State of India's Rivers

for

India Rivers Week, 2016

KARNATAKA

Author

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Contents

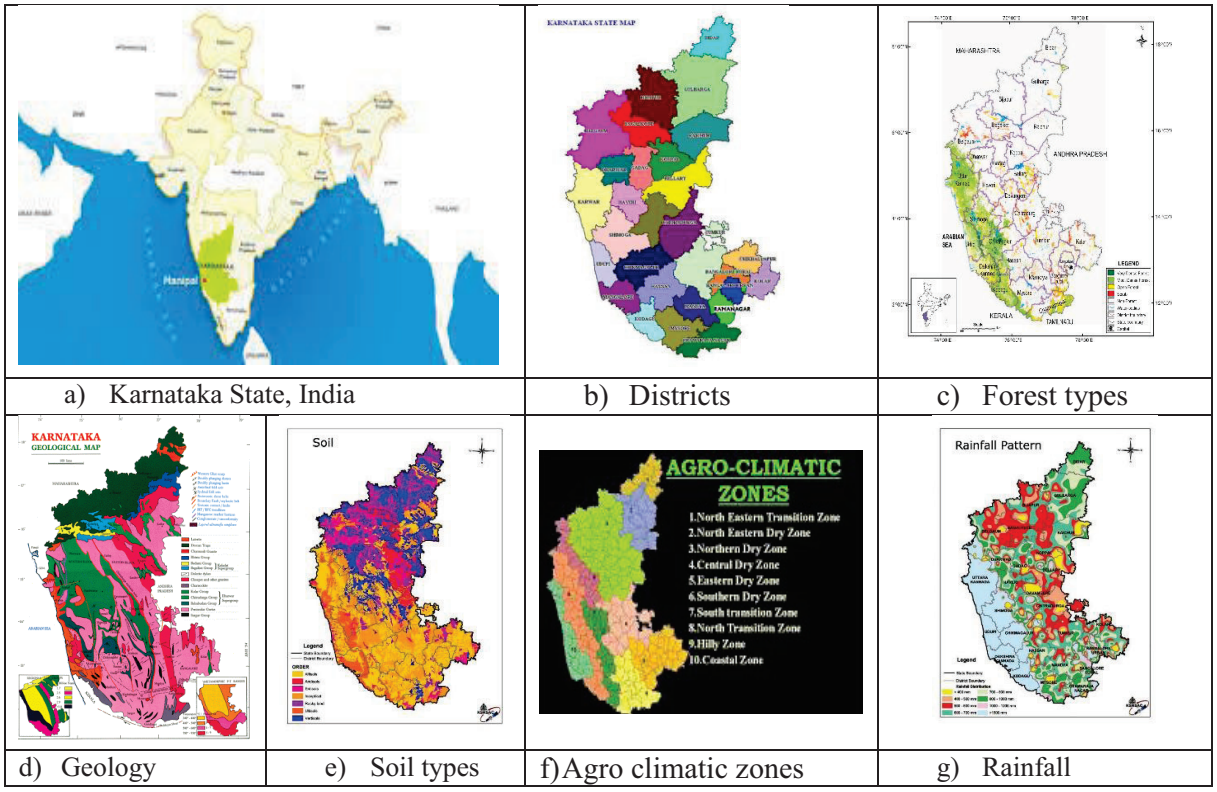
INTRODUCTION

1. STATE PROFILE:

1.1 Geography and Demography:

Karnataka is one of the four southern states of Peninsular India (Figure 1a), came into existence with the passage of the States Reorganisation Act (1956, Nov 1), with the incorporation of districts under the dominion of Bombay, Hyderabad, Madras State and Coorg within the existing state of Mysore State.Karnataka State is located 11°30' North and 18°30' North latitudes and 74° East and 78°30' East longitude (https://en.wikipedia.org/wiki/Geography_of_Karnataka). The state covers an area of 191,976 km² (5.83% of India's geographical area). Karnataka is the eighth largest Indian state by area, the ninth largest by population and comprises 30 districts (figure 1b) divided in to 4 administrative divisions, 270 towns and 29406 villages (http://ssakarnataka.gov.in/). The state is situated on a tableland where the Western and Eastern Ghats ranges converge into the complex, in the western part of the Deccan Peninsular region of India.Karnataka is bordered by the Arabian Sea to the west, Goa to the northwest, Maharashtra to the north, Andhra Pradesh to the east, Tamilnadu to the southeast, and Kerala to the southwest. Table 1 provides the details of population, forest types, climate, etc.

Figure 1: Karnataka State, India with districts and forest types



a) Karnataka State, India | b) Districts | c) Forest types

d) Geology | e) Soil types | f) Agro climatic zones | g) Rainfall

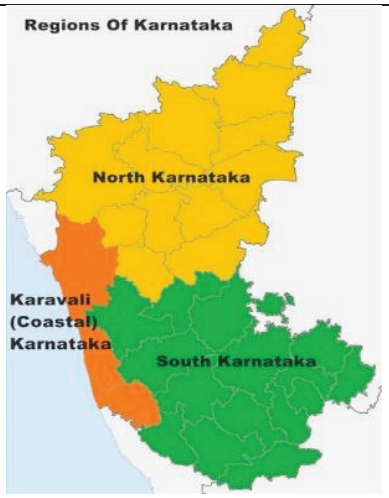
TABLE 1: Profile of Karnataka State

State	Karnataka
Capital	Bangalore
Area	1,91,791 sq. Km (eighth largest state in India); Districts: 30; Taluks: 220; Villages: 29406; Towns: 270
Length	760 Km. (north -south)
Breadth	420 Km. (east-west)
Physiography	Karavali, the Coastal Plain; Sahyadris, the Western Ghats; Malnad, the Transitional Belt; the Southern Plateau; the Northern Plateau; the Eastern Ghats (http://*www.karnataka.com/profile/physiography)*
Forest types (Figure 1c)	Tropical Evergreen, Tropical Semi-evergreen, Dry Deciduous (Malnad), Dry Deciduous(Plateau), Shrub (http://wgbis.ces.iisc.ernet.in/biodiversity)
Vegetation types	Wide variety of vegetation formations, ranging from coastal land plants to montane flora of the Western Ghats, four-storied tropical evergreen monsoon forests to arid thorn and scrub. A large chunk of the vegetation of the state is embedded in the sprawling Western Ghats that is also the home to an overwhelming number of plant species with immeasurable biological diversity and a wealth of intricate adaptations. Indeed, a majority of plant species of the Indian subcontinent are represented in the forests of the Western Ghats and account for probably 75% of the state's plant wealth (http://florakarnataka.ces.iisc.ac.in/hjcb2/karnataka.php).
Geology (Figure 1d)	Four main types of geological formations are: (i) *The Archean complex made up of Dharwad schists and granitic gneisses*: These cover around 60% of the area of the state and consist of gneisses, granites and charnockite rocks. Some of the minerals found in this region are dolomite, limestone, gabbro, quartzite, pyroxenite, manganese and iron ores and metabasalt, (ii) *The Proterozoic non-fossiliferous sedimentary formations of the Kaladgi and Bhima series*: The Kaladgi series has horizontal rocks that run for 160 km in the districts of Belgaum, Raichur, Dharwad and Bijapur districts. The Bhima series that is present on either side of the Bhima River consists of rocks containing sandstone, limestone and shale and this is present in the Gulbarga and Bijapur districts, (iii) *The Deccan trappean and intertrappean deposits*: This is a part of the Deccan traps which were formed by the accumulation of basaltic lava. This is made up of greyish to black augite-basalt, and (iv) *The tertiary and recent laterites and alluvial deposits*: Laterite capping are found over the Deccan Traps and were formed after the cessation of volcanic activity in the early tertiary period. These are found in many districts in the Deccan plateau and also in the coast (http://www.portal.gsi.gov.in).

Soil types (Figure 1e)	Soil cane be grouped into 9 categories: red sandy soils, red loamy soils, shallow black soils, medium black soils, deep black soils, mixed red and black soils, laterite soils, laterite gravelly soils and coastal alluvium (http://www.nbsslup.in)
Soil order	Alfisols, Andisols, Aridisols, Entisols, Histosols, Inceptisols, Mollisols, Oxisols, Spodosols,Ultisols, Vertisols (http://www.nbsslup.in)
Agro-climatic zones (Fig 1f)	**Ten agro climatic zones in Karnataka** (http://raitamitra.kar.nic.in) are: **(i). North Eastern Transition Zone [**Bidar (5) & Gulbarga (2)], **(ii). North Eastern Dry Zone [**Gulbarga (5) Yadgir (3) & Raichur (3)], **(iii). Northern Dry Zone [**Koppal (4), Gadag (4), Dharwad (1), Belgaum (5), Bijapur (5), Bagalkot (6), Bellary (7), Davangere (1), Raichur (2)], **(iv). Central Dry Zone** [Chitradurga (6), Davangere (3), Tumkur (6), Chickmagalur (1), Hassan (1)], **(v). Eastern Dry Zone [**Bangalore Rural (4 taluks), Ramanagar (4) Bangalore Urban (3), Kolar (5), Chikkaballpur (6) Tumkur (2)], **(vi). Southern Dry Zone [**Mysore (4), Chamarajnagar(4), Mandya (7), Tumkur (2), Hassan (2)], **(vii).Southern Transition Zone [**Hassan (4), Chickmagalur (1), Shimoga (3), Mysore (3), Davanagere (2)], **(viii). Northern Transition Zone [**Belgaum (4), Dharwad (3), Haveri (6), Gadag (1)], **(ix). Hilly Zone [**U.Kannada (6), Belgaum (1), Dharwad (1), Haveri (1), Shimoga (4), Chickmangalur (5), Kodagu (3), Hassan (1)], **(x). Coastal Zone [**Udupi (3), Dakshina Kannada (5), Uttara Kannada (5 taluks)
Climate	Semi-tropical (http://www.karnataka.com/profile/karnataka-climate/)
Seasons	Summer - March to May (18° C to 40° C); Winter -Oct to Dec (14° C to 32° C); South-West Monsoon: June to August; North-East Monsoon October to December (http://www.karnataka.com/profile/karnataka-climate/)
Rainfall (Figure 1g)	500 mm to over 4000 mm. Agumbe in the Central Western Ghats receives the second heaviest annual rainfall (7600 mm) in India (http://www.karnataka.com/profile/karnataka-climate/)
Population	611.31 (approx) (2011), 968 females per 1000 males (http://censuskarnataka.gov.in)
Population density:	Top three districts in density of population per sq km are Bangalore Urban (4,378), Dakshina Kannada (457), Bangalore Rural (431) and lowest density districts are Chickmagalur (158), Uttara Kannada (140) and Kodagu (135). (http://censuskarnataka.gov.in) Population density in other districts is: Mysore (441), Dharwad (434), Kolar (384), Mandya (365), Belgaum (356), Haveri (331), Davangere (329), Bidar (312), Udupi (304), Ramanagaram (303), Chickballapur (298), Bagalkot (288), Hassan (261), Tumkur (253), Koppal (250), Gulbarga (233), Gadag (229), Raichur (228), Yadgir

	(224), Bijapur (207), Shimoga (207), Chamarajangar (200) and Chitradurga (197) (http://censuskarnataka.gov.in)
Literacy	75.60 % (female literacy: 68.13%; male literacy 82.85%) (http://censuskarnataka.gov.in)
Traditional Products	Coffee, silk, sandalwood, agarbathis, ivory carvings, etc.
Major Crops	Ragi, jowar, rice; sugarcane, coconut, groundnuts; coffee; cotton (http:// *raitamitra.kar.nic.in/agriprofile/table10.htm*)
Major Minerals	Gold (90% of India's production), iron ore, manganese, bauxite (http:// http://www.karnataka.com/profile/mineral-resource/)
Roads	Total length of roads: 1,22,489 kms; National Highways: 2,357 kms; State Highways: 28,311 kms; Major District roads: 2,090 kms
Languages	Kannada, Telugu, Tamil, Urdu, Marathi, Tulu, Kodagu, Konkani, Hindi
River systems	Karnataka has seven river systems and their tributaries flowing through the state. The river systems of Karnataka are: Cauvery, Godavari, Krishna, North Pennar, South Pennar, Palar, The West Flowing Rivers. Karnataka has 26 east flowing rivers and 10 west flowing rivers. The west flowing rivers of Karnataka provide 60% of the state's inland water resources. (http://www.karnataka.com/rivers/)

a) **Physiographic features:** The state can be divided into four physiographic landforms – (i) the Northern Karnataka Plateau, (ii) the Central Karnataka Plateau, (iii) the Southern Karnataka Plateau and (iv) the Coastal Karnataka Region.



(i) **Northern Karnataka Plateau:** This region is mainly composed of the Deccan trap and covers the districts of Belgaum, Bidar, Bijapur and Gulbarga. It represents an extensive deforested plateau landscape. The Northern Karnataka Plateau has an elevation of 300 m to 600 m asl. The plateau slopes towards the east. The landscape is mainly covered with rich black cotton soils. The vast expanse of treeless plateau is interspersed with river plains, watersheds, residual hills and ridges. The river plains are represented by those of River Bhima, River Ghataprabha, River Krishna and River Malaprabha.

(ii) **Karnataka Coastal Region:** The coastal belt starts from the Western Ghats in the west and extends till the edge of the Karnataka Plateau in the east and includes Uttara Kannada, Udupi and Dakshina Kannada districts. The terrain consists of rivers, creeks, waterfalls, ranges of hills and peaks. This

region can be divided into two main geographical divisions, known as the Western Ghats and the plains. The coastal belt has an average width of 50 km to 80 km and covers a distance of around 267 km from north to south.

(iii) **Central Karnataka Plateau:** This region is located between the Northern Karnataka Plateau and the Southern Karnataka Plateau and consists of districts like Bellary, Chikmagalur, Chitradurga, Dharwad, Raichur and Shimoga. The elevation varies between 450 m to 700 m asl and slope towards the east. This region is the location of the Tungabhadra River basin.

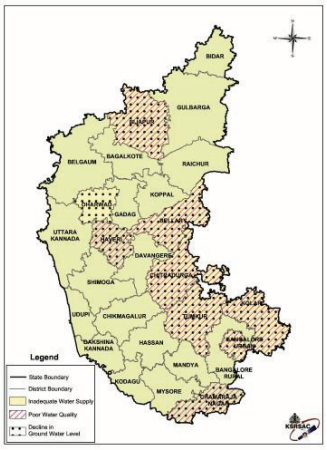
(iv) **Southern Karnataka Plateau:** This region is covered by a high degree of slope and encircled by the Western Ghats on the west and the south. Southern plateau includes the districts of Bangalore Urban, Bangalore Rural, Hassan, Kodagu, Kolar, Mandya, Mysore and Tumkur.. The Southern Karnataka Plateau has a general elevation of 600 m to 900 m asl, except Biligirirangan hills (of Mysore district) and Brahmagiri range (of Kodagu district) have elevation ranging between 1,500 m to 1,750 m. The Cauvery River basin forms a significant part of this plateau.

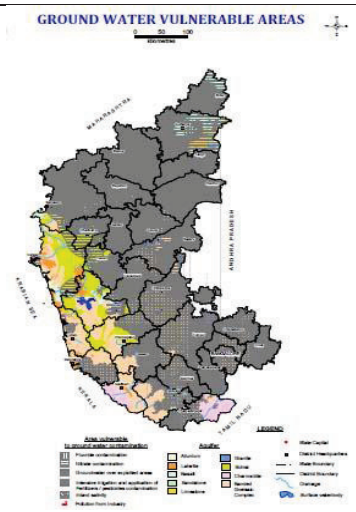
b) **Hydrogeology:** The state is covered by peninsular gneisses, granites, schists, and basalts along with sedimentaries of Kaldagi and Bhima groups. The recent alluvium is restricted to coastal areas and stream courses. The water bearing and yield characteristics in hard rock are primarily controlled by the extent of weathering and fracturing. In limestone areas, solution cavities impart secondary porosity. The yield of tube wells tapping hard rocks is as high as 50 m^3/hr. The tube wells in sedimentaries can yield up to 15 m^3/hr

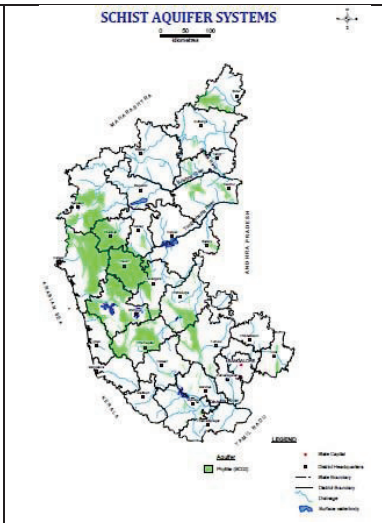
(http://cgwb.gov.in/gw_profiles/st_karnataka.html).

Dynamic Ground Water Resources	
Annual replenishable Ground water Resource	15.93 BCM
Net Annual Ground Water Availability	15.30 BCM
Annual Ground Water Draft	10.71 BCM
Stage of Ground Water Development	70 %
Ground Water Development & Management	
Over Exploited	65 talukas
Critical	3 talukas
Semi- critical	14 talukas
Artificial Recharge to Ground Water (AR)	▪ Area identified for AR: 36710 sq km ▪ Quantity of Surface Water to be Recharged: 2065 MCM
Ground Water Quality Problems	
Contaminants	**Districts affected (in part)**
Salinity (EC > 3000 µS/cm at	Bagalkot, Belgaun, Bellary, Davangiri,Gadag, Gulburga, Raichur

25 ° C)	
Fluoride (>1.5 mg/l)	Bagalkot, Bangalore, Belgaun, Bellary, Bidar, Bijapur, Chamarajanagara, Chikmagalur, Chitradurga, Davanagere, Dharwad, Gadag, Gulburga, Haveri, Kolar, Koppala, Mandya, Mysore, Raichur, Tumkur
Chloride (> 1000 mg/l)	Bagalkot, Belgaum, Gadag, Dharwar
Iron (>1.0 mg/l)	Bagalkot, Bangalore, Belgaum, Bellary, Bidar, Bijapur, Chikmagalur, Chitradurga, Dakshina Kannada, Davanagere, Gulburga, Hasan, Haveri, Kodagu, Kolar, Koppala, Mysore, Raichur, Shimoga, Tumkur, Udupi, Uttar Kannada
Nitrate (>45 mg/l)	Bagalkot, , Bangalore, Belgaum, Bellary, Bidar, Bijapur, Chamarajanagara, Chikmagalur, Chitradurga, Davanagere, Dharwad, Gadag, Gulburga, Hassan, Haveri, Kodagu, Kolar, Koppala, Mandya, Mysore, Raichur. Shimoga, Udupi, Uttar Kannada





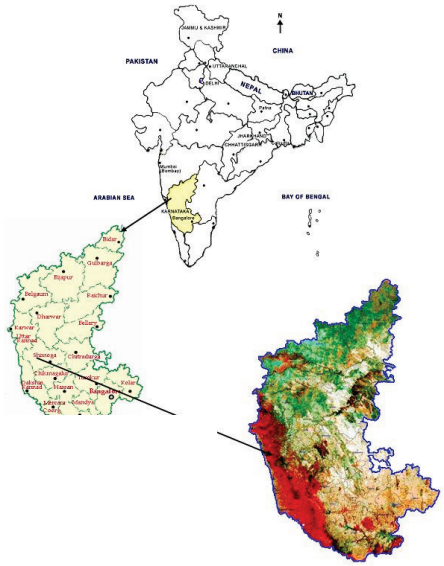


Groundwater quality	Groundwater Vulnerable area	Schist Aquifers

Enactment of Ground Water Bill to regulate and control the development of ground water (http://www.groundwaters.in/regulations): Government of Karnataka came up with a new regulation for groundwater in 2009. 2009 bill is a significant shift from 1999 act which was focused solely on drinking water protection. 2009 bill emphasizes on regulation and control of groundwater development and management. This 2009 bill was later passed as an act in 2011 and came to be recognized as Karnataka Groundwater regulations and control of development and management act, 2011. Highlights of this act includes (i) restriction and regulation of extraction of groundwater in the notified area; (ii) Specification of the minimum distance between the bore wells dug for the purpose of irrigation; (iii) Registration of existing and new borewells with the authority within 120 days of formation of authority; (iv) Declaration by

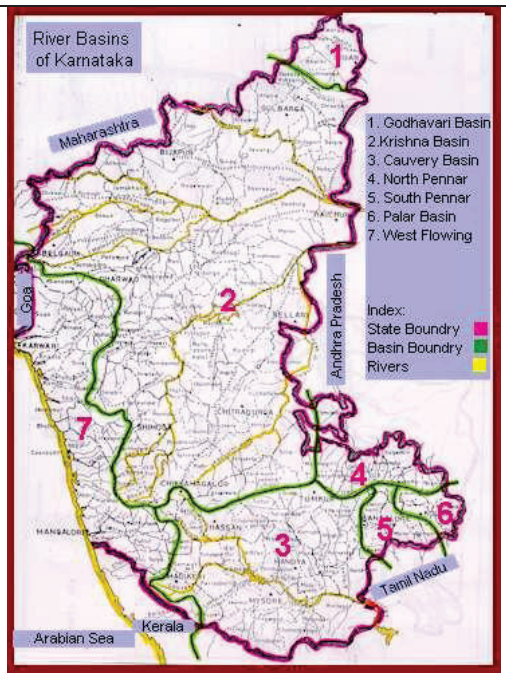
notification any areas as drought hit areas; etc.

C) River Systems of Karnataka:



The rivers are a source of water for drinking, irrigation and electricity generation in Karnataka. Most of the rivers originate in the Western Ghats that generally flow westward meet the Arabian Sea after a short run varying from 50 kilometres to 300 kilometers (http://waterresources.kar.nic.in/river_systems.htm#map).

These rivers are very steep in the upper reaches and fairly steep in the middle reaches. Near the sea, they have relatively flat gradients and a mild flood plain. Almost all the major east-flowing rivers are inter-state rivers and runs towards the eastern side of the state and drain towards the Bay of Bengal.



River basins: 1: Godavari, 2: Krishns, 3: Cauvery, 4: North Pennar, 5: South Pennar, 6: Palar, 7: West flowing rivers

There are seven river systems in Karnataka.

No.	River System	Drainage Area	
		1000 Sq. km	%
	East Flowing Rivers		
1.	Godavari	4.41	2.31
2.	Krishna	113.29	59.48
3.	Cauvery	34.27	17.99
4.	North Pennar	6.94	3.64
5.	South Pennar	4.37	2.29
6.	Palar	2.97	1.56
7.	**West Flowing Rivers**	24.25	12.73
	Total	**190.50**	**100**

Rivers	**Drainage area**	
	1000 sq.km.	**%**
East Flowing rivers (1 to 6)	166.25	12.73
West Flowing rivers	24.25	87.27
Total	190.5	

i). East-flowing Rivers: Major east flowing rivers in the state are Cauvery (or Kaveri), Krishna, Manjra, North Pennar and Palar

- **Cauvery (or Kaveri**) is the largest river in the state and originates at Talakaveri in Coorg. It is often called the Dakshina Ganga (the Ganges of the South) and considered one of the sacred rivers of India. the origin of the River Kaveri, is a famous pilgrimage and tourist spot set amidst Bramahagiri Hills near Madikeri in Coorg. The tributaries of the Kaveri include: Harangi, Hemavathi (origin in western Ghats joins the river Kaveri near Krishnarajasagar), Lakshmanatirtha, Kabini (originates in Kerala and flows eastward and joins the Kaveri at Tirumakudal, Narasipur), Shimsha, Arkavati, Suvarnavathi or Honnuholé, Bhavani, Lokapavani, Noyyal, Amaravati

- **Krishna** is second largest river in peninsular India, rises in the Western Ghats at an altitude of 1337 m. near Mahabaleshwar in Maharashtra State. It flows across the whole width of the peninsula, from west to east, for a length of about 1400 km, through Maharashtra (catchment area: 69,425 sq.km), Karnataka (113,271 sq.km) and Andhra Pradesh (76,251 sq.km). The entire catchment area of Krishna basin is 2,58,948 sq km. including the three major basin states (Maharastra (26.81%), Karnataka (43.74%) and Andhra Pradesh(29.45%)). It originates in Maharashtra and passes through Karnataka. The principal tributaries of the Krishna in Karnataka are: Ghataprabha (Origin in the Western Ghats and flows eastwards and joins the river Krishna. The river forms the well-known Gokak Falls in Belgaum District), Malaprabha (origin in Western Ghats and flows first in easterly and north-easterly directions and joins river Krishna at Kudalasangama), Bhima (originates in the forest of Bhimashankar in Pune, and flows through the states of Maharashtra and Karnataka and joins Krishna near Kudlu in Raichur taluk and Tungabhadra (formed in the district of Shimoga, by the union of the Tunga and the Bhadra rivers. The river Tungabhadra flows east across the Deccan Plateau and join river Krishna in Andhra Pradesh). Details of the principal tributaries of Krishna in Karnataka are Ghataprabha, Malaprabha, Bhima and Tungabhadra and details (catchment area, altitude, length) are given below:

Sl. No.	Name of the tributary	Catchment Sq.kms	Origin , Altitude & Length	Sub-tributaries	Name of the state
1	Ghataprabha	8829	Western Ghats, 884 m, 283 kms	Hiranyakeshi, Markandeya	Maharshatra, Karnataka
2	Malaprabha	11549	Western Ghats, 792.48 m, 306 kms	Bennihalla, Hirehalla, Tas nadi	Karnataka
3	Bhima	70,614	Western Ghats, 945 m, 861 kms	Combined waters of Mula and Mutha Ghod,	Maharastra, Karnataka

				Nira,Sina	
4	Tungabhadra	47,866	Western Ghats at Gangamula, 1198 m, 531 kms	Combined waters of Tunga and Bhadra, Varada, Hagari (vedavathy)	Karnataka & Andhra Pradesh

- **Manjra**, a tributary of the river Godavari, originates in the Bala Ghat range in Karnataka. Details of Manjra River with catchment details is given below.

