

State of India's Rivers

for
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GOA



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Rivers of Goa

1 Introduction

Goa the twenty fifth state of the Indian Union, is small but picturesque, famous all over the world as “The Tropical Paradise of Tourists”, is located about mid-way on the west coast of India. Ensnconced on the slopes of Western Ghats which skirts its eastern boundary and lapped by the blue expanse of the Arabian Sea in the West, Goa admeasures an area of about 3,702 sqkm situated between Karnataka and Maharashtra, Goa is bounded on the North by the Terekhol river, surrounded on the South and East by Karnataka while on the West is the Arabian sea. This state is divided into two districts, North and South, administered from Panaji, the capital city and Margao, respectively. It is composed of the twelve talukas of Tiwadi, Bardesh, Pernem, Bicholim, Sattari, Ponda, Sanguem, Canacona, Quepem, Salcete, Dharbandora and Marmagoa.

On account of its association with the heroes of Hindu mythology, Goa is believed to have been well known to the rest of the Indian sub-continent and to the outside World since time immemorial by various names like Gopakapattan, Gomant, Govapuri, Gouba, Gove, Gomantak.

Eleven rivers are sustaining the Goan ecosystems. These rivers have sustained the earliest forms of human habitation. The discovery of rare Stone Age carvings in Dhandole in Rivan of Sanguem, Mauxi in Sattari and Cazur in Quepem stand testimony to this. These sites lie on the bank of Kushavati and Zarme rivers. From the period of Satvahanas, Chalukyas of Badami, Bhojas Kshatrapas and Abhiras, Traikutas of Konkan, Kalachuris, Mauryas of Konkan, Shilaharas, Kadambas.... the Goan rivers have encouraged the development of civilization. Goa’s eleven river basins are the important as they have nurtured the unique ecological and cultural heritage of this lush green land.

Terekhol, Mandovi, Baga, Zuari, Colval, Saleri, Mandre, Harmal, Sal, Talpona and Galjibag are the eleven rivers of Goa which are known as the lifelines of the state. Due to the extent of their drainage areas and the human attraction they hold, this main eleven rivers and their 42 tributaries are significant, not only as the source of potable water but they support also the Goan eco-systems. The surface water system of Goa is intimately linked up to their eco-development since they provide irrigational facilities to agriculture, produces biotic and mineral resources, transport ore from the mining areas to the port and ferries men and goods to different parts of the state.

2 Main Rivers of Goa

Of the 11 rivers that Goa region is drained by, nine are prominent ones flowing generally from East (Western Ghats) to West (the Arabian Sea).ⁱ Most of these rivers originate in the Western Ghats but soon lose their energy as they wander through the Midlands and the Coastal plains to discharge into the Arabian Sea. Table-1 gives some details of these rivers. Among these rivers Mandovi and Zuari alone drain 2553 Sq. Km, about 70% of the total geographical area of Goa. In fact according to the recent findings of National Institute for Oceanography during the last glacial period, i.e. 20,000 years ago, both rivers, Mandovi and Zuari, flowed through the rocky terrain as a single river system before branching out separately.ⁱⁱ



Figure 1: Main Rivers of Goa (Base Map Curtsey: Wikipedia)

Out of nine rivers, five originate and flow exclusively within the state boundaries and do not have any interstate implications.ⁱⁱⁱ However, river Terekhol and Chapora originate in Maharashtra state while Mandovi originates in Karnataka. These rivers

form an integral part of Goan life because of their portability, irrigation facilities, agriculture and coastal resources, transportation of mining ores, etc. The rivers in Goa are a major source of potable water.

Table 1: Details of River Basins of Goa			
<i>Source: Master plan for Madei/Mandovi River Basin a report by the panel of expert (2001)</i> http://shodhganga.inflibnet.ac.in/bitstream/10603/8494/11/11_chapter%202.pdf			
Sr. No	Name of the River Basin	Length within the state (Km)	Basin area (Sqkm)
1	Terekhol	26	71
2	Chapora	32	255
3	Baga	10	50
4	Mandovi	52	1580
5	Zuari	145	973
6	Sal	40	301
7	Saleri	11	149
8	Talpona	32	233
9	Galgibag	14	90

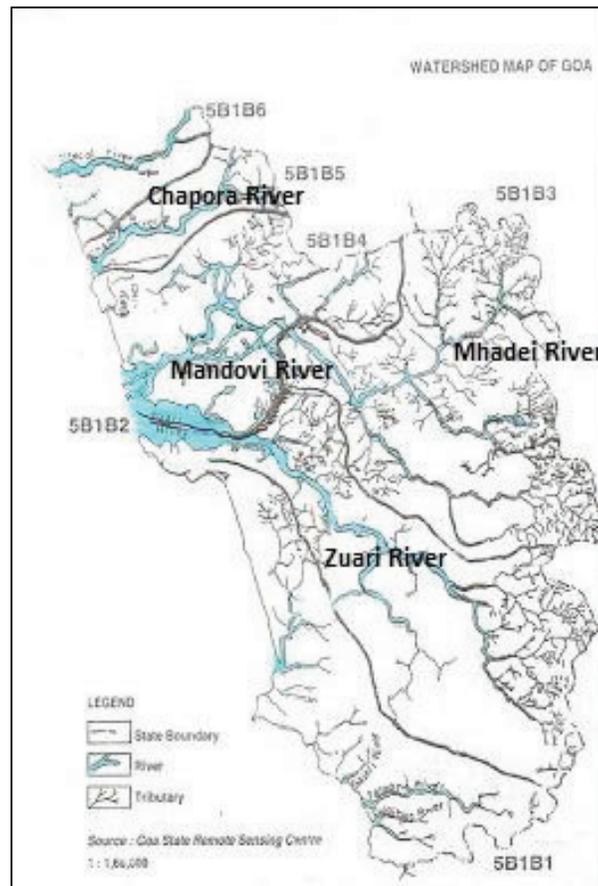


Figure 2: Watersheds of Goa (Source: MAND an Adivasi Activist Group of Goa)

