REASSESSMENT OF WATER AVAILABILITY IN INDIA USING SPACE INPUTS

(VOLUME – II)

BASIN PLANNING & MANAGEMENT ORGANISATION

CENTRAL WATER COMMISSION

NEW DELHI - 110 066

OCTOBER - 2017

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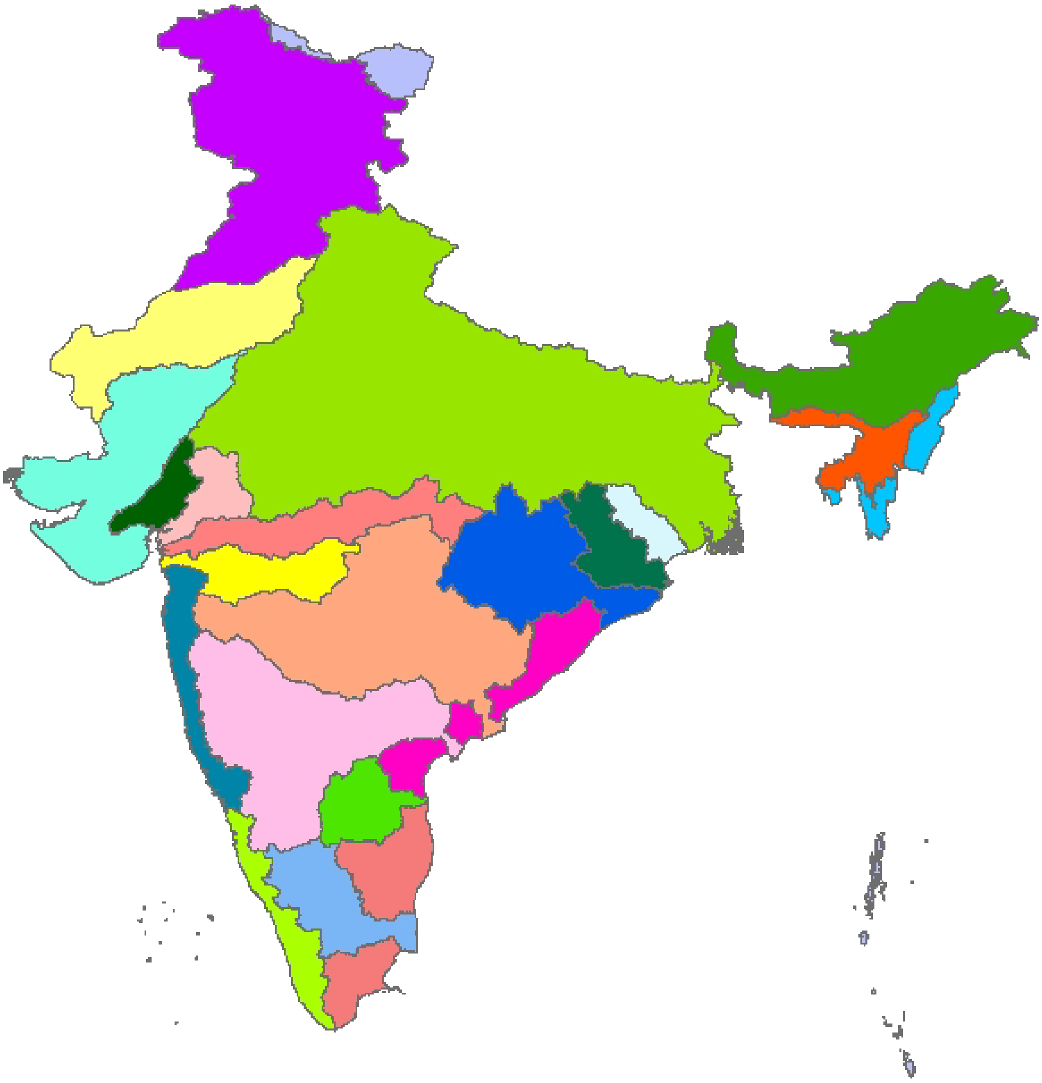

BASIN PLANNING & MANAGEMENT ORGANISATION

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Project Report Number	No: CWC/BPMO/BP/WRA /October, 2017/Vol-II

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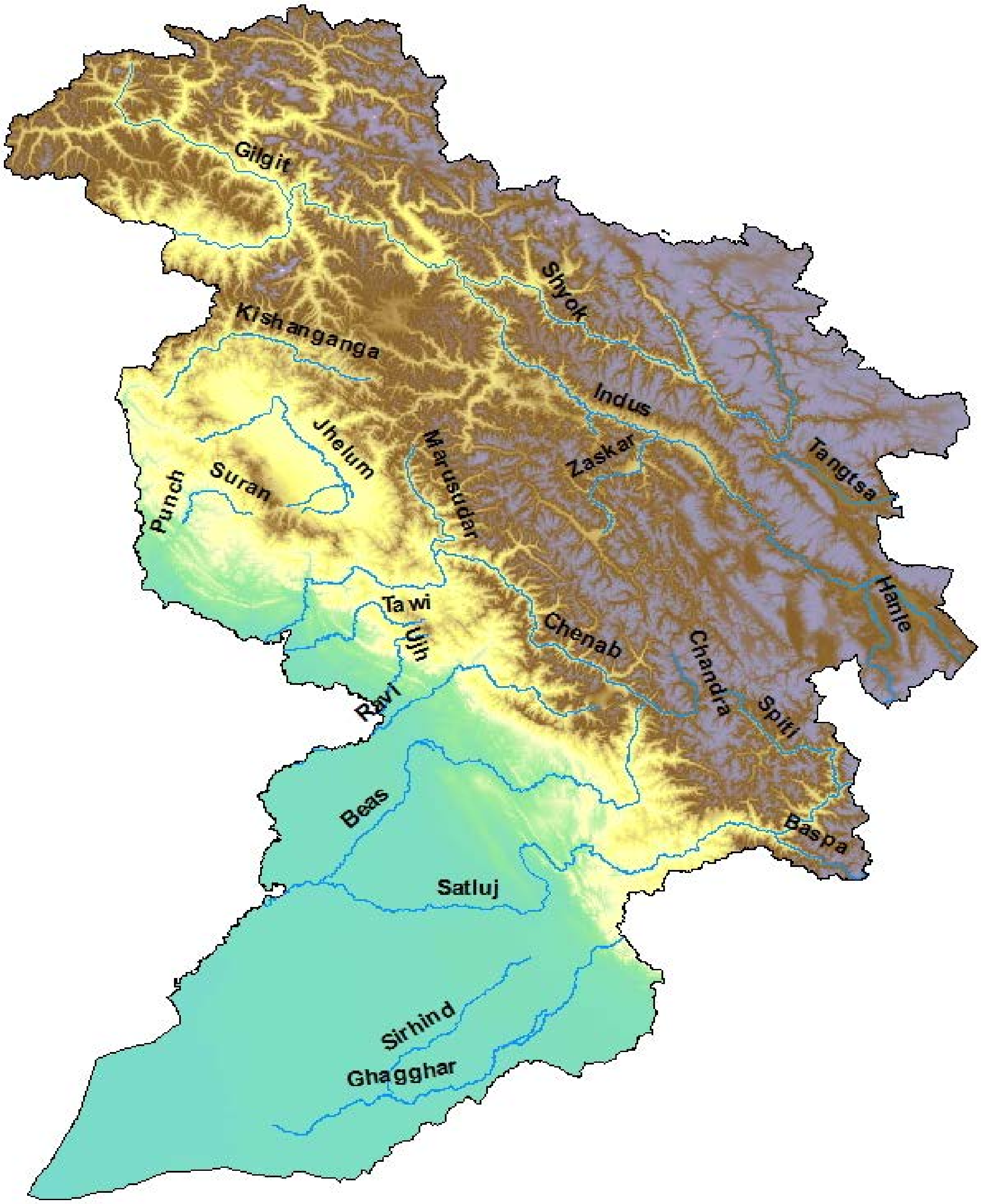
INDUS BASIN


Gilgit
Shyok
Kishanganga
Indus
Jhelum
Marusudar
Zaskar
Tangtsa
Punch
Suran
Hanle
Tawi
Ujh
Chenab
Chandra
Ravi
Spiti
Beas
Baspa
Satluj
Sirhind
Ghagghar

11.1 Geo-Spatial Datasets

11.1.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map and its distribution (in percentage) for Indus basin for year 2004-05 is shown in Figure 11.1 and Figure 11.2 respectively. As shown in Figure 11.2 major LULC classess in the basin are wasteland (34.02%), grassland (17.96%), plantation/orchard (11.14%), snow covered (8.24 %) and evergreen forest (6.61%).

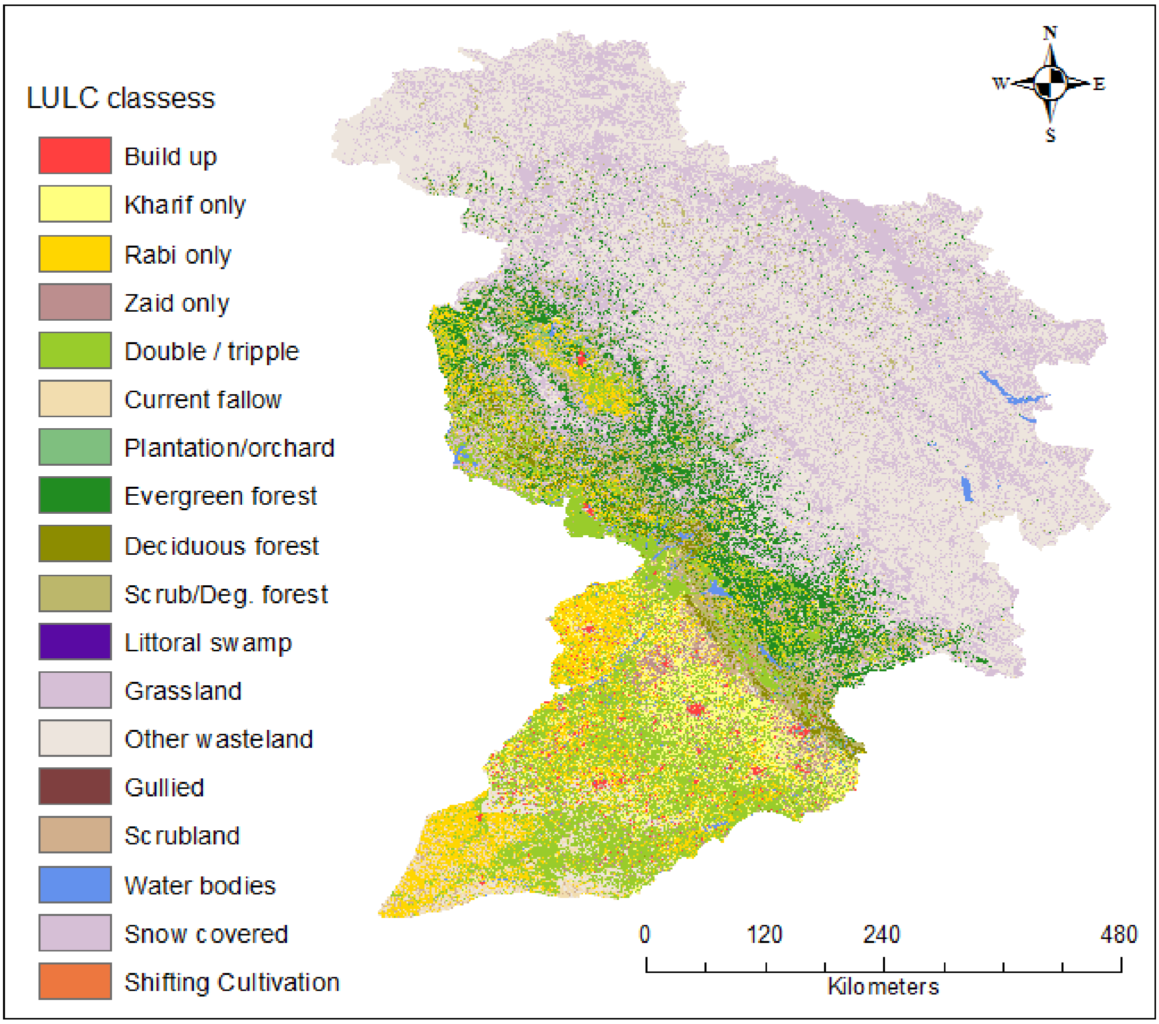


Figure 11.1 LULC map of Indus basin (2004-05)

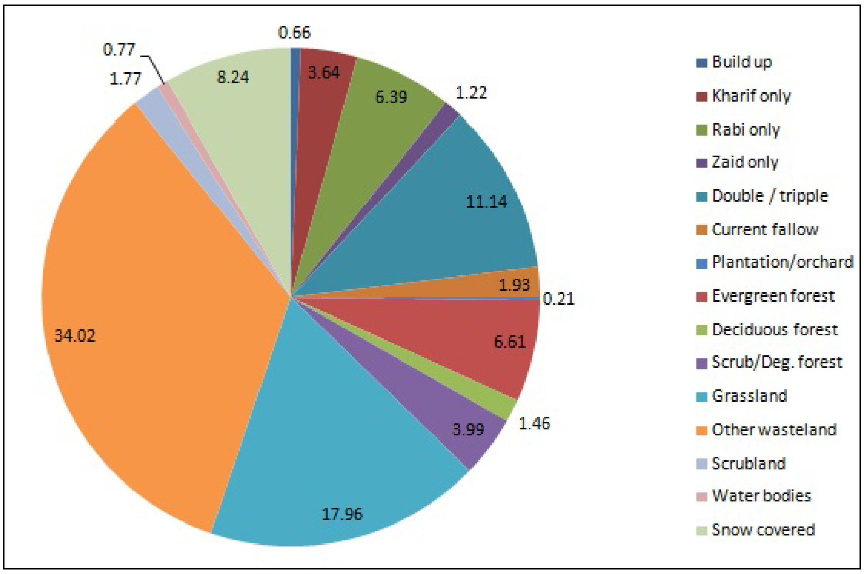


Figure 11.2 Distribution of LULC in Indus basin (2004-05)

11.1.2 Soil texture

Sandy, loamy, clayey, rock outcrops, glaciers and rock outcrops are the soil texture classes in the basin (Figure 11.3). Predominant soil texture classes in the study area are loamy and rock outcrops based on the soil texture information.

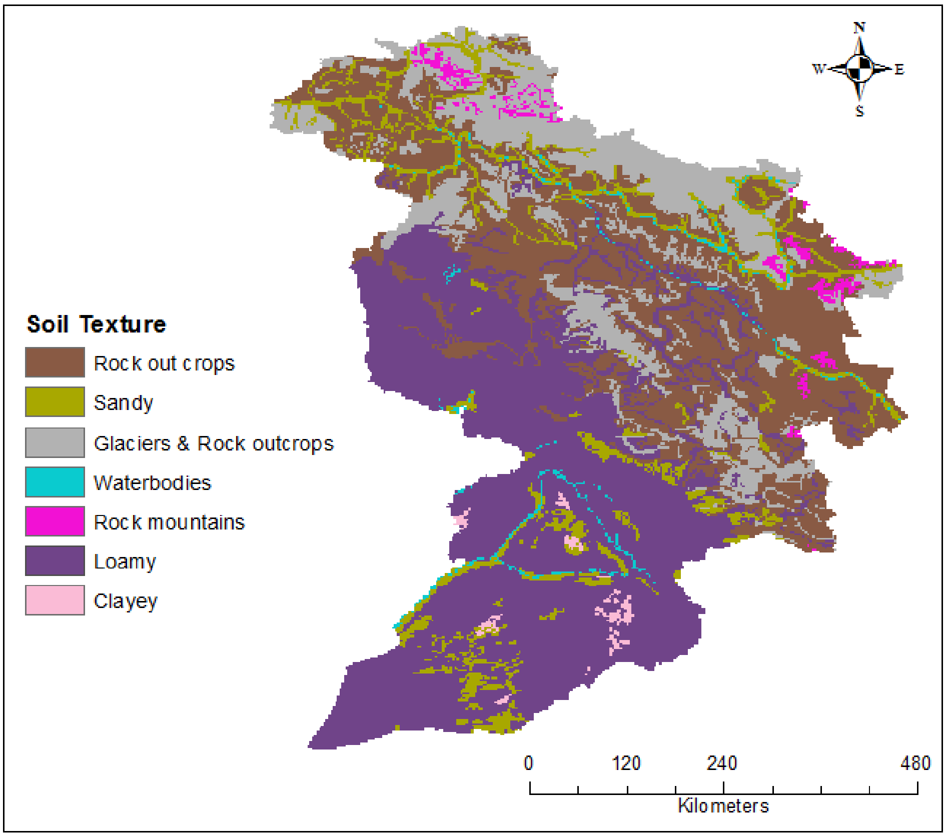


Figure 11.3 Soil texture map of Indus basin

11.1.3 Topography

In India, the Indus basin lies in the states of Jammu and Kashmir, Himachal Pradesh, Punjab, Rajasthan, Haryana and the Union Territory of Chandigarh. The upper part of the basin lies in Jammu and Kashmir and Himachal Pradesh. The basin is dominated by mountain ranges and narrow valleys. In Punjab, Haryana and Rajasthan, the basin consists of vast plains which are fertile granary of the country. There are six major rivers in the basin namely Indus, Jhelum, Chenab, Ravi, Beas and Sutlej. Indus, Jhelum and Chenab are west flowing rivers whereas Ravi, Beas and Sutlej are east flowing rivers.

From Digital Elevation Model (DEM), it is found that the elevation ranges from 96 m to 7,770 m. Basin is very rugged in the north, north-eastern part and flat towards the downstream side on the south west part. The mean elevation is 2,944 m in the basin. Figure 11.4 shows Shuttle Radar Topographic Mission (SRTM) DEM map of the Indus basin.

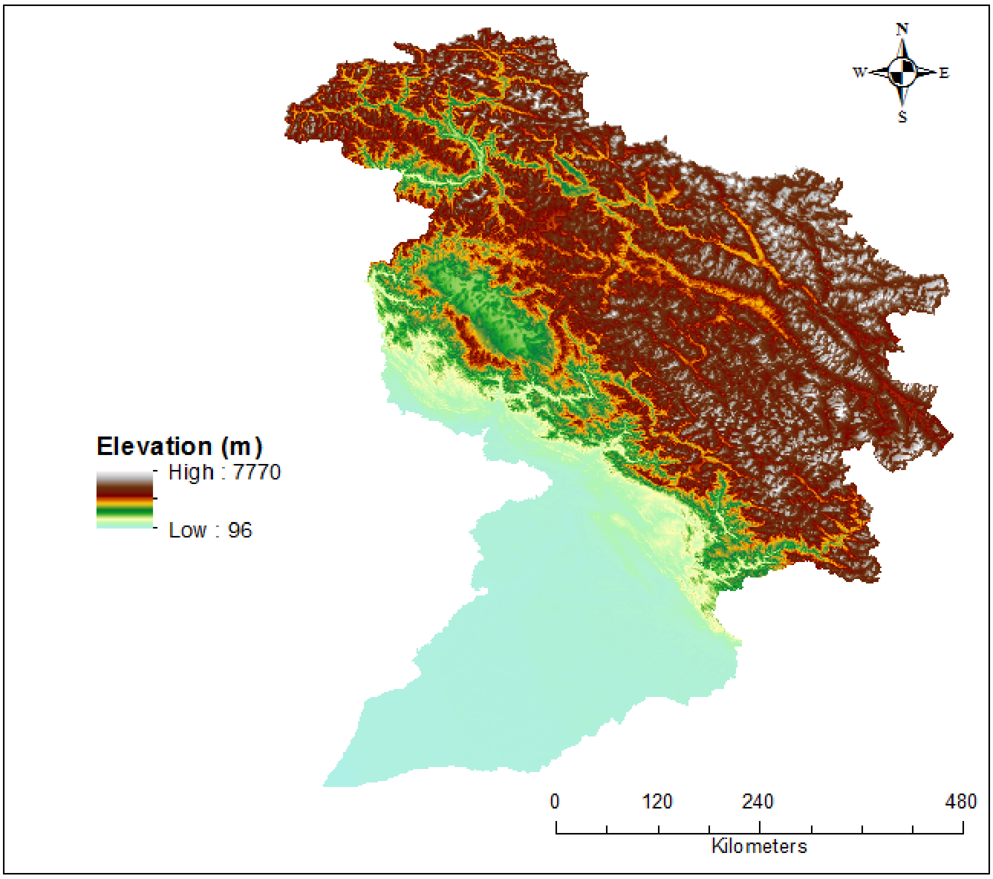


Figure 11.4 SRTM DEM map of Indus basin

11.2 Hydro-Meteorological and other Input Data

11.2.1 Rainfall grids

Figure 11.5 shows gridded rainfall map of Indus basin for year 2004-05. The annual variations in the rainfall during study period of 30 years (1985-86 to 2014-15) are shown in the Figure 11.6. Annual rainfall of the basin varies from maximum of 1,315.6 mm in 1995-96 to minimum of 512.6 mm in 2000-01. Mean rainfall of these 30 years is 896 mm. Rainfall analysis at sub-basin level during the study period reveals that minimum annual rainfall of around 619 mm is observed in Chetak sub-basin while maximum annual rainfall of 1,279 mm is observed in Akhnoor sub-basin. Of the 30 years, for 16 years annual rainfall is higher than the mean rainfall and for remaining 14 years it is lower than the mean rainfall.

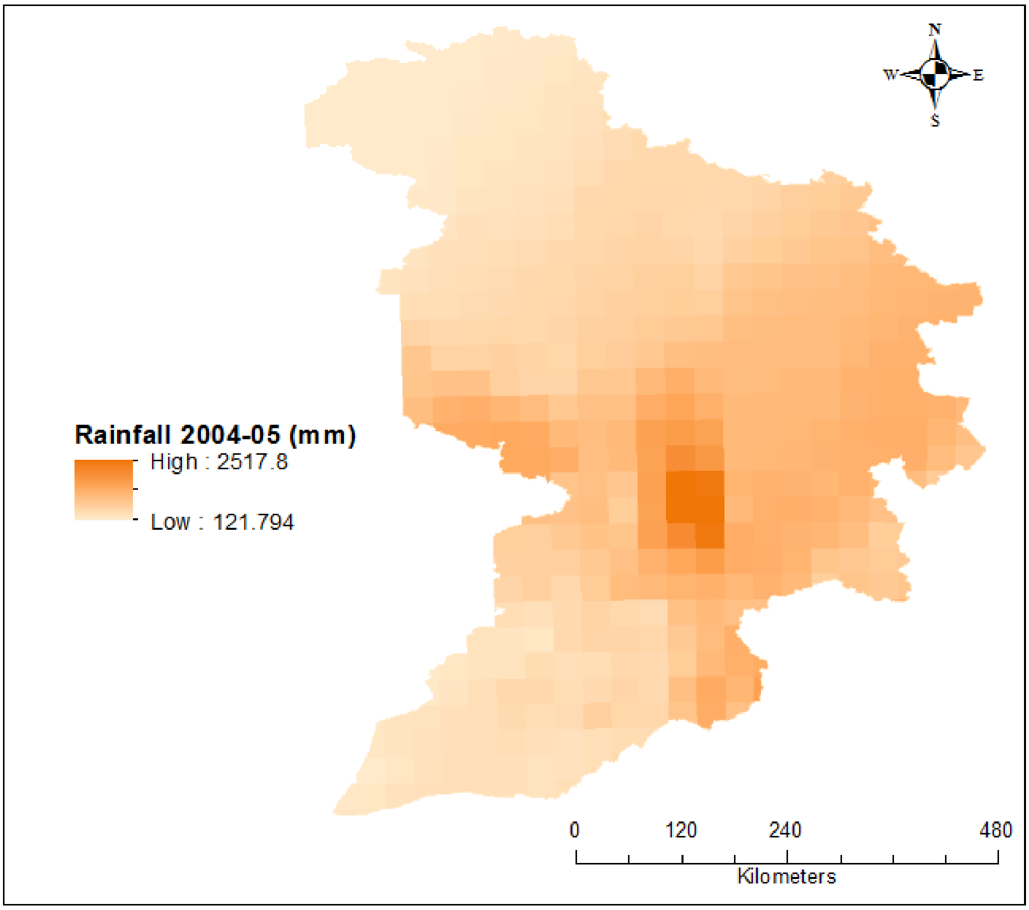


Figure 11.5 Gridded rainfall of Indus basin (2004-05)

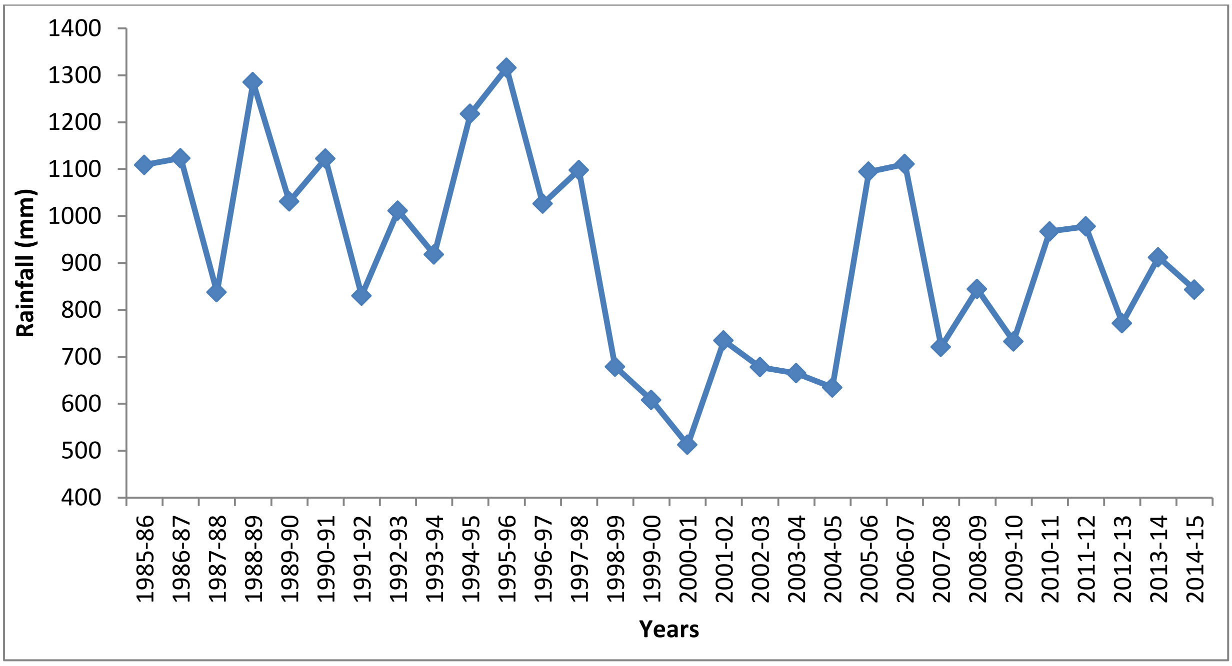


Figure 11.6 Annual rainfall in Indus basin (1985-86 to 2014-15)

11.2.2 Temperature grids

Figure 11.7 shows gridded mean annual temperature of Indus basin in 2004-05.

