THE RIVER MHADEI: THE SCIENCE AND POLITICS OF DIVERSION

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The Science and Politics of Diversion

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To

the people

of the Mhadei

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13. Valuing the River Mhadei: An Economic Exploration

Dhirendra Deshpande

Abstract: *Ancient rivers have given birth to civilizations throughout the world. Unfortunately, sharing river water has resulted in long-drawn, highly complex, even bloody disputes between states, regions, and nations. Rivers are essentially public resources; however, despite their enormous value, no serious thought has been given to quantifying their relative values in monetary terms. Globally, efforts to look at rivers as systems that also help control climate and flooding, and sustain soil fertility, aquatic life, and biodiversity have begun. This chapter is an attempt to place an economic value on the river system with reference to the Mhadei. Presently most of the economic data collected is region-specific and not for the river as an entity. Some of the intangible benefits, too, are becoming clearer in recent times. I make no claim for the accuracy of the final valuation figure though the economic model uses input data, based on credible and official data sources. The assumption made is highly conservative; the actual value may be much higher. The idea is not just arriving at a specific valuation number for the river Mhadei but rather about linking the river system with the Gross Domestic Product (GDP), in this case, in the state of Goa.*

Introduction

ALMOST all major ancient human settlements and civilizations began on the banks of rivers. Some prominent examples are ancient Egypt along the Nile River, the Indus Valley Civilization along the river Indus covering parts of Pakistan and northwest India, Mesopotamia located between the rivers Tigris and Euphrates, called the "cradle of civilization" and ancient China along the Yellow River (Huanghe river). These civilizations exemplify the basic benefits rivers have provided, such as trade, drinking water, and irrigation for agriculture.

Rivers in India are not just valuable natural resources but are also worshipped as deities. The Mhadei river, also known as the Mandovi in its

lower reaches, is worshipped as a deity just as the Ganga and other rivers in India. The Mandovi, also called Mahadayi (Mhadei) in the upper reaches—the name implying "the Great Mother Goddess"—holds a deep cultural significance to Goa and Karnataka. Quite a few ancient stone sculptures, representing the river goddess have been discovered in and around the banks of the Mahadayi river, both in Khanapur, Karnataka and in Goa, indicating the existence of a cult of the river goddess. The boat goddess sculptures depict the goddess standing in a boat, holding a dagger in her right hand and a bowl in her left hand. She is known by various names such as Naukayana Devi (Boat Goddess), Ashtabhuja (Eight Hands) Durga, Mahishasuramardini (Slayer of Mahishasura the buffalo demon), etc. All these sculptures have been found mostly in Sattari taluka and Guleli and probably belong to the Kadamba period—twelfth or thirteenth century CE (Pai 2009).

The Mandovi river watershed comprises an intricate system of wetlands, tidal marshy area and cultivated paddy fields. The total area of mangroves along this river and the Cumbarjua canal is 900 hectares. The Mandovi and the backwaters in the hinterland are governed by regular tides. Like most monsoon-fed rivers, the Mahadayi also undergoes bewildering transformation during different seasons; slack, limpid pools of winter, partially dry beds of summer turning to fearsome torrents during the monsoons.

Three large freshwater islands, viz. Divar, Chorao and Vashee, are present in the Mandovi near the town of Old Goa. However, describing them as freshwater islands is only partially correct. For instance, Chorao often comes under the influence of high tides from the sea. The saline water then gets mixed with the river water. The island of Chorao is home to the Salim Ali Bird Sanctuary. Ironically, despite their service and benefits to humankind and to birds and animals, humans have not been kind to rivers. They pollute the rivers in Goa by dumping various kinds of waste. River flows have been interrupted by construction of dams, canals, bundhs and the like. According to Goa University researchers, there are 27 mines in the Mandovi river basin; they generate 1,02, 250 tons of rejections per year (Pradhan 2017). Another study conducted by Dr. Sengupta of NIO (National Institute of Oceanography) shows that 70,000 tons of iron particulates get deposited in the river every year (Pradhan 2017). With huge rainfall (120 inches per year) and open cast mining on the hills, mountains of rejections reach the river resulting in heavy silting problem (SANDRP 2017).

The Mhadei River, a crucial multi-state resource in western India, has been at the heart of a 50-year-long dispute over water sharing between Karnataka,

Maharashtra, and Goa. Rivers, as perennial resources, are fundamental to life, impacting both human and animal populations. Attempts to comprehensively evaluate a public resource like a river in India have, unfortunately, begun only recently as pointed to by the WWF 2018 report on valuing rivers (Opperman et al. 2018). Yet, quantifying the economic values from the myriad river benefits has not been attempted. This chapter is an attempt in that direction; it uses an exploratory method of placing an economic value based on GDP or the opportunity cost of income lost due to river diversion by Karnataka.