Sl. No.	Tributary	Catchment area in Sq.kms.	Origin , Altitude	Sub-tributaries	state
1	Manjra (tributary of Godavari)	15,667 Sq.kms Maharastra, 4,406 Sq.kms -Karnataka, 10,772 Sq.kms -Andhra Pradesh	Bala Ghat range of hills, 823m	Tirina,Karanja, Haldi,Lendi & Mannar	Maharastra, Karnataka & Andhra Pradesh

- **North Pennar** or the Uttara Pinakini and the South Pennar originate in Nandi hills of Kolar district. Details of catchment extent, origin and length are given below.

Name of the tributary	Catchment area in Sq.kms.	Origin , Length	Sub-tributaries	State
Uttara Pinakini (North Pennar River)	6937	Nandi hills of Kolar, 597km	Jayamangali, Kumadavathy, Chitravathy and Papagni	Karnataka, Andhra Pradesh

- **Palar** begins in Talagavara in Kolar district and runs through Karnataka, Andhra Pradesh and Tamilnadu.

l. No.	Name of the tributary	Catchment area in Sq.kms	Origin	Sub-tributaries	Name of the state
1	South Pennar	4370	Nandi hills of Kolar	-	Karnataka, Tamil Nadu

ii). **West-flowing Rivers in Karnataka:** The Western Ghats provides a principal geographical barrier in the path of the Arabian Sea branch of the Southwest monsoon, and is principally responsible for the heavy rainfall over the western coastal belt. The Southwest monsoon season (June to September) is the principal rainy season, over 90 % of annual rainfall is realised in this period.

The rivers in the Western Ghats region generally originate at an elevation ranging from 400 meters to 1,600 meters above the mean sea level, close to the Western Ghats ridge. The rivers generally flow westward and meet the Arabian Sea after a short run varying from 50 kms to 300 kms. These rivers are very steep in the upper reaches and fairly steep in the middle reaches and relatively flat gradients near the Sea. Major West flowing rivers are Mandavi, Kali, Bedthi (or Gangavali), Aghnashini, Sharavathi and Vekatapura. The other west-flowing rivers, which run through Karnataka, are the Chakra Nadi, the Varahi, the Netravathy, and the Barapole.

- **Mandavi** originates in the Western Ghats in Belgaum and flows through Karnataka and Goa.
- **Kalinadi** originates in Bidi village in the Western Ghats.
- **Gangavalli** starts in the Western Ghats south of Dharwad.
- **Aghanashini** begins in the Western Ghats near Sirsi.
- **Sharavathi** originates at Ambuthirtha in Thirthahalli Taluk, flows north-west through the Western Ghats. It forms the famous Jog Falls before joining the Arabian Sea at Honavara.

Details of the west flowing rivers, their important tributaries are given below:

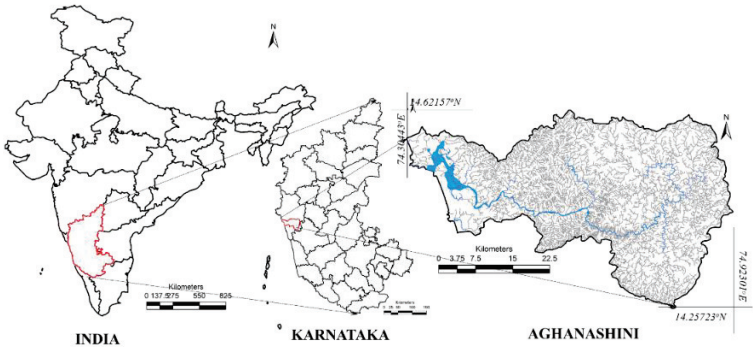
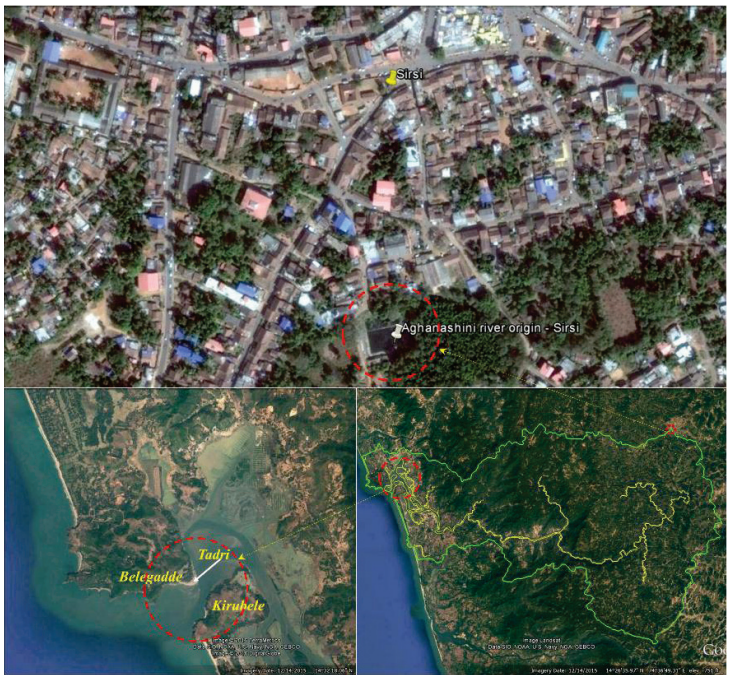
Sl.No.	Name of the tributary	Catchment area in Sq.kms.	Origin , Altitude & Length	Sub-tributaries	Name of the state
1	Mahadayi/ Mandavi	2,032	Western Ghats, Belgaum district, 600 m 87 kms.	Maderi	Karnataka, Goa
2	Kalinadi	4,188	Western Ghats, Bidi village, 600 m, 153 kms.	Pandhari, Tatti-halla and Nagi	Karnataka
3	Gangavalli (Bedthi)	3,574	Western Ghats south Of Dharwad 700 m, 152 kms.	-	Karnataka
4	Aghanashini (Tadri)	1,330	Western Ghats Near Sirsi, 500 m 84 kms.	-	Karnataka
5	Sharavathi	3,592	Westren Ghats Ambutirtha in Shimoga district, 700 m, 128 kms.	-	Karnataka

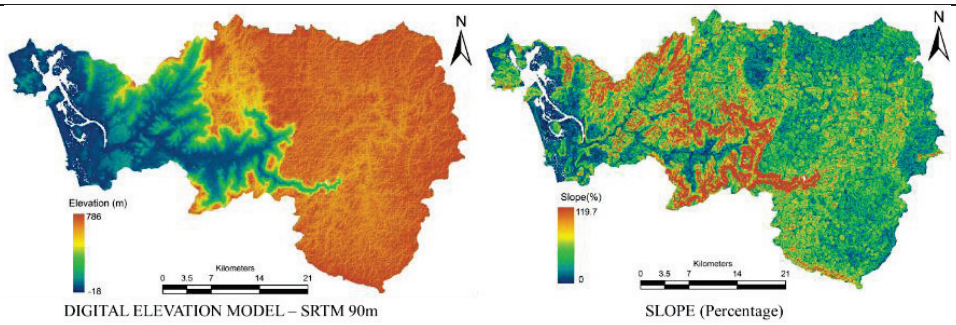
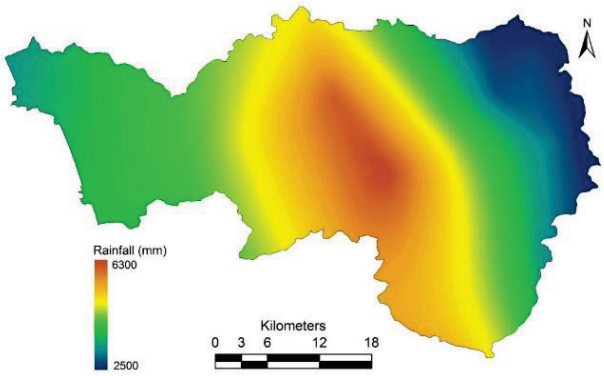
6	Chakra Nadi	336	East of Kodachadri in Shimoga district, 600 m, 52 kms.	Kollur	Karnataka
7	Varahi (Haladi)	759	Kavaledur-ga in the Shimoga district, 600 m, 66 kms	-	Karnataka
8	Netravathy	3,222	Bellarayan-a Durga in the Dakshina Kannada, 1,000 m, 103 kms	Gundiahole, Kumaradara and Shisiahole.	Karnataka
9	Barapole (Valapattanam)	1,867	Brahamagiri Ghat Reserve Forest in Coorg, 900 m, 110 kms	-	Karnataka & Kerala

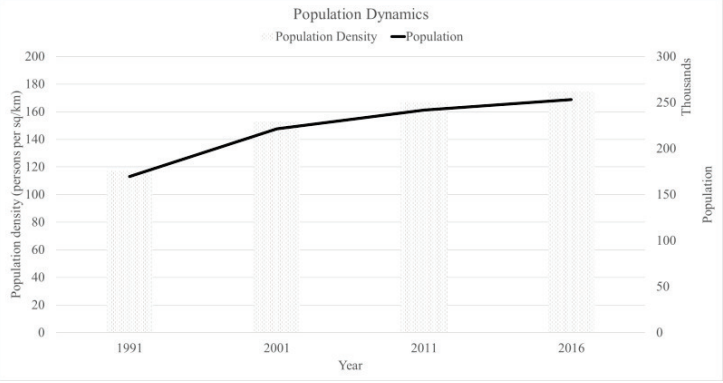
Independent streams in the west flowing river system of Karnataka are given below:

Kollur River, Ghantihole, Venkatapur, Baindurhole, Shankargundi, Kumbarhole and Yedamavinahole are the important streams in this reach.	Independent streams **between Sharavathi and Chakra rivers** joining the Arabian Sea.
Swarna, Seethanadhi, Mulki river, Pavanje, Nadisalu, Gurpur,Yennehole and Madisalhole.	Independent streams **between Varahi and Netravathi rivers**
Chandragiri (Payaswani) and Shiriya river. The Chandragiri rises west of Mercara in Coorg District of Karnataka State at an elevation of about 600 Mts. Pyayaswani River originates from Patti Ghats reserve forest in Coorg District of Karnataka at an elevation of 1350 Mts. The two river joins together at Machipana about 15 kms upstream of their out fall point into Arabian sea near Kasaragud. It drains catchment area of 1406 Sq kms out of which 836 Sq kms lies in Karnataka state and the balance portion in Kerala state.	**Streams between Netravathy and Chandragiri (Payaswani)**

2. AGHANASHINI RIVER

	River	Aghanashini
1	Geography	River Aghanashini is located in Uttara Kannada District of Karnataka (Figure 1). Originating at Sirsi (Figure 2) (Ramachandra et al 2015). Aghanashini river origin in Sirsi and flows for a distance of nearly 117 km before it joins Arabian Sea at Tadri, Belegadde/Kirubele-Kumta (Uttara Kannada) (Figure 2). Tributaries of Aghanashini include, Bakurhole, Donihalla, Chandika hole, Masti mane halla, Benne holé, Badala, Divalli, Santeguli, Hulidevara kodalu and many more. Aghanashini river has a catchment area of 1449 sq.km spread across districts of Uttara Kannada (Kumta, Sirsi, Siddapura, Ankola) and Shimoga (Sorba).  **Figure 1: Aghanashini River Location**  **Figure 2: Overlay of Google Earth**

		 **Figure 3: Topography** Topography of Aghanashini river catchment is as depicted in Figure 3, elevation ranges between < 0m and 786m w.r.t Mean Sea Level, slope of the catchment varies up to 119%. Very high slope we observed in the Ghats (Devi mane Ghat). The variations in the terrain has led to formation of various water falls such as the Burude falls, Dabbe falls, Waate halla, Benne holé falls, Unchalli falls (Ramachandra et al 2015, Balachandran et al, 2012, www. welcomenri.com, www.dreamroutes.org) *etc*. Rock types: Granites to schists, shale, quartzite's, Phyllites. Ores: Iron, limestone, bauxite, quartz, limestone, sand, clay, lime shell, Manganese, Asbestos, Mica. Soil: Red Soil, Lateritic soils, Black soil, etc
2	Rainfall and Water Yield	Rainfall assessment in Aghanashini catchment (Figure 4) indicates that rainfall in the catchment is orographic with annual rainfall varying spatially between 2500mm at the plains of Sirsi, to over 6300 mm at the Ghats. Water yield in the catchment is about 28-41 TMC (and is showing declining trend with the changes in the land uses in the catchment)  **Figure 4: Rainfall**
3	Anthropology	Population in the catchment (Figure 5) has increased from 2,21,562 in 2001 to 2,41,884 in 2011 (Census of India) and is projected to increase to 2,53,135 in the year 2016 at a growth rate of 9.2% per decade. Population density in the catchment is 175 persons per

		square kilometer as on 2016. Major Population is contained at towns such as Sirsi, Gokarna and Kumta. Communities: Kumri Marati, Goudas, Konkanis. Havyaka Brahmin, Namadhari Naik, Goud Saraswat Brahmin, Nadavas, Kurubas, Siddis, Daivajna, Muslims *etc.* (Chandran and Hughes 2000, Wikipedia, Gazetter of India-Uttara Kannada district).  **Figure 5: Population dynamics in Aghanashini river catchment**
4	History, Culture, Heritage	River Aghanashini has history beyond the Himalayas i.e., 88 Million year compared to Himalayas (50 Million years). Mirjan was known as trading hub for spices such as pepper, cardamom, etc The word Aghanashini means Destroyer of Sins. Culture • Festivals and Jatras: Uura habba (Village Festival), Nadi habba (River festival), Bandi habba, Vadya Panchami, Mahamay jatra, Durga devi jatra, Kannika parameshwari jatra, Shantika parameshwari jatra, Venkataramana jatra, etc • Dance: Folk dances (suggi kunita), bharatha natya, Kolata, bedara kunita, dhamami kunita, Huli kunita, Yakshagana, Masti Kunita, Preta kuntia, Bedara kunita, Mandala kunita, etc • Music: Folk Songs, Garatiya Haadu, Halliya Haadu, Nadapadagalu, Bingina pada, Gumatepada, Jogavve haadu, Doni pada, Jogi pada, Badi vadya etc. • Traditional Games: Kallata, kavade, Channe mane, Karu aata, Katte aata, Hulighatta, Bandi aata, Devarata, Sariya mugila aata, Achchu aata, Chowkabara, Tabalamane, etc. Major temples in the catchment of Aghanashini includes: Veknateshwara Temple (Majguni - one of the origin of river Aghanashni), Gokarna, Babbru lingeshwara (worshiped by fishermen), Devi mane, and many deities of the sacred groves. Places like Mirjan fort once provided defenses at the coasts
5	Land use	Land use analysis between 1970's till 2016 show that the catchment forest cover is

dynamics

reducing due to intense anthropogenic activities such as logging, plantation, etc. Figure 6 depicts FCC in the catchment of 1975 and 2016. Figure 7 and Table 1 depicts land use changes in the catchment between 1973 and 2016.

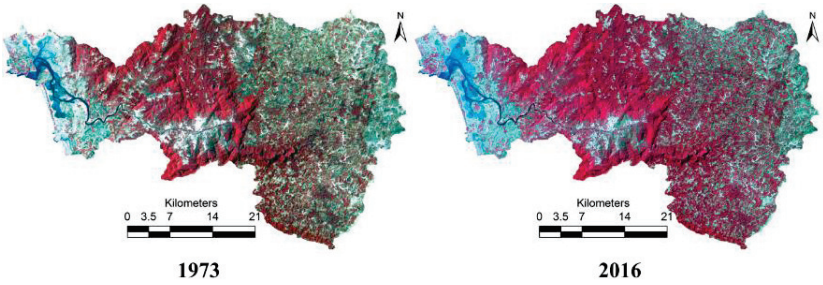


Figure 6: False colour composite (FCC) of the River basin

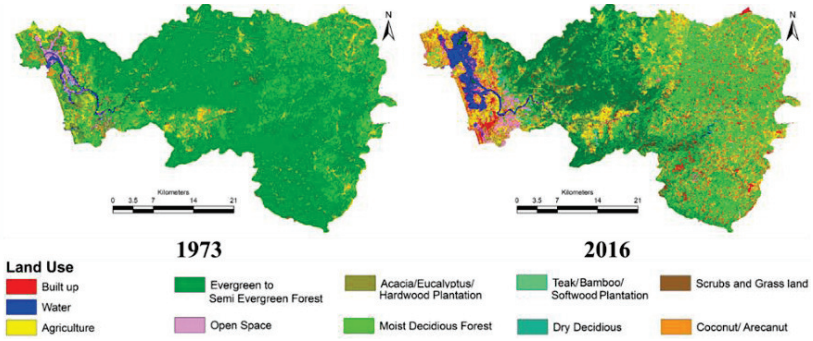


Figure 7: Land use dynamics in Aghanashini Catchment

Table1: Land use dynamics in Aghanashini Catchment

Land use	1973	2016
Built up	0.08%	4.81%
Water	0.80%	2.76%
Crop land	4.05%	16.26%
Open Space	1.43%	3.44%
Moist Deciduous	9.63%	20.41%
Evergreen - Semi Evergreen Forest	73.05%	27.73%
Scrub/Grass land	3.92%	4.01%
Acacia/Eucalyptus/Casuarina	2.86%	2.91%
Teak/Bamboo/Cashew	0.49%	7.90%

			Arecanut/Coconut	3.55%	9.22%	
			Dry Deciduous Forest	0.14%	0.57%	
6	Agriculture, Irrigation	Variety of Paddy, Sugar cane, Banana, Arecanut, Coconut, Mango, spices, etc.				
7	Diversions	Fortunately, senseless river diversion has not happened. However, there is now illogical proposal (by individuals who lacks knowledge of river hydrology and people's livelihood and known for mismanagement of natural resources) to divert water to dying city - Bangalore				
8	Bio Diversity	Aghanashini river has no diversion works or dams along the river, due to which the estuary is highly productive with rich diversity of Fishes yielding over 43 crore rupee per annum (Mahima et al, 2012), Insects (Balachandran et al, 2012), Bivalves (Table 4) yielding over rupee 5 crores per year (Boominathan et al, 2008), Flora (http://wgbis.ces.iisc.ernet.in/biodiversity/database_new/) . **Fishes: Mahima et al, 2012** *Ambassis commersoni , Apogon hyalosoma, Arius arius, Arius sps, Austrobatrachus dussumeri, Carangoides sps, Carangoids chrysophrys, Carangoids preustus, Caranx praeustus (Marine), Cephalophalis boenak, Cybium commersoni, Cynoglossus macrostomus, Eel, Etroplus suretansis, Gerres limbatus, Gerries filamentosus, Glossogobius giuris, Lactarius lactarius, Lates calcarifer EST-MAR, Liza parsia, Lutjanus argentimaculatus, Lutjanus johni, Lutjanus ruselli, Monopterus albus, Mugil cephalus, Nemipterus japonicas, Opisthopterus tardoore, Otolithus ruber, Pampus argenteus, Paraplagusia biliniata, Parastromateus niger, Platax orbicularis, Platycephalus scaber, Pomadasys maculatus, Pseudorhombus javanicus, Rastrilliger kanagurta, Rhinobatus halavi, Rhinobatus sps, Sardinella fimbriata, Scatophagus argus, Scolidon sps, Secutor insidator, Siganus vermiculatus, Sillago sihama, Sphyraena barracuda, Sphyraena obtusata, Sphyraena spp, Stoliphorus commersoni, Stoliphorus indicus, Strongylura leiura, Synaptura commersoniana, Terapon jarbua.* **Insects: Balachandran et al, 2012.** *Isonychia sp., Choroterpes sp., Thraulus sp., Isca sp., Notophlebia sp., Edmundsula sp., Petersula sp., Afronurus sp., Thalerosphyrus sp., Cinygmina sp., Ephemerella (Torleya) sp., Ephemerella (Drunella) sp., Baetis sp., Platybaetis sp., Caenis sp., Clypocaenis bisetosa, Cheumatopsyche sp., Hydropsyche sp., Lepidostoma sp., Helicopsyche sp., Psychomyia sp., Wormaldia sp., Neoperla sp., Naucoris sp., Micronecta sp., Eubrianax sp., Noterus sp.,Stenocolus , Dineutus sp., Orectochilus sp., Laccobius sp., Euphaea sp., Heliogomphus sp., Lamelligomphus sp., Crocothemis sp.,*				

		Hexatoma sp., Pilaria sp., Chironomus sp., Simulium sp., Coridalus sp. **Bivalves: Boominathan et al, 2008** *Paphia malabarica, Katelysia opima, Meretrix meretrix, Meretrix casta, Villorita cyprinoides, Arca granosa, Crassostrea sp., Perna viridis.* **Flora:** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new **(Sirsi, Kumta, Siddapura Taluks)** Forest types found in the district are: Evergreen, Semi Evergreen, Moist Deciduous, Scrub, Thorny, un wooded with following species. *Acronychia pedunculata, Actinodaphne hookeri, Actinodaphne sp, Aglaia ananmallayana, Aglaia lawii, Aglaia roxburghiana, Aglaia sp, Ailanthus excelsa, Alseodaphne semicarpifolia, Alstonia scholaris, Ancistrocladus hamatus, Antiaris toxicaria, Antidesma menasu, Aporosa lindleyana, Archidendron bigeminum, Artabotrys hexapetalus, Artocarpus gomezianus, Artocarpus heterophyllus, Artocarpus hirsutus, Atlantia racemosa, Beilschmiedia fagifolia, Bischofia javanica, Blachia sp, Bombax ceiba, Bridelia crenulata, Buchania lanzan, Calicopteris floribunda, Callicarpa tomentosa, Calophyllum apetalum, Calophyllum polyanthum, Calophyllum tomentosum, Canarium strictum, Canthium dicoccum, Carallia brachiata, Careya arborea, Carissa inermis, Caryota urens, Casearia championii, Casearia sp, Cassia fistula, Cassine glauca, Chrysophyllum roxburghii, Cinnamomum macrocarpum, Cinnamomum malabathricum, Cinnamomum verum, Cinnamomum zeylanicum, Clausena SP, Cleidion javanicum, Combretum latifolium, Cryptocarya wightiana, Dalbergia latifolia, Dalbergia rubiginosa, Dalbergia sp, Dalbergia sympathetica, Derris scandens, Derris sp, Dillenia pentagyana, Dimocarpus longan, Diospyros assimilis, Diospyros buxifolia, Diospyros candolleana, Diospyros crumenata, diospyros ebenum, Diospyros melanoxylon, Diospyros montana, Diospyros oocarpa, Diospyros paniculata, Diospyros pruriens, Diospyros saldanhae, Diospyros sp, Diospyros sylvatica, Dipterocarpus indicus, Drypetes confertiflora, Drypetes venusta, Dysoxylum, Dysoxylum binectariferum, Dysoxylum malabaricum, Elaeagnus conferta, Elaeocarpus serratus, Elaeocarpus tuberculatus, Emblica officinalis, Entada pursaetha, Ervatamia heyneana, Erycibe paniculata, Euonymus indicus, Ficus callosa, Ficus nervosa, Flacourtia montana, Garcinia gummi_gutta, Garcinia indica, Garcinia morella, Garcinia talbotii, Glochidion johnstonei, Glochidion sp, Glochidion zeylanicum, Gnetum ula, Grewia sp, Grewia tiliifolia, Gymnacranthera canarica, Harpullia imbricata, Holigarna arnotiana, Holigarna beddomii, Holigarna ferruginea, Holigarna grahamii, Homalium ceylanicum, Hopea parviflora, Hopea ponga, Hopea wightiana, Hydnocarpus laurifolia, Ixora arborea, Ixora brachiata, Knema attenuata,*

		Lagerstroemia lanceolata, Lagerstroemia microcarpa, Lepisanthes tetraphylla, Linociera malabarica, Litsea floribunda, Litsea laevigata, Litsea mysorensis, Litsea wightiana, Lophopetalum wightianum, Macaranga peltata, Madhuca longifolia, Mallotus phillipinesis, Mammea suriga, Mangifera indica, Margaritaria indica, Mastixia arborea, Meiogyne pannosa, Meliaceae sp, Memecylon talbotianum, Memecylon umbellatum, Mesua ferrea, Mimusops elengi, Moullava spicata, Murraya paniculata, Myristica dactyloides, Myristica malbarica, Neolitsea scrobiculata, Nothapodytes foetida, Nothopegia colebrookeana, Nothopegia racemosa, Odina wodier, Olea dioica, Pajanalia longifolia, Palaquim ellipticum, Persia macarantha, Phyllanthus emblica, Pittosporum dasycaulon, Polyalthia fragrance, Polyalthia sp, Pongamia pinnata, Prunus ceylanica, Pterocarpus marsupium, pterospermum acerifolium, Pterospermum diversifolium, Pterospermum reticulatum, Randia dumetorum;, Randia rugulosa, Sageraea laurina, Salacia macrosperma, Salacia oblonga, Sapindus emarginatus, Schleichera oleosa, Semecarpus Kathlekanensis, Sterculia guttata, Stereospermum personatum, Stereospermum tetragonum, Strombosia ceylanica, Symplocos racemosa, Syzigium caryophyllatum, Syzygium cumini, Syzygium gardneri, Syzygium hemesphericum, Syzygium laetum, Syzygium macrocephala, Syzygium sp, Tectona grandis, Terminalia alata, Terminalia bellirica, Terminalia chebula, Terminalia paniculata, Tetrameles nudiflora, Tetrastigma gamblei, Toddalia asiatica var floribunda, Toona ciliata, Trewia nudiflora, Vateria indica, Ventilago madraspatana, Vepris bilocularis, Vitex altissima, Walsura trifoliolata, Xantolis tomentosa, Xeromorphis spinosa, Xylia xylocarpa, **Fauna: :** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new **Mammals:** Tiger, Black Panther, Leopard, Bison, Gaur, Hare, Wild Boar, Sloth Bear, Deer, Thar, Bonnet Macaque, Lion Tailed Macaque, Giant Squirrel, Hanuman Languor. **Reptiles:** Snakes (Vipers, Cobra, Rat snake, Crate, King cobra, Python, Wolf snake, *etc*), Monitor Lizard.
9	References	1. Survey of India Topographic Sheets, 1:50000 scale. 2. Water Resource Information System of India, http://www.india-wris.nrsc.gov.in. 3. Google Earth, *https://www.google.com/earth/.* 4. Ramachandra, T.V., Chandran, M. D, S., Joshi, N. V., Karthick, B., and Vishnu, D. M., 2015, Ecohydrology of Lotic Systems in Uttara Kannada, Central Western Ghats, India, Environmental Management of River Basin

Ecosystems – Earthy System Science, 621-655.

