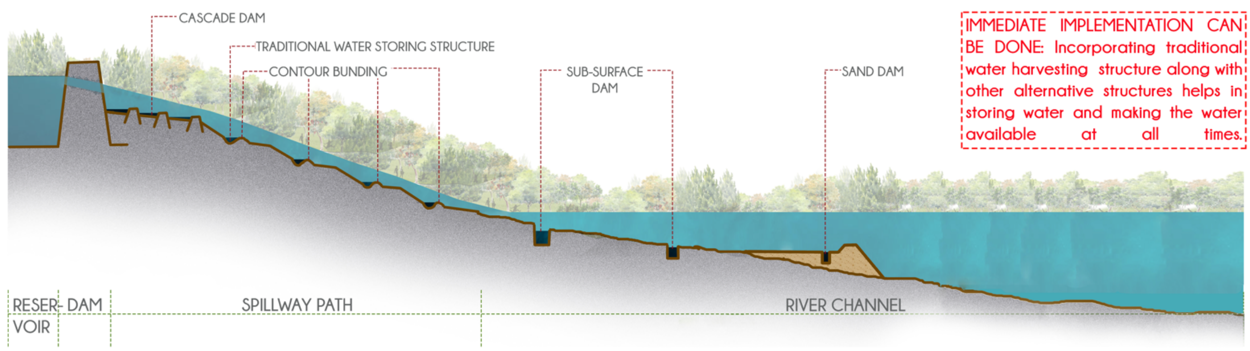


Figure 23 Incorporating traditional water harvesting systems on river beds or urban area

Source: Author

LANDSCAPE MANAGEMENT STRATEGIES SUMMARY

EXISTING SCENARIO: Currently, issues like degraded vegetation and presence of numerous dams in the upstream of Hirakud reservoir increases soil erosion and fragments the river streams. Encroachments on floodplain zones deteriorate the underground water quality and depletes the ground water table.

All these issues lead to an increase in the sediment deposit in the reservoir bed of the Hirakud, which lessens the water holding capacity of the dam and puts pressure on it, making it vulnerable.