Methodology

The methodology proposed for this chapter is drawn from the WWF Report 2018 that provides a comprehensive framework for valuation of a river, which is viewed as part of an ecosystem that integrates human activity. The report identifies and analyses four components in the framework. These are as follows:

1. Measure

The adage in management is "you can't manage what you cannot measure." However, it is not easy to measure the value of a river. Traditionally, rivers have been valued in terms of irrigation facilities provided to agricultural crops and generation of hydroelectricity. In the west, internal transport-navigation is also taken into consideration. However, a river system is much more than that; there are several hidden values which are neither officially recognized nor measured. Rivers serve an important purpose of flood mitigation. Excess and sudden rainfalls have become more frequent occurrences of late in India and elsewhere due to global warming and climate change factors. Damming rivers results in loss of delta regions. Agriculturally they are the most productive zones.

2. Value

The measurement of a river's value has been incomplete, and so our understanding of the price paid for use of water, whether for agriculture, industry, or household consumption, does not reflect its scarcity value. Several state governments give free electricity and water to farmers. Free electricity and faulty cropping patterns have resulted in over-exploitation of groundwater, because of which water tables are receding at alarming rates in Punjab and northwest India. Municipalities in India operate with obsolete water meters that almost invariably fail to record actual usage of water in urban and semi-urban areas. And the rates too are fixed by the government and remain static for decades! What should be the fair price for water pumped to households

and industries remains the relevant question.

3. Understanding trade-offs

Both measuring and valuation are themselves daunting tasks given the features of a developing nation like India with the world's largest population. However, even more challenging is decision-making and navigating through difficult trade-offs. Demands on freshwater and riverine resources are increasing every day. However, water resources are finite. Hence, balance needs to be struck among major water needs, such as drinking, agricultural operations, industrial use and generation of electricity. If for instance, an agricultural crop is consuming more water, it may be because of the wrong cropping pattern. It is also imperative to bear in mind the question of intergenerational justice involved in the use of a public resource. The Mhadei river dispute brings to the fore this challenge of making trade-offs, not just between demands within a state but also demands between states of the union. At the most obvious level, this was seen in the award of the Mhadei Water Disputes Tribunal, but here we see it broadly since it presents trade-offs between the claims of agriculture and urban dwellers and the sustainability of the Mhadei ecosystem, especially because of its biodiversity.

4. Improving governance

This entails plans and policies for optimum utilization of water as also management of river systems. River water pollution is a major problem in most parts of India. Dumping of waste of all kinds clearly indicates laxity on the part of governance and implementation by the concerned authorities. Good governance, like everywhere else, should start with participation of people right from the grass root levels—village panchayats, municipal bodies, experts in the field of agriculture, environment and ecology and industry. The top-down approach that is mostly prevalent presently does not involve the most important stakeholders and hence there is neither any incentive nor involvement to save water.

I propose to bring to bear certain key benefits from rivers to understand the total river system value in a holistic and comprehensive manner. Some of these benefits are direct and measurable whereas others are hidden but intrinsic to a river system. Further, traditional methods of viewing economic values are rather well known. I propose to look at both hidden and future potential benefits. Some of the future potential benefits are already seen in India and the west. It is proposed to project both present and future values of such benefits based on different assumptions. Though there are eleven rivers flowing in Goa, the Mhadei and Zuari are the two major rivers. The Mhadei is the lifeline of the state and supplies drinking water to 43 percent

of the population (Lokgariwar 2016). It can be assumed, therefore, that it is a key natural resource for the state.

Goa is a small state in the Indian polity, but it has created a niche for itself in terms of better governance reflected in incomes and enhanced social and health parameters. The river Mandovi is crucial for tourism-related activities in Goa. Tourism continues to be a significant contributor to Goa's economy. It contributes around 17 percent to the state GDP and supports 35 percent of the population in terms of providing direct and indirect employment (India Brand Equity Foundation 2025). The tourism minister, Rohan Khaunte, informed the State Assembly that a record 1.04 crore tourists visited the state in 2024, including 99.4 lakh domestic arrivals and 4.67 international tourists (Hegde and Mishra 2025). There is a significant fall in the number of foreign tourists arriving in Goa. Interestingly, the minister pointed out that tourism in the state is resilient; despite a huge decline of 18 percent in international tourism in Asia last year—a record in the post-COVID 19 pandemic period—Goa has seen a rise in foreign tourists' arrivals by 3 percent over the last year. As a result of the surge in tourist numbers, revenues too have grown impressively. In December 2024 alone, an increase of over Rs.75 crores over the corresponding period of the previous year was recorded. From April-December 2024, total revenues reached a figure of Rs.4,614.77 Crores. This is Rs.365.43 Crores more than the same period in the year 2023. Much of this growth is attributed to tourism, including GST and VAT collections from the services availed by the visitors (Economic Times Travel 2024). Notwithstanding the criticism and social media frenzy, tourism as a sector continues to grow at a robust 21 percent in 2023 and 2024, as can be seen from Table 13.1 below.