5. Census of India, 2001 and 2011, censusindia.gov.in.
6. Wild Wonderful Karnataka,
    a. http://www.dreamroutes.org/western/burudefalls.html.
7. Balachandran, C., Dinakaran, S., Chandran, M. D. S., and Ramachnadra, T. V., 2012, Diversity and Distribution of Aquatic Insects in Aghanashini River of Central Western Ghats, India, National Conference on Conservation and Management of Wetland Ecosystems – LAKE 2012, 6th to 8th November 2012, Mahatma Gandhi University, Kottayam, Kerala.
8. Wikipedia, https://en.wikipedia.org/wiki/Sirsi,_Karnataka.
9. Mahima, B., Nayak, V. N., Chandran, M. D. S., and Ramachnadra, T. V., 2012, Impact of Hydroelectric Dams on Fisheries in the Sharavathi Estuary of Uttara Kannada District, National Conference on Conservation and Management of Wetland Ecosystems – LAKE 2012, 6th to 8th November 2012, Mahatma Gandhi University, Kottayam, Kerala.
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11. Chandran, M. D S., Ramachandra, T. V, Joshi, N. V., Rao, G. R, Prakash, N. M., Balachandran, C., and Sumesh, N. D., 2012. Conservation Reserve Status to Lateritic Plateaus of Coastal Uttara Kannada., Sahyadri Conservation Series 21, ENVIS Technical Report: 51, November 2012, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
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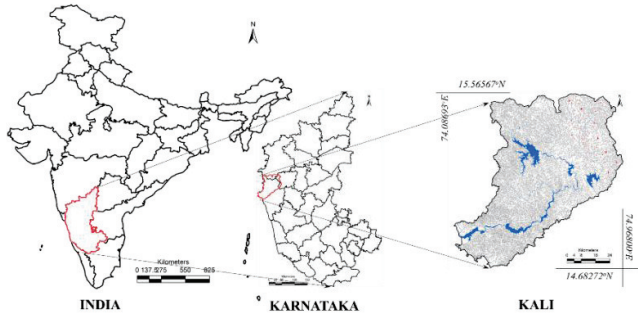
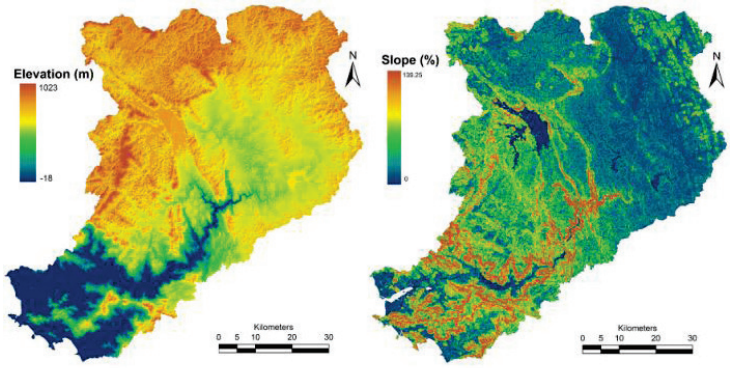
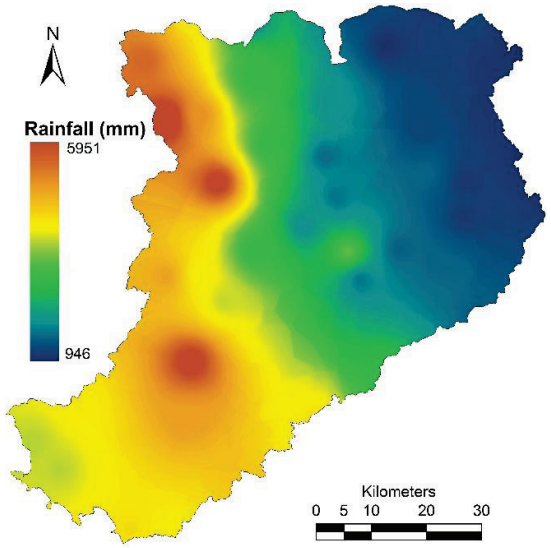
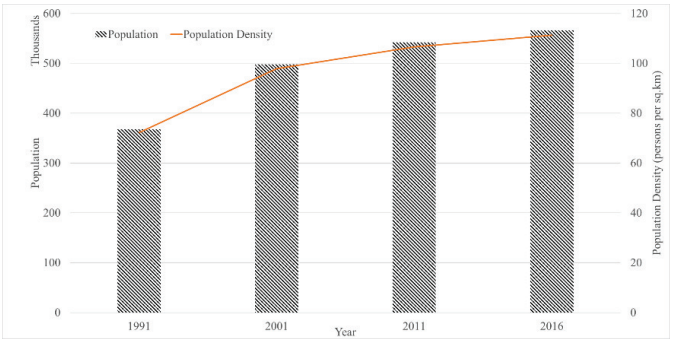
    a. http://wgbis.ces.iisc.ernet.in/biodiversity/database_new/
13. Chandran, M. D. S., and Hughes, J. D., 2000, Sacred Groves and Conservation: The Comparative History of Traditional Reserves in the Mediterranean Area and in South India, Environment and History, 6, 2, 169–186.
14. Gazetter of India, Uttara Kannada district, 1985
15. https://www.researchgate.net/profile/T_V_Ramachandra/publications
16. http://ces.iisc.ernet.in/energy
17. http://ces.iisc.ernet.in/biodiversity

3. KALI RIVER

	River	Kali
1	Geography	River Kali is located in Uttara Kannada District of Karnataka (Figure 1). Originating at Diggi Vilalge - Supa (Figure 2), Kali flows for a distance of nearly 184 km (Amit et al 2008, Survey of India Topographic sheets, Gazetteer of India- Karnataka State – Uttara Kannada) before it joins Arabian Sea at Karwar (Uttara Kannada) (Figure 2). Tributaries of Kali include, Pandrali, Kali, Tattihala, Vaki, Kaneri, Thananala, Kariholé and many more. Kali river has a catchment area of 5085.9 sq.km spread across districts of Uttara Kannada (Ankola, Karwar, Supa, Yellapur, Haliyal), Dharwad (Kalgatgi, Dharwad) and Belgaum (Khanapura, Bialhongal).  INDIA KARNATAKA KALI **Figure 1: Kali River**  **Figure 2: Overlay of Google Earth**  DIGITAL ELEVATION MODEL – SRTM 30m SLOPE (%) **Figure 3: Topography**

		Topography of Kali river catchment is as depicted in Figure 3, elevation ranges between < 0m and 1023 m w.r.t Mean Sea Level, slope of the catchment varies up to 139%. Very high slope we observed in the Ghats (Anshi-Dandeli Ghat). The variations in the terrain has led to formation of various water falls such as the Sathodi Falls, Nagarmadi falls, Devkar falls, Anshi water fall *etc*. Rock types: Granites to schists, shale, quartzite's, Phyllites. Ores: Iron, limestone, bauxite, quartz, limestone, sand, clay, lime shell, Manganese, Asbestos, Mica. Soil: Red Soil, Lateritic soils, Black soil, etc
2	Rainfall and Water Yield	Rainfall assessment in Kali catchment (Figure 4) indicates that rainfall in the catchment is orographic with annual rainfall varying spatially between 946 mm at the plains of Dharwad, to over 5951 mm at the Ghats of Anshi-Dandeli. Water yield in the catchment is 35 - 75 TMC  **Figure 4: Rainfall**
3	Anthropology	Population in the catchment (Figure 5) has increased from 497892 in 2001 to 542036 in 2011 (Census of India) and is projected to increase to 566065 in the year 2016 at a growth rate of 8.8% per decade. Population density in the catchment is 111.3 persons per square kilometer as on 2016. Major Population is contained at towns such as Dandeli, Haliyar, Dharwad, Karwar, Yellapura, Ramnagar, Virje, Majali, Ammadalli. Communities: Ambiga, Arer, Bandi, Bedar, Bandaris, Brahmins, Devadiga, Devalis, Gabit, Ganiga, Gouli, Gudikar, Harikanta, Hulsvara, Kahrvi, Vaishyas, Maratha, Kumri Maratha, Lingayath,, Maratha Kubri, Nadava, Namdharis, Padits, Gidbudukis, Siddis, Buddists, Jains, Muslims, Sikhs, Christians, etc (Chandran and Hughes 2000, Wikipedia,

		Gazetter of India-Uttara Kannada district).  **Figure 5: Population dynamics in Kali river catchment**
4	History, Culture, Heritage	River Kali has history beyond the Himalayas i.e., 88 Million year compared to Himalayas (50 Million years). Culture • Festivals and Jatras: Kurumgad jatra, Karavali utsava, karwar utsava, Uura habba (Village Festival), Nadi habba (River festival), Bandi habba, Vadya Panchami, Mahamay jatra, Durga devi jatra, Kannika parameshwari jatra, Shantika parameshwari jatra, Venkataramana jatra, etc • Dance: Folk dances (suggi kunita), bharatha natya, Kolata, bedara kunita, dhamami kunita, Huli kunita, Yakshagana, Masti Kunita, Preta kuntia, Bedara kunita, Mandala kunita, etc • Music: Folk Songs, Garatiya Haadu, Halliya Haadu, Nadapadagalu, Bingina pada, Gumatepada, Jogavve haadu, Doni pada, Jogi pada, Badi vadya etc. • Traditional Games: Kallata, kavade, Channe mane, Karu aata, Katte aata, Hulighatta, Bandi aata, Devarata, Sariya mugila aata, Achchu aata, Chowkabara, Tabalamane, etc. Major temples in the catchment of Kali includes: Uluvi, Shanthadurga temple, **Kavale Caves**, etc.
5	Land use dynamics	Land use analysis of 2013 show that the catchment forest cover is about 55 % (about 38% covered with evergreen species). Figure 6 depicts FCC of the catchment, Figure 7 and Table 1 depicts land use in the catchment as on 2013.

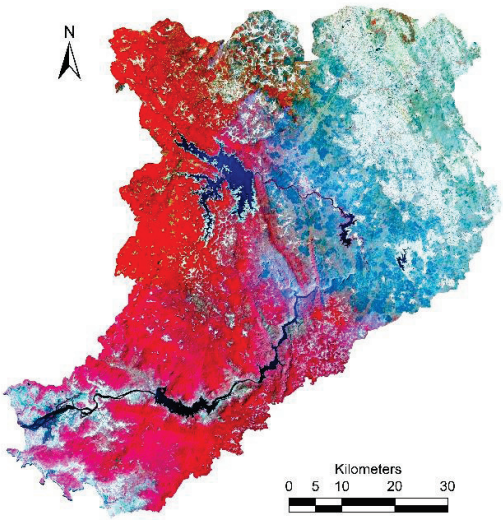


Figure 6: False colour composite

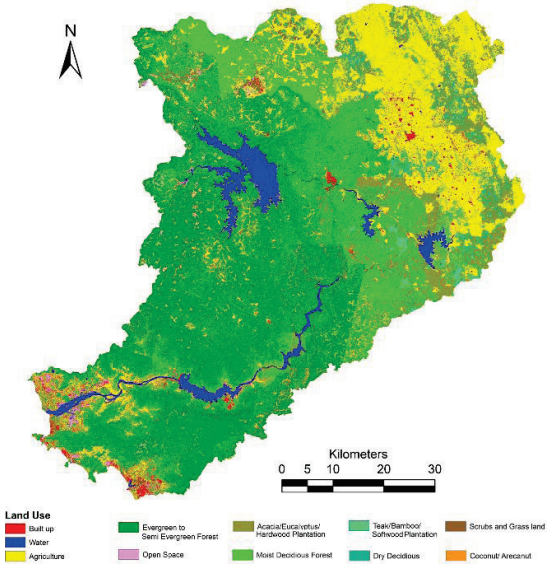


Figure 7: Land use in Kali Catchment

Table1: Land use of Kali Catchment

Land use	2013
Urban	1.7%
Water	3.7%
Agriculture	17.4%
Open lands	1.9%
Moist Deciduous Forest	14.5%
Evergreen to Semi Evergreen forest	38.6%
Scrub/Grassland	3.3%

			Acacia/Eucalyptus	11.8%
			Teak/Bamboo	3.3%
			Coconut/Arecanut	1.7%
			Dry Deciduous	2.1%
6	Agriculture, Irrigation	Variety of Paddy, Sugar cane, Banana, Arecanut, Coconut, Mango, spices, etc.		
7	Diversions /Reservoirs	Supa, Kodasalli, Tattihalla, Bommanalli Balancing Reservoir, Kaneri, Kadra.		
8	Bio Diversity	Anshi Dandeli is Tiger Reserve, habitat of wild elephants, Hornbill reserves and also wild life corridor. **Bivalves: Ramachandra et al, 2012, http://www.cmfri.org.in** *Paphia malabarica, Meretrix meretrix, Meretrix casta, Villorita cyprinoides, Arca granosa, Polymesoda erosa, Oysters, Perna viridis* **Flora: Chandran et al 2012,** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new Forest types found in the district are: Evergreen, Semi Evergreen, Moist Deciduous, Scrub, Thorny, un wooded with following species. *Acacia auriculiformis, Acanthus ilicifolius, Aegiceras corniculatum, Albizia lebbeck, Alseodaphne semicarpifolia, Alstonia scholaris, Alysicarpus vaginalis, Anacardium occidentale., Anogeisus latifolia, Aporosa lindleyana, Aristalochia indica, Artabotrys zeylanica, Artocarpus heterophyllus, Artocarpus hirsutus, Arundinella metzii, Atalantia racemosa, Avicinnia officinalis, Bacopa monnieri, Bambusa sp., Barringtonia acutangula, Bauhinia racemosa, Blyxa aubertii , Bombax ceiba, Breynia retusa, Bridelia scandens, Bridelia crenulata, Bridelia retusa, Bridelia scandens, Buchanania lanzan, Calicopteris floribunda, Callicarpa wightii, Calophyllum inophyllum, Calophylum wightii, Canscora decurrens, Canthium dicoccum, Canthium parviflorum, Caralia antigerrima, Carallia brachiata, Careya arborea, Carissa carandas, Caryota urens, Casearia rubescens, Cassia fistula, Cassia tora, Centranthera indica, Cinnamum macrocarpum, Clerodendrum inerme, Clerodendrum paniculatum, Cordia myxa, Crotalaria filipes, Crotalaria lutescens, Crotalaria retusa, Cyperus compressus , Cyperus difformis , Cyperus halpan , Cyperus malaccensis, Cyperus iria , Dactyloctenium aegyptium, Dalbergia horrida, Dalbergia latifolia, Derris scandens, Derris trifoliate , Desmodium triflorum, Desmodium laxiflorum, Dilenia pentagyna, Dillenia pentagyna, Dillinia pentagyna, Dimeria hohenackeri, Dimeria ornithopoda, Diospyros montana, Diospyros paniculata, Diospyros pruriens, Dolichondrone spathaceae, Elaeocarpus serratus, Eleocharis acutangula , Embelia ribes, Epaltes divaricata, Eragrostis uniloides, Ervatamia heyneana, Eupatorium*		

		odoratum, Euphorbia notoptera, Excoecaria agallocha, Ficus arnottiana, Ficus drupacea, Ficus hisda, Ficus sp., Ficus tinctoria, Fimbristylis bisumbellata , Fimbristylis ferruginea, Fimbristylis tetragona , Fimbristylis dichotoma, Flacourtia indica, Flacourtia montana, Fuirena ciliaris , Garcinia indica, Geissaspis cristata, Glochidion sp., Gloriosa superba, Glycosmis pentaphylla, Glyphochloa acuminata, Gnedia glauca, Grewia microcos, Grewia tiliaefolia, Grewia tilifolia, Gymnema sylvestre, Hedyotis herbacea, Helicteres isora, Hemidesmus indicus, Holarrhena antidysenterica, Holigarna arnotiana, Hopea ponga, Hopea wightiana, Hoppea dichotoma, Hydnocarpus laurifolia, Hydnocarpus, Ichnocarpus frutescens, Isacne globosa , Ischaemum indicum, Ixora arborea, Ixora brachiata, Ixora coccinea, Justica simplex, Kandelia candel, Kyllinga melanosperma , Lagerstroemia microcarpa, Lagerstroemia microcarapa, Lagerstromia lanceolata, Lagerstromia microcarpa, Lannea coromandelica, Lea indica, Lea robust, Lea sp, Leucas lavandulifolia, Lindernia crustacea, Lindernia tenuifolia, Litsea laevigata, Lobelia alsinoides, Lobelia nicotianifolia, Ludwigia perennis, Macaranga peltata, Madhuca neriifolia, Mallotus phillipensis, Mallotus, Mammea suriga, Mangifera indica, Mariscus javanicus , Mellotus phillipinesis, Memecylon talbotianum, Memycelon sp., Mimosa pudica, Mimusops elengi, Moullava spicata, Moulva spicata, Movalva spicata, Murraya koenghii, Myristica malabarica, Nothapodytes foetida, Nymphaea nouchali, Ochlandra, Ocimum canum, Odina wodier, Olea dioica, Oplismenus burmanii, Paspalum scrobiculatum, Phyllanthus simplex, Phyllanthus emblica, Phyllanthus urinaria, Piper nigrum, Polyalthia fragrans, Pongamia pinnata, Porteresia coarctata, Portulaca oleracea, Pseudanthistiria umbellata , Psidium guajava, Pycreus pumilus , Pycreus sanguinolentus , Pycreus stramineus , Pycreus polystachyos, Randia dumatorum, Rauvolfia serpetina, Rhizophora apiculata, Rhizophora mucronata, Rhynchospora wightiana, Rhynchostylis retusa, Sapindus laurifolia, Sapium insigne, Saraca asoca, Schleichera oleosa, Schoenoplectus lateriflorus , Sida acuta, Smilax zeylanica, Smithia hirsuta, Sonneratia caseolaris, Spaeranthus indicus, Spermacoce articularis, Spermacoce verticillata, Sphenoclea Zeylanica, Sporobolus virginicus , Stereospermum personatum, Streblus asper, Striga lutea, Strobilanthus heyneana, Strobilanthus, Strychnos nux-vomica, Symplocos racemosa , Syzigium caryophyllatum, Syzigium cumini, Syzygium caryophyllatum, Syzygium hemispericum, Syzygium, Teak, Tephrosia pulcherrima, Terminalia alata, Terminalia bellarica, Terminalia chebula, Terminalia paniculata, Terminalia tomentosa, Theriophonum dalzellii, Trewia nudiflora, Tricholepis glaberrima, Triumfetta rhomboidea , Urena lobata ,

		Utricularia reticulata, Vernonia divergens, Vitex altissima, Vitex negundo, Weisneria triandra , Wendlandia thyrasoides, Xylia xylocarpa, Zizhiphus rugosa, Ziziphus oenoplia, Ziziphus sp, Ziziphus xylopyrus, Zornia gibbosa, Zoysia matrella,. ***etc.***. **Fauna: :** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new **Mammals: Elephants, Tiger**, Black Panther, Leopard, Bison, Gaur, Hare, Wild Boar, Sloth Bear, Deer, Thar, Bonnet Macaque, Lion Tailed Macaque, Giant Squirrel, Hanuman Languor. **Reptiles:** Snakes (Vipers, Cobra, Rat snake, Crate, King cobra, Python, Wolf snake, *etc*), Monitor Lizard, **Crocodile**. **Birds: Amit et al, 2008** *Acridotheres tristis, Aegithina tiphia, Alcedo athis, Alcedo meninting, Amaurornis fusca, Amaurornis phoenicurus, Anas creca, Anas penelope, Anas poecilorhynca, Anas querquedula, Anas Strepera, Anastomus oscitans, Anhinga rufa, Ans clypeata, Anthracoceros coronatus, Anthropoides virgo, Anus acuta, Apus nipalensis, Ardea alba, Ardea cinerea, Ardea purpurea, Ardeola grayii, Ardeola grayii , Arenaria interpres, Aythya nyroca, Botaurus stellaris, Bubulcus ibis, Bulbulcus ibis, Burhinus oedicnemus, Butorides striatus, Calidris alpina, Calidris minuta, Calidris temnickii, Calidris testacea, Casmerodius albus, Centropus sinensis, Ceryle rudis, Ceyx erithacus, Charadrius alexandrinus, Charadrius d. jerdoni, Charadrius dubius, Charadrius leschenaultii, Charadrius mongolus, Charadrius veredus, Chliodinas hybridus, Ciconia episcopus, Ciconia nigra, Circus aeruginosus, Columba livia, Copsychus saularis, Corvus levaillantii, Corvus splendens, Cursorius coromandelicus, Dendrocygna javanica, Dicrurus macrocercus, Egretta garzetta, Egretta gularis, Egretta intermediata, Esacus magniristris, Eudynamys scolopaceus, Fulica atra , Gallicrex cinerea, Gallinago gallinago, Gallinago minima , Gallinago stenura, Gallinula chloropus , Gelochelidon nilotica, Glareola lactea, Gorsachius melanolophus, Haematopus ostralegus, Halcyon pileata , Halcyon smyrnensis, Haliastur indus, Halycon Chloris , Himantopus himantopus, Hydrophasianus chirurgus , Hydroprogne caspia , Ixobrychus cinnamomeus, Ixobrychus flavicollis, Lanius schach, Larus brunnicephalus, Larus genei, Larus icthyaetus , Larus ridibundus , Leptoptilos javanicus, Limicola falcinellus , Limosa Limosa , Lonchura striata, Merops leschenaulti, Merops Orientalis, Merops philippinus, Metopidius indicus, Milvus migrans, Mycteria leucocephalus, Nattapus coromandelicus, Nectarinia zeylonica, Numenius arquata , Numenius phaeopus, Nycticorax nycticorax, Oriolus oriolus, pelargopsis capensis, Phalacrocorax fuscicollis, Phalacrocorax niger, Philomachus pugnax, Phoenicopterus roseus, Platalea leucorodia, Plegadis falcinnellus, Pluvialis dominica, Pluvialis squatarola, Porphyrio porphyrio, Porzona parva, Porzona*

		pusilla, Prinia Socialis, Pseudibis papilosa, Psittacula cyanocephala, Psittacula krameri, Pycnonotus cafer, Rallina eurizonoides, Rallus striatus , Recurvirostra avosetta , Rhynchops albicollis, Rostratula benghalensis, Sarkidiornis melanotos, Saxicola caprata, Spilornis cheela, Sterna acuricauda, Sterna anaethetus, Sterna aurantia, Sterna bengalensis, Sterna bergii, Sterna fuscuta, Sterna Sandvicensis, Streptopelia chinensis, Sturnus roseus, sypheotides indicus, Tadorna ferruginea, Threskiornis melanocephala, Tringa erythropus, Tringa glareola, Tringa hypoleucos, Tringa nebularia , Tringa ochropus , Tringa stagnatilis, Tringa terek, Tringa totanus, Vanellus cinereus, Vanellus indicus, Vanellus malabaricus, Venellus indicus.
9	References	1. Survey of India Topographic Sheets, 1:50000 scale. 2. https://www.researchgate.net/profile/T_V_Ramachandra/publications 3. http://ces.iisc.ernet.in/energy 4. http://ces.iisc.ernet.in/biodiversity 5. Google Earth, *https://www.google.com/earth/.* 6. Ramachandra, T.V., Chandran, M. D, S., Joshi, N. V., and Boominathan, M., 2012. Edible Bivalves of Central West Coast, Uttara Kannada District, Karnataka, India., Sahyadri Conservation Series 17, ENVIS Technical Report : 48, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012. 7. Census of India, 2001 and 2011, censusindia.gov.in. 8. Chandran, M. D. S., Rao, G.R., Vishnu, D. M., Prakash, M., and Ramachandra, T. V., 2012. Grasslands of Anshi-Dandeli Tiger Reserve., ENVIS Technical Report: 36, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012. 9. ENVIS Sahyadri Web Portal, 10. http://wgbis.ces.iisc.ernet.in/biodiversity/database_new/ 11. Chandran, M. D. S., and Hughes, J. D., 2000, Sacred Groves and Conservation: The Comparative History of Traditional Reserves in the Mediterranean Area and in South India, Environment and History, 6, 2, 169–186. 12. Gazetter of India, Uttara kannada district, 1985 13. Central Marine and Fisheries Institute, http://www.cmfri.org.in 14. Amit S. Yadav, Gururaja, K.V., Karthik, B., Rao, G. R., Vishnu, D. M., Chandran, M.,D. S and Ramachandra, T.V., 2008, Ecological Status of Kali River Flood Plain, ENVIS Technical Report: 29, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012.