3 Basin boundaries and physiography

Goa being part of the west coast region of India, many of its physical features are common to the neighboring regions of Karnataka and Maharashtra states. But there are some other characteristics of its own which are typical of this state. Goa is basically divided in to three major physiographic divisions^{iv}, namely-

1. The Saihyadries- in the east.

The mountainous region of the Sahyadris that lies in the state occupies an area of about 600 sqkms and an average elevation of around 800 meters above the mean sea level. The range of mountains along the outer periphery of the half-moon formation that Goa forms numerous watersheds in their midst and act as source of water for most of rivers that flow down them through Goan territory. The face of their escarpment is cut through at several places by streams that blossom into waterfalls.

2. The Plateaus- the central portion of Goa plains

The plateaus constitute central portion of Goa and is another physiographic division with heights ranging from a hundred meters (metres) down to thirty meters (100 meters to 30 metres from the mean sea level). These formations are fairly level at the top, but in some, places they are deeply cut into gullies with sharp rivers and escarpments sloping towards the plains below them gradually or abruptly.

3. The Coastal and River Plains of Goa

The state has maximum 105 kilometers of Coastline in length significantly broken up by the large estuaries of the two major rivers and other minor rivers. The river plains or the alluvial lowlands of Goa are the stretches of land bordering the banks of rivers, deposited with the eroded materials washed down by the rivers. River Zuari and Mandovi together constitute one of the most fertile areas in the entire Konkan coast land and provide ideal condition for growth of mangroves.

Most of the rivers are responsible for the creation of estuarine and riverine islands and their ecosystems. There are almost 100 riverine islands that are colonized by vegetation and are not much known since they are in small size and are prone to erosion. Most of these riverine islands are inhabited but have significant patches of vegetation.

4 Climate of Goa

The state is situated within the tropic and surrounded by the Arabian Sea to west and western ghats, rising to an average height of 1000 meters. The east and south region is experiencing tropical and oceanic climate conditions with profound orographic influence. Accordingly, the climate is balanced and moist throughout the year.

The monsoon arrives in the state in the beginning of June and withdraws from early October. 90% of the total rainfall occurs during this season. The rainfall ranges from 3000 to 5000 millimeters annually in different parts of Goa. The coastal belt is receiving 4000 mm rainfall while the Western Ghats receives more than 5000 mm rainfall annually. Northeast monsoon starting from early October to the end of November contributes remaining 10% of the total rainfall. Different parts of Goa receive an occasional rainfall during northeast monsoon which is irregular in times and places.

Winter season in Goa commences from early December to the end of February. On an average temperature ranges from 19°C to 32°C with clear skies.

The summer starts from early March to the end of May. Marked by the absence of winds, the temperatures often reach 40°C by the end of May, which leads to pre-monsoon showers. The percentage of humidity varies from early March to the end of May.

Paradox of high precipitation and low per capita water availability

Draft State Water Policy for Goa drafted in 2015 states that in the State of Goa, despite of a copious annual rainfall, rivers have very low flow for the non-monsoon months resulting in scarcity of drinking water for the period especially in the months of april to start of june. Moreover, the narrow width of the state, steep slopes of western ghats, porous sub-stratum, non-uniform distribution of rainfall over time and space cause temporal imbalances of water availability in the state. This also explains the paradox that though Goa is situated in high precipitation zones, it has one of the lowest per capita fresh water availability.

5 Mandovi River Profile

Mandovi is the major river of Goa. This river earlier was popular by the name Goamati. It is believed that the state of Goa has received the name Gomantak from Gomati as this river had significant place in the life of Goan. As the Mandovi sustains the entire resource- rich Sattari taluka, besides nourishing the ecology of Sanguem, Bicholim, Dharbandora, Tiswadi, Bardez and of Ponda talukas it is known in Karnataka and Sattari as Mhadei meaning the great mother. Indeed, such is the impact influence and importance of Mhadei in the life, culture and economy of Sattari taluka that people consider her indispensable for their existence.



Figure 3: Mahadayi in its upper reaches (Photo: Parineeta Dandekar)

5.1 Salient Features

Mandovi is one of the two important rivers of Goa. It is regarded as the lifeline of the State of Goa as its watershed covers about 42% of the total area of the State resulting in extensive use of its water for drinking and agriculture purposes. It also serves as an important internal navigation route for commercial purpose.

Catchment of Mandovi River lies in Goa and partly in Karnataka making it an interstate river. The Mandovi also called Mahadayi rises at an elevation of 600 m in the main Sahyadris above the Kelil Ghat in a Degao village of Belgaum district of Karnataka state, located on the western fringe of the Karnataka Plateau.

In the upper reaches of the Sattari valley, this river is called the Mhadei (meaning Great Mother) which runs in the North- East direction for about 5 km and then follows in the West ward direction for about 20 kms reaching a point of confluence with the Khandepar river at Bembol (Bicholim) from where it is called Mandovi till it meets the Arabian sea ahead of Panaji. With its cerulean waters, Dudhsagar Falls and Varapoha Falls, it is also known as the Gomati in a few places.

Within Goa State the Mandovi River drains an area of 1,580 sq km., which lies in Tiswadi, Berdez, Bicholim, Sanguem and Ponda Talukas of the State. After originating the river flows for 29 km through Karnataka State before entering Goa from Uttara Kannada District of Karnataka via the Sattari Taluka in Goa State where it flows a length of 52 km and falls into Arabian Sea at the Marmagao Bay near Panjim.

