Smart Laboratory on Clean Rivers- An Approach to Small River Rejuvenation in India

(Laboratoire Intelligent pour des Rivières Propres - Une Approche pour la Réhabilitation des Petites Rivières en Inde)

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RÉSUMÉ

Le changement climatique et les pressions anthropiques ont gravement affecté les écosystèmes et les ressources en eau à l'échelle mondiale, et l'Inde ne fait pas exception. Pour résoudre ces problèmes liés aux rivières, un plan holistique de rajeunissement des rivières est nécessaire, permettant de tester, d'innover et de mettre en œuvre des solutions durables pour une gestion durable des rivières. Le projet Smart Laboratory for Clean Rivers (SLCR), une collaboration indo-danoise, offre un laboratoire vivant réunissant toutes les parties prenantes pour s'engager, apprendre, co-créer et expérimenter en vue d'une rivière propre et durable qui résiste à l'épreuve du temps. Le SLCR a choisi un petit bassin versant de la rivière Varuna, situé dans le bassin moyen du Gange en Inde, pour un projet pilote. Adoptant une approche intégrée pour le rajeunissement des rivières, le SLCR met en œuvre diverses techniques et améliorations visant à maintenir un débit pérenne clair, à favoriser une biodiversité florissante, à reconnecter les communautés à leur rivière et à valoriser la relation symbiotique. Une fois achevé, le SLCR fournira un manuel de restauration des petites rivières, proposant un plan stratégique détaillé et des méthodes de mise en œuvre pour aider les parties prenantes et les administrations locales à préserver la propreté et la durabilité de nos rivières.

ABSTRACT

Climate change and anthropogenic stress have severely affected ecosystems and water bodies and exploited natural resources all over the globe and India is not any exceptions. To counter all these issues associated with the rivers a holistic river rejuvenation plan is needed that tests, innovates and implements sustainable solutions in the river space for sustainable river management. Smart Laboratory for Clean Rivers (SLCR) an Indo-Danish collaboration project, provides a living lab setup that brings all the stakeholders together to engage, learn, co-create and experiment for a clean and sustainable river that lasts for ages. SLCR has opted for a small catchment of the Varuna River for piloting, located in the Middle Ganga Basin in India. Considering the integrated approach of river rejuvenation, SLCR embraces various techniques and upgrades for rejuvenation, likely to maintaining clear perineal flow, thriving biodiversity, connecting community to the river and embrace the symbiotic relation. In its completion, SLCR with provide a restoration manual for small rivers, which will strategize the detailed plan and way of implementation for stakeholders and local administrations to keep our rivers clean and sustainable.

KEYWORDS

Climate Adaptation, Ecological sustainability, Integrated River Management, River Rejuvenation, Stakeholders involvement

Adaptation au changement climatique, durabilité écologique, gestion intégrée des rivières, rajeunissement des rivières, implication des parties prenantes

1 INTRODUCTION

River rejuvenation is a holistic approach to restore the health of a riverine body encompassing their ecological health, water quality, flow regime and flood plain improvement (Nardini and Conte, 2021). It is an integrated approach accounting for various components associated with the sustainable growth of the riverine ecosystem. While ecosystem conservation was historically the primary focus of restoration projects, economic considerations have become increasingly important. Multi-dimensional holistic river rejuvenation approaches are now being accepted by various governments and stakeholders for riverine management (Fliervoet et al., 2013; Srinivas et al., 2020).

India is the home of 18% global population living in just 2.5% of the global land coverage. This has resulted in an immense stress to the environment (Rao et al., 2015). This rising issue is just the beginning, as this Pandora bubble will keep on expanding with the country's economic rise. India is a 3.57 trillion USD economy, the fifth largest in the world (Rangarajan and Shanmugam, 2023). With the current growth rate, India is anticipated to become a 6.4 trillion USD economy, the third largest in the world, by the year 2029 (Kumar, 2013). Currently, the service sector accounts for 55% of the Indian economy, whereas the manufacturing sector contributes just 27% (Goldar and Das, 2024). Lately, the Indian government has recognised the importance of manufacturing in achieving a sustainable economy; as a result, several incentive-led schemes have been introduced in recent years with the view of unleashing the unprecedented growth of new India.

