सत्यमेव जयते

Government of India
Ministry of Jal Shakti
Department of Water Resources,
River Development & Ganga Rejuvenation

ASSESSMENT OF WATER RESOURCES OF INDIA

Volume-II

MAJOR SUB BASINS

केन्द्रीय जल आयोग CENTRAL WATER COMMISSION आपो ज्योति रसोऽमृतम्

Central Water Commission
September 2024

Government of India
Ministry of Jal Shakti
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ASSESSMENT OF WATER RESOURCES OF INDIA

(Volume-II)

MAJOR SUB-BASINS

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1. BACKGROUND OF THE STUDY

1.1 Background

The study on “Assessment of Water Resources of India” was recently accomplished by Central Water Commission in which basin-wise water resources of India was assessed for the period 1985-86 to 2022-23 (38 years) using open source Remote Sensing products.

The average annual water resources of the country for the period 1985-2023 was assessed as about **2116 BCM** in the study while the average annual precipitation was assessed as about **3729 BCM**.

In continuation to the basin-wise assessment of water resources, it was decided that to further enrich the study, an assessment of the water resources in some major sub-basins of India may also be taken up as Volume - II of the study. With this in view, some of the major sub-basins in India were selected considering their wide-spread geographical locations across the country so that a multifaceted picture may emerge for the study. The list of the selected sub basins is given below:

S. No.	Sub Basin Name	Basin Name
1.	Bharathapuzha	WFR between Tadri to Kanyakumari
2.	Chambal	Ganga
3.	Damodar	Ganga
4.	Ghaghra	Ganga
5.	Kangsabati	Ganga
6.	Kosi	Ganga
7.	Palar	EFR between Pennar & Kanyakumari
8.	Periyar	WFR between Tadri to Kanyakumari
9.	Pranhita	Godavari
10.	Ramganga	Ganga
11.	Sabri	Godavari
12.	Seonath	Mahanadi
13.	Sone	Ganga
14.	Tungabhadra	Krishna
15.	Vaitarna	WFR between Tapi to Tadri
16.	Vamsdhara	EFR between Mahanadi & Pennar
17.	Yamuna (excluding Chambal)	Ganga

The combined catchment area of selected sub basins is 8,18,406 Sq Km which is approx. 25 % of the entire country; accounting for 455.58 BCM of the water availability which is about 21.5 % of the total water availability for the country.

1.2 Objective of the study

This study aims to assess the average annual water resources availability in the major sub basins of India for the period from 2003-04 to 2022-23. It is mentioned that the Evapotranspiration product viz. operational Simplified Surface Energy Balance (SSEBop) is available from 2003-04 onwards and therefore the study period has been kept accordingly.

1.3 Input Data, Methodology & Validation

The input data-sets, methodology and Water resources Assessment tool developed in-house in the CWC, etc. are given in detail in the Main report of the study. By evolving the methodology, this assessment has come closer to the ground situation.

1.4 Conclusion

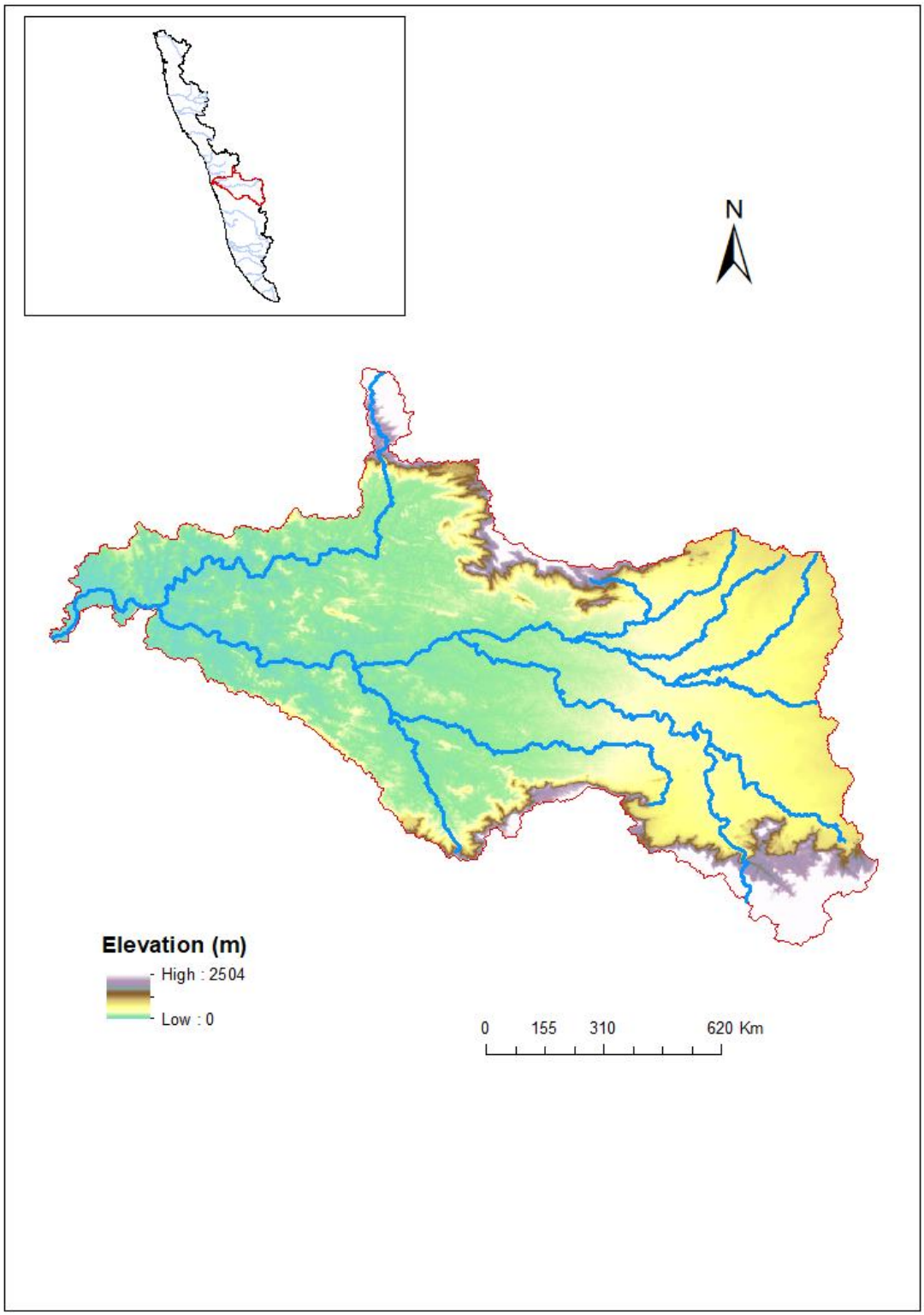
The water availability has been worked out for the period of 2003-2023. The precipitation and Water availability of Major sub basins is estimated as 835.30 and 455.58 BCM respectively. The summarized results of all the selected major sub basins are given in Table 1.1.

Table 1.1: Summary of Annual Water Availability of Sub-Basins

S. No.	Sub- Basin	Basin	Catchment Area (Sq. Km.)	Precipitation (BCM)	Water Availability (BCM)
1	Bharathapuzha	WFR between Tadri to Kanyakumari	5,970	10.10	5.23
2	Chambal	Ganga	1,42,221	120.3	44.42
3	Damodar	Ganga	22,488	26.44	12.08
4	Ghaghra	Ganga	58,355	69.06	92.68*
5	Kangsabati	Ganga	5,728	8.04	4.11
6	Kosi	Ganga	19,915	24.46	69.44*
7	Palar	EFR between Pennar & Kanyakumari	17,711	18.59	3.53
8	Periyar	WFR between Tadri to Kanyakumari	6,177	14.62	10.91
9	Pranhita	Godavari	1,08,285	126.60	46.78
10	Ramganga	Ganga	24,691	26.34	11.52
11	Sabri	Godavari	21,474	34.17	14.93
12	Seonath	Mahanadi	30,934	35.24	13.15
13	Sone	Ganga	66,901	71.51	22.12
14	Tungabhadra	Krishna	70,764	59.97	19.78
15	Vaitarna	WFR between Tapi to Tadri	3,790	10.72	7.38
16	Vamsdhara	EFR between Mahanadi & Pennar	10,504	14.10	4.70
17	Yamuna (excluding chambal)	Ganga	2,02,498	165.04	72.82
	Total		**8,18,406**	**835.30**	**455.58**

* Including Trans-boundary

2. BHARATHAPUZHA SUB-BASIN



2.1 About Bharathapuzha Sub-basin

The Bharathapuzha river is the second longest West Flowing River that drains into the Arabian Sea in Kerala State. This basin is bounded in the East by the Cauvery basin, in the West by the Arabian Sea. The basin lies between 10^0 26' and 11^0 13' North latitude and 75^0 53' to 77^0 13' East longitude. The basin is spread over the two states namely Tamil Nadu and Kerala. The basin is elongated in shape and finds its outlet into the Arabian Sea. The Catchment area of the sub-basin is approximately 5,970 sq. km.

2.2 Geo-Spatial Datasets

2.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Bharathapuzha sub-basin for year 2022-23 is shown in Figure 2.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Deciduous woodland, Double/Triple, Plantation etc.

Table 2.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

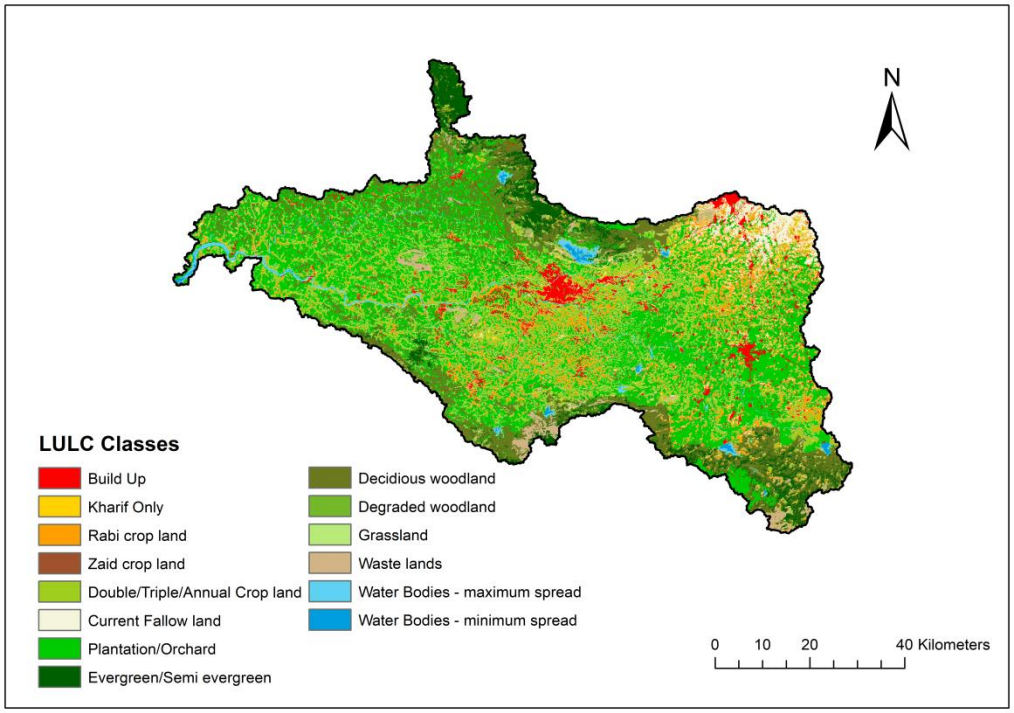


Figure 2.1: LULC Map of Bharathapuzha sub-basin

Table 2.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	3.70
2.	Kharif only	0.98
3.	Rabi crop	8.35
4.	Zaid crop	0.01
5.	Double/Triple/Annual crop	14.66
6.	Current Fallow	8.34
7.	Plantation/Orchard	37.63
8.	Evergreen/Semi evergreen	5.79
9.	Deciduous woodland	15.48
10.	Degraded woodland	0.49
11.	Grassland	0.01
12.	Waste lands	2.58
13.	Water Bodies - maximum spread	1.59
14.	Water Bodies - minimum spread	0.38

2.3 Hydro-Meteorological and other Input Data

2.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 2.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 2.3. The average precipitation of 20 years is approximately 10.10 BCM (1691 mm).

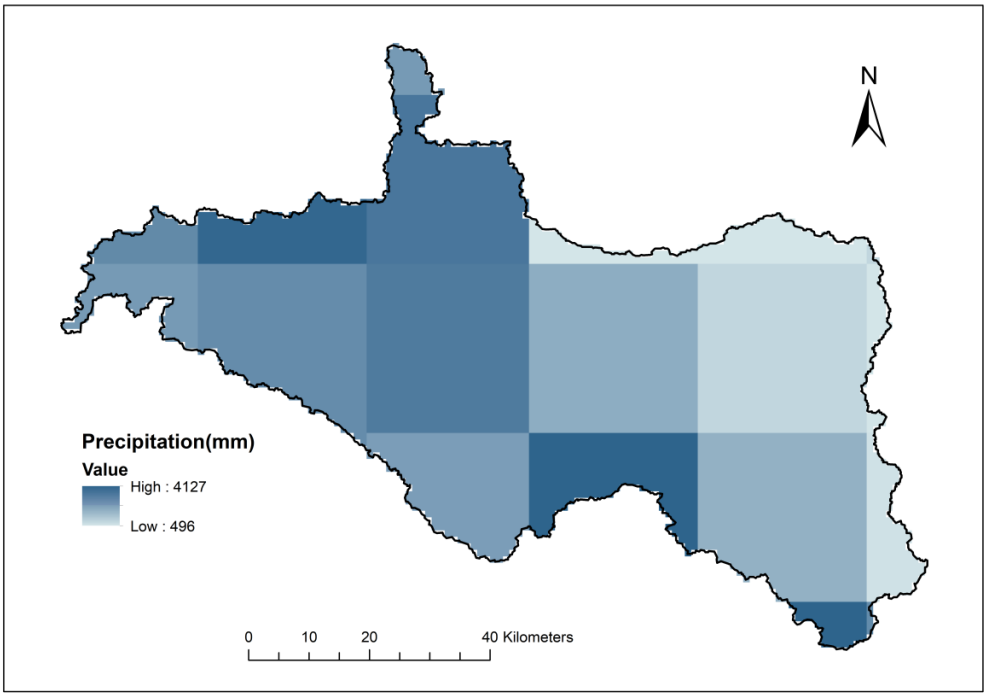


Figure 2.2: Precipitation map of Bharathapuzha sub-basin

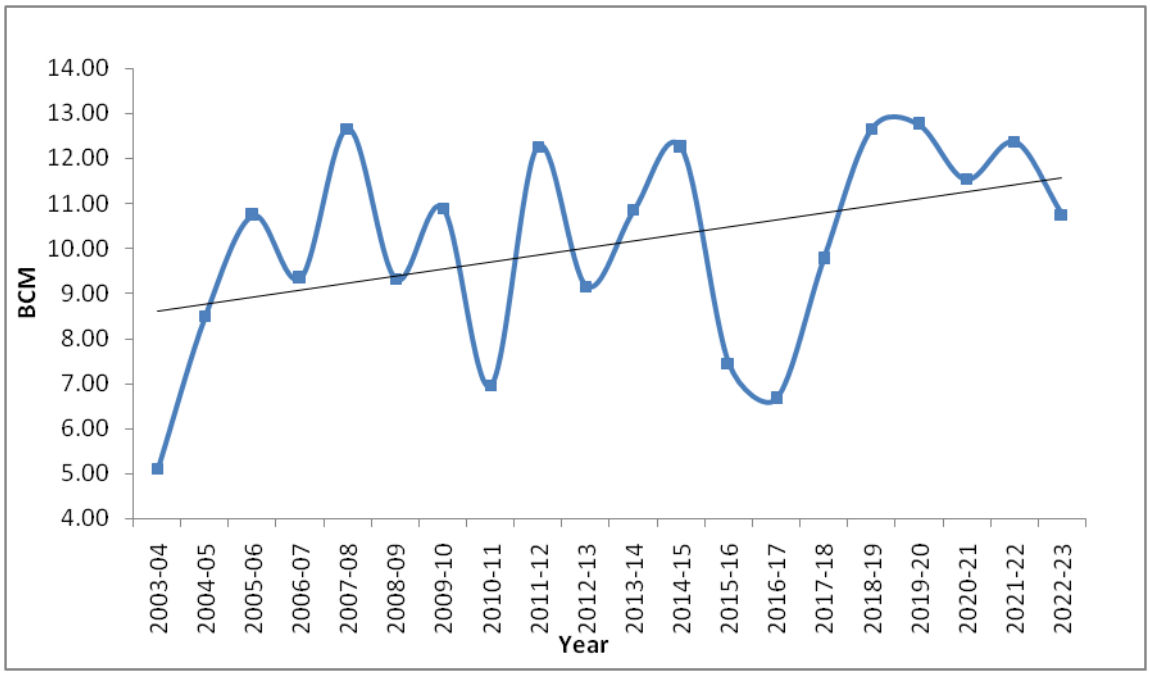


Figure 2.3: Annual Precipitation in Bharathapuzha sub-basin

2.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 4.43 BCM (743 mm) to 5.64 BCM (944 mm). The average ET of 20 years is 5.25 BCM (879.68 mm).

2.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.06 BCM.

2.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 0.33 BCM.

2.3.5 Groundwater flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux) for the sub-basin for 2003-04 to 2022-23 is 0.09 BCM. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.10 BCM.

2.4 Annual Water Availability of Bharathapuzha Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 5.23 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 2.4. The results of Bharathapuzha sub-basin are shown in Table 2.2.

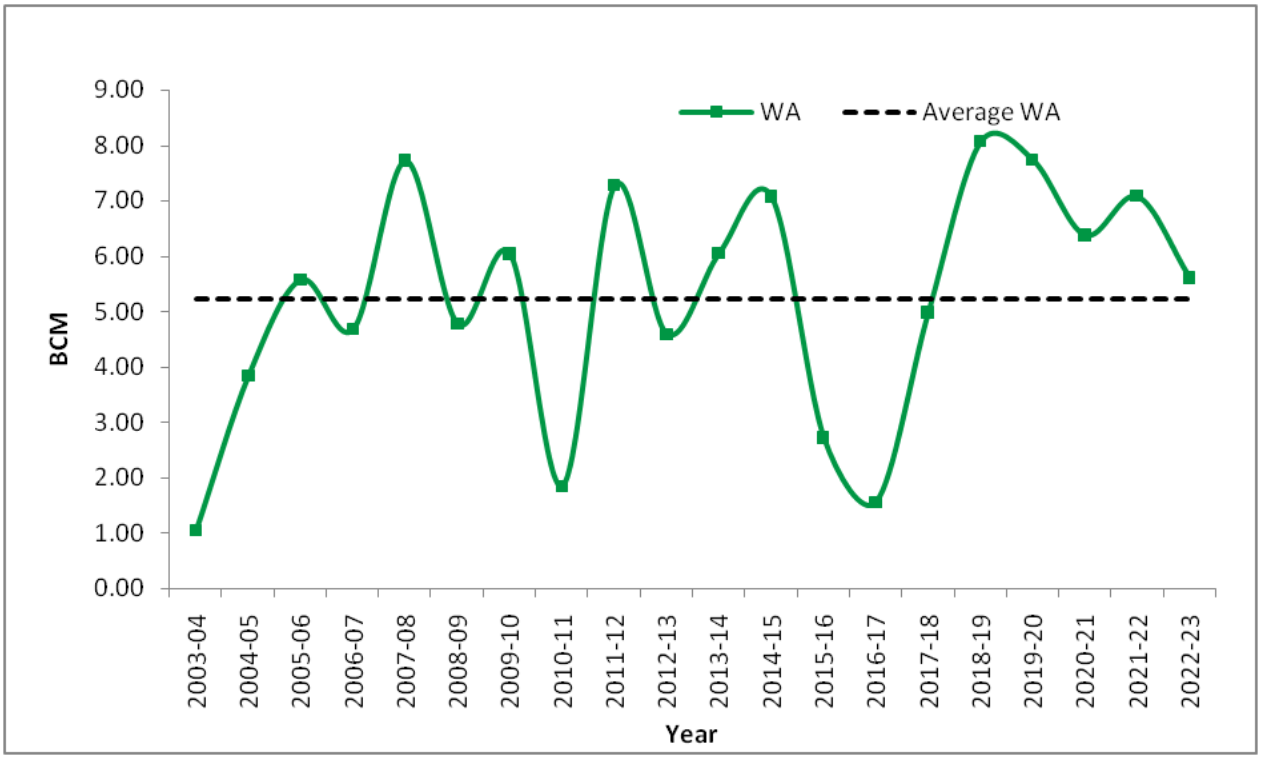


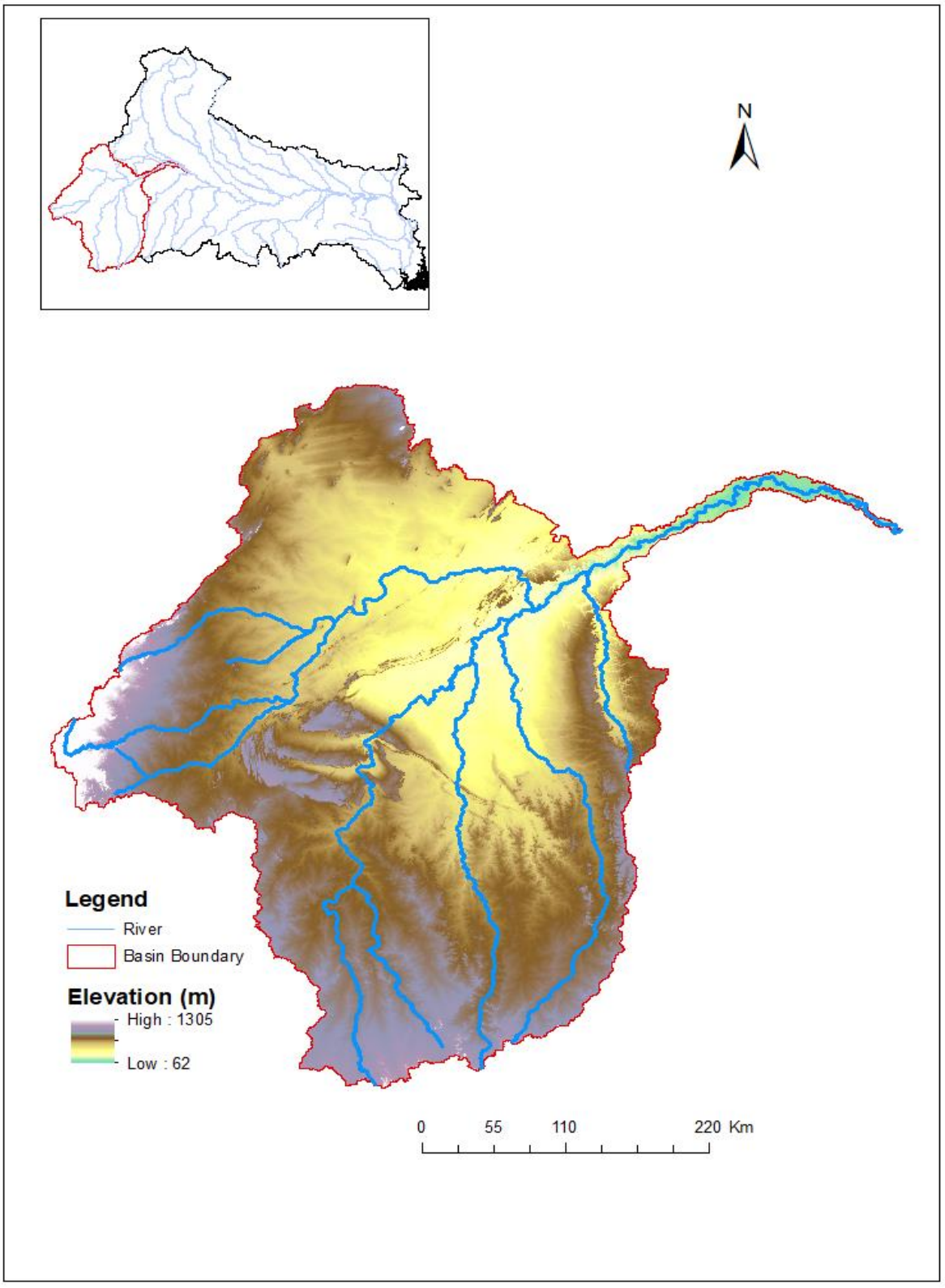
Figure 2.4: Water Availability of Bharathapuzha sub-basin

Table 2.2: Water Availability of Bharathapuzha sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	5.11	4.06	1.05
2004-05	8.50	4.66	3.84
2005-06	10.74	5.16	5.57
2006-07	9.33	4.66	4.68
2007-08	12.66	4.94	7.72
2008-09	9.32	4.55	4.77
2009-10	10.89	4.85	6.03
2010-11	6.95	5.11	1.84
2011-12	12.26	4.99	7.27
2012-13	9.16	4.57	4.59
2013-14	10.85	4.80	6.05
2014-15	12.24	5.17	7.07
2015-16	7.44	4.72	2.72
2016-17	6.65	5.10	1.55
2017-18	9.77	4.79	4.98
2018-19	12.65	4.58	8.06
2019-20	12.76	5.02	7.74
2020-21	11.54	5.16	6.38
2021-22	12.37	5.29	7.08
2022-23	10.74	5.14	5.61
Average	**10.10**	**4.87**	**5.23**

3. CHAMBAL SUB-BASIN



3.1 About Chambal Sub-basin

The most important tributary of the Yamuna is the Chambal river also known as Charmanvati in ancient times is the largest river flowing through Rajasthan state. It rises in the Vindhya range near Mhow in the Indore district of Madhya Pradesh at an elevation of 854 m and flows generally northerly direction up to the Madhya Pradesh-Rajasthan border. In this reach, the Chamla, the Siwana and the Retam join the river from the left and the Shipra and the Chhoti Kali Sindh from the right. It receives a major tributary from the right near the village of Laban, the Kali Sindh and another tributary the Kural from the left. The Banas the major left bank tributary of Chambal, joins the Chambal near the village of Rameshwar and other major right bank tributary, the Parbati joins the river near the village of Pali district. The river is mainly a rainfed river. Catchment area of Sub basin is approximately 1,42,221 sq km.

3.2 Geo-Spatial Datasets

3.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Chambal sub-basin for year 2022-23 is shown in Figure 3.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Deciduous woodland, Double/Triple, Kharif only etc.

Table 3.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

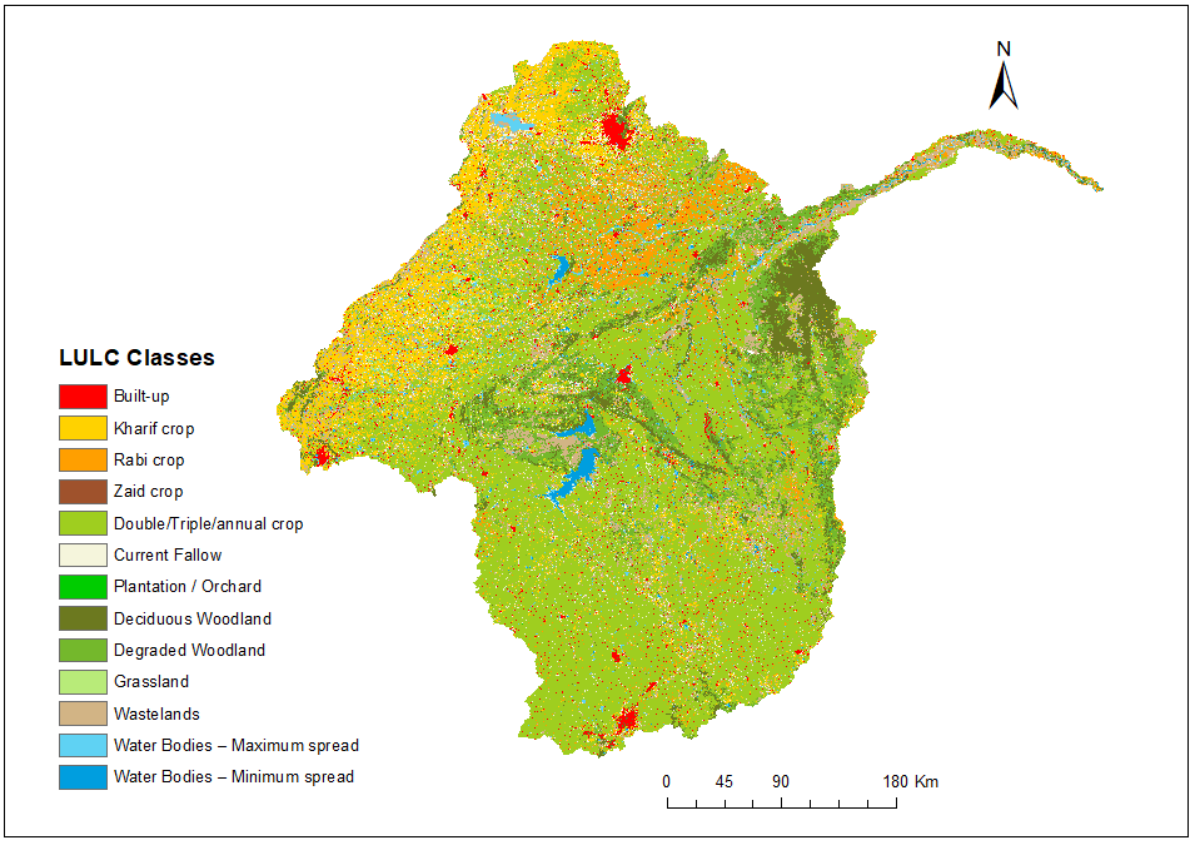


Figure 3.1: LULC Map of Chambal sub-basin

Table 3.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	2.91
2.	Kharif crop	11.24
3.	Rabi crop	5.97
4.	Zaid crop	0.00
5.	Double/Triple/Annual crop	49.45
6.	Current fallow land	4.21
7.	Plantation/Orchid	0.02
8.	Deciduous woodland	6.13
9.	Degraded woodland	7.91
10.	Grassland	0.60
11.	Waste lands	8.15
12.	Water Bodies - maximum spread	2.52
13.	Water Bodies - minimum spread	0.88

3.3 Hydro-Meteorological and other Input Data

3.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 3.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 3.3. The average precipitation of 20 years is approximately 120.30 BCM (845.90 mm).

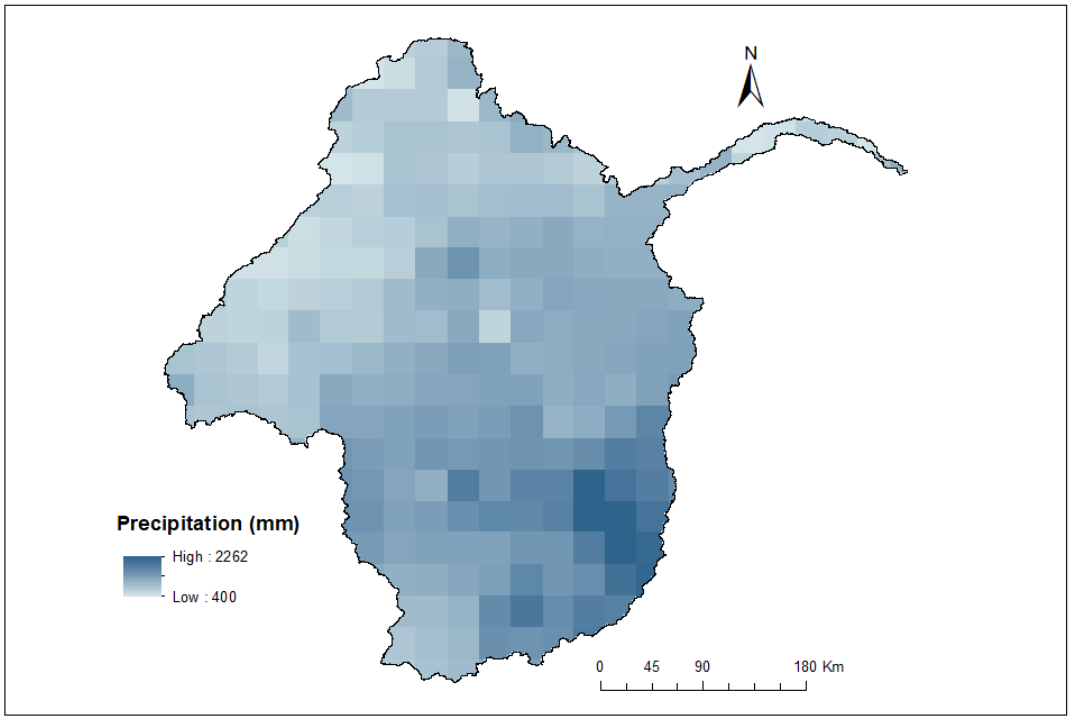


Figure 3.2: Precipitation map of Chambal sub-basin

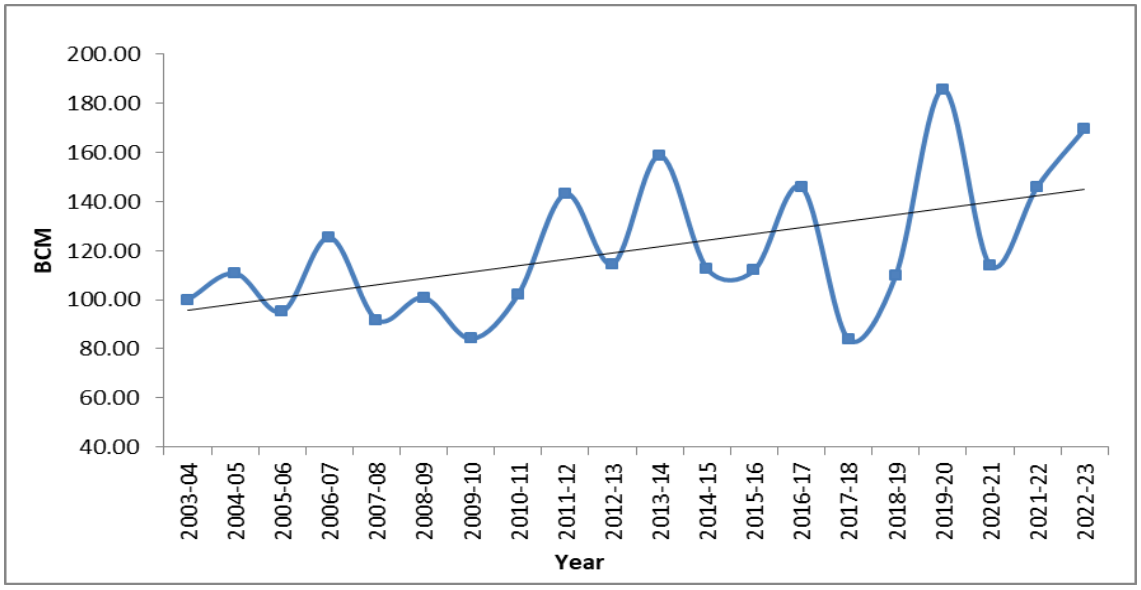


Figure 3.3: Annual Precipitation in Chambal sub-basin

3.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 82.30 BCM (579 mm) to 118.10 BCM (830 mm). The average ET of 20 years is 98.73 BCM (694.21 mm).

3.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 2.18 BCM.

3.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 20.67 BCM.

3.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux), Reservoir flux for the sub-basin for 2003-04 to 2022-23 is 0.04 BCM and 0.22 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 1.10 BCM.

3.4 Annual Water Availability of Chambal Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 44.42 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 3.4. The results of Chambal sub-basin are shown in Table 3.2.