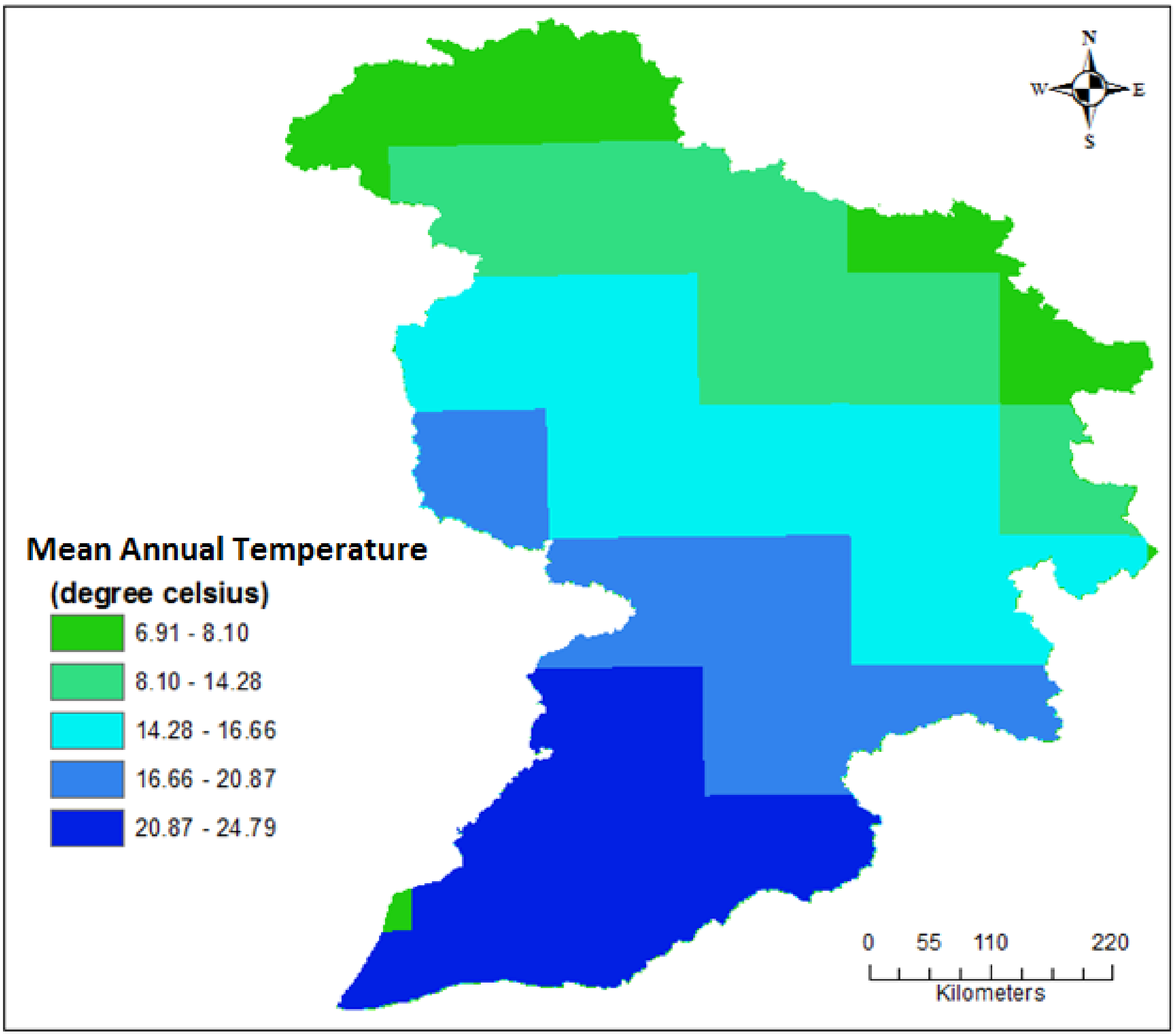


Figure 11.7 Gridded mean annual temperature of Indus basin (2004-05)

11.2.3 Sub-basins of Indus basin

Four outlet points are considered for delineating the sub-basins of Indus basin: i) Nimoo (on river Indus), ii) Akhnoor (on river Chenab), iii) Harike (downstream of Harike barrage after the confluence of river Beas and Sutlej), and iv) Chetak (on river Ghaggar). The remaining area is named as Rest of Indus (ROI) sub-basin. The sub-basins are shown in Figure 11.8, while Table 11.1 gives details of each sub-basin.

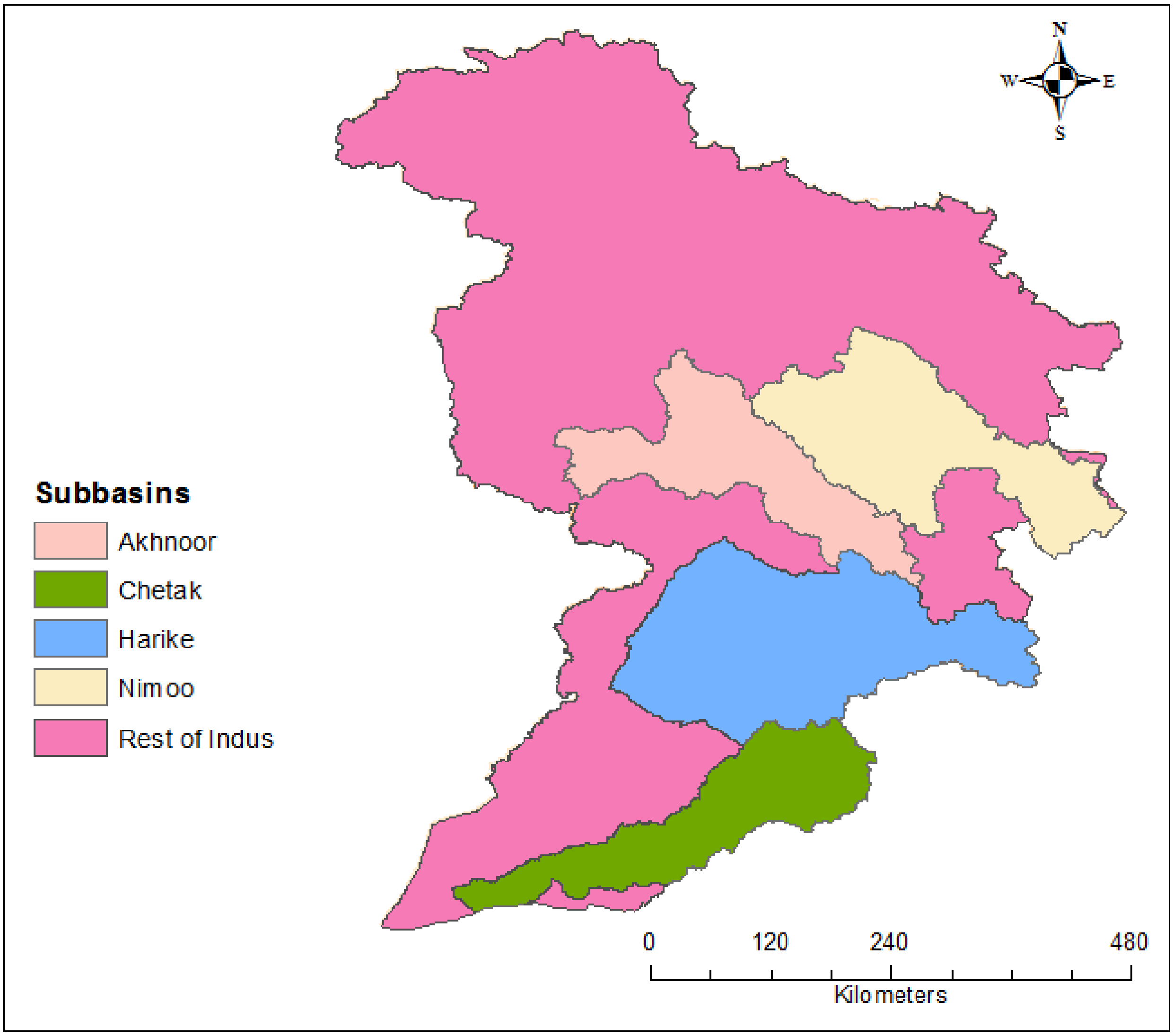


Figure 11.8 Sub-basins of Indus basin

Table - 11.1 Sub-basin wise details of Indus basin

S.No.	Sub-basin	River	Individual drainage area (sq.km)
1	Nimoo	Indus	22683
2	Akhnoor	Chenab	22788
3	Harike	Satluj	40363
4	Chetak	Ghaggar	21786
5	ROI	Indus, Jhelum	167107
		Area of North Ladakh not draining into India	42981
		Total basin area	317708

11.2.4 River discharge

The river discharge data was available at two G&D sites (Akhnoor located on river Chenab and Harike after confluence of river Sutlej and river Beas) for the study period of 30 years. The daily discharge data is aggregated to annual scale and has been used for calibration and validation of model computed runoff at sub-basin level.

11.2.5 Reservoir flux

There are three major reservoirs in the Indus basin namely Gobind Sagar/Bhakra reservoir on the river Sutlej, Thein/Ranjit Sagar reservoir on the river Ravi and Maharana Pratap Sagar/Pong reservoir on the river Beas. Location of the dams in the basin is shown in the Figure 11.9. Bhakra and Pong Reservoirs fall in Harike sub-basin and Thein reservoir falls in Rest of Indus sub-basin.

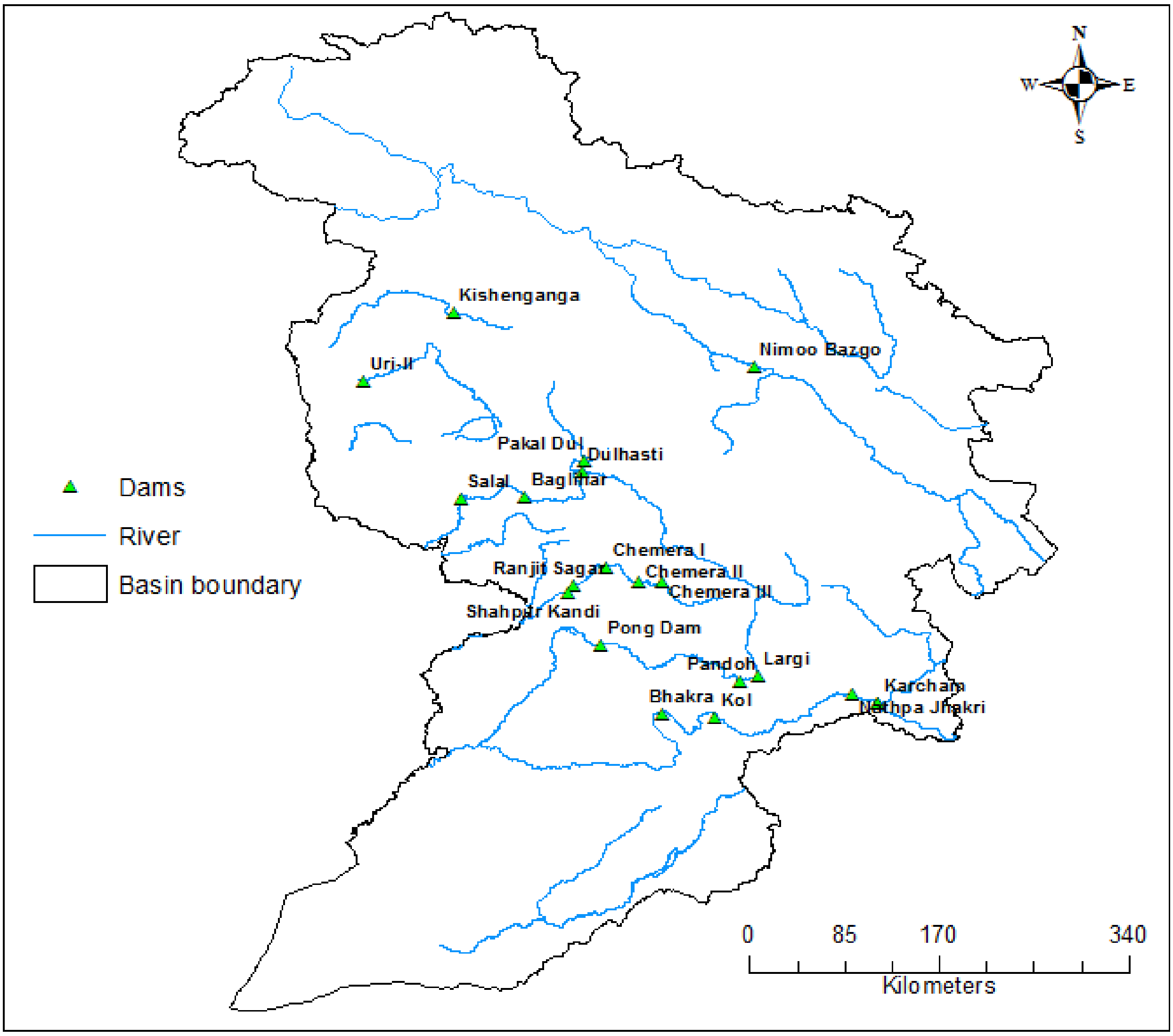


Figure 11.9 Major reservoirs in Indus basin

11.2.6 Groundwater flux

Spatial variation of annual groundwater flux for year 2004-05 is shown in Figure 11.10. The annual groundwater flux in the basin varies from 719.2 MCM to - 618.9 MCM during year 1984-85 to 2014-15 as shown Figure 11.11. The mean annual groundwater flux from 1984-85 to 2014-15 of Indus basin is estimated as -0.0621 BCM.

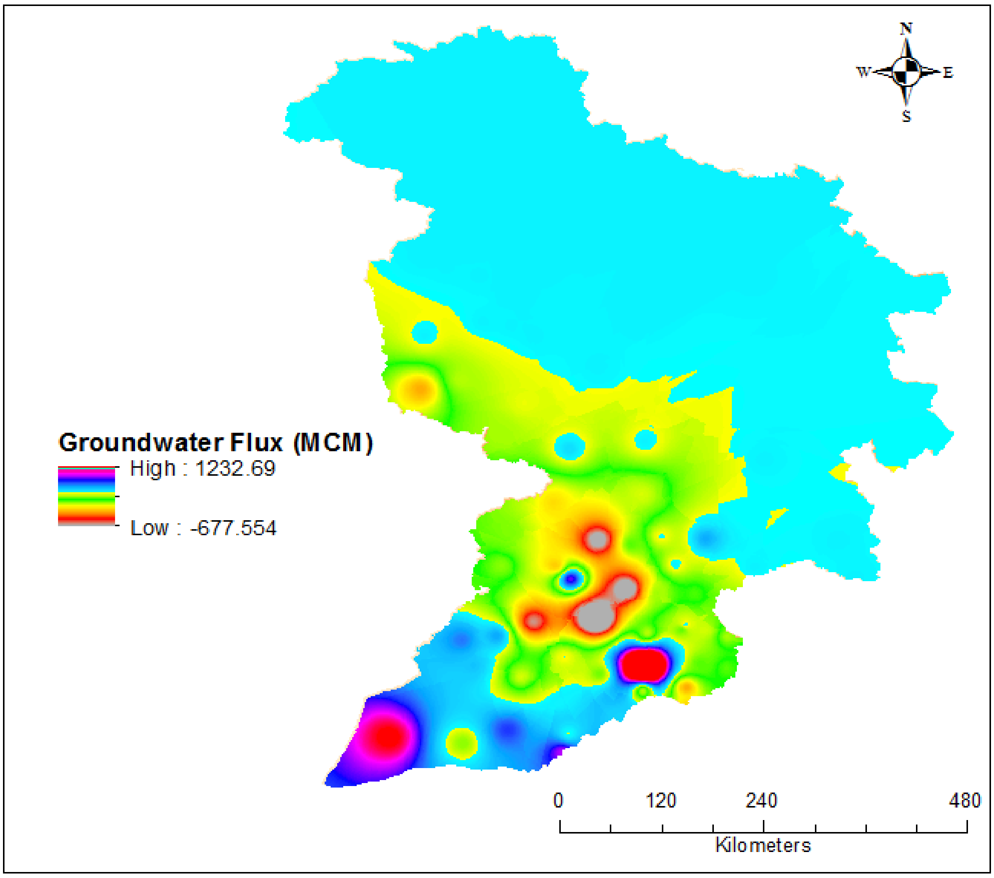


Figure 11.10 Groundwater flux (spatial data) estimated during 2004-05

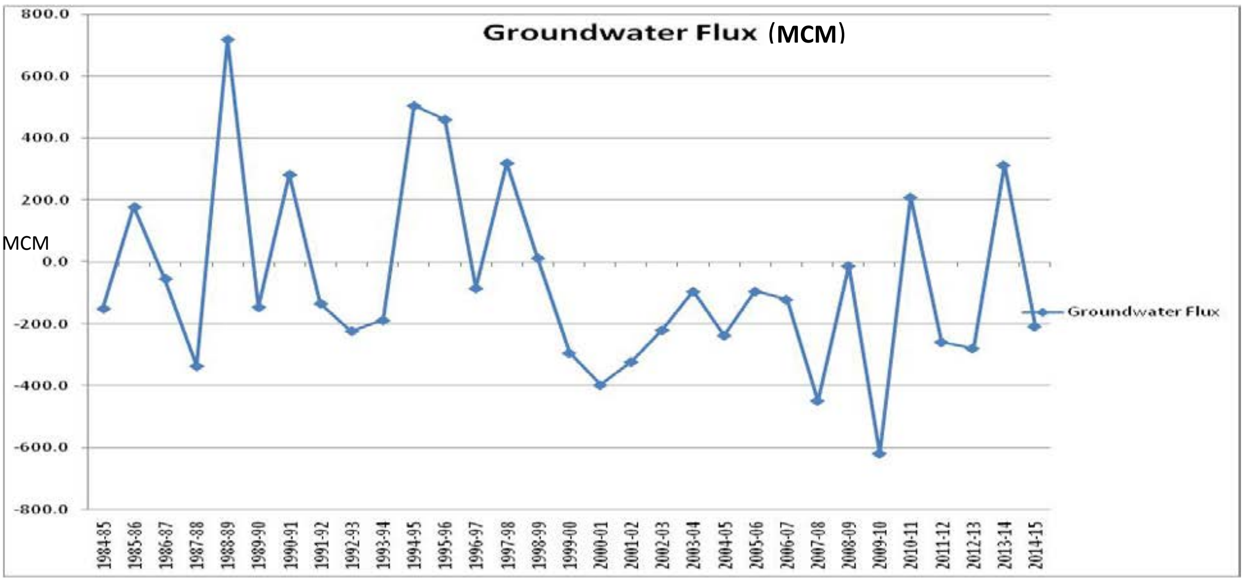


Figure 11.11 Annual groundwater flux of Indus basin (1984-85 to 2014-15)

11.2.7 Major crops in the basin

Based on the district-wise crop area statistics, district wise major crops for each crop season have been identified. Predominant crops in each sub-basin during each cropping season (Kharif, Rabi, Double/Triple) have been identified from the historic district-wise crop statistics collected from various sources (http://lus.dacnet.nic.in/dt_lus.aspx).

11.2.8 Irrigation command area

The command area covers approximately 21.31% of the total basin area. Canal networks and command area map in the basin are shown in Figures 11.12 and 11.13 respectively.

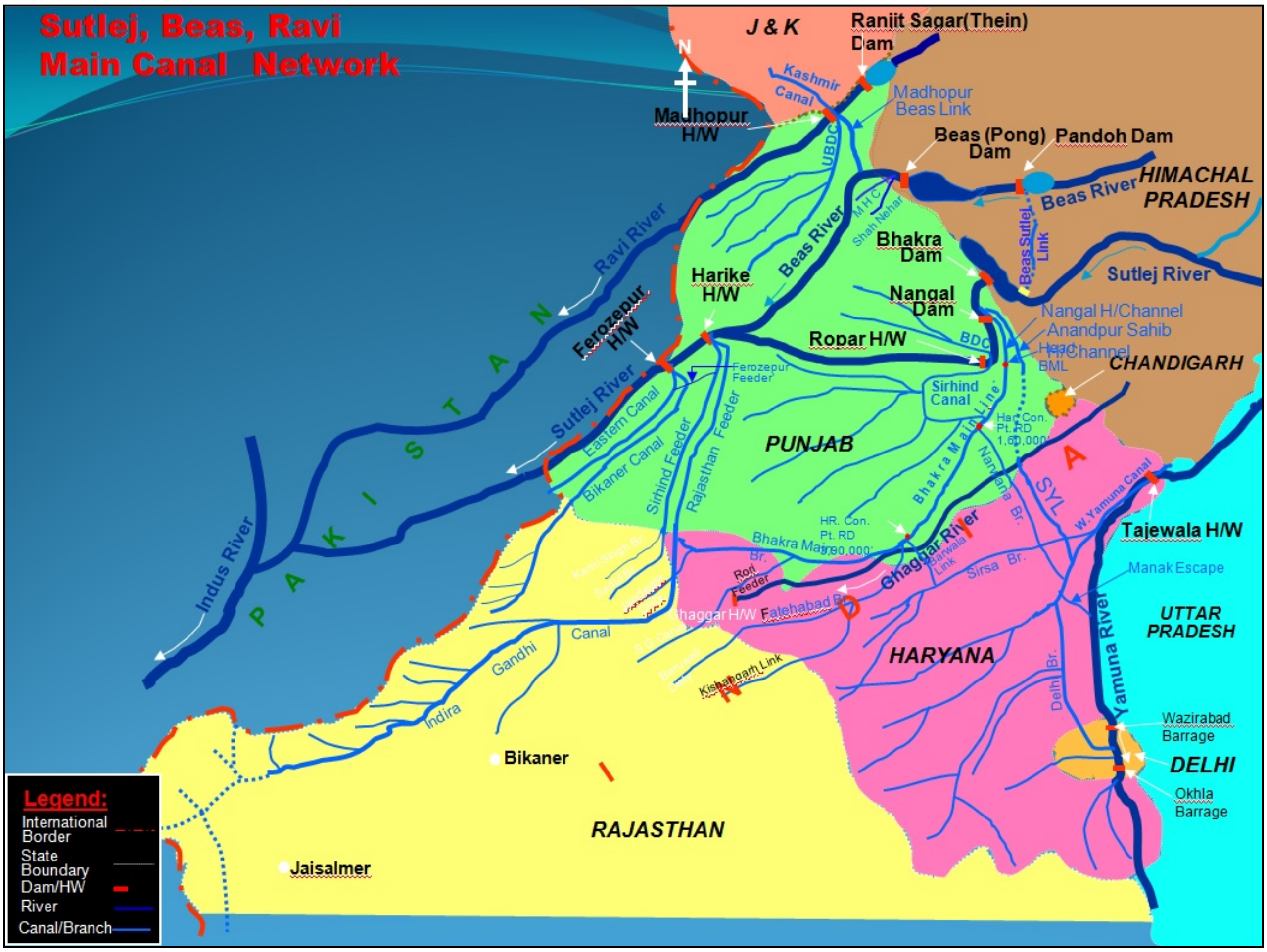


Figure 11.12 Canal networks of eastern rivers of Indus basin

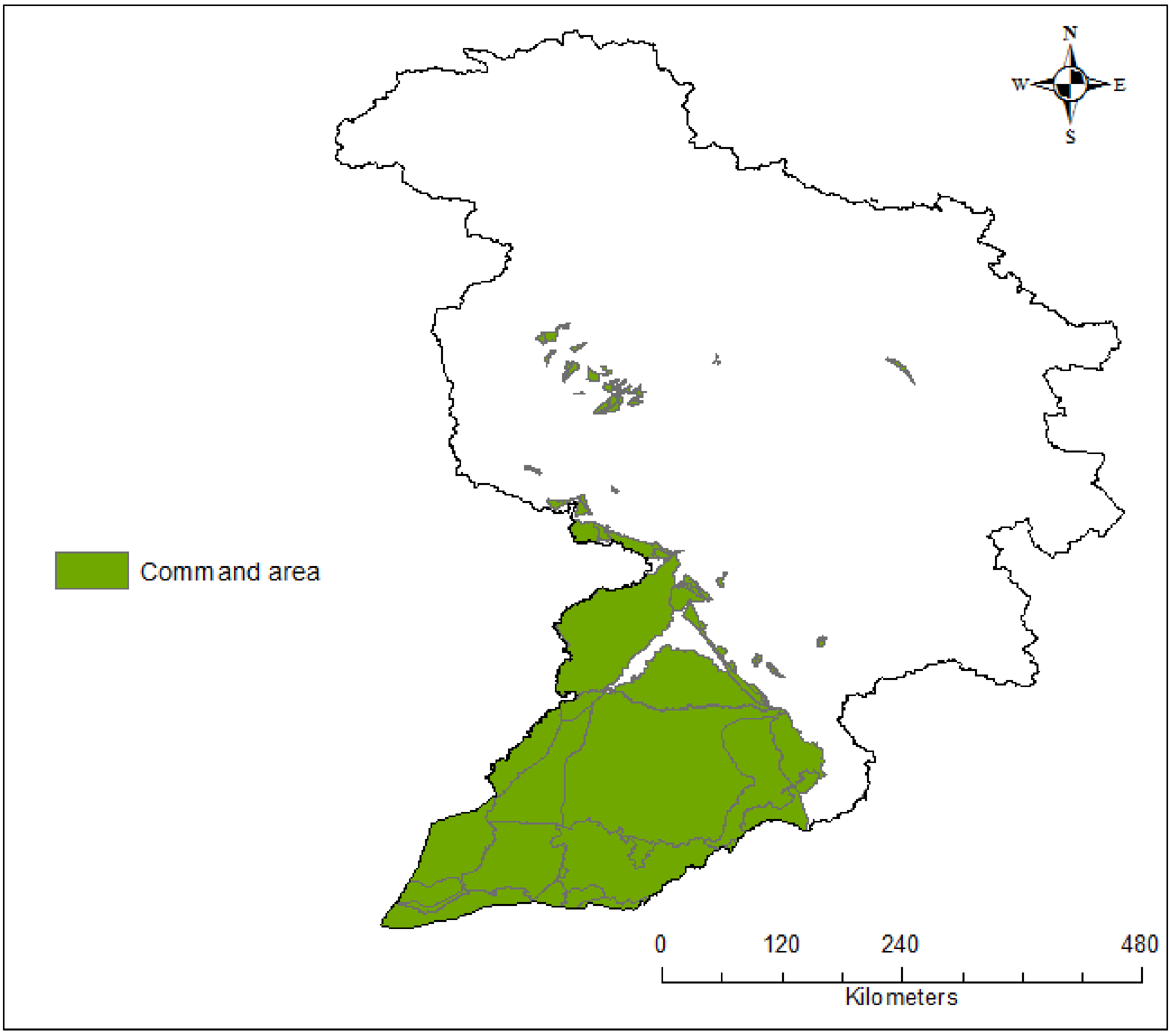


Figure 11.13 Irrigation command boundaries of Indus basin

11.2.9 Domestic, industrial and livestock demand

The mean annual domestic, industrial and livestock demand is estimated as 0.376 BCM in Indus basin. District boundaries in the basin are shown in Figure 11.14.