Mandovi joins with the Zuari at a common point at Cabo Aguada, forming the Mormugao harbour. Panaji, the state capital and Old Goa, the former capital of Goa, are both situated on the left bank of the Mandovi.

5.2 Topography of Mandovi Basin

The basin of the Mandovi River extends over all the physiographic divisions of Goa, namely the Coastal plain, the Midland region and the Western Ghats, as well as on the Karnataka plateau. The western part of the basin lies in the Central midland region of Goa, this region consists of elongated hills having elevations below 400m amsl (above mean sea level), the central part of the basin comprises of the Western Ghats and the eastern part of the basin lies in the plateau region of Karnataka.^v

The Mandovi River comprises an intricate system of wetlands, tidal marshy area and cultivated paddy fields.^{vi} The total area of mangroves along this river and the Cumbarjua canal is 900 hectares. Mandovi and the backwaters in the hinterland are governed by regular tides. Like most monsoon-fed rivers, the Mahadayi also undergoes bewildering transformation during her 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. The island of Chorao is home to the Salim Ali Bird Sanctuary, named after the renowned ornithologist Salim Ali.

5.3 Principal Tributaries

After originating in the Khanapur taluka of Belgaum district located on the western fringe of the Karnataka plateau Initially, for some distance it flows due north-east, then takes a turn and flows due south-west. In its upper reaches it is joined by Kotrachi nadi, the Surla nadi and Ragda nadi form some main tributaries of the Mhadei River.^{vii} At Usgao, the Mhadei River is joined by the Khandepar River, the other major tributary. Then onwards it is referred to as the Mandovi River which flows due north-west. At Amona, it is joined by the Valvanti River which has two main tributaries, namely, the Bicholim River and the Kudne River. Further, the Mandovi enters the coastal plains where the river channel bifurcates and re-converges around the Diwar Island. Then, it is joined by the Mapusa River (which has two tributaries namely, the Asnode River and the Moida River) and the Sinqerim River on the coastal plains before it discharges into the Arabian Sea

5.4 Cultural Significance

River Mandovi also called as *Mahadayi* – name implying “the Great Mother Goddess” holds a deep cultural significance to Goa.^{viii} A number of ancient carved images found scattered at Amgaon and Parvada in Khanapur Taluka and Sattari taluka of Goa at Caranzol, Savarde, Kodol, Rivem, Irvem, etc. represents the cult of the Mother Goddess worship on the banks of the Mhadei. Quite a number of 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 dominating cult of the River Goddess in the area. 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', etc. All these sculptures have been found mostly in Sattari taluka at Nadve, Savarde, Dhamashe, Shel-Melawalli, Dhada and Guleli and probably belong to Kadamba period (12th or 13th Century AD).

5.5 Significance for Goa

Mandovi basin is one of the principle watersheds for Goan Rivers. The Mahadayi or Mhadei as it is called in upper reaches is a comparatively minor stream that arises in the Western Ghats. The core catchment area of the river lies in the heavy rainfall, thickly forested, approximately 200 sq km of mountain topography of Khanapur taluka of Karnataka State. For Goa, the fresh water flows from this core catchment area. A very large quantity of water that flows down the Mandovi all the year round originates in the streams and rivulets that spring around this region. Most of Goa's major streams - Tiracol, Chapora, Mandovi, Surla, Ragoda, Khandepar and Galgibag originate just across the border in the Western Ghats of either Maharashtra or Karnataka. Every variation in the Mahadayi water level in these upper reaches is thus crucial for Goa's ecology, forests, wildlife, agriculture, drinking water, fishing and transportation.

In that sense Goa has been at the mercy of its two larger and powerful neighbouring states viz. Maharashtra and Karnataka. Ambitious plans of these states to create large storages or divert waters close to the sources of rivers flowing into Goa have made the State of Goa vulnerable.

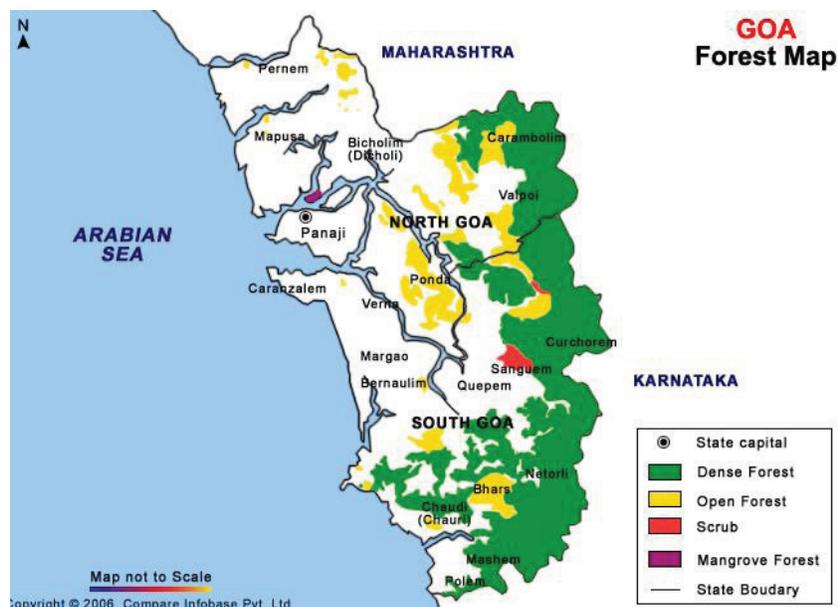


Figure 4: Fresh water flows for Goa are dependent on forests in upper reaches (Photo: Maps of India)

5.6 Biodiversity

Mhadei River which is an important tributary of Mandovi holds a great ecological significance for the state. About 85% of the area of Mhadei watershed is forest and is home for Mhadei Wildlife Sanctuary.