Table 13.1: Tourism numbers in Goa, 2019–2024. Source: Goa Department of Tourism (27 March 2025).

Holiday Destination				
Year-wise number of domestic and foreign tourist arrivals in Goa				
Year	Domestic	Foreign	Total	% Change
2019	7127287	937113	8064400	0.61
2020	2671533	300193	2971726	-63.15
2021	3308089	22128	3330217	12.06
2022	7018945	169005	7187950	115.84
2023	8175460	452702	8628162	20.04
2024	9941285	467911	10409196	20.64

The river provides quick and efficient internal transport for carrying ores to

the port. Mining in the state peaked in 2011 and plummeted after a Supreme Court order in 2018 that quashed the renewal of 88 mining leases in Goa, triggering a spectacular fall in mining fortunes. Iron ore exported fell from a peak level of over 54 million tons in 2011–12 to just 1 million tons in 2017–18. While the worst seems to be over and mining is reviving, it still has a long distance to cover to reach the levels of 2011–12 (Times News Network 2025). The table below shows this trend in Goa's mining industry writ large.

Table 13.2: Mining receipts in Goa for five years upto 2020-21. Source: Natural Resource Account Report of Goa 2020-21. CAG of India June 2023

Year	2016-17	2017-18	2018-19	2019-20	2020-21
Tax and non-tax receipts	6973	7764	7745	7437	7053
Mining receipts	348	333	34	9	168
Percentage of mining receipts to total tax and non-tax receipts	4.99	4.29	0.44	0.12	2.38

The purpose of the chapter is to bring out economic values arising from various benefits of a river system in a state. More than precision, the idea is to showcase the size, variety, and potential of all the benefits. As the WWF 2018 report points out, rivers should not be seen as mere conduits of water from one place to another. Their hidden and intrinsic value needs recognition and focus. It is hoped that this exercise will help stakeholders in viewing a public resource in a more holistic and comprehensive manner. There are, however, certain limitations in this study; the most serious being the non-availability of relevant and authentic data. Most of the data relating to rivers and water in Goa is not specific to an individual river. Generally, the data pertaining to rivers is collected and analysed by government/public agencies. However, the problem is that it is fragmented and mostly based on geographical regions such as a state, district, or taluka.

Since precise data is not available, a reasonable assumption is made in this regard. Further with the help of the current economic value, future values of the river system for the next 20-plus years are attempted. In addition, rivers like Mhadei are for generations and need to be preserved for the sake of posterity. I shall also discuss situations where water flows will be impacted due to diversion by the upper riparian state, climate change, droughts and floods.

Newer methodologies of integrating data systems, using AI (Artificial Intelligence) and more focused hydro-economic models are evolving. They can, perhaps, offer scope for further research and discoveries on the subject.

What follows is a detailed parsing of the potential value of the river and a calculation of its benefits.

Ecosystem Services

1. Water Supply and Freshwater Provision

The Mhadei River is a crucial source of freshwater for domestic, agricultural, and industrial use in Goa, especially in the areas around the river basin. It supports drinking water needs for local communities and is integral to irrigation systems, ensuring agricultural productivity.

2. Biodiversity Support

The Mhadei River basin is rich in biodiversity. The river and its surrounding habitats support various plant and animal species, including endemic and threatened species. It is an integral part of the Western Ghats, a UNESCO World Heritage site, known for its biodiversity hotspots. The forest areas along the river provide habitats for several wildlife species, including tigers, elephants, and various birds, amphibians, and reptiles, many of which are of conservation concern.

The Mhadei sanctuary formed in 1999, hosts one of the lushest and most verdant pockets of the Western Ghats biodiversity hotspot. This comparatively new sanctuary area in Goa is in the northern Part of the state, near the village of Valpoi. The sanctuary covers a vast area of 208 sq. km. The formation of this sanctuary makes Goa the only state in the country that protects the entire area of the Western Ghats that falls within the state (Pradhan 2017).

Bengal tigers have also been spotted within the area covered by this sanctuary. Apart from a large number of commonly seen animals like Indian gaur, barking deer, civet, wild boar, etc., animals seen rarely include the black panther, sloth bear, leopard, tiger, dhole, jungle cat, mouse deer, giant squirrel, flying squirrel, Indian pangolin and the slender loris, which is an endangered species. The sanctuary is also home to more than 255 species of birds and has been declared an International Bird Area (Pradhan 2017).