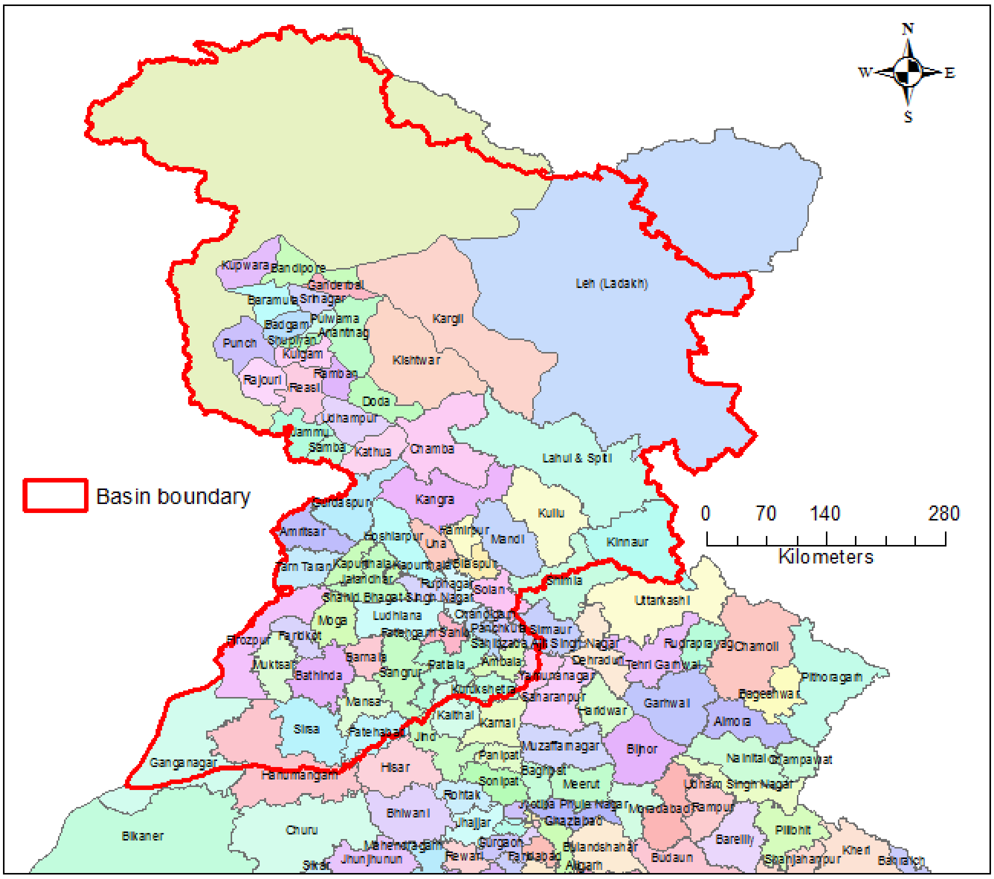


Figure 11.14 District boundaries in Indus basin

11.2.10 Evaporation from major/medium/ minor reservoirs and other water bodies

Table - 11.2 gives annual evaporation values from two sub-basins namely Harike and Rest of Indus (ROI), since only these two sub-basins have reservoirs.

Table - 11.2 Evaporation in reservoirs of Indus basin

Reservoir Evaporation in sub-basin (in BCM)								
Years	**Harike**	**ROI**	**Years**	**Harike**	**ROI**	**Years**	**Harike**	**ROI**
1985-86	0.63	0.94	**1995-96**	0.45	0.84	**2005-06**	0.63	0.82
1986-87	0.65	0.99	**1996-97**	0.64	0.98	**2006-07**	0.53	0.82
1987-88	0.37	0.49	**1997-98**	0.63	0.81	**2007-08**	0.41	0.59
1988-89	0.58	0.98	**1998-99**	0.50	0.47	**2008-09**	0.45	0.64
1989-90	0.51	0.83	**1999-00**	0.43	0.49	**2009-10**	0.36	0.63
1990-91	0.58	0.94	**2000-01**	0.43	0.57	**2010-11**	0.52	0.57
1991-92	0.41	0.57	**2001-02**	0.39	0.58	**2011-12**	0.69	0.80
1992-93	0.54	0.84	**2002-03**	0.34	0.63	**2012-13**	0.53	0.68
1993-94	0.38	0.59	**2003-04**	0.40	0.61	**2013-14**	0.70	0.69
1994-95	0.47	0.76	**2004-05**	0.39	0.58	**2014-15**	0.70	0.70
Average (1985-2015) = 1.22 BCM								

11.2.11 Snowmelt runoff component

Upper reaches of Indus basin are snow covered and the rainfall is almost negligible. CWC with the help of NRSC developed snowmelt runoff forecasting model for Himalayan rivers, which include Chenab, Beas and Sutlej. The output from the snowmelt runoff model for Beas and Sutlej has been used for the study. In the Harike sub-basin, Sutlej enters near Shipki Laa in Kinnaur district of Himachal Pradesh. After entering into Indian territory, Spiti river joins Sutlej from right bank at Khab. Snowmelt runoff of Tibet region as transboundary addition and Spiti river at Khab are taken as input for Harike sub-basin. Further, due to lack of any alternative site data, the output from CWC-NRSC snowmelt runoff model for Beas river and Lower Sutlej area is directly taken for the study (average of 2002 to 2012 values). This snowmelt runoff value is 2.30 BCM.

11.3 Previous Estimates

Section 4.1 of CWC report on Reassessment of Water Resources Potential of India, 1993, (Basins for which reassessment was considered not necessary) mentions: "Indus is an international river. The water resources potential of the various sub-basins of India upto the Indian border has been estimated by Indus Commission, CWC and Irrigation Commission of 1972. The water resources development in this basin is governed by the provisions of the Indus Water Treaty of 1960 between India and Pakistan. According to this treaty, the water of the Eastern Rivers, namely, Ravi, Beas and the Sutlej shall be available for the unrestricted use by India. Also, India has been permitted to use the waters of the Western Rivers for Domestic non-consumptive purposes, for hydroelectric plants and for specified agricultural purposes and construction of storage works. In view of the above, it is obvious that not much useful purpose will be served by reassessing the water potential of the Indian portion of the whole basin."

However, the water resources potential of Indus basin in 1993 report was kept as 73.3 BCM with remarks "No revision" (Table 2(c), Page 18 of the report).

11.4 Runoff Estimation

The historical discharge data at CWC site Akhnoor (Chenab) and BBMB/Punjab site at Harike have been used for calibration of model for Akhnoor and Harike sub-basins respectively. As there is no historical discharge data available for Chetak, Nimoo and Rest of Indus sub-basin, the calibration of model output has not been carried out for these sub-basins. Tables K.1 to K.5 (at Annexure K) give rainfall, ECII, DIL, GW flux, reservoir evaporation, reservoir flux, snowmelt, calibrated discharge, observed discharge and water availability for all the sub-basins. Figures 11.15 to 11.19 give comparative graphs of rainfall, calibrated runoff and observed discharge.

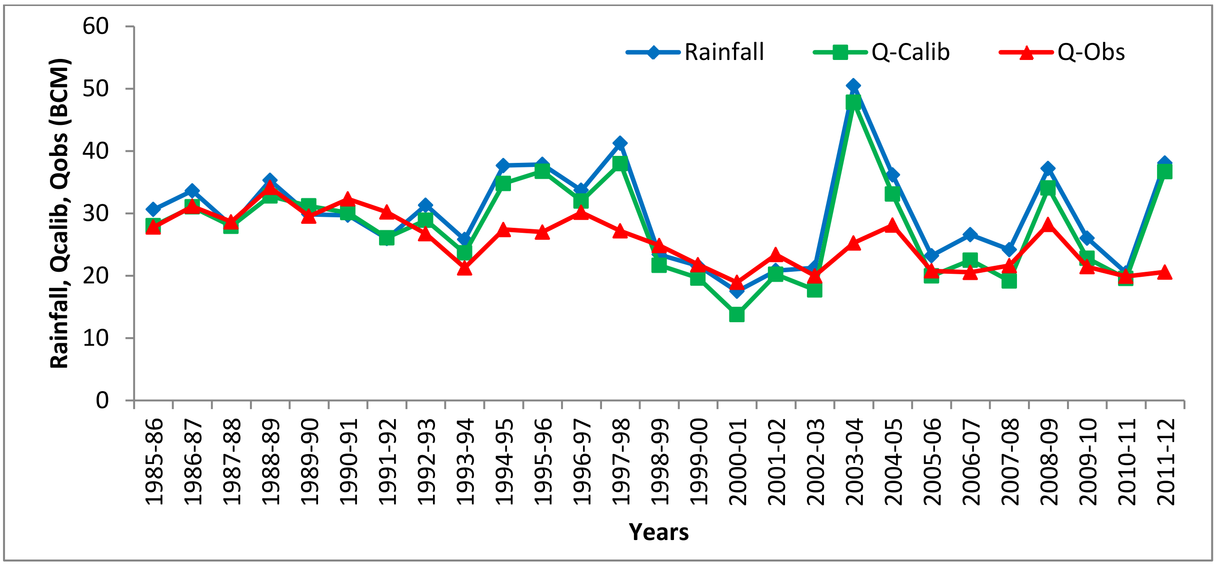


Figure 11.15 Calibrated runoff and observed discharge at Akhnoor

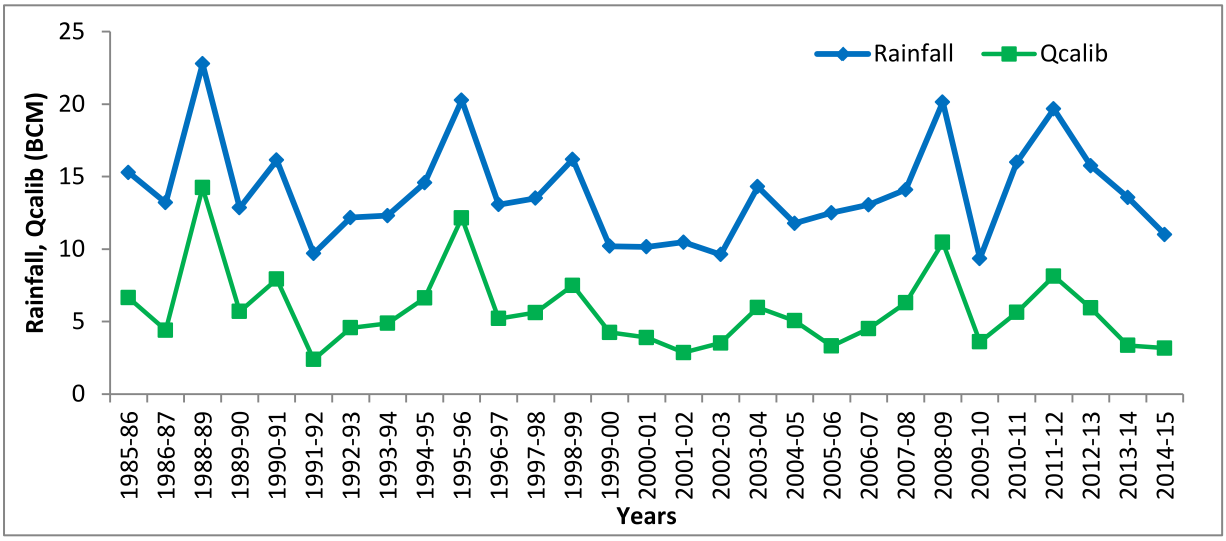


Figure 11.16 Calibrated runoff and rainfall at Chetak

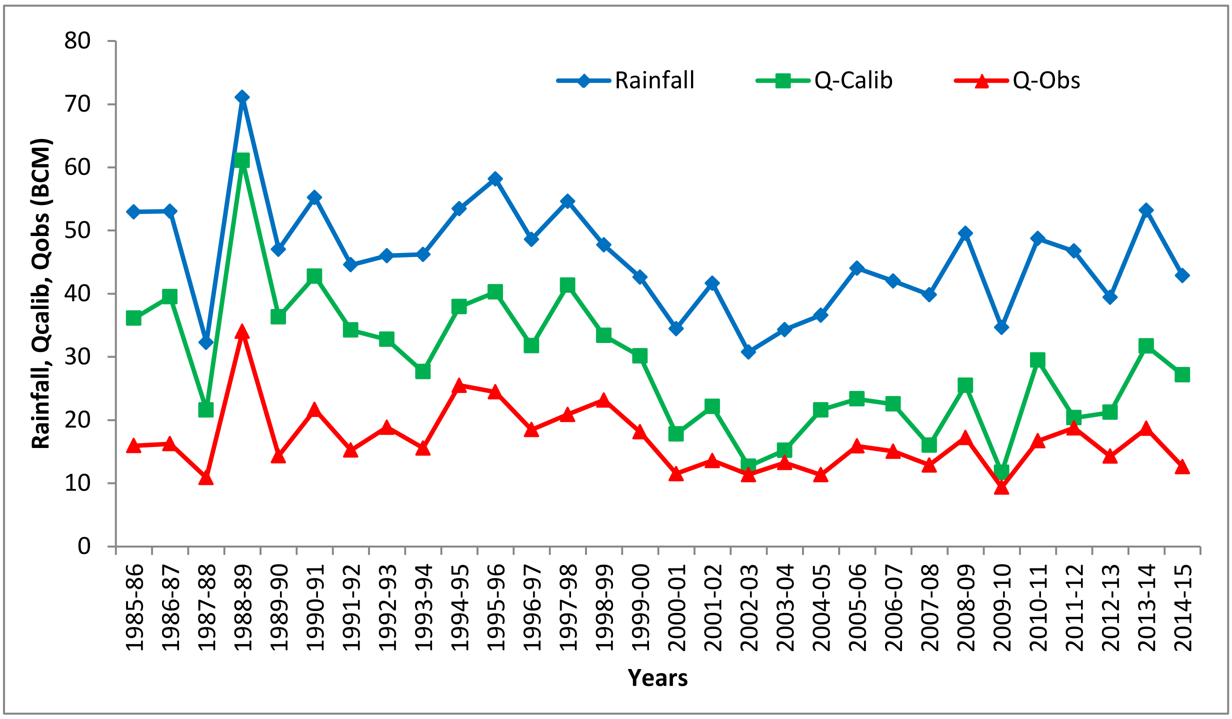


Figure 11.17 Calibrated runoff and observed discharge at Harike

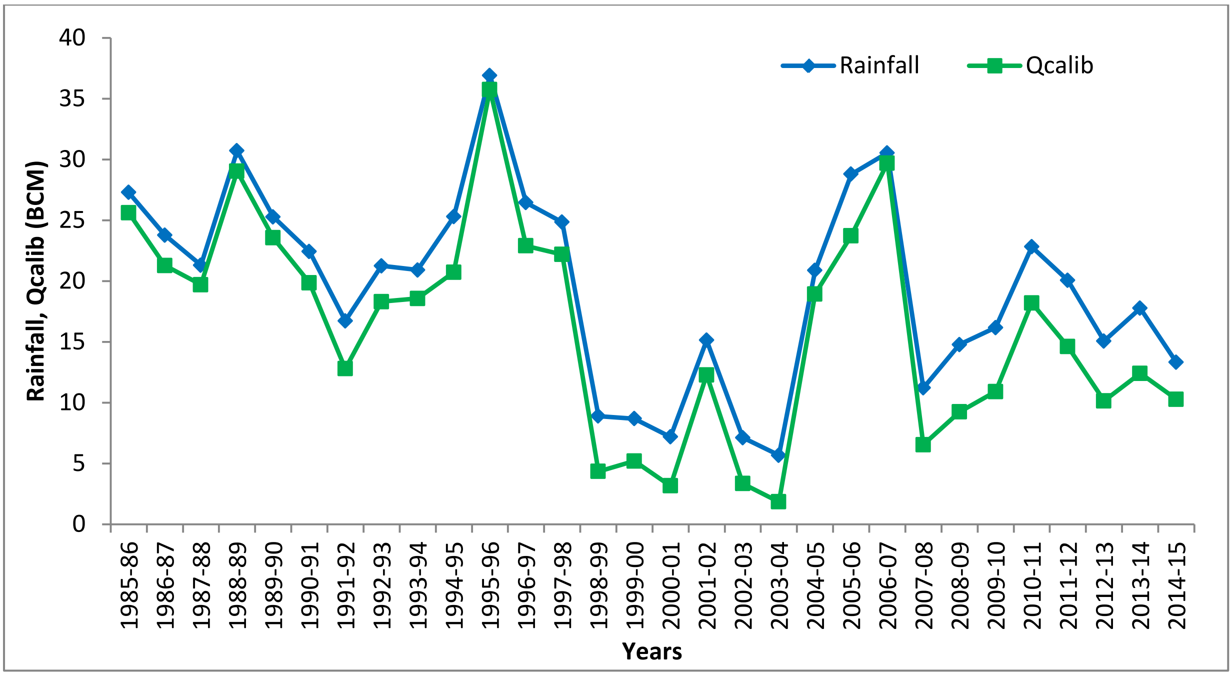


Figure 11.18 Calibrated runoff and rainfall at Nimoo

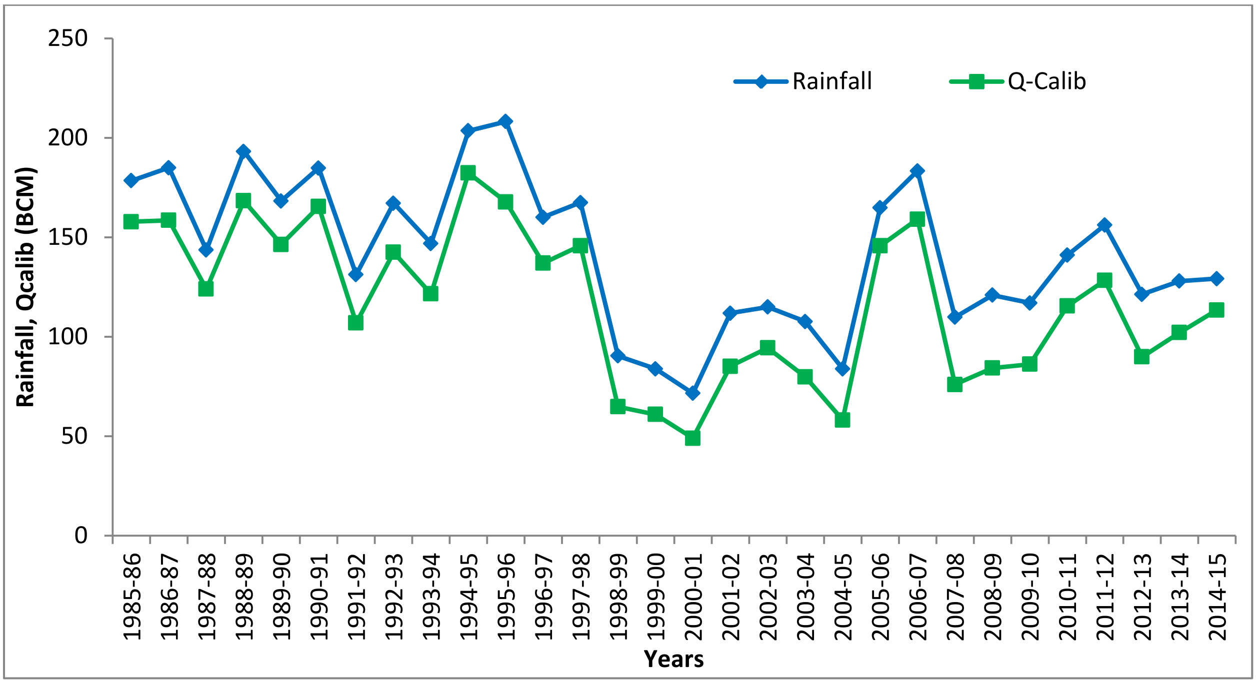


Figure 11.19 Calibrated runoff and rainfall of Rest of Indus

11.5 Annual Water Resources Availability of Indus Basin

As per Indus Water Treaty -1960, India has been given the right to utilize waters of Ravi, Beas and Sutlej, whereas the waters of Indus, Jhelum and Chenab are to be utilized by Pakistan, subject to other provisions of the Treaty.

As said earlier, for reassessment of water availability in Indus basin, the whole basin has been divided into five sub-basins. The outlets of the sub-basins are at Nimoo for river Indus, Akhnoor for river Chenab, Harike for river Beas, Sutlej and Ravi (water being diverted from Madhopur head works), Chetak for non-perennial river Ghaggar and remaining area named as Rest of Indus (ROI).

Based on the data required for calibration of the WRA model and the existing operational water resources projects and canal networks under eastern river system, Harike has been identified as a suitable terminal point for reassessment of water availability of Ravi, Beas and Sutlej rivers. Similarly, Chetak has been found suitable terminal point for river Ghaggar. Accordingly, calibrated runoff has been computed for Harike and Chetak sub-basins, subtracting ECII and all fluxes from the model runoff. Water resources availability in the Harike sub-basin comprises the model runoff, snowmelt runoff, water imported to the basin through Madhopur-Beas Link and Upper Bari Doab Canal (UBDC), transboundary addition of water through river Sutlej at Khap in Kinnaur district and export of water from the sub-basin through Bhakra Main Line (BML).

The mean water resource of the Indus basin has been computed by taking sum of the mean water resource availability of Harike and Chetak sub-basins.

Mean water resource of Indus basin = Water availability of Harike sub-basin + Water availability of Chetak sub-basin = 39.05 + 6.48 BCM = 45.53 BCM

75% dependable yield for Indus basin is estimated as 37.15 BCM.

Water assessment for Chenab river under Akhnoor sub-basin has been carried out separately and the model output and observed discharge at Akhnoor G&D site are shown in Table K.1. Water assessment for Indus river at Nimoo and Rest of Indus sub-basin has been also been carried out, but due to non-availability of historical data, calibration of model could not be done. The results are shown in Tables - K.4 and K.5.

11.5.1 Annual water resources of Indus basin during extreme rainfall conditions

Out of total 30 years of meteorological data of study period, during the years 1995-96 and 2002-03, extreme wet and dry rainfall conditions occurred in Indus basin respectively. The annual water resources of Indus basin during these two extreme rainfall conditions are 65.47 BCM and 28.29 BCM, respectively (sum of water availability of Harike and Chetak sub-basins during extreme rainfall years) as shown in Table - 11.3.

Table - 11.3 Water resources availability in Indus basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water resources availability
Maximum rainfall	1995-96	78.44	65.47
Minimum rainfall	2002-03	40.39	28.29

The water balance components during these years are presented in the Figures 11.20 and 11.21, Water resources availability: rainfall ratios during the maximum and minimum rainfall years of Indus basin (Harike and Chetak sub-basin) are found to be 0.83 and 0.70 respectively. This shows that the higher the rainfall, the higher percentage of runoff. During wet years potential evapotranspiration is less compared to the dry years, this has cumulative effect on runoff.

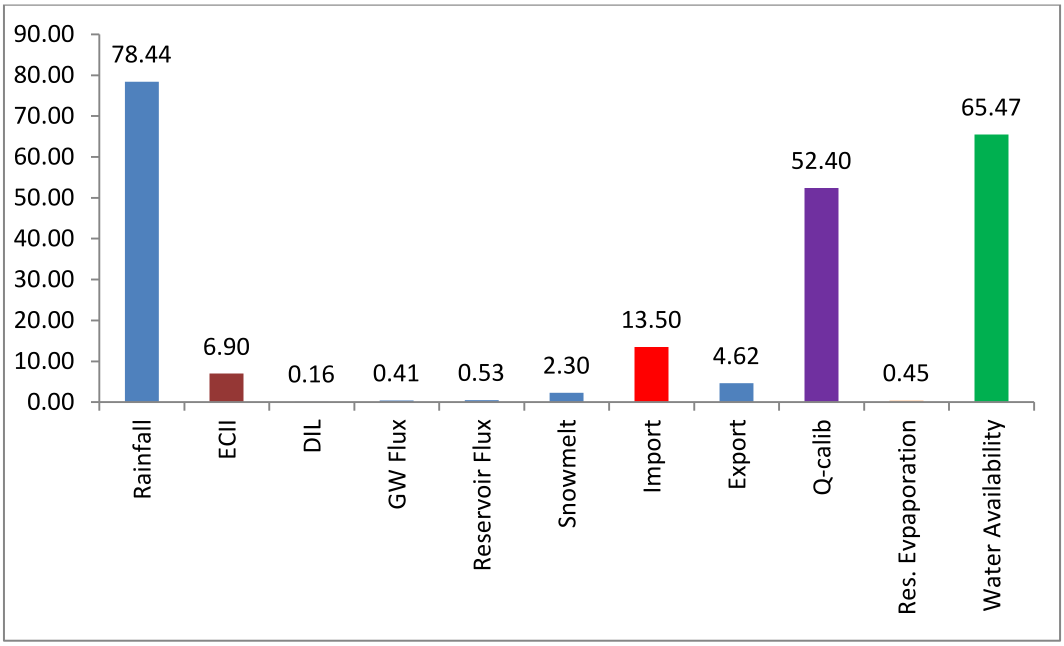


Figure 11.20 Water balance components of Indus basin during extreme high rainfall (1995-96)

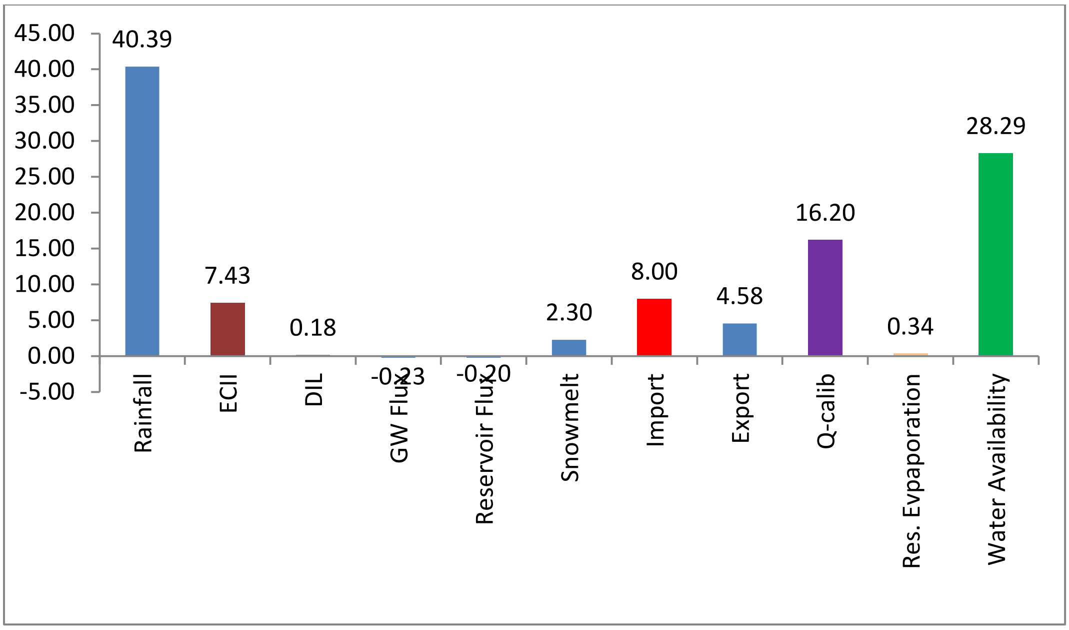


Figure 11.21 Water balance components of Indus basin during extreme low rainfall (2002-03)

11.5.2 Mean water resources of Indus basin

Mean water resources availability of Indus basin is 45.53 BCM and 75 % dependable availability is 37.15 BCM. Figure 11.22 shows various water balance components averaged over the study period (excluding 1987-88 and 1988-89 because of high variation of rainfall during these years).