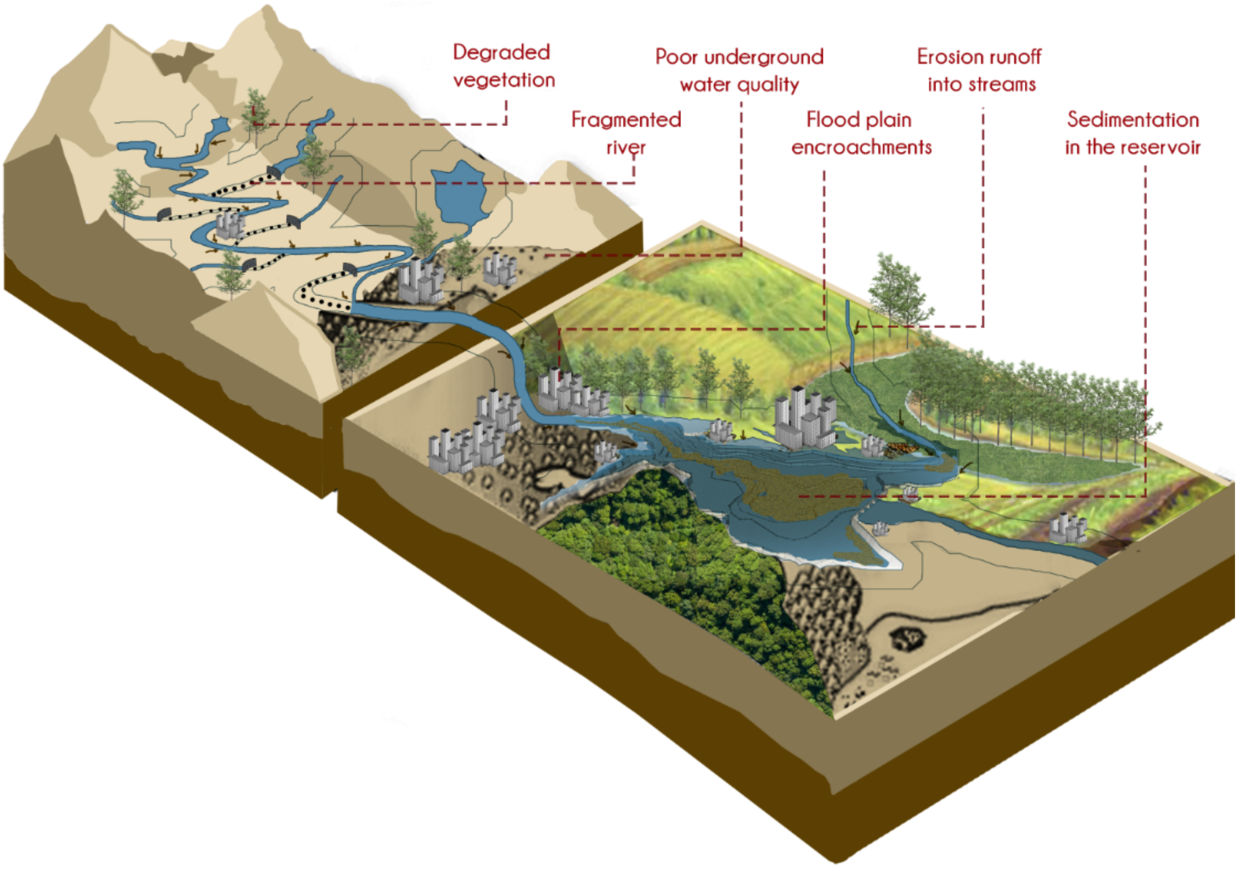


Figure 24 Existing scenario of Hirakud dam and its watershed

Source: GIS, Author

PROPOSED SCENARIO:

Strategies	Area addressed	Time required	Reduction %	Reduction rate
Erosion control measures	3323.04 sq.km	1- 5 years	26.5%	436.8 Cum/Yr
Reducing dependency from dams	5171.4 sq.km	5-15 years	42.5%	384.8Cum/Yr
River fragmentation control measures	23187.01 sq.km	20-25 years	99.6%	5.2 Cum/yr

All these measures are nature-based solutions; its functioning will take 20-25 years but it will be a sustainable solution for the working of the dam. Until then, the proposed spillways can handle the excess water removal from the dam for 20 years.