In 2022, in acknowledgment of the importance of water, the first UN Climate Change Conference (COP27) highlighted the links between water, biodiversity and global warming, Csaba Kőrösi, president of the United Nations General Assembly, reiterated: "This is the water COP" (Abdulali and Pendharkar 2023). Like other rivers originating in the Western Ghats, a UNESCO world biodiversity hotspot, the Mandovi river supports various species of endemic and other fish, including the barramundi and mangrove jack. A recent study identified 84 species of fish in Goan rivers (Abdulali and Pendharkar 2023).

3. Flood Regulation

The Mhadei River plays a role in mitigating flood risks by regulating the flow of water during the monsoon season. The wetlands and riparian zones along the river help in absorbing excess water, reducing the likelihood of floods downstream. These areas also help in groundwater recharge by absorbing water into the aquifers, which supports drinking water and agricultural needs, especially during dry periods.

The flood vulnerability analysis of the state of Goa reveals that 14.73 percent of its land mass is under 15-meter elevation from sea level. Most of this is in the coastal belt and hence highly vulnerable to risks of flooding, both from rise in sea levels and extreme weather events such as high rainfall. While global warming has led to rise in temperatures, extreme weather events too have increased in intensity. Already the mean annual temperature in Goa has shot up by 1°C between 1901 to 2018, and much of this increase has occurred post-1990. Mean annual temperatures could rise by 2°C by 2030 and 4°C by 2080 in a scenario of high levels of green gas emissions. It was predicted that by the end of this century Goa would start experiencing a maximum temperature of 40°C. That level seems to have been breached already, albeit still briefly. Minimum temperatures will also rise by 8°C (Goa State Biodiversity Board 2023).

The mean annual rainfall in Goa has increased by 68 percent between 1901 and 2015. However, this is due to an increase in extreme weather events—category 3 of the IMD. Events of heavy and exceptionally heavy rainfall activities have shot up at an alarming rate of 100 percent during the said period. Light and moderate rainfall activity—category 1 of the IMD—is beneficial as it supports life forms and ecosystems. However, such weather events have declined during the same period (Goa State Biodiversity Board 2023). Under such circumstances, attempts to interrupt/divert the Mandovi's waters will add to risks of floods in vulnerable areas.

A NIO study that has developed a vulnerability index also shows similar results. Accordingly, a 30 Km stretch along the coastline covering Bardez, Salcete and Tiswadi talukas is at highest risk of flooding due to rise in sea level (Goa State Biodiversity Board 2023).

4. Climate Regulation

The river and its surrounding forests contribute to climate regulation. Forests along the Mhadei River act as carbon sinks, absorbing carbon dioxide from the atmosphere and contributing to the mitigation of climate change. The river also helps moderate local temperatures by maintaining a stable microclimate in the region.

This means they absorb and store carbon dioxide (CO) from the atmosphere, which helps reduce the overall concentration of greenhouse gases in the air. The process occurs through photosynthesis, where trees and other plants take in CO and release oxygen, storing carbon in their biomass, i.e., trunks, branches, roots, and leaves (Gopalkrishnan 2012).

5. Soil Fertility and Nutrient Cycling

The Mhadei river helps in the deposition of nutrient-rich sediments along its banks. This natural process supports the fertility of the soil in the river's floodplains, which is crucial for agriculture in the region. The river plays a key role in nutrient cycling by transporting organic matter and minerals from the forested areas to the agricultural lands and wetlands, supporting diverse ecosystems.

The natural process of sedimentation helps replenish the soil with essential nutrients, enhancing agricultural productivity and supporting the livelihoods of local communities. This natural fertilization process also promotes ecological balance, supports biodiversity, and contributes to the sustainability of farming practices, ensuring that the fertile floodplains remain productive for generations to come (Bhat 2012).

6. Cultural and Recreational Benefits

The Mhadei River holds cultural significance for local communities, particularly the people of Goa, who rely on the river for their traditional practices, festivals, and rituals. The river also plays a role in religious ceremonies and local traditions. It provides opportunities for recreation and tourism, such as eco-tourism, river cruises, and fishing. These activities bring economic benefits to the local population while raising awareness about environmental conservation.

Also, the social and cultural value of the populace it supports has unique and intrinsic value. The recreational value of rivers is rapidly rising and casinos operating on river Mandovi generate huge revenues and pay hefty sums as tax and license fees to the state. Off-shore and onshore casinos, as per the Chief Minister's statement in the state assembly, have contributed Rs. 411 crores to the state's exchequer in 2018–19. There is a resistance from the local population to the casino culture. It started as a necessity when the mining activities came to a grinding halt following the Supreme Court directive. Now, it appears to have become an integral and inevitable part of tourism in Goa.

Water sports on river systems are becoming popular in India among all age groups especially the youth who prefer more "adventure-oriented" activities.