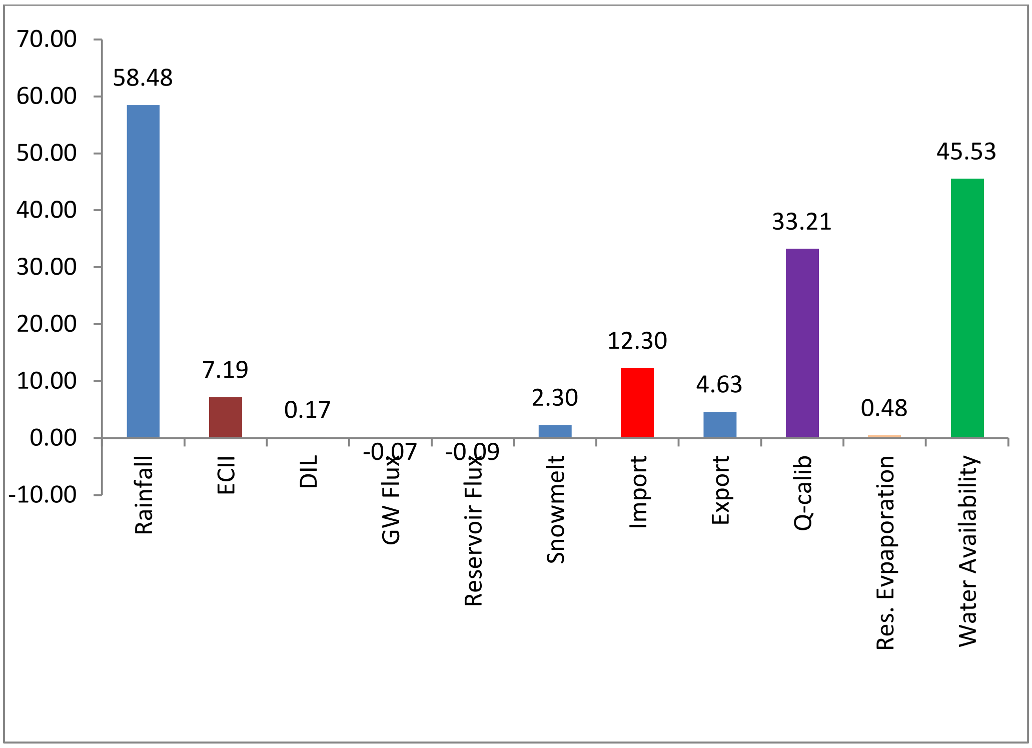
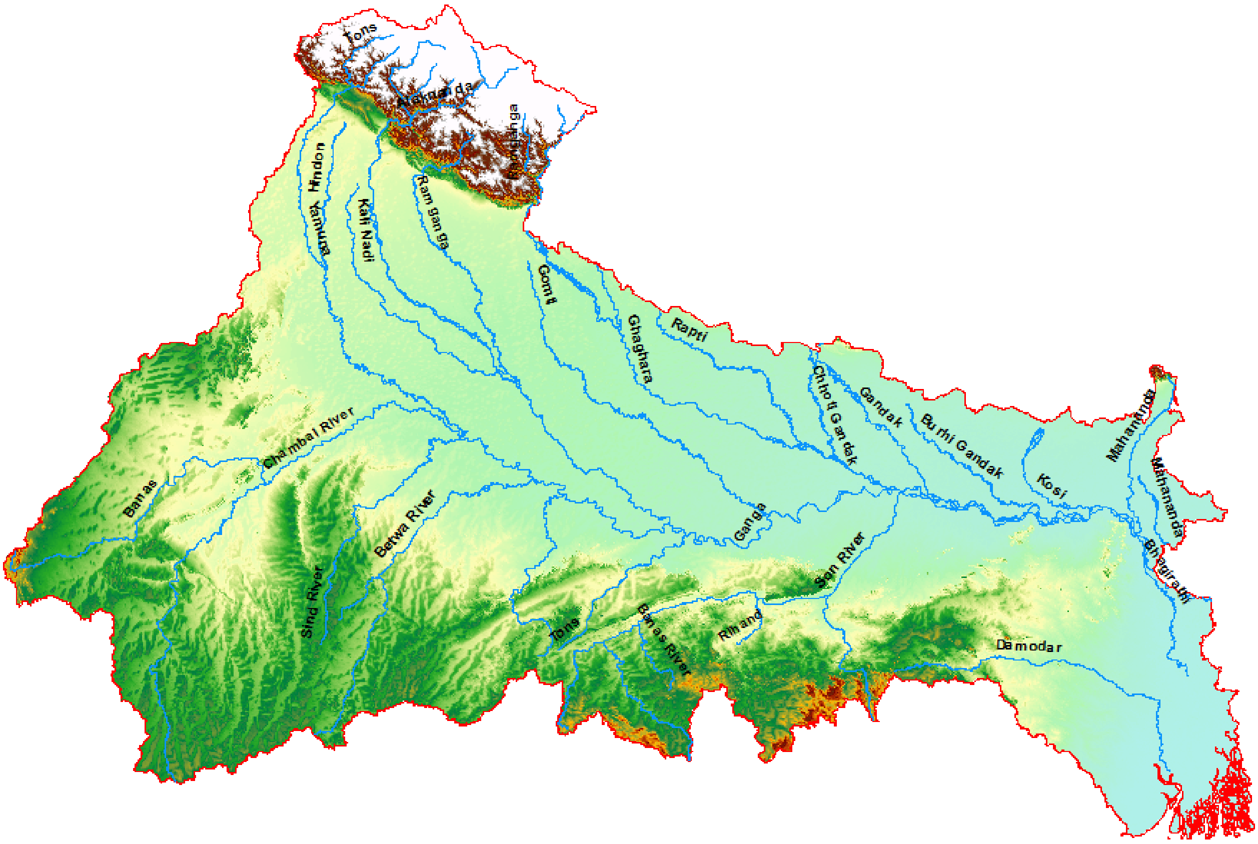


Figure 11.22 Mean water balance components of Indus basin

HIGHLIGHTS

- *Mean annual available water resources of Indus basin is 45.53 BCM.*
- *Maximum annual water availability is 65.47 BCM during 1995-96.*
- *Minimum annual water availability is 28.29 BCM during 2002-03.*
- *Annual rainfall in the basin varies from 1,315.6 mm to 512.6 mm during 1985-86 to 2014-15 and mean rainfall of these 30 years is 896 mm.*
- *Indus basin is divided into five sub-basins for the reassessment study viz. Nimoo, Akhnoor, Harike, Chetak and Rest of Indus.*
- *Average annual domestic, industrial and livestock demand in the basin is 0.17 BCM.*
- *Average annual evaporation from water bodies in the basin is 0.48 BCM.*

GANGA BASIN


Tons
Alaknanda
Hindon
Yamuna
Kali Nadi
Ramganga
Gomti
Ghaghara
Rapti
Chhoti Gandak
Gandak
Burhi Gandak
Kosi
Mahananda
Mahananda
Chambal River
Banas
Betwa River
Sind River
Ganga
Son River
Bhagirathi
Tons
Banas River
Rihand
Damodar

12.0 Introduction

The Ganga basin outspreads in India, Tibet (China), Nepal and Bangladesh. The major part of the geographical area of the Ganga basin lies in India and it is the biggest river basin in the country draining an area of 8,38,803 sq.km (Considered for the present study), which is slightly more than one-fourth (26.3 %) of the total geographical area of the country. In India, it covers states of Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, West Bengal, Uttarakhand, Jharkhand, Haryana, Chhattisgarh, Himachal Pradesh and Delhi. The basin lies between longitudes 73°2'E to 89°5'E and latitudes 21°6'N to 31°21'N having maximum length and width of approximately 1,543 km and 1,024 km respectively. The basin is bounded by the Himalayas on the north, by the Aravalli on the west, by the Vindhyas and Chottanagpur plateau on the south and by the Brahmaputra ridge on the east. The Great Desert of Rajasthan and the Aravalli hills form the ridge between the Indus and Ganga drainage system. The delta of the greater Ganga basin is one of the largest in the world and is known by the name Sundarbans after the Sundari trees covering an area of 60,000 sq.km.

For the present study, the whole Ganga basin has been divided into three major sub-basins i.e. Upper Ganga, Lower Ganga and Yamuna. The Yamuna sub-basin has been delineated with the outlet point at Naini G&D site (Allahabad) of CWC just before Yamuna meets Ganga. The terminal points for delineating upper Ganga has been taken as Turtipar and Ghazipur G&D sites of CWC. Remaining area has been taken as the Lower Ganga sub-basin.

Mean annual rainfall in the whole Ganga basin for the period 1985-86 to 2014-15 has been estimated as 914 BCM and the mean water resource availability for the Ganga basin has been summed up for all the above three sub-basins.

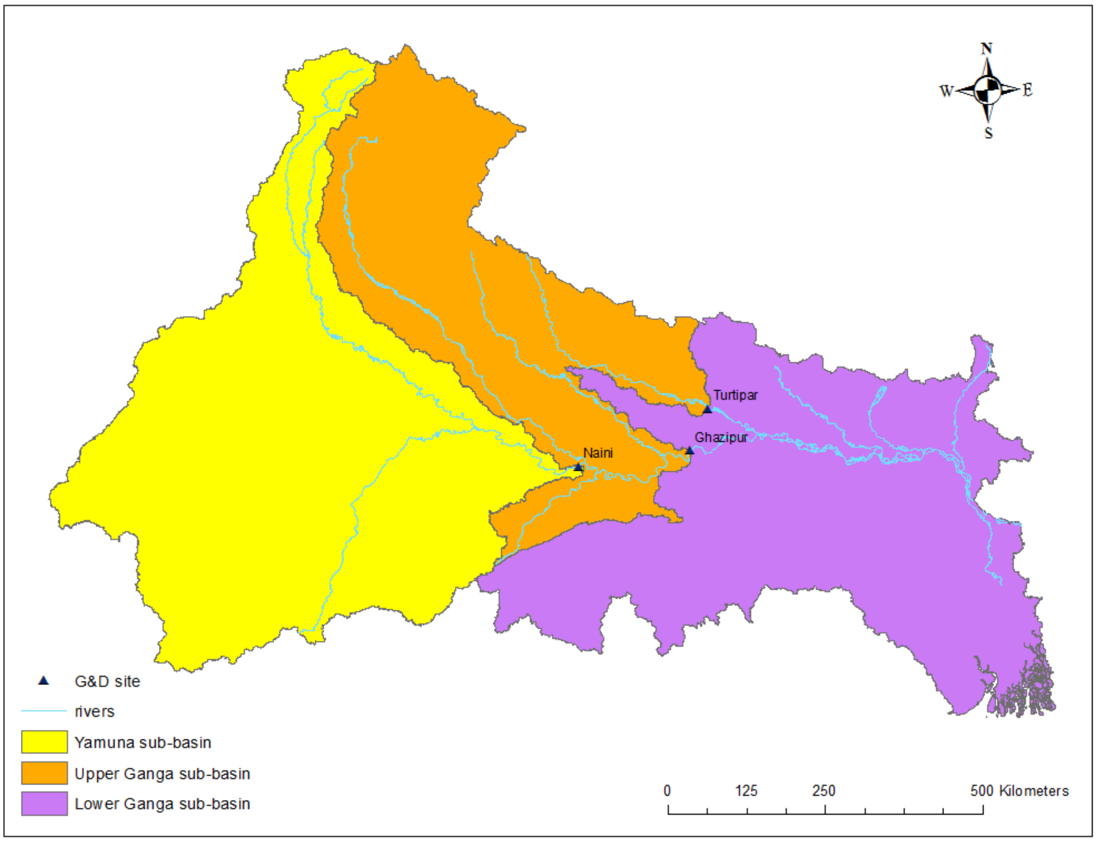
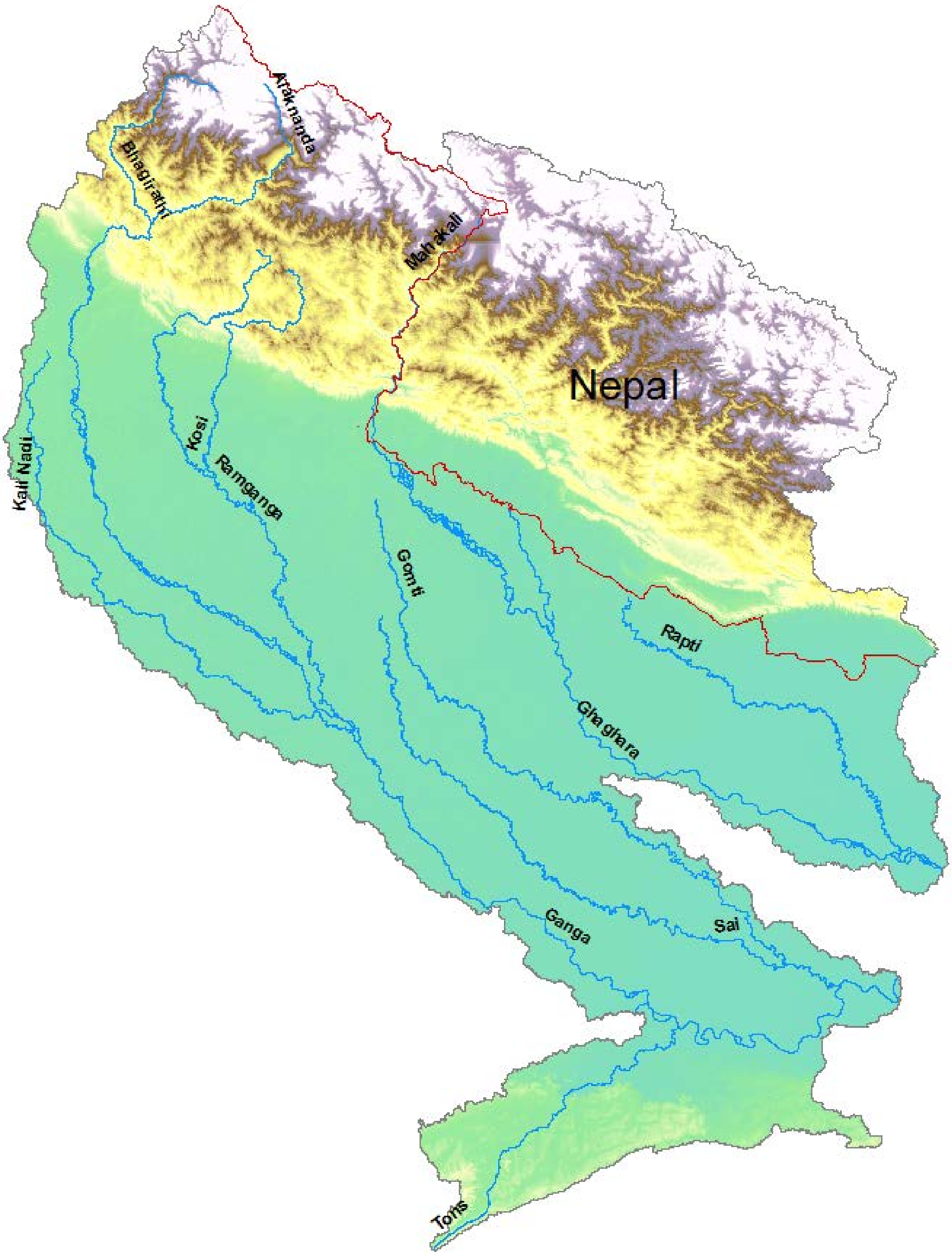


Figure 12 Sub-basin map of Ganga basin

HIGHLIGHTS

- *Mean annual available water resources of Ganga basin is 509.52 BCM*
- *509.52 BCM comprises 179.98 BCM in Upper Ganga (excluding contribution from Nepal 17.24 BCM), 192.60 BCM in Lower Ganga and 136.94 BCM in Yamuna sub-basins*
- *Annual rainfall in the basin varies from 1,307 mm to 5,871 mm during 1985-86 to 2014-15 and mean rainfall of these 30 years is 2,748 mm.*
- *Ganga basin is divided into three major sub-basins for the reassessment study viz. Upper Ganga, Lower Ganga and Yamuna basin.*
- *Average annual domestic, industrial and livestock demand in the basin is 8.05 BCM.*

UPPER GANGA SUB-BASIN



12 (a).1 Geo-Spatial Datasets

12 (a).1.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) data was available for the period of 10 years (2004-05 to 2014-15) for main Ganga stem (including Gomti) while for Ghaghra, it was available for one year only. The LULC map of the basin is shown in Figure 12.1. The percentage distribution of LULC in the sub-basin (Indian portion only) is shown in Figure 12.2. It shows that predominant LULC classess in the upper Ganga sub-basin are Double/Triple (33.80 %), Rabi only (14.67%), Kharif only (11.31%), forest (13.97%), scrubland (5.08%) and other wasteland (4.98%).

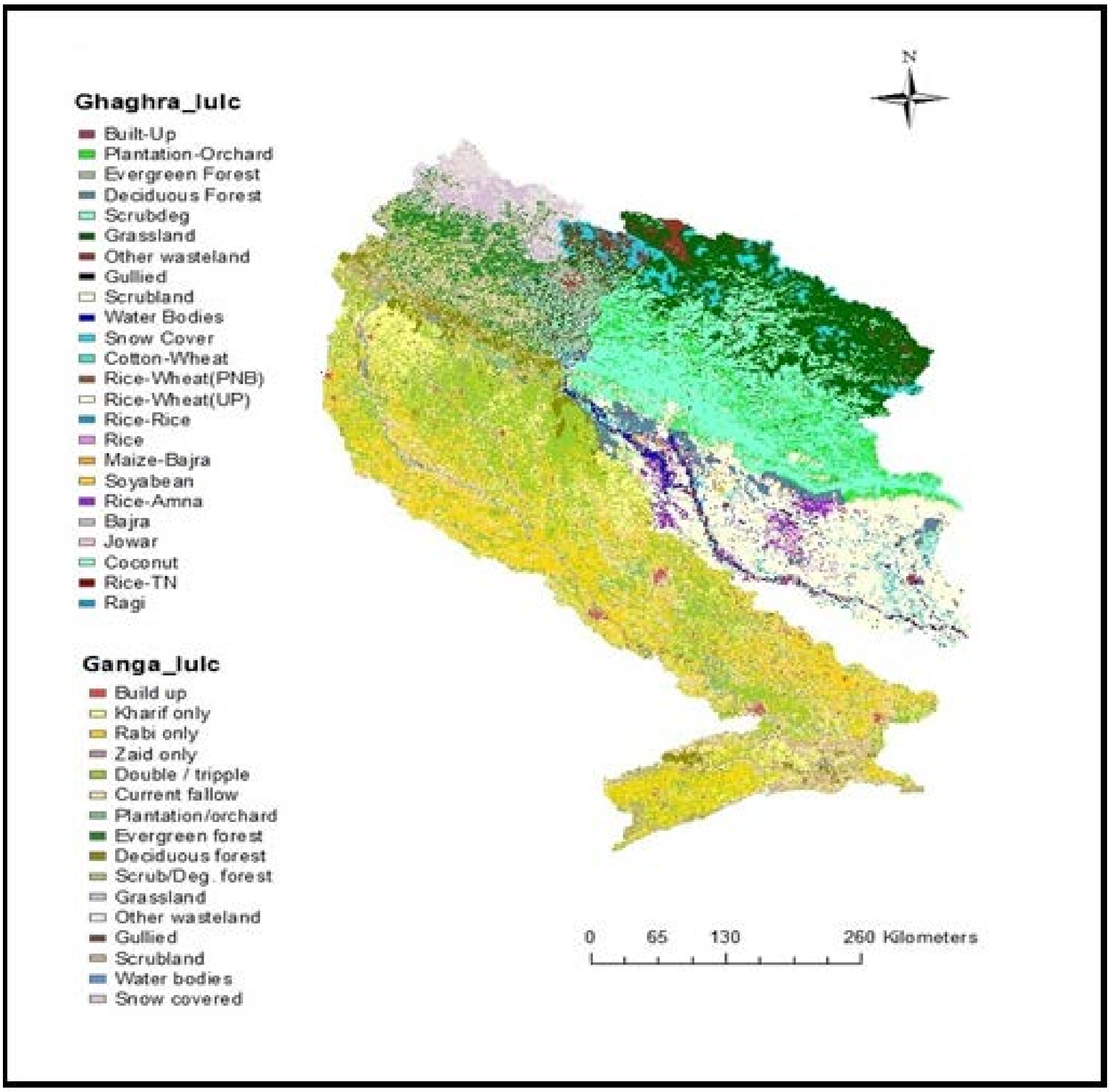


Figure 12.1 LULC map of Upper Ganga sub-basin (2004-05)

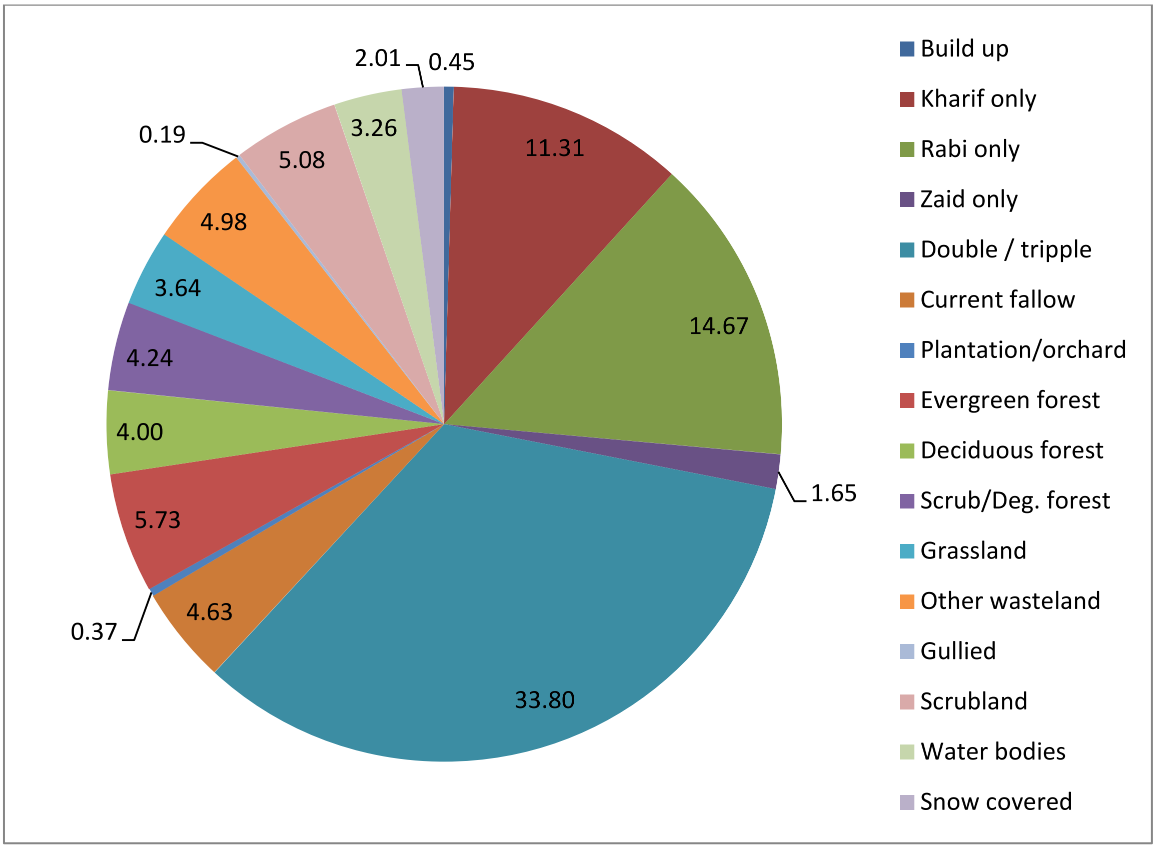


Figure 12.2 Distribution of LULC in Upper Ganga sub-basin (2004-05)

12 (a).1 .2 Soil texture

The main soil types found in the basin are sandy, clay and loamy soils. Figure 12.3 shows various categories of soil in the basin. The soils are classified as sandy, loamy, clayey and rock outcrops based on the soil texture information.