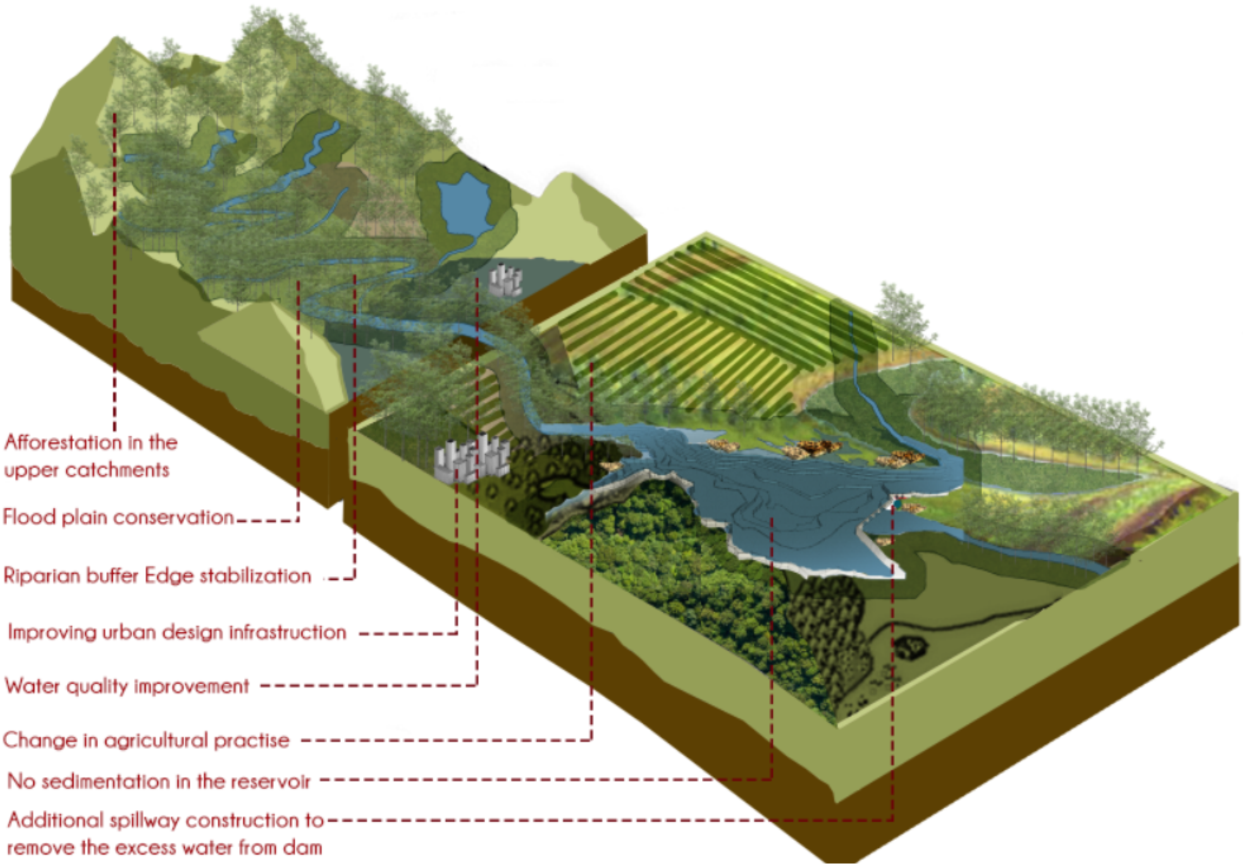


Figure 25 Proposed scenario of Hirakud dam and its watershed

Source: GIS, Author

SHORT TERM GOALS: INCORPORATING TRADITIONAL WATER HARVESTING STRUCTURES

The water crisis is becoming worse with each passing day. The severity of the situation is increasing with climate change, posing disastrous effects on all water resources. Therefore, traditional water harvesting structures are the best sources to ensure the availability of water at all times. It not only ensures the availability of water, but also allows the safety, security, health and hygiene of water catering to the population demand.

A traditional water harvesting structure needs to be maintained and it requires the effort of not only government agencies or non-governmental organisations, but a huge effort is required from the local communities to make any such structure sustainable.

Two such heartening case studies have been identified, wherein local traditional harvesting structures have been the source of water supply for the communities which serve the entire population of that area.

1. WATER HARVESTING STRUCTURE BRINGS LIFE TO COMMUNITY BIJEPUR, BARGARH.

Figure 26 Case example of Traditional water harvesting structure "KATA" which brings life to community Bijepur, Bargarh.

Source: Author

In the 1800s, the initiatives of the village landlord Damodar resulted in the creation of this huge traditional water harvesting structure named Damodar Kata that flourished with community efforts. The embankment made of stones put together with clay not only helped to hold water for the kata but also functioned as ghats for bathing purposes for the people.

Figure 27 The 250-acre kata named after the zamindar

Source: Author

This kata put an end to the water woes of the villagers, and their lives and livelihood revolved around it.

Evolution over the years and decay:

However, around 3 decades ago, this structure started degrading as the community ownership was pulled out.

In 2009, its revival process began with the community claiming its responsibility, women being the first to raise their voice.

Revival efforts:

The revival work started in 2016/2017, as the farmers recall. The embankment was heightened and strengthened, & the tank water was cleaned.

Government chipped in with its support and now the Kata thrives again providing many benefits to the communities