With growing disposable incomes and tourism picking up pace, the potential is immense. Goa is already quite substantially on the national and international tourism map. Data pertaining to economic values of these activities is not available at present at either the state or national levels.

7. Pollution Filtration and Water Purification

The natural vegetation and wetlands along the Mhadei river function as filters, helping to purify the water by absorbing pollutants and trapping sediments. These natural filtration processes improve the quality of water, making it suitable for consumption and supporting aquatic life.

8. Hydropower Potential

The Mhadei River has potential for hydropower generation. Although this service is often debated due to environmental concerns, hydropower could provide a renewable energy source for the region, reducing reliance on fossil fuels. The waterfalls at Dudhsagar are a major tourist attraction. The water falling from great heights is a spectacular sight. It is also a potential region for producing hydroelectricity.

The Western Ghats, where the Mhadei river originates, have been identified as a key potential region for development of hydroelectricity due to their abundant water resources. It can provide a stable, reliable energy supply, which is particularly important in remote areas that may not be connected to national or regional electricity grids. The development of hydropower from the Mhadei river can help reduce the region's dependence on coal and other fossil fuels for electricity generation. By shifting to renewable energy sources like hydropower, India can lower its carbon footprint and make progress toward achieving its climate change mitigation goals.

While the Mhadei has hydropower potential, it is essential to carefully manage its development to avoid negative environmental and social consequences. The Western Ghats are recognized for their biodiversity and ecological importance. The construction of dams and hydropower plants can disrupt local ecosystems, affecting flora and fauna. Species endemic to the region, such as the Western Ghats' unique fish species, may be at risk from habitat destruction. The river's aquatic biodiversity, including freshwater mussels, fish, and other organisms, could also be impacted by changes in water flow and quality (Choudhari 2015). Smaller electricity projects that do not disturb nature, perhaps, could be optimal solutions.

Hydroelectricity projects referred to as "run-of-river" (ROR) give the impression that they produce electricity without disturbing the flow of the river. This sort of "innovation" is popular with influential institutions like

the World Bank that proudly display run-of-river hydro projects in their portfolio. However, the reality is often different. The term "run-of-river" itself is misleading. All such projects impound river water. They may minimize some damage caused by large reservoirs in cases of conventional hydroelectricity projects. Yet ROR also impacts ecology, biodiversity and human and animal life especially in downstream areas (International Rivers 2017).

9. Aquatic Habitat and Fisheries

The Mhadei river supports a variety of aquatic species, including fish, molluscs, and other invertebrates, making it important for local fisheries. It offers a key food source and livelihood for many people living in the river basin. The river's ecosystem also supports the breeding and migration of several fish species, contributing to local fisheries' sustainability. The river's waters support a diverse range of aquatic species due to the rich ecosystems found in the region, including both its fast-moving streams and calmer stretches.

In many riverine communities, fishing is not only an economic activity but also a cultural practice passed down through generations. Fish festivals, local customs, and traditional fishing techniques are an essential part of the cultural identity of the people living in the Mhadei River basin.

10. Tourism and Economic Opportunities

Ecotourism in the Mhadei River and its surrounding areas (including the Mhadei Wildlife Sanctuary) promotes local economic development. Tourists visit the region for its natural beauty, wildlife, and the river, generating revenue and creating jobs for local communities.

Analysis and Discussion

Let us now consider providing a value model for the river keeping in mind the components that we discussed in the beginning, namely, measurement, value, trade-offs, etc.

Flowing rivers are notoriously difficult to measure. Yet attempts are being made to learn from the past and present experiences all over the world. River deltas are the most productive zones. For example, the Mekong delta is home to 17 million people in Vietnam, one of the most productive regions in the world for agriculture, accounting for production of half of the nation's staple crops. And 90 percent of the rice exported from Vietnam is grown here. This scenario is already changing. The flow of the river and sediments are affected by theconstruction of multiple dams and reservoirs. More such projects are planned, in the name of development. Sediment supply has dropped from about 160 million tonnes in 1990 to 75 million tonnes (less than half) by 2014.

Due to loss of sediments and with rising sea levels, it is predicted that nearly half of this delta will be under sea waters by the end of this century (Opperman et al., 2017). The Indo-Gangetic plains, another example of a fertile riparian area, in northern India, support over 520 million people inhabiting these regions.

The river Ganga, like all other major river systems, especially in India, is polluted, diverted and overused. In recent years, the government has spent over Rs. 20,000 Crores to rejuvenate it, but the state of the river remains unchanged (Das 2017). Similarly, inland freshwater fisheries are a much-neglected area both in India and abroad. According to the WWF Report 2018, they account for 12 million tons of annual production valued at $65 to $80 billion. This is indeed a conservative estimate for both production and values are either understated or not recorded at all! Especially in developing nations, they are vital sources of availability of cheaper food options with adequate nutrient value (Opperman et al., 2018).