However, it is often seen that growth in the country's manufacturing generates unwanted waste India, a rising economy with a massive population to support, will also likely face enormous challenges as a result of looming threats like global climate change. Among these, degraded water bodies and mismanaged groundwater resources will be of major concern. To counter these challenges an all-inclusive management ecosystem needs to be created that ensures the sustainability of the river catchments and the societal developments. Similar living lab initiatives focused on creating sustainable solutions for the respective domains such as water living lab by WATER VALLEY DENMARK, Nordic Urban Living Labs, etc (Cayuela Lozano, 2024). have been undertaken in recent times. To counter catchment scale challenges, the Smart Laboratory for Clean Rivers (SLCR) has been formulated by the collective efforts of India and Danmark to approach clean rivers. Initially, the focus shall be on the small rivers, since the variables are relatively controllable. The prime objective of SLCR is to explore the synergies between India and Denmark for clean rivers. The smart laboratory shall function as a platform for mutual sharing of technical knowledge between both countries on holistic and sustainable river water rejuvenation, to test, innovate and implement sustainable solutions in the river space. These joint efforts will develop tenets for bringing global and local sustainable solutions to solve the complex challenges of achieving clean rivers. The River Varuna (Varanasi, U.P., India) has been selected for the pilot stretch demonstration.

2 STUDY AREA

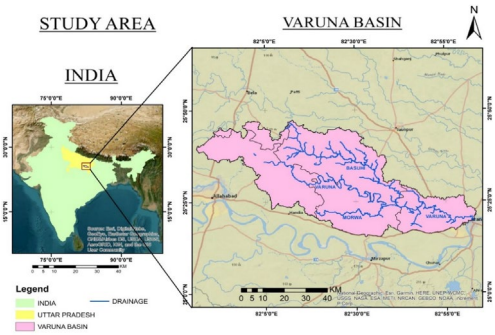

Figure 1 Varuna Basin

River Varuna is one of the many tributaries of the mighty Ganges. The river Varuna originates from groundwater sources in Prayagraj district of Uttar Pradesh state of India. The river flows about 230 km through the alluvium terrain of North Indian Plains before meeting the Ganga River. During its journey, several major and minor streams join and enhances drainage network. There are two major tributaries, namely, Morawa and Basuhi Rivers, meet the master stream from the right and left in middle reaches. The Varuna watershed is about 3364 sq. km in area and has a 550 km long drainage network, comprising of both rural and urban areas. The climate of the region is sub-humid, characterized by hot, dry summers and chilling winters. The majority precipitation of about 80% is during four months of monsoon (June-September), which creates a flooding condition in the basin.

However, the Varuna River and the watershed face multiple challenges, such as depleted flow, over drafting of groundwater, poor river water quality, encroachment, various types of waste discharging into the river, lack of awareness in community etc.

3 METHODOLOGY

To counter all such issues associated with the Varuna River watershed, SLCR has introduced a panoramic approach towards river rejuvenation by providing a living lab setup that brings all the stakeholders together to engage, learn, co-create and experiment for a clean and sustainable river that lasts for ages to come. The challenges associated with the Varuna River are mostly water quality and flow, driven by several anthropogenic factors. The river rejuvenation approaches adopted by SLCR in the Varuna River Basin primarily focuses on relentless flow followed by integrated watershed management. This approach is complemented by efforts to improving water quality and ecosystem restoration, including upgrading STP (Sewage Treatment Plant) technology followed by real-time monitoring, nature-based solutions and developing riparian zones.

Furthermore, the SLCR embraces the 'carbon-neutral' and 'water-positive' concept in the Varuna River rejuvenation, supported by capacity building and awareness programs. Lastly, the approach brings all the stakeholders together to achieve the goal of a clean river.