4. SHARAVATHI RIVER

	River	Sharavathi
1	Geography	River Sharavathi is spread across Uttara Kannada and Shimoga District of Karnataka (Figure 1). Originating at Ambutirthha (Tirthahalli) (Figure 2) (Karnataka State Gazetteer, Ramachandra et al 2004), Sharavathi flows for a distance of nearly 128 km (Survey of India Topographic sheets, Water resource information system of India) before it joins Arabian Sea at Karki, Honnavar (Uttara Kannada) (Figure 2). Tributaries of Aghanashini include, Nandiholé, Haridravathi, Sharmanavathi, Hilkunjiholé, Nagodiholé, Hurliholé, Yenneholé, Mavinaholé, Gundabalaholé, Kalkatteholé, Kandodiholé and many more. Sharavathi river has a catchment area of 3042 sq.km spread across districts of Uttara Kannada (Honavara, Siddapura, Kumta) and Shimoga (Sagara, Hosanagara, Tirthahalli).

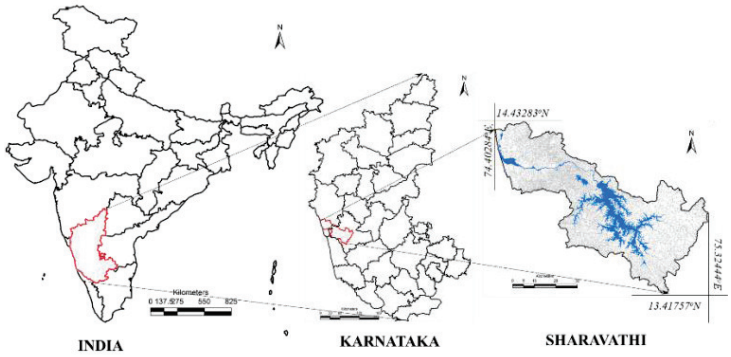


Figure 1: Sharavathi River Location

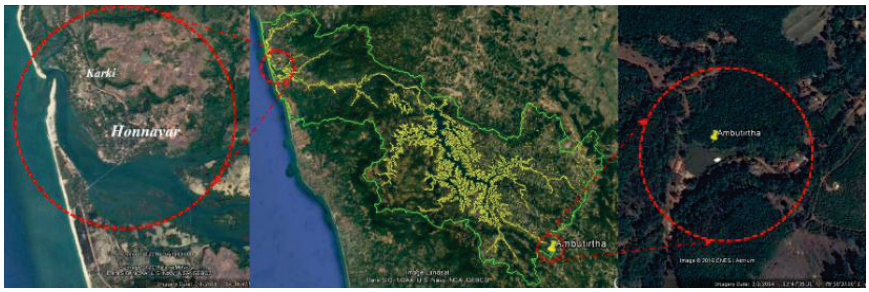


Figure 2: Overlay of Google Earth

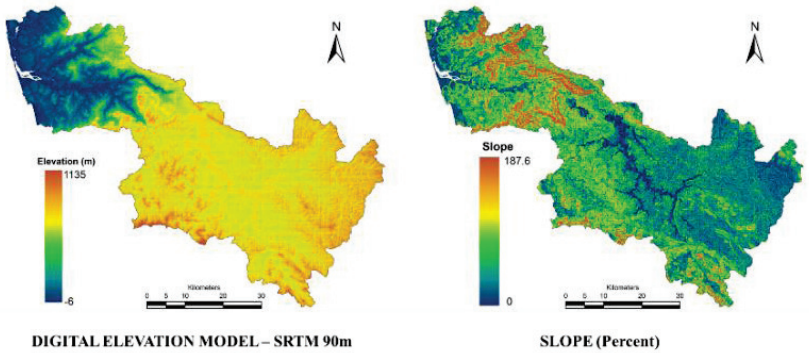
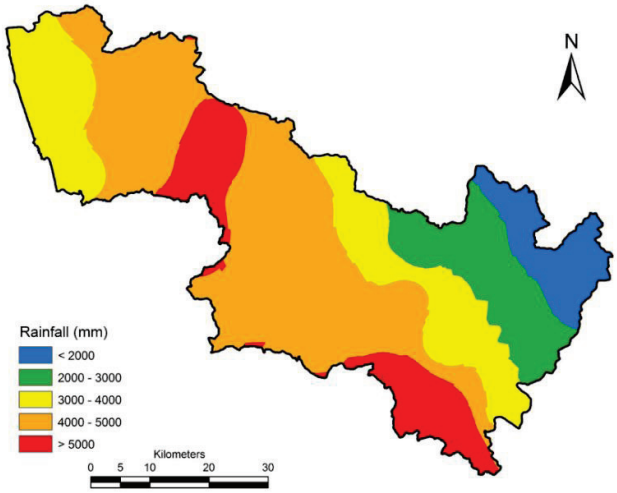
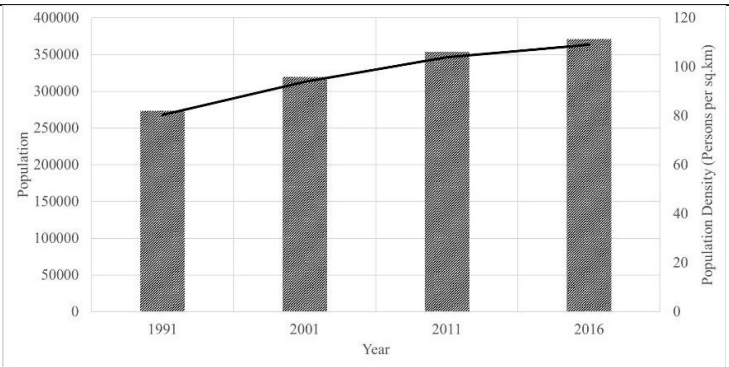


Figure 3: Topography

		Topography of Sharavathi river catchment is as depicted in Figure 3, elevation ranges between < 0m and 1135m w.r.t Mean Sea Level, slope of the catchment varies up to 187%. Very high slope we observed in the Ghats (Gersoppa Ghat). The variations in the terrain has led to formation of various water falls such as the Jog falls, Apsarakonda, Mavinagundi falls, Dabbe fall (http://www.karnataka.com) *etc*. The plain regions of the catchment are dominated by lakes whereas the Ghats are dominated by streams. Rock types: Granites to schists, Quartzite's, Phyllites, Porphyry, etc. Ores: Iron, bauxite, quartz, sand, clay, lime shell, Manganese, Asbestos, Mica. Soil: Red Soil, Lateritic soils, etc
2	Rainfall and Water Yield	Rainfall assessment in Sharavathi river catchment (Figure 4) indicates that rainfall in the catchment is orographic with annual rainfall varying spatially between 1700mm at the plains of Siddapura, to over 6500 mm at the Ghats (Gersoppa to Mavinagundi). Water yield in the catchment is ~60 - 110 TMC  **Figure 4: Rainfall**
3	Anthropology	Population in the catchment (Figure 5) has increased from 319380 in 2001 to 353800 in 2011 (Census of India) and is projected to increase to 371010 in the year 2016 at a growth rate of 9.72% per decade. Population density in the catchment is 109 persons per square kilometer as on 2016. Major Population is contained at towns such as Honnavar, Sagar, Talguppa. Communities: Kumri Marati, Goudas, Konkanis. Havyaka Brahmin, Namadhari Naik, Goud Saraswat Brahmin, Nadavas, Kurubas, Siddis, Daivajna, Muslims, *etc.* (Chandran and Hughes 2000, Wikipedia, Gazetter of India-Uttara Kannada district).

		 **Figure 5: Population dynamics in Sharavathi river catchment**
4	History, Culture, Heritage	River Shatravathi has history beyond the Himalayas i.e., 88 Million year compared to Himalayas (50 Million years). Mirjan was known as trading hub for spices such as pepper, cardamom, etc River Sharavathi origins at ambutirtha, and is also explained in Epic of Ramayana and Mahabharatha. Culture • Festivals and Jatras: Marikamba jatra, Shani deva jatra, Rameshwara Jatra, Gram deva Jatra, Nandi Jatra, Lakshmi narasimha jatra, Venkataramana jatra, Ganapathi jatra, Shambhulingeshwara Jatra, Uura habba (Village Festival), Nadi habba (River festival), Bandi habba, Vadya Panchami, Mahamay jatra, Durga devi jatra, Kannika parameshwari jatra, Shantika parameshwari jatra, Mari habba, etc • Dance: Folk dances (suggi kunita), bharatha natya, Kolata, bedara kunita, dhamami kunita, Huli kunita, Yakshagana, Masti Kunita, Preta kuntia, Bedara kunita, Mandala kunita, etc • Music: Folk Songs, Garatiya Haadu, Halliya Haadu, Nadapadagalu, Bingina pada, Gumatepada, Jogavve haadu, Doni pada, Jogi pada, Badi vadya etc. • Traditional Games: Kallata, kavade, Channe mane, Karu aata, Katte aata, Hulighatta, Bandi aata, Devarata, Sariya mugila aata, Achchu aata, Chowkabara, Tabalamane, etc. Major temples in the catchment of Sharavati includes: Siganduru, Kollur Mookambika, Gersoppa Hanumatha, Bellimakki Hanumantha, Idugunji, Ramatirtha, Karikan Parameshwari, Mugva Subramanya, Gundbala Hanumanta, Chandavara Hanumantha, Gunavateshwara, and many deities of the sacred groves.
5	Land use dynamics	Land use analysis of 2013 show that the catchment forest cover is reducing due to intense anthropogenic activities such as logging, plantation, etc. Figure 6 depicts FCC, Figure 7 and Table 1 depicts land use in the catchment. Sharavathi catchment has a

forest cover of 33.7% (Evergreen 19.6%, Moist Deciduous 14.1%). Upstream of Sharavathi is dominated by agriculture (paddy), and downstream is dominated by horticulture activities (Arecanut).

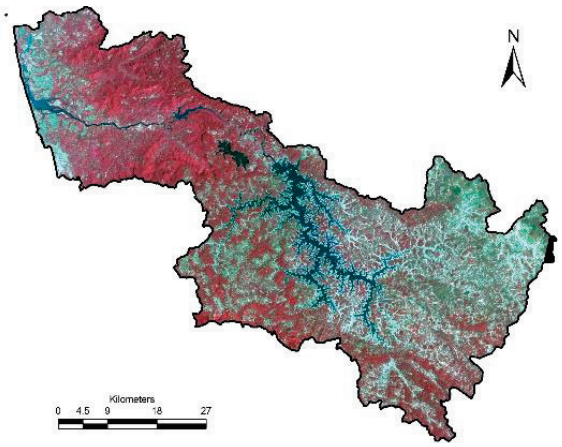


Figure 6: False colour composite

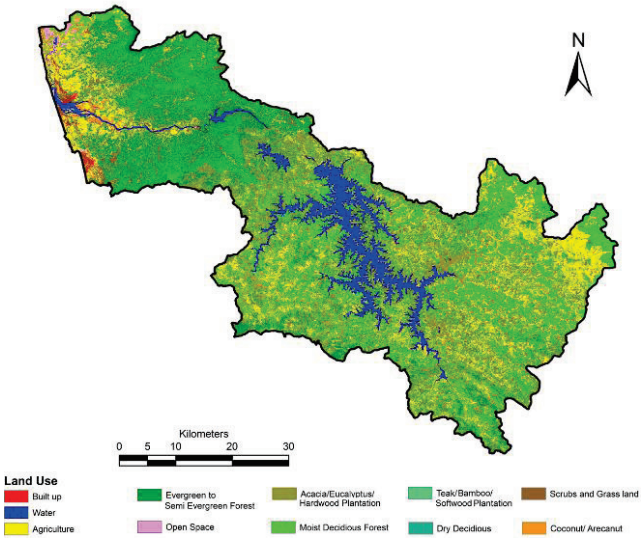


Figure 7: Land use in Sharavati Catchment

Table1: Land use in Sharavati Catchment

Land use	2013
Urban	1.0%
Water	6.9%
Agriculture	14.1%
Open lands	1.1%

			Moist Deciduous Forest	14.1%
			Evergreen to Semi Evergreen forest	19.6%
			Scrub/Grassland	9.1%
			Acacia/Eucalyptus	13.6%
			Teak/Bamboo	8.5%
			Coconut/Arecanut	12.0%
6	Agriculture, Irrigation	Variety of Paddy, Sugar cane, Banana, Arecanut, Coconut, Mango, spices, etc.		
7	Diversions	Sharavathi Generating Station (1035 MW) commissioned in 1964-65, the Linganamakki Dam Power House (55 MW) and the Sharavathi Tail Race Project (240 MW) at Gerusoppa in 2001. (Ramachandra et al 2004). Yet another dam proposed near Jog falls		
8	Bio Diversity	**Fishes: Mahima et al, 2014., Mahima et al, 2012., Sreekantha and Ramachandra, 2005., Sreekantha et al 2006.** *Ambassis ambassis, Amblyphyrngodon mol, Aplocheilus lineatus, Arius ariu, Arothron stellat, Barilius canarensis, Carangoides chrysophrys, Carangoides chrysophrys, Catla catla, Chanda nama, Channa marulius, Cirhina fulungee, Cirhina mrigala, Cirrhinus reba, Clarius byatracus, Cyprinus carpio, Danio aequipinnatus, Dawkinsia filamentosa, Eleutheronema tetradactylum, Etroplus suretansis, Etroplus suratensi, Garra gotyla stenorynchus, Gerres limbatus , Gerries filamentosus, Glossogobius giuris , Glossogobius giurus, Grammoplites scaber, Heteropneustis fossilis, Hyporhamphus xanthopterus, Hyporhampus xanthopterus, Labeo fimbriatus, Labeo rohita, Lates calcarifer, Lepidocephalichthys thermalis, Liza parsia, Lutjanus argentimaculatus, Lutjanus johni, Lutjanus johnii, Lutjanus ruselli, Lutjanus russellii, Mastacembalus arnatus, Mugil cephalus, Mystus cavesius, Mystus keletius, Mystus malabaricus, Namacheilus rueppell, Ompok bimaculatu, Ompok sp, Oreochromis mossambica, Otolithus ruber, Platycephalus scaber, Pseudambasis ranga, Pseudeutropius atherenoide, Pseudorhombus javanicus, Puntius arulius, Puntius dorsalis, Puntius fasciatus, Puntius filamentosis, Puntius filamentosus, Puntius kolus, Puntius narayani, Puntius parrah, Puntius ticto, Rasbora daniconius, Ray fish, Salmostoma boopis, Sardinella fimbriata, Scatophagus argus, Schistura nagodiensis, Schistura. Sharavathiensis, Secutor ruconius, Siganus vermiculatus ,*		

		Sillago sihama, Sphyraena baracuda, Stolephorus commersonnii, Stolephorus indicus , Stoliphorus commersoni, Strongylura strongylura, Terapon jarbua, Tor khudree, Tor mussullah, Tylosurus strongylurus, Wallago attu, Xenentodon cancil, **Ants: Ramachandra et al 2012a** *Acantholepis opaca, Acantholepis sp, Anoplolepis longipes, Aphaenogaster beccari, Bothriomyrmex sp, Camponotus (Colobopsis) sp, Camponotus angusticollis, Camponotus compressus, Camponotus invidus, Camponotus irritans, Camponotus paria, Camponotus rufoglaucus, Camponotus sericeus, Camponotus sp, Cardiocondyla sp, Cardiocondyla wroughtonii, Cataulacus taprobanae, Crematogaster nr dohrni, Crematogaster rothneyi, Crematogaster sp 1, Crematogaster sp 2, Crematogaster sp 3, Crematogaster sp 4, Crematogaster sp 5, Crematogaster sp 6, Crematogaster wroughtoni, Diacamma rugosm, Dolichoderus sp, Harpegnathos saltator, Holcomyrmex sp, Leptogenys diminuta, Leptogenys processionalis, Leptogenys sp, Lophomyrmex quadrispinosa, Meranoplus bicolor, Monomorium dichroum, Monomorium floricola, Monomorium gracillimum, Monomorium indicum, Monomorium latinode, Monomorium pharaonis, Monomorium scabriceps, Monomorium sp 1, Monomorium sp 2, Monomorium sp 3, Monomorium sp 4, Myrmicaria brunnea, Oecophylla smaragdina, Pachycondyla henrie, Pachycondyla luteipes, Pachycondyla rufipes, Pachycondyla tesserinoda, Paratrechina longicornis, Paratrechina sp, Pheidole nr sharpi, Pheidole parva, Pheidole sp 1, Pheidole sp 2, Pheidole sp 3, Pheidole spathifera, Pheidole watsoni, Pheidole wood-masoni, Pheidologeton affinis, Pheidologeton diversus, Platythyrea parallela, Platythyrea sagei, Polyrhachis mayri, Polyrhachis rastellata, Polyrhachis simplex, Polyrhachis tibialis, Prenolepis, Recurvidris recurvispinosa, Solenopsis geminata, Tapinoma sp, Technomyrmex albipes, Tetramorium sp 1, Tetramorium sp 2, Tetramorium sp 3, Tetramorium sp 4, Tetramorium sp 5, Tetramorium walshi, Tetraponera aitkeni, Tetraponera nigra, Tetraponera rufonigra,* **Flora: Ramachandra et al 2012b,** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new **(Siddapura, Honnavar, Sagar, Hosnagara, Tirthahalli Taluks)** Forest types found in the district are: Evergreen, Semi Evergreen, Moist Deciduous, Scrub, Thorny, un wooded with following species. *Actinodaphne hookeri, Aglaia anamallayana, Aglaia roxburghiana, Aglaia sp, Agrostistaches indicus, Alpinia malaccensis, Ancistrocladus heyneanus, Antidesma menasu, Aporosa lindleyana, Arenga whiti, Artabotrys zeylanica, Artocarpus hirsutus, Atalantia racemosa, Atylosia sp, Beilschmiedia fagifolia, Blachia denudata,*

		Boesenbergia pulcherrima, Briedelia stipularis, Calamus sp, Calamus thwaitesii, Callicarpa tomentosa, Calophyllum tomentosum, Canarium strictum, Canthium dicoccum, Canthium rheedei, Canthium sp., Capparis sp., Carallia brachiata, Carex sp., Careya arborea, Caryota urens, Casearia sp., Cassine glauca, Cassine sp, Celtis cinnomomea, Cinnamomum macrocarpum, Cleidion javanicum, Clerodendrum viscosum, Combretum latifolium, Connaraceae member, Croton gibsonianus, Croton sp., Cyclea peltata, Cyrtococcum oxyphyllum, Dichapetalum gelonioides, Dimocarpus longan, Dimorphocalyx lawianus, Dioscorea bulbifera, Diospyros candolleana, Diospyros crumenata, Diospyros oocarpa, Diospyros paniculata, Diospyros saldanhae, Diospyros sp, Dipterocarpus indicus, Dracaena terniflora, Drypetes elata, Drypetes sp (2), Drypetes sp(1), Elaeocarpus tuberculatus, Ervatamia heyneana, Euonymus indicus, Euphorbiaceae-1, Euphorbiaceae-2, Fahrenhetia zeylanica, Ficus callosa, Ficus nervosa, Flacourtia montana, Flacourtia sp, Flemingia strobilifera, Garcinia cambogia, Garcinia morella, Garcinia talbotii, Glochidion javanicum, Glycosmis pentaphylla, Gnetum scandens, Gomphandra axillaris, Gymnacranthera canarica, Gymnosporia rothiana, Hemidesmus indicus, Hibiscus furcatus, Holigarna ferruginea, Holigarna grahamii, Hopea ponga, Hydnocarpus laurifolia, Hydnocarpus pentandra, Ixora brachiata, Ixora nigricans, Ixora parviflora, Ixora polyantha, Ixora sp., Justicia simplex, Knema attenuata, Lagenandra ovata, Lagerstroemia microcarpa, Leea indica, Lepisanthes deficiens, Litsea floribunda, Litsea ghatica, Litsea laevigata, Litsea sp., Litsea sp.(2), Lophopetalum wightianum, Luvunga sarmentosa, Macaranga peltata, Mallotus philippensis, Mallotus sp, Mallotus sp., Mallotus stenanthus, Mangifera indica, Mastixia arborea, Meiogyne pannosa, Memecylon terminale, Mesua ferrea, Microtropis wallichiana, Mimusops elengi, Mitrephora heyneana, Murraya paniculata, Myristica dactyloides, Myristica fatua, Myristica malabarica, Neolitsea zeylanica, Nothapodytes foetida, Nothopegia colebrookeana, Ochlandra sp, Olea dioica, Ophiorrhiza hirsutula, Orophea zeylanica, Palaquium ellipticum, Pandanus sp, Persea macrantha, Phoebe cathia, Phyllanthus lawii, Pinanga dicksonii, Piper sp., Polyalthia fragrans, Polyalthia sp, Pothos scandens, Pothos scandens, Psychotria flavida, Pterospermum diversifolium, Randia rugulosa, Randia ruugosa, Rungia pectinata, Sageraea laurifolia, Santalum album, Scutia myrtina, Smilax spp, Smilax zeylanica, Strobilanthus heynianus, Strombosia ceylanica, Strychnos climber, Strycnos sp., Symplocos racemosa, Syzigium hemisphericum, Syzigium laetum, Syzigium sp(1), Syzigium sp(2), Syzygium cumini, Syzygium gardneri, Syzygium macrophylla, Terminalia paniculata, Tetrameles nudiflora, Tiliaceae member, Todalia asiatica, Ventilago maderaspatana,

		Vepris bilocularis, Vitaceae member, Walsura trifolia, Zingiber cernum, Zingiber sp., Zingiberaceae, Ziziphus rugose. **Bivalves: Ramachandra et al 2012c, Boominathan et al, 2014.** *Polymesoda erosa, Oysters* **Fauna: :** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new **Mammals:** Tiger, Black Panther, Leopard, Bison, Gaur, Hare, Wild Boar, Sloth Bear, Deer, Thar, Bonnet Macaque, Lion Tailed Macaque, Giant Squirrel, Hanuman Languor. **Reptiles:** Snakes (Vipers, Cobra, Rat snake, Krait, Pythons, King cobra, Python, Wolf snake, *etc*), Monitor Lizard.
9	References	1. Survey of India Topographic Sheets, 1:50000 scale. 2. Water Resource Information System of India, http://www.india-wris.nrsc.gov.in. 3. Google Earth, *https://www.google.com/earth/.* 4. Ramachandra, T. V., Chandran, M. D, S., Sreekantha, Mesta, D., Rao, G. R., and Sameer, A., 2004, Cumulative Impact Assessment in the Sharavathi river basin, International Journal of Environment and Development, 1(1), 113 – 135. 5. Ramachandra, T.V., Chandran, M. D, S., Joshi, N. V., Karthick, B., and Vishnu, D. M., 2015, Ecohydrology of Lotic Systems in Uttara Kannada, Central Western Ghats, India, Environmental Management of River Basin Ecosystems – Earthy System Science, 621-655. 6. Census of India, 2001 and 2011, censusindia.gov.in. 7. Welcome NRI Web portal, 8. http://www.welcomenri.com/Tourism/Waterfalls/waate-halla-waterfall-in-karnataka.aspx. 9. Wild Wonderful Karnataka, 10. http://www.dreamroutes.org/western/burudefalls.html. 11. http://www.karnataka.com 12. Mahima, B., Nayak,V. N., Chandran, M. D. S., and Ramachandra, T. V., 2014. Impact of hydroelectric projects on finfish diversity in the Sharavathi River estuary of Uttara Kannada District, central west coast of India, International Journal of Environmental Sciences, 5(1): 58-66 13. Mahima, B., Nayak, V. N., Chandran, M. D. S., and Ramachnadra, T. V., 2012, Impact of Hydroelectric Dams on Fisheries in the Sharavathi Estuary of Uttara Kannada District, National Conference on Conservation and

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16. Ramachandra, T. V., Chandran, M. D., Joshi, N. V., and Boominathan, M., 2012. Edible Bivalves of Central West Coast, Uttara Kannada District, Karnataka, India., Sahyadri Conservation Series 17, ENVIS Technical Report: 48, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
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23. Sreekantha., Gururaja, K. V., Ramadevi, K., Indra, T. J., and Ramacahndra, T.