The Mandovi is one of the two most important rivers of Goa. Within Goa, the Mandovi river drains an area of 1,580 sq. km., which lies in Tiswadi, Bardez, Bicholim, Sanguem and Ponda talukas. The river flows a length of 52 km and drains into the Arabian Sea at the Mormagao Bay near Panjim. It is regarded as its lifeline as its watershed covers about 42 percent of the state's total area, resulting in extensive use of its water for drinking and agricultural purposes. It also serves as an important internal navigation route for commercial purposes (Pradhan 2017).

Value

Water is essential for life, for food production and a key input for virtually all economic activities (UNESCO 2021) However, water demand is growing at a pace that cannot be met by increasingly volatile climate and diminishing supply (IPCC 2021). The state of Goa, situated on the west coast of India gets plenty of precipitation from the southwest monsoons. With a relatively small total population, one gets the impression that fresh water may not be scarce in the state. However, that is not the case. It can be referred to as the paradox of high precipitation and low per-capita water availability (Pradhan 2017).

The Draft State Water Policy for Goa 2015 states that despite copious annual rainfall, rivers in Goa have very low flow for the non-monsoon months resulting in scarcity of drinking water especially during summer (Government of Goa 2015). The narrow width of the state, steep slopes of the Western Ghats, non-uniform distribution of rainfall over time and space cause temporal imbalances of water that has an impact on water availability in the state. This explains the paradox that although Goa is situated in a high precipitation

zone, it has one of the lowest per-capita freshwater availabilities. In case Karnataka is allowed to divert water as per its demand, then the situation will become acute for Goa. As noted earlier, the river Mandovi caters to the drinking water needs of 42 percent of Goa's total population.

The proposed diversion of the river water and construction of dams and canals will affect the catchment area. Dr T.V. Ramachandra, head of Energy and Wetland Research Group, Indian Institute of Science (IISc) cautions that the river catchments are essential to ensure water flow throughout the season or for most of the year. "The rich tree cover, and the panoramic landscape hold the rainwater beneath it which is used during the drier seasons. And once the catchment area at the river's origin is destroyed, it's difficult to restore it. As it is, the catchments of Kalasa and Banduri are in bad shape due to deforestation and the implementation of projects with no consideration for the environment," he says (SANDRP 2016).

When the resource is available in abundance, its value is not realized. But when basic human needs, such as water, become scarce, there is a real scramble to get it, store it, and preserve it. After decades of hectic growth of population and reckless urbanization, Bengaluru, the IT capital of India is facing massive water shortage. Even after good rainfall in 2024, there were shocking press reports that residents in Whitefield (Bengaluru) were forced to shell out Rs. 25,000 per month per home for water supplied through tankers (Mandyam 2024)! Sustainable Development Goal 6 as articulated by the UN focuses on a range of values of water. The sub-themes include equitable access, water quality, efficient use of water by various sectors and improved governance (United Nations DESA n.d.). Globally, demand for water is growing by 1 percent annually both due to increase in population as well as change in food habits with more meat consumption. As a result, Schlosser et al. (2014) predict that over half of the world population will live in regions affected by water stress.

Understanding Trade-offs

As India sustains the world's largest population, demand for water will increase more here than in any other part of the world. Since the resource is finite and is increasingly becoming scarce, it is of utmost importance to save and conserve water resources. Within agriculture, water can be used for growing different crops. The trade-off is that if too much of the precious resource is diverted for sugarcane cultivation, then it will not be available for other crops and vegetables.

Karnataka is a major state for the production of sugarcane in India. The districts of Dharwad and Belagavi figure prominently in the sugarcane produc-

tion list (Manju and Dinesha 2024). Goa has made out a case against Karnataka for diversion of Mhadei waters to provide irrigation water for cane cultivation.

Along with other states, such as Punjab, Maharashtra and Uttar Pradesh, Karnataka too has not paid sufficient attention to judicious use of water for irrigation. North Karnataka consists of twelve semi-arid districts. It is drained by the river Krishna and its tributaries such as Malaprabha. The river Malaprabha originates in the Western Ghats at Kankumbi, Belagavi district. According to a 2008 report "Hydrology and Water Allocation in Malaprabha" prepared by the Norwegian Institute of Water Research based on data gathered between 2001 and 2004, the unsustainable land use practices have made the Malaprabha basin the most deficit sub-basin of the Krishna river (Reshmi et al. 2008).