The Mhadei sanctuary formed in 1999, hosts one of the lushest and verdant pockets of the Western Ghats Biodiversity Hotspot. This comparatively new sanctuary area in Goa is located 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. ^{ix}



Figure 5: Mhadei Wildlife Sanctuary, Goa (Source: Sanctuaries India)

This sanctuary is known for the recent spotting of Bengal tigers within its grounds. There is a proposal to make it into a 'Project Tiger' tiger reserve. The area of the sanctuary is thickly forested with moist deciduous vegetation and some evergreen species. The sanctuary is particularly well-known for its sacred groves that protect rare and indigenous trees. There are over a thousand species of flowering plants that are found here including rare and endemic orchids.

Apart from a large number of commonly seen animals like Indian Gaur, Barking deer, civet, wild boar etc. the 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. The Mhadei wildlife sanctuary is also home to a number of amphibians, record

number of butterflies and a large variety of snakes including all of the 'big four' of Indian venomous snakes which are Indian krait, Russell's viper, Saw-scaled viper and Spectacled cobra. Of the 330 butterfly species known to reside in the Western Ghats, 257 have been spotted within the sanctuary.

5.7 Threats to Mandovi Basin

The fragile ecology of Mahadayi Valley has been facing many threats.^x Illegal felling of trees and illegal mining has been going on for decades. Large scale plantation of exotic species (acacia & mangium) has also been damaging the ecology of the area.

Many forest patches in the valley are privately owned. Violating the provisions of Forest (conservation) Act of 1980 which are also applicable to private forest lands many malki lands have been denuded of tree covers and converted to food and cash crops. There are instances of valuable forest lands being sold to unscrupulous elements. Illegal tree felling also continues with a powerful timber lobby. Timber felling also clears the way for manganese mining. Private mining interests are taking advantage of the situation to carry on illegal mining. Tata Energy Research Institute which prepared "Area-wise Environmental Quality Plan" states in its report that "around 21,000 hectares of private and forest land, which accounts for at least 18% of Goa's private and Government forest, has been lost due to mining".

In fact Mandovi is worst affected of the rivers of Goa due to mining. According to Goa University researchers there are 27 major mines within the Mandovi river basin. These mines together generate about 1,01,250 tonnes of rejection per year. According to studies conducted by Dr. Sengupta, from the National Institute of Oceanography, 70000 cu tons of iron particulates get deposited in river Mandovi every year ! With rainfall of more than 120 inches and open cast mining on the hills, huge mountains of mining rejections reach this river, which is getting heavily silted.

The main threat that is now looming over the valley is the Karnataka Government's plans to divert a large quantum of water from the Mahadayi River and its tributaries to the Malaprabha river basin to help the acute water scarcity faced by the region in the Malaprabha basin. The massive diversion of the Mahadayi water from this area will see a quantum drop in the silt flowing down from the denuded mountain ranges from across the border and will result in water flow being reduced to a trickle.

For Karnataka, Mhadei River appears to offer surplus. For Goa, such a diversion implies choking of a lifeline and putting their sustainable riverine based lifestyles at a risk. Mhadei water diversion will adversely affect the traditional practice of Puranichi sheti, a primitive form of agriculture practiced in the flood plain silt of the river which is the source of livelihood for more than 500 households in about 27 villages of the Sattari. It will also create the paucity of water for various lift irrigation schemes supporting the huge plantation of coconut, arecanut, banana and others in Sattari and also for the water treatment plant of Dabos.

Evergreen forest of 700 sq. kms. lying in the districts of Belgaum and North Kanara in Karnataka, Viridi of Maharashtra and partly in Goa; which are home to a large variety of endemic flora and fauna including the tiger will be under immediate threat due to the proposed project of Karnataka.

5.8 Mahadayi Water Dispute

Mahadayi River has been making headlines because of the inter-state water sharing dispute over its water between Karnataka and Goa.

Dispute triggered in 2002 when Karnataka began the work on diversion of Mahadayi waters to Malaprabha River (a tributary of Krishna River). It planned two dams, one each on the Kalasa and the Banduri tributaries of the Mahadayi, to store water to be diverted via canals to the Malaprabha.

Karnataka's dual plan of Hydropower generation and river diversion for irrigation and drinking water included multiple dams like Kotni reservoir, Irti, Bailnadi and two diversion dams planned, Kalasa and Haltar. Total submergence of these dams would be 2915.5 hectares, most of which is not only Forest Land, but also part of Mahadayi Wildlife Sanctuary.^{xi} Karnataka started construction and digging canals at Kalasa Bhanduri, just 1.2 kms from the Mhadei Wildlife Sanctuary without securing any Environment, Forest or Wildlife Clearances. Work came to a halt the same year when in July 2002 Goa made a request under Section 3 of the Inter-State River Water Disputes Act, 1956 for constitution of Mahadayi Tribunal. The two states have been at loggerheads since.

Efforts of Union Water Resources Ministry to facilitate negotiations between two states failed and Goa went ahead to file a suit in the Supreme Court for constitution of the tribunal in September 2006. After a long dragged process of eight years the Mahadayi Water Disputes Tribunal (MWDT) was established in November 2010. The tribunal inspected the Kalsa Banduri project in 2013 MWDT and ordered in 2014 that Karnataka will not utilise waters of Kalsa Bhanduri Project unless final orders are issues. Also that the canal should be plugged and excavated ridge line should be restored.

Karnataka's original application to MWDT sought allocation of 24.15 TMC water from Mahadayi for consumptive use outside the basin and 13. 347 TMC non consumptive use for generating hydropower under Mahadayi HEP project at Kotni Site. Since December 2015 Karnataka has been seeking an interim relief for granting 7 TMC water for drought relief in Malaprabha Command.