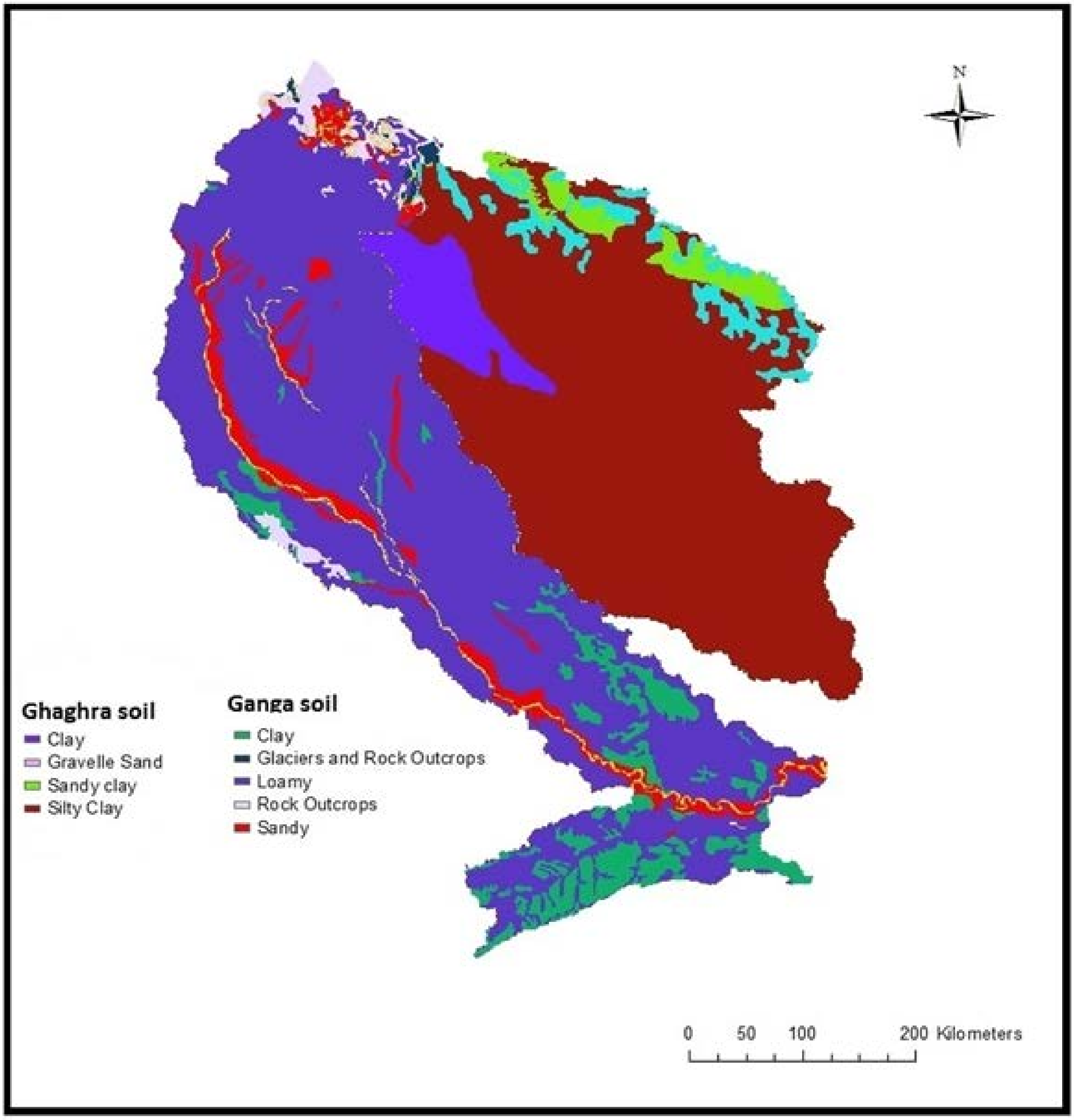


Figure 12.3 Soil texture map of Upper Ganga sub-basin

12 (a).1.3 Topography

The topography of the basin consists of hilly region and plains. The upper regions of the basin are mostly hilly and forested. The elevation values ranges from a minimum of 67 m to a maximum of 7,549 m. The average elevation is about 1121.18 m in the basin. Figure 12.4 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the sub-basin.

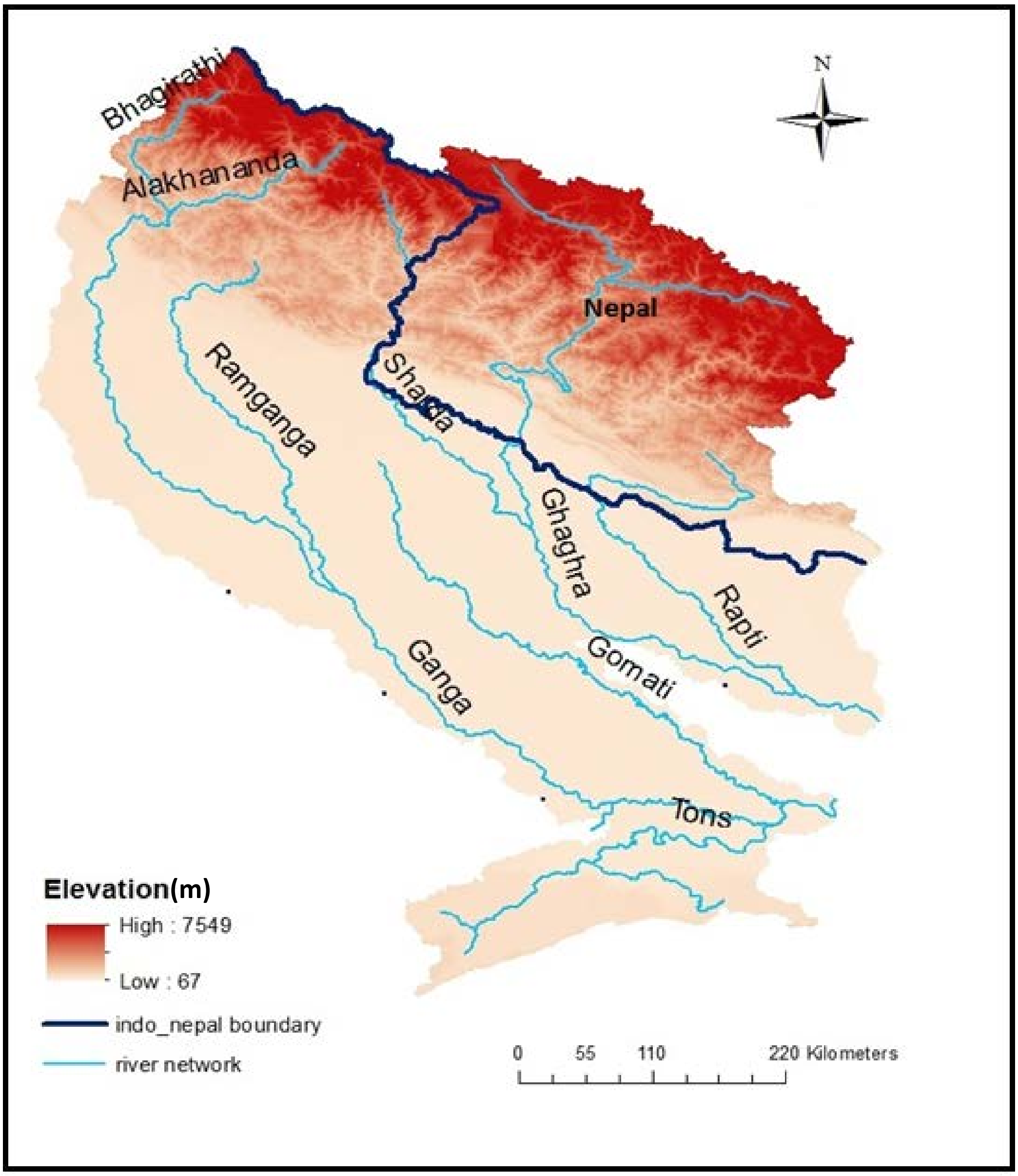


Figure 12.4 SRTM DEM map of Upper Ganga sub-basin

12 (a).2 Hydro-Meteorological and other Input Data

12 (a).2.1 Rainfall grids

Figure 12.5 shows gridded annual rainfall map of Upper Ganga sub-basin (Indian portion) for year 2004-05. The temperature and rainfall data for the transboundary region (Ghagra River) is available only till 2012-13. Hence, to maintain uniformity, study for the whole Upper Ganga sub-basin is carried out from 1985-86 to 2012-13 (28 years) only.

The annual variations in the rainfall during study period of 28 years (1985-86 to 2012-13) are shown in the Figure 12.6. Annual rainfall of the basin varies from 562 mm to 951 mm. The mean rainfall of 30 years (1985-2015) in the Upper Ganga sub-basin is 697 mm. Rainfall analysis at sub-basin level during the study period reveals that minimum annual rainfall of around 460 mm is observed in Chhatnag sub-basin while high annual rainfall of 2,683 mm is observed in Palliankalan sub-basin. Out of the 28 years, for 16 years annual rainfall is higher than the mean rainfall and for remaining 12 years it is lower than the mean rainfall.

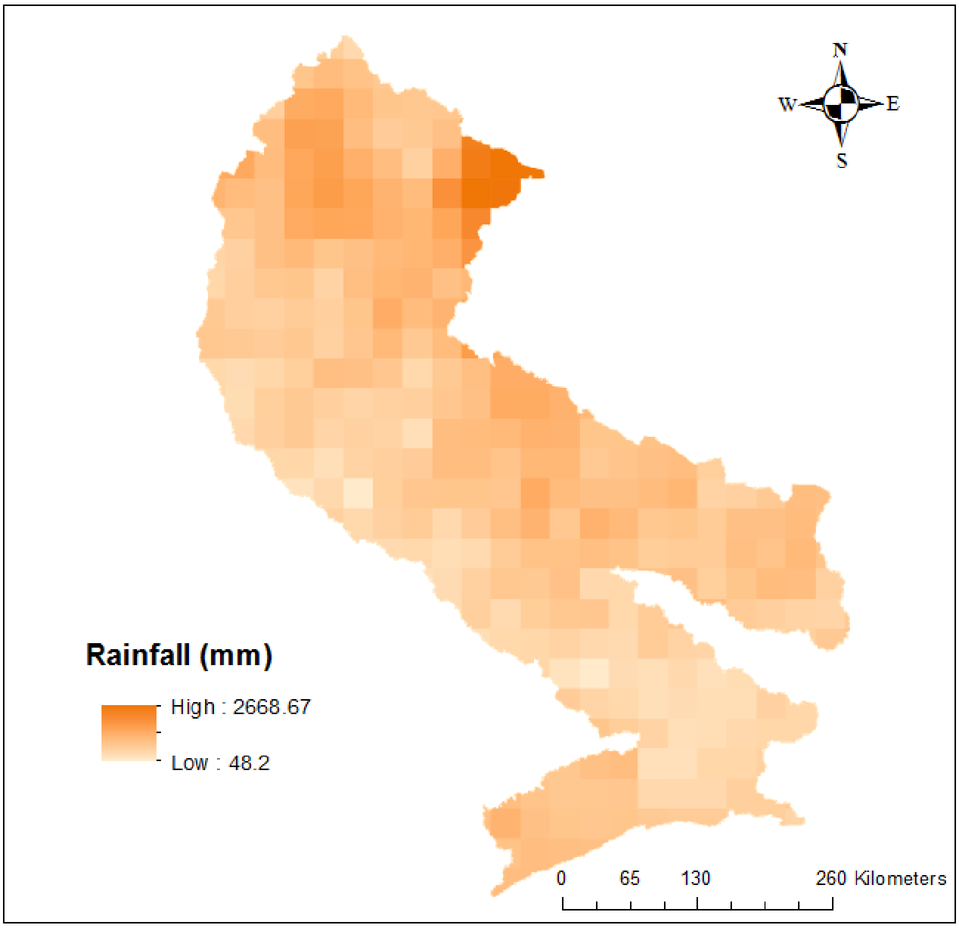


Figure 12.5 Gridded rainfall of Upper Ganga sub-basin (2004-05)

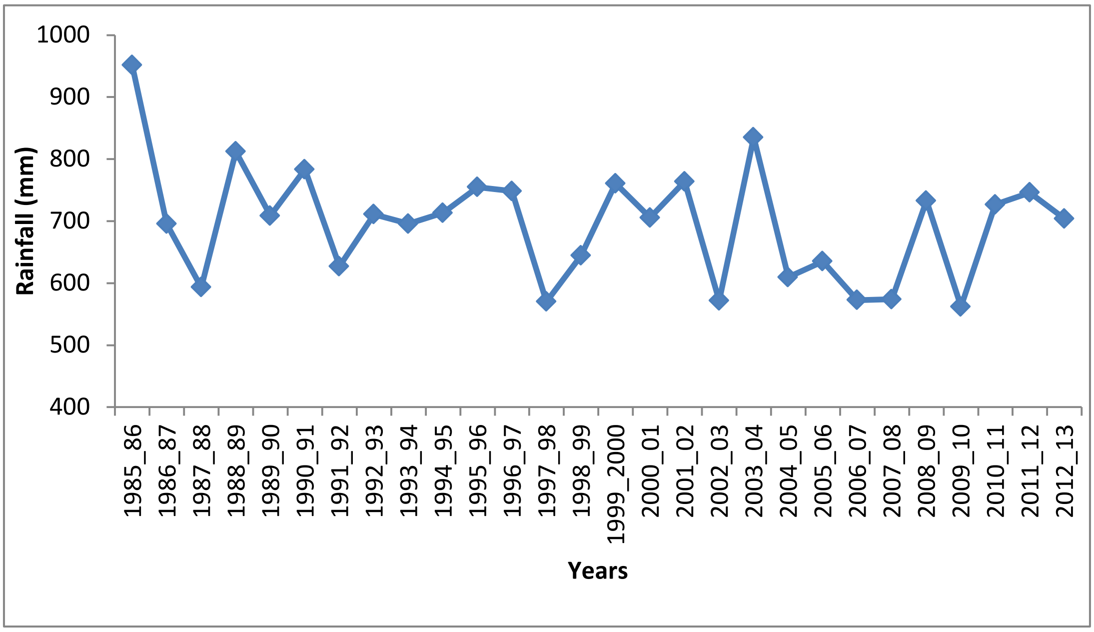


Figure 12.6 Annual rainfalls in Upper Ganga sub-basin (1985-86 to 2012-13)

12 (a).2.2 Temperature grids

The gridded mean annual temperature map of Upper Ganga sub-basin during 2004-05 is shown in Figure 12.7.

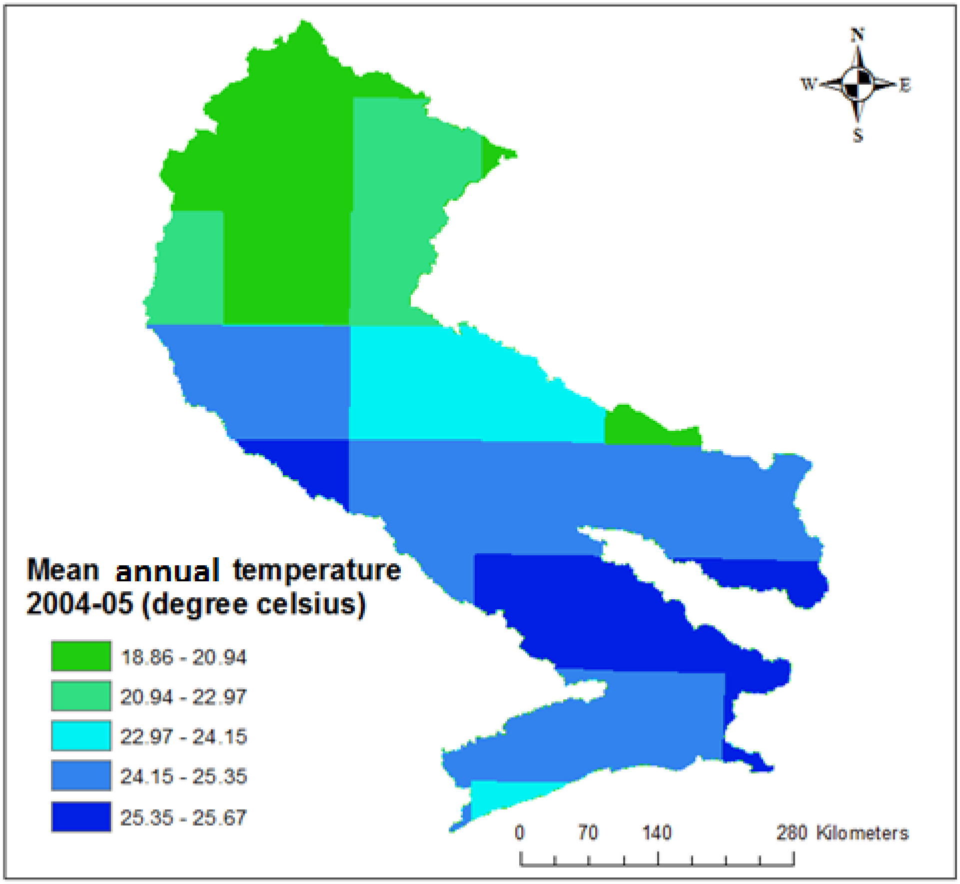


Figure 12.7 Gridded mean annual temperature of Upper Ganga sub-basin (2004-05)

12 (a).2.3 Sub-basins of Upper Ganga sub-basin

The Upper Ganga sub-basin is divided into three major river systems (Figure 12.8) viz. main Upper Ganga, Gomti and Ghaghra. Upper Ganga system has four sub-basins, viz. Rishikesh, Dabri, Chhatnag and Varanasi. Similarly, Gomti has one sub-basin i.e. Maighat and Ghaghra has three sub-basins, viz. Elginbridge, Paliankalan and Turtipar. Table - 12.1 outline details of each sub-basin. The sub-basins are divided in such a way that the location of CWC G&D sites is taken as sub-basin terminal point.

Figure 12.8 Sub-basins of Upper Ganga sub-basin

Table - 12.1 Sub-basin wise details of Upper Ganga sub-basin

S. No.	Sub-basin	River	Individual drainage area (sq.km)
1	Rishikesh	Main Ganga	21,777
2	Dabri	Ramganga	24,158
3	Chhatnag	Main Ganga	49,601
4	Varanasi	Main Ganga	21,985
5	Maighat	Gomti	30,050
6	Elginbridge	Ghaghra	10,223*
7	Paliankalan	Ghaghra	11,581*
8	Turtipar	Ghaghra	30,997*
9	Ungauged	Main Ganga	6,760
		Total basin area	2,07,132

**Areas within India boundary. Actual areas of Elginbridge, Paliankalan and Turtipar Sub-basins are 60,576 sq.km, 16,409 sq.km and 46, 808 sq.km respectively.*

12 (a).2.4 River discharge

The river discharge data is available at all the four G&D sites (Rishikesh, Dabri, Chhatnag, and Varanasi) located on main Upper Ganga, at one G&D site (Maighat) located on Gomti and three G&D sites (Elginbridge, Paliankalan, Turtipar) on Ghaghra for the study period of 28 years. The daily discharge data have been aggregated to annual scale and used for calibration and validation of model computed runoff at sub-basin level.

12 (a).2.5 Reservoir flux

Figure 12.9 shows the location of some of the major reservoirs in Upper Ganga sub-basin. The data of two major reservoirs namely, Tehri and Kalagarh received from State Governments have been considered for estimating reservoir flux changes for each water year for 28 year period.

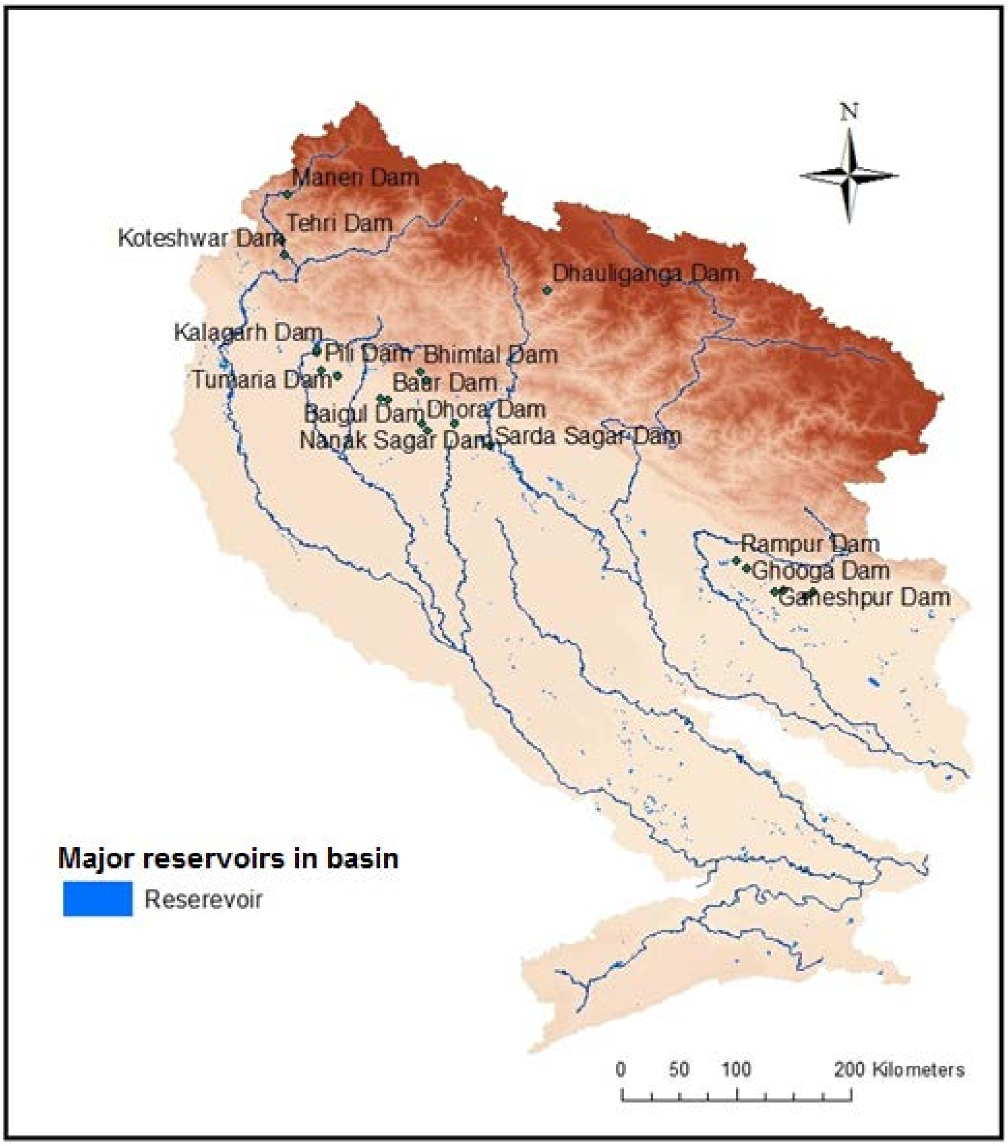


Figure 12.9 Major reservoirs in Upper Ganga sub-basin

12 (a).2.6 Groundwater flux

The spatial annual groundwater flux for the year 2005-06 is shown in Figure 12.10 and variation of annual groundwater flux during the study period (1985-86 to 2012-13) is shown in Figure 12.11.

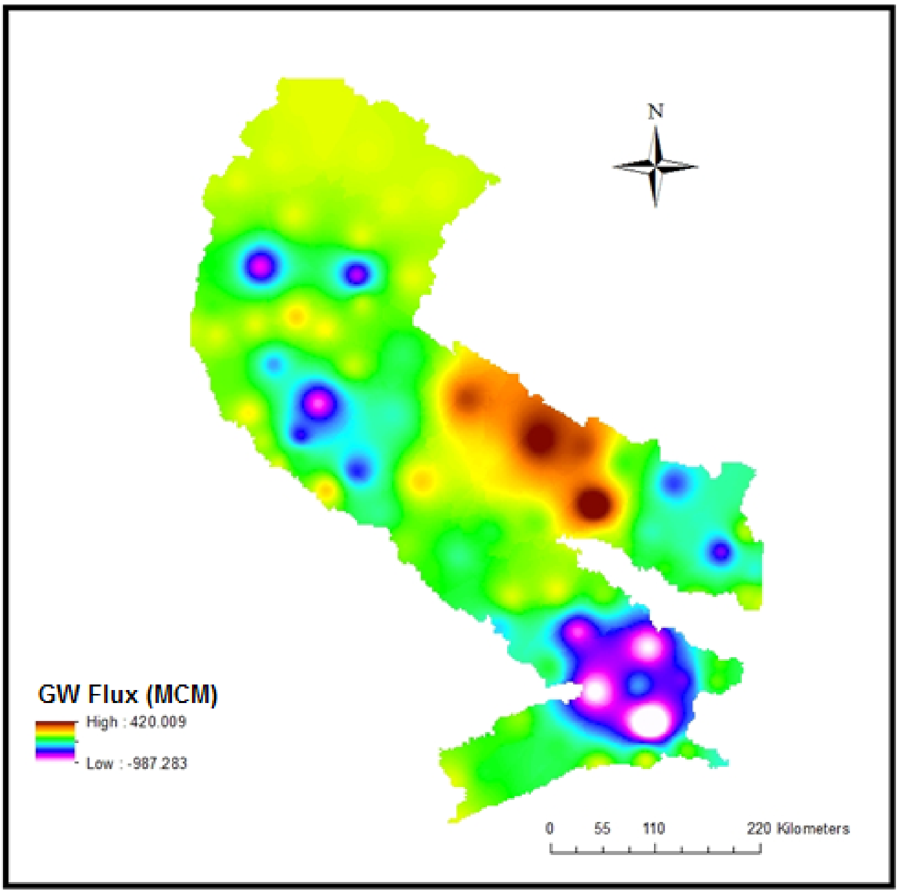


Figure 12.10 Groundwater flux (spatial data) estimated during 2005-06

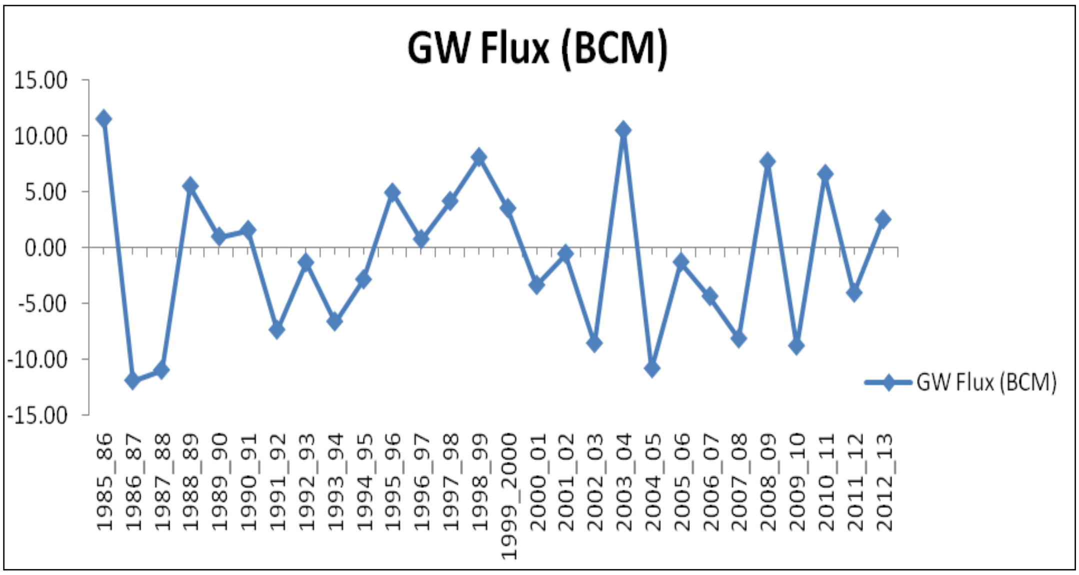


Figure 12.11 Annual groundwater flux of Upper Ganga sub-basin (1985-86 to 2012-13)

12 (a).2.7 Major crops in the basin

Based on the district-wise crop area statistics, district wise major crops for each crop season are identified. The Upper Ganga sub-basin is divided into seven regions based on the historic district-wise crop statistics collected from various sources (http://lus.dacnet.nic.in/ dt_lus.aspx). Each region specifies a unique crop for each crop season both spatially and temporally within the basin. Hence, the coefficients have been taken as per the crop in that particular region/district. On examining the cropping pattern within the basin, crop growing seasons have been decided as Kharif only crop during 4 months (July to October), Rabi only crop during 4 months (November to February), Double/Triple crop during 8-12 months.