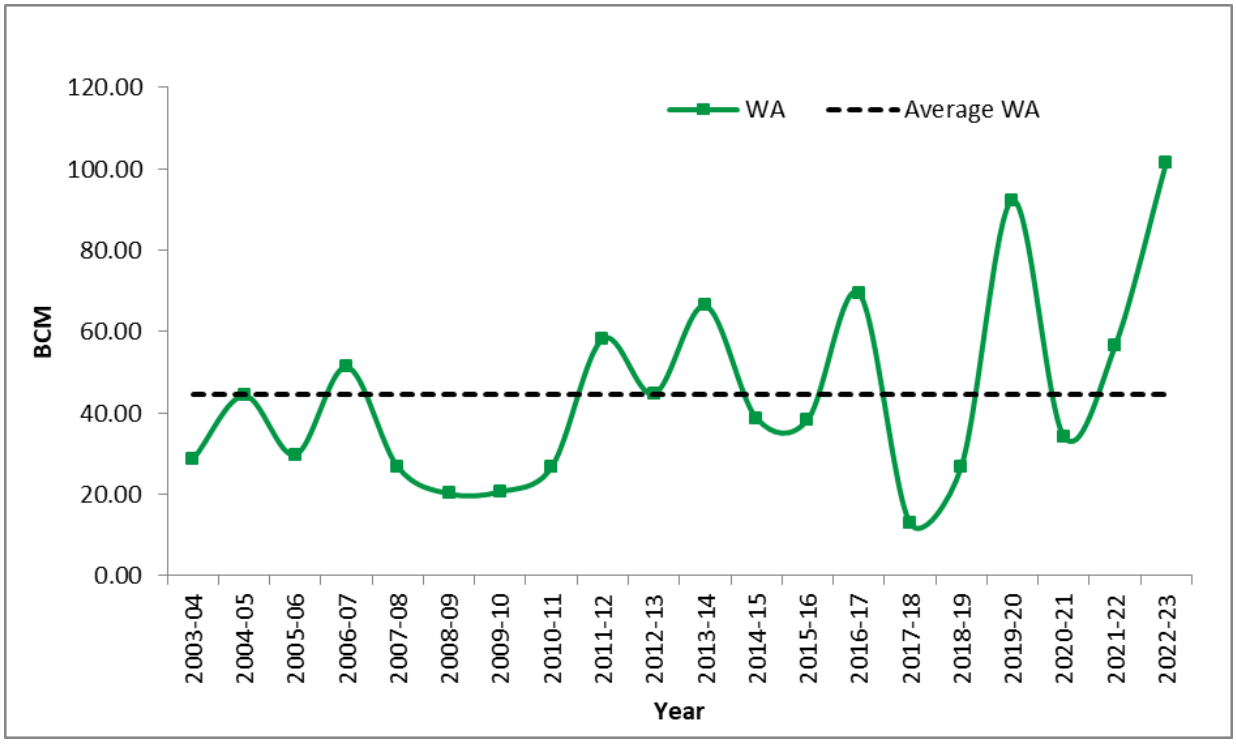


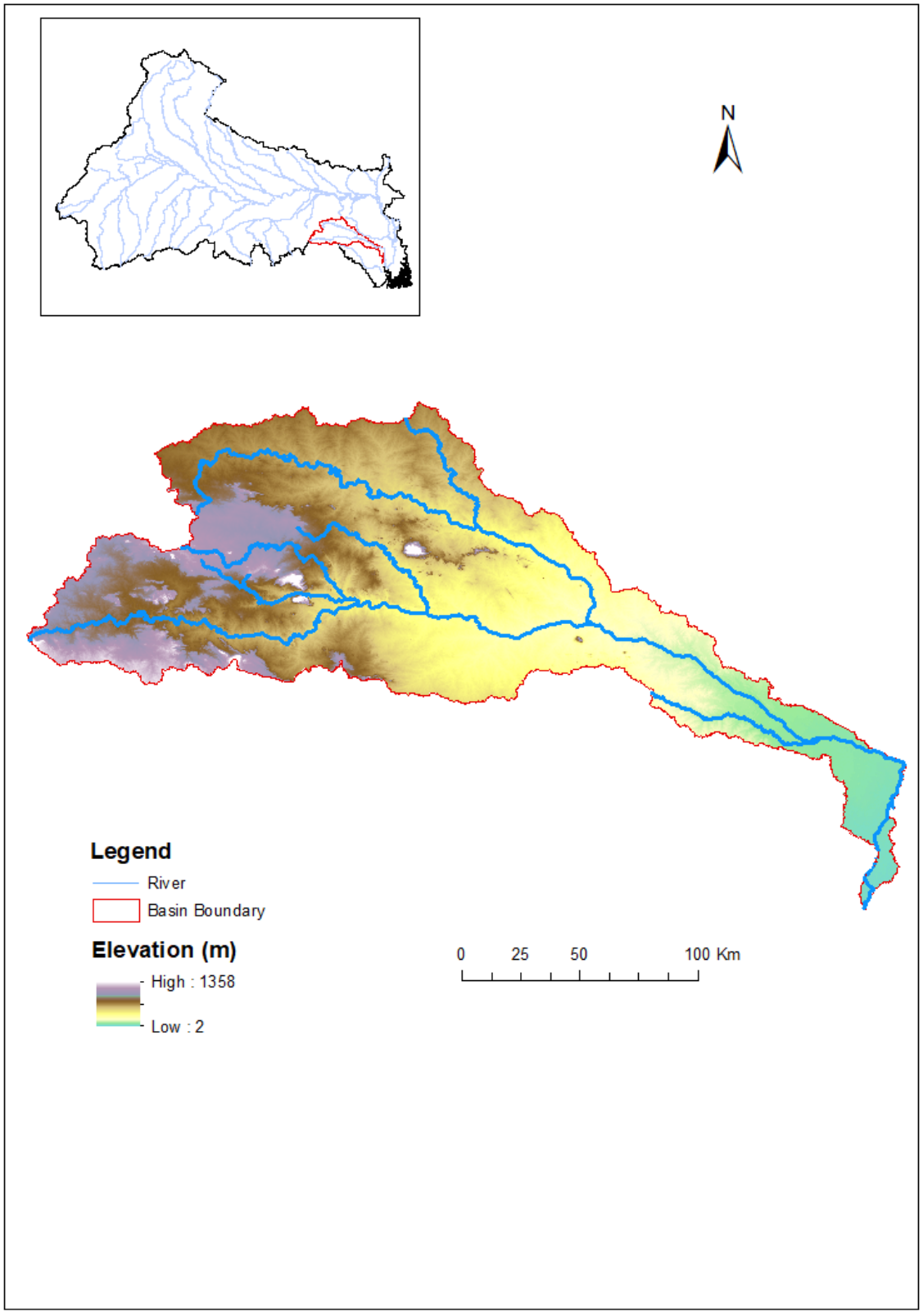
Figure 3.4: Water Availability of Chambal sub-basin

Table 3.2: Water Availability of Chambal sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	99.99	71.41	28.58
2004-05	110.80	66.52	44.27
2005-06	95.13	65.34	29.79
2006-07	125.43	74.08	51.36
2007-08	91.82	65.10	26.72
2008-09	100.88	80.68	20.20
2009-10	84.12	63.45	20.68
2010-11	102.18	75.49	26.69
2011-12	143.10	84.87	58.23
2012-13	114.55	69.86	44.69
2013-14	158.70	92.31	66.38
2014-15	112.65	73.91	38.74
2015-16	111.98	73.60	38.38
2016-17	145.94	76.52	69.42
2017-18	83.78	70.86	12.92
2018-19	109.85	82.99	26.85
2019-20	185.71	93.40	92.30
2020-21	114.03	79.79	34.25
2021-22	146.02	89.58	56.44
2022-23	169.44	67.88	101.55
Average	**120.30**	**75.882**	**44.42**

4. DAMODAR SUB-BASIN



4.1 About Damodar Sub-basin

The Damodar basin is located between 84°45' E longitude and 22° 15' to 24° 30' N latitude, entirely situated in the two states of Jharkhand (earlier Bihar) and West Bengal. The Damodar river rises in the Palamu Hills of Chhotanagpur in Jharkhand at about 609.57m above mean sea level. The hilly terrain is almost within the state of Jharkhand and the flatter portion lie within the state of West Bengal. The catchment is irregular in shape and somewhat elongated in the lower reach. Catchment area of the Damodar sub-basin is approximately 22,488 sq. km.

4.2 Geo-Spatial Datasets

4.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Damodar sub-basin for year 2022-23 is shown in Figure 4.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Kharif only, Deciduous woodland, Current Fallow, etc.

Table 4.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

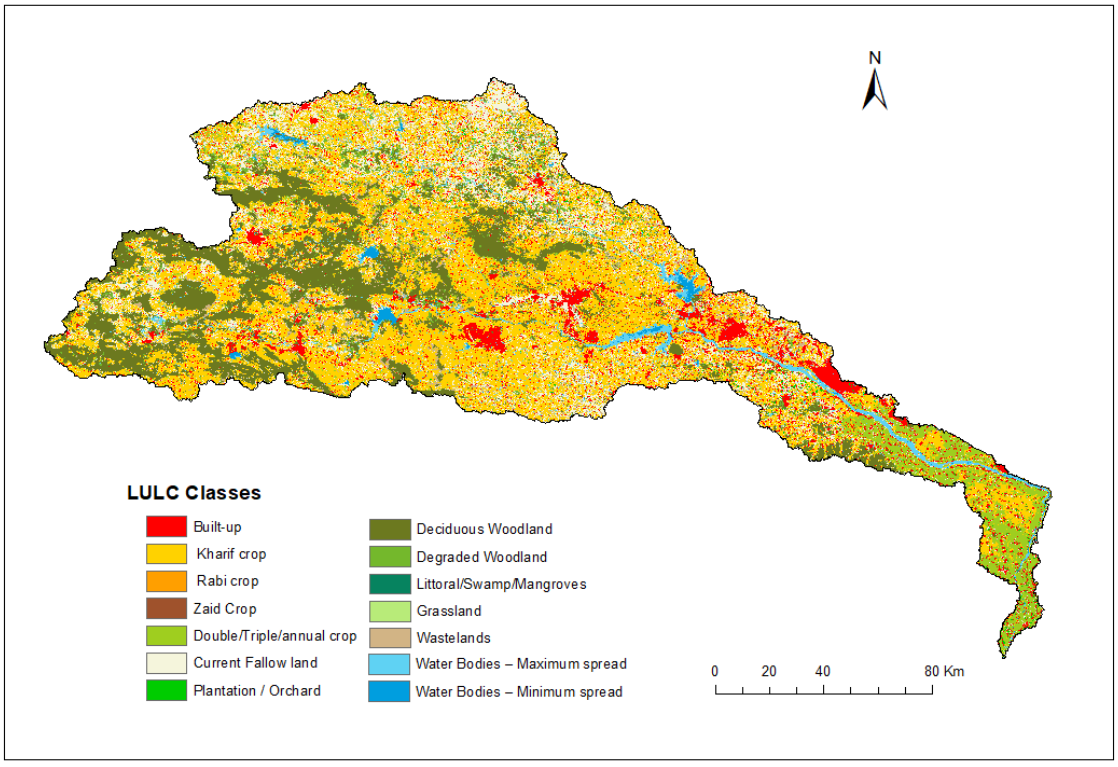


Figure 4.1: LULC Map of Damodar sub-basin

Table 4.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	8.60
2.	Kharif crop	40.84
3.	Rabi crop	0.49
4.	Zaid crop	0.00
5.	Double/ Triple/Annual crop	5.98
6.	Current fallow	15.67
7.	Orchard	0.48
8.	Deciduous woodland	17.88
9.	Degraded woodland	2.63
10.	Littoral swamp	0.00
11.	Grassland	0.00
12.	Waste land	3.81
13.	Water bodies max	2.92
14.	Water bodies min	0.69

4.3 Hydro-Meteorological and other Input Data

4.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 4.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 3.3. The average precipitation of 20 years is approximately 26.44 BCM (1176 mm).

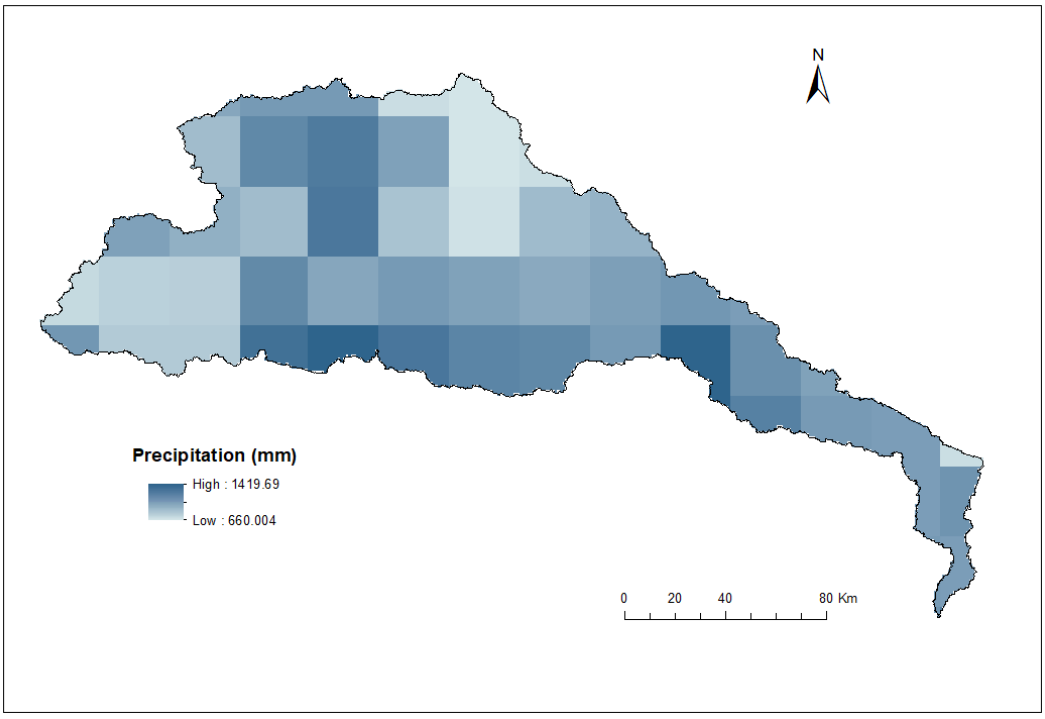


Figure 4.2: Precipitation map of Damodar sub-basin

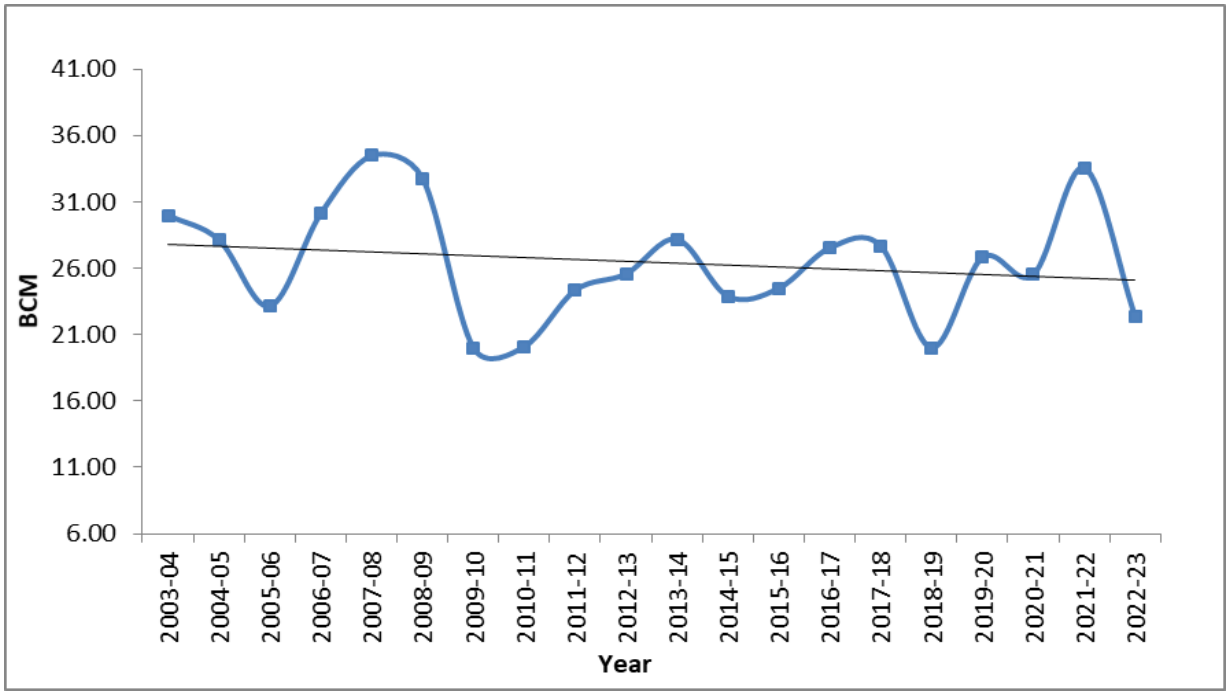


Figure 4.3: Annual Precipitation in Damodar sub-basin

4.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 17.17 BCM (763 mm) to 24.62 BCM (1095 mm). The average ET of 20 years is 15.11 BCM (896 mm).

4.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.02 BCM.

4.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 0.74 BCM.

4.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux), Reservoir flux for the sub-basin for 2003-04 to 2022-23 is -0.02 BCM and 0.01 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.41 BCM.

4.4 Annual Water Availability of Damodar Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 12.08 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 4.4. The results of Damodar sub-basin are shown in Table 4.2.

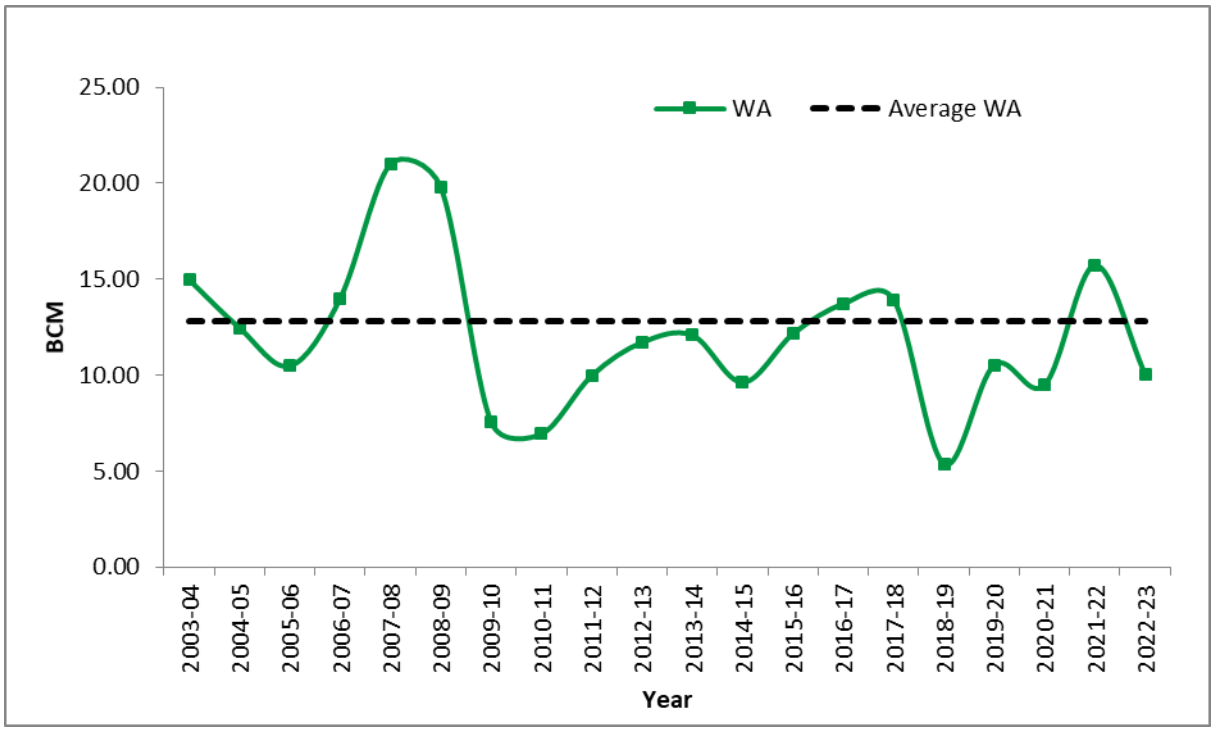


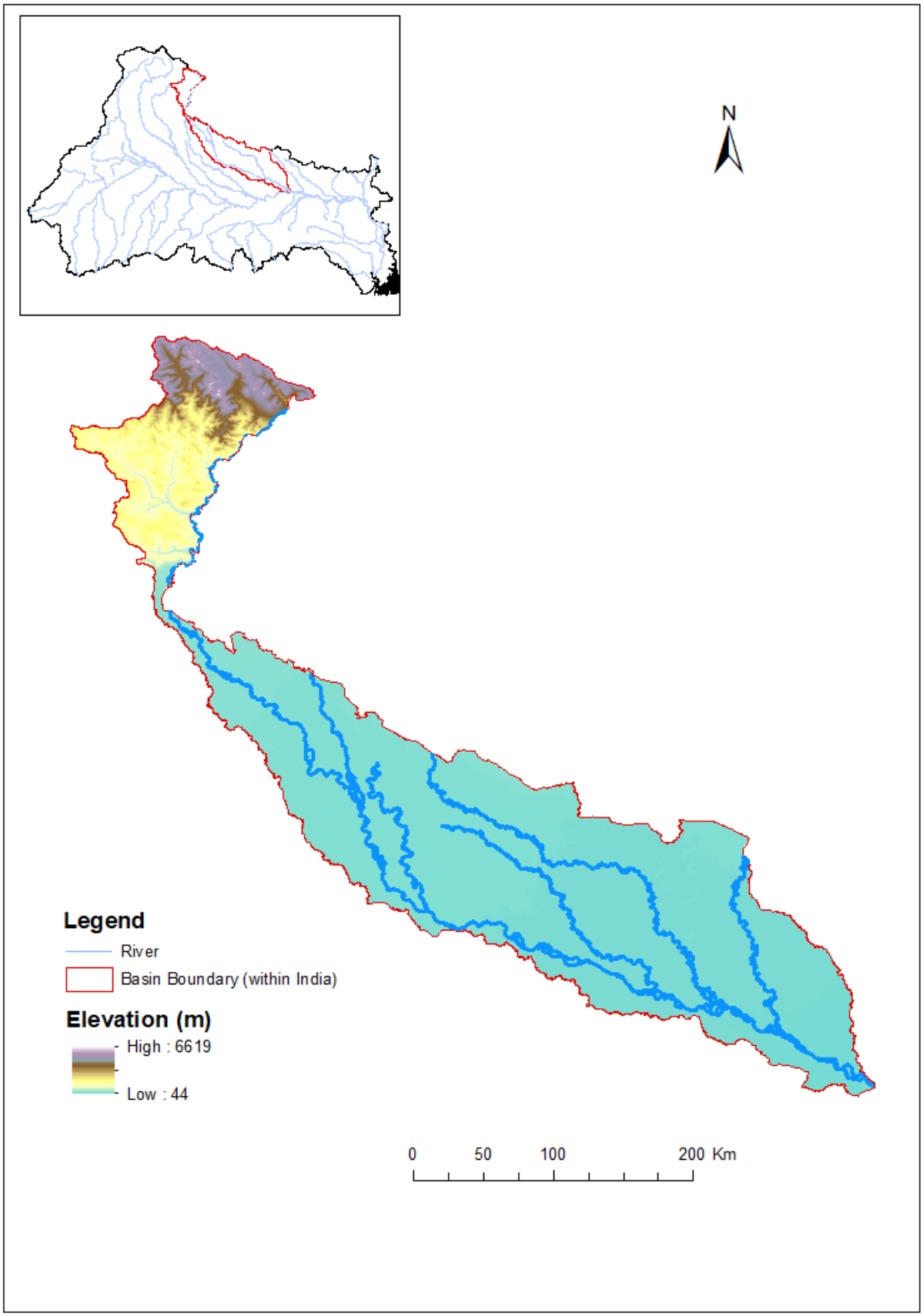
Figure 4.4: Water Availability of Damodar sub-basin

Table 4.2: Water Availability of Damodar sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	29.98	15.02	14.97
2004-05	28.14	15.68	12.46
2005-06	23.14	12.66	10.49
2006-07	30.12	16.11	14.01
2007-08	34.48	13.46	21.02
2008-09	32.78	12.99	19.79
2009-10	20.00	12.45	7.55
2010-11	20.10	13.16	6.94
2011-12	24.35	14.36	9.98
2012-13	25.58	13.87	11.71
2013-14	28.18	16.10	12.08
2014-15	23.89	14.26	9.63
2015-16	24.50	12.33	12.16
2016-17	27.53	13.81	13.72
2017-18	27.69	13.75	13.93
2018-19	20.01	14.63	5.38
2019-20	26.82	16.28	10.54
2020-21	25.52	16.04	9.48
2021-22	33.56	17.83	15.73
2022-23	22.38	12.33	10.05
Average	**26.44**	**14.36**	**12.08**

5. GHAGHRA SUB-BASIN



5.1 About Ghaghra Sub-basin

The Ghaghara river, also known as the Sarju or the Dehwa, contains the combined waters of the Chauka or Sarda and the Kauriala which unite near Bahramghat in the Barabanki district in the Uttar Pradesh. The Ghaghara is a mighty river with a considerable Himalayan catchment. The Ghaghara (Karnali or Kauriala) rises in the glaciers of Mapchachungo in Nepal, north-west of Taklakot and collecting the waters of the Tila, the Seti and the Beri rivers carves out a deep 600 m gorge at Shishapani. In the plains it is joined by the Sarda (Kali or Kaliganga) and flows south-eastward so as to meet the Ganga at Chapra. Ghaghara enters into India at Kotia Ghat near Royal Bardia National Park, Nepal Ganj, where it is known as Girwa for about 25 km. A barrage called Girijapuri barrage is constructed and below the barrage the river Girwa attains the name of the Ghaghara. Out of the total catchment of the Ghaghara only 45 percent lies in India. The Sarda river is the important tributary of the Ghaghara, which forms the boundary between India and Nepal for some distance. The total length of the Ghaghara before its confluence with Ganga river at Doriganj downstream of Chapra town in Bihar is 1,080 km. The Sarju, the Rapti and the Little Gandak are other important tributaries of the Ghaghara. The Catchment area of the sub-basin in india is approximately 58,355 sq. km.

5.2 Geo-Spatial Datasets

5.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Ghaghra sub-basin for year 2022-23 is shown in Figure 5.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Double/Triple, Kharif, and Evergreen etc.

Table 5.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

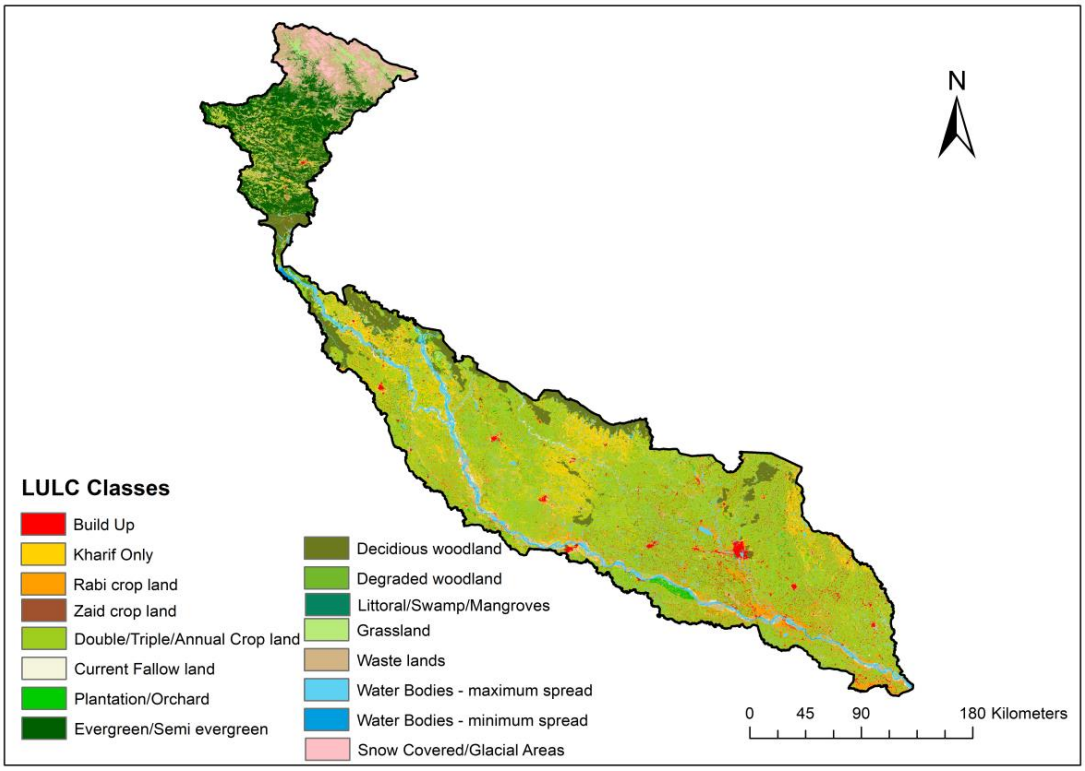


Figure 5.1: LULC Map of Ghaghra sub-basin

Table 5.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	3.73
2.	Kharif only	11.01
3.	Rabi crop	4.36
4.	Zaid crop	0.00
5.	Double/Triple/Annual crop	46.91
6.	Current Fallow	2.74
7.	Plantation/Orchard	1.46
8.	Evergreen/Semi evergreen	6.35
9.	Deciduous woodland	8.03
10.	Degraded woodland	1.00
11.	Littoral Swamp	0.04
12.	Grassland	0.92
13.	Waste lands	6.10
14.	Water Bodies - maximum spread	5.60
15.	Water Bodies - minimum spread	0.41
16.	Snow	1.34

5.3 Hydro-Meteorological and other Input Data

5.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 5.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 5.3. The average precipitation of 20 years is approximately 69.06 BCM (1183.50 mm).

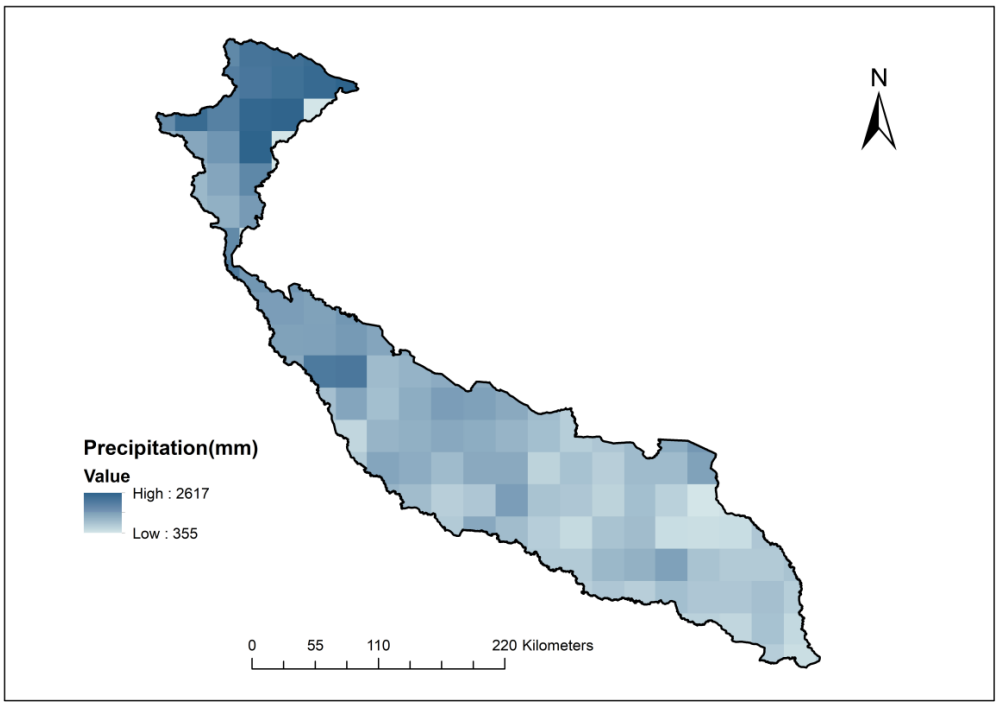


Figure 5.2: Precipitation map of Ghaghra sub-basin

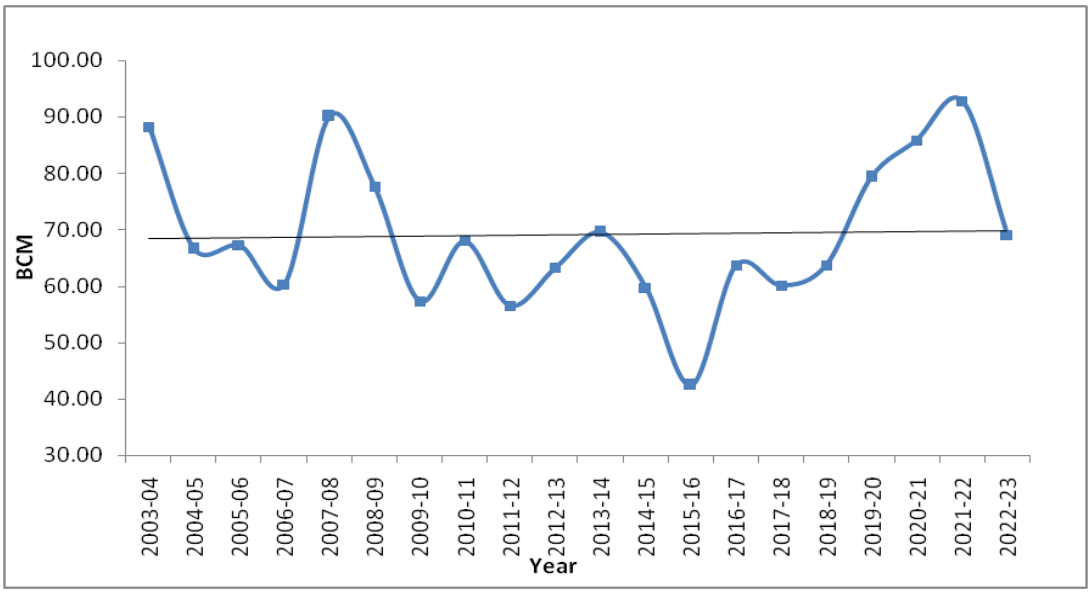


Figure 5.3: Annual Precipitation in Ghaghra sub-basin

5.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 32.22 BCM (552 mm) to 47.54 BM (815 mm). The average ET of 20 years is 43.05 BCM (737.72 mm).

5.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.07 BCM.

5.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 12.45 BCM.

5.3.5 Groundwater flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux) for the sub-basin for 2003-04 to 2022-23 is -0.59 BCM. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.50 BCM.

5.4 Annual Water Availability of Ghaghra Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 92.68 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 5.4. The results of Ghaghra sub-basin are shown in Table 5.2.

The Catchment Area of Ghaghra Sub Basin lying in Nepal is about 70,992 sq. Km (55% of the total catchment area). The transboundary inflow from Nepal into India is estimated as difference of Precipitation & Evapotranspiration over the corresponding Nepal catchment. Precipitation has been taken from available Global products GPM / CHIRPS while for Evapotranspiration SSeBOP Data has been used.