4 RESULTS

The SLCR has adopted various approaches to enhance the degraded quality of small rivers

4.1 Relentless Flow

A River is a geological entity, whereas, the water flows in it makes it alive. A free-flowing channel is a characteristic of a healthy river. The continuous flow of the river supports riverine ecology and contributes to the river health (Sofi et al., 2020). Varuna River was once perennial but has now become seasonal. The flow in the river is now mainly attained in monsoon and post-monsoon months. There are several reasons associated with the degradation of flow, majorly its over-drafting of groundwater and lack of recharge. An integreated water resource model and Managed Aquifer Model (MAR) model addresses the critical need for a region-specific platform to enhance basin-level water management through a comprehensive analysis of aquifers and surface water dynamics. These tools will integrate groundwater and surface water models to derive key parameters essential for informed decision-making. By doing so, this aims to offer policymakers greater flexibility and ease of operation in their efforts to implement MAR. This precisely addresses all steps of the MAR design process, encompassing site selection, recharge scheduling, and meticulous consideration of environmental factors.

4.2 Improving water quality

The river water quality in the Varuna River has degraded to critical levels, especially around urban settlements, due to increased inflow of municipal, pharmaceutical and industrial (textile) waste. Additionally, more than half of the catchment is associated with agricultural activity, producing substantial non-point pollution.

To make the Varuna River clean and to achieve desirable water quality, innovative approaches like integration of IoT-based solutions, Characterization of micro-pollutants, upgrading existing STP with real time sensor-based technology and nature-based solutions etc.

4.3 Ecosystem Restoration

More than half of the Varuna Basin is sheared by agricultural practices, which generates agricultural runoff, ultimately entering into the Varuna River, causing nitrification and degrading the river health. To counter it, SLCR has suggested developing a riparian buffer which shall act as a natural filter, reducing the influx of pollutants and sediments directly into the water. They will also play a crucial role in maintaining water quality, preserving biodiversity, mitigating pollution, preventing erosion, and enhancing overall ecosystem health.

4.4 Carbon Conservations

Carbon neutrality and water-positive catchment are the two sides of a single coin. These two fields are closely related within the field of environmental sustainability and climate change. Attaining carbon neutrality pays to overall environmental sustainability, including the health and vitality of rivers. By reducing emissions, enhancing resilience, conserving biodiversity, and improving water quality, carbon neutrality is intricately linked with the rejuvenation and preservation of our vital river systems. SLCR has adopted four villages in the Varuna catchment

under the pilot project to make them carbon-neutral and water-positive flows by a relentlessly flowing river with a healthy catchment.

4.5 Capacity Building and Stakeholders Engagement

River rejuvenation is an integrated field that involves multiple disciplines of science and technology. Likewise, several stakeholders are involved in such projects. All the stakeholders are equally important in the rejuvenation work segment. But while technical expertise is crucial, local communities living within the river's catchment area are vital component and must not be overlooked. The local people residing closest to the river system have shown a vested interest in the success of rejuvenation efforts. Their participation lends these projects legitimacy, public support and a sense of grassroots ownership.

Additionally, SLCR is strictly focused on the awareness and continuous flow of knowledge through town hall meetings, community workshops, conferences, seminars etc. This input helps shape Varuna River and other small river rejuvenation plans to respect cultural connections, minimize livelihood disruption and match on-the-ground realities.

5 DISCUSSIONS

A living lab setup like SLCR, which brings physical lab findings into the field can be revolutionary in the field of river rejuvenation. The effectiveness of the SLCR multi-folds with the stakeholder's involvement and community participation. However, there can be some potential challenges that can be associated with such integrated approaches such as multidisciplinary coordination, stakeholder engagement, data availability and management, financial constraints, land use and urbanization, climate change, community awareness and participations etc. In addressing such challenges, robust monitoring and evaluation are required to analyse the trails and process and upcoming challenges. While integrating science, technology, policy and community engagement to achieve sustainable outcomes in river rejuvenation projects.

6 CONCLUSIONS

The establishment of a Smart Laboratory for Clean Rivers (SLCR) setup characterises a substantial leap forward in the pursuit of sustainable river management and rejuvenation. Integrating such innovative ideas and advanced technologies from around the world characterizes a revolutionary initiative that unites all stakeholders in synergy to achieve a clean river. Ultimately, this setup promises to deliver substantial benefits, not only for the Varuna River but also as a base model for the revival of other small rivers, ensuring cleaner, healthier water bodies for future generations.

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