V., 2006, Two Species of Fishes of the Genus Schistura McClelland(Cypriniformes:Balitoridae) from Western Ghats, India,

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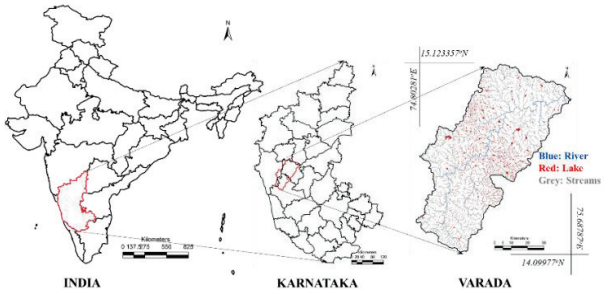
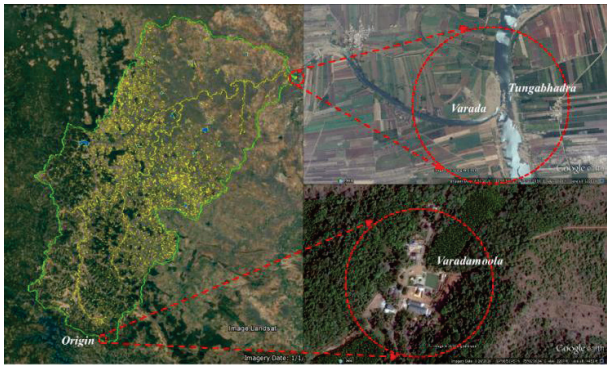
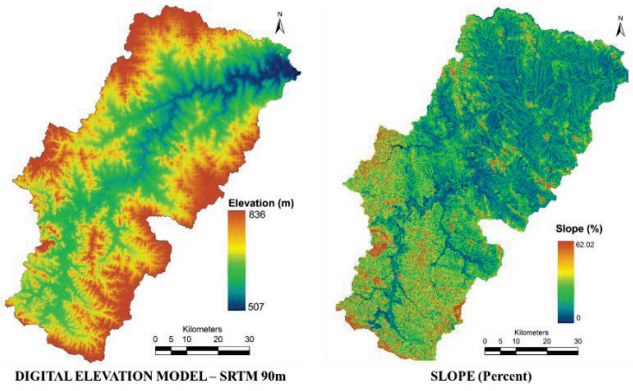
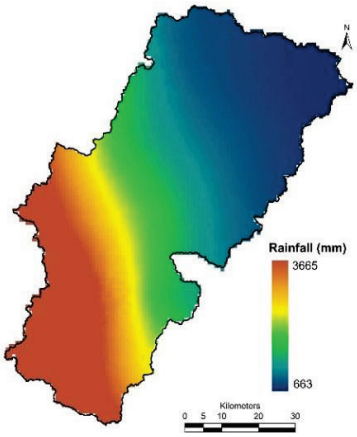
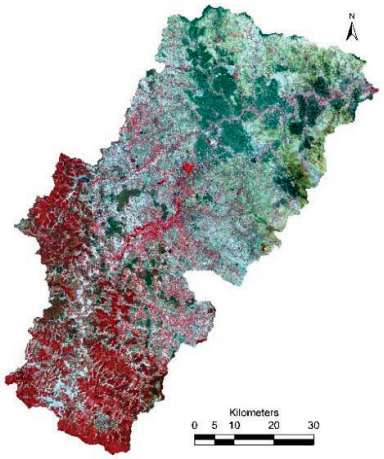
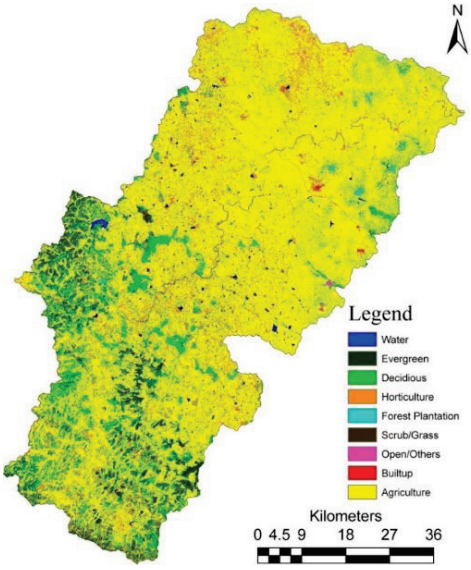
26. https://www.researchgate.net/profile/T_V_Ramachandra/publications
27. http://ces.iisc.ernet.in/energy
28. http://ces.iisc.ernet.in/biodiversity

5. VARADA RIVER

	River	Varada
1	Geography	River Varada is spread across Shimoga, Uttara Kannada and Haveri districts of Karnataka (Figure 1). Originating at Varadamoola (Figure 2) (Ramachandra et al 2014), Varada flows in the north east direction for a distance of nearly 198 km (Survey of India Topographic sheets,) before it joins Tungabhadra at Galagantha village Haveri district (Figure 2). Tributaries of Varada include, and many more. Varada river has a catchment area of 5135 sq.km.  **Figure 1: Varada River Location**  **Figure 2: Overlay of Google Earth**  **Figure 3: Topography** Topography of Varada river catchment is as depicted in Figure 3, elevation ranges between 507m and 836m w.r.t Mean Sea Level, slope of the catchment varies up to

		119%. The catchment has gentle slope flowing to the north eastern direction. Due to the flatter terrain, numerous lakes (over 4000) in the catchment could be observed which serves as a reserve, recharge pit, for fish culture, agriculture and other activities. Rock types: Granite, Schists, Porphyry, Chlorite, Limestone Ores: Iron, Manganese, Limestone, Clay Soil: Red Soil, Lateritic soils, Black soil, etc
2	Rainfall and Water Yield	Rainfall assessment in Varada catchment (Figure 4) indicates that rainfall in the catchment is orographic with annual rainfall varying spatially between 663mm at the plains of Haveri, to over 3600 mm at the Ghats of Sagar (Shimoga). Water yield in the catchment is 40 – 80 TMC  **Figure 4: Rainfall**
3	Anthropology	Population in the catchment (Figure 5) is about1234523. Population density in the catchment is 245 persons per square kilometer as on 2016. Major Population is contained at towns such as Sagara, Siddapura, Haveri, Sorab, Shiggaon, Savanur, Hangal. Agasanahalli, Byadgi, *etc.* Communities: Kumri Marati, Goudas, Konkanis. Havyaka Brahmin, , Nadavas, Kurubas, Siddis, Daivajna, Muslims, Lingayaths *etc.* (Chandran and Hughes 2000, Wikipedia, Gazetter of India-Uttara Kannada district, Mysore Gazetteer).
4	Culture, Heritage	Culture • Festivals and Jatras: Uura habba (Village Festival), Nadi habba (River festival), Renukanma jatra, Mari habba, Ganapathi jatra, Rameshwara Ratha jatra, Basaveshwara Jatra, Gam devara jatra, Nandi jatra, etc • Dance: Folk dances (suggi kunita), bharatha natya, Kolata, bedara kunita, dhamami kunita, Huli kunita, Yakshagana, Masti Kunita, Preta kuntia, Bedara kunita, Mandala kunita, etc • Music: Folk Songs, Garatiya Haadu, Halliya Haadu, Nadapadagalu, Bingina

		pada, Gumatepada, Jogavve haadu, Jogi pada, Badi vadya etc. • Traditional Games: Kallata, kavade, Channe mane, Karu aata, Katte aata, Hulighatta, Bandi aata, Devarata, Sariya mugila aata, Achchu aata, Chowkabara, Tabalamane, etc. Major temples in the catchment of Ikkeri, Keladi, Marikamba, Varadambe, Varadalli, Banavasi, Chandragutgi, Tarakeshwara, Siddeswhara, Kaginele, Kedareswhara, Bankapura, Hosagunda, Ranganatha etc and many deities of the sacred groves.
5	Land use dynamics	Land use analysis as on 2013 show that the catchment is dominated by agricultural activities towards the plains (69.11% of the total catchment) and plantation activities in the Ghats. Forests cover only 15.4% of the entire catchments, dominated at Ghats. Figure 5 depicts FCC , Figure 6 and Table 1 depicts land use in the catchment as on 2013.  **Figure 5: False colour composite**  **Figure 7: Land use dynamics in Varada Catchment**

<table>
<tr><td></td><td></td><td>Table1: Land use in Varada Catchment
<table>
<tr><th>Land use</th><th>Area (%)</th></tr>
<tr><td>Water</td><td>1.08</td></tr>
<tr><td>Evergreen Forest</td><td>5.24</td></tr>
<tr><td>Deciduous Forest</td><td>10.23</td></tr>
<tr><td>Horticulture</td><td>6.95</td></tr>
<tr><td>Forest Plantation</td><td>3.45</td></tr>
<tr><td>Scrub/Grass</td><td>1.26</td></tr>
<tr><td>Open/Others</td><td>1.95</td></tr>
<tr><td>Built up</td><td>0.74</td></tr>
<tr><td>Agriculture</td><td>69.11</td></tr>
</table></td></tr>
<tr><td>6</td><td>Agriculture, Irrigation</td><td>Variety of Paddy, Sugar cane, Jowar, Ragi, Cotton, Maize, Pineapple, Ginger, Banana, Arecanut, Coconut, Mango, spices, etc.</td></tr>
<tr><td>7</td><td>Diversions</td><td>Numerous barrages, check-dams, lakes for maintaining water demand of agriculture and horticulture crops.</td></tr>
<tr><td>8</td><td>Bio Diversity</td><td>Flora: http://wgbis.ces.iisc.ernet.in/biodiversity/database_new (Sorba, Sagara,) Forest types found in the district are: Evergreen, Semi Evergreen, Moist Deciduous, Scrub, Thorny, un wooded with following species.
Actinodaphne hookeri, Adina cordifolia, Aglaia ananmallayana, Aglaia roxburghiana, Alangium salvifolium, Albizia sp, Alseodaphne semicarpifolia, Alstonia scholaris, Antiaris toxicaria, Aphanamixis polystachya, Aphananthe cuspidata, Aporosa lindleyana, Artocarpus gomezianus, Artocarpus heterophyllus, Artocarpus hirsutus, Beilschmiedia fagifolia, Bombax ceiba, Butea monosperma, Calicopteris floribunda, Careya arborea, Caryota urens, Casearia championii, Cassine glauca, Celtis cinnomomea, Chrysophyllum roxburghii, Chukrasia tabularis, Clausena anisata, Cleidion javanicum, Cordia sp, Dalbergia latifolia, Dalbergia sympathetica, Diospyros crumenata, Diospyros montana, Diospyros oocarpa, Diospyros sylvatica, Drypetes confertiflora, Dysoxylum malabaricum, Entada pursaetha, Ervatamia heyneana, Erythrina variegata, Fagraea ceilanica, Ficus callosa, Ficus nervosa, Ficus tsjahela, Flacourtia montana, Glochidion zeylanicum, Gnetum ula, Grewia tiliifolia, Harpullia imbricata, Holigarna arnotiana, Holigarna beddomii, Holigarna ferruginea, Holigarna grahamii, Hydnocarpus laurifolia, Ipomoea sp, Ixora brachiata, Knema attenuata, Lagerstroemia microcarpa, Lannea coromandelica, Linociera malabarica, Macaranga peltata, Mammea suriga, Mangifera indica, Margaritaria indica, Memecylon talbotianum, Merremia emarginata, Mimusops elengi, Mussaenda belilla, Nothapodytes foetida, Olea dioica, Phyllanthus emblica, Pterocarpus marsupium, Pterospermum reticulatum, Sapindus emarginatus, Sapindus</td></tr>
</table>

		laurifolia, Saraca asoca, Schefflera wallichiana, Spatholobus parviflorus, Spondias pinnata, Sterculia guttata, Stereospermum tetragonum, Streblus asper, Strombosia ceylanica, Strychnos nuxvomica, Syzygium cumini, Terminalia alata, Terminalia bellirica, Terminalia chebula, Terminalia paniculata, Tetrameles nudiflora, Tetrastigma gamblei, Toddalia asiatica var floribunda, Toona ciliata, Trema orientalis, Uvaria narum, Vengueria spinosa, Ventilago madraspatana, Vepris bilocularis, Vitex altissima, Xantolis tomentosa, Xeromorphis spinosa, Xylia xylocarpa, Zanthoxylum rhetsa. **Fauna: :** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new **Mammals:** Tiger (Ghats), Black Panther, Leopard, Bison, Gaur, Hare, Wild Boar, Sloth Bear, Deer, Thar, Bonnet Macaque, Giant Squirrel, Hanuman Languor, Fox, etc **Reptiles:** Snakes (Vipers, Cobra, Rat snake, Krait, King cobra, Python, Wolf snake, *etc*), Monitor Lizard.
9	References	1. Survey of India Topographic Sheets, 1:50000 scale. 2. Water Resource Information System of India, http://www.india-wris.nrsc.gov.in. 3. Google Earth, https://www.google.com/earth/. 4. Census of India, 2001 and 2011, censusindia.gov.in. 5. Ramachandra, T. V., Chandran, M. D. S., Vinay, S., Bharath, H. Aithal., 2014, Water Scarcity in Varada Catchment: Need to arrest Deforestation on Priority, ENVIS Technical Report No. 82, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012, India 6. ENVIS Sahyadri Web Portal, http://wgbis.ces.iisc.ernet.in/biodiversity/database_new/ 7. Chandran, M. D. S., and Hughes, J. D., 2000, Sacred Groves and Conservation: The Comparative History of Traditional Reserves in the Mediterranean Area and in South India, Environment and History, 6, 2, 169–186. 8. Gazetter of India, Uttara Kannada district, 1985 9. Mysore Gazetteer, Volume 5, Part 2, 2011. 10. https://www.researchgate.net/profile/T_V_Ramachandra/publications 11. http://ces.iisc.ernet.in/energy 12. http://ces.iisc.ernet.in/biodiversity

6. VENKARAPURA RIVER

	River	Venkarapura
1	Geography	River Venkatapura is spread across the Western Ghats in Uttara Kannada and Shimoga districts of Karnataka (Figure 1). Originating at Sagara (Figure 2), Originating near Bhimeshwara temple -Sagara (Shimoga), Venkarapura flows for a distance of nearly 50 km (Survey of India Topographic sheets, High resolution satellite data-optical and radar) before it joins Arabian Sea at Alvekodi/ Tenginagundi - Bhatkal (Uttara Kannada) (Figure 2). Tributaries of Venkatapura include, Chitihalla, Katagar Nala, Basti Halla, Kitreholé, Venkatapura river and many more. Venkatapura river has a catchment area of 459.70 sq.km spread across districts of Uttara Kannada (Bhatkal) and Shimoga (Sagar).

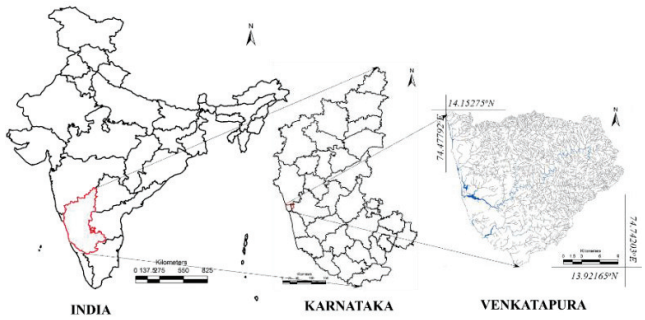


Figure 1: Venkatapura River Location

Figure 2: Overlay of Google Earth

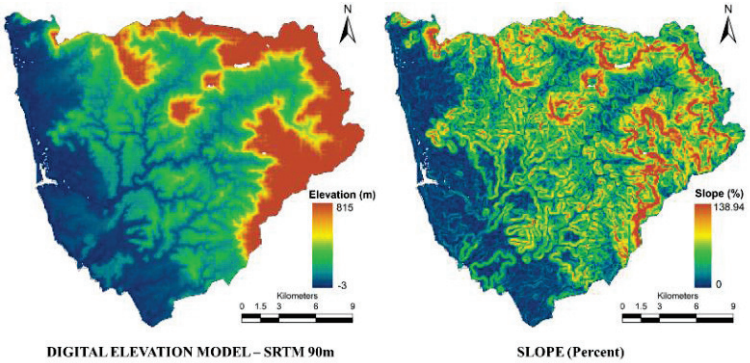
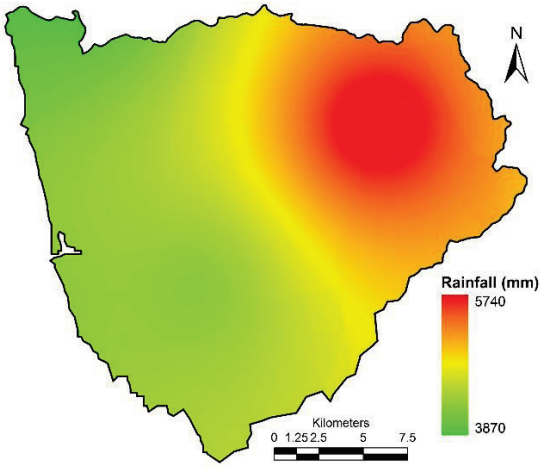
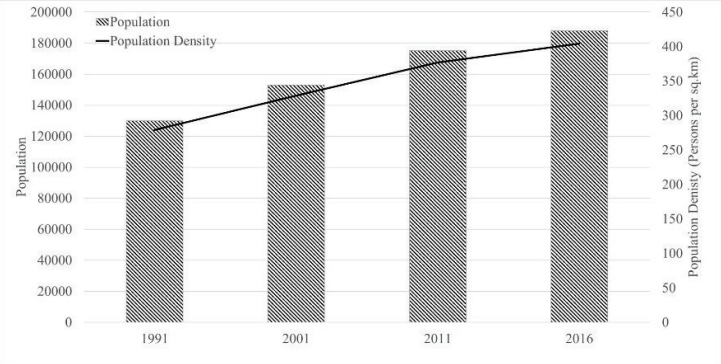


Figure 3: Topography

		Topography of Venkatapura river catchment is as depicted in Figure 3, elevation ranges between < 0m and 815m w.r.t Mean Sea Level, slope of the catchment varies up to 119%. Very high slope we observed in the Ghats (Kogar Ghat). Water falls such as the Bhimeshwara falls *etc* form in the Ghats of Venkatapura. Rock types: Granites to schists, shale, quartzite's, Phyllites. Ores: Iron, limestone, bauxite, quartz, limestone, sand, clay, shell, Manganese, Asbestos, Mica,Bauxitr Soil: Red Soil, Lateritic soils, Black soil, etc
2	Rainfall and Water Yield	Rainfall assessment in Venkatapura catchment (Figure 4) indicates that rainfall in the catchment is orographic with annual rainfall varying spatially between 3700mm at the plains of coast, to over 5700 mm at the Ghats. Water yield in the catchment is 8 - 16 TMC  **Figure 4: Rainfall**
3	Anthropology	Population in the catchment (Figure 5) has increased from 153032 in 2001 to 175279 in 2011 (Census of India) and is projected to increase to 188020 in the year 2016 at a growth rate of 14.5% per decade. Population density in the catchment is 404 persons per square kilometer as on 2016. Major Population is contained at towns/villages such as Bhatkal, Shirali, Heble. Communities: Ambiga, Bedar, Devadiga, Devali, Havyaka Brahmin, Kurubas, Siddis, Konkani Kharvi, Kumri Maratha,Namadhari, Muslims, Jains, *etc.* (Chandran and Hughes 2000, Gazetter of India-Uttara Kannada district).

		 **Figure 5: Population dynamics in Venkatapura river catchment**
4	History, Culture, Heritage	River Venkatapura has history beyond the Himalayas i.e., 88 Million year compared to Himalayas (50 Million years). Epic of Mahabharatha explains about Bheemeshwara temple, that was constructed by Bheema, during the agnaythavasa and was established by Dharmaraya on Shivrathri. Arjuna bowed an arrow at the nearby mountain to bring the water for worship which is there even today as Sarala river which has not drained out so far (Tripadvisor web portal). Culture • Festivals and Jatras: Hanumantha devara rathotsava, Mahasati Jatra, Mari jatra, Bhavani shankara rathotsava, Mahaganapathi rathotsava,Uura habba (Village Festival), Nadi habba (River festival), Bandi habba, Vadya Panchami, Mahamay jatra, Durga devi jatra, Kannika parameshwari jatra, Shantika parameshwari jatra, Venkataramana jatra, etc • Dance: Folk dances (suggi kunita), bharatha natya, Kolata, bedara kunita, dhamami kunita, Huli kunita, Yakshagana, Masti Kunita, Preta kuntia, Bedara kunita, Mandala kunita, etc • Music: Folk Songs, Garatiya Haadu, Halliya Haadu, Nadapadagalu, Bingina pada, Gumatepada, Jogavve haadu, Doni pada, Jogi pada, Badi vadya etc. • Traditional Games: Kallata, kavade, Channe mane, Karu aata, Katte aata, Hulighatta, Bandi aata, Devarata, Sariya mugila aata, Achchu aata, Chowkabara, Tabalamane, etc. Religious places in the catchment of Venkatapura includes: Bastis, Khetappayya Narayana,Chindnadapalli mosque etc.
5	Land use dynamics	Land use analysis of 2013 show that the catchment is dominated by evergreen forest cover (~42.7%), followed by Agriculture (~21.8%), etc. Figure 6 depicts FCC, Figure 7 and Table 1 depicts land use in the catchment as on 2013.

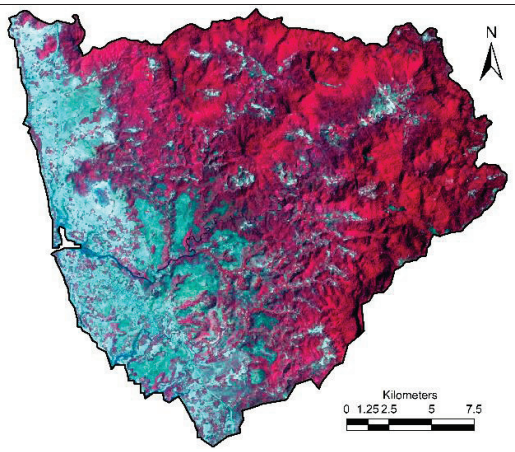


Figure 6: False colour composite

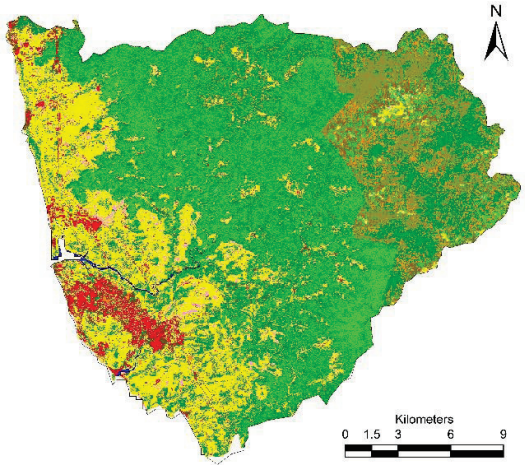


Figure 7: Land use of Venkatapura Catchment

Table1: Land use in Venkatapura Catchment

Land use	2013
Built up	3.8%
Water	0.4%
Crop land	21.8%
Open Space	2.5%
Moist Deciduous	13.5%
Evergreen - Semi Evergreen Forest	42.7%
Scrub/Grass land	2.2%

			Acacia/Eucalyptus/Casuarina	7.3%
			Teak/Bamboo/Cashew	0.8%
			Arecanut/Coconut	5.1%
6	Agriculture, Irrigation	Variety of Paddy, Sugar cane, Banana, Arecanut, Coconut, Mango, spices, etc.		
7	Diversions	No Major Diversion works in the catchment		
8	Bio Diversity	**Bivalves: Ramachandra et al 2012** *Villorita cyprinoides* **Flora:** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new **(Sagara, Bhatkal Taluks)** Forest types found in the district are: Evergreen, Semi Evergreen, Moist Deciduous, Scrub, Thorny, un wooded with following species. *Actinodaphne hookeri, Aglaia ananmallayana, Aglaia roxburghiana, Ailanthus excelsa, Alphonseo sp, Alstonia scholaris, Ancistrocladus hamatus, Aphananthe cuspidata, Aporosa lindleyana, Artabotrys hexapetalus, Artocarpus gomezianus, Artocarpus hirsutus, Beilschmiedia fagifolia, Bischofia javanica, Calophyllum polyanthum, Canarium strictum, Canthium dicoccum, Canthium parviflorum, Caryota urens, Casearia championii, Cassine glauca, Celtis cinnomomea, Chrysophyllum roxburghii, Cinnamomum macrocarpum, Cinnamomum malabathricum, Dillenia pentagyana, Dimocarpus longan, Diospyros buxifolia, Diospyros candolleana, Diospyros montana, Diospyros paniculata, Diospyros sylvatica, Dipterocarpus indicus, Elaeocarpus serratus, Entada pursaetha, Ervatamia heyneana, Ficus nervosa, Flacourtia montana, Garcinia gummi_gutta, Garcinia morella, Glochidion zeylanicum, Gnetum ula, Harpullia imbricata, Holigarna arnotiana, Holigarna ferruginea, Holigarna grahamii, Holigarna nigra, Homalium ceylanicum, Hopea ponga, Hydnocarpus laurifolia, Ixora brachiata, Knema attenuata, Lagerstroemia microcarpa, Linociera malabarica, Litsea floribunda, Lophopetalum wightianum, Macaranga peltata, Mallotus philippensis, Mangifera indica, Mimusops elengi, Myristica dactyloides, Nothopegia racemosa, Olea dioica, Persia macarantha, Pittosporum dasycaulon, Pterospermum diversifolium, Pterospermum reticulatum, Schleichera oleosa, Sterculia guttata, Stereospermum tetragonum, Strombosia ceylanica, Symplocos racemosa, Syzygium cumini, Syzygium laetum, Syzygium travancoricum, Terminalia bellirica, Tetrameles nudiflora, Trichilia connaroides, Vitex altissima, Xantolis tomentosa.* **Fauna: : http://wgbis.ces.iisc.ernet.in/biodiversity/database_new**		