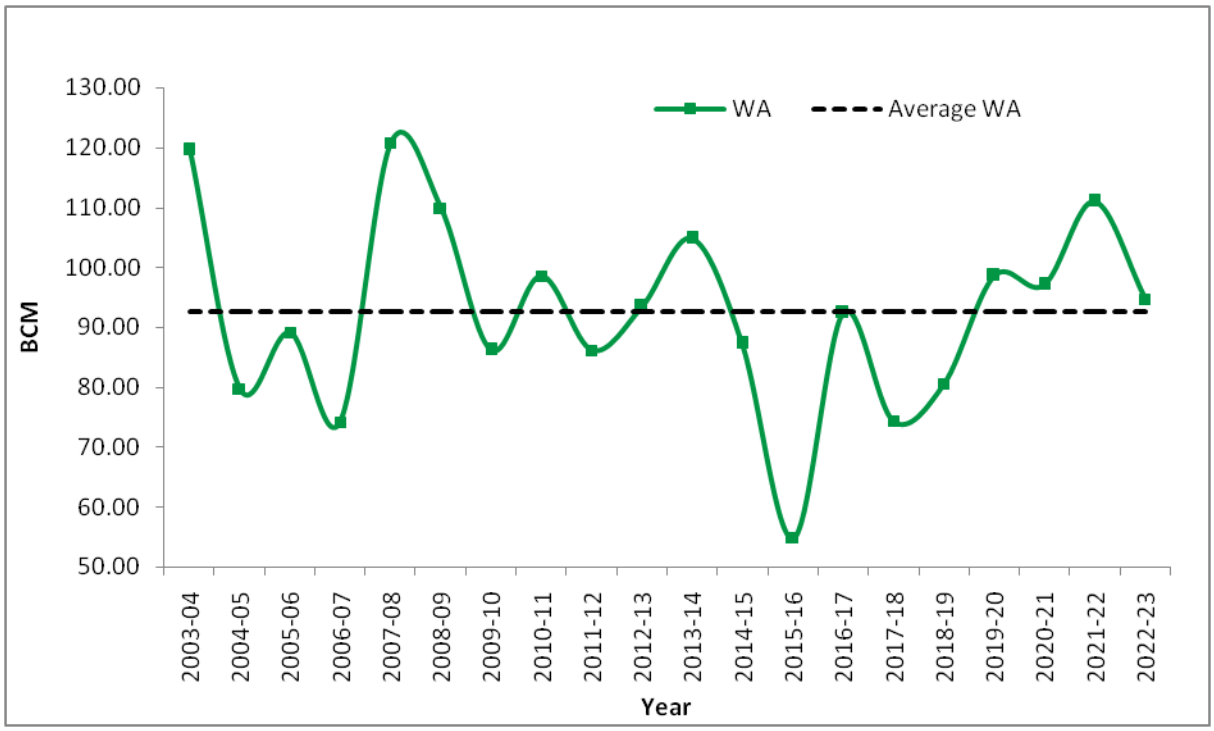


Figure 5.4: Water Availability of Ghaghra sub-basin

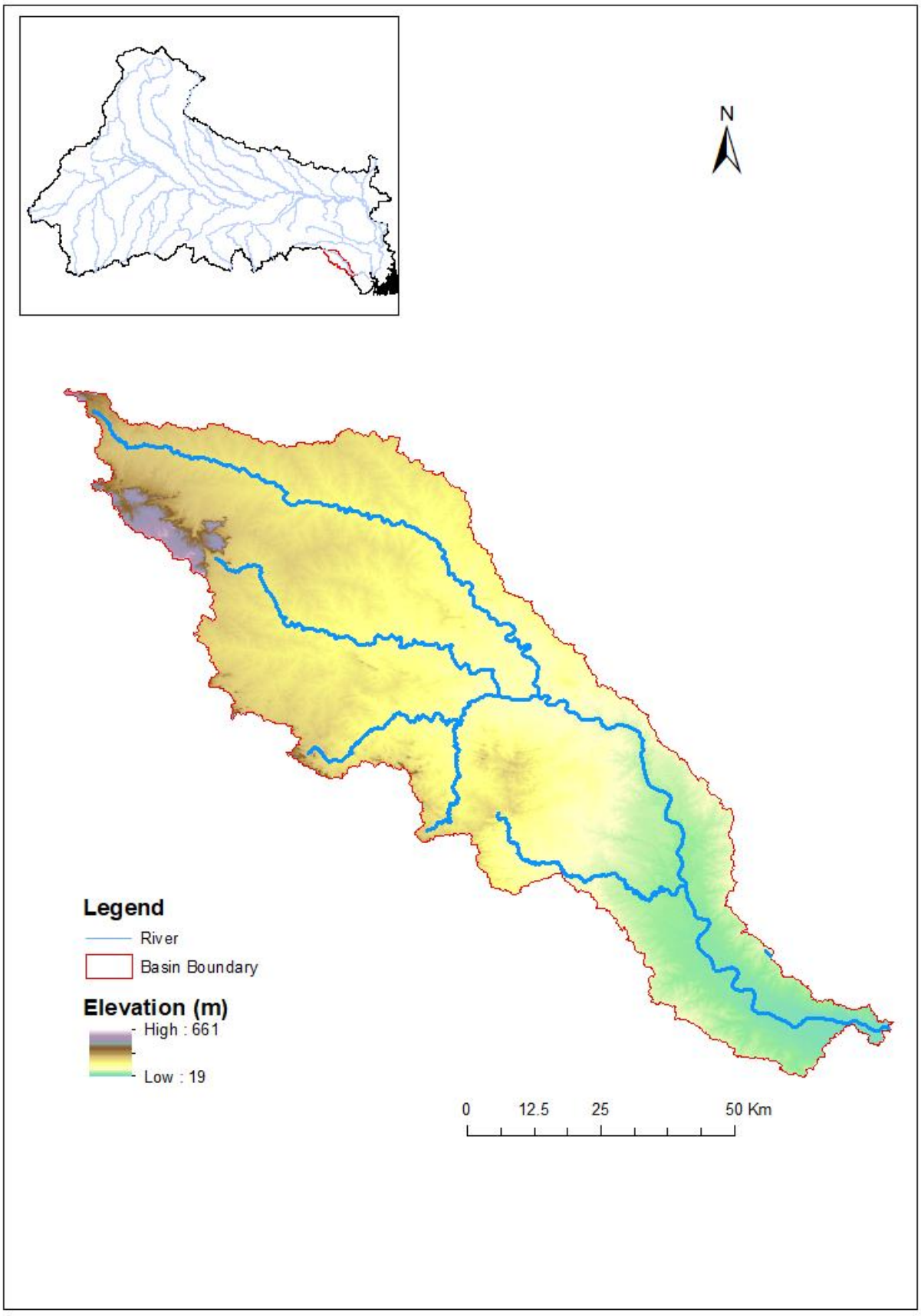
Table 5.2: Water Availability of Ghaghra sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability*
2003-04	88.23	33.56	119.56
2004-05	66.57	31.60	79.78
2005-06	67.22	30.04	89.16
2006-07	60.30	34.52	74.21
2007-08	90.09	29.44	120.78
2008-09	77.66	32.27	109.83
2009-10	57.28	28.40	86.26
2010-11	67.99	30.36	98.51
2011-12	56.54	29.84	86.19
2012-13	63.24	28.41	93.49
2013-14	69.54	31.94	104.86
2014-15	59.73	31.26	87.32
2015-16	42.40	26.26	54.85
2016-17	63.65	30.28	92.41
2017-18	60.10	27.88	74.33
2018-19	63.69	29.95	80.63
2019-20	79.32	31.11	98.62
2020-21	85.83	33.48	97.11
2021-22	92.77	36.23	111.05
2022-23	69.08	23.71	94.68
Average	**69.06**	**30.53**	**92.68**

**including trans-boundary contribution*

6. KANGSABATI SUB-BASIN



6.1 About Kangsabati Sub-basin

The Kangsabati river also known as the Kasai and Cossye originates from Ghoramara hill (Jhalda - 23º32´30´´N and 85º56´30´´E) the Eastern Chotonagpur plateau, flows towards east through the Districts of Puruliya, Bankura, and undivided Midnapore. Kangsabati meets with Rupnarayan river near Ghatal (Bandar). The combined flow of Rupnarayan and Kangsabati is known Keleghai. The Catchment area of the sub-basin is approximately 5,728 sq. km.

6.2 Geo-Spatial Datasets

6.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Kangsabati sub-basin for year 2022-23 is shown in Figure 6.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Kharif, Decidious Woodland and Current Fallow etc.

Table 6.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

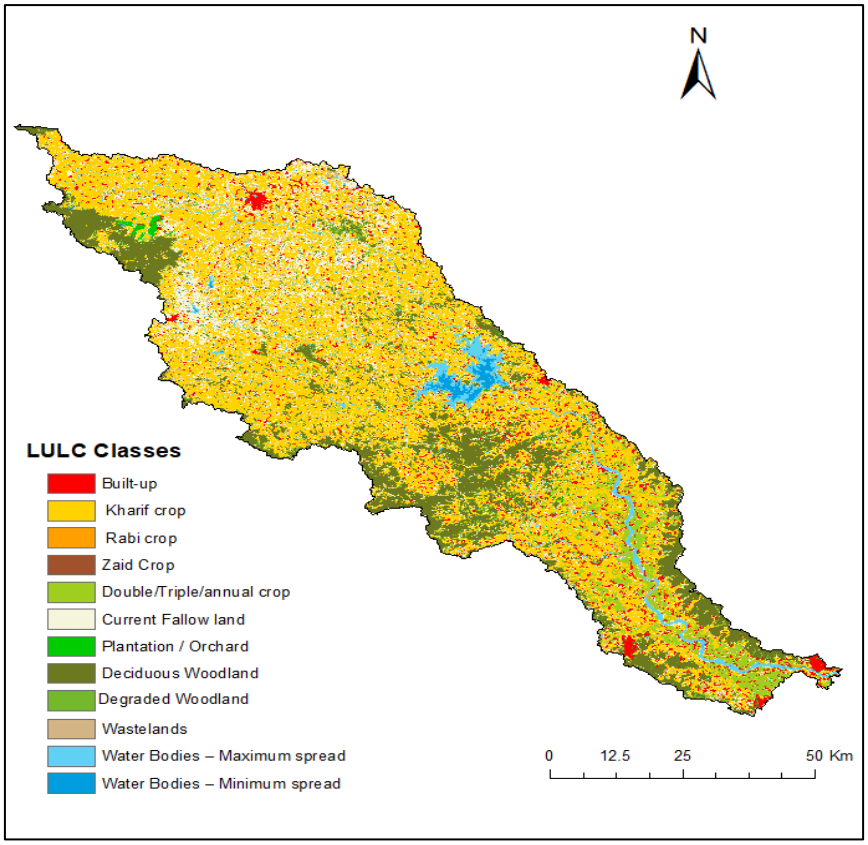


Figure 6.1: LULC Map of Kangsabati sub-basin

Table 6.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	5.56
2.	Kharif only	48.13
3.	Rabi crop	0.21
4.	Zaid crop	0.00
5.	Double/Triple/Annual crop	6.07
6.	Current Fallow	14.31
7.	Plantation/Orchard	1.46
8.	Deciduous woodland	16.98
9.	Degraded woodland	1.68
10.	Waste lands	6.10
11.	Water Bodies - maximum spread	3.60
12.	Water Bodies - minimum spread	0.70

6.3 Hydro-Meteorological and other Input Data

6.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 6.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 6.3. The average precipitation of 20 years is approximately 8.04 BCM (1402.97 mm).

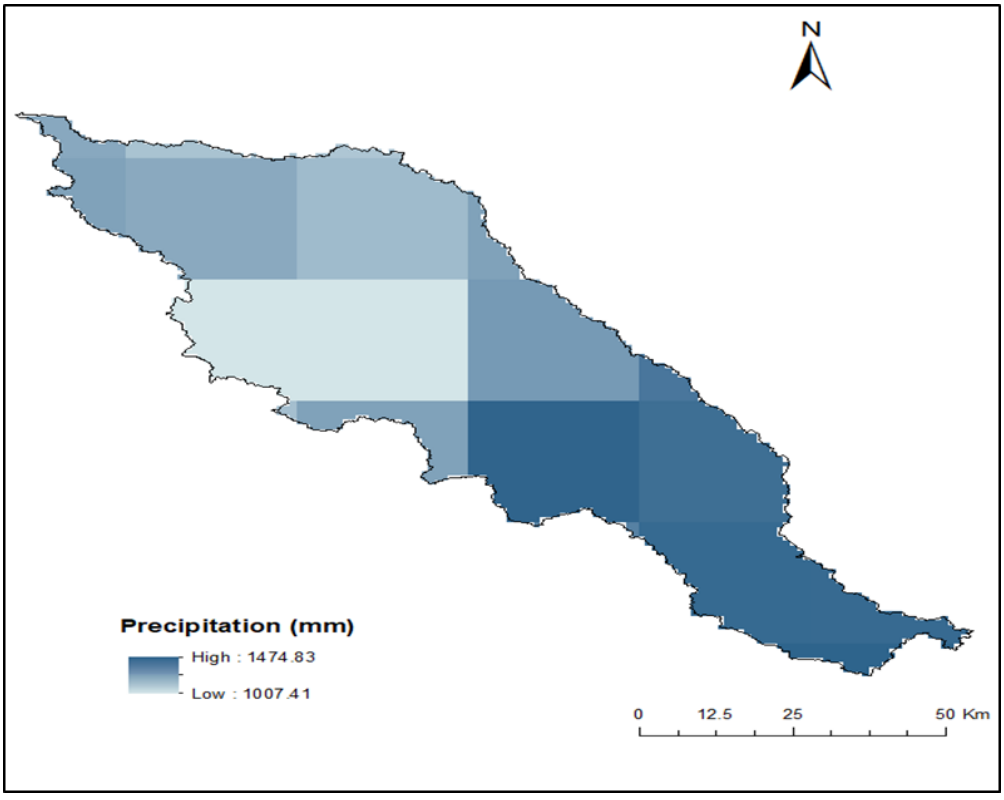


Figure 6.2: Precipitation map of Kangsabati sub-basin

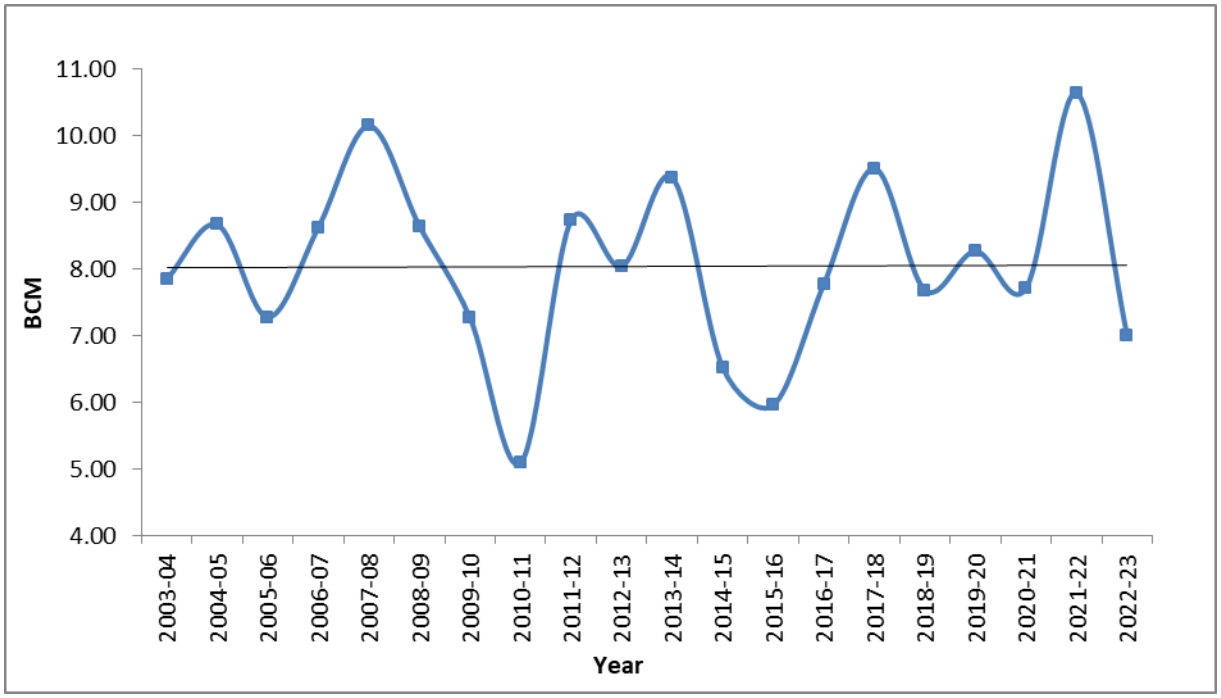


Figure 6.3: Annual Precipitation in Kangsabati sub-basin

6.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 4.37 BCM (762 mm) to 5.47 BCM (954 mm). The average ET of 20 years is 4.37 BCM (762.42 mm).

6.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.09 BCM.

6.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 0.35 BCM.

6.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux), Reservoir flux for the sub-basin for 2003-04 to 2022-23 is -0.05 BCM and 0.03 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.11 BCM.

6.4 Annual Water Availability of Kangsabati Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 4.11 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 6.4. The results of Kangsabati sub-basin are shown in Table 6.2.

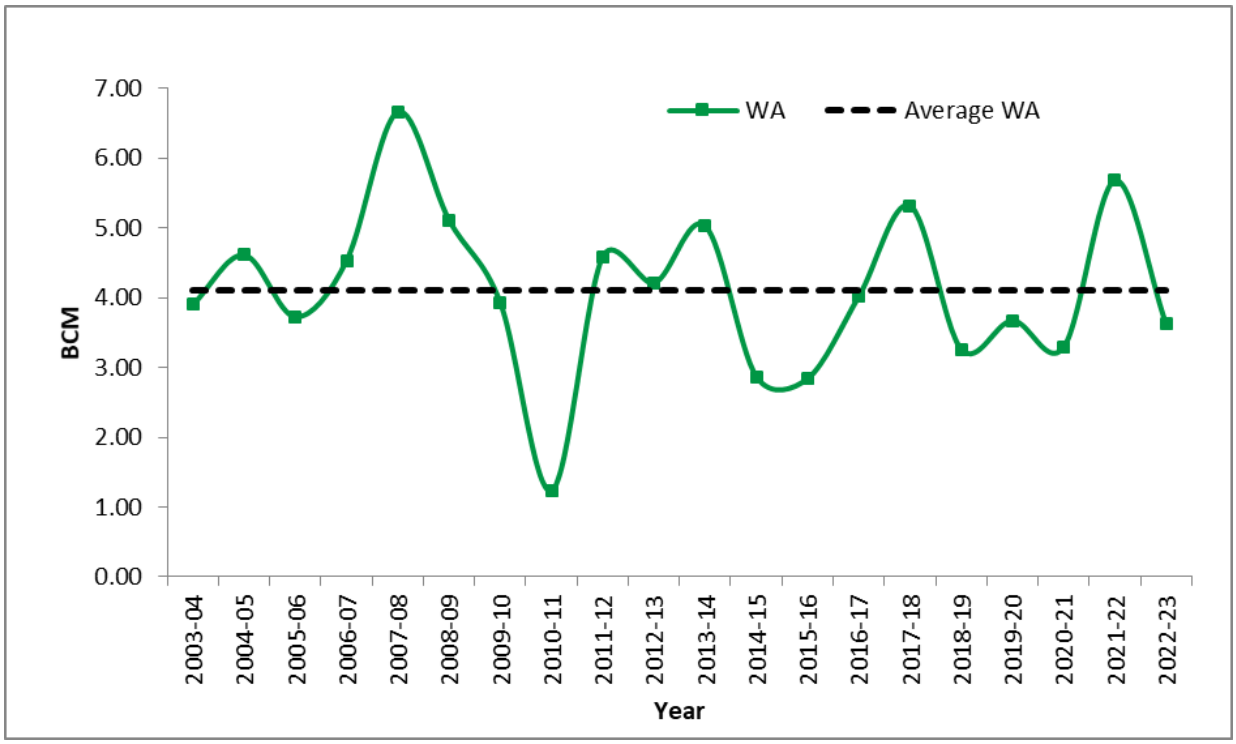


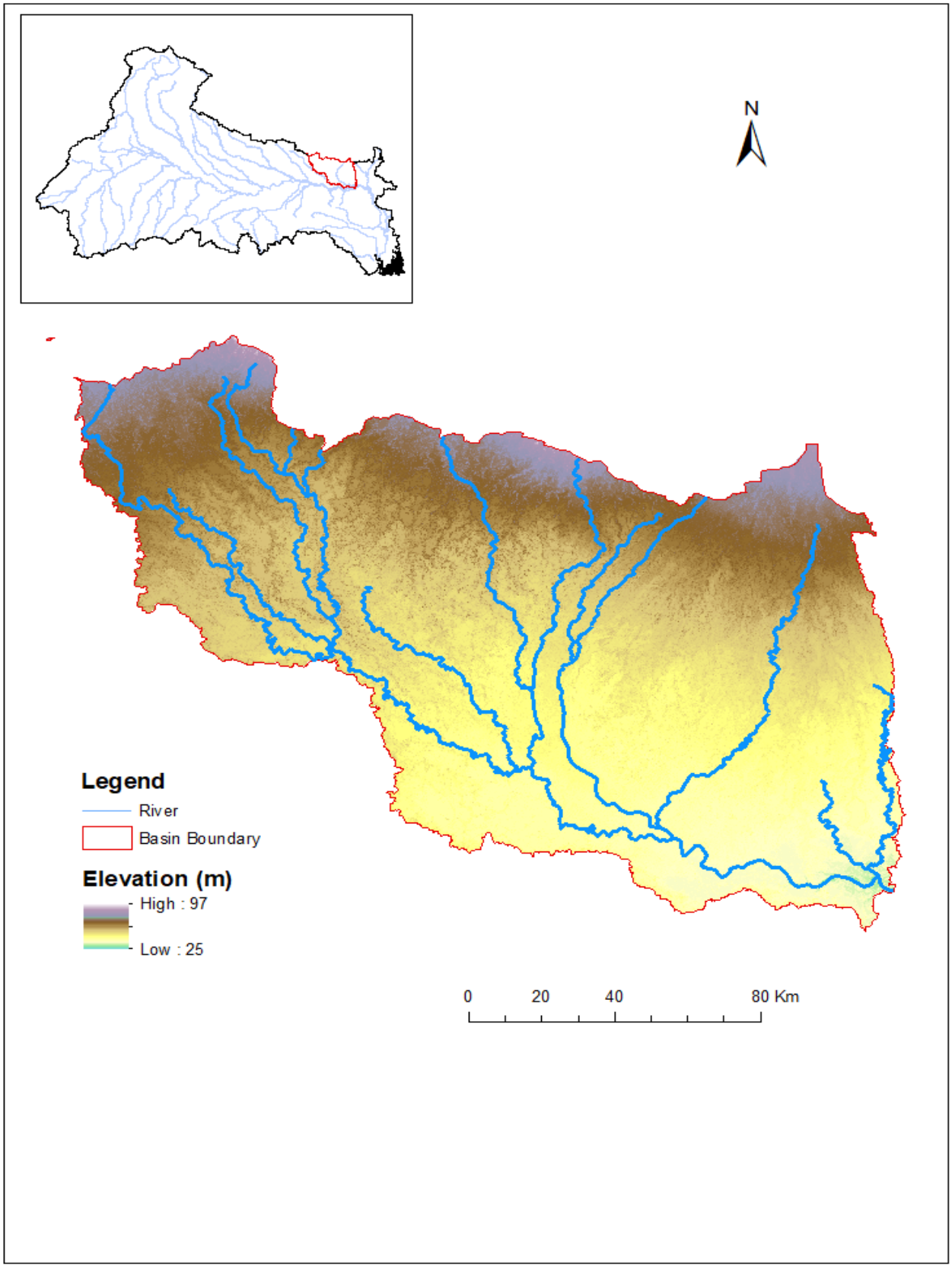
Figure 6.4: Water Availability of Kangsabati sub-basin

Table 6.2: Water Availability of Kangsabati sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	7.85	4.36	3.90
2004-05	8.66	4.42	4.61
2005-06	7.28	3.94	3.73
2006-07	8.62	4.53	4.53
2007-08	10.14	3.93	6.66
2008-09	8.64	3.86	5.11
2009-10	7.26	3.71	3.93
2010-11	5.09	4.27	1.24
2011-12	8.73	4.72	4.59
2012-13	8.04	4.25	4.21
2013-14	9.37	4.72	5.03
2014-15	6.52	4.13	2.87
2015-16	5.96	3.53	2.84
2016-17	7.77	4.24	4.02
2017-18	9.51	4.77	5.32
2018-19	7.68	4.90	3.26
2019-20	8.26	4.95	3.67
2020-21	7.71	4.95	3.29
2021-22	10.64	5.47	5.68
2022-23	7.00	3.70	3.62
Average	**8.04**	**4.37**	**4.11**

7. KOSI SUB-BASIN



7.1 About Kosi Sub-basin

The Kosi (Kausika) is the largest of the tributaries of the Ganga is formed by the confluence of three streams namely the Sun Kosi, the Arun Kosi and the Tamur Kosi, all taking their origin in the Himalayan region of Nepal and Tibet. The Arun Kosi (Phungchu in Tibet) rises to the north of Gosainthan is the biggest of the three streams and has two of the highest peaks in the world namely Mount Everest and Mount Kanchenjunga in its catchment. The Kosi is notorious for its frequent and disastrous floods and shifting of courses. It is also called as 'the sorrow of Bihar' and meets the Ganga 32 km west of Manihari. The main tributaries of Kosi river are Bagmati and the Kamala rivers. The catchment area of the Kosi Basin spans approximately 19,915.066 square kilometers in India and 67,663 Sq. Km in Nepal.

7.2 Geo-Spatial Datasets

7.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Kosi sub-basin for year 2022-23 is shown in Figure 7.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Deciduous woodland, Double/Triple, Kharif only etc.

Table 7.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

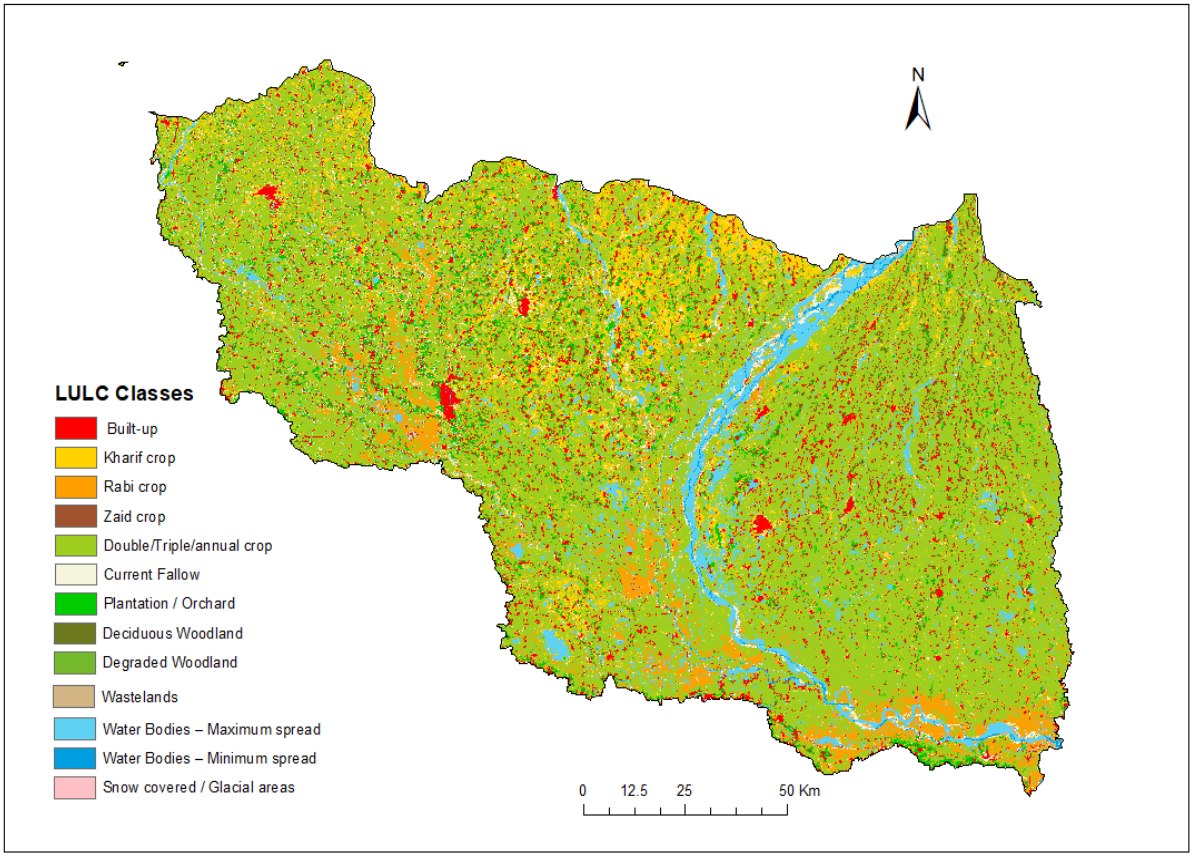


Figure 7.1: LULC Map of Kosi sub-basin

Table 7.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	5.92
2.	Kharif crop	11.27
3.	Rabi crop	5.32
4.	Zaid crop	0.00
5.	Double/Triple/Annual crop	60.49
6.	Current fallow land	3.13
7.	Plantation/Orchid	4.06
8.	Deciduous woodland	3.06
9.	Degraded woodland	0.04
10.	Waste lands	0.21
11.	Water Bodies - maximum spread	6.14
12.	Water Bodies - minimum spread	0.37

7.3 Hydro-Meteorological and other Input Data

7.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 8.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 8.3. The average precipitation of 20 years is approximately 24.46 BCM (1228 mm).

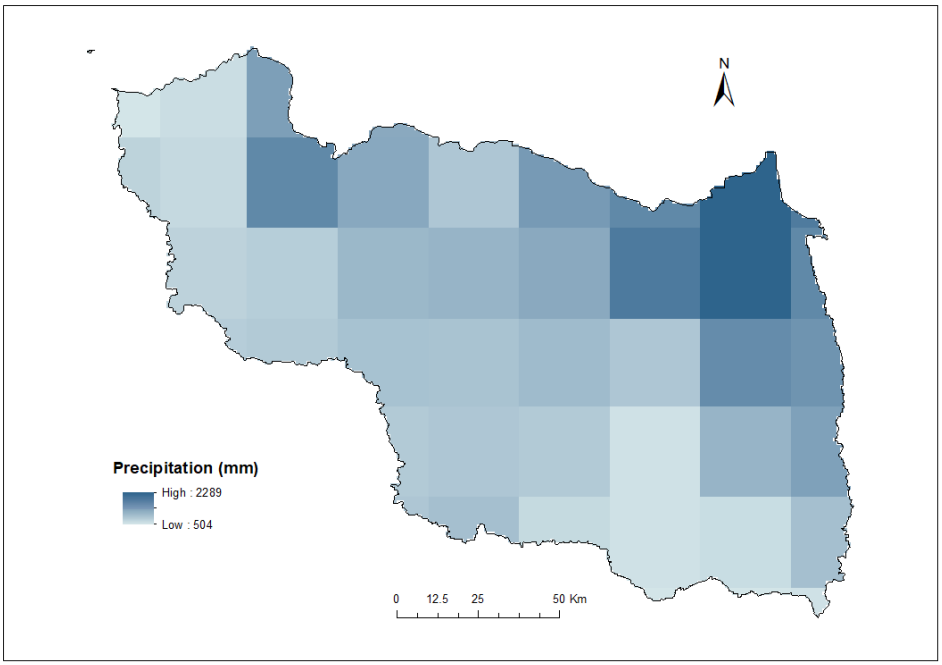


Figure 7.2: Precipitation map of Kosi sub-basin

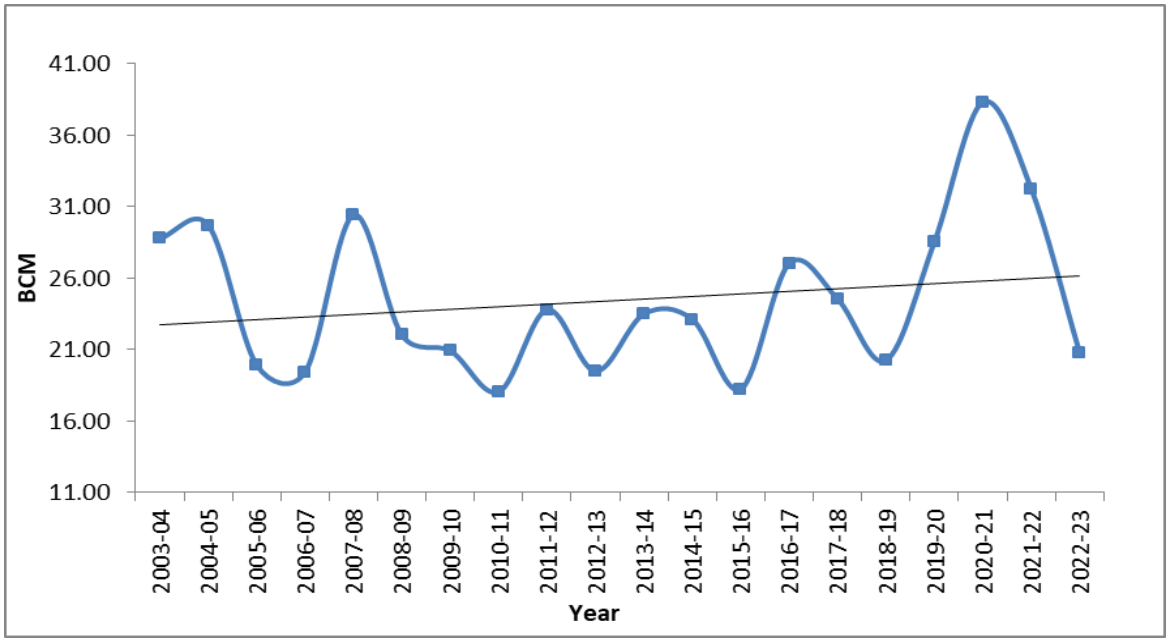


Figure 7.3: Annual Precipitation in Kosi sub-basin

7.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 13.60 BCM (683 mm) to 16.83 BCM (845 mm). The average ET of 20 years is 15.17 BCM (762 mm).

7.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.03 BCM.

7.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 4.03 BCM.

7.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux), Reservoir flux for the sub-basin for 2003-04 to 2022-23 is -0.55 BCM and 0 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.68 BCM.

7.4 Annual Water Availability of Kosi Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 69.44 BCM. In this availability, the Trans boundary component (i.e. from Nepal) is 56.12 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 7.4. The results of Kosi sub-basin are shown in Table 7.2.

The Catchment Area of Kosi Sub Basin lying in Nepal is about 67,662 sq. Km (77.26 % of total catchment area). The transboundary inflow from Nepal into India is estimated as difference of Precipitation & Evapotranspiration over the corresponding Nepal catchment. Precipitation has been taken from available Global products GPM / CHIRPS while for Evapotranspiration, SSeBOP Data has been used.

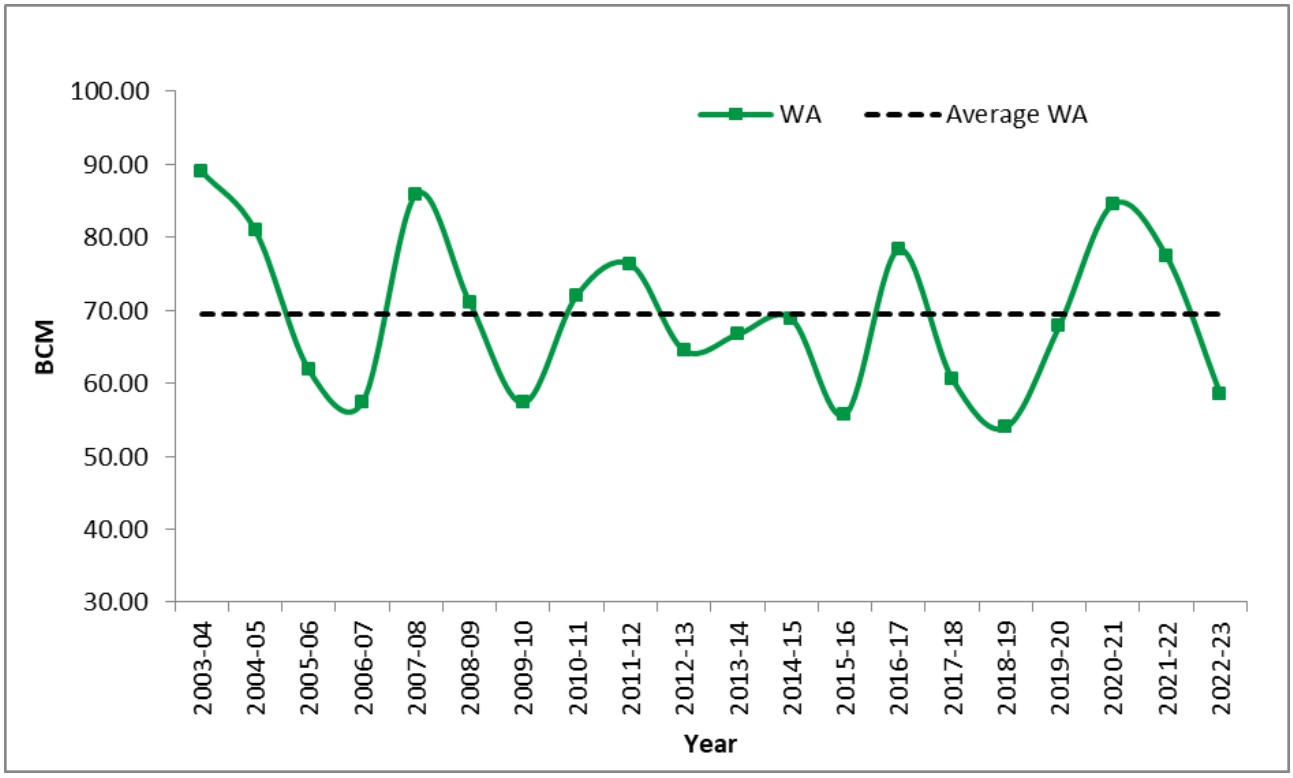


Figure 7.4: Water Availability of Kosi sub-basin (Indian Region and Transboundary)

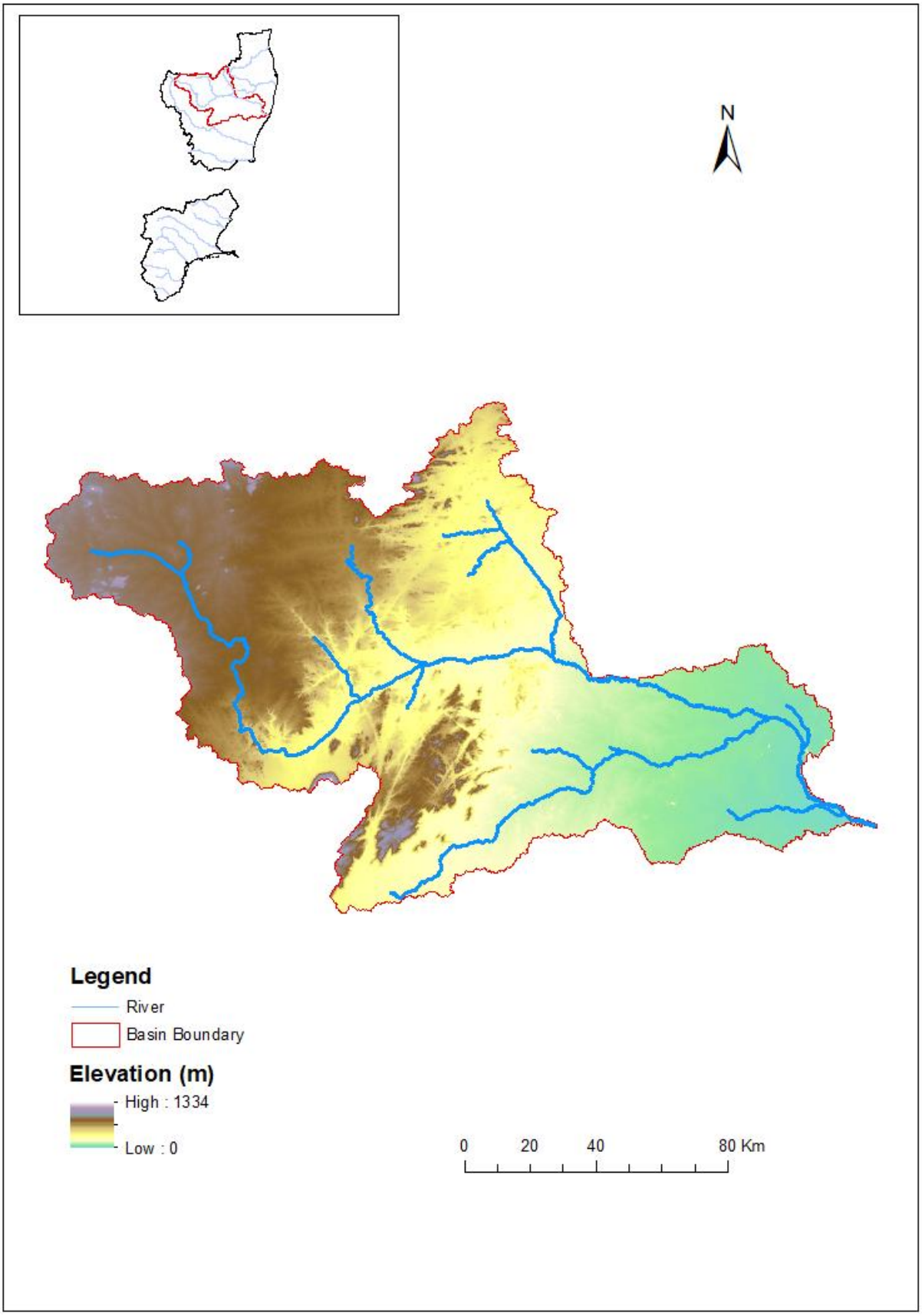
Table 8.2: Water Availability of Kosi sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability* (Total)
2003-04	28.77	13.31	88.99
2004-05	29.69	11.87	80.94
2005-06	19.91	10.62	61.83
2006-07	19.44	11.22	57.41
2007-08	30.42	10.79	85.88
2008-09	22.02	11.22	71.06
2009-10	20.92	9.86	57.31
2010-11	18.05	10.97	72.08
2011-12	23.80	10.94	76.28
2012-13	19.50	10.96	64.51
2013-14	23.50	11.02	66.70
2014-15	23.11	11.72	68.86
2015-16	18.23	9.25	55.67
2016-17	27.03	12.27	78.32
2017-18	24.55	10.56	60.63
2018-19	20.24	10.68	53.95
2019-20	28.55	11.74	67.88
2020-21	38.31	12.15	84.49
2021-22	32.25	12.55	77.41
2022-23	20.81	9.10	58.60
Average	**24.46**	**11.14**	**69.44**

**including trans-boundary contribution*

8. PALAR SUB-BASIN



8.1 About Palar Sub-basin

The Palar Basin is an important basin among the 12 basins lying between the Pennar and the Cauvery basins. This basin is divided into three major topographical divisions namely, i) the hill ranges of Eastern Ghats ii) the plateau region and iii) the coastal plains. Though most of the drainage area lies in Tamil Nadu, its drainage area extends to cover the South-East and South-Western parts of Karnataka and Andhra Pradesh respectively. The shape of the basin is rhombus and finds its outlet in to Bay of Bengal.