Undertaking sugarcane cultivation on a large scale in these areas is unsustainable. Even so cane was cultivated in a huge area spanning 1,81, 470 hectares of Dharwad and Belagavi districts in 2011–12, requiring use of 160 TMC of water annually according to the Dharwad-based Society for Community Participation and Empowerment or SCOPE (Jamwal 2016). The Government of Goa too has pointed out these figures in its affidavit (SANDRP 2016). The faulty cropping pattern and undue emphasis on growing cash crops are clear from the fact that the amount of irrigated water needed is six times the total yield of the Malaprabha project!

Soft drink manufacturers need large quantities of water daily. In water-stressed areas, they have been criticized for reckless use of groundwater. The Pepsico plant in Dharwad is supplied 0.4 million litres of water daily, which, according to the affidavit filed by the Goa government, is enough to meet the drinking water needs of 16,000 people. This is again a case of lopsided priority, this time in respect of industrial use of water (SANDRP 2016).

It is not just the Malaprabha basin where water is allocated and managed improperly. There are numerous examples across the country that prove that the answers to water woes lie closer to home, not in far-away transfers. As Bangalore's Zen Rain Man, Vishwanath Srikantaiah says, "Belgaum itself has shown a way to water security through managing its groundwater. Through the leadership of R.S. Nayak, about 400,000 people in the city are serviced with clean groundwater. Drinking water is something every city and settlement can secure for its own by cleaning and reviving lakes and tanks is the first step. It does not need to seize a different river for that" (SANDRP 2016). Dr. TV Ramchandra of the Indian Institute of Science (IISc) says: "We are not

asking the right questions. What we should be concerned with is why has Malaprabha's yield reduced? Why the anomaly? The reasons lie in reduced percolation and deforestation in the catchment. If we continue mismanagement of water, then another diversion will be needed in no time" (SANDRP 2016).

The government of Karnataka has argued that Goa is not utilizing the Mhadei water resources fully. Of the total availability of water in the river basin, 108.72 TMC, just 8 percent of the total water is used whereas the rest is emptied by the river into the Arabian Sea (Pradhan 2017). There is, however, a question of equity and intergenerational justice involved here with Goa pointing out that by 2051 this use percentage would rise to 86 percent (Jamwal 2016). This estimate probably does not consider the inevitable impact of climate change due to global warming and release of greenhouse gases, which might reduce water availability further. There is some evidence to show that it is already resulting in overall reduced rainfall during the monsoon period and increase in the number of extreme weather events. Even with current usage of the river water, it is not right to say that the river water is wasted. Rivers joining the sea bring precious nutrients with them that aid fish breeding in the sea. In addition, they also help in reducing salinity in fish habitats which again helps with breeding. Further benefit is in terms of the impact on river water on rainfall activity. River water evaporates faster than saline sea water. Hence, if river water is diverted or the flow is interrupted, it will impact the seasonal total rainfall in the area.

In this context, the interim award of the Mahadayi Water Disputes Tribunal dated 17 July 2016 says, "Rivers are important for many reasons. One of the most important things they do is to carry large quantities of water from the land to the ocean. There, seawater constantly evaporates. The resulting water vapour forms clouds. Clouds carry moisture over land and release it as precipitation. This rainwater feeds rivers and smaller streams. The movement of water between land, ocean, and air is called the water cycle. The water cycle constantly replenishes Earth's supply of freshwater which is essential for almost all living things. Except for a few rivers, all rivers in India ultimately flow into the sea whether it is Arabian Sea or Bay of Bengal. Before merging into the sea, the water of the river is available for consumptive and non-consumptive uses by the States concerned. Therefore, merging of water of river Mahadayi to the Arabian Sea irrespective of uses, cannot be wastage of water" (Pradhan 2017).

Improved Governance

The apex court has rightly called for states' intervention in agricultural land

use and cropping patterns. It has also stressed the need to investigate aspects of the incentives and disincentives offered to farmers. There is an imperative for the Centre to cover more crops meaningfully under MSP (minimum support price) and procurement policy. Presently, it mostly covers only two crops—wheat and rice. Excessive reliance on these two crops is harming the environment. Even where rainfall is inadequate or not timely, paddy cultivation is undertaken on a large scale, particularly in north India.

As noted earlier, the river Mandovi is the lifeline of Goa, meeting drinking water needs of nearly half of the state's population. According to Public Works Department (PWD) officials, presently there are 4.75 lakh households with a total population of 19 lakhs. It is estimated that household water consumption for an urban family of four is 21 cubic metres per month (Manny 2021). The average water bill for a household is Rs. 300 per month. The conservative estimate of cost recovery for pumped water to households comes to Rs. 171 crores. There is dearth of official data on water consumption by industries including the hospitality industry. Considering the year-on-year increase in tourists and the number of hotels and resorts coming up in the state, commercial and industrial consumption of water could be substantially more than regular household consumption.