Karnataka's argument for demanding 7 TMC is hinged on reduced water inflow of Malaprabha reservoir. It also claimed that while water utilization for Goa till 2051 has been estimated at 94.4 TMC the available yield for Goa is 108.72 TMC. Thus lifting 7

TMC from the surplus 14.32 TMC will not affect Goa's water supply. Karnataka also went ahead to say that '200 TMC go waste to Sea' in Goa.

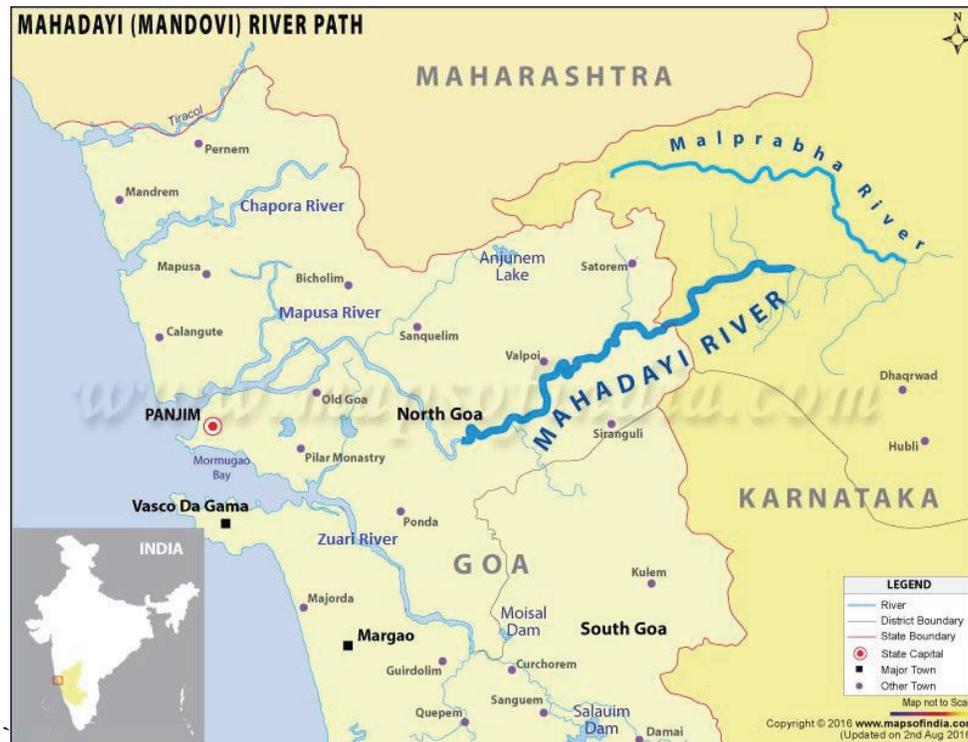


Figure 6: Mahadayi & Malaprabha Basins (Source: <http://www.itsgoa.com/wp-content/uploads/2016/09/mahadayi-river-map.jpg>)

Goa however maintained that the forecasted demand does not include environmental flows for Mahadayi basin which it also claimed is not a surplus basin. It has maintained that water scarcity in Malaprabha basin is attributed to mismanagement of available water. It strengthened its argument pointing to the 1,81,470 ha area under Sugarcane in Malaprabha basin which guzzles 160 TMC water annually and Pepsico plant which is supplied with 4 lakh liters on Malaprabha water every day.

Finally in July 2016 the Tribunal passed Interim Order, rejecting Karnataka's request noting that Karnataka failed to provide in front of the tribunal details of the schemes it proposed, had not secured requisite clearances, and also had not assessed the impact of water diversion on Mahadayi River. This however is only an interim order and dispute is likely to carry on.

Court passed strictures over Karnataka for calling the Mahadayi water reaching sea as 'waste'. In that context what the interim award dated July 17, 2016 of the Mahadayi Tribunal says is educative^{xii}: "Rivers are important for many reasons. One of the most important things they do is to carry large quantity 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 freshwater, 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 some few rivers, all rivers ultimately flow into the sea whether it is Arabian Sea or Bay of Bengal etc. 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 considered to be wastage of water. The plea of wastage of water may become relevant if surplus water is available. As indicated in the earlier part of this order, this tribunal has come to the conclusion that the State of Karnataka has failed to establish at this stage that the surplus water is available at the three points from which the water is sought to be transferred to Malaprabha basin if water available is 108.72 tmc at 75% dependability in the Mahadayi basin. For this reason, it is difficult for the Tribunal to accept the case of Karnataka that water goes into the sea is wastage."

6 Zuari Basin Profile

6.1 Salient Features

The Zuari River is the longest river in the state of Goa, and has second largest basin after Mandovi. Zuari is believed to have been known in the earlier times as the Aghanashini, the destroyer of sun.

The Zuari's source water; lie entirely within the state, with the inter-state boundary almost following the water divide. Referred to as a tidal river, Zuari originates in the Dighi Ghat of the Karnataka part of the Sahyadri Hills and after flowing a zigzag stretch of about 145 km joins the Arabian Sea at Mormugao - Dona Paula point. Zuari basin extending from Netravali to Panjim covers an area of about 975 km² and constitutes about 27 % of the total area of Goa. The basin has forest area of 31.4% and hosts Netravali Wildlife Sanctuary.

Zuari flows in the north-western direction through the talukas of Tiswadi, Ponda, Mormugao, Salcete, Sanguem and Quepem. It has two sub-basins formed by Kushavati and the Gulolil Sanguem rivers both, which have a north-westerly flow.