The Palar drains an area of 17,711 sq. km. out of which nearly 57 percent lies in Tamil Nadu and the balance in the states of Karnataka and Andhra Pradesh.

8.2 Geo-Spatial Datasets

8.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Palar sub-basin for year 2022-23 is shown in Figure 8.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Deciduous woodland, Double/Triple, Kharif only etc.

Table 8.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

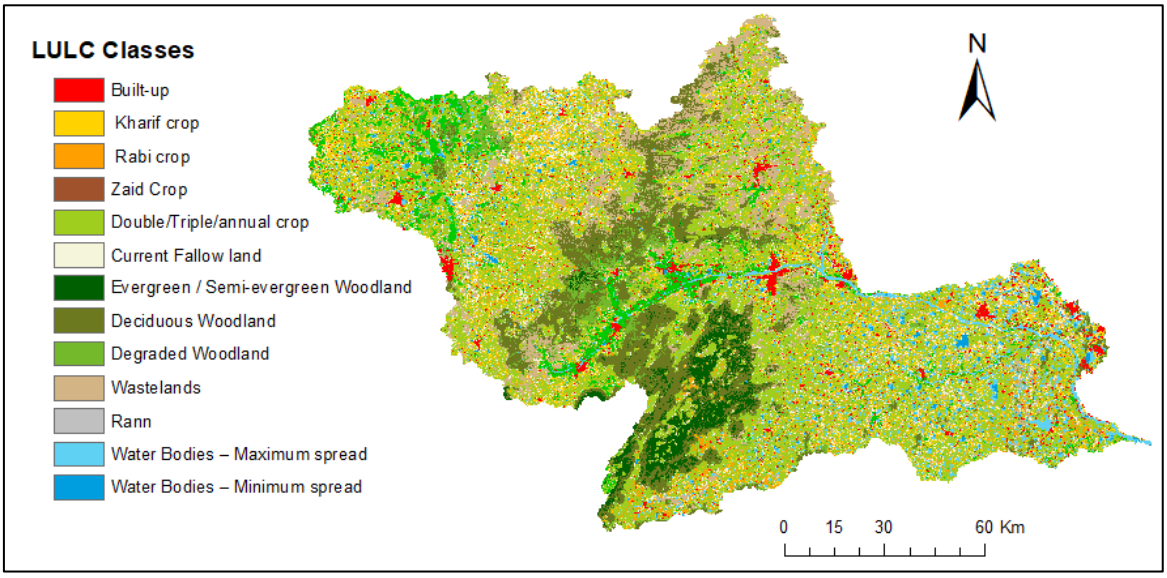


Figure 8.1: LULC Map of Palar sub-basin

Table 8.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	3.18
2.	Kharif crop	10.61
3.	Rabi crop	2.92
4.	Zaid crop	0.03
5.	Double/Triple/Annual crop	35.19
6.	Current Fallow	7.81
7.	Plantation/Orchard	4.92
8.	Evergreen/Semi evergreen	2.95
9.	Deciduous woodland	12.47
10.	Degraded woodland	3.33
11.	Waste Lands	9.66
12.	Water Bodies - maximum spread	5.92
13.	Water Bodies - minimum spread	1.03

8.3 Hydro-Meteorological and other Input Data

8.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 8.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 8.3. The average precipitation of 20 years is approximately 18.59 BCM (1050mm).

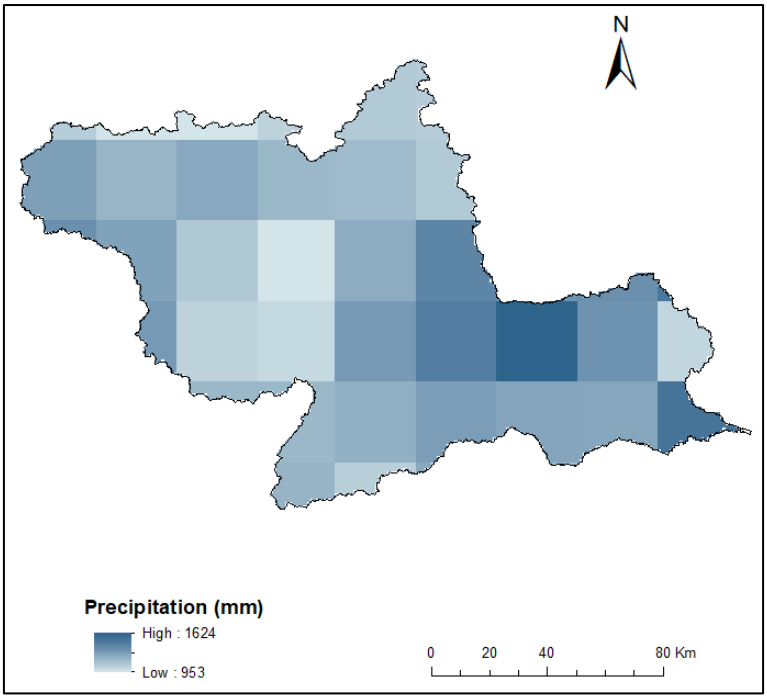


Figure 8.2: Precipitation map of Palar sub-basin

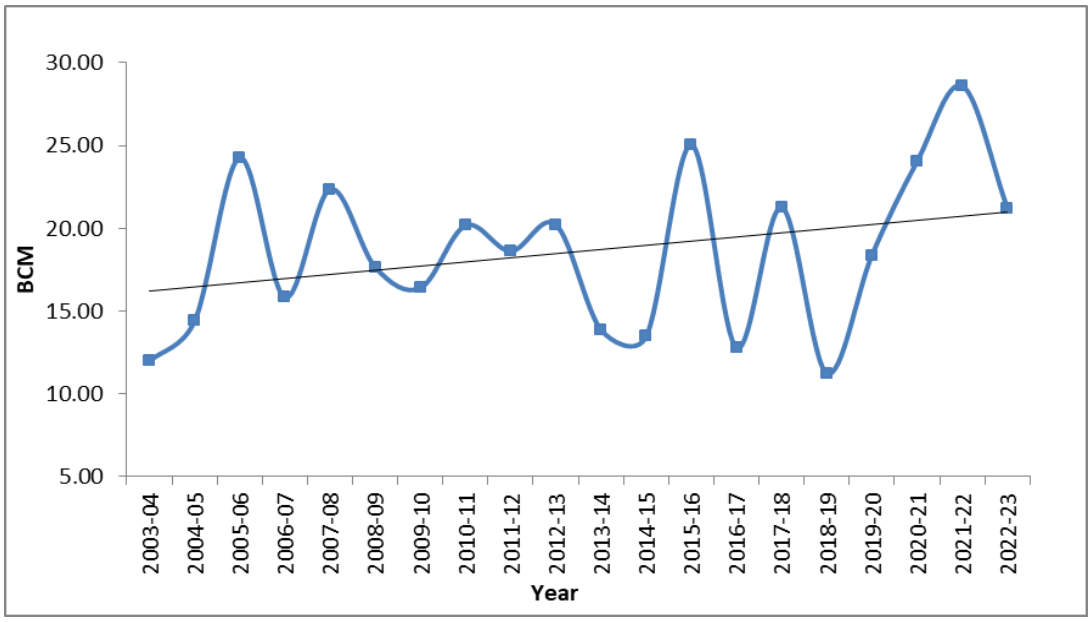


Figure 8.3: Annual Precipitation in Palar sub-basin

8.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 10.86 BCM (613 mm) to 23.48 BCM (1326 mm). The average ET of 20 years is 18.04 BCM (1018mm).

8.3.3 Reservoir Evaporation

The are no reservoirs having area greater than 100 hectare Palar sub-basin.

8.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 2.98 BCM

8.3.5 Groundwater flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux) for the sub-basin for 2003-04 to 2022-23 is -0.07 BCM. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.23 BCM.

8.4 Annual Water Availability of Palar Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 3.53 BCM.

The annual variations from year 2003-04 to 2022-23 are shown in Figure 8.4. The results of Palar sub-basin are shown in Table 8.2.

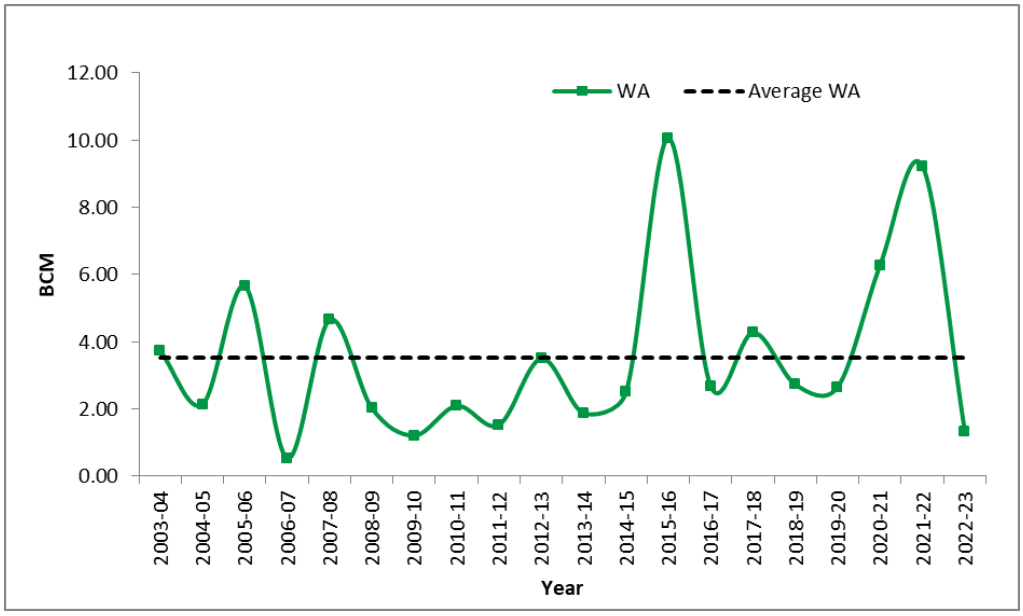


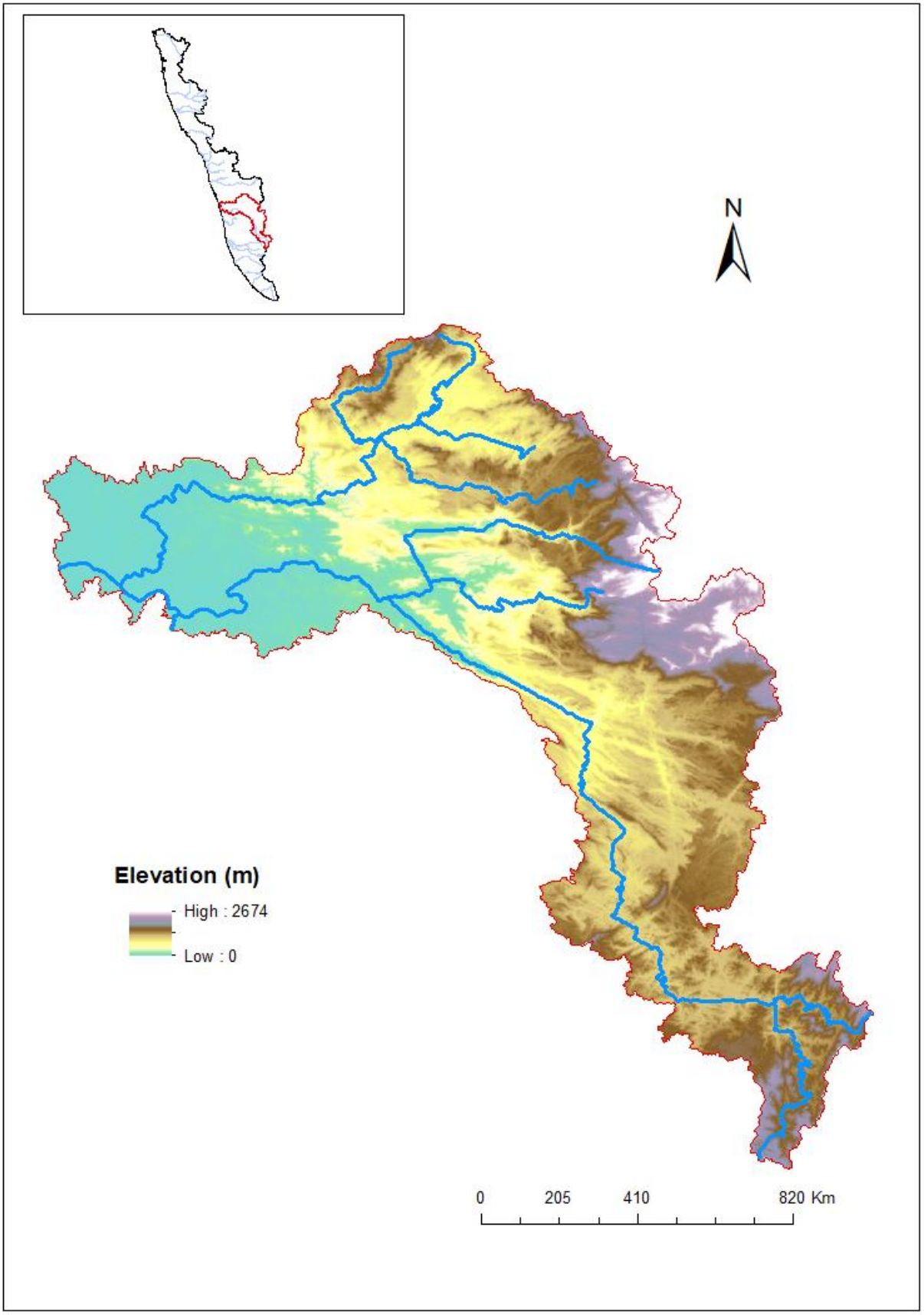
Figure 8.4: Water Availability of Palar sub-basin

Table 8.2: Water Availability of Palar sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	11.98	8.25	3.73
2004-05	14.41	12.26	2.14
2005-06	24.25	18.60	5.65
2006-07	15.82	15.28	0.53
2007-08	22.36	17.71	4.65
2008-09	17.64	15.62	2.03
2009-10	16.39	15.18	1.21
2010-11	20.17	18.08	2.09
2011-12	18.62	17.09	1.53
2012-13	20.22	16.72	3.50
2013-14	13.86	11.99	1.87
2014-15	13.48	10.97	2.51
2015-16	25.05	14.99	10.06
2016-17	12.79	10.11	2.68
2017-18	21.26	16.99	4.28
2018-19	11.24	8.51	2.73
2019-20	18.38	15.72	2.66
2020-21	24.04	17.76	6.28
2021-22	28.60	19.37	9.22
2022-23	21.23	19.89	1.33
Average	**18.59**	**15.05**	**3.53**

9. PERIYAR SUB-BASIN



9.1 About Periyar Sub-basin

The Periyar 244 km in length is the longest river of Kerala. It rises at the forest land Sivagiri peak 80 km South of Devikulam at an elevation of 2,438m above MSL and traverses the steep mountainous terrain before it is joined by the Multiyear, 16 km downstream. The river then turns west and continues to flow in the direction for about 16 km in a sandy bed. The Catchment area of the sub-basin is approximately 6,177 sq. km.

9.2 Geo-Spatial Datasets

9.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Periyar sub-basin for year 2022-23 is shown in Figure 9.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Deciduous woodland, Evergreen, Plantation etc.

Table 9.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

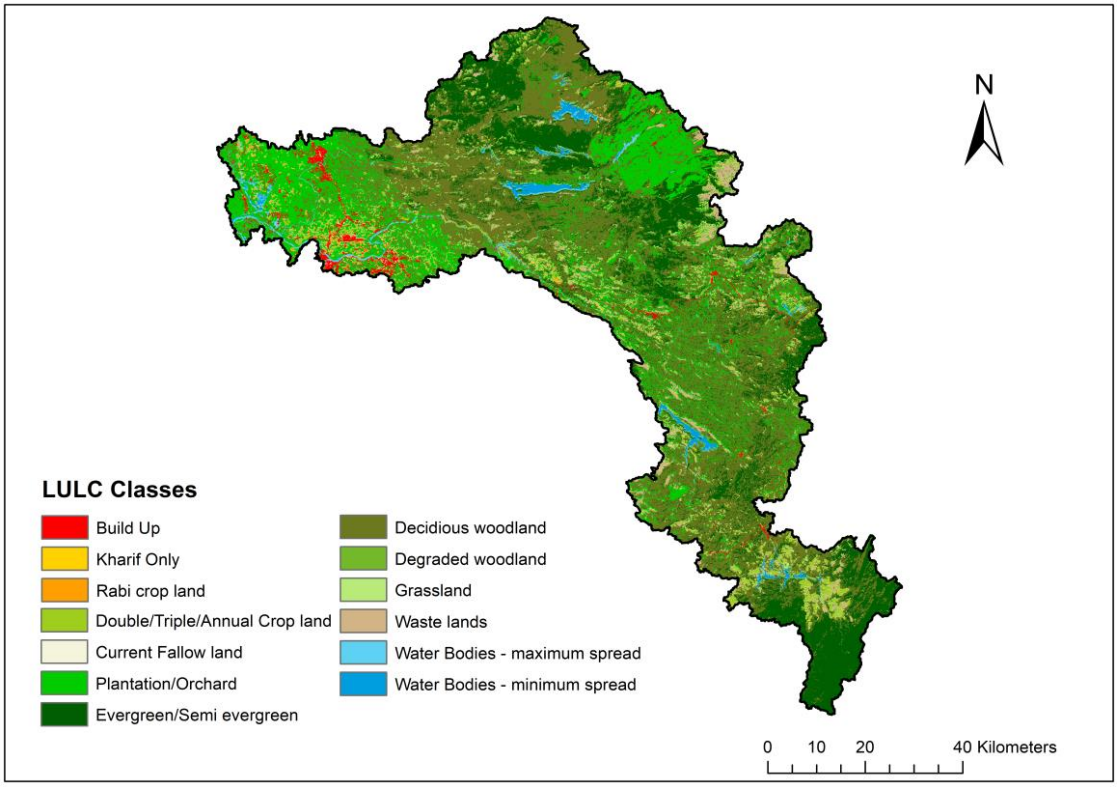


Figure 9.1: LULC Map of Periyar sub-basin

Table 9.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	1.97
2.	Kharif only	0.09
3.	Rabi crop	0.60
4.	Double/Triple/Annual crop	5.02
5.	Current Fallow	2.05
6.	Plantation/Orchard	20.94
7.	Evergreen/Semi evergreen	22.81
8.	Deciduous woodland	40.71
9.	Degraded woodland	0.41
10.	Grassland	0.09
11.	Waste lands	2.94
12.	Water Bodies - maximum spread	1.19
13.	Water Bodies - minimum spread	1.19

9.3 Hydro-Meteorological and other Input Data

9.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 9.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 9.3. The average precipitation of 20 years is approximately 14.62 BCM (2368 mm).

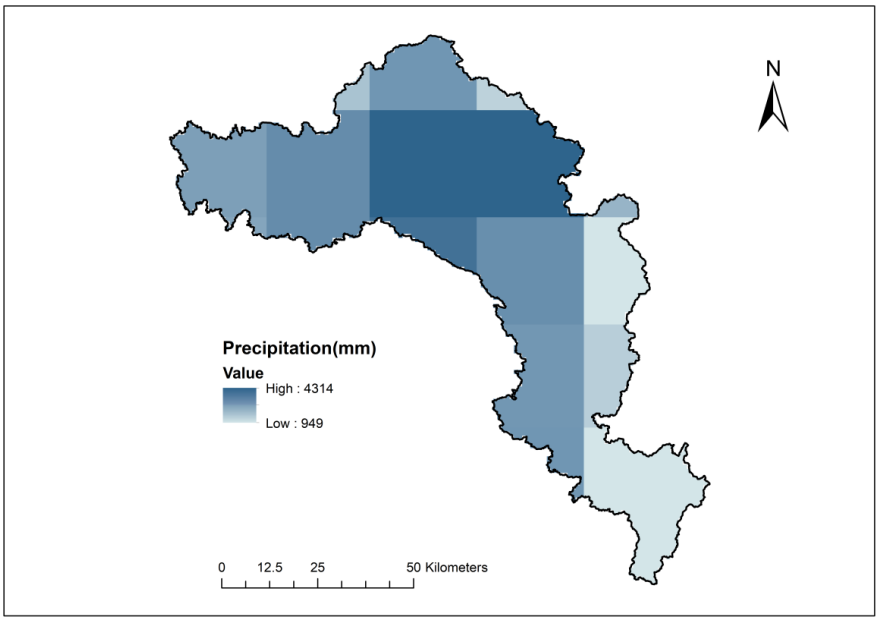


Figure 9.2: Precipitation map of Periyar sub-basin

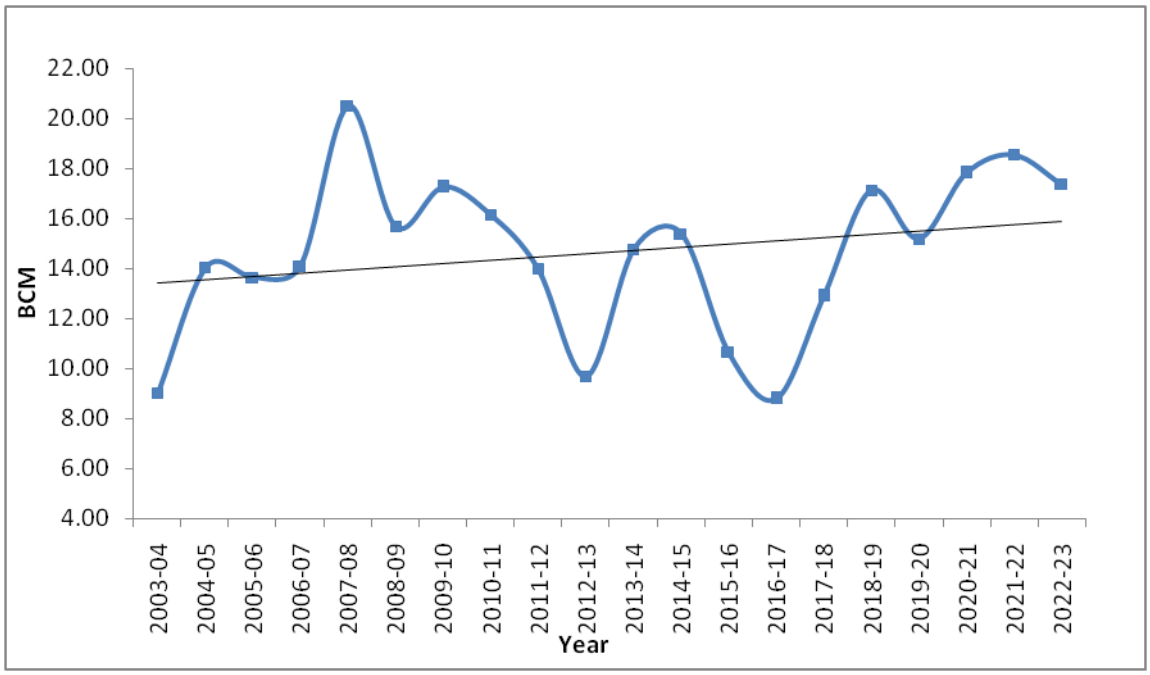


Figure 9.3: Annual Precipitation in Periyar sub-basin

9.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 3.58 BCM (580 mm) to 3.96 BCM (642 mm). The average ET of 20 years is 3.80 BCM (615.78 mm).

9.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.05 BCM.

9.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 0.04 BCM.

9.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux), Reservoir flux for the sub-basin for 2003-04 to 2022-23 is -0.02 BCM and 0.27 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.08 BCM.

9.4 Annual Water Availability of Periyar Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 10.91 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 9.4. The results of Periyar sub-basin are shown in Table 9.2.

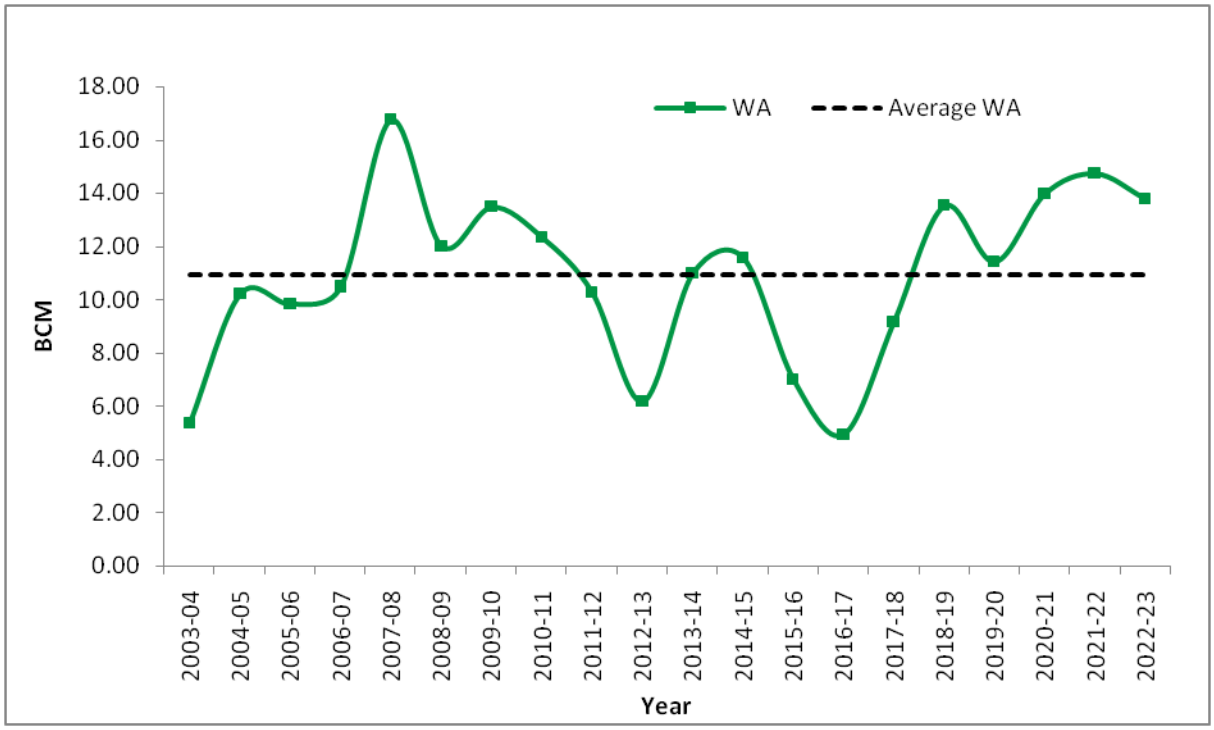


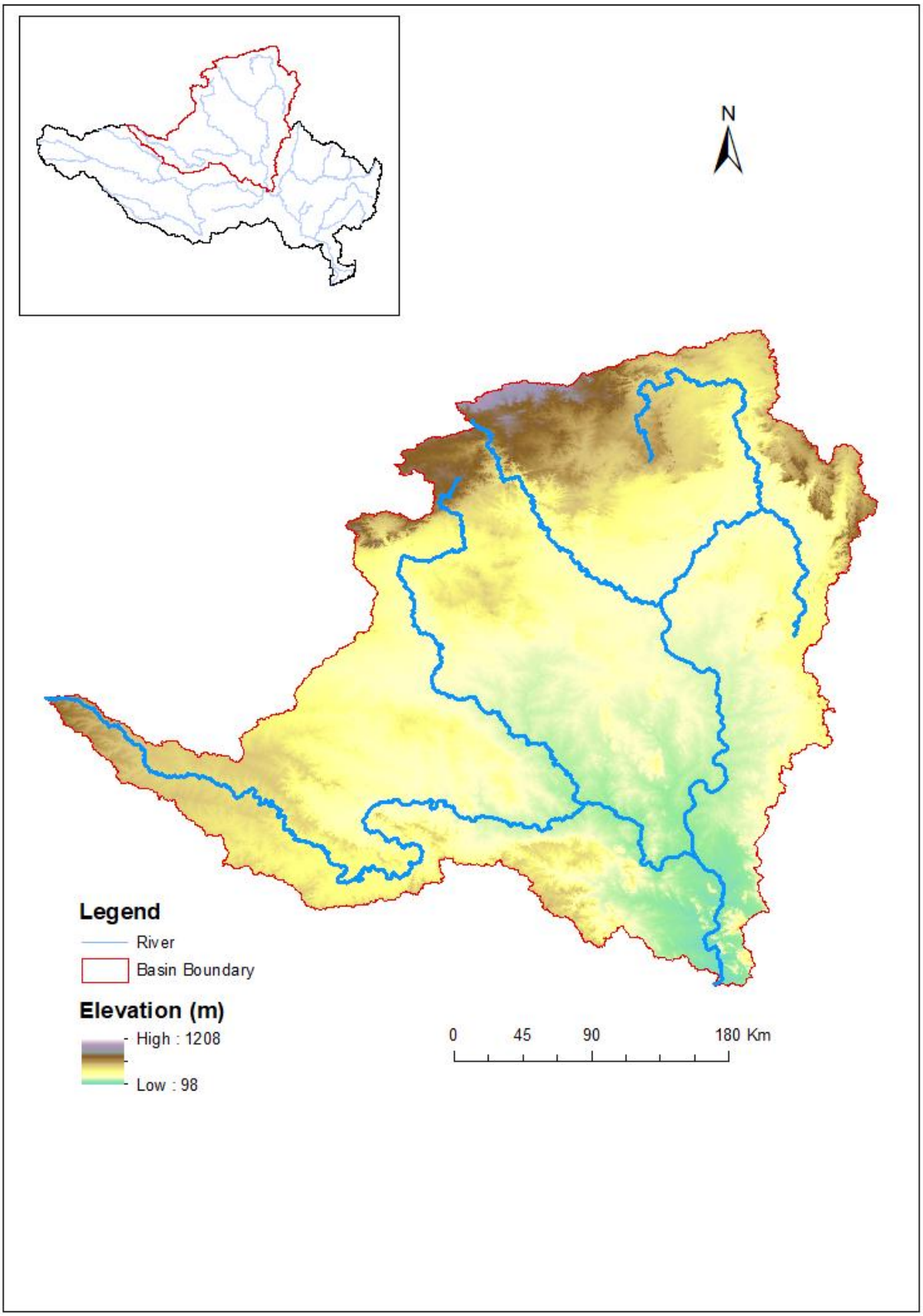
Figure 9.4: Water Availability of Periyar sub-basin

Table 9.2: Water Availability of Periyar sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	9.02	3.64	5.38
2004-05	14.03	3.81	10.22
2005-06	13.63	3.79	9.84
2006-07	14.08	3.60	10.49
2007-08	20.49	3.73	16.76
2008-09	15.68	3.67	12.02
2009-10	17.24	3.76	13.48
2010-11	16.14	3.79	12.35
2011-12	14.00	3.72	10.27
2012-13	9.69	3.51	6.18
2013-14	14.76	3.76	11.00
2014-15	15.38	3.79	11.59
2015-16	10.65	3.63	7.01
2016-17	8.79	3.85	4.95
2017-18	12.89	3.72	9.17
2018-19	17.13	3.60	13.53
2019-20	15.18	3.76	11.42
2020-21	17.81	3.83	13.98
2021-22	18.54	3.79	14.75
2022-23	17.36	3.56	13.80
Average	**14.62**	**3.72**	**10.91**

10. PRANHITA SUB-BASIN



10.1 About Pranhita Sub-basin

The Pranhita river is part of Godavari river basin with an total catchment area of 1,08,285 Sq.Km. The Pranhita Sub-basin lies between East longitudes 75^0 55' to 80^0 55' & North Latitudes 18^0 45' to 22^0 50'. It flows through Satpura ranges & Ajantha ranges & further through Satpura Plateau & plains of Vidharbha region of Maharashtra before meeting Godavari river at Keleshwaram on the Andhra Pradesh – Maharashtra border. The Pranhita River System consists of mainly four major tributaries namely a) Wainganga b) Wardha c) Penganga d) Peddavagua.

10.2 Geo-Spatial Datasets

12.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Pranhita sub-basin for year 2022-23 is shown in Figure 10.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of deciduous woodland, Double/Triple/Annual Cropland, Kharif, etc.

Table 10.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

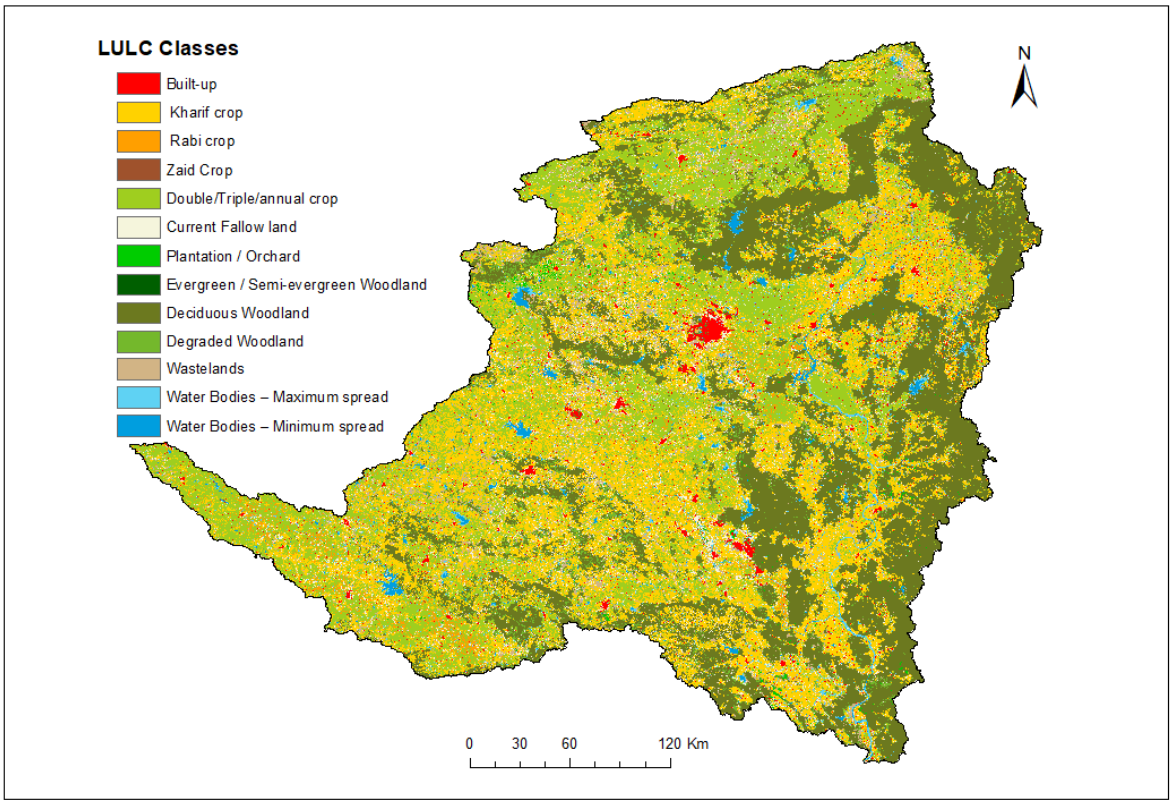


Figure 10.1: LULC Map of Pranhita sub-basin

Table 10.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Builtup land	1.87
2.	Kharif crop	29.07
3.	Rabi	1.64
4.	Zaid	0.00
5.	Double/Triple/Annual	24.05
6.	Current Fallow land	5.08
7.	Plantation Orchard	0.34
8.	Evergreen /Semi-evergreen woodland	0.00
9.	Decidous woodland	27.55
10.	Degraded	3.10
11.	Wastelands	4.29
12.	Water bodies -Maximum Spread	1.96
13.	Water bodies -Minimum Spread	1.04

10.3 Hydro-Meteorological and other Input Data

10.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 10.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 10.3. The average precipitation of 20 years is approximately 126.62 BCM.