		Mammals: Tiger, Black Panther, Leopard, Bison, Gaur, Hare, Wild Boar, Sloth Bear, Deer, Thar, Bonnet Macaque, Lion Tailed Macaque, Giant Squirrel, Hanuman Languor. **Reptiles:** Snakes (Vipers, Cobra, Rat snake, Krait, King cobra, Python, Wolf snake, *etc*), Monitor Lizard, etc.
9	References	1. Survey of India Topographic Sheets, 1:50000 scale. 2. Water Resource Information System of India, http://www.india-wris.nrsc.gov.in. 3. Google Earth, *https://www.google.com/earth/*. 4. Census of India, 2001 and 2011, censusindia.gov.in. 5. Wild Wonderful Karnataka, a. http://www.dreamroutes.org/western/burudefalls.html. 6. ENVIS Sahyadri Web Portal, a. http://wgbis.ces.iisc.ernet.in/biodiversity/database_new/ 7. Chandran, M. D. S., and Hughes, J. D., 2000, Sacred Groves and Conservation: The Comparative History of Traditional Reserves in the Mediterranean Area and in South India, Environment and History, 6, 2, 169–186. 8. Gazetter of India, Uttara kannada district, 1985 9. Ramachandra, T. V., Chandran, M. D., Joshi, N. V., and Boominathan, M., 2012. Edible Bivalves of Central West Coast, Uttara Kannada District, Karnataka, India., Sahyadri Conservation Series 17, ENVIS Technical Report: 48, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012. 10. https://www.researchgate.net/profile/T_V_Ramachandra/publications 11. http://ces.iisc.ernet.in/energy 12. http://ces.iisc.ernet.in/biodiversity

7. CAUVERY RIVER

Cauvery (or Kaveri) is the largest river in the state and originates at Talakaveri in Coorg. It is often called the Dakshina Ganga (the Ganges of the South) and considered one of the sacred rivers of India. the origin of the River Kaveri, is a famous pilgrimage and tourist spot set amidst Bramahagiri Hills near Madikeri in Coorg. The tributaries of the Kaveri include: Harangi, Hemavathi (origin in western Ghats joins the river Kaveri near Krishnarajasagar), Lakshmanatirtha, Kabini (originates in Kerala and flows eastward and joins the Kaveri at Tirumakudal, Narasipur), Shimsha, Arkavati, Suvarnavathi or Honnuholé, Bhavani, Lokapavani, Noyyal, Amaravati

Salient Features of Cauvery Basin

1	Catchment Area (Sq. Kms)	81,155
2	Basin Extent - Longitude Latitude	75° 30’ to 79° 45’ E 10° 05’ to 13° 30’ N
3	Length of Cauvery River (Km)	800
4	Average Water Resource Potential (MCM)	21358
5	Utilizable Surface Water Resource (MCM)	19000
6	Live Storage Capacity of Completed Projects (MCM)	8978.00
7	Live Storage Capacity of Projects under cnstruction (MCM)	15.0
8	Total Live Storage Capacity of Projects (MCM)	8993.00
9	No. of Hydrological Observation Stations (CWC)	34
10	No. of Flood Forecasting Stations (CWC)	-

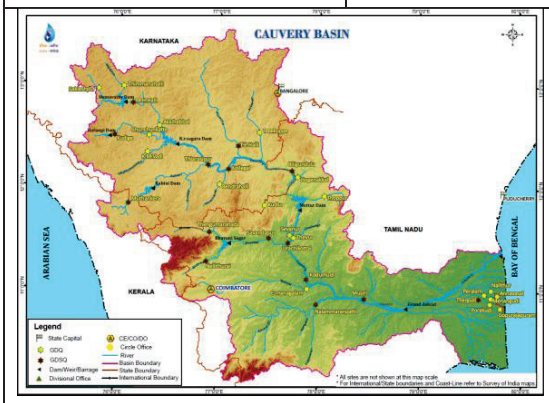
Brief Description

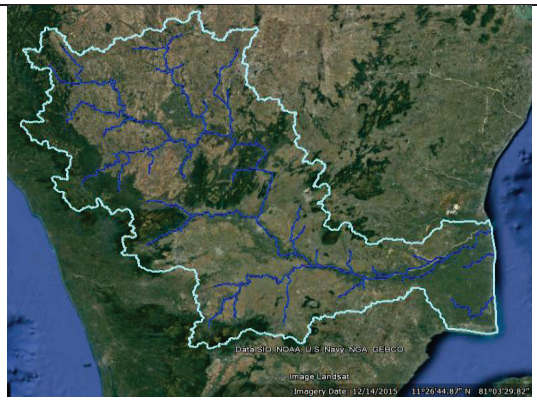
- The Cauvery River rises in the Western Ghats and flows in eastwardly direction passing through the states of Karnataka, Tamil Nadu, Kerala and Pondicherry before it drains into Bay of Bengal. The basin lies between latitudes 10^0 05’ N and 13^0 30’ N and longitudes 75^0 30’ E and 79^0 45’ E.

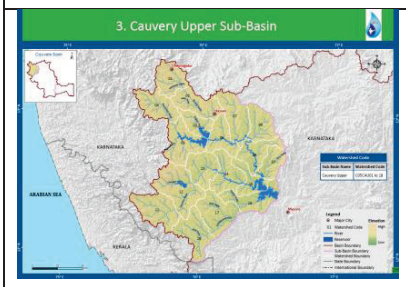
- It is bounded on the west by the Western Ghats, on the east and south by the Eastern Ghats and on the north by the ridges separating it from

the Tungabhadra (Krishna) and Pennar basins.

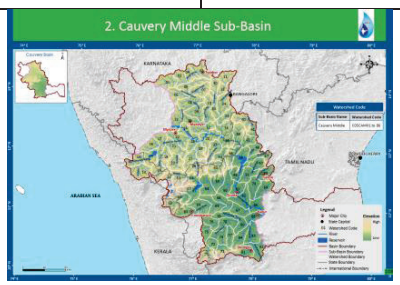
- The total length of the river from source to its outfall into Bay of Bengal is about 800 km. Of this, 320 km is in Karnataka, 416 km is in Tamil Nadu and 64 km forms the common boundary between Karnataka and Tamil Nadu States.
- The Cauvery basin extends over an area of 81,155 km^2, which is nearly 24.7% of the total geographical area of the country
- The basin lies in the States of Tamil Nadu (55.44%), Karnataka (41.23%), Kerala (3.33%).and Pondicherry
- The shape of the basin is somewhat rectangular with a maximum length and breadth of 360 km and 200 km, respectively.



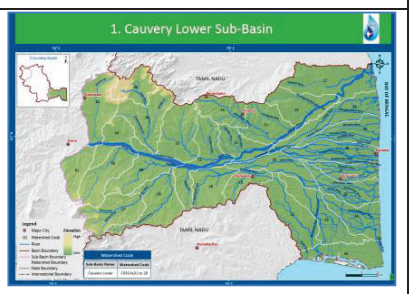




Upper Sub-Basin (WRIS)

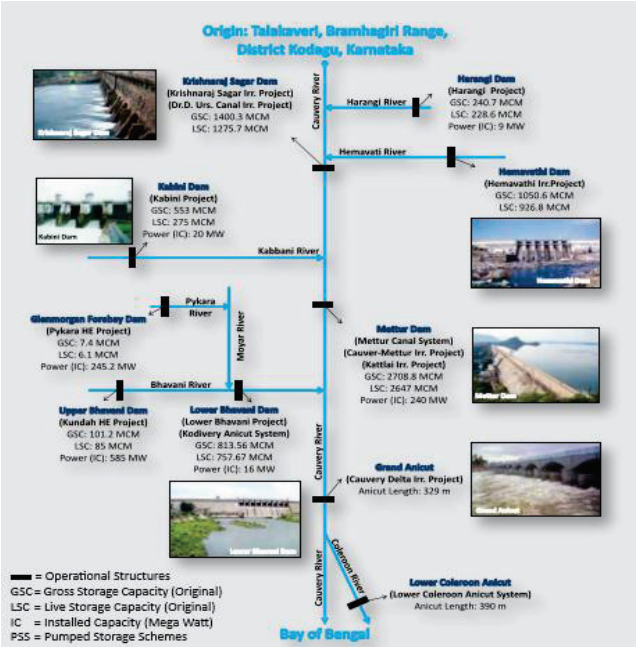


Middle (WRIS Portal)

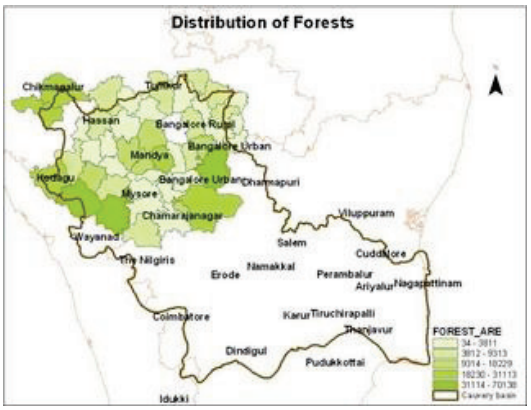


Lower basin (WRIS Portal)

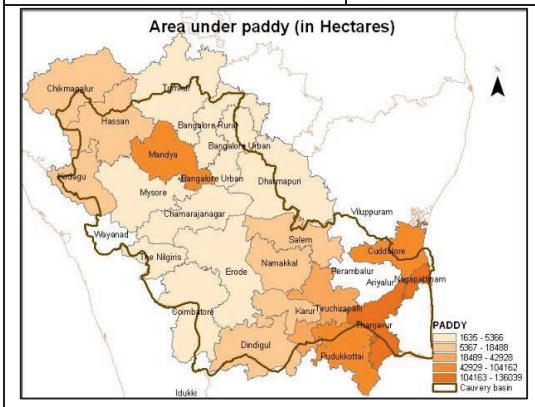
Flow of river Cauvery (Source: WRIS Portal http://wrmin.nic.in)

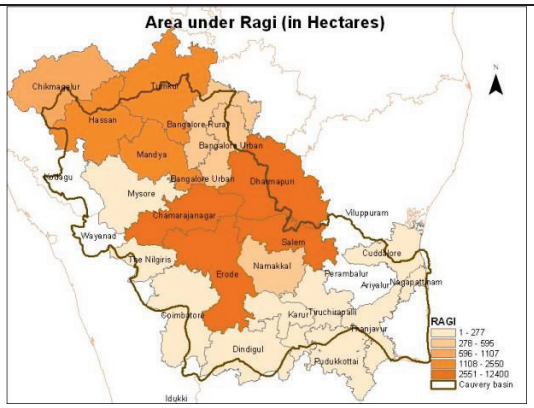


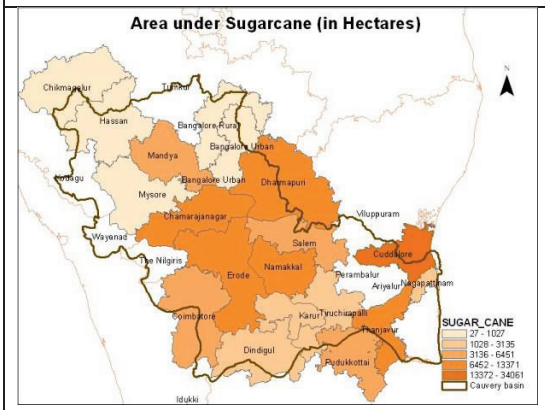
Physiography	Physiographically, the basin can be divided into three parts: the Western Ghats area, the Plateau of Mysore and the Delta. The delta area is the most fertile tract in the basin.		
Drainage Area (Km^2)	Statewise Drainage Area (Km^2)	Name of State	Drainage area
		Tamil Nadu	43,867
		Karnataka	34,273
		Kerala	2,866
		Pondicherry	149
	Total Drainage Area (Km^2)		81,155
Geology of the Basin	The geology of the drainage basin is predominantly formed from Precambrian rocks, principally the Dharwars, Peninsular granitic Gneiss, Charnockites and the Closepet Granite. The Dharwar metamorphics mainly comprise of phyllites, slates, schists with chlorite, biotite, garnet, and hornblende. Accompanying these are greenstones and quartzite. The Closepet Granite of the upper reaches of the Cauvery basin is a pink granite consisting mainly of quartz, plagioclase, microcline, perthite, and subordinate hornblende. Over the main basin, the peninsular granites and gneisses comprising of biotite granitic		

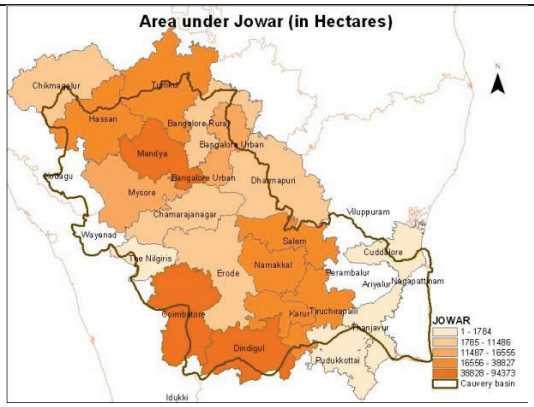
	gneiss, hornblende granitic gneiss are widely found. The Charnockites are confined to the Nilgiri Range in the central part of the drainage basin. These are represented by gabbros, olivine norites, and pyroxene. Cretaceous sediments crop out in the coastal region and consist of conglomeratic sandstone, coralline limestone, and shale.
Soil of the Basin	The principal soil types found in the basin are black soils, red soils, laterites, alluvial soils, forest soils, and mixed soils. Red soils occupy large areas in the basin. Alluvial soils are found in the delta areas. The culturable area of the basin is about 58,000 km^2 which is about three percent of the culturable area of the country.
Forest 	Out of the total area of the basin, the area under forest is just 19.53%. In Kerala part of the basin, the forest cover is much higher but considering that area forms a small part of the basin, this comes out to be negligible. The forest cover is much below the desirable forest cover of 33%. The minimal forest cover is in the districts of Thanjavur (1.5%), Tumkur (2%) and Mandya (4.8%). These forests are ecologically unique and very rich. Home to some of the unique flora and fauna, the area is famous for its many sanctuaries.
Climate of Cauvery Basin	Cauvery basin experiences tropical climate. Here, the main climatic feature is the monsoon rain. The north-east monsoon provides the greater portion of the annual precipitation. The far north-western part of the drainage basin has a per-humid climate which passes eastwards into humid, moist sub-humid, dry sub-humid and semi-arid zones. The recorded maximum and minimum temperatures are 44°C and 18°C respectively. The highest rainfall in the basin is received along the western border of the basin during the southwest monsoon. The eastern side of the basin gets most of the rain during the northeast monsoon. Depressions in the Bay of Bengal affect the basin in the monsoon, causing cyclones and widespread heavy rains

Water Potential of the Basin	Surface Water potential	66.88 km^3
	Ground Water potential	16.46 km^3
Major Tributaries with drainage area in sq. km.	The important tributaries joining Cauvery in the Coorg district are the Kakkabe, the Kadanur and the Kummahole. Cauvery then enters the Mysore district where important tributaries joining the river from the left are the Harangi, the Hemavathi, the Shimsha and the Arkavathi. The tributaries joining it from the right are the Lakshmanathirtha, the Kabbani, and the Survanavathi. Further down, the river enters Tamil Nadu state where the many tributaries, namely, the Bhavani, the Noyil, and the Amravathi join it.	
Major Projects	Krishnaraja sagar dam, Nugu, Mettur and Grand Anicut projects	
Agriculture	The major part of basin is covered with agricultural land accounting to 66.21% of the total area and 4.09% of the basin is covered by water bodies. The basin spreads over 33 parliamentary constituencies (2009) comprising 18 of Tamil Nadu, 11 of Karnataka, 3 of Kerala and 1 of Puducherry.	









Water Quality	Several studies were made by the Central Pollution Control Board to ascertain the status of water quality in the Cauvery River. The results show that at many places, the quality of water was quite poor compared to what was the desired class.
Problems in the Basin	Occasional flood problem in lower reaches and delta areas of Cauvery river.
Mythology	The Cauvery River, also known as Dakshin Ganga or 'Ganga of South', is one of the holy rivers of South India.

References

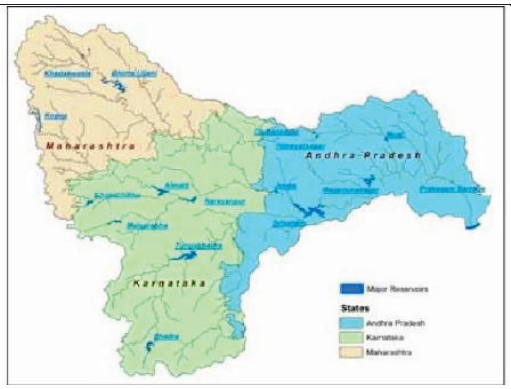
1. Water Resource Department, http://waterresources.kar.nic.in/river_systems.htm,Date of access 07.09.2016
2. http://wrmin.nic.in/forms/list.aspx?lid=378, Date of access 07.09.2016
3. http://www.india-wris.nrsc.gov.in/wrpinfo/index.php?title=Cauvery, Date of access 07.09.2016

8. KRISHNA RIVER

Brief Description: Krishna is second largest river in peninsular India, rises in the Western Ghats at an altitude of 1337 m. near Mahabaleshwar in Maharashtra State, about 64 km from the Arabian Sea*(*http://*nihroorkee.gov.in/)*. On the north, the basin is bounded by the range separating it from the Godavari basin, on the south and east by the Eastern Ghats and on the west by the Western Ghats. It flows across the whole width of the peninsula, from west to east, for a length of about 1400 km, through Maharashtra (a distance of 305 km; catchment area 69,425 sq.km), Karnataka (length 483 km; catchment area 113,271 sq.km) and Andhra Pradesh (length 612 km; catchment area76,251 sq.km). Krishna basin lies between latitudes 13° 07' N and 19° 20' N and longitudes 73° 22' E and 81° 10' E with the catchment area of 2,58,948sq km., spanning across the three major basin states (Maharastra (26.81%), Karnataka (43.74%) and Andhra Pradesh(29.45%)). It originates in Maharashtra and passes through Karnataka. The principal tributaries of the Krishna in Karnataka are: Ghataprabha (Origin in the Western Ghats and flows eastwards and joins the river Krishna. The river forms the well-known Gokak Falls in Belgaum District), Malaprabha (origin in Western Ghats and flows first in easterly and north-easterly directions and joins river Krishna at Kudalasangama), Bhima (originates in the forest of Bhimashankar in Pune, and flows through the states of Maharashtra and Karnataka and joins Krishna near Kudlu in Raichurtaluk and Tungabhadra (formed in the district of Shimoga, by the union of the Tunga and the Bhadra rivers. The river Tungabhadra flows east across the Deccan Plateau and join river Krishna in Andhra Pradesh).

http://India-wris.nrsc.gov.in

State-wise Drainage area of the Basin



State wise	Drainage area (Km^2)
Maharashtra	**69,425**
Karnataka	**113,271**
Andhra Pradesh	**76,252**
Total	**258,948**

Details of the principal tributaries of Krishna in Karnataka are Ghataprabha, Malaprabha, Bhima and Tungabhadra and details (catchment area, altitude, length) are given below:

Name of the tributary	Catchment Sq.kms	Origin , Altitude & Length	Sub-tributaries	Name of the state
Ghataprabha	8,829	Western Ghats, 884 m, 283 kms	Hiranyakeshi, Markandeya	Maharshatra, Karnataka
Malaprabha	11,549	Western Ghats, 792.48 m, 306 kms	Bennihalla, Hirehalla, Tasnadi	Karnataka
Bhima	70,614	Western Ghats, 945 m, 861 kms	Combined waters of Mula and MuthaGhod, Nira,Sina	Maharastra, Karnataka
Tungabhadra	71,417	Western Ghats at Gangamula, 1198 m, 531 kms	Combined waters of Tunga and Bhadra, Varada, Hagari (vedavathy)	Karnataka & Andhra Pradesh

Tungabhadra River	Tungabhadra River also known as Pampa or Hampiis formed by the Tunga River and Bhadra River that originate in the Western Ghats and flows in Karnataka and Andhra Pradesh. The Tunga and Bhadra Rivers rise at Gangamoola, in VarahaParvatha in the

	Western Ghats forming parts of the Kuduremukh, at an elevation of 1198 metres. Bhadra flows through Bhadravati city and is joined by numerous streams. At Koodli, a small town near Shimoga City, Karnataka, these two rivers meet (Tungabhadra) and then Thungabhadra meanders through the plains to a distance of 531 km and mingles with the Krishna at Gondimalla, near Mahaboobnagar in Andhra Pradesh. **Significance ofTungabhadra River are:** • Presence of ancient and holy sites on the banks, for example Harihareshwara temple at Harihara. • The river surrounds the modern town of Hampi, where are the ruins of Vijayanagara, the site of the powerful Vijayanagara Empire's capital city and now a World Heritage Site. • Alampur, on the left – northern bank of the river, known as DakshinaKashi in Mahabubnagar Dist. The Nava Brahma Temples complex is one of the earliest models of temple architecture in India. • Bhadravthi, Hospet, Hampi, Mantralayam, Kurnool are located on its bank. **Tributaries of Tungabhadra:**Tunga River, Kumudvati River, Varada River, Bhadra River, Vedavathi River, Handri River
Bhima River	Bhima River originates in Bhimashankar hills near Karjat in Maharashtra and flows southeast for 861 km through Maharashtra, Karnataka, Andhra Pradesh states. Bhimariver catchment is densely populated and form a fertile agricultural area. During its 861 km journey, many smaller rivers flow into it. Kundali River, Kumandala River, Ghod river, Bhama, Indrayani River, Mula River, Mutha River and Pavna River are the major tributories of this river around Pune. Of these Indrayani, Mula, Mutha and Pawana flow through Pune and PimpriChinchwad city limits. Chandani, Kamini, Moshi, Bori, Sina, Man, Bhogwati and Nira are the major tributaries of the river in Solapur. Of these Nira river meets with the Bhima in Narsingpur, in Malshirastaluka in Solapur district. Tributaries of Bhima are: Ghod, Sina, Kagini, Bhama, Indrayani, Mula-Mutha, Nira. Significance of this river are: • Pandharpurcity of is on the bank of Bhima River. • Bhimashankar is one of the twelve esteemed Jyotirlinga shrines.Other temples are Siddhatek, Siddhivinayak Temple of Ashtavinayak Ganesh PandharpurVithoba Temple in Solapur district., Sri Dattatreya Temple, Ganagapura, Gulbarga district, Karnataka, Sri KshetraRasangiBalabheemasena Temple in Rasanagi, JevargiTaluq, Gulbarga district, Karnataka

Malaprabha River	Malaprabha River It rises at Kanakumbi in the Belgaum district and joins Krishna River at Kudalasangama in Bagalkot district. It also flows through Dharwar District. Hubli city gets its drinking water from this reservoir. Tributaries of Malprabha: Bennihalla, Hirehalla and Tuparihalla are the major tributaries to Malaprabha.		
Ghataprabha River	Ghataprabha is a tributary of Krishna that flows in Karnataka with the hydroelectric and irrigational dam at Hidkal. Tributaries of Ghataprabha: Hiranyakeshi and Markandeya rivers are tributaries of Ghataprabha.		
Other tributaries are: Other tributaries are Koyna River (catchment: 4,890 **Km^2)** ,Kudali river, Venna River, Yerla River, Warna River, Dindi River (**3,490 Km^2**), Halia (**3,780 Km^2**), **Peddavagu (2,343 Km^2),** Paleru River, Musi River (**11,212 Km^2**), Urmodi River, Tarli River and Dudhganga River. The rivers Venna, Koyna, Vasna, Panchganga (**2,575 Km^2)**, Dudhganga (**2,350 Km^2)**, Ghataprabha, Malaprabha and Tungabhadra join Krishna from the right bank; while the Yerla River, Musi River, Halia, Maneru and Bhima rivers join the Krishna from the left bank.		
Geology of the Basin	The geology of the Krishna basin is dominated in the northwest by the Deccan Traps, in the central part by unclassified crystallines, and in the east by the Cuddapah Group. The Dharwars (southwest central) and the Vindhian (east central) form a significant part of the outcrops within the unclassified crystallines. Krishna delta is predominantly formed by Pleistocene to recent material.		
Water Potential	Surface Water potential		78.1 km^3
	Ground Water potential		26.41 km^3
Hydropower Potential	Nagarjunsagar	815	
	Nagarjunsagar RC	91	
	Nagarjunsagar CH	61	
	Srisailam	770	
	Srisailam LB	900	
Water Utilization	Surface Water Utilization		Drinking
			Irrigation
	Ground Water Utilization		Drinking
			Irrigation purposes
Major Projects	Upper Krishna Project Stage-1,Upper Krishna Project Stage-2, Srisailam dam, Pulichintala project,Nagarjunasagar project,Ghatprabha dam, Tungabhadra project, VanivilasSagar project,Bennihora project,Bhadha Reservoir project,Bhima Irrigation project,Hipparagi Barrage, Malprabha project, Upper Tunga project,Koyna dam,Markendaya project, Singatalurlift irrigation, Krishna irrigation project, OsmanSagar reservoir and Prakasam barrage.		