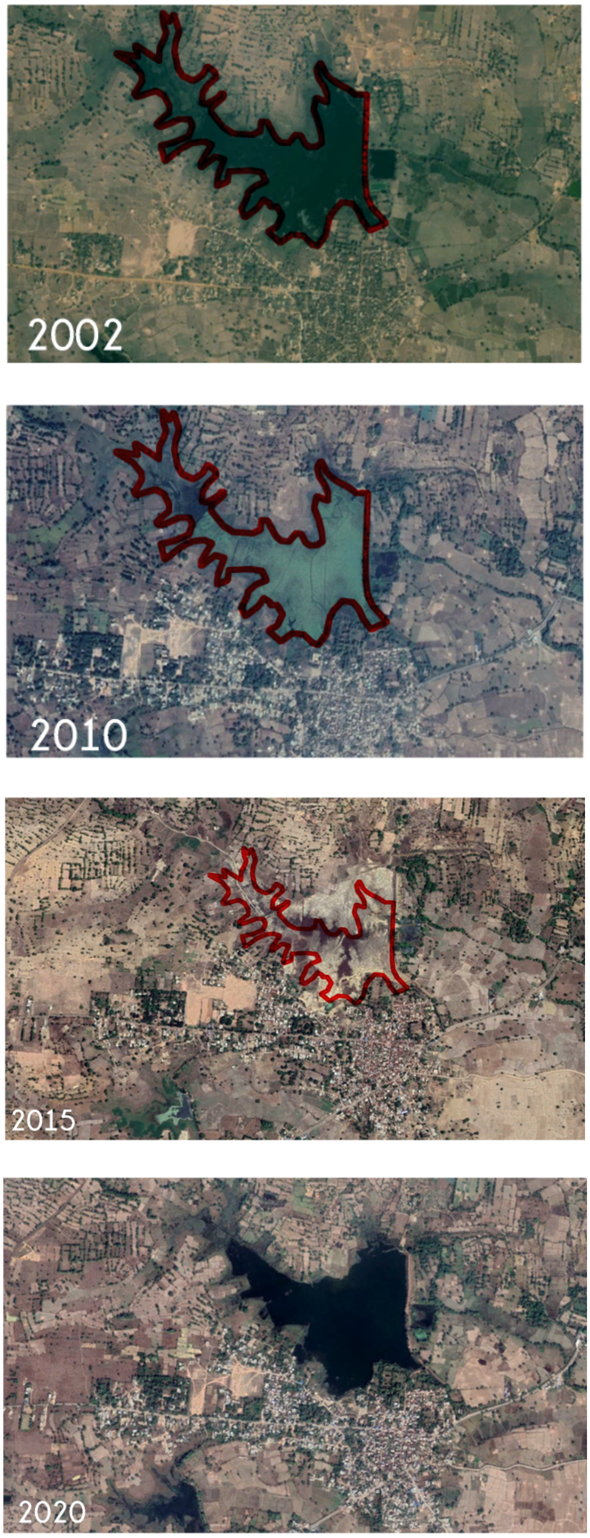


Figure 28 Change in landscape over a period of time, showing how the degraded KATA got revived again with community participation, serving the entire village with water supply.

Source: Google earth

BENEFITS PROVIDED BY THE KATA

- It supported about 150 acres of farming during Rabi and 1,000 acres during Kharif by ensuring water supply through two canals.

-About five nearby villages depend on Damodar Kata for bathing and other purposes.

LEARNINGS

-Such traditional water harvesting systems offer a big solution for the modern-day water crisis.

-When the communities convene on a goal to bring prosperity to their village, they successfully achieve the target.

Figure 29 Visuals of KATA

Source: COMMUNITIES IN WATER CONSERVATION & SECURITY, YOUTH4WATER and AUTHOR

2. THE EXISTING TANK BENEFITS OF LAIDA, SAMBALPUR.

Source: WATER RESOURCES OF ODISHA ISSUES AND CHALLENGES Bikash Kumar Pati Regional Centre for Development Cooperation and AUTHOR

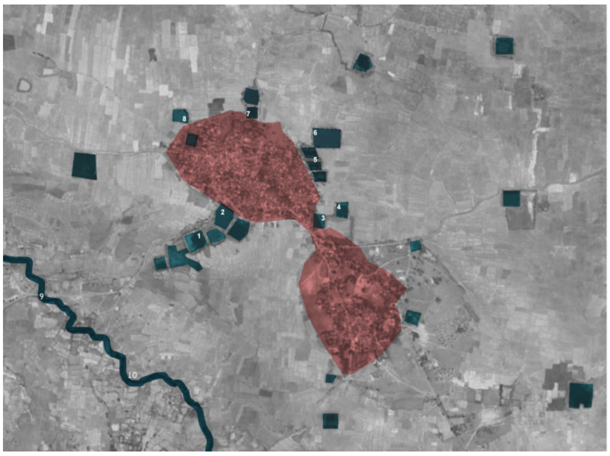


Figure 30 Map showing existing tank benefits of Laida, Sambalpur, a systematic water management plan with the use of tanks and ponds.

Source: Author

According to villagers there are about 27 surface water bodies of different sizes in the village. Except for one pond, the rest were dug by people themselves.

Figure 31 Survey done for understanding the system of traditional water management system

Source: Author

After having a conversation with the villagers about their system of water supply, it was found that the village had a systematic water management plan and the uses of the tanks and ponds are well defined. Twelve to fifteen tanks and ponds are devoted to agriculture and the rest for other purposes. A few ponds are exclusively being maintained for drinking water; one for washing clothes; a few for livestock and utensils; and so on.