6.2 Physiography

The river Zuari follows the major NW synclinal axis. Like Mandovi, Zuari basin also extends over all the physiographic divisions of Goa, namely the Coastal plain, the Midland region and the Western Ghats, as well as on the Karnataka plateau. The river valleys are 'V' shaped in the western high hill ranges, but broaden in central midlands and become 'U' shaped in the low lands and coastal plains.^{xiii}

6.3 Netravali Wildlife Sanctuary

Netravali Wildlife Sanctuary (NWS) is located in Sanguem Taluka of South Eastern Goa. It is spread in an area of 211 sqkm and is connected to the Mhadei Wildlife Sanctuary.^{xiv} Together they cover an area of 420 sqkm. The sanctuary is named after the Netravali or Neturli River that originates in the sanctuary. Netravali is a key tributary of River Zuari. Netravali Wildlife Sanctuary is an extremely significant source of fresh water for Goa. The Sanctuary in turn forms a contiguous protected area along with Goa's Mhadei Wildlife Sanctuary; and Karnataka's Bhimgad Wildlife Sanctuary.



Figure 7: Netravali Wildlife Sanctuary (Source: www.govisit.goa.com)

Forests in the sanctuary mostly consist of moist deciduous vegetation interspersed with evergreen and semi-evergreen habitat. The Sanctuary sustains a good mammal population due to its rich habitat and plenty of perennial streams. The wildlife habitat found in Netravali Wildlife Sanctuary consists of Black Panthers, Slender Loris, Great Pied Hornbills, Malabar Giant Squirrels, Hornbills, King Cobras, Gaur Bos Gaurus, Ratus Indica, Four-Horned Antelope or Chousingha Tetracerus Quadricornis, Leopard Panthera and a host of predators and herbivores find home in the sanctuary. The Netravali Sanctuary is also home to many rare birds and butterfly species.

7 Brief River Profiles of other Goan Rivers

7.1 Terekhol

Terekhol is the northernmost river which originates in the Manohargad in the Sahyadris and runs along the border of Goa in a southwesterly direction and then assumes a northwesterly flow before discharging itself into the Arabian Sea. It is about 27.5 kms in the length. Patradevi is the entry point of Terekhol in Goa. Torxe, Khadshi and Pedne are its main tributaries. Except for the historic fort of the Terekhol tract on its right bank, only the left bank portion lies in Goa. Terekhol sustain the traditional livelihood of thousands of people of Pernem. It is also known as the river Aronde.

7.2 Colval

Colval river which is known as Chapora rises above Ramghat at Tudy in Chandgad in Maharashtra and follows a zigzag course, demarcating the border of Pernem, Barde and Bicholim before debouching into the Arabian sea near the historic fort of Chapora. The Colval river enters Goa at Ibrampur village of Pernem. This river is about 32 kms long. Sal, Kalana Virnoda and Parshe are the tributaries of the Colval.

7.3 Sal

Sal which is the important river of the South Goa, rises near Verna and flows parallel to the coast meets the sea at Betul. Navelim and Cuncolim are the two significant tributaries of this river. This river has the length of 35 kms.

7.4 Talpan

Talpan is the important river of Canacona. Originating in the Ambaghat in Canacona, the river runs 31 kms long course. Nadke, Gaondongri Bhatpal and Khalvade are the tributaries of this river.

7.5 Galjibag

Galjibag is one of the important rivers in the South Goa. Two rivers of Canacona namely Mashe and Loliye are the main feeders of Galjibag. It originates in the hilly areas of Uttar Kannada district of Karnataka and enters Canacona near Mule and flows Northwest till Poinguinim for about 15 kms in Canacona. It meets the sea near Mashe.

7.6 Saleri

The Saleri, originates in the forested areas bordering Barcem and Gokuldem villages of Quepem. Flowing for the distance of about 12km, the river joins the Arabian Sea near Devakaran. 4km long the Padi originating from jungle of Padi hill joins the Saleri river

near Pissondi whereas the Agonda joins the Saleri. It has length of 7.5km. The Molore river that starts from Damani with the length of 6km joins the Saleri. Today, increasing agriculture, deforestation and other man-made activities are responsible for threatening very existence of this river.

7.7 Mandre

The Mandre, originates from the jungle of Corgao, passes through various hamlets of Mandre, Corgao, finally unite with the sea after covering 8.75km distance. Today, this river is on the way of extinction as very anthropogenic activities are responsible for threatening it's existence.

7.8 Harmal

The Harmal river originates in the hilly areas of Corgao and flows westward for the distance of 11km before becoming one with the Arabian Sea at Harmal. The haphazard projects undertaken for tourism purpose have adversely affected the natural course of the river.

7.9 Baga

The Baga river is the smallest river of Goa that emerges from the forested areas of Assagao of Bardez. A small stream which comes from the Saligao hill joins the Baga river at Arpora. By flowing for the about 10km, the river joins finally to the Arabian Sea. Since last more than three decades, village of Baga has been witnessing a massive tourism activities. To provide facilities, hotel and restaurants has increased by manifold in Baga and surrounding areas. Garbage disposal and sewerage treatment too, has resulted in polluting the Baga river. Several encroachments have reduced the river to gutter. This river has already on the path of privatization. Some of the private resorts have started boating and cruising facilities for the tourists. These various activities have resulted in seriously destroying the natural drainage of the river.

8 Mandovi and Zuari Estuaries

Rivers, Mandovi and Zuari are joined by Cumbarjua canal near their estuaries giving rise to the largest estuarine complex of Goa which is considered as lifeline of Goa's economy.^{xv} Throughout the course of these rivers an intricate system of wetlands, tidal marshes and cultivated paddy fields interconnected by canals, inland lakes, bays, lagoons and creeks governed by regular tides.