Water Quality of the Basin	Due to the sustained inflow of untreated sewage and industrial effluents, the water quality is very poor evident from higher values of BOD, lower values of DO and the presence of total coliform.
Problems in the Basin	The Krishna basin particularly in east coast faces periodically flood problems in the wake of cyclonic storms.
Mythology	Krishna is a mighty east flowing river of peninsular India. It is the same river as Krsnavena in the Puranas or Krsnaveni in the Yoginitantra. It is also known as Kanhapenna in Jatakas and Kanhapena in the Hathigumpha inscription of Kharavela. The word *Krishna* also indicates dark color
Important places	**Mahabaleshwar**the 'land of five rivers - Krishna, Koyna, Venna, Gayatri and Savitri'is located at an altitude of 1,372 meters in the Western Ghats. Some of tourist locations are: Lodwick Point, Arther Point,Elphinstone Point, Tiger's Spring, Kate's Point, Bombay Point, Wilson Point, Venna Lake and Kate's Point, Lingmala, Chinaman and Dhobi waterfalls (http://www.gktoday.in/blog/krishna-river/). **Srisailam**(in Andhra Pradesh) is a holy town with a sanctuary (an area of 3568 sqkms) located on the banks of the Krishna. Srisailam is surrounded by lush greenery and has beautiful locations around.Krishna river meanders through Narsobachi, Wadi in Maharashtra and flows through Karnataka to Andhra Pradesh. **NagarjunaSagar**or NagarjunaSagar Dam (one of the world's largest man-made lake) stretches across the mighty river Krishna. Nagarjunakonda was the largest and most important Buddhist centres in South India. **Amaravati**is a small town in Guntur district of Andhra Pradesh and was once the capital of Satavahanas. The Shiva temple is with five lingams -Pranaveswara, Agasteswara, Kosaleswara, Someswara and Parthiveswara. The remains of a 2000-year-old Buddhist settlement along with the great Buddhist stupa are among the main attractions in Amaravati. Mahachaitya or the Great Stupa was constructed approximately 2000 years ago. The stupa is made of brick with a circular vedika and depicts Lord Buddha in a human form, subduing an elephant (http://www.gktoday.in/blog/krishna-river/). **Vijayawada:** Vijayawada is the third largest city and a popular trade and commerce centre in Andhra Pradesh on the banks of Krishna River.

River		Gangavali / Bedthi
1	Geography	River Gangavali (also known as Bedthi or Gangavalli) is spread across in Uttara Kannada, Dharwad, Haveri Districts of Karnataka (Figure 1). Originating at Dharwad district (Huble- Bedti stream, Dharwad-Shalmal stream) (Figure 2), Gangavali flows for a distance of nearly 161 km (Survey of India Topographic sheets, Uttara Kannada District – Gazetteer of India) before it joins Arabian Sea at Manjguni-Ankola (Uttara Kannada) (Figure 2). Tributaries of Gangavali include, Gangavali, Bedthi, Vibuthi holé , Huli devara kodlu, Yenne hole, Shalmala, Sonda and many more. Gangavali river has a catchment area of 3935 sq.km spread across districts of Uttara Kannada (Sirsi, Mundgod, Ankola), Dharwad (Hubli, Dharwad, Kundgol) and Haveri (Shiggaon).
2	Topography	Topography of Gangavali river catchment is as depicted in Figure 3, elevation ranges between < 0m and 834m w.r.t Mean Sea Level, slope of the catchment varies up to 536.8%. Very high slope we observed in the Yellapura (Arabial Ghat). The variations in the terrain has led to formation of various water falls such at the Ghats as the Magod, Vibuthi, *etc*. Flatter terrains in the plain land have led to creation of large number of lakes (Figure 1).

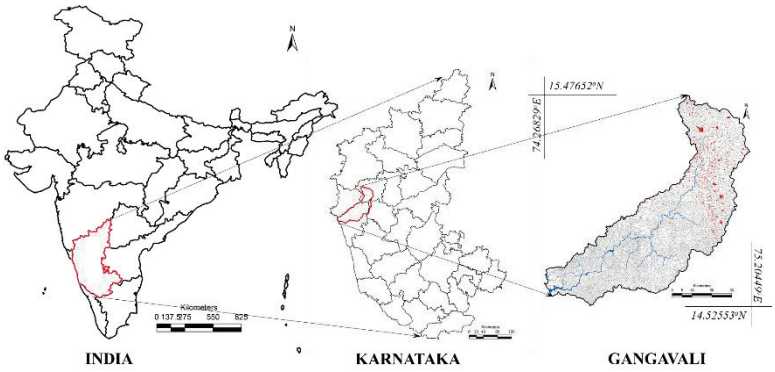


Figure 1: Gangavali River Location

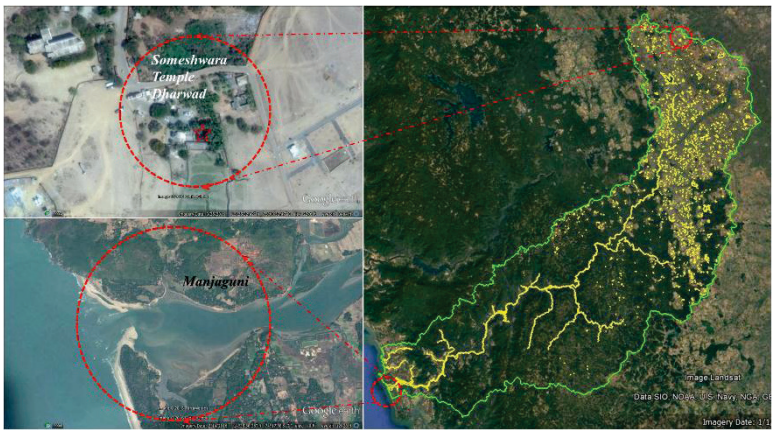
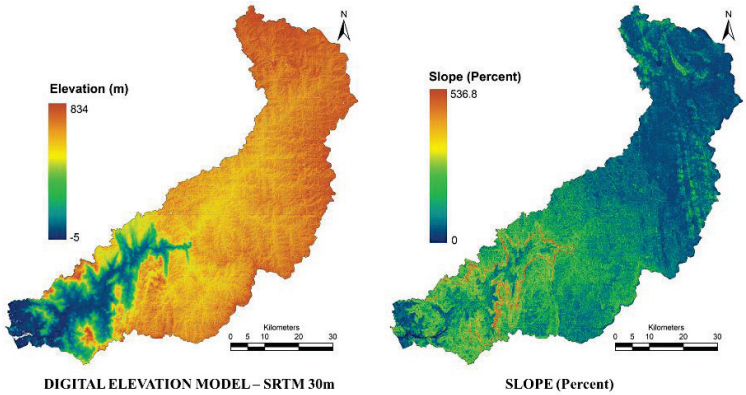
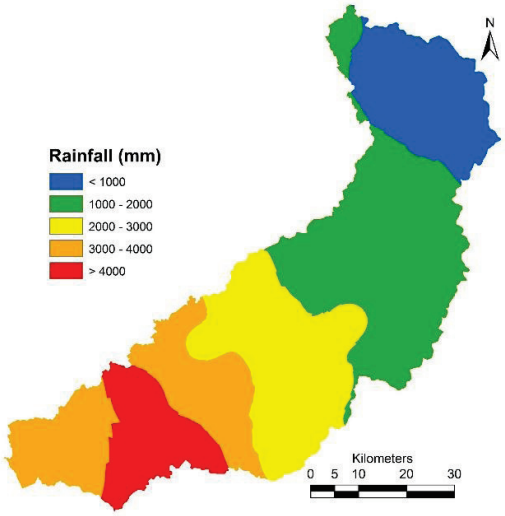
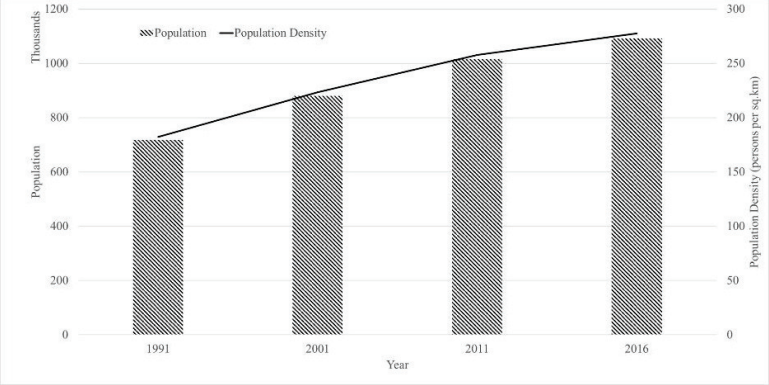


Figure 2: Overlay of Google Earth

		Rock types: Granites to schists, shale, quartzite's, Phyllites, Dolerite rocks including granite, basalt, etc. Ores: Iron, limestone, bauxite, quartz, limestone, sand, clay, lime shell, Manganese, Asbestos, Mica. Soil: Red Soil, Lateritic soils, Black soil, etc.  **Figure 3: Topography**
3	Rainfall and Water Yield	Rainfall assessment in Gangavali catchment (Figure 4) indicates that rainfall in the catchment is orographic with annual rainfall varying spatially between 1000mm at the plains of Hubli, to over 4500 mm at the Ghats of Yellapura (Arabial Ghats). Water yield in the catchment is 45 to 70 TMC  **Figure 4: Rainfall**
4	Demography	Population in the catchment (Figure 5) has increased from 879809 in 2001 to 1014711 in 2011 (Census of India) and is projected to increase to 1092504 in the year 2016 at a growth rate of 15.3% per decade. Population density in the catchment is 277.5 persons per square kilometer as on 2016. Major Population is contained at towns such as Ankola, Yellapura, Hubli, Dharwad, Mundgod, Sirsi,

		etc. Communities: Ambiga, Arer, Bandi, Bedar, Bandaris, Brahmins, Devadiga, Devalis, Gabit, Ganiga, Gouli, Gudikar, Harikanta, Hulsvara, Kahrvi, Vaishyas, Maratha, Kumri Maratha, Lingayath,, Maratha Kubri, Nadava, Namdharis, Padits, Gidbudukis, Siddis, Buddists, Jains, Muslims, Sikhs, Christians,*etc.* (Chandran and Hughes 2000, Wikipedia, Gazetter of India-Uttara Kannada district).  **Figure 5: Population dynamics in Gangavali river catchment**
5	History, Culture, Heritage	• Festivals and Jatras: Uura habba (Village Festival), Nadi habba (River festival), Bandi habba, Vadya Panchami, Mahamay jatra, Durga devi jatra, Kannika parameshwari jatra, Shantika parameshwari jatra, Venkataramana jatra, etc • Dance: Folk dances (suggi kunita), bharatha natya, Kolata, bedara kunita, dhamami kunita, Huli kunita, Yakshagana, Masti Kunita, Preta kuntia, Bedara kunita, Mandala kunita, etc • Music: Folk Songs, Garatiya Haadu, Halliya Haadu, Nadapadagalu, Bingina pada, Gumatepada, Jogavve haadu, Doni pada, Jogi pada, Badi vadya etc. • Traditional Games: Kallata, kavade, Channe mane, Karu aata, Katte aata, Hulighatta, Bandi aata, Devarata, Sariya mugila aata, Achchu aata, Chowkabara, Tabalamane, etc. Major temples in the catchment of Gangavali includes: Mari Kamba, Someshewara, Ganga Temple, Chandramauleshwara, Navagraha teertha,
6	Land use dynamics	Land use analysis of 2013 show that the catchment forest cover is about 32.16 % (about 18.17% covered with evergreen species). Figure 6 depicts FCC of the catchment, Figure 7 and Table 1 depicts land use in the catchment as on 2013. The catchment is dominated by agriculture in the plains (34.89% of total area)

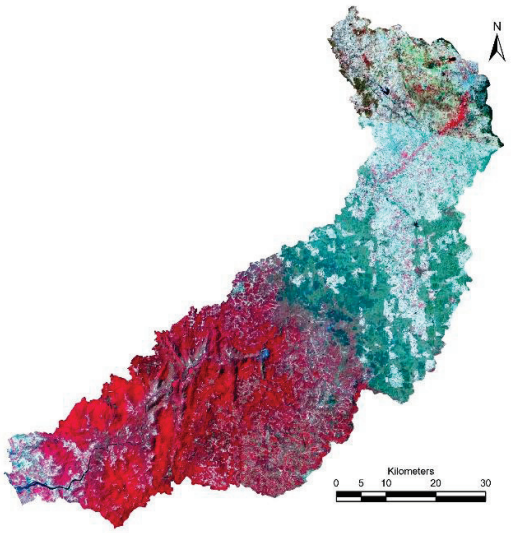


Figure 6: False colour composite

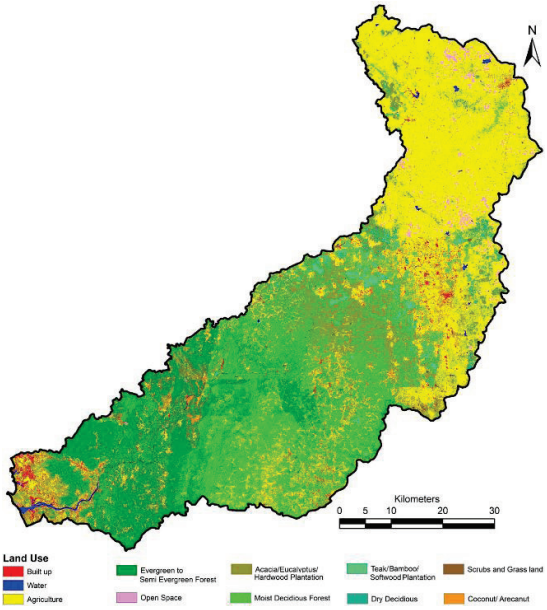


Figure 7: Land use dynamics in Gangavali Catchment

Table1: Land use in Gangavali Catchment

Land use	2013
Urban	2.18%
Water	0.44%
Agriculture	34.89%
Open lands	2.46%

			Moist Deciduous Forest	12.61%
			Evergreen to Semi Evergreen forest	18.17%
			Scrub/Grassland	3.01%
			Acacia/Eucalyptus	15.07%
			Teak/Bamboo	6.19%
			Coconut/Arecanut	3.59%
			Dry Deciduous	1.38%
7	Agriculture, Irrigation	Variety of Paddy, Sugar cane, Banana, Arecanut, Coconut, Mango, spices, Jowar, Ragi, Ground Nut, Cotton, etc.		
8	Diversions/Storage Structures	Numerous small scale diversions (check dams, bunds) can be found along the valley (the plains are dominated by lakes namely Neersagara, Devargudihal, *etc…*)		
9	Bio Diversity	**Fishes: Mahima et al 2016** *Cephalopholis boenak, Caranx ignobilis, Trichiurus lepturus, Colletteichthys dussumieri, Nemipterus japonicus, Sardinella fimbriata, Opisthopterus tardoore, Stolephorus commersonnii, Thryssa mystax, Siganus vermiculatus, Sillago sihama, Otolithes ruber, Sphyraena barracuda, Lactarius lactarius, Eubleekeria splendens, Lobotes surinamensis, Secutor insidiator, Johnius belangeri, Sphyraena obtusata, Lutjanus johnii, Lutjanus russellii, Synaptura commersonnii, Grammoplites scaber, Arius arius, Tricanthus biaculeatus, Arothron stellatus, Etroplus suratensis, Monopterus albus, Pisoodonophis cancrivorus, Mugil cephalus, Liza parsia, Scatophagus argus, Lutjanus argentimaculatus, Glossogobius giuris, Gerres filamentosus, Eleutheronema tetradactylum, Terapon jarbua, Gerres limbatus, Secutor ruconius, Lates calcarifer, Ambassis ambassis, Apogon hyalosoma and Cynoglossus punticeps,* ***etc****.* **Bivalves: Boominathan et al, 2014, Ramesha et al 2013** *Paphia malabarica, Katelysia opima, Meretrix meretrix, Meretrix casta, Villorita cyprinoides, Perna viridis, Tegillarca granosa, Polymesoda erosa,. L. marginalis, Parreysia corrugate, P. favidens, P. rajahensis, P. theobaldi* **Flora: Ramchandra et al, 2012,** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new **(Sirsi, Yellapura, Ankola, Hubli Taluks)** Forest types found in the district are: Evergreen, Semi		

		Evergreen, Moist Deciduous, Scrub, Thorny, un wooded with following species. **Endemic Flowering Species (Trees, Shrubs, Plants):** *Actinodaphne hookeri, Aerides maculosum, Aerides crispa, Aglaia anamalayana, Ancistrocladus heyneanus, Arenga wightii, Argostemma courtallense, Artocarpus hirsuta, Arundinella metzii, Asystastia dalzelliana, Begonia integrifolia, Begonia malabarica, Beilschmiedia fagifolia, Blepharis asperrima, Boesenbergia pulcherrima, Calamus thwaitesii, Canscora decurrens, Canscora perfoliata, Canthium parviflorum, Casearia rubescens, Chrysophyllum roxburghii, Cinnamomum macrocarpum, Cleisostoma tenuifolium, Connarus wightii, Crotalaria filipes, Crotolaria heyneana, Cryptocoryne spiralis, Curcuma neilgherrensis, Cyanotis papilionaceae, Cyanotis tuberosa, Cyclea peltata, Dimeria hohenackeri, Dimorphocalyx beddomei, Diospyros assimilis, Diospyros candolleana, Diospyros paniculata, Diospyros saldanhae, Drypetes elata, Dysoxylum malabaricum, Erinocarpus nimmonii, Ervatamia heyneana, Euonymus indicus, Flacourtia montana, Garcinia indica, Glochidion johnstonei, Grewia umbellifera, Holigarna arnotiana, Holigarna ferruginea, Holigarna grahamii, Hopea ponga, Hydnocarpus laurifolia, Jasminum malabaricum, Knema attenuata, Linociera malabarica, Litsea floribunda, Litsea laevigata, Mammea suriga, Memecylon talbotianum, Memecylon umbellatum, Memecylon wightii, Myristica malabarica, Neanotis foetida, Nothopegia colebrookeana, Oberonia brunoniana, Oberonia recurva, Oberonia santapaui, Ochlandra scriptoria, Orophea zeylanica, Pittosporum dasycaulon, Polyalthia fragrans, Porpax reticulata, Porpax jerdoniana, Psychotria dalzellii, Psychotria flavida, Psychotria truncata, Pterospermum reticulatum, Sageraea laurifolia, Strobilanthus heyneanus, Symplocos racemosa, Syzygium laetum, Syzygium macrocephala, Tragia hispida, Vepris bilocularis, Walsura trifolia.* **Trees:** *Acacia spp, Actinodaphne hookeri, Adina cordifolia, Aglaia anamalayana, Aglaia roxbhurgii, Ailanthus excelsa, Alangium salvifolium, Albizzia lebbeck, Alstonia scholaris, Alseodaphne semecarpifolia, Anacardium occidentale, Annonaceae sp, Anogeissus latifolia, Antidesma menasu, Aporosa lindleyana, Artocarpus hirsuta, Artocarpus gomezianus, Atlantia racemosa, Bauhinia foveolata, Beilschmiedia fagifolia, Bombax ceiba, Bridelia crenulata, Buchanania lanzan, Butea monosperma, Careya arborea, Carallia brachiata, Caryota urens, Cassine glauca, Cassia spp, Casuarina spp, Chrysophyllum roxburghii, Cinnamomum macrocarpum, Dalbergia latifolia, Dillenia pentagyna,*

		Diospyros assimilis, Diospyros buxifolia, Diospyros candolleana, Diospyros ebenum, Diospyros melanoxylon, Diospyros buxifolia, Diospyros montana, Diospyros oocarpa, Diospyros paniculata, Diospyros spp, Dysoxylum malabaricum, Ervatamia heyneana, Euphorbiaceae spp, Ficus benghalensis, Ficus drupacea, Ficus nervosa, Ficus racemosa, Ficus spp, Ficus tsjahela, Flacourtia montana, Garcinia gummi-gutta, Garcinia indica, Garcinia morella, Gliricidia sepium, Gmelina arborea, Grewia tiliaefolia, Heterophragma roxburgii, Hiptage benghalensis, Holigarna arnotiana, Holigarna ferruginea, Holigarna grahamii, Hopea ponga, Hydnocarpus laurifolia, Ixora arborea, Ixora brachiata, Knema attenuata, Lagerstroemia microcarapa, Lannea coromandelica, Lepisanthes tetraphylla, Linociera malabarica, Litsea spp, Lophopetalum wightianum, Macaranga peltata, Madhuca latifolia, Mallotus philippensis, Mangifera indica, Mimusops elengi, Mitragyna parviflora, Myristica malabarica, Olea dioica, Pajanalia longifolia, Persea macrantha, Phyllanthus emblica, Polyalthia fragrans, Pterospermum diversifolium, Pterocarpus marsupium, Randia dumetorum, Saccopetalum tomentosum, Santalum album, Sapindus laurifolia, Saraca asoca, Schleichera oleosa, Scutia myrtina, Sageraea laurifolia, Semecarpus anacardium, Sapium insigne, Spondias pinnata, Steriospermum personatum, Sterculia guttata, Strychnos nux-vomica, Symplocos racemosa, Syzygium caryophyllatum, Syzygium cumini, Syzygium gardnerii, Syzygium hemesphericum, Syzygium laetum, Tectona grandis, Terminalia bellirica, Terminalia chebula, Terminalia paniculata, Terminalia alata. ***etc****…* **Fauna: :** http://wgbis.ces.iisc.ernet.in/biodiversity/database_new **Mammals:** Tiger, Black Panther, Leopard, Bison, Gaur, Hare, Wild Boar, Sloth Bear, Deer, Thar, Bonnet Macaque, Lion Tailed Macaque, Giant Squirrel, Hanuman Languor, etc. **Reptiles:** Snakes (Vipers, Cobra, Rat snake, Crate, King cobra, Python, Wolf snake, *etc*), Monitor Lizard, Crocodile.
10	References	1) Survey of India Topographic Sheets, 1:50000 scale. 2) Water Resource Information System of India, http://www.india-wris.nrsc.gov.in. 3) Google Earth, *https://www.google.com/earth/*. 4) Ramachandra, T.V., Chandran, M. D, S., Joshi, N. V., Karthick, B., and Vishnu, D. M., 2015, Ecohydrology of Lotic Systems in Uttara Kannada, Central Western Ghats, India, Environmental Management of River

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6) Boominathan, M., Ravikumar, G., Chandran, M. D. S., and Ramachandra, T. V., 2014, Impact of Hydroelectric Projects on Bivalve Clams in the Sharavathi Estuary of Indian West Coast, The Open Ecology Journal,7, 52 – 58.
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11) ENVIS Sahyadri Web Portal, http://wgbis.ces.iisc.ernet.in/biodiversity/database_new/
12) http://www.karnataka.gov.in/Gazetteer
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9. MAHADAYI –MANDOVI RIVER

River		**Mahadayi -Mandovi**
1	Geography	River Mahadayiis Spread acrossthe Districts of Goa, Karnataka and Maharashtra. Originating at Khanpur (Belgaum-Karnataka), Mahadayi flows for a distance of nearly 117 km (http://thesurveyofindia.gov.in, Survey of India Topographic sheets) before it joins Arabian Sea at Panji (North-Goa) (Figure 1).   **Figure 1: Mahadayi River** Tributaries of Mahadayi include,KalasaNala, SurlaNala, HaltarNala, PotiNala, MahadayiNala, PansheerNala, Bail Nala, AndherNala and many more. Mahadayi river has a catchment area of 2032 sq.km. Topography of Mahadayi river: Elevation ranges between < 0m and > 980m w.r.t Mean Sea Level, slope of the catchment varies up to 150%. Very high slope we observed in the Ghats (Braganja Ghats). The variations in the terrain has led to formation of various water falls such as the Doodhsagarfalls,Vajrapoha falls*etc*. Rock types: Granites to schists, shale, quartzite's, Phyllites.Charnockites. *etc*. Ores: Iron, limestone, bauxite, quartz, limestone, sand, clay, lime shell, Manganese, Asbestos, Mica, Lead, Cadmium,

<table>
<tr><td></td><td></td><td>Soil: KanhaplicRhodustalfs, KanhaplicHapustalfs, TypicKandiustalfs, UstoxicKanhaplustalfs, TypicUstropepts, UsticKandihumults, UsticHaplohumults, KandicPaleustalfs, TypicRhodustalfs,TypicChromusterts, RhodicPaleustalfs, UsticPalehumults, etc.</td></tr>
<tr><td>2</td><td>Rainfall and Water Yield</td><td>Rainfall assessment in Mahadayi catchment indicates that rainfall in the catchment is orographic with annual rainfall varying spatially between 1918 mm at the plains(Khanapur), to over 5425 mm at the Ghats (Gavalli).
Water yield in the catchment is 3164 M.cum to 5703 M.cum.</td></tr>
<tr><td>3</td><td>Anthropology</td><td>Major Population is contained at towns such as Belgaum, Panji.
Communities: KumriMarati, Goudas, Konkanis.Havyaka Brahmin, ,Kurubas, Siddis, Daivajna, Muslims, Christians,etc.</td></tr>
<tr><td>4</td><td>Land use</td><td>Table 1 depicts land use changes in the catchment
Table1: Land use in MahadayiCatchment
<table>
<tr><td>Land use</td><td></td></tr>
<tr><td>Forest</td><td>36.6%</td></tr>
<tr><td>Non Agriculture Land</td><td>4.10%</td></tr>
<tr><td>Barren and Uncultivable land</td><td>4.60%</td></tr>
<tr><td>Cultivable waste land including fallow land</td><td>19.7%</td></tr>
<tr><td>Permanent pastures and other grazing land</td><td>0.60%</td></tr>
<tr><td>Land under miscellaneous trees and crops</td><td>0.30%</td></tr>
<tr><td>Gross Sown Area</td><td>35.3%</td></tr>
</table></td></tr>
<tr><td>5</td><td>Agriculture, Irrigation</td><td>Variety of Paddy, Sugar cane, Banana, Arecanut, Coconut, Mango, spices, Cashew nutetc.</td></tr>
<tr><td>6</td><td>Diversions</td><td>No major diversion works in the catchment, however numerous small scale check dams are built for irrigation practice.</td></tr>
<tr><td>7</td><td>Bio Diversity</td><td>Bivalves: EIA of Proposed Mahadayi HEP,1997
Flora: Forest types found in the district are: Evergreen, Semi Evergreen, Moist Deciduous, Scrub, Thorny, un wooded with following species.
Acacia sp., Artabotryshexapetalus, Atlantiarecemosa, Bombaxsp, Buteamonosperma, Calophyllumwightianum, Calophyllumelatum, Caralliabrachiata, Careyaarborea, Cassia fistula,</td></tr>
</table>