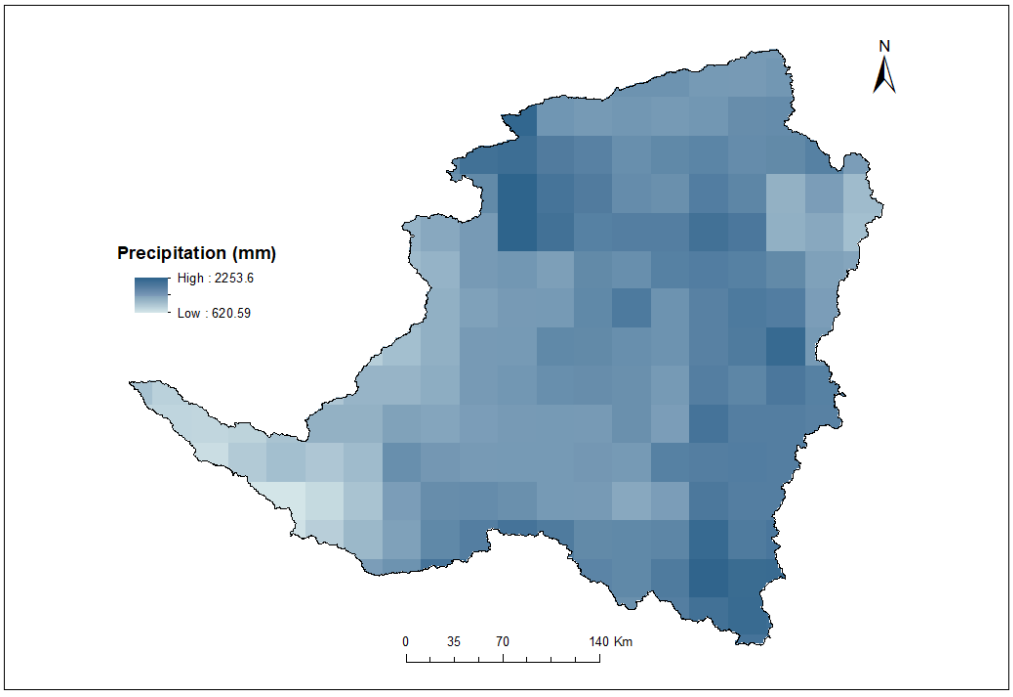


Figure 12.2: Precipitation map of Pranhita sub-basin

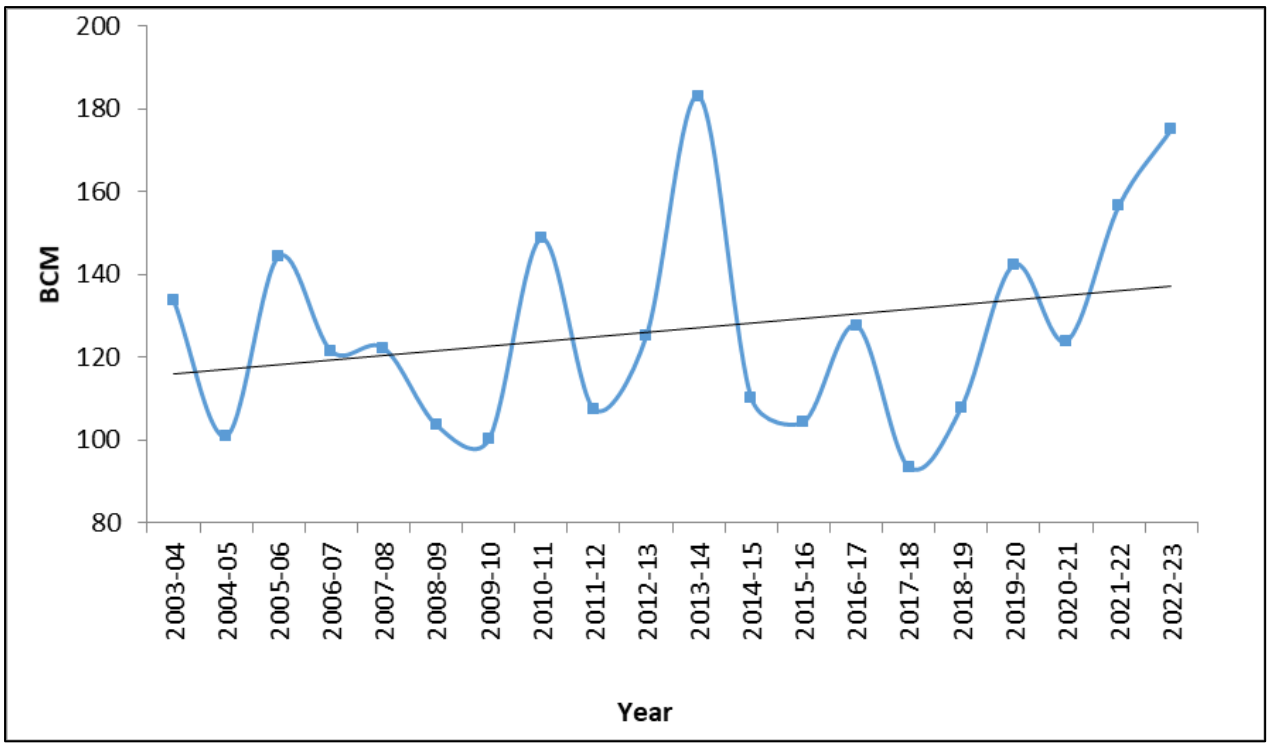


Figure 12.3: Annual Precipitation in Pranhita sub-basin

10.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 72.97 BCM (674 mm) to 108.23 BCM (1000 mm). The average ET of 20 years is 93.87 BCM (993 mm).

10.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.35 BCM.

10.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ETII) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 12.32 BCM.

10.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux), Reservoir flux for the sub-basin for 2003-04 to 2022-23 is 0.163 BCM and 1.048 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.58 BCM.

10.4 Annual Water Availability of Pranhita Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 46.78 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 10.4. The results of Pranhita sub-basin are shown in Table 10.2.

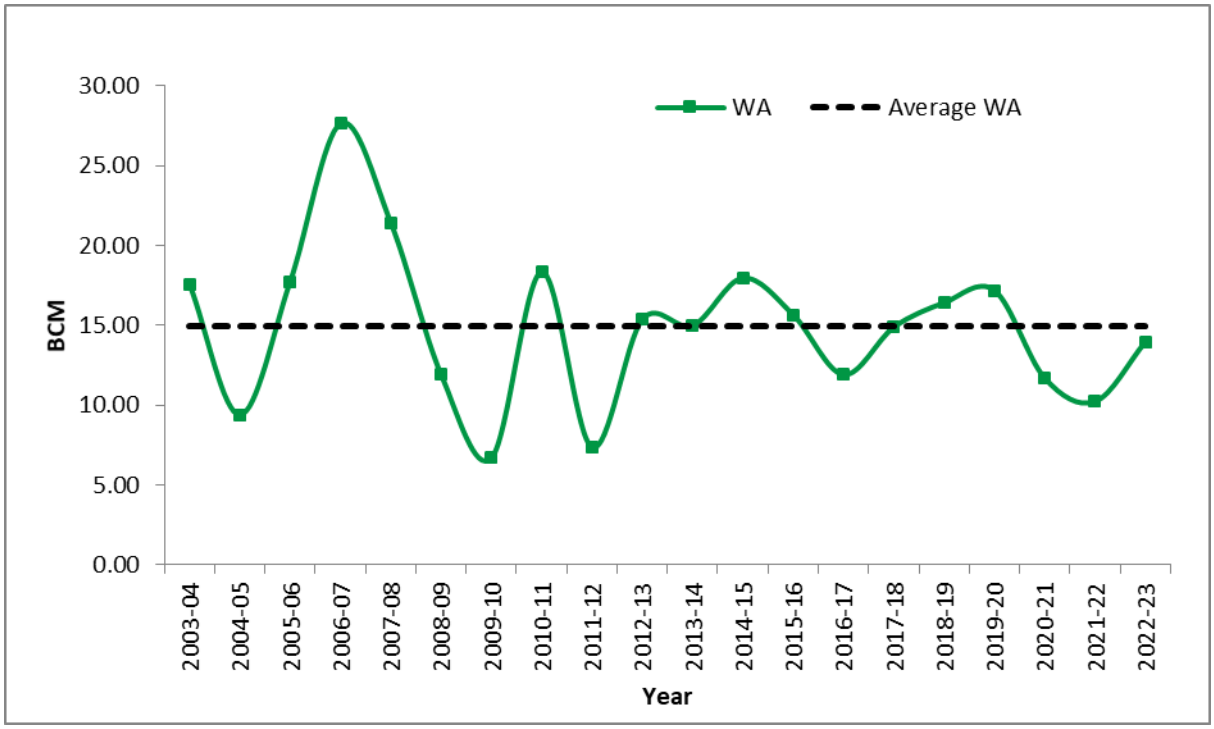


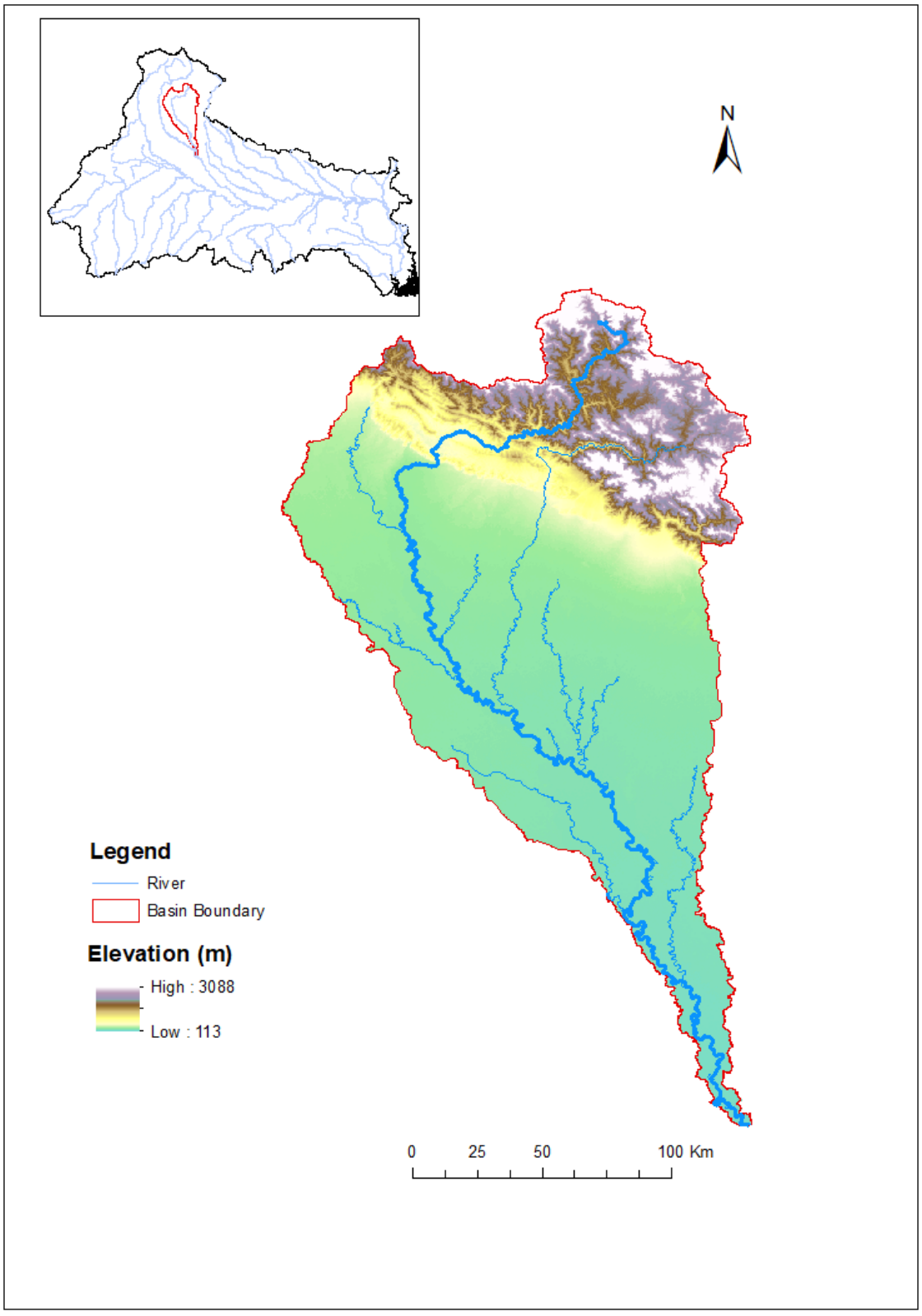
Figure 12.6: Water Availability of Pranhita sub-basin

Table 10.2: Water Availability of Pranhita sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	133.69	79.45	54.24
2004-05	101.01	65.10	35.91
2005-06	144.35	83.40	60.95
2006-07	121.49	79.02	42.47
2007-08	122.23	81.68	40.55
2008-09	103.67	71.75	31.93
2009-10	100.16	72.26	27.90
2010-11	148.69	85.54	63.15
2011-12	107.55	77.16	30.39
2012-13	125.09	81.55	43.53
2013-14	183.07	89.11	93.96
2014-15	110.19	77.52	32.67
2015-16	104.36	78.75	25.61
2016-17	127.70	77.70	50.00
2017-18	93.53	78.91	14.62
2018-19	107.86	73.95	33.91
2019-20	142.36	85.74	56.63
2020-21	123.87	88.25	35.62
2021-22	156.54	90.16	66.38
2022-23	175.02	79.74	95.27
Average	**126.62**	**79.84**	**46.78**

11. RAMGANGA SUB-BASIN



11.1 About Ramganga Sub-Basin

Ramganga is the major tributary of river Ganga which meets the Ganga at Kannauj, Uttar Pradesh. Along its course, the river originates in the lower Himalaya in Uttarakhand and passes through Uttarakhand and major towns of western Uttar Pradesh. Several small tributaries such as Khoh, Gangan, Aril, Kosi, Gaula, Dhela, Bhela, and Garra also meet the main stem of Ramganga at different locations, mostly after the city of Moradabad. The Ramganga Sub-basin has a catchment area of approximately 24,691 sq. Km.

11.2 Geo-Spatial Datasets

11.2.1 Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Ramganga Sub- basin for year 2022-23 is shown in Figure 11.1. Major land use classes consist of Double/Triple/Annual crop land, Forest, Kharif only, Rabi crop land, etc.

Table 11.1 shows the percentage area of each land use class in the basin for year 2022-23.

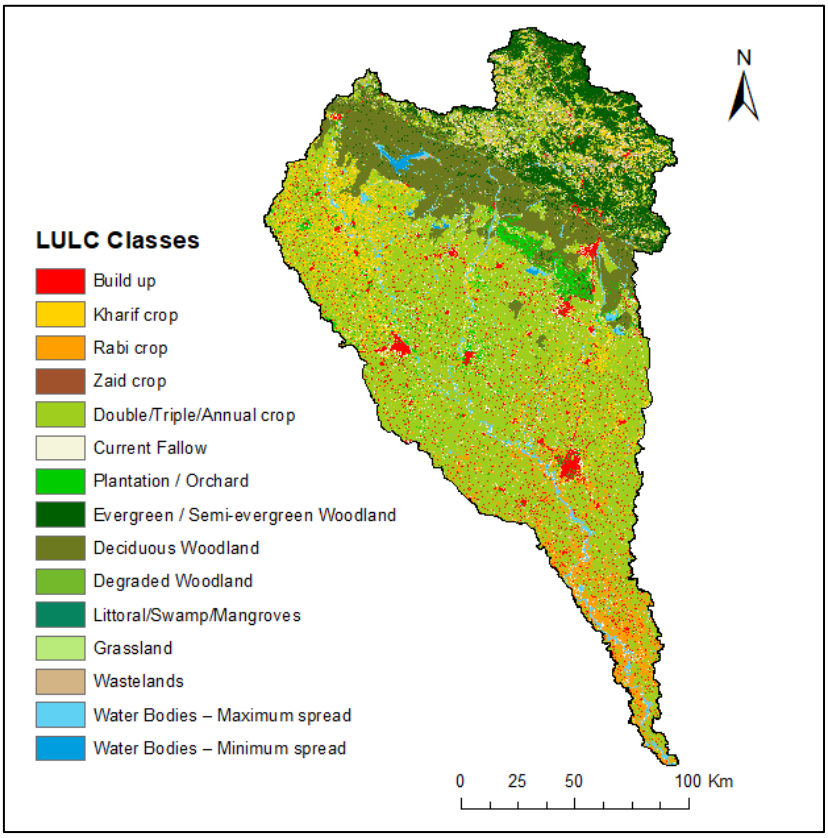


Figure 11.1: LULC Map of Ramganga Sub-basin

Table 11.1: Percentage area of Land Use and Land Cover

S. No.	LULC class	Area (%) in 2022-23
1.	Built-up	4.64
2.	Kharif crop	7.28
3.	Rabi crop	4.81
4.	Zaid crop	0.00
5.	Double/Triple/Annual crop	47.68
6.	Current fallow land	4.13
7.	Plantation/Orchid	2.14
8.	Evergreen/Semi-evergreen woodland	7.57
9.	Deciduous woodland	15.91
10.	Degraded woodland	0.94
11.	Littoral/Swamp/Mangroves	0.00
12.	Grassland	0.04
13.	Waste lands	2.25
14.	Water Bodies - maximum spread	2.30
15.	Water Bodies - minimum spread	0.31

11.3 Hydro-Meteorological and other Input Data

11.3.1 Precipitation

The spatial variation of precipitation in the basin for the year 2022-23 has been shown in Figure 11.2. The variation in the annual precipitation during study period of 20 years (2002-03 to 2022-23) is shown in the Figure 11.3. The average precipitation of 20 years is approximately 26.34 BCM (1067 mm).

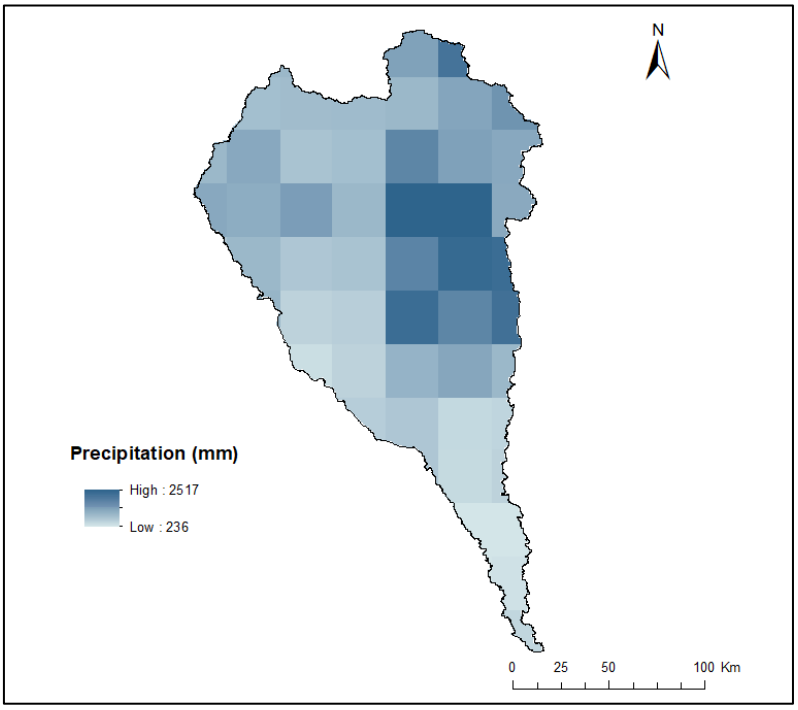


Figure 11.2: Precipitation map of Ramganga Sub-basin

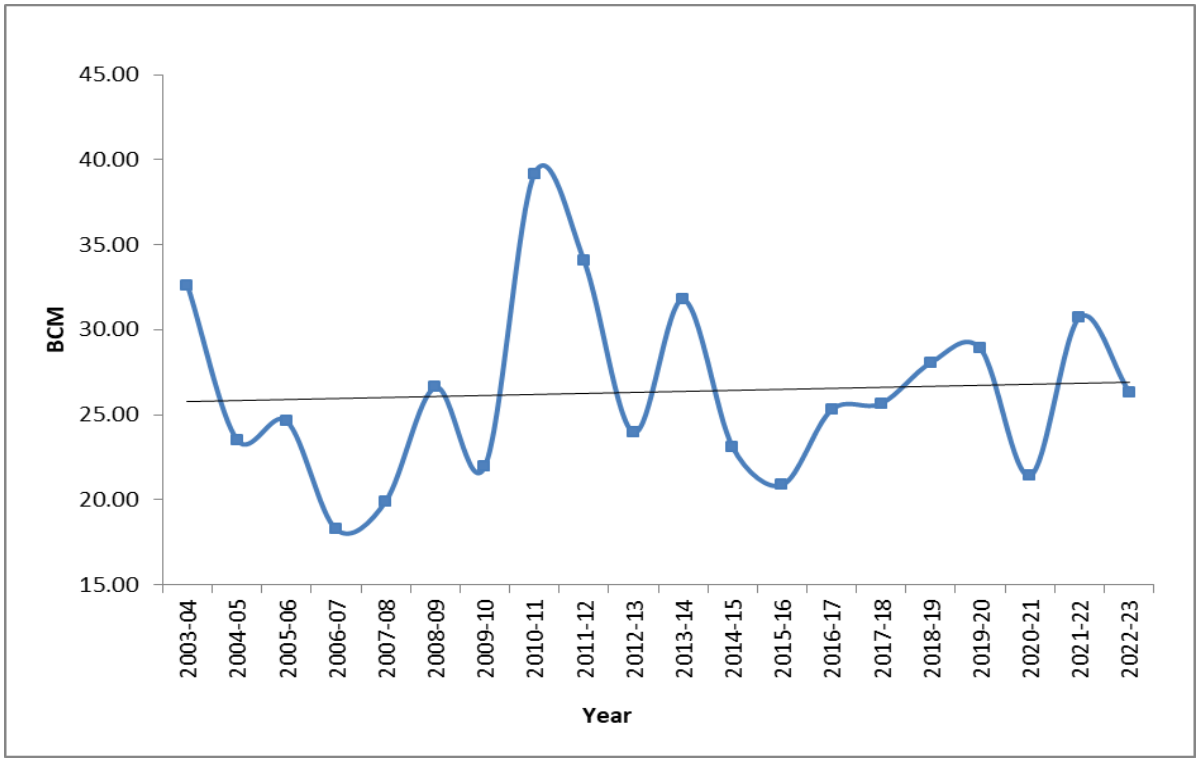


Figure 11.3: Annual Precipitation in Ramganga Sub-basin

11.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 17.91 BCM (725 mm) to 22.45 BCM (909 mm). The average ET of 20 years is approximately 19.54 BCM (791 mm).

11.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average annual evaporation from the reservoirs in the basin is 0.18 BCM.

11.3.4 Evapotranspiration from Irrigation Input

The Evapotranspiration from Irrigation Input (ETII) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 6.25 BCM.

11.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux and Reservoir flux for the basin for 2003-04 to 2022-23 is -0.19 BCM and 0.06 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.28 BCM.

11.4 Annual Water Availability of Ramganga Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other input data, the average annual water availability from year 2003-04 to 2022-23 is estimated as 11.52 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 11.4. The results of Ramganga sub-basin are shown in Table 11.2.

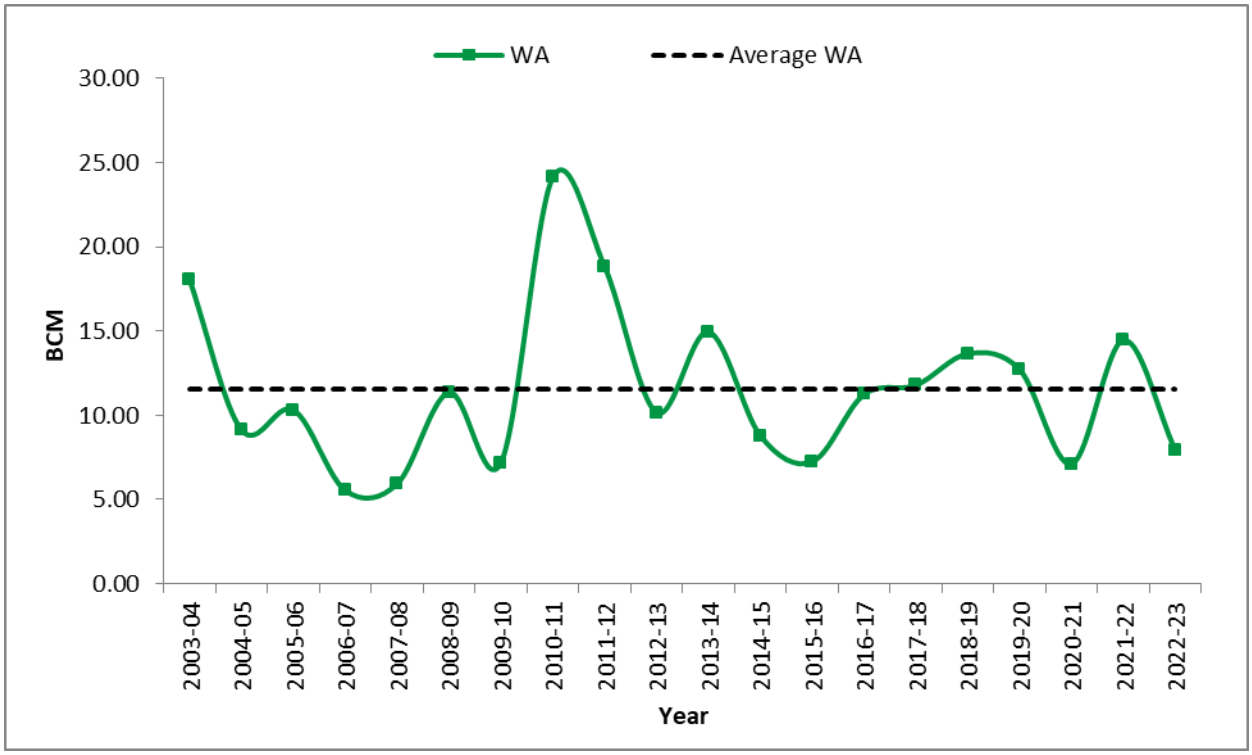


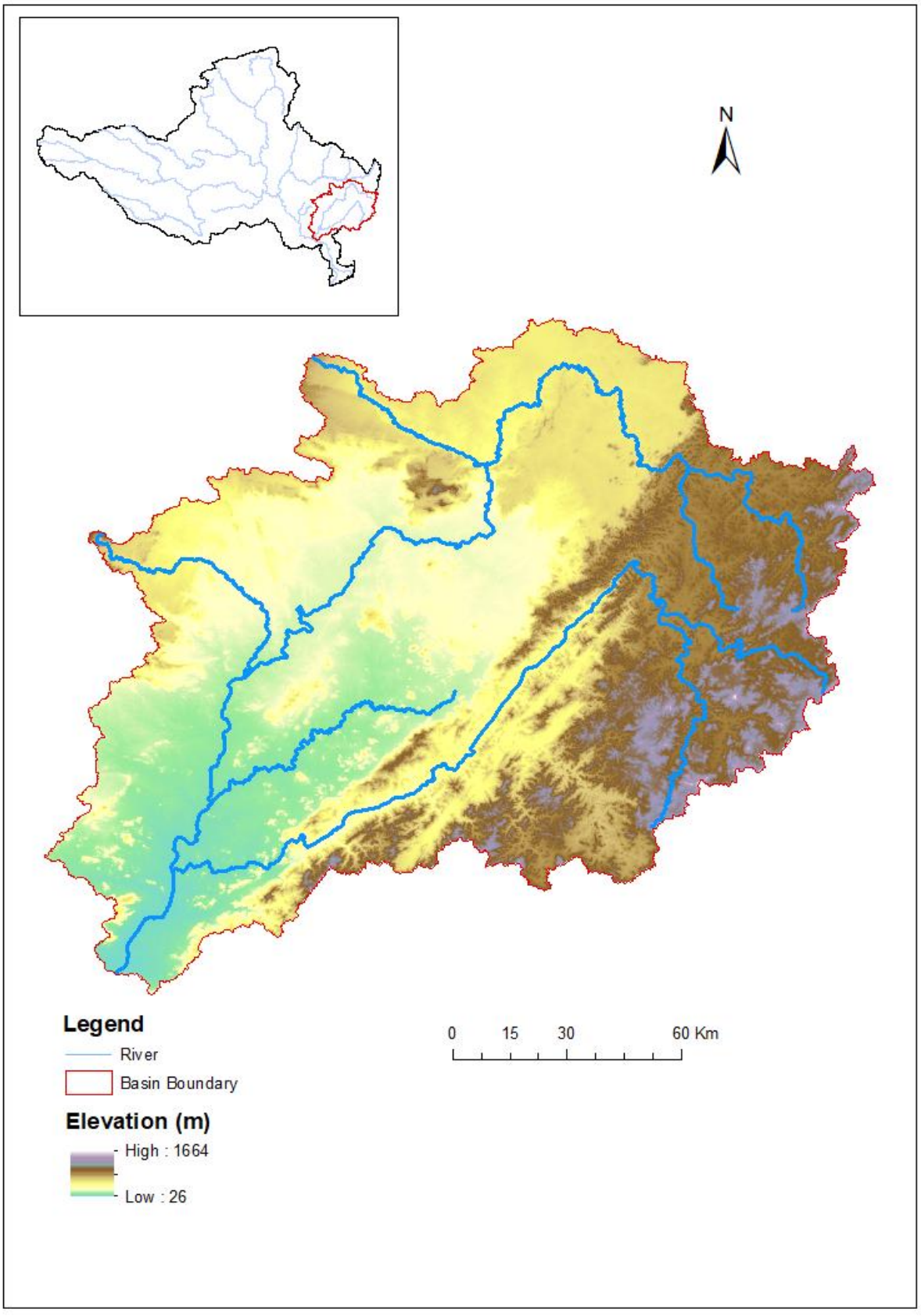
Figure 11.4: Water availability of Ramganga Sub-basin

Table 11.2: Water Availability of Ramganga Sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	32.60	12.89	18.04
2004-05	23.52	12.54	9.12
2005-06	24.64	12.61	10.31
2006-07	18.24	10.98	5.53
2007-08	19.90	12.41	5.93
2008-09	26.61	13.53	11.35
2009-10	21.95	12.54	7.19
2010-11	39.17	13.86	24.13
2011-12	34.06	13.81	18.81
2012-13	23.96	12.32	10.16
2013-14	31.78	15.09	14.95
2014-15	23.08	12.56	8.78
2015-16	20.86	11.88	7.24
2016-17	25.30	12.31	11.24
2017-18	25.65	12.13	11.79
2018-19	28.06	12.66	13.65
2019-20	28.88	14.44	12.70
2020-21	21.41	12.55	7.11
2021-22	30.73	14.53	14.46
2022-23	26.34	16.69	7.91
Average	**26.34**	**13.12**	**11.52**

12. SABARI SUB-BASIN



12.1 About Sabari Sub-basin

Sabari River is one of the main tributaries of Godavari. It originates from the western slopes of Eastern Ghats in Odisha state from Sinkaram hill ranges. It is also known as Kolab river in Odisha. Sabari subbasin forms common boundary between Chhattisgarh and Odisha states. It later enters into Andhra Pradesh to merge with River Godavari. Catchment area of the sub-basin is approximately 21,474 sq. km.

12.2 Geo-Spatial Datasets

12.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Sabari sub-basin for year 2022-23 is shown in Figure 12.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of deciduous woodland, Double/Triple/Annual Cropland, Kharif, etc.

Table 12.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

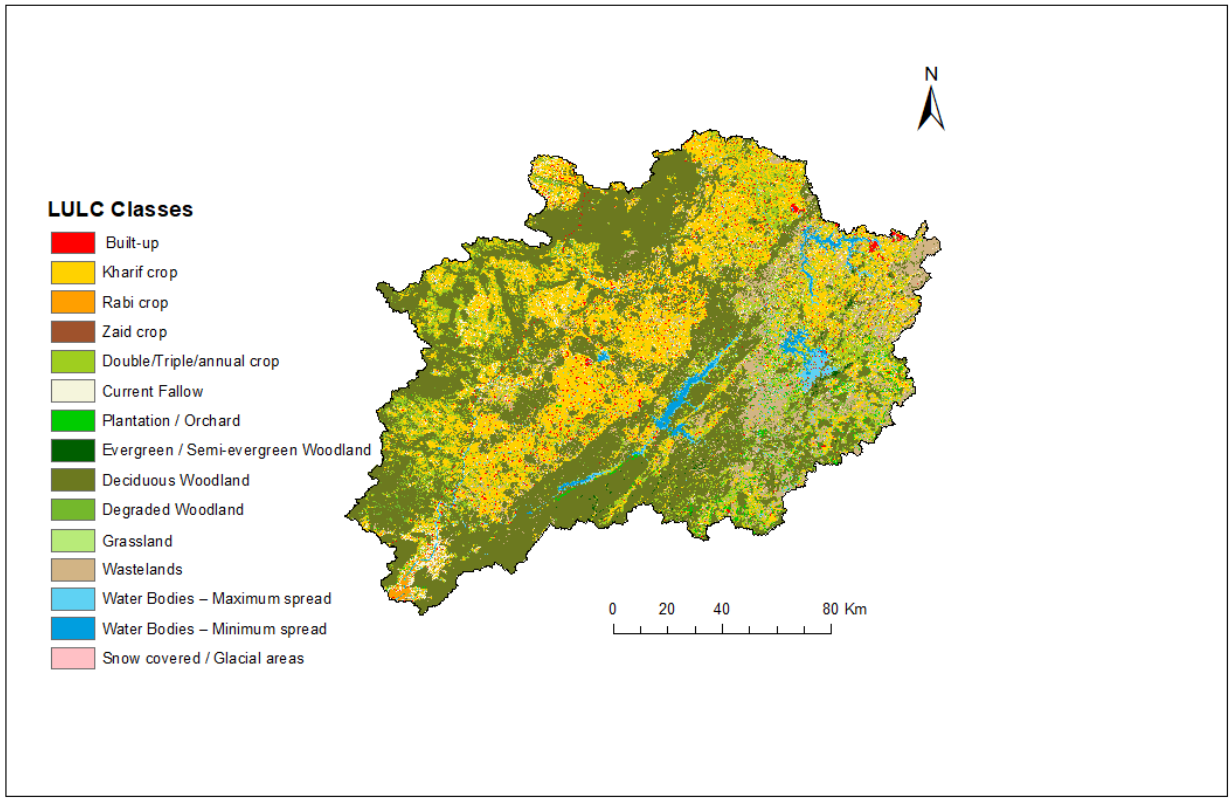


Figure 12.1: LULC Map of Sabari sub-basin

Table 12.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	1.64
2.	Kharif crop	24.98
3.	Rabi crop	0.34
4.	Zaid crop	0.00
5.	Double/Triple/Annual crop	12.26
6.	Current Fallow	3.01
7.	Plantation/Orchard	0.91
8.	Evergreen/Semi evergreen	0.21
9.	Deciduous woodland	42.49
10.	Degraded Woodland	2.19
11.	Grassland	0.19
12.	Waste lands	11.02
13.	Water Bodies - maximum spread	1.89
14.	Water Bodies - minimum spread	1.16

12.3 Hydro-Meteorological and other Input Data

12.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 12.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 12.3. The average precipitation of 20 years is approximately 34.17 BCM.