Mandovi and Zuari with the Cumbarjua Canal form the largest estuarine complex of Goa and are considered as lifeline of Goa's economy. Throughout the course of these rivers an intricate system of wetlands, tidal marshes and cultivated paddy fields interconnected by canals, inland lakes, bays, lagoons and creeks governed by regular

tides. A luxuriant growth of mangroves is found bordering the estuaries thereby playing a major role in protecting the coast from heavy wave action and winds.

The total area covered by the estuaries in Goa including the major Mandovi Zuari estuarine complex is approximately 12,000 ha of which the mangrove forest occupy 2000 ha.^{xvi} About 900 ha of mangroves are found along the Zuari estuary, 700 ha along the Mandovi estuary and 200 ha along the Cumbarjua canal.

The Mandovi and Zuari estuarine network along with the Cumbarjua canal is used extensively for transport of goods (mainly iron ore), for fishing, and for dumping domestic and industrial waste. The increase in population and industrial activities in Goa, during the last few decades, has increased the dependence of the state on the said network.

9 Impacts of mining on rivers

Goa's North to South length is 105 km length, of which 95 km, mostly the plateau region comes under mining stretch. The state has the most extensive mining ratio in the country. Ongoing operation of more than 800 mines many of which are located just few meters away from the river banks are causing severe pollution due to mining rejects. River banks dotted with numerous loading points for the mines have been destroying the riparian belt.^{xvii}

Every year the heavy monsoon run off carries the overflow and wash off from the huge quantum of mining rejects into the rivers. These mining rejects along with slime and pumped out turbid water from deep mining pits are then transported further downstream by the rivers. Such polluted river water is very high in total suspended matter and eventually results in loss of estuarine plankton life.

When the river traverses flat terrain, the velocity gets reduced and mining reject which is carried in suspension gets settled in the channel, resulting ultimately in the overflowing of banks and inundation of low-lying areas along the banks. Silt settled in estuarine zone changes the geomorphology of the estuarine bed and results saline water intrusion to the upstream. Study conducted by Dr. G.N.Nayak of Marine Science of Goa University revealed that heavy metals from the mining rejects get concentrated by tidal currents, change the sediments composition and creates havoc in benthic communities of the estuary.

Salaulim dam built on Salaulim River, a tributary of the Zuari River, which supplies drinking water to 55% of Goa's population has more than 15 mining leases in the catchment of its reservoir. River Khandepar, tributary of Mandovi, which is source of drinking water to 30% of Goa's population has 21 mines within its catchment. The siltation problem is acute in the Khandepar river. The silt often chokes the filter beds of the water treatment plant. The Bicholim River that once was navigable has its navigability on account of siltation. The main rivers of Goa, the Mandovi and Zuari are

also heavily polluted due to mining activities. While zuari has 10 operating mines in its catchment Mandovi has 27 mines depositing whopping 70,000 cubic tonnes of iron particulates every year in the Mandovi River.

State Mining Policy of Goa does not acknowledge the impact of the sector on rivers and water bodies and fails to lay guidelines regarding distance of mines from water bodies, sustainable waste disposal, safe transport of ore from rivers, etc.

10 Impacts of Sand Mining in the river beds

The haphazard and the unregulated growth of alluvial sand mining have extracted ill effects on ecology and has already disturbed the river ecosystem. Dr. M.S.Swaminathan's task force on eco-development of Goa in 1982, made recommendations for sustainable exploitation levels and zones for alluvial sand mining in Goa. The Hon. Supreme Court of India too, heavily criticized on the unrestricted, unplanned and illegal sand mining going on in the rivers of Goa and expressed the need of establishing monitoring cells at the district levels to look into the matter of quantum, timing and other aspects. But, in spite of this, excavation of sand since last two decades is going on in haphazard way by increasing the depth of the river. Areas were known for shellfish resources, too lost the wealth as their natural is disturbed. The traditional fishermen have already suffered losses. Government has not designed and implemented mechanism for long term control measures for exercising check on illegal sand mining.



Figure 8: Mining in Goa resulting in severe pollution of water bodies (Photo: The Hindu)

11 River Pollution in Goa

All the eleven main rivers and their 42 tributaries today are facing numerous problems. The Goan Rivers are facing various threats and if steps are not taken appropriately and timely, it will result in the extinction of these water bodies. Due to lack of sustainable eco-hydrological planning, several commercial activities associated these rivers and tributaries like river-traffic, eco-tourism, fisheries and traditional industries are affected badly. An inland commerce that was carried out through their navigable channels too has become history.

As the iron ore is transported by barges through the rivers to the Marmagoa harbour, oil and grease along with mineral ore, pollute adversely these rivers. Ammonium Nitrate used as the explosive for mining, adds nitrates to the river water causing eutrophication. Washing and cleaning of mining trucks done in the rivers and streams also intensifies water pollution. Some of the industries too are responsible for causing water pollution. Though, affected farmers are lodging complaints regarding discharge of untreated waste water into the streams, the concerned authorities are not sincere in restraining the polluters.



Figure 9: pollution on Tourist Beaches of Goa (Photo: goaprism)

Runoff from agricultural fields using chemical fertilizers, pesticides and insecticides are releasing persistent organic pollutants in the river. Throwing of garbage or other waste covered in plastic bags have resulted in clogging of the drains and rivers. Plastic

wastes that enter into the bodies of fishes and other aquatic life too have ill effect on the living beings. In various parts of Goa, there is an annual tradition of immersing the clay idols of gods and goddesses worshipped during the festive occasions into the streams and rivers and this has resulted in polluting water bodies through clay, plaster of Paris and also chemical colours. Although, lead-based paints have been banned, they continue to dominate the market.