		Cinnamomumzeylancium, Dalbergialatifolia, Dilleniapentagyana, Diospyroscandolleana, Diospyrosmontana, Embilcaofficinalis, Euphoria longana, Ficusbenghalensis, Ficusreligiosa, Glycosmis sp., Holigarnaarnotiana, Hopeaparviflora, Ixorabrachiata, Lagerstroemia lanceolata, Lygodium sp., Lophopetalumwightianum, Macarangapeltata, Mallotusphilippensis, Mangiferaindica, Memecylonedula, Mimusopselengi, Myristica sp., Oleadioica, Pongamia sp., Pongamiapinnata, Randiadumetorum, Spatholobus sp., Strobilanthes sp., Symploca sp., Syzygiumcumini, Tectonagrandis, Terminaliachebula, Terminaliapaniculata, Terminaliatomentosa, Vitexnegundo, Xanthium sp., Ziziphusoenoplia, Artocarpushirsutus, Falconeriasp, Garciniaindica, Holigarnasp, Madhucaindica, Syzygiumsp, ***etc*** **Fauna: : EIA of Proposed Mahadayi HEP,1997** **Mammals:**Tiger, Black Panther, Leopard, Bison, Gaur, Hare, Wild Boar, Sloth Bear, Deer, Thar, Bonnet Macaque, Lion Tailed Macaque, Giant Squirrel, Hanuman Languor, Wroughton'sFreetailed bat (endemic-endangered), Sambar, Chital, Porcupine, Giant Squirrel, Barking Deer, Mouse Deer, **Reptiles:** Snakes (Vipers, Cobra, Rat snake, Crate, King cobra, Python, Wolf snake, Blind snake, Shield tail snake, Boa, Banded kurki, RusselKurki snake, Flying snake, coral snake, Russel viper, rat snake, *etc*), Monitor Lizard.
9	References	1) Survey of India Topographic Sheets, 1:50000 scale, http://thesurveyofindia.gov.in 2) Water Resource Information System of India, http://www.india-wris.nrsc.gov.in. 3) Google Earth, *https://www.google.com/earth/.* 4) Census of India, 2001 and 2011, http://censusindia.gov.in. 5) Environmental Impact assessment of proposed Mahadayi Hydroelectric Project, KPCL, Bangalore September 1997

10. BIO-MONITORING TO ASSESS RIVER HEALTH

Western Ghats is the primary catchment for most of the rivers in peninsular India. Pristine forests in this region are rich in biodiversity and are being cleared due to unsound developmental activities. This has given rise to concerns about land use/land cover changes with the realization that land processes influence climate. Rapid land-use changes have undermined the hydrological conditions, there by affecting all the components in the hydrological regime. The development programmes based on ad-hoc decisions, is posing serious challenges in conserving fragile ecosystems. Considerable changes in the structure and composition of the land use and land cover in the region have been very obvious during the last four decades. Pressure on land for agriculture, vulnerability of degraded ecosystems to the vagaries of high intensity of rainfall and high occurrence of steep erosion and landslide-prone areas, lack of integrated and coordinated land use planning are some of the reasons for rapid depletion of the natural resource base. These changes have adversely affected the hydrological regime of river basins resulting in diminished river / stream flows. This necessitates conservation of ecosystems in order to sustain the biodiversity, hydrology and ecology. In this situation, in order to resolve present problems and to avoid a future crisis, a comprehensive assessment of land use changes, its spatial distribution and its impact on hydrological regime was carried out and accordingly, appropriate remedial methods are being explored for the sustainable utilization of the land and water resources of the catchment.

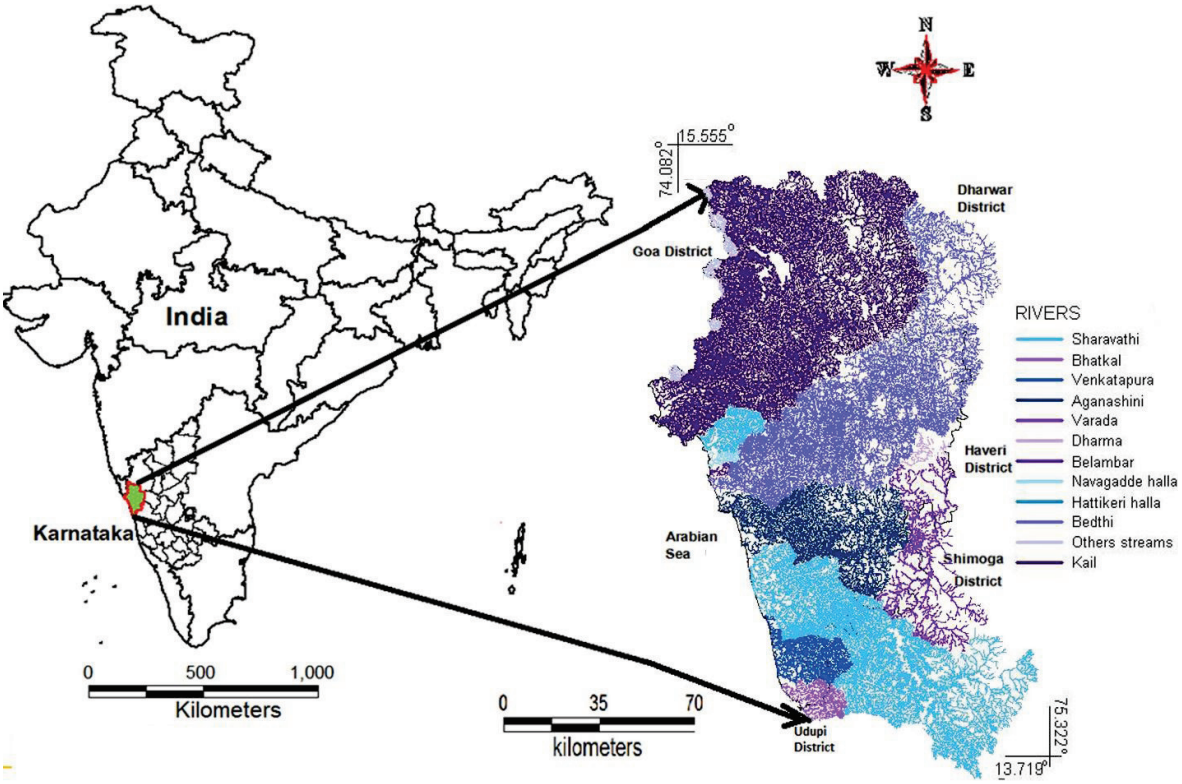

Figure 1: Study region - Uttara Kannada district with rivers (Source: Energy & Wetlands Research Group, CES, Indian Institute of Science)

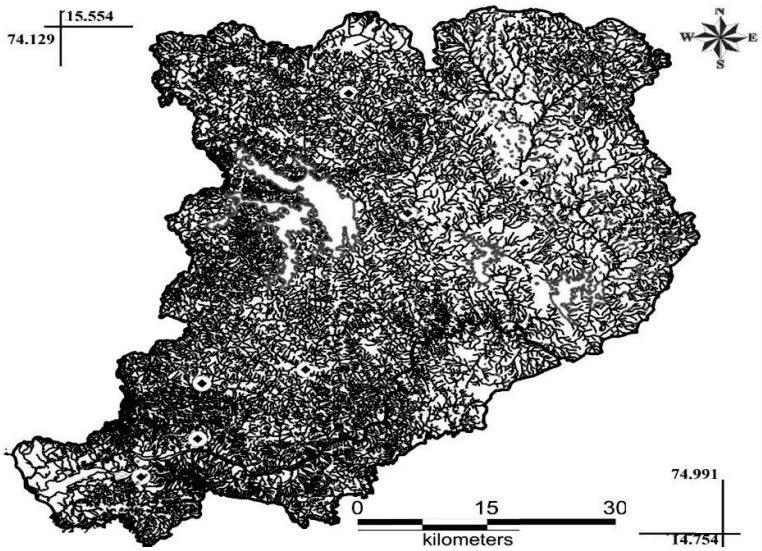

Figure 2: River Kali with sampling sites

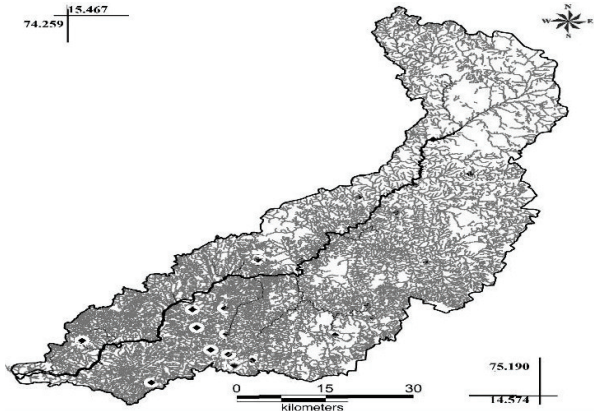

Figure 3: River Bedthi with sampling sites

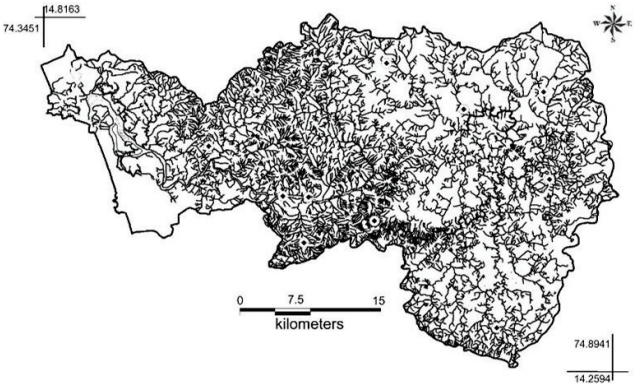

Figure 4: River Aghanashini with sampling sites

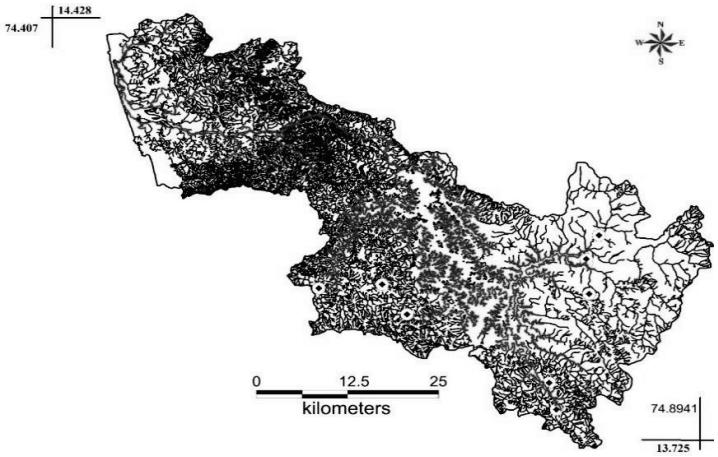

Figure 5: River Sharavathi with sampling sites

A total of 140 diatom taxa were identified across sites (Figure 2-5: River basin wise sampling locations), 61 of them reaching a relative abundance of over 5% in at least one site. The species compositions were dominated by *Gomphonema gandhii* Karthick and Kociolek, *Achnanthidium minutissimum* Kützing, *Achnanthidium* sp., *Gomphonema* sp., *Gomphonema parvulum* Kützing, *Nitzschia palea* (Kützing) W.Smith, *Nitzschia frustulum* (Kützing) Grunow var. *frustulum*, *Navicula* sp., *Navicula cryptocephala* Kützing, *Cyclostephanos* sp., *Cymbella* sp., *Eolimna subminuscula* (Manguin) Moser Lange-Bertalot and Metzeltin, *Sellaphora pupula* (Kützing) Mereschkowksy, *Eunotia minor* (Kützing) Grunow in Van Heurck, *Nitzschia amphibian* Grunow f. *amphibia*, *Cyclotella meneghiniana* Kützing, *Gomphonema difformum* Karthick and Kociolek, *Navicula rostellata*Kützing, *Cocconeis placentula* Ehrenberg var. *euglypta* (Ehr.) Grunow, *Brachysira* sp., *Stauroneis* sp., *Encyonema minutum* (Hilse in Rabh.) D.G. Mann, *Cyclotella* sp. and *Nitzschia* sp. The species composition contains cosmopolitan to possible Western Ghats endemic species and in general species from oligotrophy to highly eutrophic condition were also observed. The current study also documents some of the species for the first time in Western Ghats and many new species descriptions are underway. In some sampling locations, water quality show tendency towards alkalinity in the streams drained from agriculture and urban catchment. The highest ionic and nutrient values correspond to the agriculture catchment dominated streams, particularly in the leeward side of the mountains. Oxygenation was generally close to saturation; the lowest values are due to wastewater water inflows in few localities. Streams closer to industries and city reflect higher amount of nutrients and is reflected by pollution tolerant tax (Figure 6). The most oligotrophic sites were located in mountain watercourses, while downstream sites were generally more polluted, becoming eutrophic in condition. The detailed water chemistry variables are presented in Table 1 (Source: Ramachandra T V, Subash Chandran M.D., Joshi N V, Karthick B and Vishnu D. Mukri, 2015. Ecohydrology of Lotic Ecosystems of Uttara Kannada, Central Western Ghats, In: Ramkumar, M., Kumaraswamy, K. and Mohanraj, R. (Eds.). Environmental management of River Basin ecosystems, Springer Earth System Sciences, DOI 10.1007/978-3-319-13425-3_29).

Table 1: water chemistry variables in 45 sites (streams) across river basins

Variables	Mean	Std. dev	Median	Min	Max
pH	7.22	0.49	7.14	6.03	8.16
WT (°C)	25.31	2.70	25.07	19.00	33.00
EC (µScm^{-1})	160.55	207.10	107.67	41.55	1164.67
TDS (mg L^{-1})	122.24	204.98	60.30	20.88	1299.67
Alkalinity (mg L^{-1})	54.55	50.32	30.00	6.81	180.00
Chlorides (mg L^{-1})	32.39	40.40	22.72	5.90	220.24
Hardness (mg L^{-1})	51.26	71.05	28.00	10.00	348.00
Calcium (mg L^{-1})	13.88	16.14	8.02	1.60	78.56
Magnesium (mg L^{-1})	16.35	16.73	9.36	1.17	65.95
DO (mg L^{-1})	6.96	1.68	7.23	2.93	10.87
Phosphates (mg L^{-1})	0.36	0.56	0.04	0.00	2.30
Nitrates (mg L^{-1})	0.74	1.10	0.13	0.03	4.30
Sulphates (mg L^{-1})	25.73	20.84	16.87	0.00	74.10
Sodium (mg L^{-1})	25.77	72.18	9.09	4.11	370.00
Potassium (mg L^{-1})	6.33	15.72	1.30	0.19	75.00

The species composition contains cosmopolitan to possible Western Ghats endemic species and in general species from oligotrophy to highly eutrophic condition were also observed. Among the species observed in this study, two species were possibly endemic to Western Ghats (*G. gandhii*, *G. difformum* and few other species yet to identify). In few sites these species were very dominant reaching more than 80% of the total assemblages. The remaining dominant taxa were cosmopolitan and well documented in international literatures (Krammer and Lange Bertalot, 1986-1991). It is important to note that the indices that were developed and tested in European rivers, lacks Western Ghats endemic taxa. Most sites were oligo-mesotrophic and only a few of the streams were eutrophic. The differences in the water quality of these

rivers were reflected in the values for the diatom indices, by the relative abundances of indicators of trophic/saprobic stage and by different types of diatom community.

Diatom Assemblages: Among the 113 taxa the most common and dominant diatom taxa are *Eolimna subminuscula, Achnanthidium* sp., *Navicula* sp., *Nitzschia palea, Gomphonema parvulum, Gomphonema* sp., *Gomphonema gandhii, Achnanthidium minutissima and Cyclostephanos* sp. Species richness varied from 4 to 29 with an average of 15. Shannon-Wiener diversity varied from 0.71 to 2.94 with an average of 1.76. According to the pH classification, diatom assemblages were characterized by a high proportion of neutrophilous diatom species (64.62%) followed by alcaliphilous species (26.64%). Salinity classification based on the diatom species assemblages infer the fresh to brackish water species were the dominant form with 86.16% followed by brackish to freshwater (7.84%) and exclusively freshwater (5.3%) flora.

Nitrogen autotrophic taxa, which tolerate elevated concentrations of organically bound nitrogen, were dominant with 53.31%. Species which require 100% oxygen saturation were prevailing community with 42.98% followed by low level (30% oxygen saturation) oxygen requirement species by 29.08%. The composition of diatom community with respect to saprobity in the order or oligosaprobous, β-mesosaprobous, α-mesosaprobous, α-meso-/polysaprobous and polysaprobous were 7.8%, 46.09%, 10.58%, 26.56% and 8.97% respectively. The species occurs in the eutraphentic and oligo to eutraphentic were equally dominant with respect to the trophic state explained by diatoms.

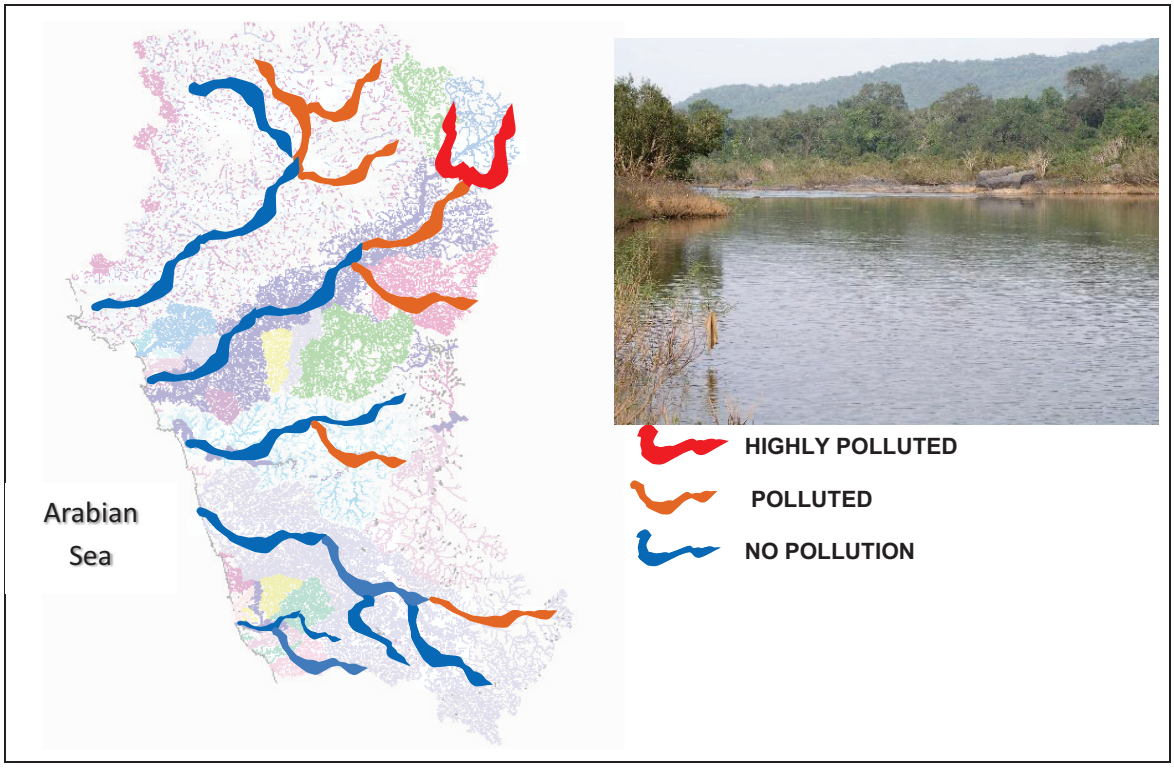

Figure 6: Pollution status in the rivers of Uttara Kannada

11. THREATS TO RIVER ECOSYSTEMS OF UTTARA KANNADA

11.1 Dams:

Large to small sized dams used for hydroelectricity production and small size local check dams for intense agriculture purposes (Figure 7). Both large and small check dam affects the riverine biodiversity and water quality. Removal of riparian vegetation is observed in all river basins (figure 7). In particular streams flows next to the agriculture lands shows significant removal of riparian vegetations.

Figure 7: check dam and loss of riparian vegetation. Site: Beegar, Yellapura

Figure 8: Site showing sewage flowing in tributary of Bedthi

11.2 Water pollution due to domestic sewage:

Bedthi River Basin, in particular upper reaches of Bedthi shows high level of water quality degradation due to the domestic sewage disposal in the main streams (Figure 9). Certain portion of the domestic sewage of Hubli town is disposed into upper Bedthi River (Figure 10). Sewage contaminants flows in to Bedthi River and later gets diluted by the water from tributary like Hasehall, which drains more water even during the summer months. Some of the sites, which are severely affected by the water pollution in Bedthi River basin are Sangadevarakoppa, Kalghatghi and Manchikeri (Yellapura).

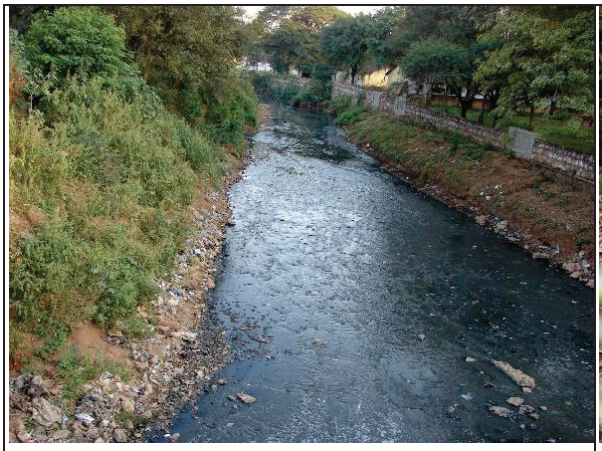

Figure 9: sewage inflow in the tributary of Bedthi

Figure 10: Mugger crocodile (*Crocodylus palustris*) in Kervada, Paper Mill effluent confluence point in Kali River Basin

11.3 Industrial Pollution:

Kali River Basin is under the influence of industrialization in Uttara Kannada, in particular Dandeli region with polluting industries. The West Coast Paper Mills Ltd situated in the bank of River Kali pollutes the water and surrounding riparian environment by letting partially treated or untreated effluents into the river. Kervada village, next to Dandeli witness severe water and air pollution due to the effluent of paper mill. Paper mill waste increases total dissolved and suspended solids, turbidity and ionic content. In addition to the effluents the river also receives sewage. Organic waste let in to the river decreases the dissolved oxygen, which eventually causes threat to aquatic biodiversity. Site where confluence of sewage is also witnessed soaring population of Mugger crocodiles (Figure 10) resulting in the higher instances of human wildlife conflicts.

11.4 Sand Mining:

Sand mining is one of the common problems observed in lower reaches of all the river basins (Figure 11). Sand mining is predominant in brackish water region of Kali and Sharavathi River Basins, where mechanized sand mining is in practice for a while. Sand mining cause severe threat to the benthic organisms. Most of the marine and esturine benthic organisms breed in brackish regions faces severe threat due to the mechanized sand mining. Mangrove regions in Kali estuary is also threatened by sand mining due to loss or alteration of habitat.

Figure 11: Mechanized sand mining in Kali River Basin

Table 2 lists the river basin wise threats with the appropriate mitigation measures to enhance the functional aspects of aquatic ecosystems.

Table 2: Threats and Mitigation Measures

River Basin	Region	Problem	Remedial Measures
Kali	Dandeli	Paper mill effluent	Enforce effluent treatment by the industry (implementation of the control of water pollution, Polluter pays principle)
Kali	Ramnagar	Non-point source pollution in streams and rivers from Agriculture fields	Avoiding intense use of chemical fertilizers and pesticides
Kali	Honkon (Brackish)	Mechanized sand mining	Stopping of sand mining in certain ecologically sensitive region and regulated sand mining in selected localities
Bedthi	Sangdevarkoppa	Non-point source pollution	Avoiding intense use of chemical fertilizers and pesticides

Bedthi	Kalghatghi	Urban domestic sewage, non-point source pollution	Implementation of sewage treatment plant in Hubli town. Sewage should be treated before letting in to the river.
Bedthi	Kalghatghi	Solid Waste Disposal in River	Setting up Solid waste treatment and landfill facility in outskirts of Hubli town.
	Manchikeri	Urban domestic sewage, non-point source pollution	Implementation of sewage treatment plant in Hubli town. Sewage should be treated before letting in to the river.
Sharavathi	Gerusoppa and downstream	Mechanized sand mining	Stopping of sand mining in certain ecologically sensitive region and regulated sand mining in selected localities

11.5 References

1. Ramachandra T V, Subash Chandran M.D., Joshi N V, Karthick B and Vishnu D. Mukri, 2015. Ecohydrology of Lotic Ecosystems of Uttara Kannada, Central Western Ghats, In: Ramkumar, M., Kumaraswamy, K. and Mohanraj, R. (Eds.). Environmental management of River Basin ecosystems, Springer Earth System Sciences, DOI 10.1007/978-3-319-13425-3_29
2. Ramachandra, T.V. 2014. Hydrological Responses at Regional Scale to Landscape Dynamics, J Biodiversity, 5(1,2): 11-32.