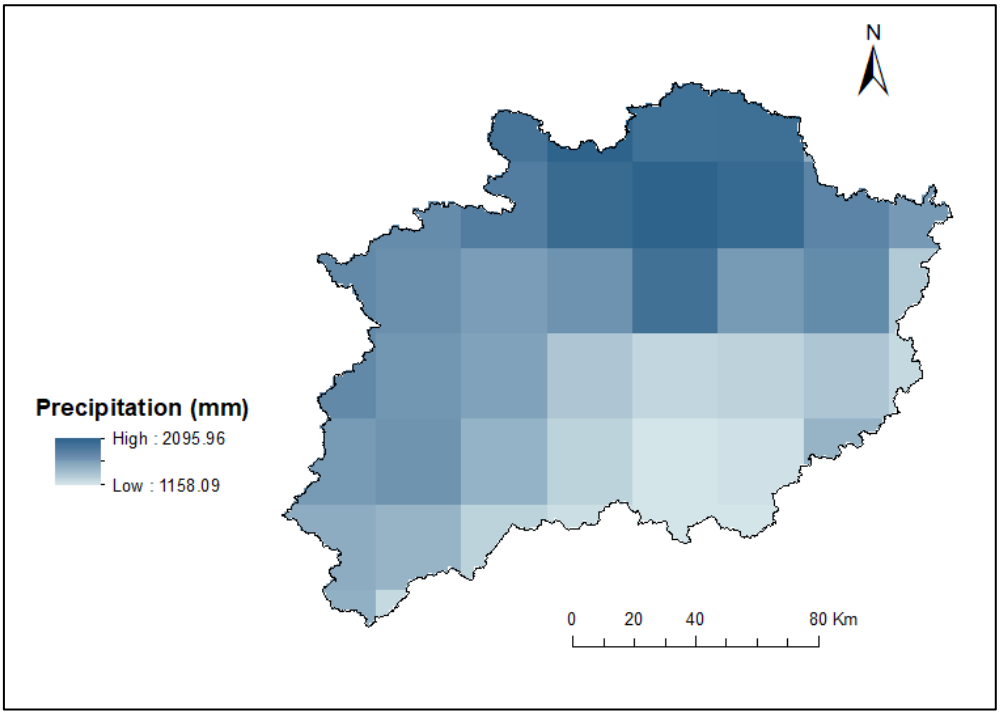


Figure 12.2: Precipitation map of Sabari sub-basin

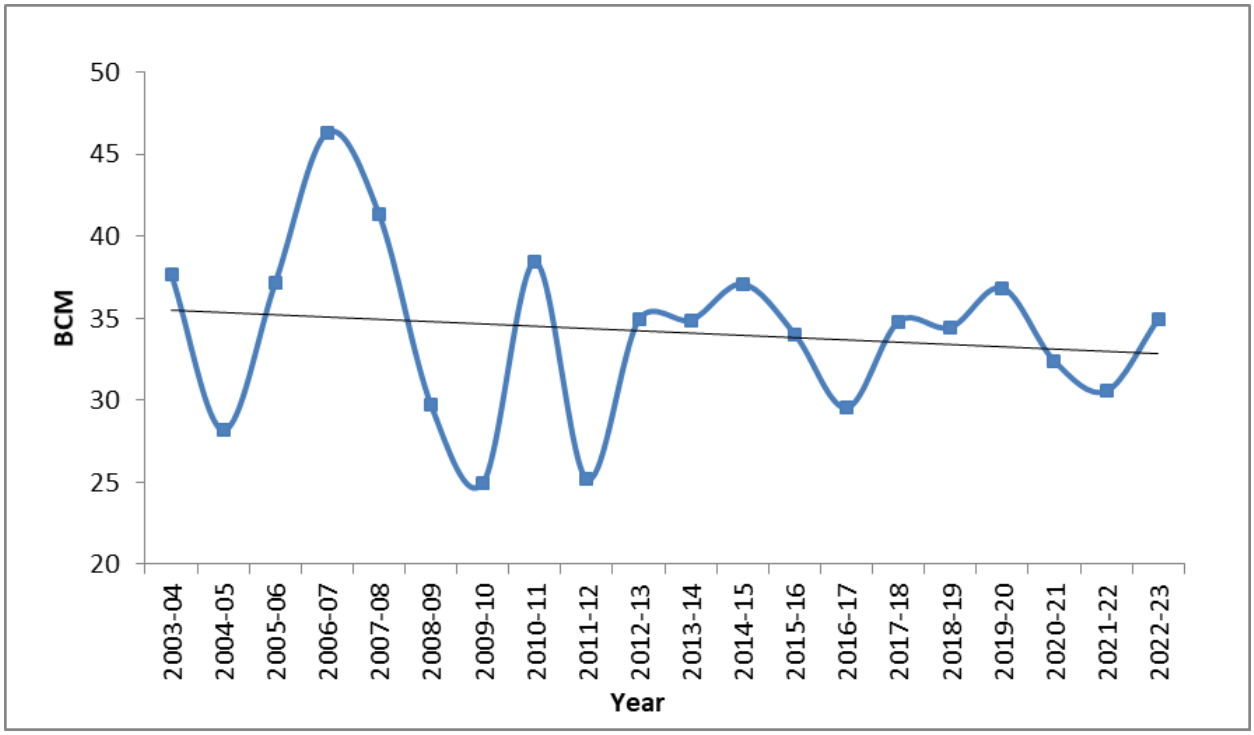


Figure 12.3: Annual Precipitation in Sabari sub-basin

12.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 18.72 BCM (872 mm) to 23.22 BCM (1081 mm). The average ET of 20 years is 20.58 BCM (993 mm).

12.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.35 BCM.

12.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 0.98 BCM.

12.3.5 Groundwater flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux) for the sub-basin for 2003-04 to 2022-23 is -0.58 BCM. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.08 BCM.

12.4 Annual Water Availability of Sabari Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 4.70 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 12.4. The results of Sabari sub-basin are shown in Table 12.2.

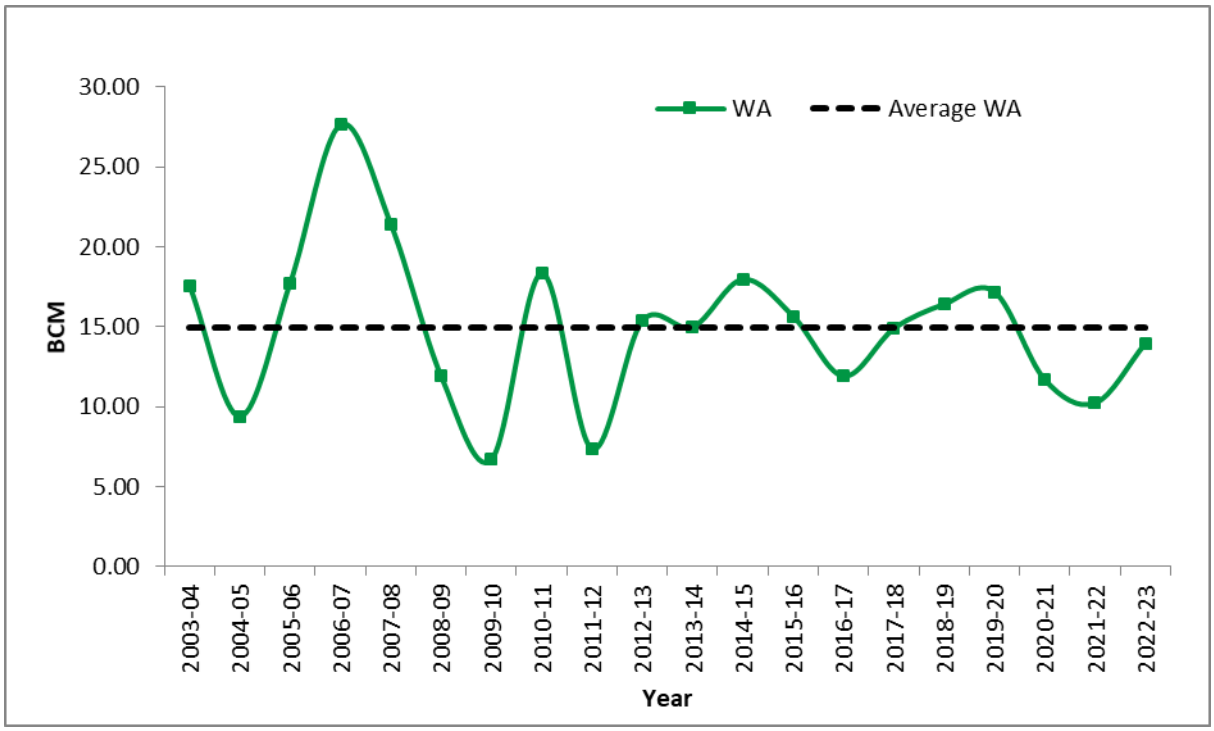


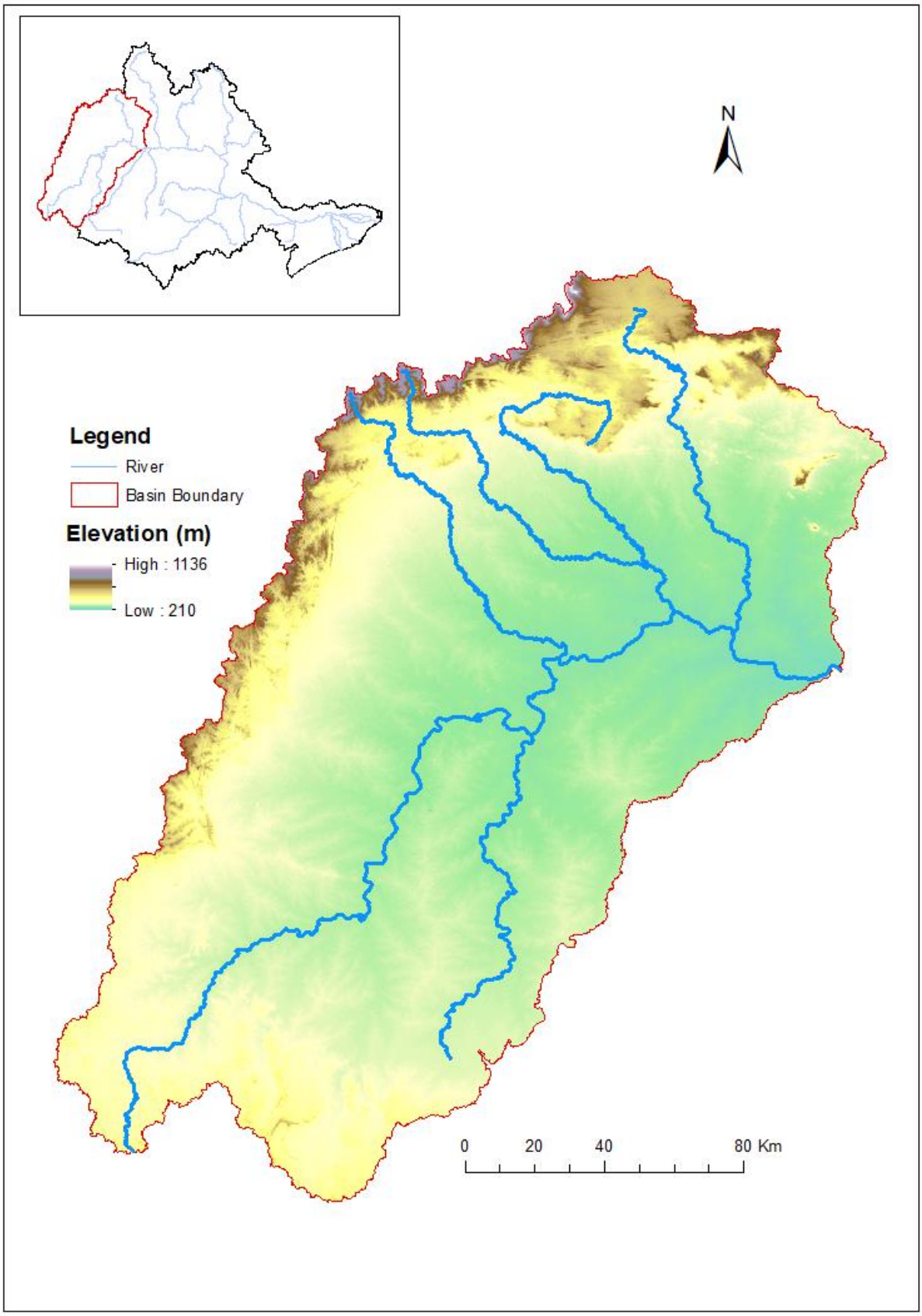
Figure 12.4: Water Availability of Sabari sub-basin

Table 12.2: Water Availability of Sabari sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	37.67	20.09	17.58
2004-05	28.18	18.78	9.40
2005-06	37.16	19.42	17.74
2006-07	46.32	18.68	27.64
2007-08	41.33	19.89	21.44
2008-09	29.71	17.77	11.93
2009-10	24.97	18.28	6.69
2010-11	38.43	20.07	18.36
2011-12	25.19	17.82	7.37
2012-13	34.92	19.54	15.38
2013-14	34.89	19.90	14.99
2014-15	37.10	19.12	17.97
2015-16	34.04	18.38	15.66
2016-17	29.54	17.62	11.92
2017-18	34.80	19.91	14.89
2018-19	34.45	18.03	16.42
2019-20	36.85	19.66	17.19
2020-21	32.39	20.69	11.70
2021-22	30.57	20.34	10.23
2022-23	34.96	20.99	13.97
Average	**34.17**	**19.24**	**14.93**

13. SEONATH SUB-BASIN



13.1 About Seonath Sub-basin

Seonath river originates from Godari village in Gadchiroli district, Maharashtra, and flows northeast for almost 300 kms then joins the Mahanadi river near the town Shivrinarayan in Chhattisgarh. The basin elevation ranges between 216 to 1,111 m of average mean sea level. The catchment area is mostly hilly. Catchment area of the sub-basin is approximately 30,934 sq. km.

13.2 Geo-Spatial Datasets

13.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Seonath sub-basin for year 2022-23 is shown in Figure 13.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Deciduous woodland, Double/Triple, Kharif only etc.

Table 13.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

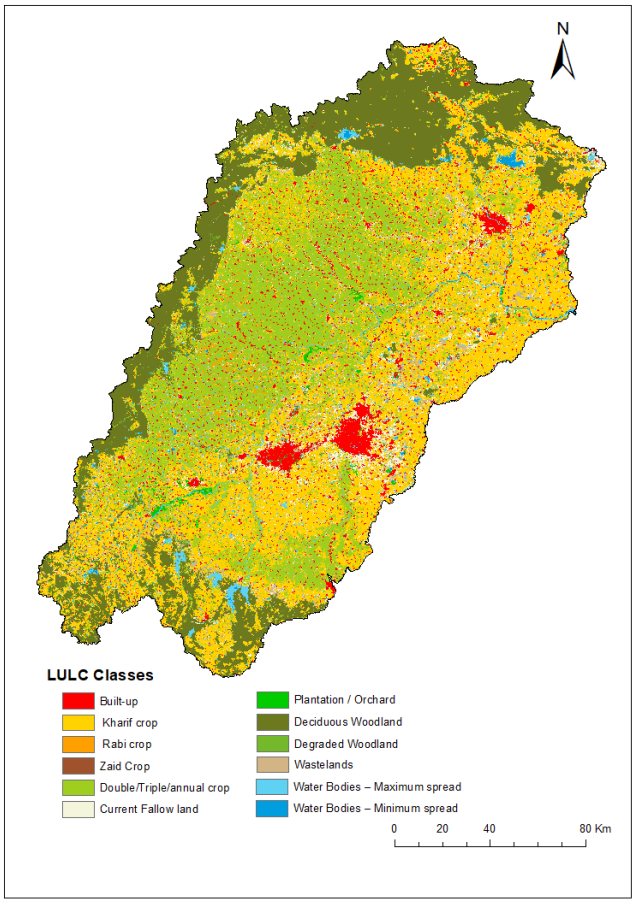


Figure 13.1: LULC Map of Seonath sub-basin

Table 13.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	5.76
2.	Kharif crop	35.99
3.	Rabi crop	0.89
4.	Zaid crop	0.00
5.	Double/Triple/Annual crop	24.67
6.	Current Fallow	4.68
7.	Plantation/Orchard	0.45
8.	Deciduous woodland	19.76
9.	Degraded woodland	1.75
10.	Waste Lands	2.86
11.	Water Bodies - maximum spread	2.62
12.	Water Bodies - minimum spread	0.52

13.3 Hydro-Meteorological and other Input Data

13.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 13.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 13.3. The average precipitation of 20 years is approximately 35.24 BCM (1139 mm).

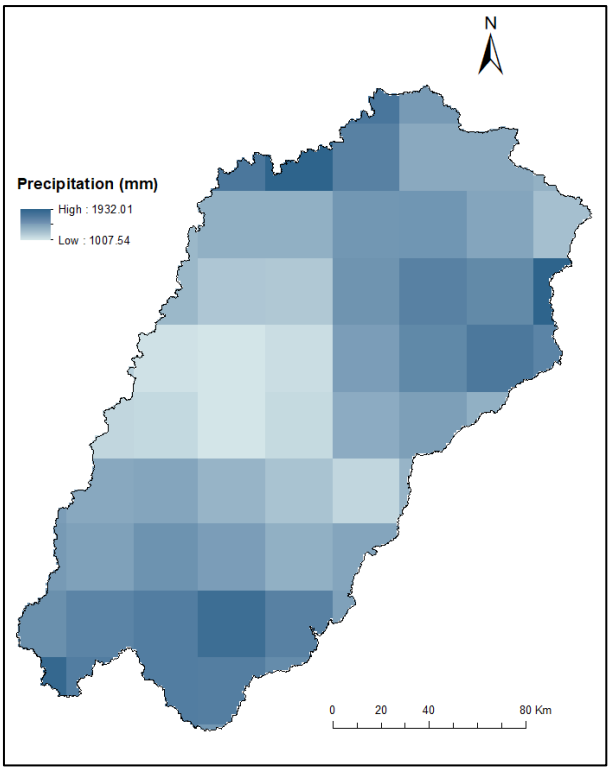


Figure 13.2: Precipitation map of Seonath sub-basin

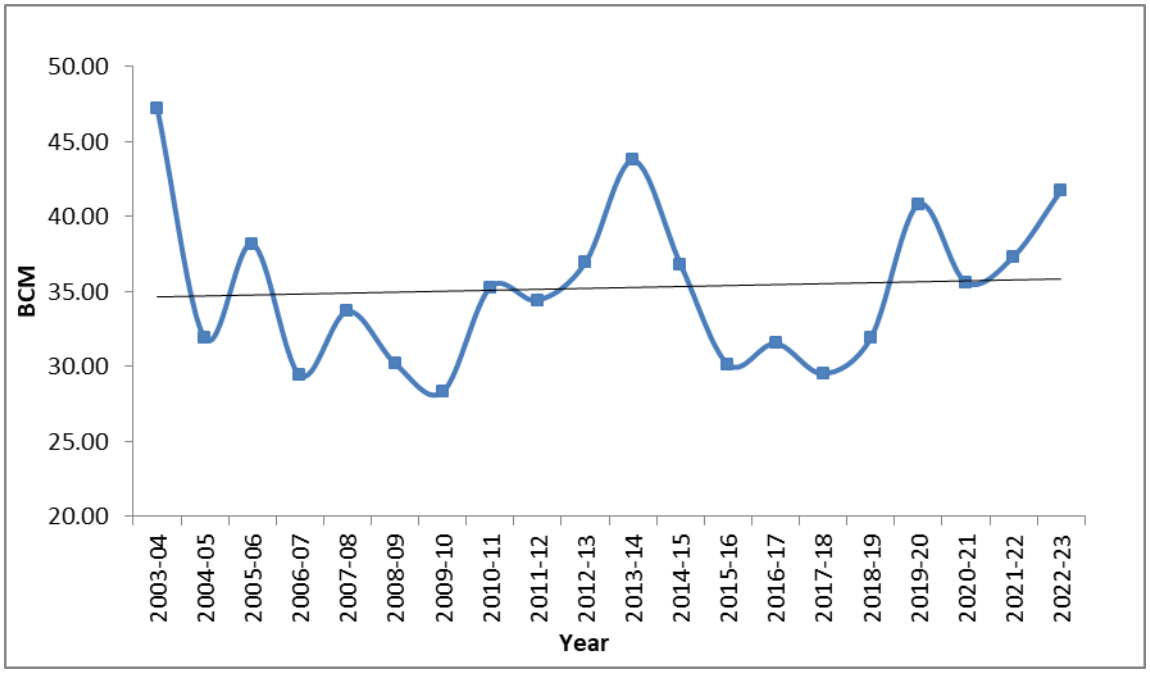


Figure 13.3: Annual Precipitation in Seonath sub-basin

13.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 24.04 BCM (777 mm) to 33.44 BCM (1081 mm). The average ET of 20 years is 28.48 BCM (921mm).

13.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.03 BCM.

13.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 6.37 BCM.

13.3.5 Groundwater flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux) for the sub-basin for 2003-04 to 2022-23 is -0.01 BCM. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.07 BCM.

13.4 Annual Water Availability of Seonath Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 13.15 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 13.4. The results of Seonath sub-basin are shown in Table 13.2.

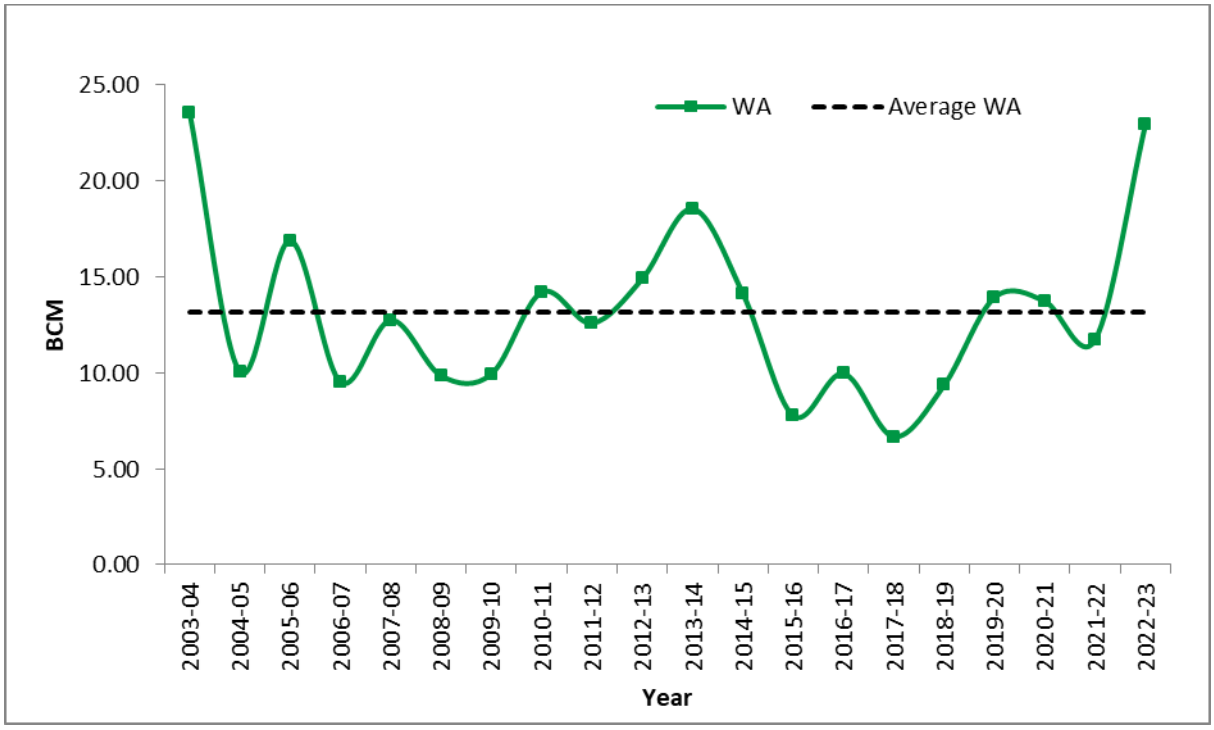


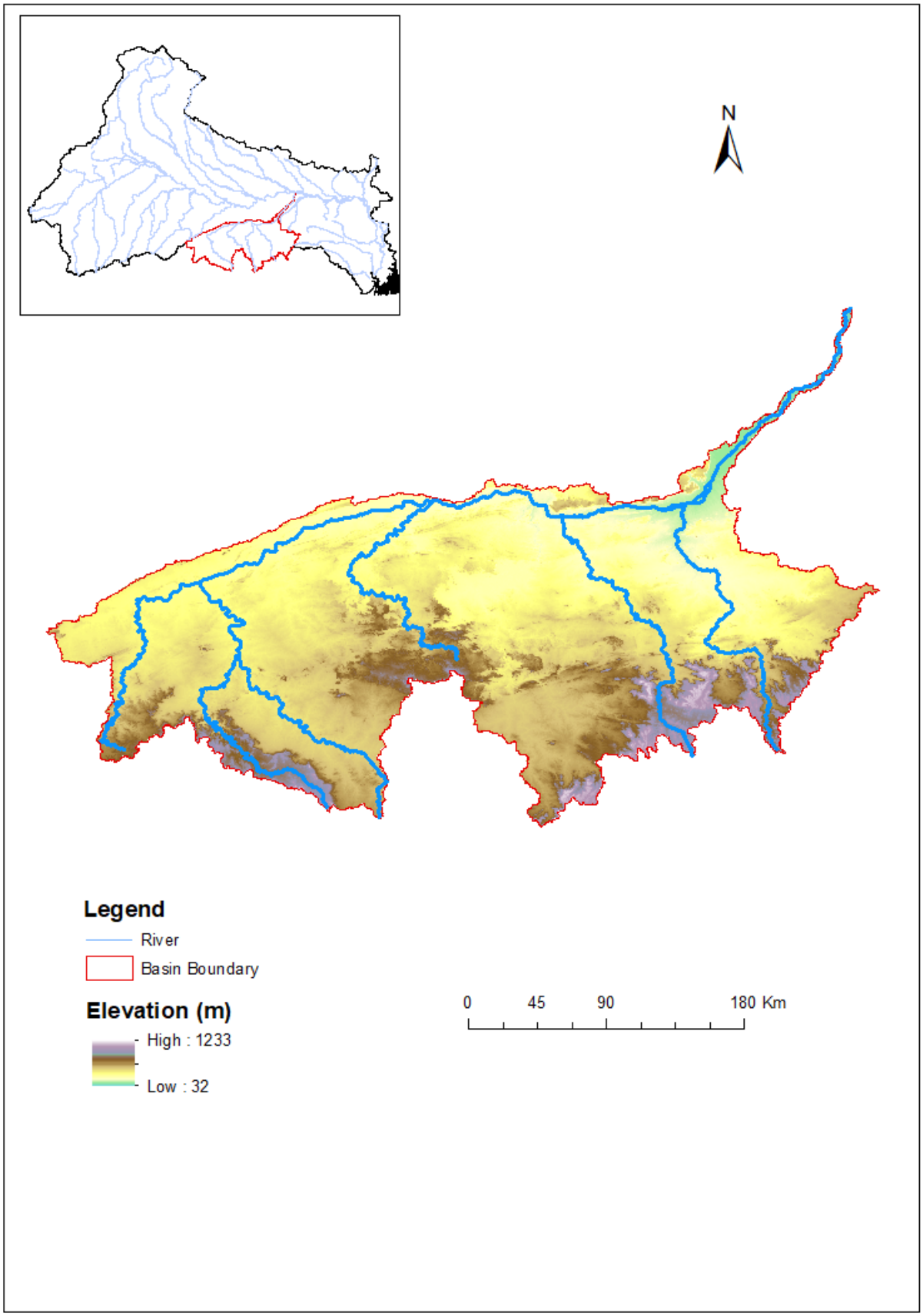
Figure 15.6: Water Availability of Seonath sub-basin

Table 13.2: Water Availability of Seonath sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	47.21	23.66	23.55
2004-05	31.90	21.84	10.05
2005-06	38.19	21.30	16.89
2006-07	29.40	19.88	9.52
2007-08	33.69	20.94	12.75
2008-09	30.20	20.36	9.85
2009-10	28.31	18.37	9.94
2010-11	35.28	21.08	14.21
2011-12	34.42	21.84	12.59
2012-13	36.93	22.03	14.91
2013-14	43.75	25.20	18.55
2014-15	36.81	22.70	14.11
2015-16	30.14	22.38	7.76
2016-17	31.54	21.57	9.97
2017-18	29.53	22.85	6.67
2018-19	31.90	22.54	9.37
2019-20	40.81	26.89	13.93
2020-21	35.61	21.88	13.73
2021-22	37.34	25.61	11.73
2022-23	41.74	18.80	22.94
Average	**35.24**	**22.09**	**13.15**

14. SONE SUB-BASIN



14.1 About Sone basin

The river Sone is an important right bank tributary of the river Ganga. It originates from Amarkantak high lands in hills of Maikala range in Bilaspur district of Chhattisgarh at an elevation of 640 m and latitude 20°44' N and longitude 82°4'E'. The river outfalls into the Ganga at about 16 km. upstream of Patna at latitude 25°14' N and longitude 84°42' E. The total length of the river is 881 km. The catchment of the whole river system is surrounded by the Vindhyachal range in the North, the Punpun river system and the Chotanagpur plateau on the East, the Baghelkhand plateau and the Mahadeva hills on the South and the forest clad Maikal and Bhamver ranges on the West . After flowing a distance of 655 km through the states of Chhattisgarh, Madhya Pradesh and Uttar Pradesh, the river Sone enters in Jharkhand. Its important tributaries lying in the states of Chhattisgarh, Madhya Pradesh, Uttar Pradesh and Jharkhand are Johilla, Mahanadi, Banas, Gopad, Rihand, Ghagher, Kanhar and North Koel. The river Kanhar which flows South to North and in the downstream reach forms boundaries between Jharkhand and Madhya Pradesh. After meeting with the river Kanhar, the river Sone enters Jharkhand and joined by the river North Koel on its right bank. The river, thereafter, takes a sharp North-East turn and finally joins the river Ganga. The Catchment area of the sub-basin is approximately 66,901 sq. km.

14.2 Geo-Spatial Datasets

14.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Sone sub-basin for year 2022-23 is shown in Figure 14.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Deciduous Woodland, Kharif Only, Double Triple etc.

Table 14.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

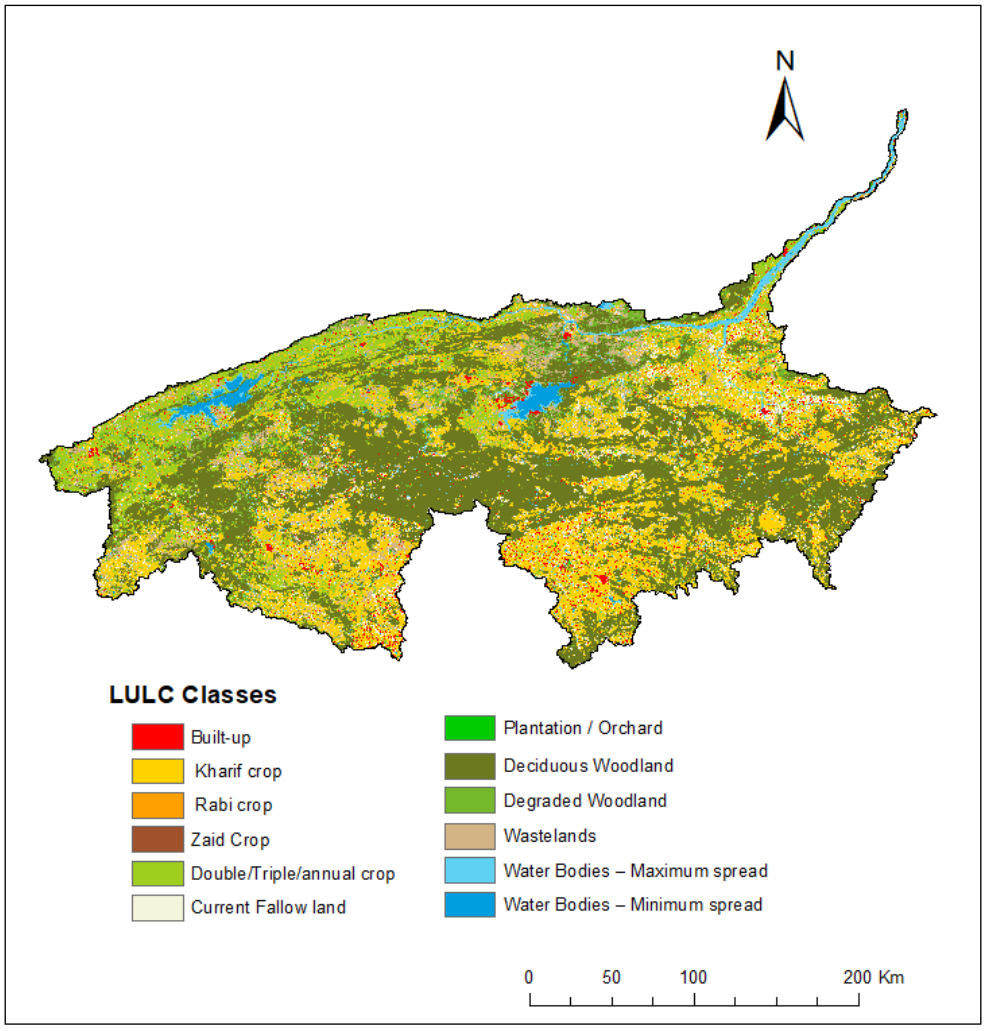


Figure 14.1: LULC Map of Sone sub-basin

Table 14.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	1.95
2.	Kharif only	24.74
3.	Rabi crop	0.64
4.	Zaid crop	0.00
5.	Double/Triple/Annual crop	11.64
6.	Current Fallow	5.43
7.	Plantation/Orchard	0.09
8.	Deciduous woodland	39.11
9.	Degraded woodland	6.10
10.	Waste lands	6.19
11.	Water Bodies - maximum spread	2.94
12.	Water Bodies - minimum spread	1.18

14.3 Hydro-Meteorological and other Input Data

14.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 14.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 14.3. The average precipitation of 20 years is approximately 71.51 BCM (1068.84 mm).

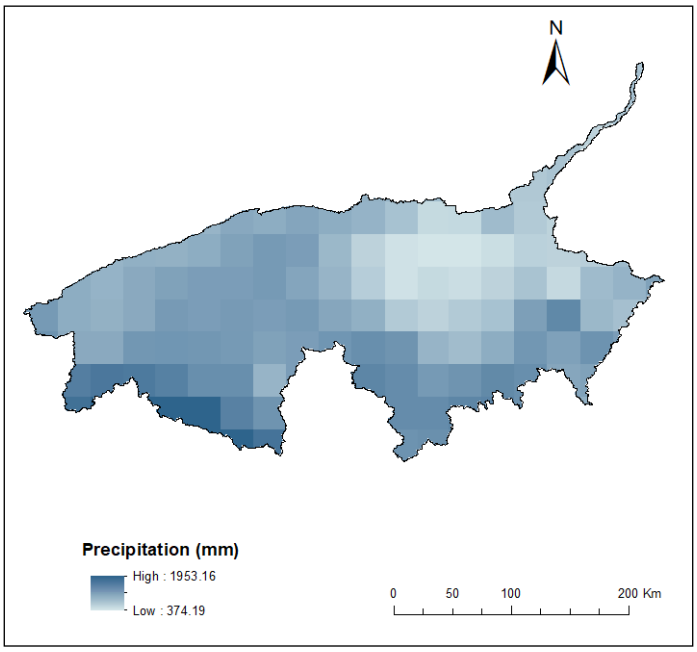


Figure 14.2: Precipitation map of Sone sub-basin

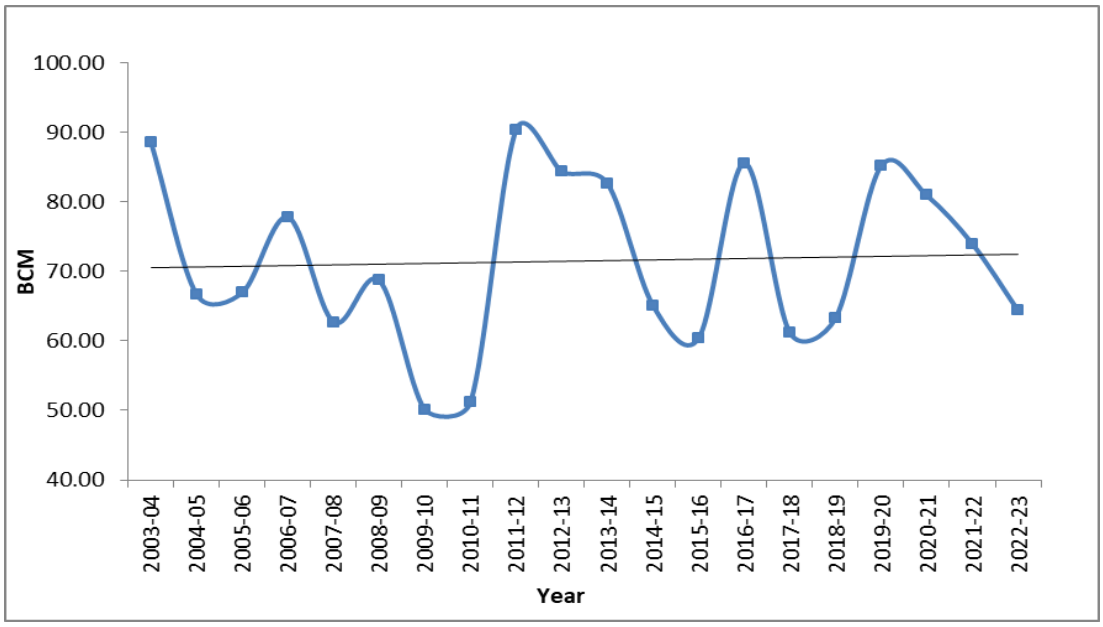


Figure 14.3: Annual Precipitation in Sone sub-basin

14.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 44.36 BCM (663 mm) to 64.18 BCM (959 mm). The average ET of 20 years is 53.89 BCM (879.68 mm).