Central Pollution Control Board has identified 8 river stretches in Goa which are critically polluted. They include stretches of Mandovi, Assonora, Bicholim, Chapora, Khandepar, Mapusa, Sal and Valvanti rivers are polluted. Details are given in Table-2.

Table 2:Polluted River Stretches of Goa						
Source: Central Pollution Control Board						
http://cpcb.nic.in/upload/Publications/Publication_528_RESTORATION-OF-POLLUTED-RIVER-STRETCHES.pdf						
Sr. No.	River Name	Polluted Stretch	Towns Identified	Approx length of stretch (km)	BOD Range / Max Value	Priority
1	Mandovi	Marcela to Volvoi	Marcela, Volvoi	10	3.9	V
2	Assonora	Assonora to Sirsaim	Assonora	5	7.0	IV
3	Bicholim	Bicholim to Curchirem	Bicholim	6	3.9	V
4	Chapora	Pernem to Morjim	Chikhli, Siolim	18	5.0	V
5	Khandepar	Ponda to Opa	Ponda	10	3.9	V
6	Mapusa	Mapusa to Britona	Mapusa	16	6.2	IV
7	Sal	Khareband to Mobor	Margao	14	3.2-10.6	III
8	Valvant	Sankli- Bicholim to Poreim	Bicholim	5	3.1	V

In the capital city of Goa, the river Mandovi has become attraction for the indigenous and foreign tourists. For gambling, as the floating casino boats are there in Panaji since last few years, polluting the river water as well as social environment. It has been indicated that the untreated waste water, sewage that are released is responsible for increasing pollution of the river water.

Since 2013, Southern River Adventure Sports Pvt. Ltd. under John Pollard in association with Goa Tourism Development Corporation has introduced white water rafting in the Mhadei River from Uste to Sonal of Sattari. It is necessary to regulate such tourism activities introduced in hinterland of Goa so that the river does not become victim of the pollution.

12 Dams in Goa

National Register of Large Dams maintained by Central Water Commission lists five dams in Goa. The details are as follows-

Table 3: Details of Dams in Goa							
Source: Central Water Commission							
http://www.cwc.nic.in/main/downloads/new%20nrld.pdf							
Sr. No.	Dam Name	Completion Year	River	District	Height (m)	Length (m)	Status
1	Amthane Dam	1988	Amthane Nallah (Mandovi Basin)	North Goa	29.4	450	Completed
2	Anjunam Dam	1989	Mandovi	North Goa	42.8	185.2	Completed
3	Panchwadi	1986	Zuari	South Goa	20	230	Completed
4	Chapoli Dam	2000	Chapoli Nallah	South Goa	25.5	760	Completed
5	Salaulim Dam	2000	Sanguem	South Goa	42.5	1004	Completed

13 Proposed 'nationalization' of Goan Rivers

The Inland Waterways Authority of India (IWAI) of Union Ministry for Shipping has identified six rivers of Goa as national waterways and has proposed "nationalisation" of these rivers under the National Waterways Act enacted in March 2016. Goa's six rivers are included in the schedule of 111 national waterways. The purpose primarily is to develop waterways.

The pact is to be sealed between the Governments of Goa, India and Mormugao Port Trust (MPT) as a logistic partner.^{xviii} Goa will decide on river developments while central government will call the shots on finance and planning.

The Central government has already notified six rivers of Goa as national waterways.^{xix}

In September, 2016, IWAI signed a memorandum with Dredging Corporation of India and MPT to accelerate the development of Inland Water Transport. 41 km length of the Mandovi, 50 km of Zuari, 33 km of Chapora, 17 km of Cumbharjua canal, 27 km of Mapusa and 14 km of Sal have been notified as national waterways.

Thus total 182-Km river stretches in Goa will be subjected to dredging, river training works, concretization of banks, and construction of navigation aids such as light houses, jetties etc. However, this move has been opposed as it would adversely hit marine environment and the livelihood of the fishing community and the rights of Goa over all these six rivers. Locals have alleged that the nationalisation has been

happening to help the coal importing firms to use the inland waterways, and not to promote the use of rivers for transportation.

14 Need for river conservation policy

In the times of worsening inter-state water disputes, increased ill effects of mining, growing tourism and associated pollution; rivers of Goa need to be protected on priority. Need of the hour is for the state to have a comprehensive river conservation policy and also to make the best use of the available surface water resources. As the rivers are the main source of the fresh water, the state has to plan a strategy to conserve and protect the unique ecological, cultural heritage of Goa's river basins and the sustainable economic activities dependent upon them and their life support systems. Various illegal and detrimental activities in the riverine areas are increasing.

Though, all the rivers flowing in Goa are small in size, they are a source of life and livelihood and there is urgent need to draw a visionary plan for sustainable use of the river in the development of locals by creating independent basin management cell for each river for looking into protection and conservation of the water resources. From source to mouth, river is a living entity and that is why a master plan drawn should focus on the sustainable development with the utmost respect to environment ecology and wildlife. In July 1997, the Goa River Conservation Network (GORICON) was established under the initiative of Nandkumar Kamat with Rajendra Kerkar as the state organizer to empower the riverine people to fight for their traditional, ecological, cultural, social and economic rights and for the sustainable use of the biotic and abiotic resources. GORICON has planned to survey, identify, document hot spots of aquatic pollutions initiate appropriate and timely action at community and governmental level to prevent and control the same. GORICON, is an initiative of riverine people of Goa to prepare peoples master plan for conservation and sustainable and utilization of the riverine resources. As Goa's Water Security is relied on these rivers and tributaries, there is urgent need to a well-planned strategy for protecting them for present and posterity.

This report has been jointly prepared by Shri Rajendra P. Kerkar, Amruta Pradhan (SANDRP) and Parineeta Dandekar (SANDRP)

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End Notes:

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