12 (a).2.8 Irrigation command area

Figure 12.12 shows location of irrigation command boundaries inside and outside the Upper Ganga sub-basin considered for the year 2012-13. Since annual command boundary maps are not available, command area has been selected from the year 2012-13 based on the completion of the project/dam. Hence, the command area considered during the latest year is 1,53,91,581 ha. Basin outside command has been taken uniformly for all years while working out ECII from these areas.

12 (a).2.9 Domestic, industrial and livestock demand

Figure 12.13 shows district boundaries layer with population for the year 2011 as per census. The mean annual domestic, industrial and livestock demands are estimated as 1.42 BCM in the Upper Ganga sub-basin.

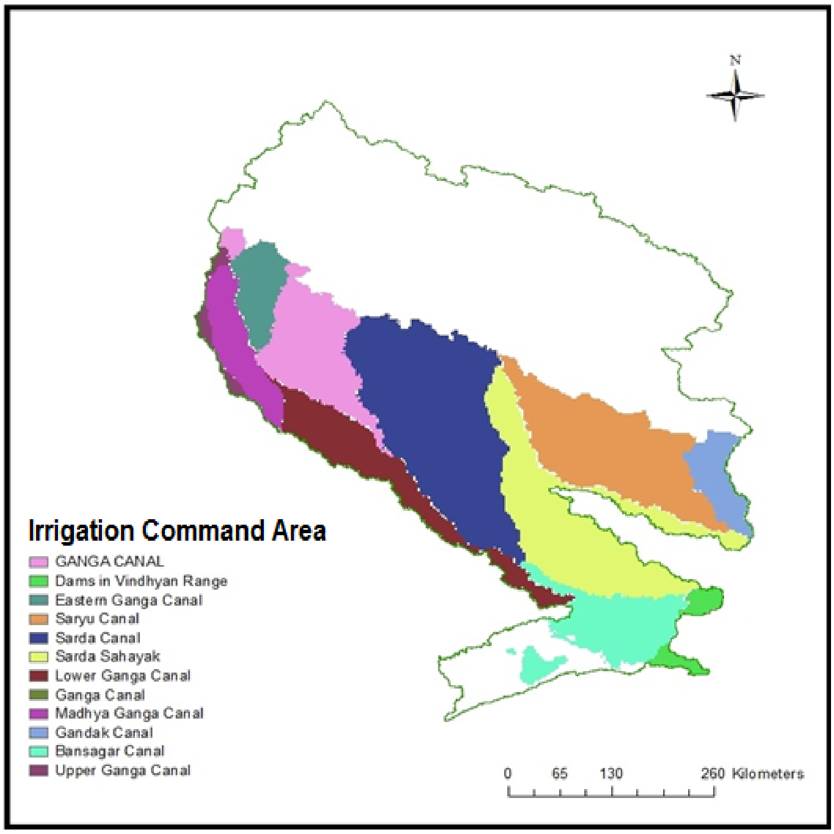


Figure 12.12 Irrigation command boundaries of Upper Ganga sub-basin

Figure 12.13 District boundaries in Upper Ganga sub-basin

12 (a).2.10 Evaporation from major/medium/minor reservoirs and other water bodies

Table 12.2 provides annual evaporation values from each of sub-basins for the period of 1985-86 to 2012-13 (28 years). The average annual evaporation volume for the whole Upper Ganga sub-basin is worked out as 0.76 BCM.

Table - 12.2 Evaporation in reservoirs of Upper Ganga sub-basin

Year	Reservoir evaporation in each independent sub-basin (in BCM)	
	Main Ganga (including Gomti)	Ghaghra
1985-86	0.27	0.56
1986-87	0.27	0.56
1987-88	0.33	0.45
1988-89	0.22	0.49
1989-90	0.24	0.62
1990-91	0.23	0.53
1991-92	0.33	0.47
1992-93	0.23	0.59
1993-94	0.25	0.56
1994-95	0.21	0.44
1995-96	0.22	0.54
1996-97	0.24	0.53
1997-98	0.22	0.42
1998-99	0.31	0.43
1999-00	0.25	0.58
2000-01	0.22	0.53
2001-02	0.25	0.54
2002-03	0.30	0.45
2003-04	0.25	0.58
2004-05	0.33	0.56
2005-06	0.23	0.49
2006-07	0.21	0.52
2007-08	0.18	0.48
2008-09	0.24	0.53
2009-10	0.20	0.56
2010-11	0.17	0.48
2011-12	0.29	0.34
2012-13	0.24	0.42
Avg	0.25	0.51

12 (a).3 Previous Estimates

No separate assessment of water resources potential for Lower Ganga sub-basin had been done in the past. However, in respect of Ganga, the erstwhile Ganga Basin Water Studies Organisation of Central Water Commission carried out the assessment of water resources potential and had presented the details of the study in their report of 1986. Ganga basin was divided into ten sub-basins for the study and the assessment was based on the actual observed flow data available at several locations for durations ranging from 5 years to 20 -25 years. Simple rainfall-runoff regression analysis and multi-site data generation were resorted to wherever the observed flow data were found to be inadequate. As per 1993 studies for Reassessment of Water Resources Potential of India, the water resource potential was estimated as 525 BCM for the whole Ganga basin for a catchment area of 8,61,452 sq.km.

12 (a).4 Runoff Estimation

Tables - L.1 to L.7 at Annexure L(a) give calibrated runoff along with observed discharge, ECII, etc. during 28 years for the six G&D sites for the Upper Ganga sub-basin. Figures 12.14 to 12.19 show comparative graphs of calibrated runoff and observed discharge at these discharge stations. As per Table - L.7, the mean annual calibrated runoff in the Upper Ganga sub-basin is about 114.55 BCM. The maximum annual calibrated runoff is 177.71 BCM during 1985-86. The minimum annual calibrated runoff is 62.31 BCM during 1987-88. The mean annual ECII is about 63.57 BCM. The maximum annual ECII is about 97.92 BCM during 2009-10. The minimum annual ECII is about 44.68 BCM during 1986-87.

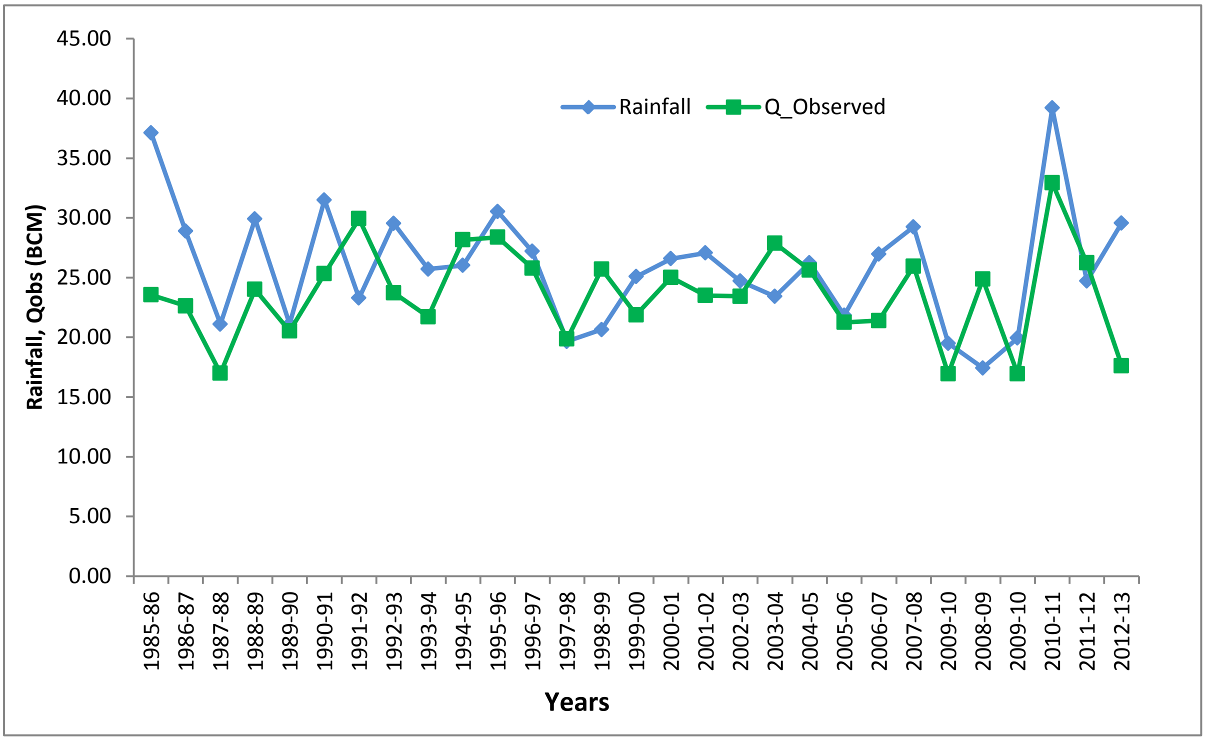


Figure 12.14 Observed discharge and rainfall at Rishikesh

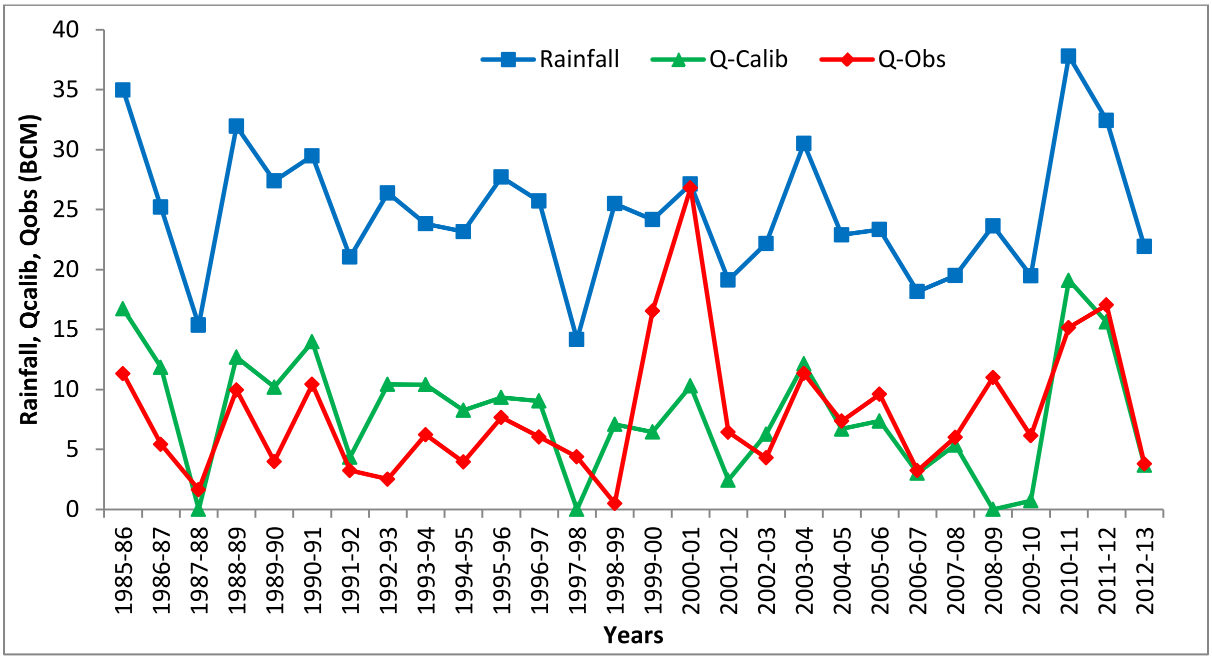


Figure 12.15 Calibrated runoff and observed discharge at Dabri

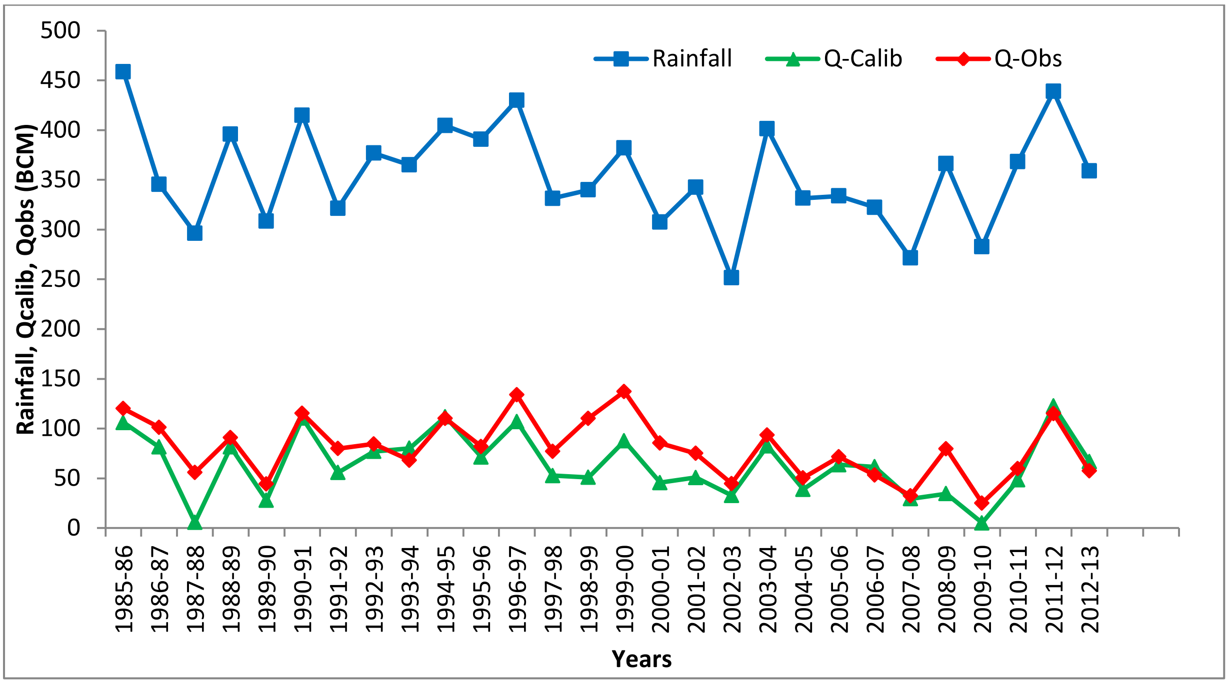


Figure 12.16 Calibrated runoff and observed discharge at Chhatnag

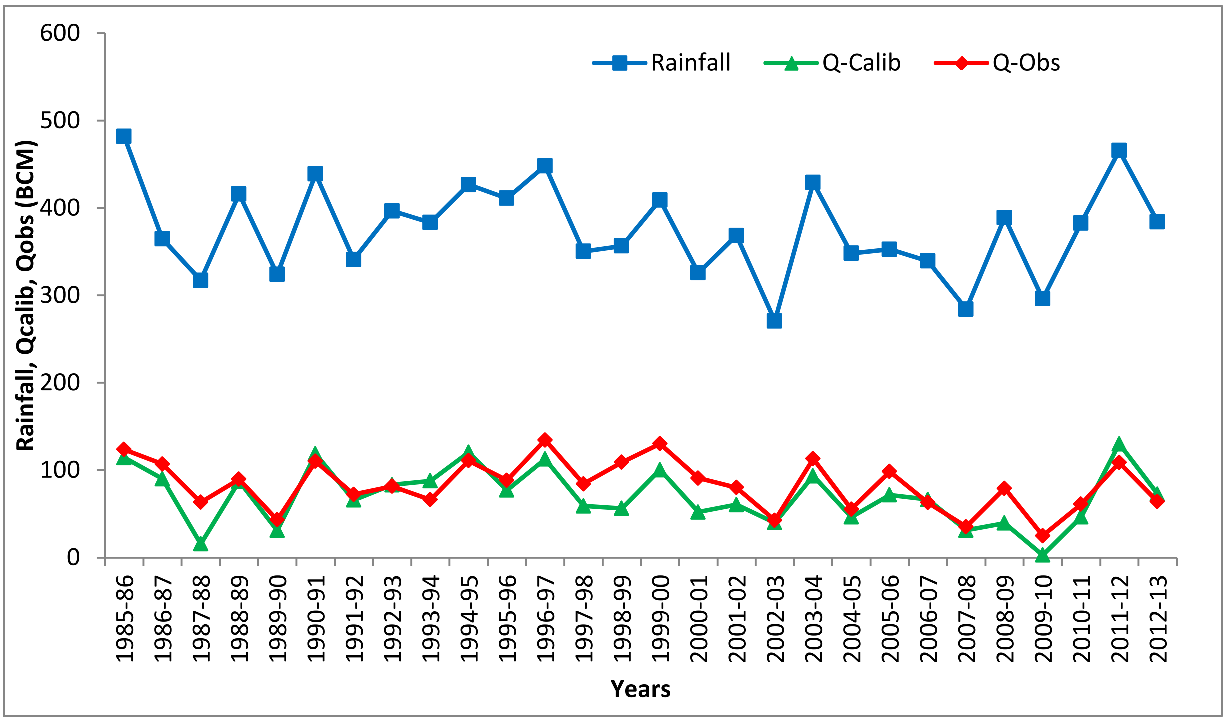


Figure 12.17 Calibrated runoff and observed discharge at Varanasi

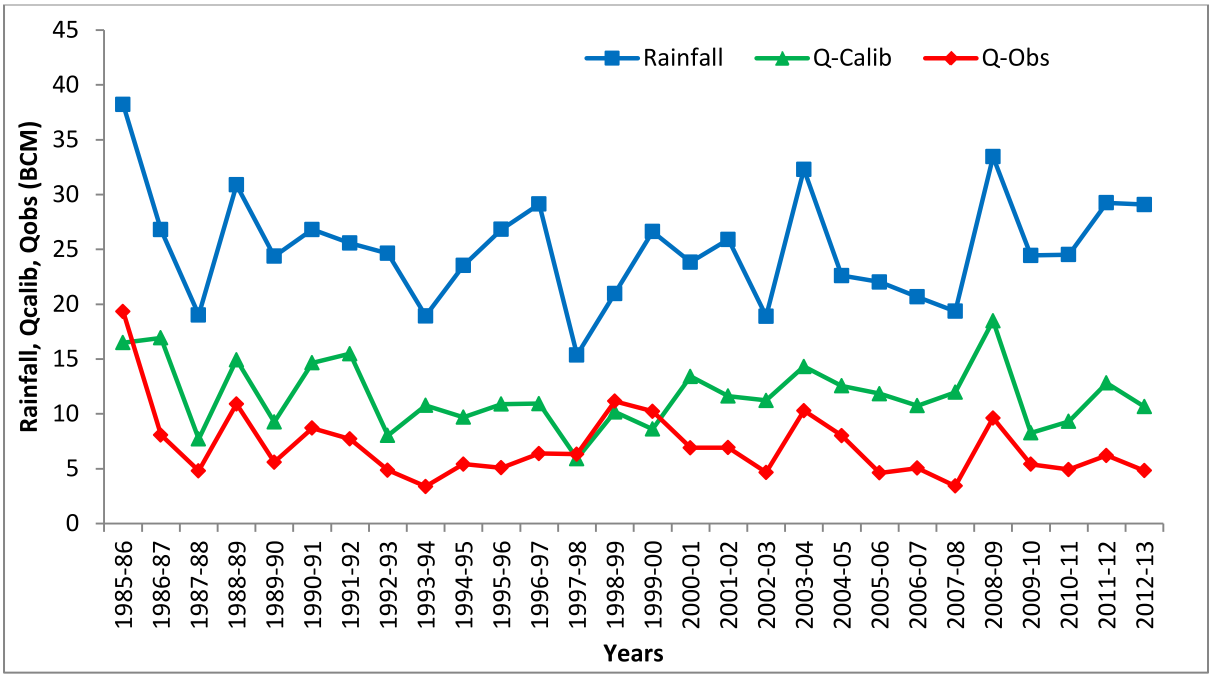


Figure 12.18 Calibrated runoff and observed discharge at Maighat on river Gomti

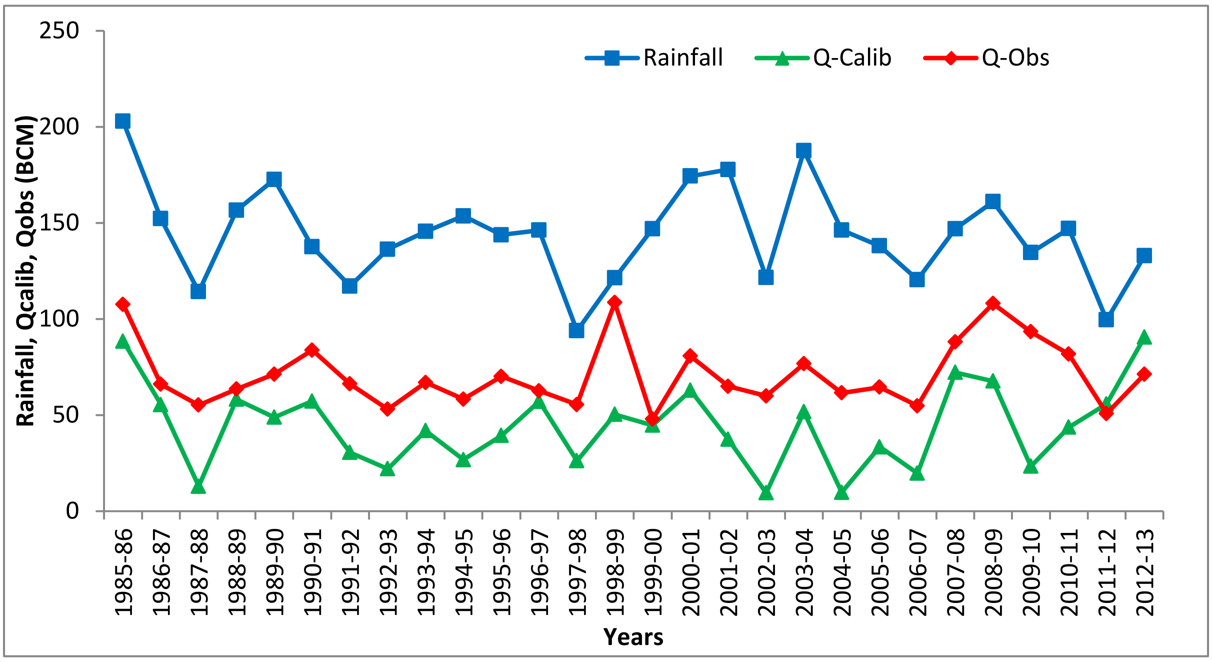


Figure 12.19 Calibrated runoff and observed discharge at Turtipar on river Ghaghra

12 (a).5 Annual Water Resources Availability of Upper Ganga Sub-basin

Table L.7 shows the different components that are required to estimate the basin level water resources of Upper Ganga for 28 years. The mean water resource availability of the ungauged sub-basin has been estimated as 2.86 BCM. The maximum annual water resources of Upper Ganga sub-basin is 245.72 BCM during 1985-86 in the 28 years. The minimum annual water resource is 147.72 BCM during 1987-88. The mean annual available basin water resource is 197.22 BCM.

12 (a).5.1 Annual water resources of Upper Ganga sub-basin during extreme rainfall conditions

Out of the total 28 years of meteorological data of study period, during the years 1985-86 and 1997-98, extreme wet and dry rainfall conditions occurred in Upper Ganga river basin. The annual water resources of Upper Ganga sub-basin during these two extreme rainfall conditions are 245.72 BCM and 169.89 BCM respectively as shown in Table -12.3. The water balance components during these years are presented in Figures 12.20 and 12.21. Water resources avilability-rainfall ratio during the extreme maximum and minimum rainfall years is found to be 0.624 and 0.92 respectively.