14.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 1.23 BCM.

14.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 3.28 BCM.

14.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux), Reservoir flux for the sub-basin for 2003-04 to 2022-23 is 0.53 BCM and 0.25 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.46 BCM.

14.4 Annual Water Availability of Sone Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 22.12 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 14.4. The results of Sone sub-basin are shown in Table 14.2.

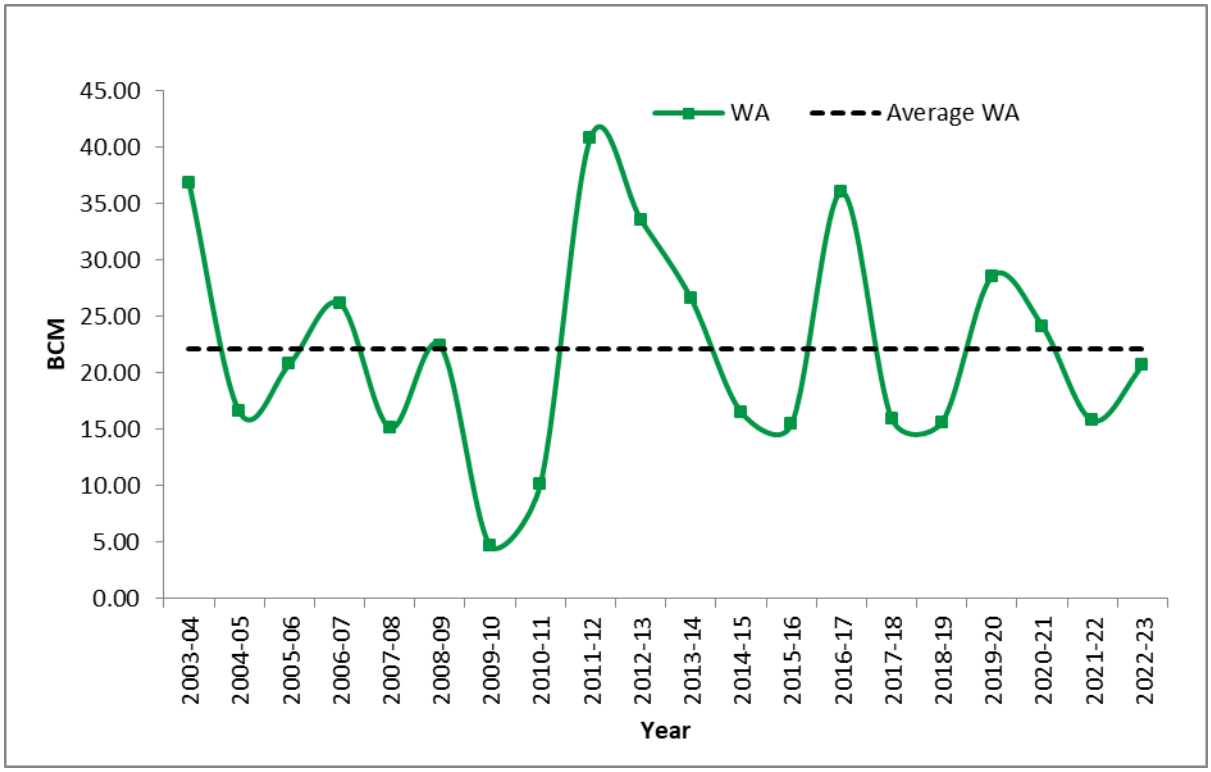


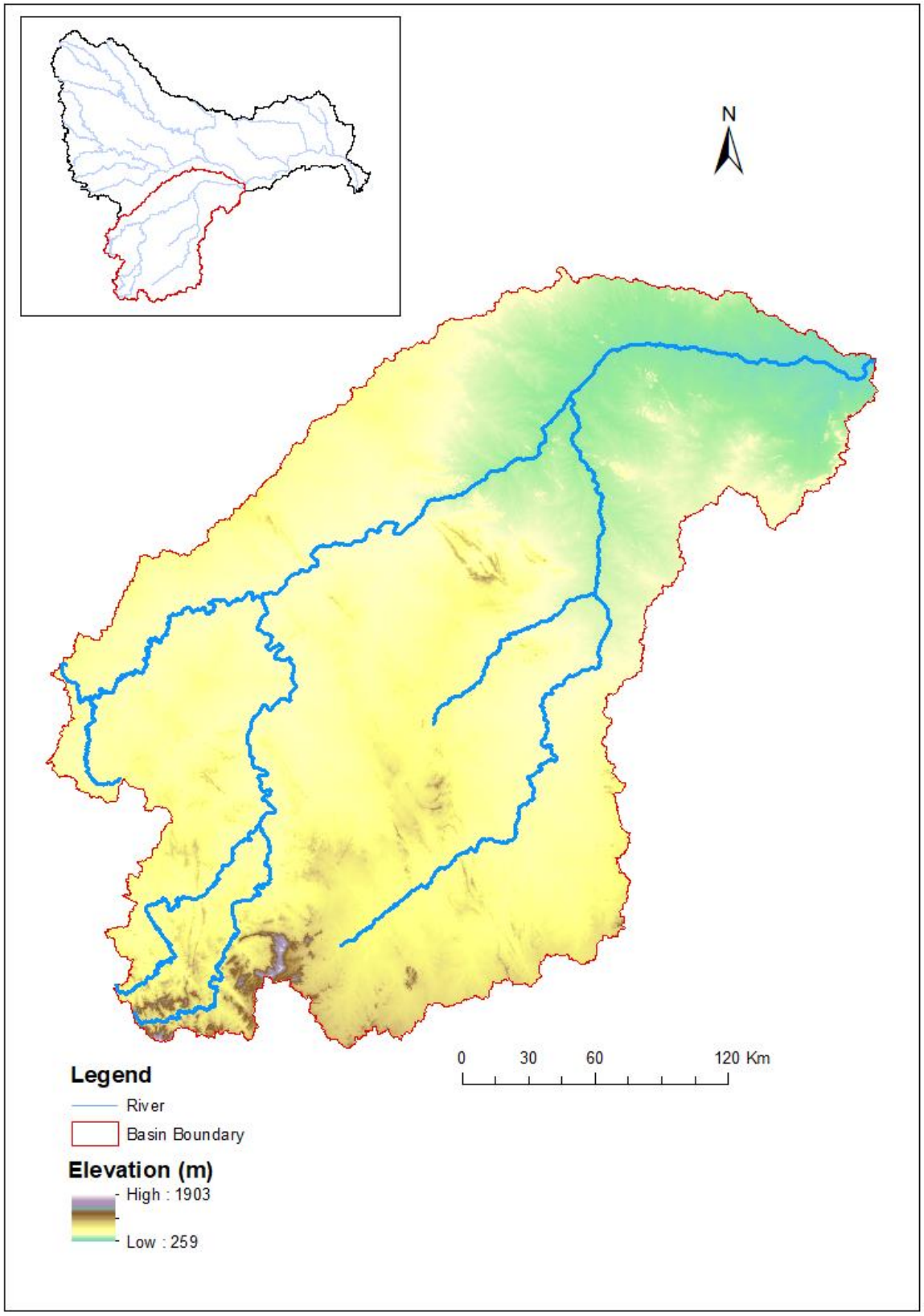
Figure 14.4: Water Availability of Sone sub-basin

Table 14.2: Water Availability of Sone sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	88.53	51.74	36.79
2004-05	66.67	50.11	16.56
2005-06	66.95	46.17	20.78
2006-07	77.82	51.65	26.17
2007-08	62.70	47.55	15.15
2008-09	68.72	46.30	22.42
2009-10	50.10	45.42	4.68
2010-11	51.21	41.06	10.15
2011-12	90.38	49.54	40.83
2012-13	84.37	50.78	33.59
2013-14	82.67	56.06	26.60
2014-15	65.07	48.56	16.52
2015-16	60.41	44.97	15.43
2016-17	85.61	49.56	36.04
2017-18	61.17	45.23	15.95
2018-19	63.30	47.68	15.62
2019-20	85.20	56.65	28.55
2020-21	80.94	56.78	24.16
2021-22	73.96	58.17	15.79
2022-23	64.34	43.68	20.66
Average	**71.51**	**49.38**	**22.12**

15. TUNGABHADRA BASIN



15.1 About Tungabhadra Sub-basin

The Tungabhadra sub-basin lies between latitudes 13°30'N and 16°50'N and longitudes 75°00'E and 78°30'E, spanning the states of Karnataka and Andhra Pradesh. It is a sub-basin of the Krishna River system. The sub-basin is bordered to the north by the Krishna sub-basin, to the west by the Vedavati and Bhima sub-basins, to the south by the Cauvery sub-basin, and to the east by the Penna sub-basin. The terrain of the catchment area is primarily undulating and hilly. The total catchment area of the sub-basin is approximately 70,764 square kilometers.

15.2 Geo-Spatial Datasets

15.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Tungabhadra sub-basin for year 2022-23 is shown in Figure 15.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Current Fallow, Kharif only, Double/Triple, etc. Table 15.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

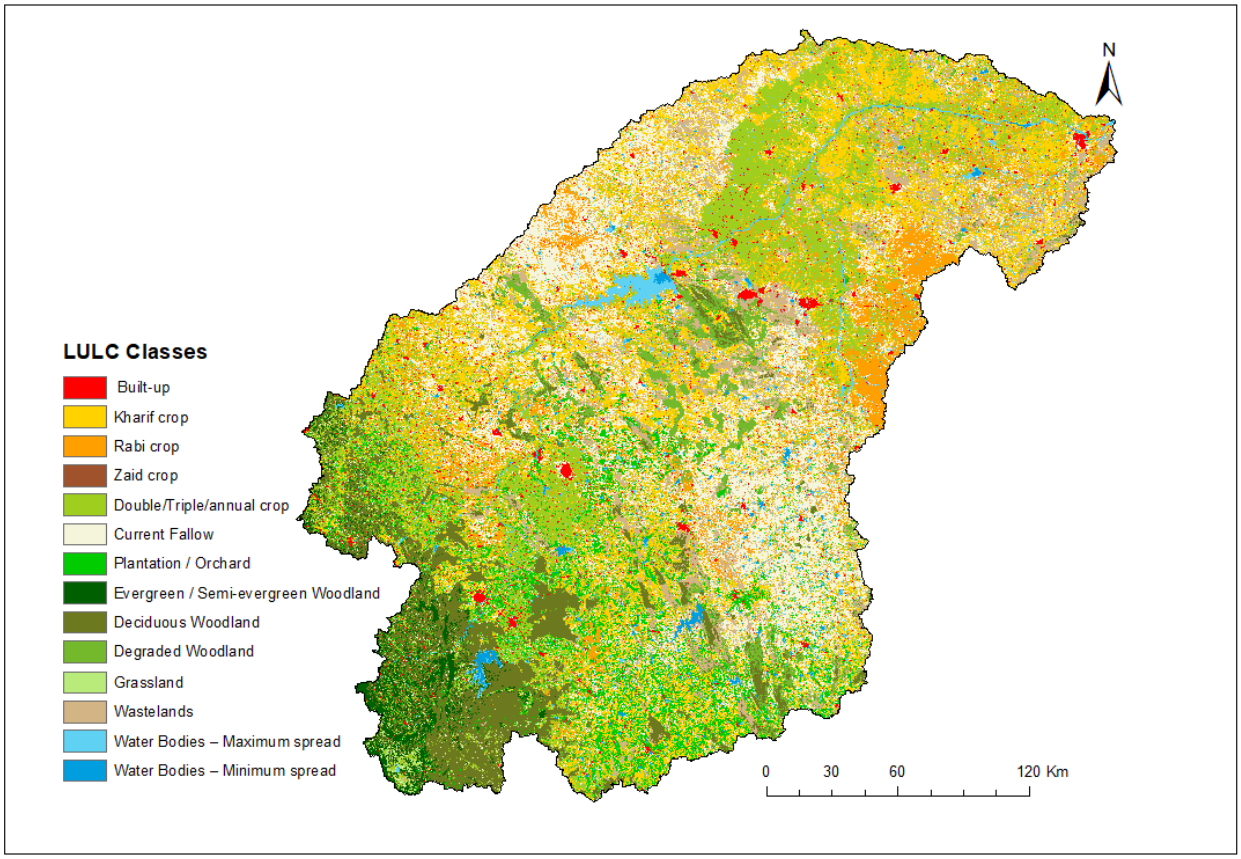


Figure 15.1: LULC Map of Tungabhadra sub-basin

Table 15.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Build up	2.39
2.	Kharif crop	19.31
3.	Rabi crop land	8.15
4.	Zaid crop land	0.02
5.	Double/Triple/Annual crop land	18.21
6.	Current Fallow land	19.49
7.	Plantation/Orchard	6.18
8.	Evergreen/Semi evergreen	1.98
9.	Deciduous woodland	8.79
10.	Degraded woodland	3.46
11.	Shifting Cultivation	0.13
12.	Waste lands	8.11
13.	Water Bodies - maximum spread	2.90
14.	Water Bodies - minimum spread	0.88

15.3 Hydro-Meteorological and other Input Data

15.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 15.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 14.3. The average precipitation of 20 years is approximately 61.03 BCM (862.47 mm).

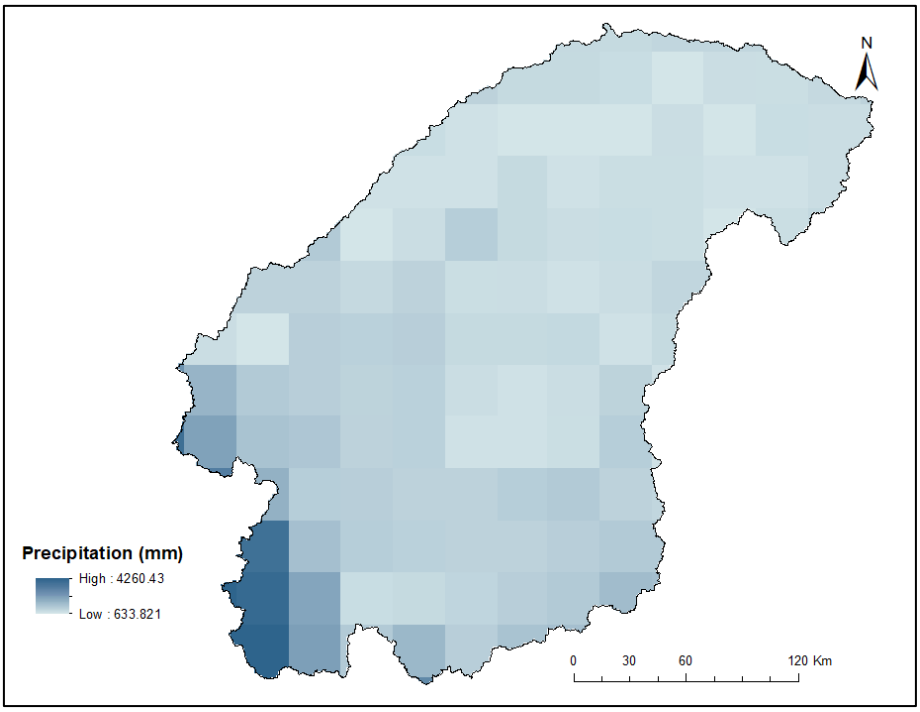


Figure 15.2: Precipitation map of Tungabhadra sub-basin

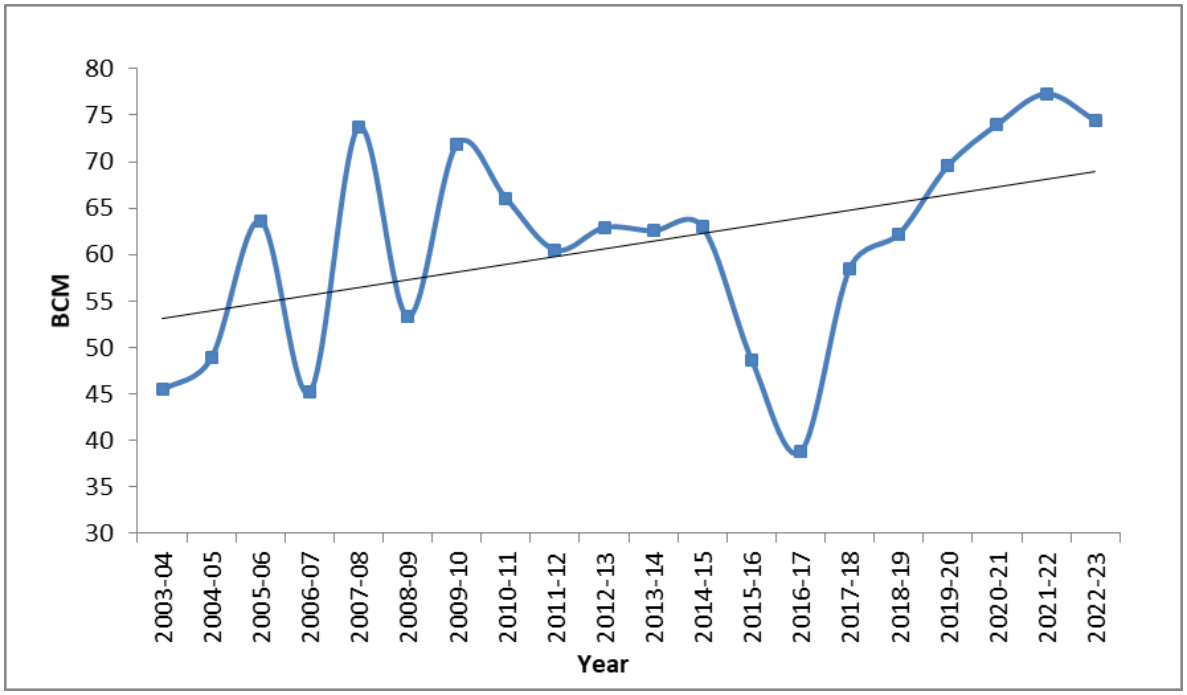


Figure 15.3: Annual Precipitation in Tungabhadra sub-basin

15.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 35.47 BCM (501 mm) to 65.10 BCM (920mm). The average ET of 20 years is 46.24 BCM (653 mm).

15.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.68 BCM.

15.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 5.38 BCM.

15.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux), Reservoir flux for the sub-basin for 2003-04 to 2022-23 is -0.103 BCM and -0.096 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.44 BCM.

15.4 Annual Water Availability of Tungabhadra Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 19.8 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 15.4. The results of Tungabhadra sub-basin are shown in Table 15.2.

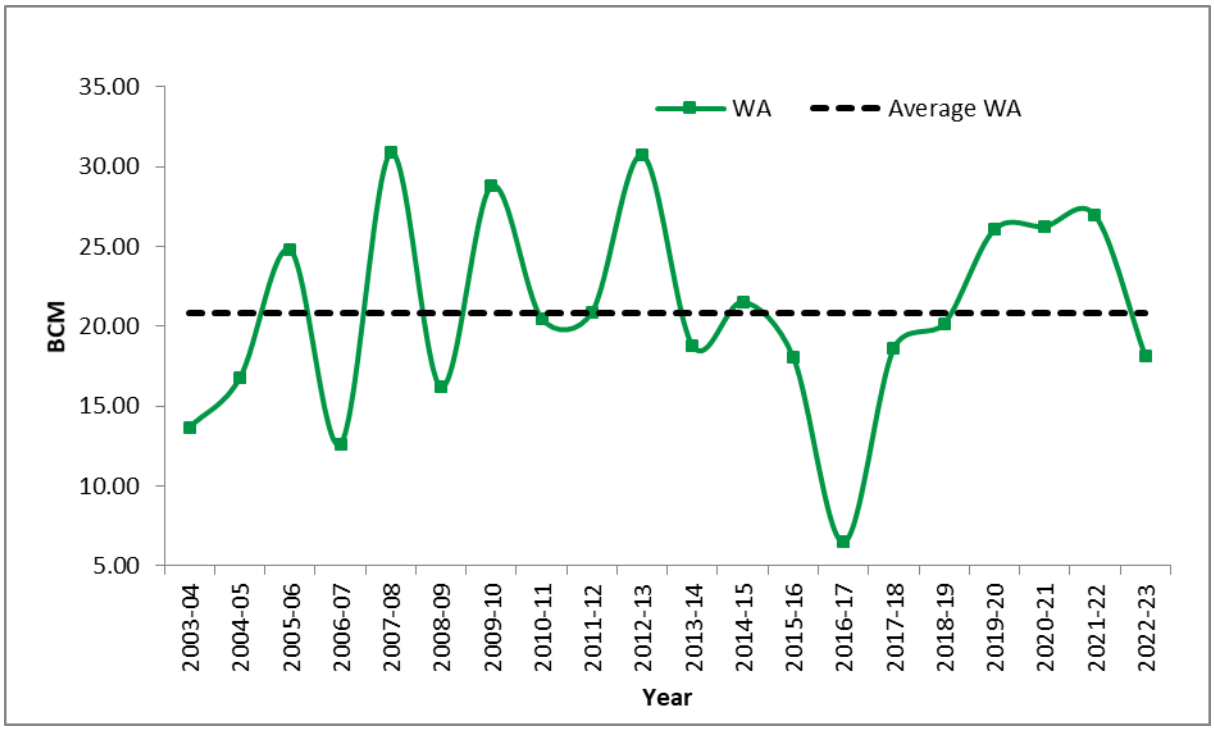


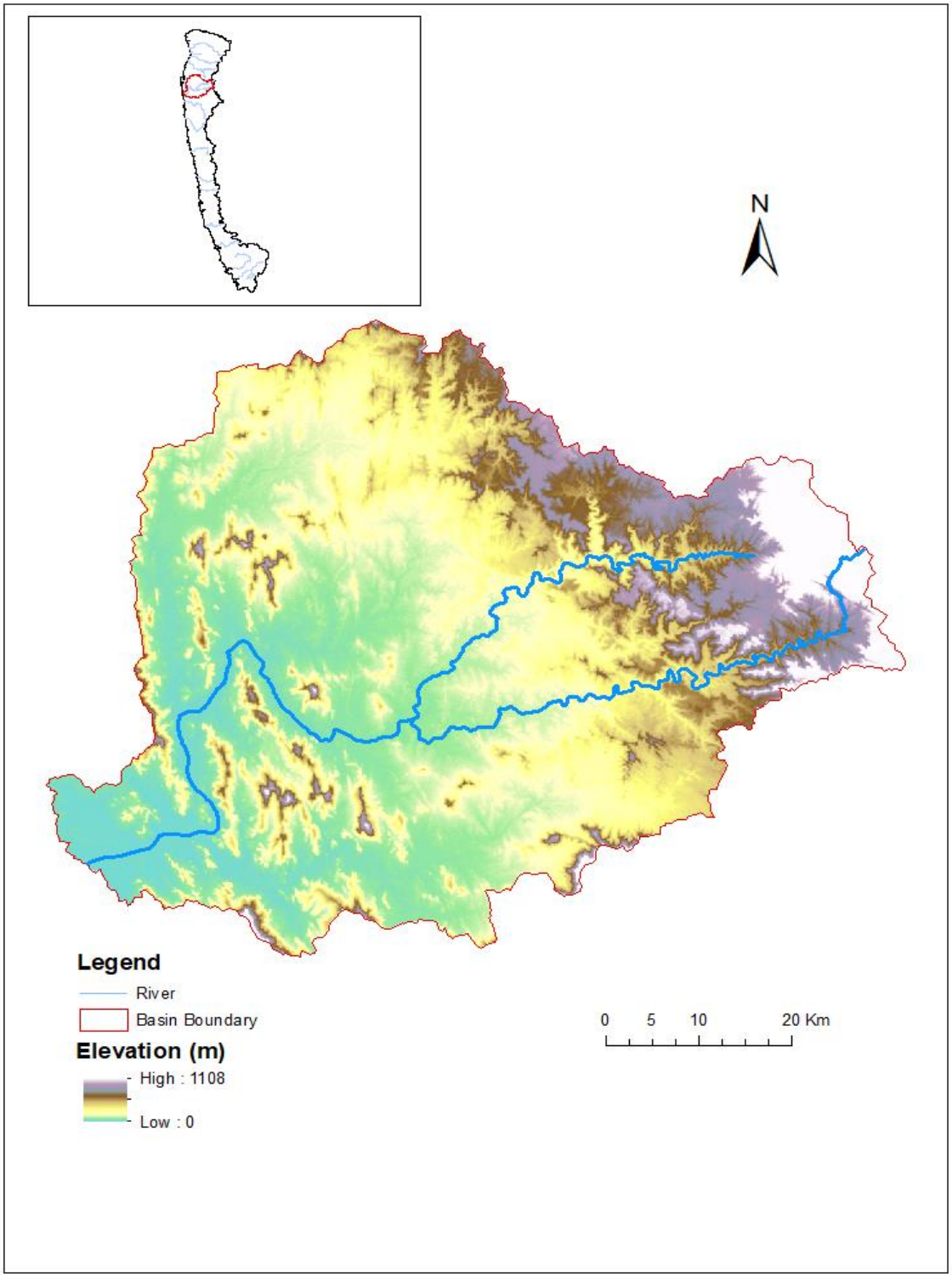
Figure 15.4: Water Availability of Tungabhadra sub-basin

Table 15.2: Water Availability of Tungabhadra sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	45.45	31.76	13.69
2004-05	48.90	32.11	16.78
2005-06	63.64	38.86	24.78
2006-07	45.19	32.55	12.64
2007-08	73.73	42.86	30.87
2008-09	53.32	37.11	16.21
2009-10	71.87	43.09	28.78
2010-11	66.06	45.56	20.49
2011-12	60.51	39.61	20.90
2012-13	62.91	32.19	30.72
2013-14	62.57	43.77	18.79
2014-15	62.98	41.43	21.54
2015-16	48.69	30.61	18.08
2016-17	38.81	32.32	6.49
2017-18	58.52	39.90	18.63
2018-19	62.21	42.05	20.16
2019-20	69.56	43.50	26.06
2020-21	73.99	47.73	26.26
2021-22	77.30	50.35	26.95
2022-23	74.44	56.32	18.12
Average	**61.03**	**40.18**	**20.85**

16. VAITARANA SUB-BASIN



16.1 About Vaitarana Sub-basin

Vaitarna-rises north of the village of Jarvar in Nasik district of Maharashtra State at an elevation of 800 m. It flows for about 20km in a generally north- south direction with one sharp bend, where after it follows a south-west course for about 42 km up to the village of Vada. About 6 Km. Lower down, the Pinjal joins from the right. Catchment area of Sub basin is approximately 3,790 sq km

16.2 Geo-Spatial Datasets

16.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Vaitarana sub-basin for year 2022-23 is shown in Figure 16.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Deciduous woodland, Double/Triple, Kharif only etc.

Table 16.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

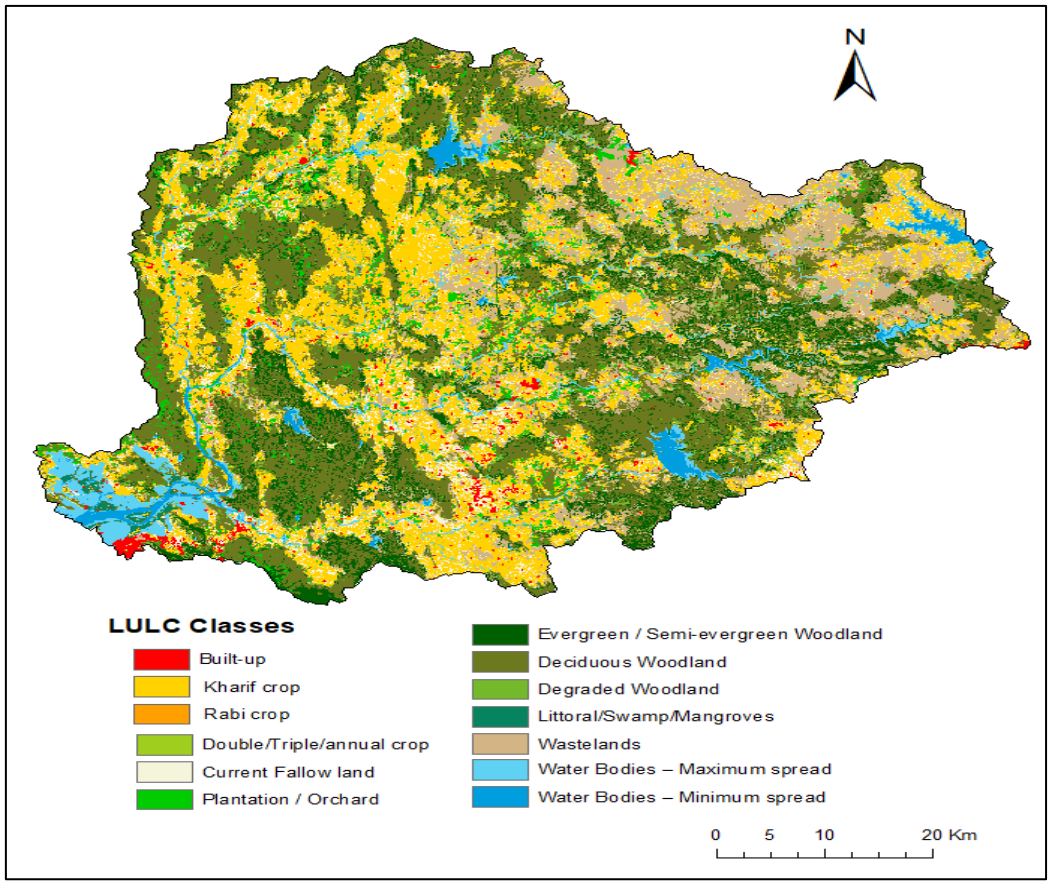


Figure 16.1: LULC Map of Vaitarana sub-basin

Table 16.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	1.25
2.	Kharif crop	25.16
3.	Rabi crop	0.07
4.	Double/Triple/Annual crop	0.71
5.	Current fallow land	5.87
6.	Plantation/Orchid	3.27
7.	Evergreen/Semi-evergreen woodland	10.27
8.	Deciduous woodland	29.66
9.	Degraded woodland	3.71
10.	Littoral/Swamp/Mangroves	0.27
11.	Waste lands	13.88
12.	Water Bodies - maximum spread	4.04
13.	Water Bodies - minimum spread	1.83
	Total	100

16.3 Hydro-Meteorological and other Input Data

16.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 16.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 16.3. The average precipitation of 20 years is approximately 10.72 BCM (2828 mm).

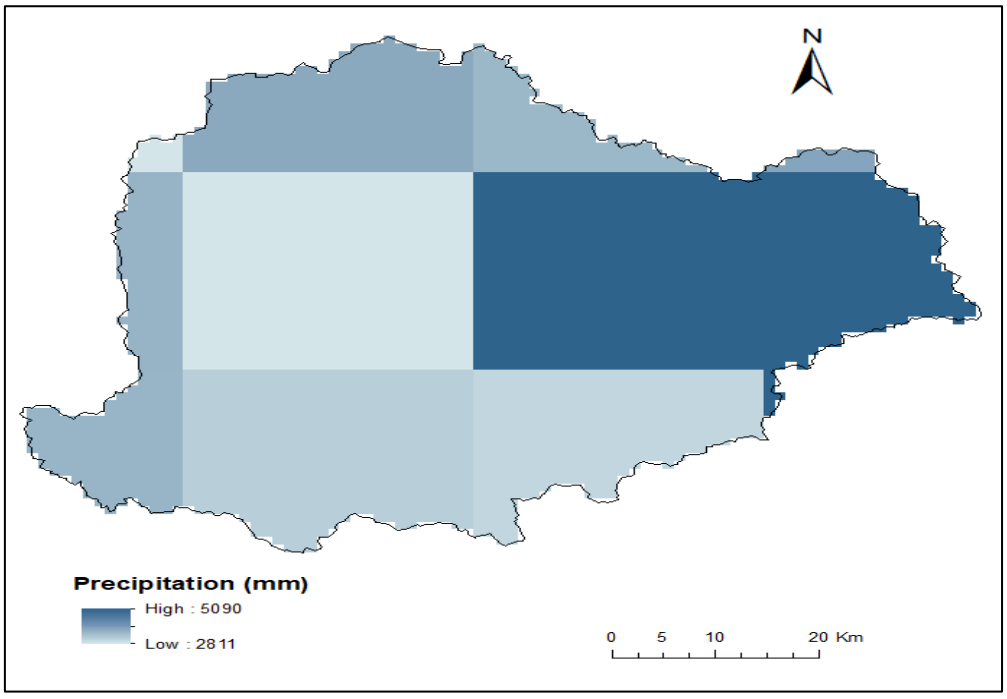


Figure 16.2: Precipitation map of Vaitarana sub-basin

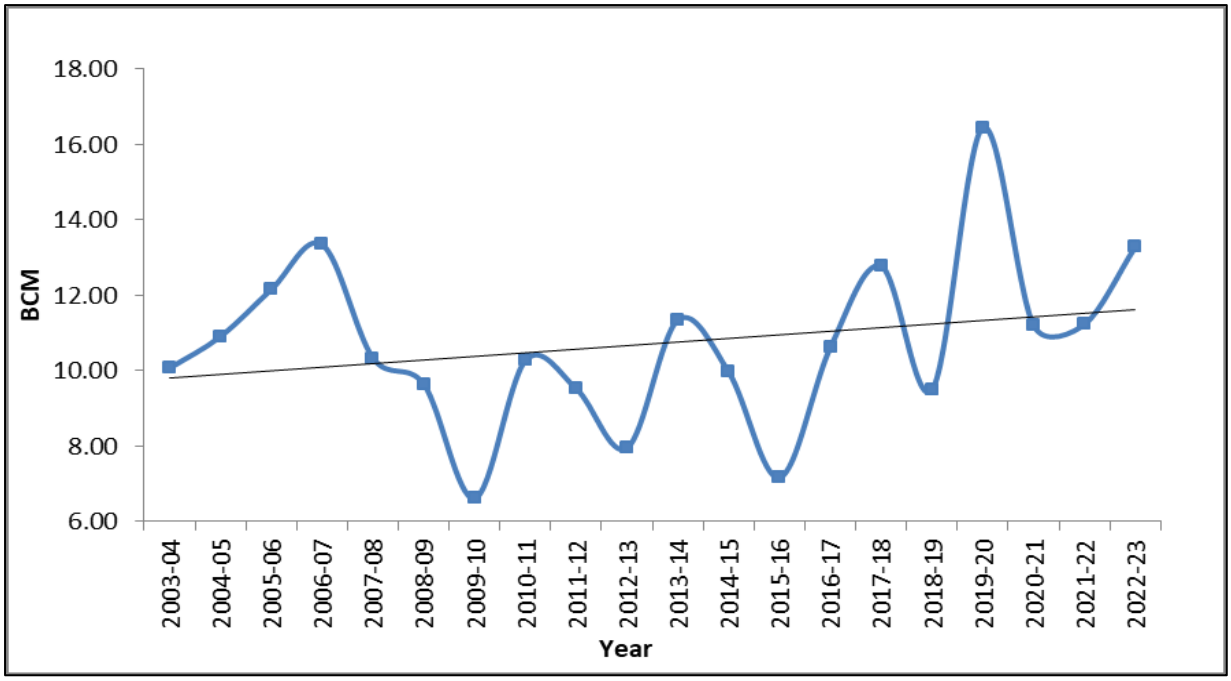


Figure 16.3: Annual Precipitation in Vaitarana sub-basin

16.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 3.09 BCM (816 mm) to 4.11 BCM (1085 mm). The average ET of 20 years is 3.50 BCM (922 mm).

16.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.091 BCM.

16.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 0.067 BCM.

16.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux), Reservoir flux for the sub-basin for 2003-04 to 2022-23 is -0.03 BCM and 0.005 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.12 BCM.

16.5 Annual Water Availability of Vaitarana Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 7.379 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 16.4. The results of Vaitarana sub-basin are shown in Table 16.2.