About 1981 acres of land is cultivated in the village in which paddy is the major crop in Kharif. In the Rabi season, about 300 acres of the total cultivable land is put to agriculture, for mustard.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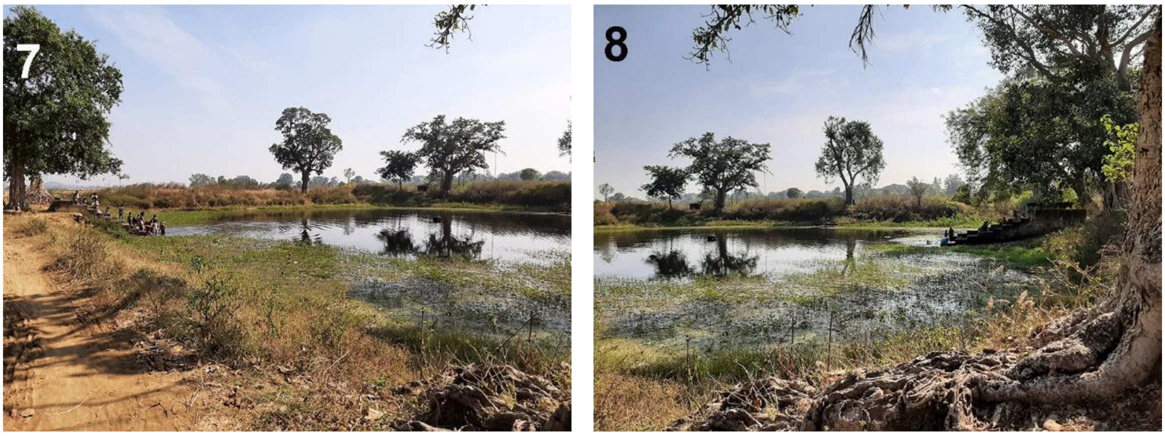

Figure 32 Visuals of the tanks

Source: Author

These tanks were made such that they were connected to each other in terms of the topography of the land and the underground water table.

Some farmers in Laida made a medium irrigation project by building a canal that passes by the village, ultimately achieving a permanent solution to water woes.

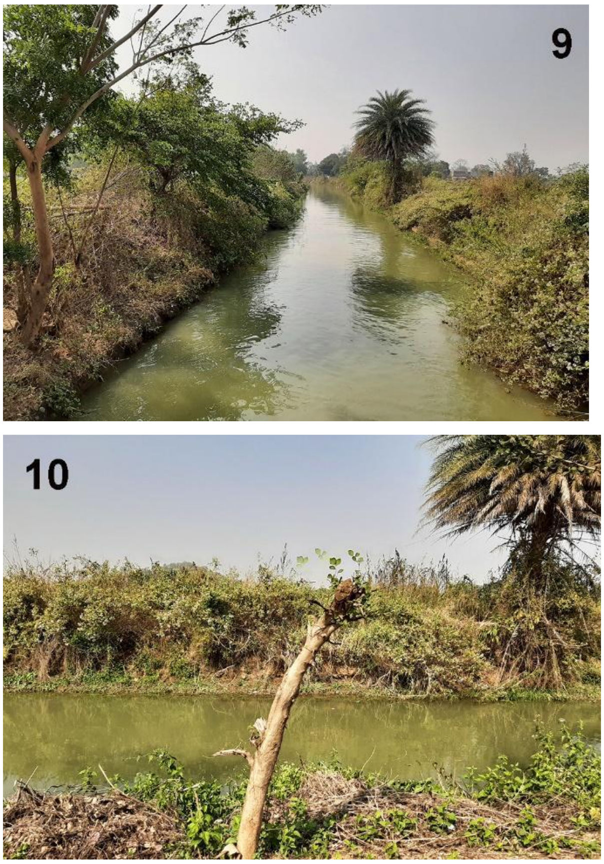

Figure 33 Medium irrigation project from the tanks for agriculture and farming

Source: Author

Apart from the benefits identified, one other major benefit is that it created a wetland in the catchment of the individual tanks, which allowed the growth of grasses and other vegetation for the cattle to graze.

Figure 34 Greenery in the catchment of the individual tanks allowing growth of vegetation, also serving areas for the cattles to graze.

Source: Author

These traditional water harvesting structures are a very beneficial answer to the water crisis which the world is facing right now. Both the villages had an approximate population of 1500 and they were being served by these resources. There was no need for any municipality water supply requirement. Thus, this measure can be one of the ways to reduce dependency on dam reservoirs.

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