Table - 12.3 Water resources availability in Upper Ganga sub-basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	1985-86	393.55	245.72
Minimum Rainfall	1997-98	184.76	169.89

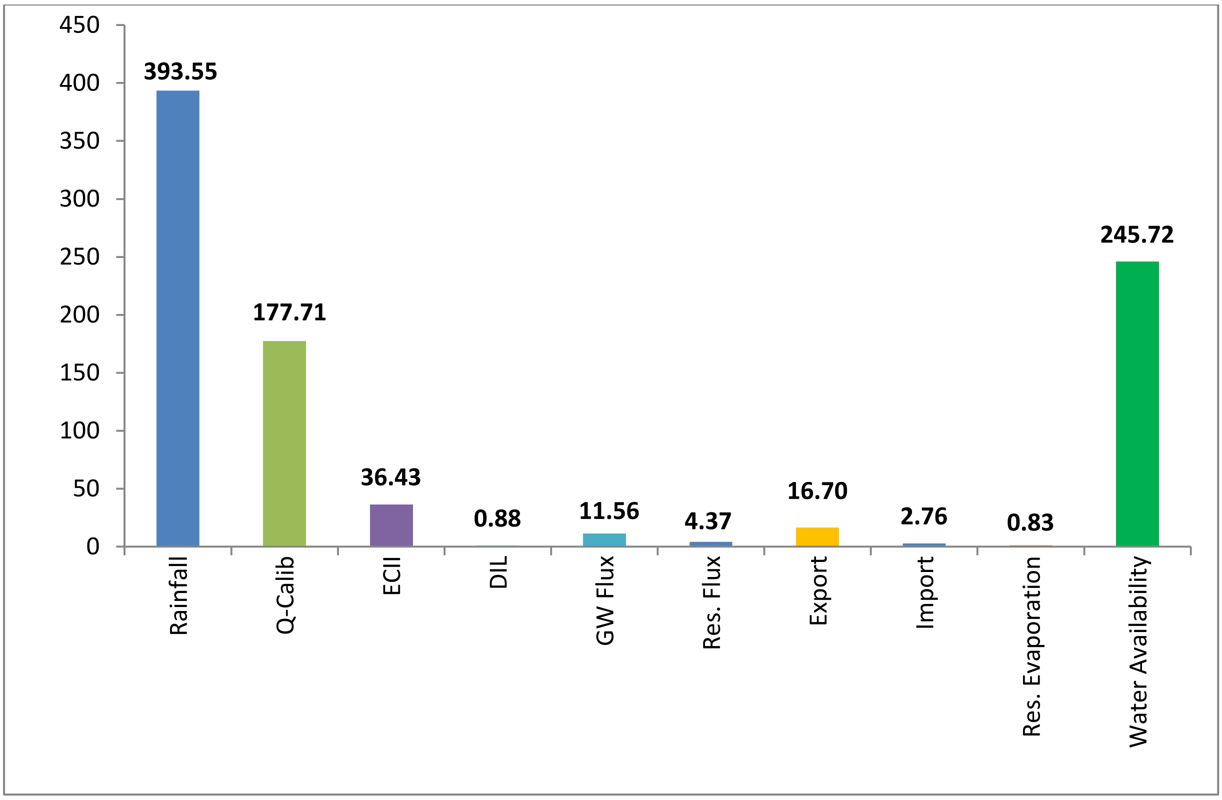


Figure 12.20 Water balance components of Upper Ganga sub-basin during extreme high rainfall (1985-86)

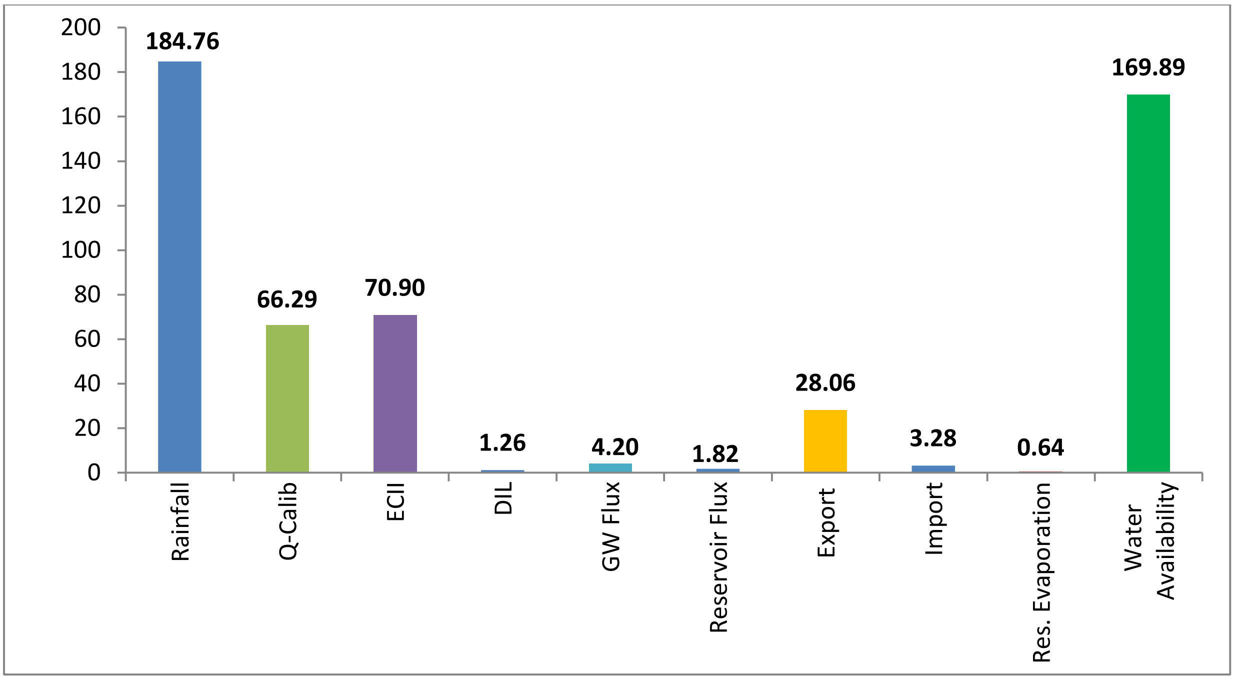


Figure 12.21 Water balance components of Upper Ganga sub-basin during extreme low rainfall (1997-98)

12 (a).5.2 Mean water resources of Upper Ganga sub-basin

Mean water resources availability = Mean of (Qcalib + ECII + DIL + Reservoir Flux + GW Flux + Reservoir evaporation + Export - Import) = 114.55 + 63.57 + 1.31 + (-0.37) + (-0.78) + 0.76 + 21.66 (UGBO to LGBO and YBO) - 3.48 (LGBO to UGBO) = 197.22* BCM

**This includes contribution from Nepal (17.24 BCM).*

75% dependable flow of Upper Ganga sub-basin = 173.68 BCM.

Figure 12.22 shows the various water balance components of basins (Main Ganga, Gomti and Ghaghra) excluding Unguaged portion averaged over a period of 28 years during 1985-86 to 2012-13.

It is observed that the computed runoff factors varies from 0.14 (1,168 mm rainfall) to 0.72 (1323 mm rainfall). The mean runoff factor for 30 year period is 0.47.

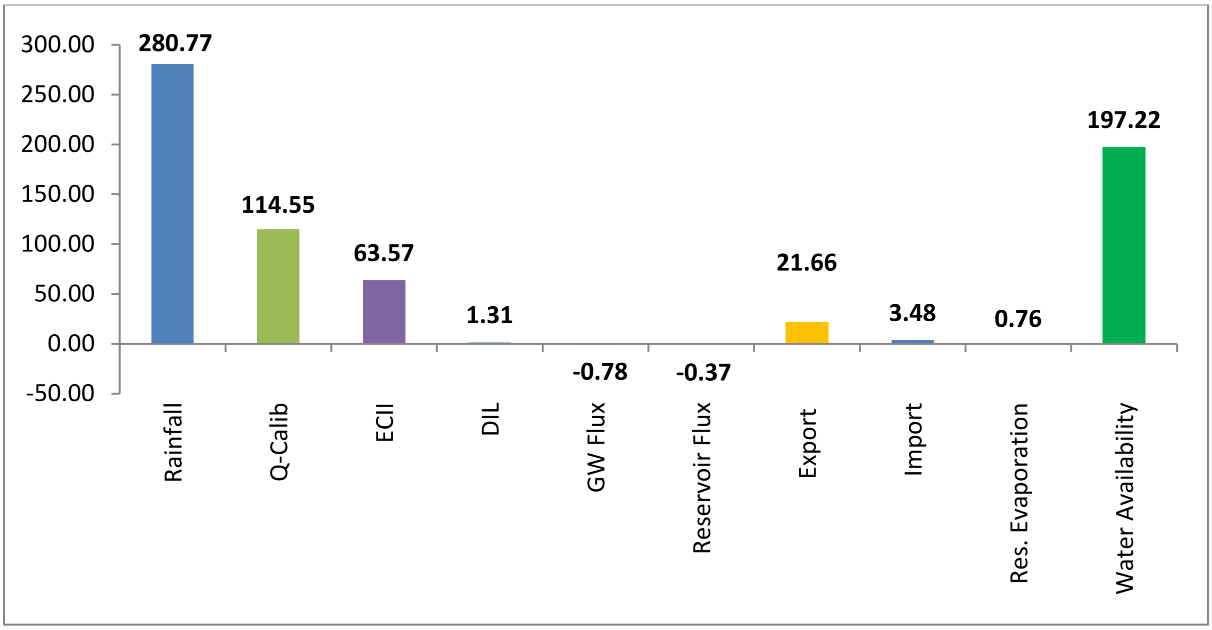


Figure 12.22 Mean water balance components of Upper Ganga sub-basin (1985-86 to 2012-13)

12 (a).6 Basin Outward Diversions/Imports

Upper Ganga sub-basin receives water from the Lower Ganga sub-basin into Varanasi sub-basin and exports water to Yamuna sub-basin (Pratappur and Galeta sub-basins) and Lower Ganga Basin. In the present study, the imports and exports have been estimated using ERDAS Imagine software. The AET and rainfall image files have been generated by the WRA tool in the output for all the sub-basins of Upper Ganga, Lower Ganga and Yamuna. The details are given in Table - 12.4.

Table - 12.4 Details of diversions considered for the study

S.No.	Name of Projects	Export (BCM)	Import (BCM)	Remarks
1	Upper Ganga Canal Project, Haridwar and Lower Ganga Canal	15.14	-	The diversions takes place through Upper Ganga Canal and Lower Ganga Canal to YBO
2	Sarda and Sarda Sahayak Canals	6.52	-	The diversions takes place through Sarda and Sarda Sahayak canals to LGBO
3	Bansagar Canal Project	-	3.48	The diversions takes place through Bansagar Canal Project from LGBO to Varanasi sub-basin of UGBO

12 (a).7 Assumptions/Limitations of the Study in Upper Ganga Sub-basin

The assumptions and limitations of the study in Upper Ganga sub-basin are given in Table - 12.5.

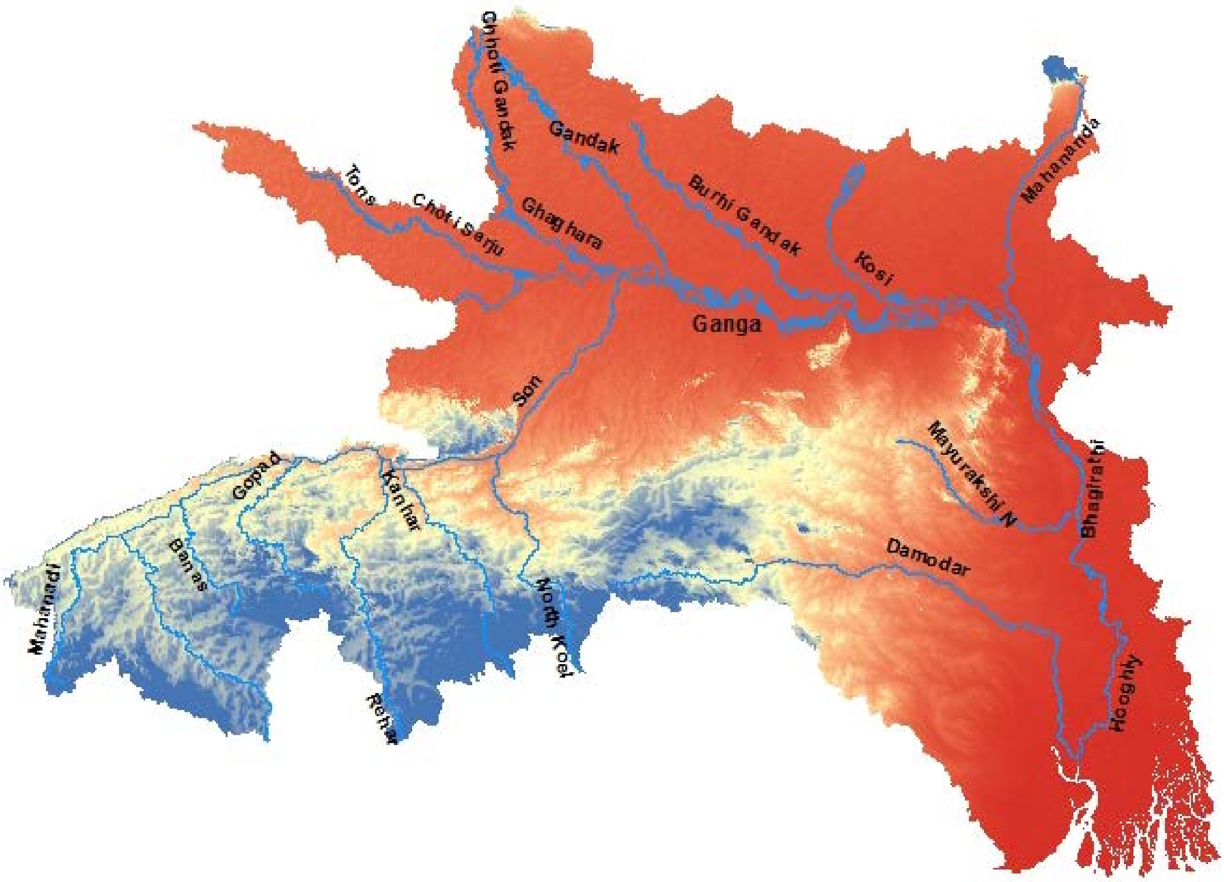
Table - 12.5 Assumptions and limitations of the study in Upper Ganga sub-basin

S. No.	Input/Factors	Assumption/Limitation	Output Affected	Sites Affected
1	Snow melt	As informed by NRSC, the WRAT tool doesn't take into account snow melt. Therefore, assumption taken, $R_{calibrated}$ = $R_{observed}$.	Water Resource Availability	Rishikesh Paliankalan Elgin Bridge Turtipar
2	Temperature and Rainfall image Files (provided by IMD)	Temperature values for hilly regions are inconsistent, as informed by M/s Deltares. They are using same data for carrying out the study on Strategic basin plan of Ganga basin.	Potential Evapotranspiration (PET) Actual Evapotranspiration (AET) Reservoir Evaporation	Rishikesh
3	Land Use and Land Cover image file (provided by NRSC)	In case of Main Ganga stem (including Gomti) LULC maps of the period 2004-05 to 2012-13 are used for runoff calculations in the study. For runoff computations prior to 2004-05, land-use maps of 2004-05 to 2012-13 have been used based on the average rainfall nearest to that year. In case of Ghaghra, only one Trans-boundary land-use map was available.	Model runoff values of years prior to 2004-05 Model runoff values of all years	All sites on Main Ganga All sites on Main Ghaghra
4	All Exports/Imports	All exports/imports through Canal system has been calculated using shape files. Factors like actual operation time of Canals not taken into account.	ECII values	All sites
5	Domestic, Industrial and Livestock demand (based on census data)	DIL for portion falling under Nepal not available.	$R_{calibrated}$ values	All sites on Ghaghra
6	Groundwater Flux	Groundwater flux for portion falling under Nepal not available.	$R_{calibrated}$ values	All sites on Ghaghra

HIGHLIGHTS

- *Mean annual available water resources of Upper Ganga Sub-basin is 197.22 BCM.*
- *Maximum annual water availability is 245.72 BCM during 1985-86.*
- *Minimum annual water availability is 196.89 BCM during 1997-98.*
- *Annual rainfall in the basin varies from 562 mm to 951 mm during 1985-86 to 2014-15 and mean rainfall for these 30 years is 697 mm.*
- *Upper Ganga sub-basin is divided into three sub-basins for the reassessment study viz. main Upper Ganga stem, Gomti and Ghaghra. Further, Upper Ganga sub-basin has been divided into four smaller sub-basins viz. Rishikesh, Dabri, Chhatnag, and Varanasi. Similarly, Gomati at Maighat and Ghaghra sub-basin has been divided into three smaller sub-basins viz. Elginbridge, Paliankalan and Turtipar.*
- *Average annual domestic, industrial and livestock demand in the basin is 1.31 BCM.*
- *Average annual evaporation from water bodies in the basin is 0.76 BCM.*

LOWER GANGA SUB-BASIN



12(a).8 Geo-Spatial Datasets

12 (a).8.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map of Lower Ganga sub-basin for the year 2004-05 is shown in Figure 12.23. Figure 12.24 shows the distribution (in percentage) of LULC in the basin. The major LULC class in the sub-basin consists of cropped area (Double/Triple, Rabi only, Kharif only) which accounts for 49.46% of the total area.

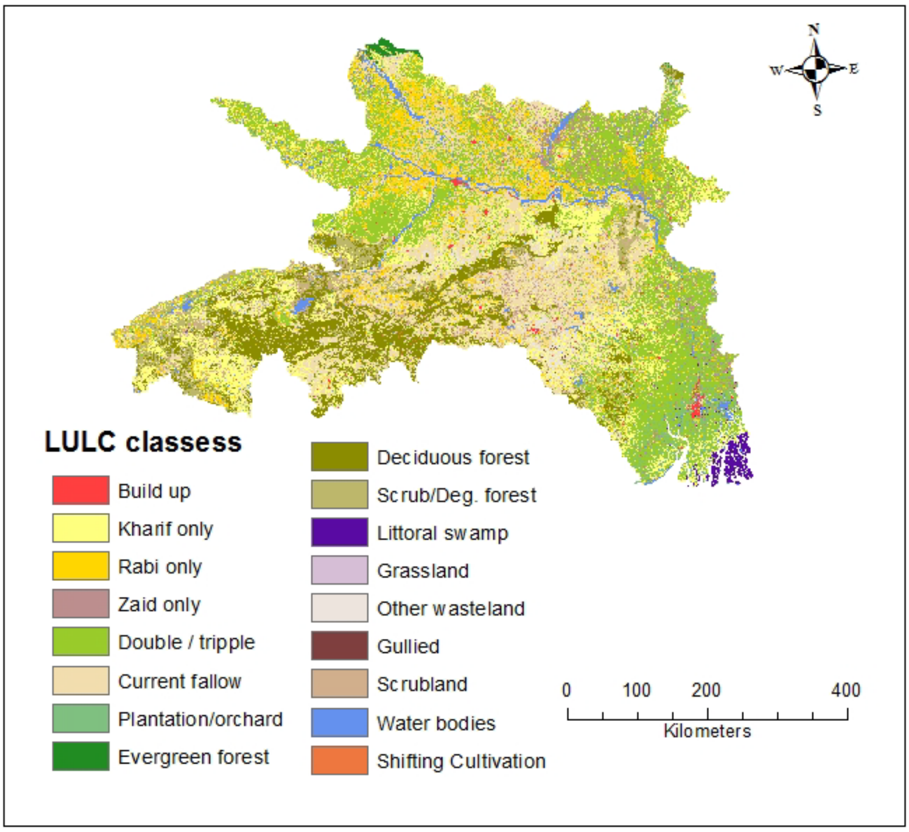


Figure 12.23 LULC map of Lower Ganga sub-basin (2004-05)

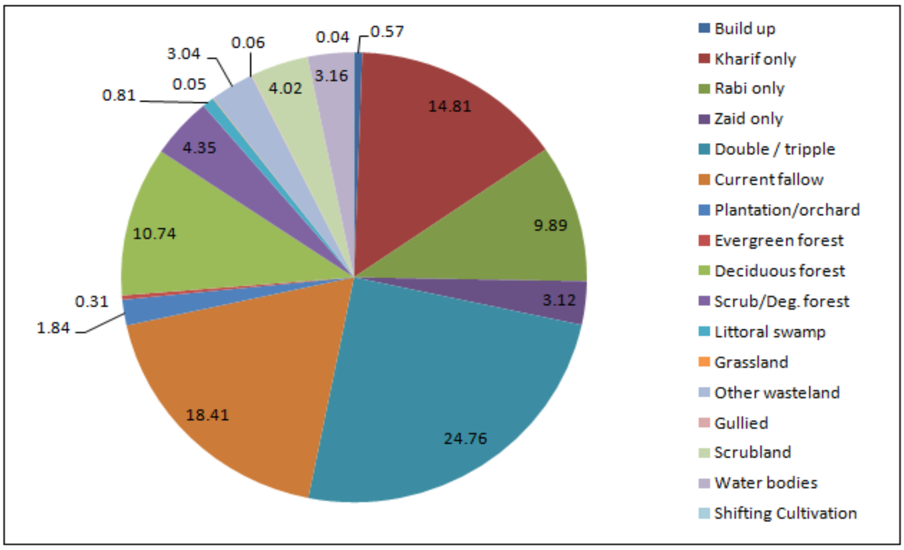


Figure 12.24 Distribution of LULC in Lower Ganga sub-basin (2004-05)

12 (a).8.2 Soil texture

The soil texture of the sub-basin may be classified as clayey, loamy, sandy and some rock outcrops. Figure 12.24 shows the soil texture map of the sub-basin.

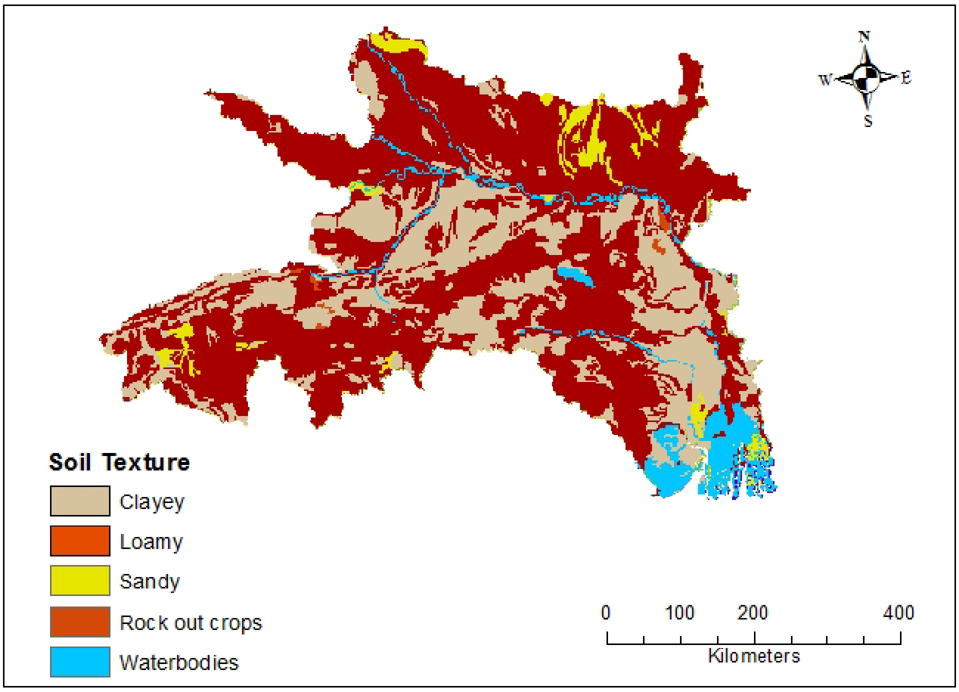


Figure 12.25 Soil texture map of Lower Ganga sub-basin

12 (a).8.3 Topography

The Lower Ganga sub-basin extends from the eastern margin of the Punjab in the west to Bangladesh border in the east. This is an extensive plain encompassing States of Uttar Pradesh, Bihar, Chhattigarh, Jharkhand, Madhya Pradesh and West Bengal. It is drained by the rivers such as Yamuna, Ganga, Ghaghara, Gandak and Kosi from the Himalayas in the north and Chambal, Betwa, Son and Damodar from the plateau in the south. The entire region slopes towards south and south-east.

This sub-basin is in alluvial plains with low undulation. The lower reaches of the sub-basin are slightly above the sea-level, however, the upper portion rises up to 200 meters. The Ganga forms a great delta on its mouth. The elevation values ranges from a minimum of 0 m to a maximum of 2,566 m. The average elevation is about 192 m in the basin. Figure 12.26 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the sub-basin.

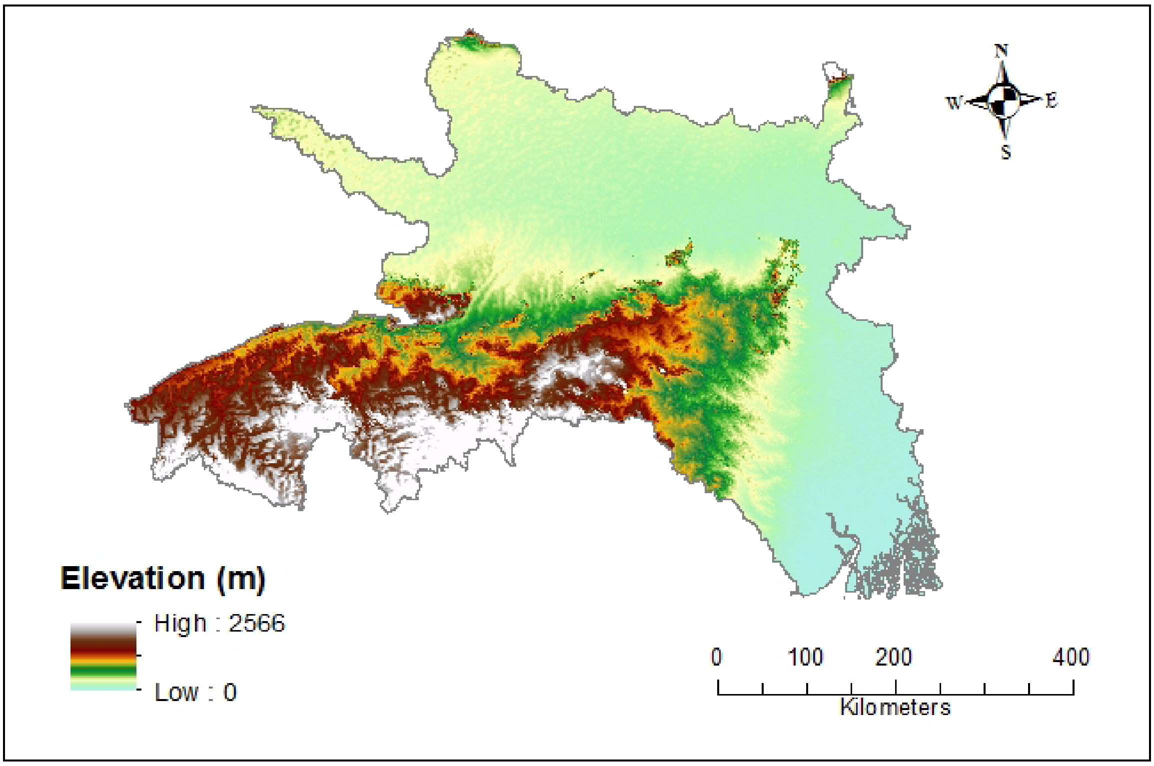


Figure 12.26 SRTM DEM map of Lower Ganga sub-basin

12 (a).9 Hydro-Meteorological and other Input Data

12 (a).9.1 Rainfall grids

Figure 12.27 shows gridded annual rainfall map of Lower Ganga sub-basin for year 2004-05. The variation in the annual rainfall during study period of 30 years (1985-86 to 2014-15) is shown in the Figure 12.28. Annual rainfall of the basin varies from 244 mm to 3,782 mm and mean rainfall of 30 years is found to be 1,270 mm. Out of 30 years, for 15 years annual rainfall is higher than the mean rainfall and for remaining 15 years it is lower than the mean rainfall.