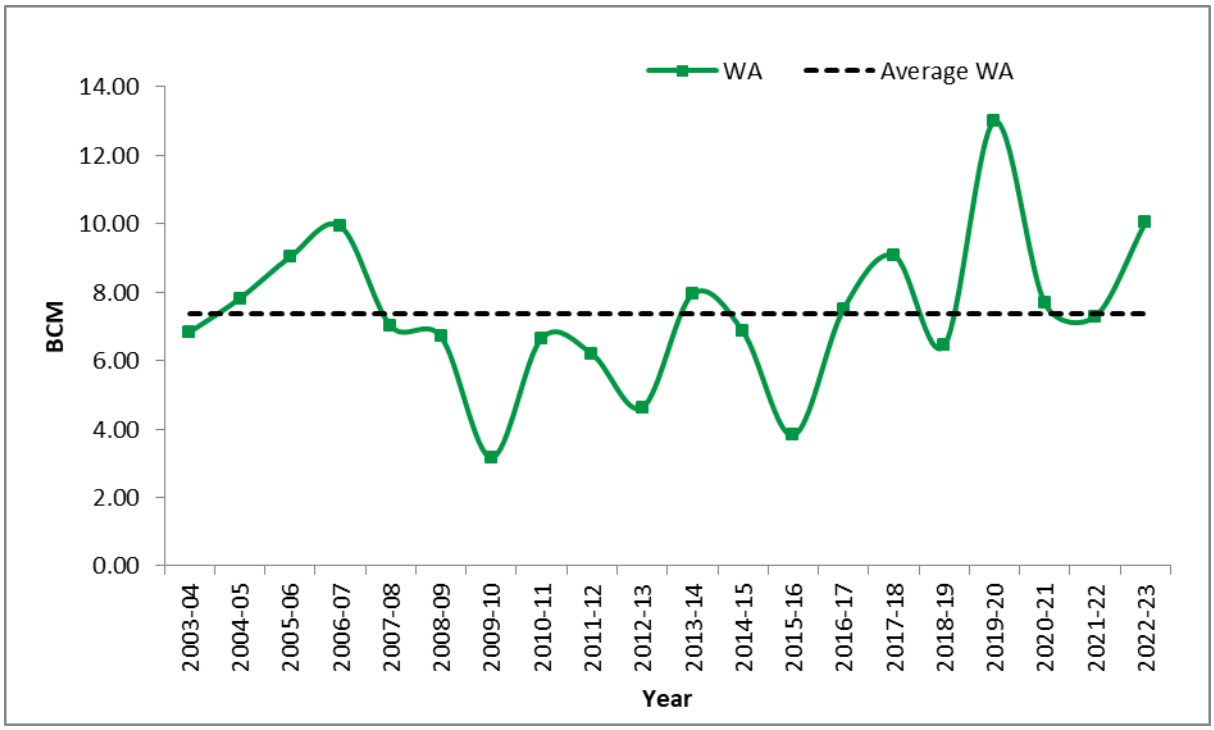


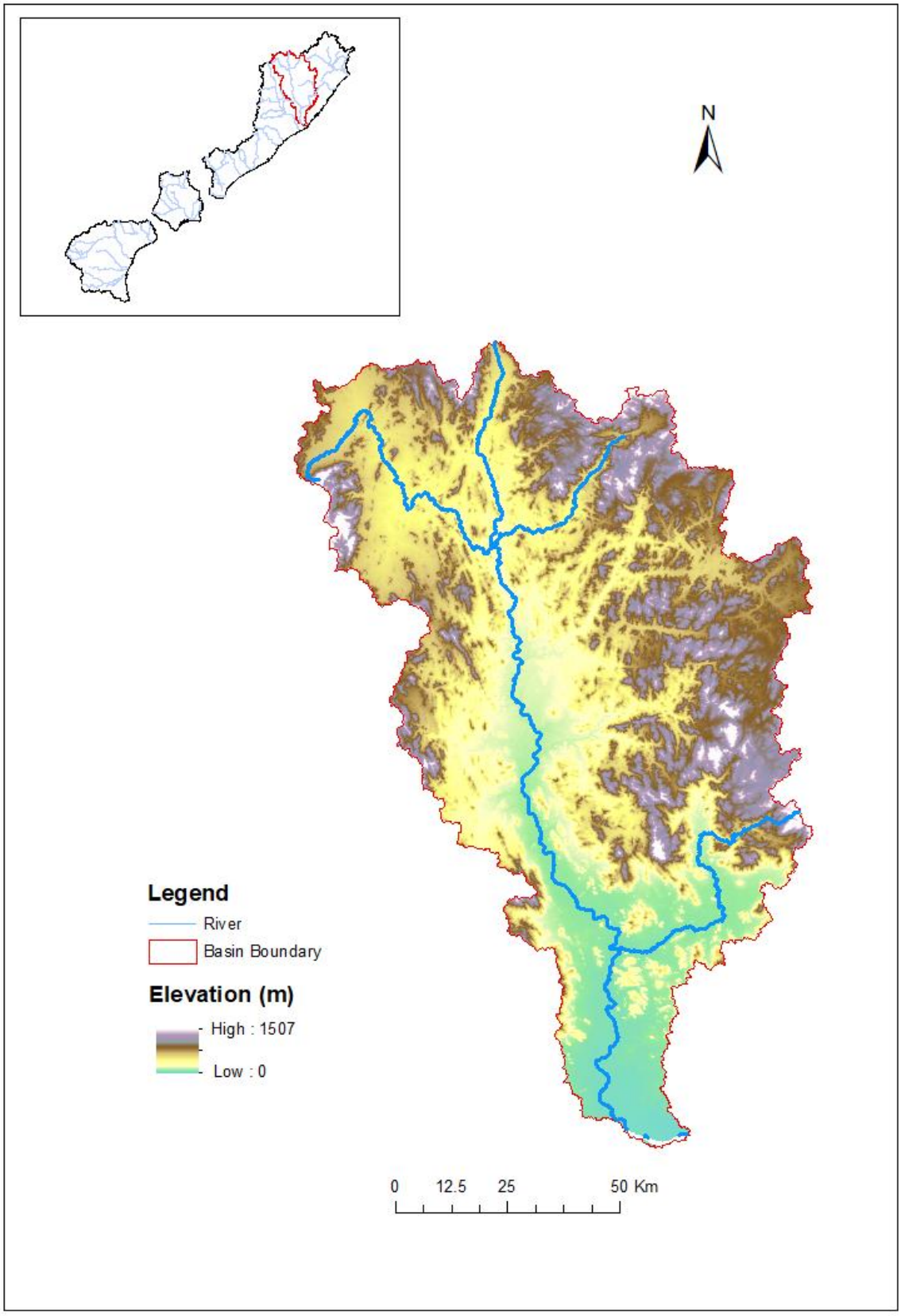
Figure 16.4: Water Availability of Vaitarana sub-basin

Table 16.2: Water Availability of Vaitarana sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	10.07	3.24	6.83
2004-05	10.91	3.09	7.82
2005-06	12.16	3.13	9.03
2006-07	13.35	3.42	9.93
2007-08	10.33	3.32	7.01
2008-09	9.64	2.95	6.70
2009-10	6.62	3.45	3.17
2010-11	10.28	3.62	6.66
2011-12	9.53	3.33	6.19
2012-13	7.95	3.32	4.63
2013-14	11.35	3.41	7.95
2014-15	9.96	3.11	6.85
2015-16	7.17	3.35	3.82
2016-17	10.62	3.11	7.51
2017-18	12.78	3.71	9.07
2018-19	9.50	3.06	6.44
2019-20	16.45	3.46	12.99
2020-21	11.20	3.52	7.67
2021-22	11.23	3.94	7.29
2022-23	13.28	3.24	10.04
Average	**10.72**	**3.34**	**7.38**

17 VAMSADHARA SUB-BASIN



17.1 About Vamsadhara Sub-basin

The Vamsadhara sub-basin lies between latitudes 18^0 17^l N and 19^0 57^l N and longitudes 83^0 20^l E and 84^0 20^l E, and lies in Odisha and Andhra Pradesh states. It is sub-basin of West Flowing Rivers from Mahanadi and Pennar. It is bounded on the north by the Mahanadi sub-basin, on the north east by the Rushikulya sub-basin, on the west by the Nagavali sub-basin and on the east by the Bay of Bengal. The catchment area is mostly hilly. Catchment area of the sub-basin is approximately 10,504 sq. km.

17.2 Geo-Spatial Datasets

17.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Vamsadhara sub-basin for year 2022-23 is shown in Figure 17.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Deciduous woodland, Double/Triple, Kharif, etc.

Table 17.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

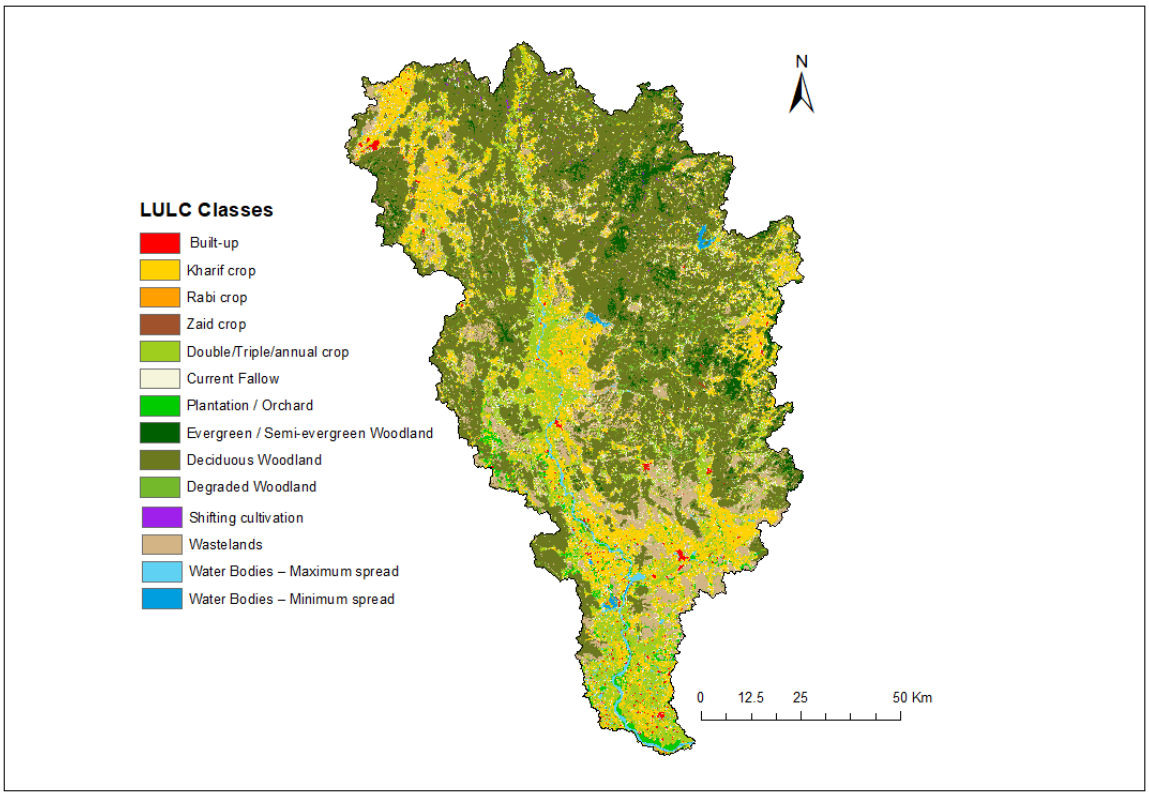


Figure 17.1: LULC Map of Vamsadhara sub-basin

Table 17.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Built-up	0.62
2.	Kharif crop	15.94
3.	Rabi crop	0.02
4.	Zaid crop	0.00
5.	Double/Triple/Annual crop	13.61
6.	Current Fallow	5.51
7.	Plantation/Orchard	1.12
8.	Evergreen/Semi evergreen	3.06
9.	Deciduous woodland	45.06
10.	Degraded woodland	2.29
11.	Shifting Cultivation	0.19
12.	Waste lands	11.02
13.	Water Bodies - maximum spread	1.29
14.	Water Bodies - minimum spread	0.26

17.3 Hydro-Meteorological and other Input Data

17.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 17.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 17.3. The average precipitation of 20 years is approximately 14.10 BCM (1342 mm).

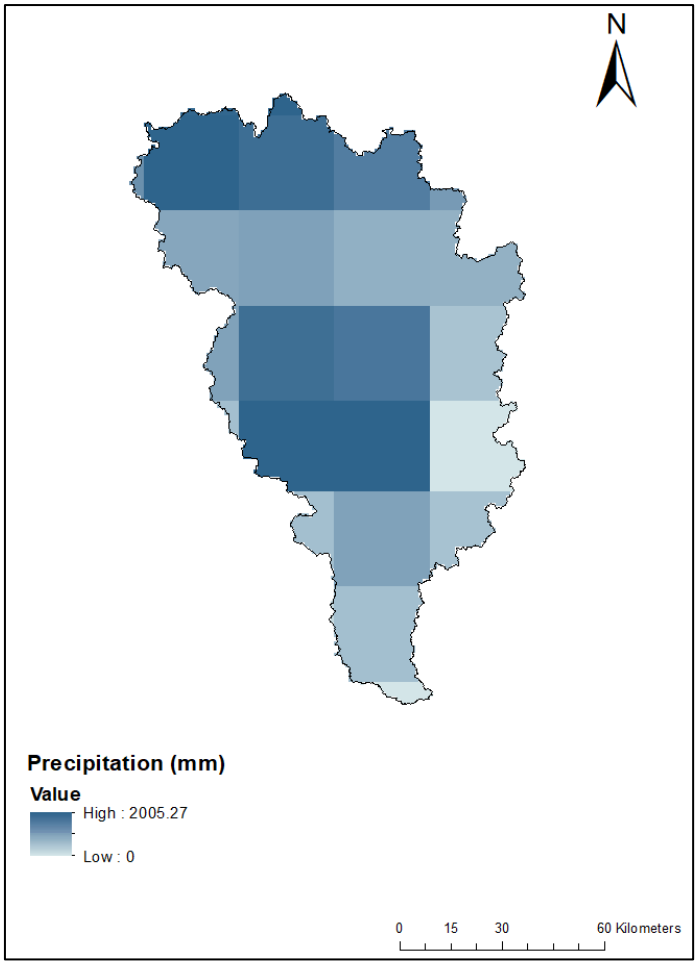


Figure 17.2: Precipitation map of Vamsadhara sub-basin

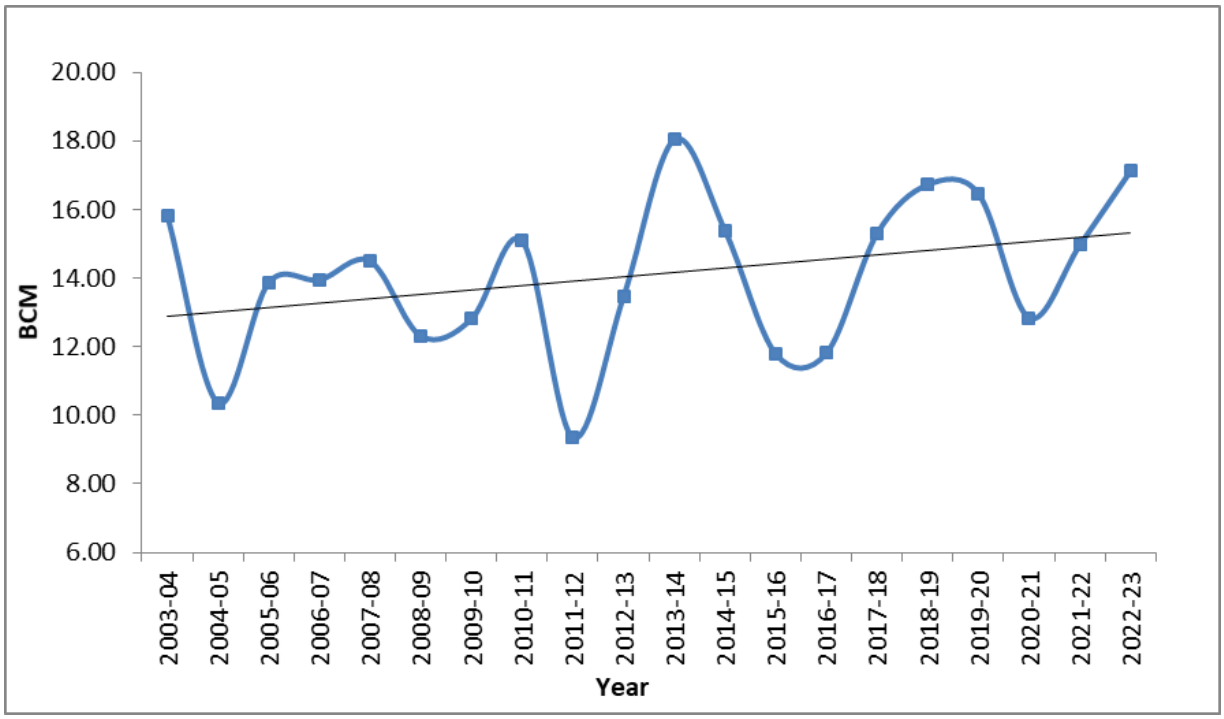


Figure 17.3: Annual Precipitation in Vamsadhara sub-basin

17.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 8.63 BCM (865 mm) to 11.12 BCM (1115 mm). The average ET of 20 years is 9.91 BCM (993 mm).

17.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 0.03 BCM.

17.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 0.46 BCM.

17.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux), Reservoir flux for the sub-basin for 2003-04 to 2022-23 is -0.02 BCM and 0 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 0.02 BCM.

17.4 Annual Water Availability of Vamsadhara Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 4.70 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 17.4. The results of Vamsadhara sub-basin are shown in Table 17.2.

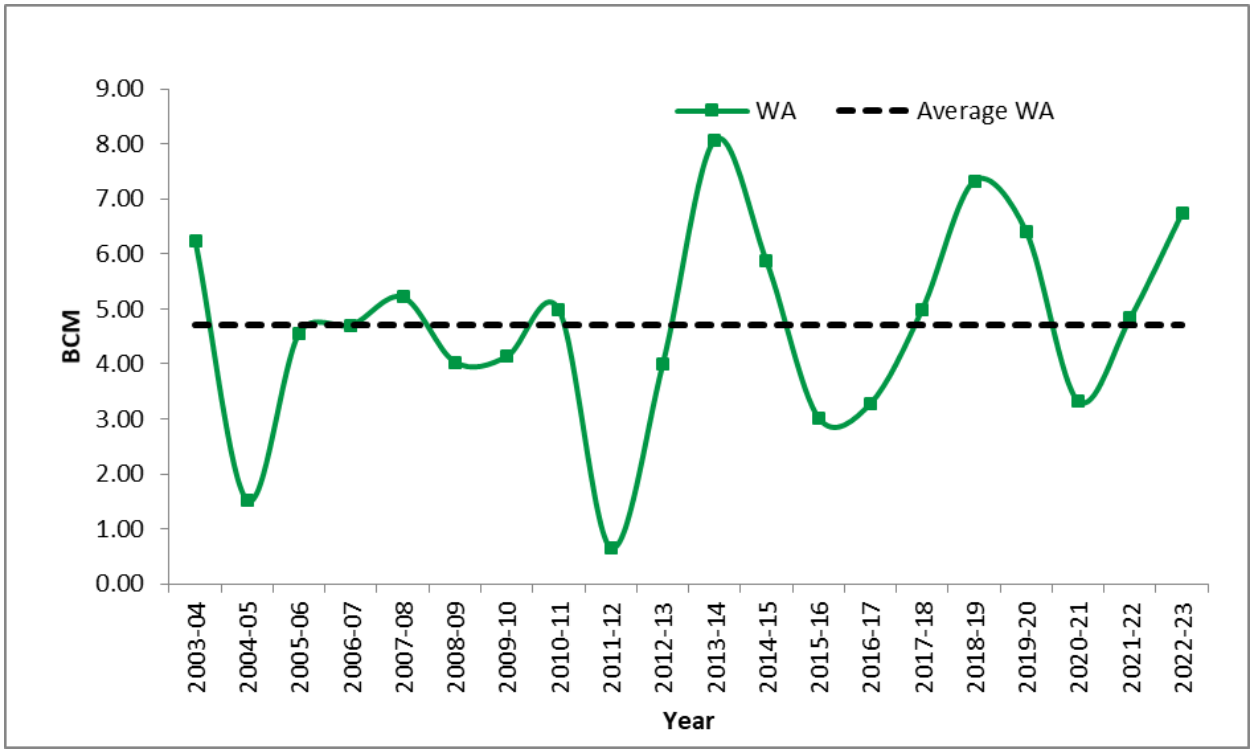


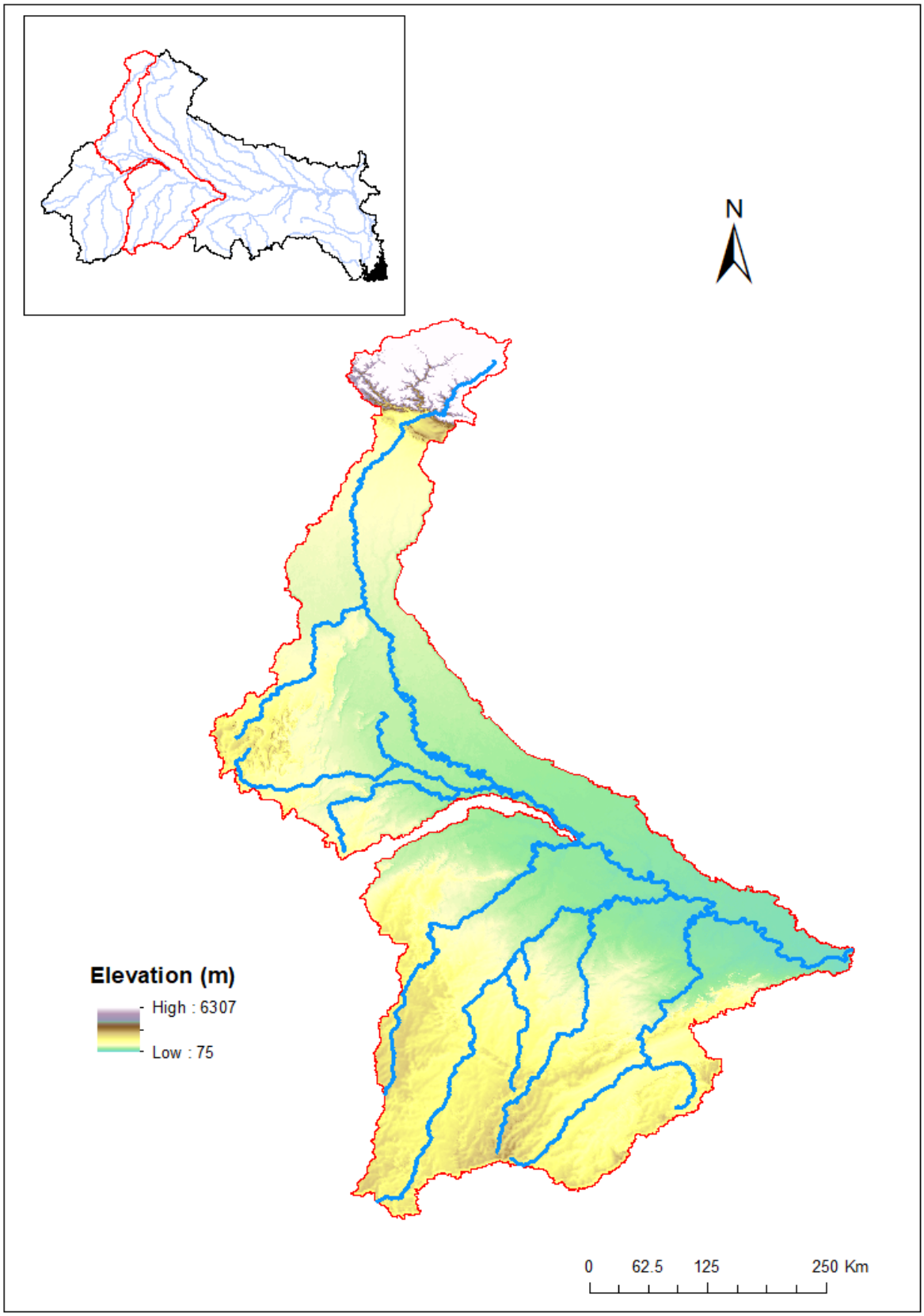
Figure 17.4: Water Availability of Vamsadhara sub-basin

Table 17.2: Water Availability of Vamsadhara sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	15.83	9.58	6.24
2004-05	10.36	8.84	1.52
2005-06	13.87	9.30	4.56
2006-07	13.95	9.25	4.70
2007-08	14.49	9.28	5.22
2008-09	12.31	8.28	4.04
2009-10	12.81	8.67	4.14
2010-11	15.08	10.09	4.99
2011-12	9.36	8.92	0.66
2012-13	13.46	9.47	3.99
2013-14	18.03	9.97	8.07
2014-15	15.39	9.52	5.86
2015-16	11.79	8.77	3.02
2016-17	11.81	8.53	3.28
2017-18	15.29	10.30	5.00
2018-19	16.72	9.39	7.33
2019-20	16.46	10.06	6.41
2020-21	12.84	9.51	3.33
2021-22	14.96	10.13	4.83
2022-23	17.12	10.37	6.74
Average	**14.10**	**9.41**	**4.70**

18. YAMUNA SUB-BASIN (excluding Chambal)



18.1 About Yamuna Sub-basin

The river Yamuna, a major tributary of river Ganges, originates from the Yamunotri glacier near Banderpoonch peaks (38^0 59' N 78^0 27' E) in the Mussourie range of the lower Himalayas in district Uttarkashi (Uttranchal). The important tributaries includes Tons, Chambal, Hindon, Betwa and Ken. Other small tributaries of the Yamuna River are Giri, Sind, Uttangan, Sengar and the Rind. The main Yamuna and Tons are fed by glaciers, viz., the Bandar Punch Glacier and its branches and originates from the Great Himalayan range. Catchment area of the sub-basin is approximately 2,02,498 sq. km.

18.2 Geo-Spatial Datasets

18.2.1: Land Use and Land Cover Classification

The Land Use and Land Cover (LULC) map of Yamuna sub-basin for year 2022-23 is shown in Figure 18.1. The map indicates various land classes and land use patterns in the sub-basin. The major land use classes consist of Double/Triple/Annual crop, Rabi crop, Woodland, etc.

Table 18.1 shows the percentage area of each land use class in the sub-basin for year 2022-23.

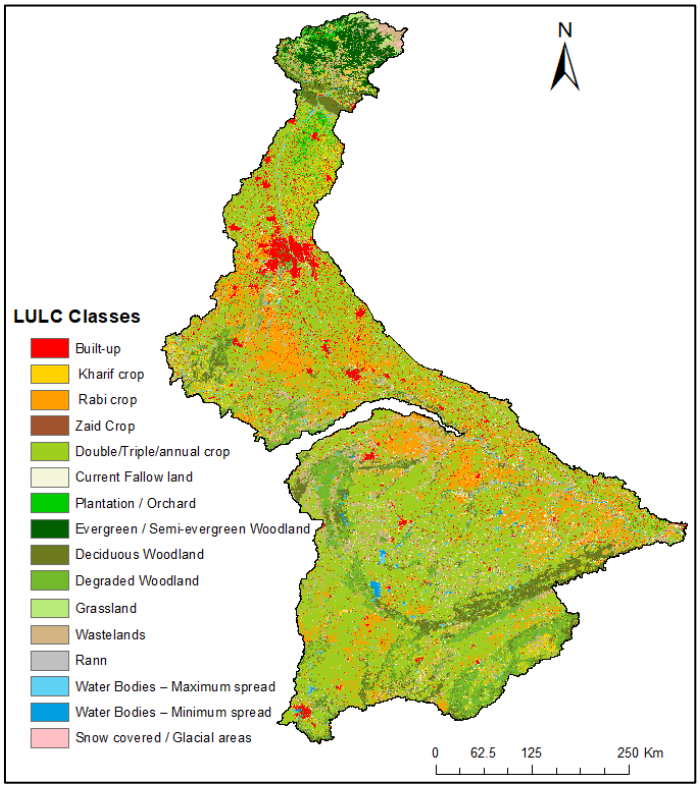


Figure 18.1: LULC Map of Yamuna sub-basin

Table 18.1: Percentage area of Land Use and Land Cover

S. No.	LULC Class	Area (%) in 2022-23
1.	Build up	5.05
2.	Kharif crop	3.34
3.	Rabi crop	13.13
4.	Zaid crop	0.00
5.	Double/Triple/Annual crop	47.54
6.	Current Fallow	2.99
7.	Plantation/Orchard	0.85
8.	Evergreen/Semi evergreen	2.00
9.	Deciduous woodland	6.76
10.	Degraded woodland	7.78
11.	Grassland	0.36
12.	Wasteland	7.95
13.	Water Bodies – Maximum spread	1.72
14.	Water Bodies – Minimum spread	0.42
15.	Snow covered / Glacial areas	0.10

18.3 Hydro-Meteorological and other Input Data

18.3.1 Precipitation

The spatial variation of precipitation in the sub-basin for the year 2022-23 has been shown in Figure 18.2. The variations in the annual precipitation during study period of 20 years (2003-04 to 2022-23) are shown in the Figure 18.3. The average precipitation of 20 years is approximately 165 BCM (815 mm).

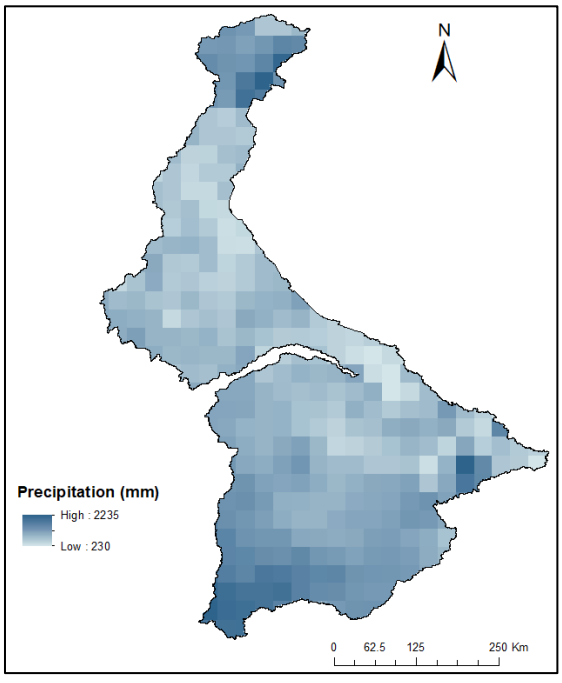


Figure 18.2: Precipitation map of Yamuna sub-basin

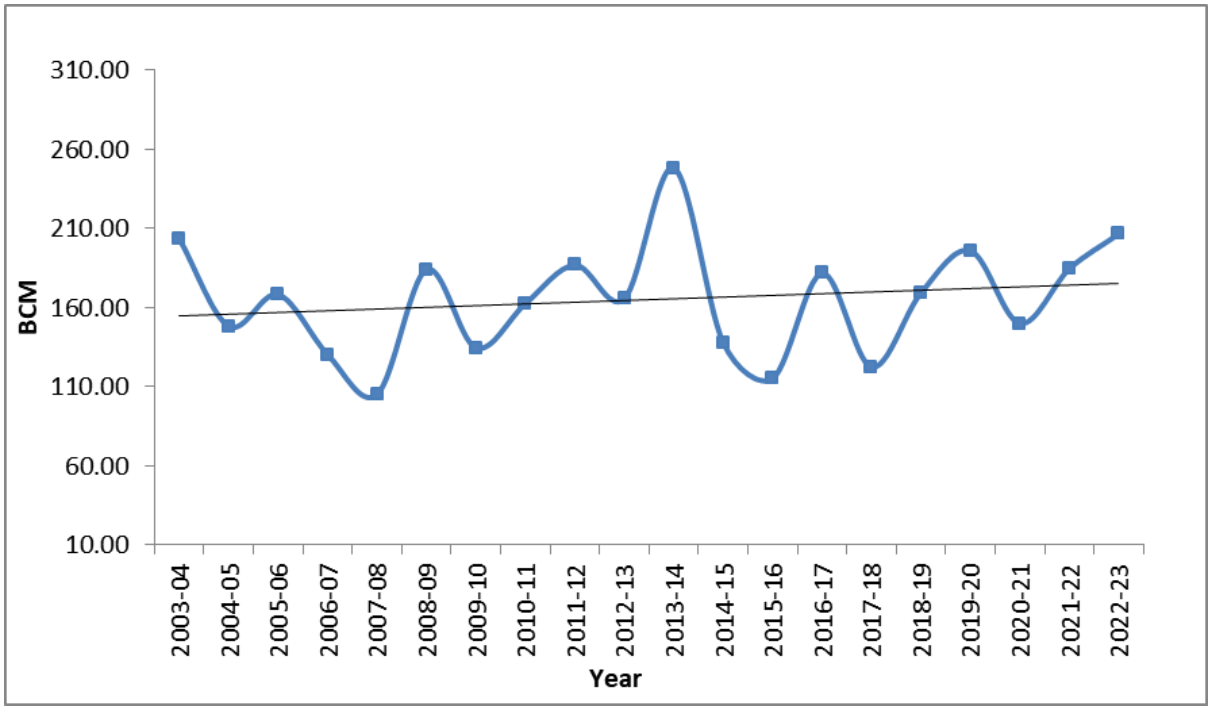


Figure 18.3: Annual Precipitation in Yamuna sub-basin

18.3.2 Actual Evapotranspiration

The annual Evapotranspiration during study period of 20 years (2003-04 to 2022-23) varies from 113.38 BCM (560 mm) to 159.54 BCM (788). The average ET of 20 years is 135 BCM (667 mm).

18.3.3 Reservoir Evaporation

The reservoirs having area greater than 100 hectare has been used for the estimation of reservoir evaporation. The average evaporation from the reservoirs in the sub-basin is 1.20 BCM.

18.3.4 Evapotranspiration from Irrigation Input

The Average Annual Evapotranspiration from Irrigation Input (ET_{II}) for the sub-basin for the years 2003-04 to 2022-23 has been estimated as 46.566 BCM.

18.3.5 Groundwater flux, Reservoir flux and Domestic, Industrial and Livestock consumptive use

The average annual Groundwater flux (GW flux) and Reservoir flux for the sub-basin for 2003-04 to 2022-23 is -1.61 BCM and 0.06 BCM respectively. Domestic, Industrial and Livestock consumptive use for 2022-23 has been estimated as 3.16 BCM.

18.4 Annual Water Availability of Yamuna Sub-basin

Using the Geospatial Datasets, Hydro-Meteorological and other inputs, the average annual water availability from year 2003-04 to 2022-23 is estimated as 72.82 BCM. The annual variations from year 2003-04 to 2022-23 are shown in Figure 18.4. The results of Yamuna sub-basin are shown in Table 18.2.

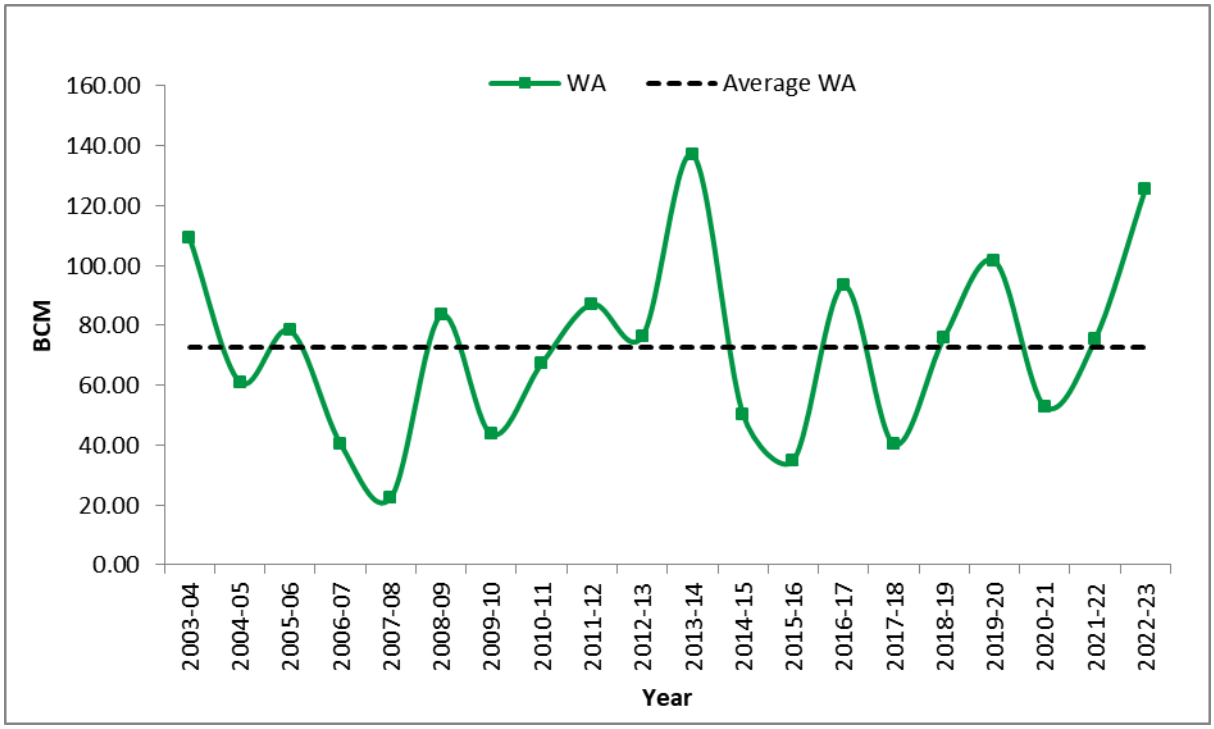


Figure 11.6: Water Availability of Yamuna sub-basin

Table 18.2: Water Availability of Yamuna sub-basin

(All values in BCM)

Year	Precipitation	Evapotranspiration (Natural)	Water Availability
2003-04	203.55	89.41	109.14
2004-05	148.29	82.23	61.07
2005-06	168.17	84.88	78.29
2006-07	130.31	84.82	40.49
2007-08	105.16	77.66	22.50
2008-09	184.06	95.68	83.38
2009-10	134.60	85.97	43.64
2010-11	162.56	90.27	67.29
2011-12	186.85	94.78	87.07
2012-13	165.68	84.32	76.36
2013-14	248.17	106.16	137.02
2014-15	137.74	82.40	50.34
2015-16	115.28	75.43	34.85
2016-17	181.71	83.42	93.29
2017-18	122.39	77.04	40.35
2018-19	169.35	88.35	76.00
2019-20	195.90	89.40	101.50
2020-21	149.98	92.07	52.91
2021-22	184.55	104.20	75.35
2022-23	206.56	75.91	125.65
Average	**165.04**	**87.22**	**72.82**

Central Water Commission
September 2024