It is widely known that the coverage of water meters is not universal; they are faulty and outdated, the bills are neither issued at regular intervals nor are defaulters brought to account. Cost recovery is therefore an area that needs complete overhaul. Water is even more precious than electricity. Cost recovery in respect of power is better than water.

Cruise rides have become popular attractions for tourists and again there is lack of official data on incomes and employment generated by these activities. Water sports too hold huge potential though presently they are mostly restricted to beaches in Goa. Mining activities have begun in the state of Goa, after a gap of six years following the 2018 ban. The Mandovi river provides quick and efficient internal transport for carrying ores to the port. Mining has contributed Rs. 400 Crores in 2016-17 (Financial Express 2018); hence the potential for economic activity is immense. At the peak of mining activities in 2011–12, the sector contributed 16 percent to the state GDP. In 2023–24 tourism's share in the state's income was 16 percent, providing employment to 35% of the population (IBEF 2025).

Conclusion: Adding Up the Value of the River

Considering all the direct, hidden and potential benefits, it would be appropriate to assign a 4 percent weightage to river Mandovi in the state GDP. This

is a very conservative estimate; it could be even 6 to 7 percent. The state GDP in 2023–24 in nominal terms is Rs.1,21,309 Crores (IBEF 2025). The breakup of this assessed 4 percent is as follows:

a) The supply of drinking water to households, commercial establishments and for industrial use, and inland waterways for transporting ores to the port constitutes 1 percent of the state GDP.

b) Casinos operating in Goa are contributing Rs. 400 Crore annually to the state exchequer as stated by the CM Pramod Sawant in the state assembly (New Indian Express 2019). Taking five as a reasonable multiplier, the income and employment generated could be valued at Rs. 2,000 crores. Nearly half the casinos operate on the river Mandovi and are popular tourist attractions. Therefore, 1 percent is the share in the breakup.

c) Agriculture contributes 6 to 7 percent to the state GDP (Government of Goa DPSE 2024a). The Mandovi is the principal source of irrigation in Goa. The total irrigated area is 42,376 hectares; total production is 91,000 tons of food grains (Government of Goa DPSE 2024b).

d) The state's inland fisheries produced 8,651 tons of fish valued at Rs. 195 Crores (Government of Goa DPSE 2024b). Mandovi's share-irrigation and inland fisheries- is placed at another 1 percent share. The hidden values of rivers such as temperature control, flood mitigation, reducing salinity, and preserving soil fertility by carrying sediments combined account for another 1 percent share.

Even a conservative estimate of 4 percent (current value) share in state GDP amounts to approximately Rs. 5,000 Crores. The economic value is at best an estimate. It is not accurate due to data deficit and modelling shortcomings. More sophisticated tools and techniques are evolving as the WWF Report 2018 on valuing rivers mentions (Opperman et al. 2018). These are methods that use AI (Artificial Intelligence) and hydrological models. In any case, it is very difficult to capture and value, using traditional methods, certain intangibles such as rivers' beauty, the pleasing music of flowing waters or the splendour of each sunset and sunrise. A moonlit night on the banks of a river is a delight for anyone, more so for those who have a literary or artistic bent of mind.

It is seen that the state GDP at current prices has shot up from Rs.71,85,334 lakhs in 2018–19 to Rs.1,21,309 Crores in 2023–24.16 (IBEF 2024) It includes two years that were hit by the COVID-19 pandemic; yet the average annual growth comes to 9.7 percent. Since 2024 the increase has been nearly 20 percent and the future too looks promising. Assuming a minimum 10 percent yearly growth, the future value of the river Mandovi is estimated at Rs.12,969

Crores after ten years, and twenty years hence it would be Rs. 30,959 Crores. The figures of these values will go up proportionately if the share in GDP increases from 4 percent to say 7 percent.

Again, this discussion is not about absolute values or their accuracy. Valuation is about re-imagining river systems in a more holistic and comprehensive manner. It is an attempt to measure the size and quantify the asset value. In conclusion, it is apt to quote Dr. Rajendra Singh who won the Stockholm Water Prize, known as the Nobel prize for water, for his water conservation efforts in Rajasthan in 2015. Called the water man of India," Singh says, "every river has three rights, first is the right to land. You can't alter the land that belongs to the river. Second is the right to ecological flow of the river. By damming we are killing rivers. Yes, we need electricity but for that the design of the dam needs to be changed. The third right is to remain separate from sewers..." (Das 2017).

The answer comes from the people involved in the dispute. As Rajendra Kerkar points out, "Trying to resurrect a dying river or transferring water from outside is futile. Neither is it ecologically sound nor is it politically possible when there are fights within villages." Instead, he suggests that governments and communities should protect the catchment areas of their local rivers. This needs to be combined with water-wise agriculture and by selecting cropping patterns that are appropriate for the region's water availability (Lokgariwar 2016).

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