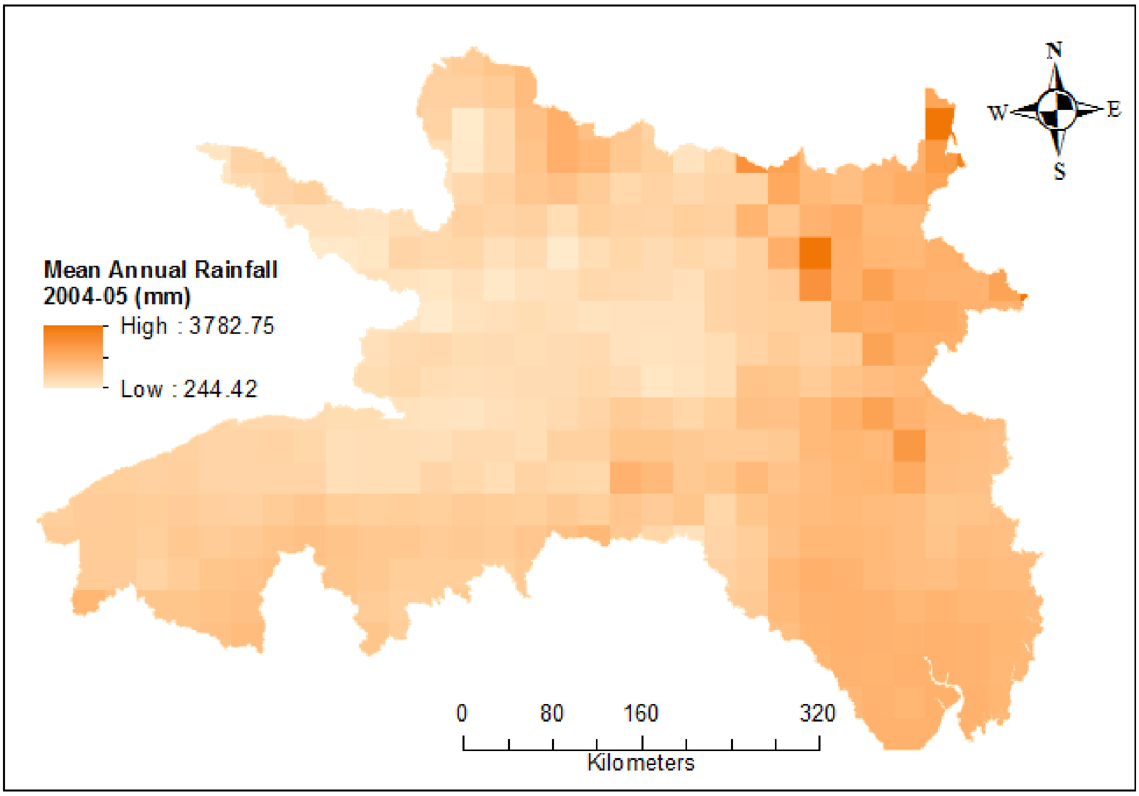


Figure 12.27 Gridded rainfall of Lower Ganga sub-basin (2004-05)

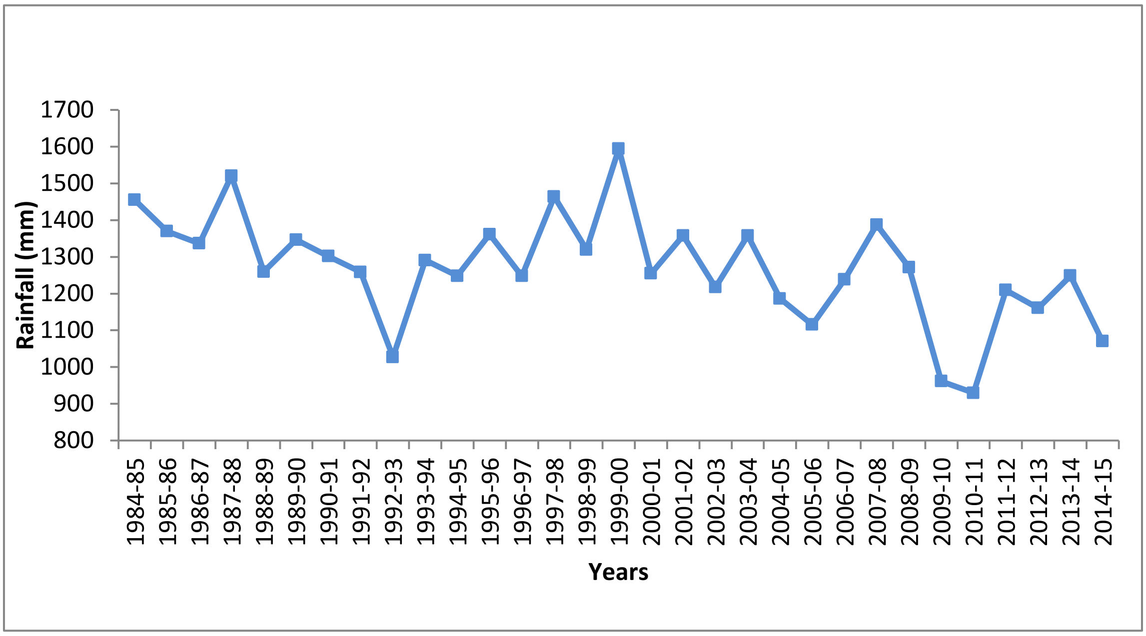


Figure 12.28 Annual rainfalls in Lower Ganga sub-basin (1985-86 to 2014-15)

12 (a).9.2 Temperature grids

Gridded mean annual temperature map of the basin for 2004-05 year is shown in Figure 12.29.

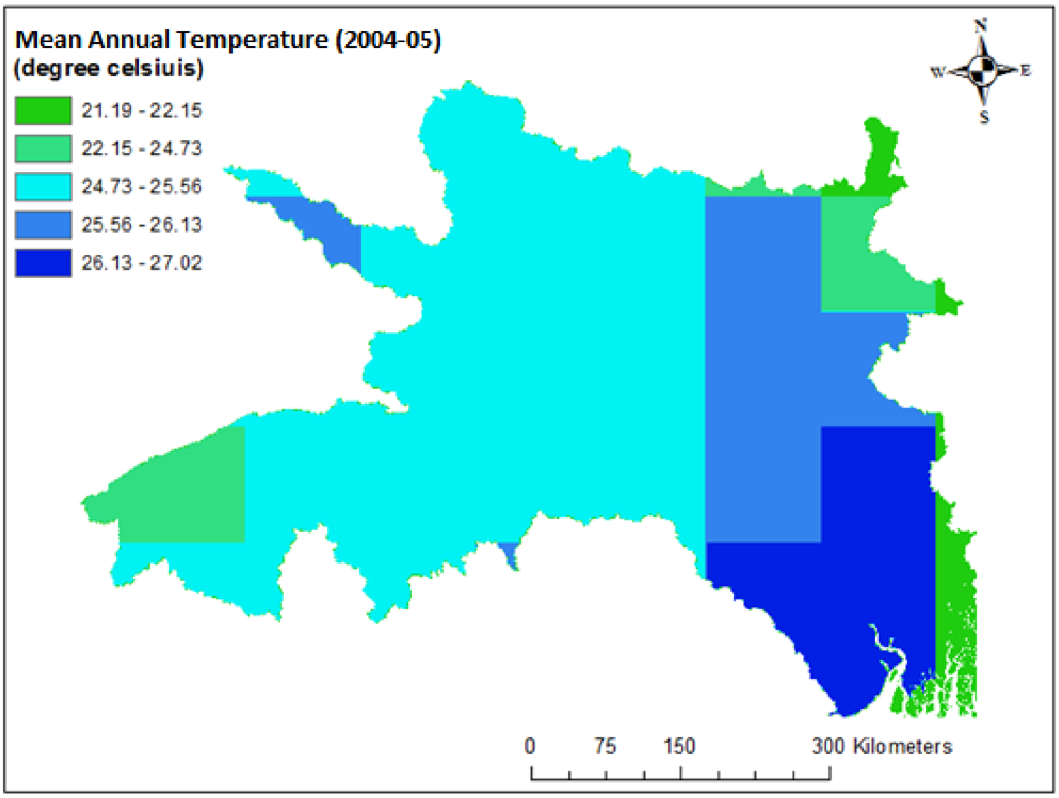


Figure 12.29 Gridded mean annual temperature for Lower Ganga sub-basin (2004-05)

12 (a).9.3 Sub-basins of Lower Ganga sub-basin

The Lower Ganga sub-basin is divided into ten sub-basins (Figure 12.30) viz. Chopan, Koelwar, Gandhighat, Hathidah, Farakka, Hanskhali, Chapra, Jamalpur, Mohanpur and combined Delta region as one sub-basin. Table 12.6 gives details of each sub-basin. The sub-basins are divided in such a way that the location of CWC discharge sites is taken as sub-basin terminal point.

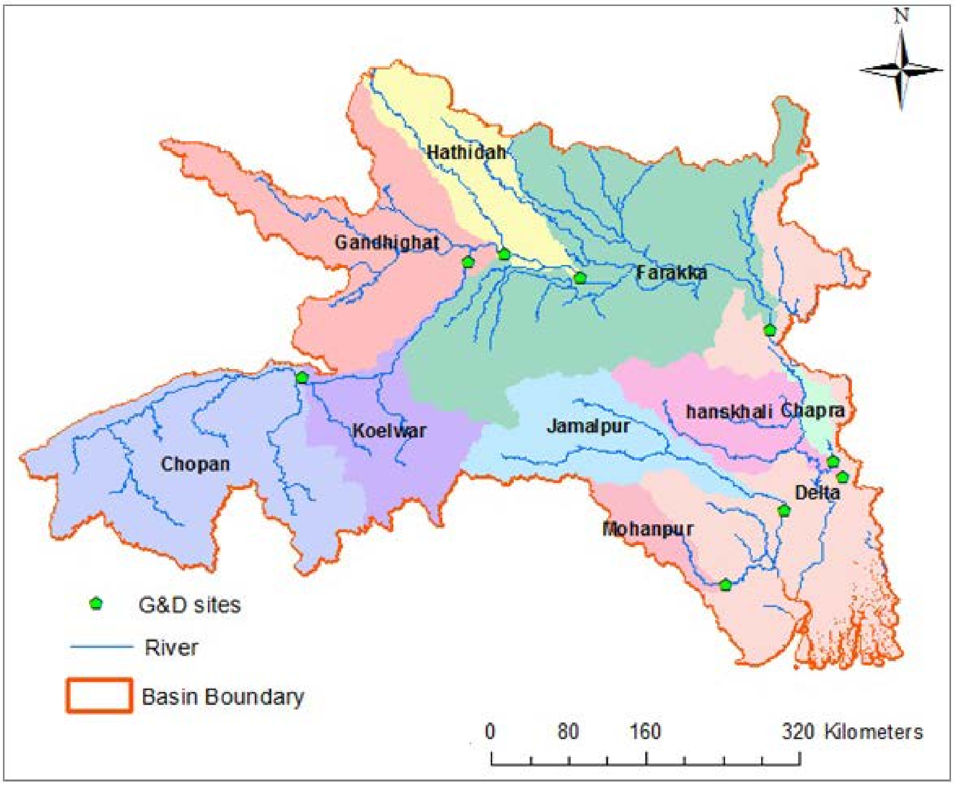


Figure 12.30 Sub-basins of Lower Ganga sub-basin

Table - 12.6 Sub-basin wise details of Lower Ganga sub-basin

S.No.	Sub-basin	River	Individual drainage area (sq.km)
1	Chopan	Sone	46,460
2	Koelwar	Sone	20,441
3	Gandhighat	Ganga	35,528
4	Hathidah	Ganga	18,579
5	Farakka	Ganga	70,280
6	Hanskhali	Churni	16,749
7	Chapra	Jalangi	2,666
8	Jamalpur	Damodar	21,327
9	Mohanpur	Kangsabati	5,728
10	Delta	Ganga	50,525
		Total basin area	2,88,283

12 (a).9.4 River discharge

The river discharge data are available at all the nine sites for the study period of 30 years. The daily discharge data have been aggregated to annual scale and used for calibration and validation of model computed runoff at sub-basin level.

12(a).9.5 Reservoir flux

Figure 12.31 shows the location of some of major reservoirs in the basin. Reservoir flux data of Maithon, Panchet, Konar, Tilaiya, Tenughat and Bansagar reservoirs have been used in the calibration of different sub-basins.

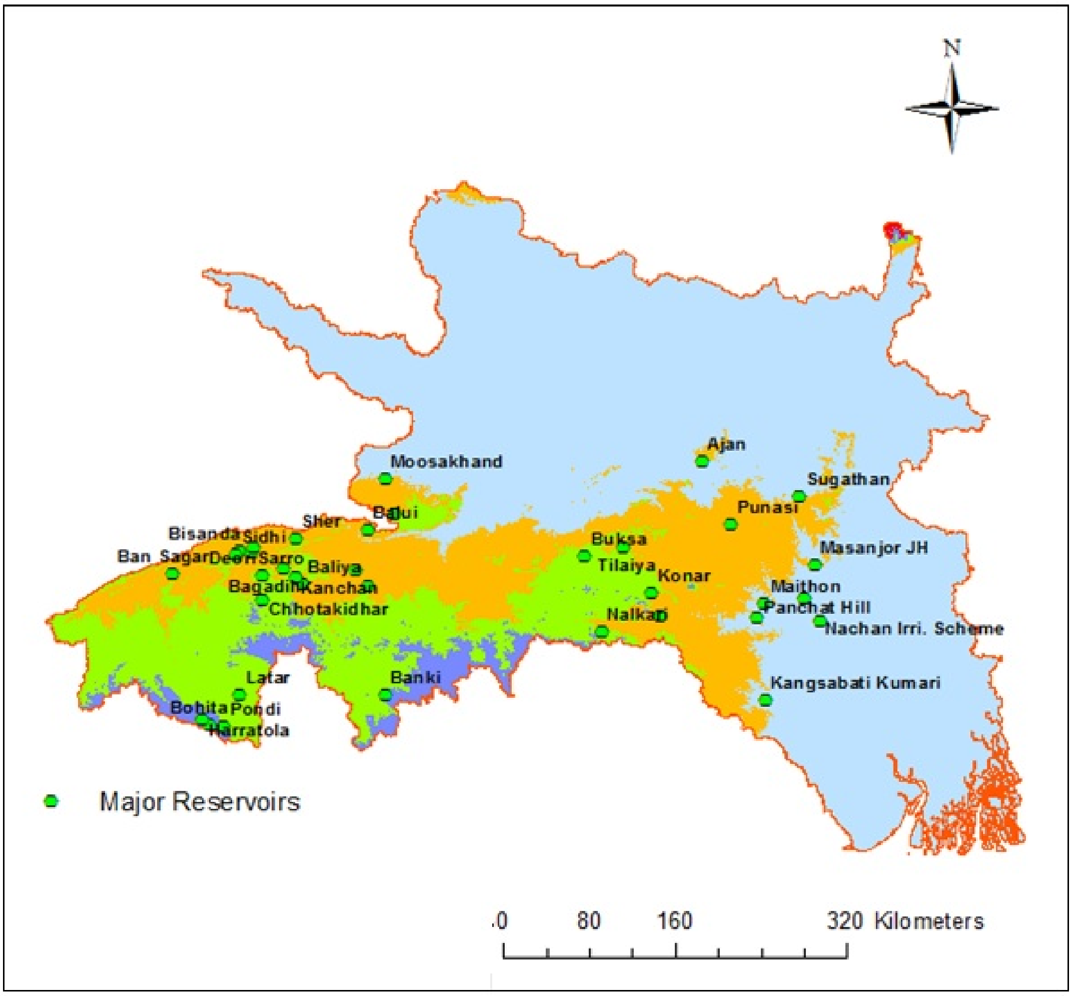


Figure 12.31 Major reservoirs in Lower Ganga sub-basin

12 (a).9.6 Groundwater flux

The spatial groundwater flux in the lower Ganga sub-basin for the year 2004-05 is shown in Figure 12.32. The annual variation in the flux for the study period (1985-86 to 2014-15) is shown in Figure 12.33.

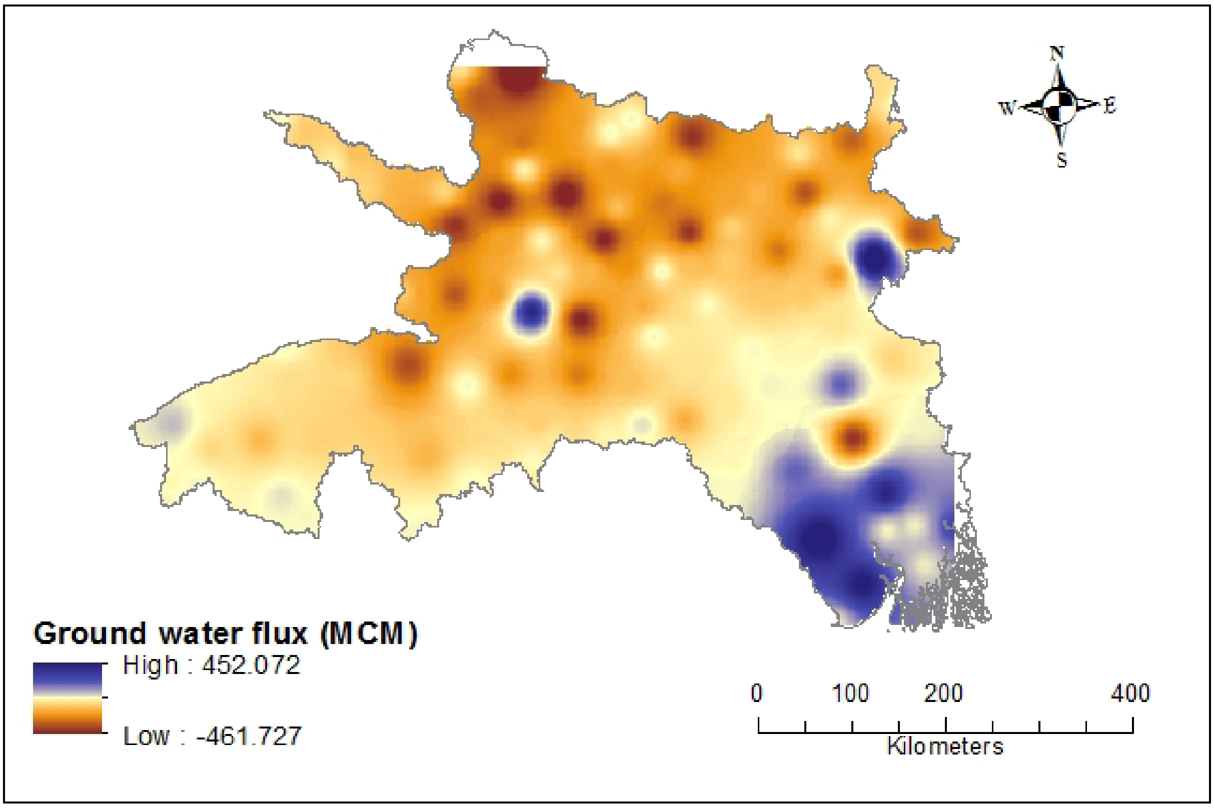


Figure 12.32 Groundwater flux (spatial data) estimated during 2004-05

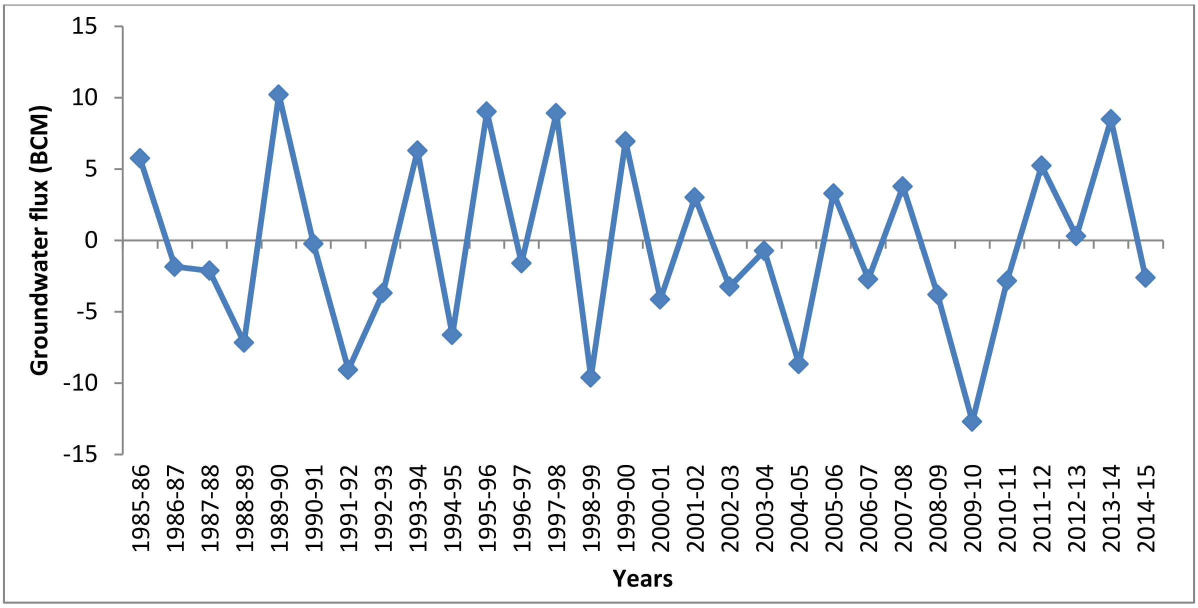


Figure 12.33 Annual groundwater flux of Lower Ganga sub-basin (1985-86 to 2014-15)

12 (a).9.7 Major crops in the basin

Based on the district-wise crop area statistics, district wise major crops for each crop season have been identified. The basin is divided in three regions based on the historic district-wise crop statistics collected from various sources (http://lus.dacnet.nic.in/ dt_lus.aspx). Each region specifies a unique crop for each crop season both spatially and temporally within the basin. Hence, the coefficients are taken as per the crop in that particular region/district. On examining the cropping pattern within the basin, crop growing seasons have been decided as Kharif only crop during 4 months (July to October), Rabi only crop during 4 months (November to February), Double/Triple crop during 8-12 months.

12 (a).9.8 Irrigation command area

Figure 12.34 shows location of irrigation command boundaries inside and outside the Lower Ganga sub-basin considered for the year 2014-15. Since annual command boundary maps are not available, command area has been selected from the year 2014-15 based on the completion of the project/dam. Hence, the command area considered during the year 2014-15 has been worked out to be 9,71,31,000 hectare (excluding the basin outside command). Basin outside command has been taken uniformly for all years while working out ECII from these areas.

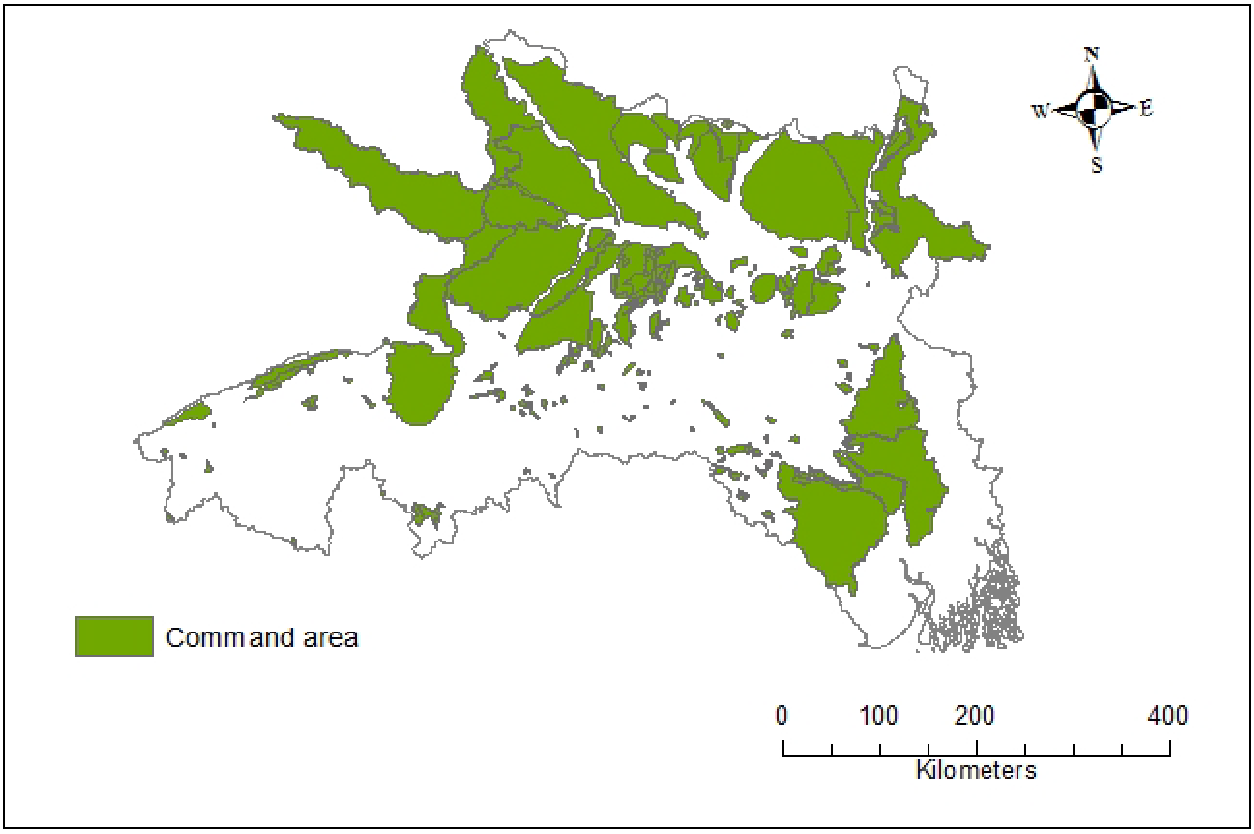


Figure 12.34 Irrigation command boundaries of Lower Ganga sub-basin

12 (a).9.9 Domestic, industrial and livestock demand

Figure 12.35 shows district boundaries map for the sub-basin as per 2011 census. The mean annual domestic, industrial and livestock demands are estimated as 4.05 BCM in the Lower Ganga sub-basin.

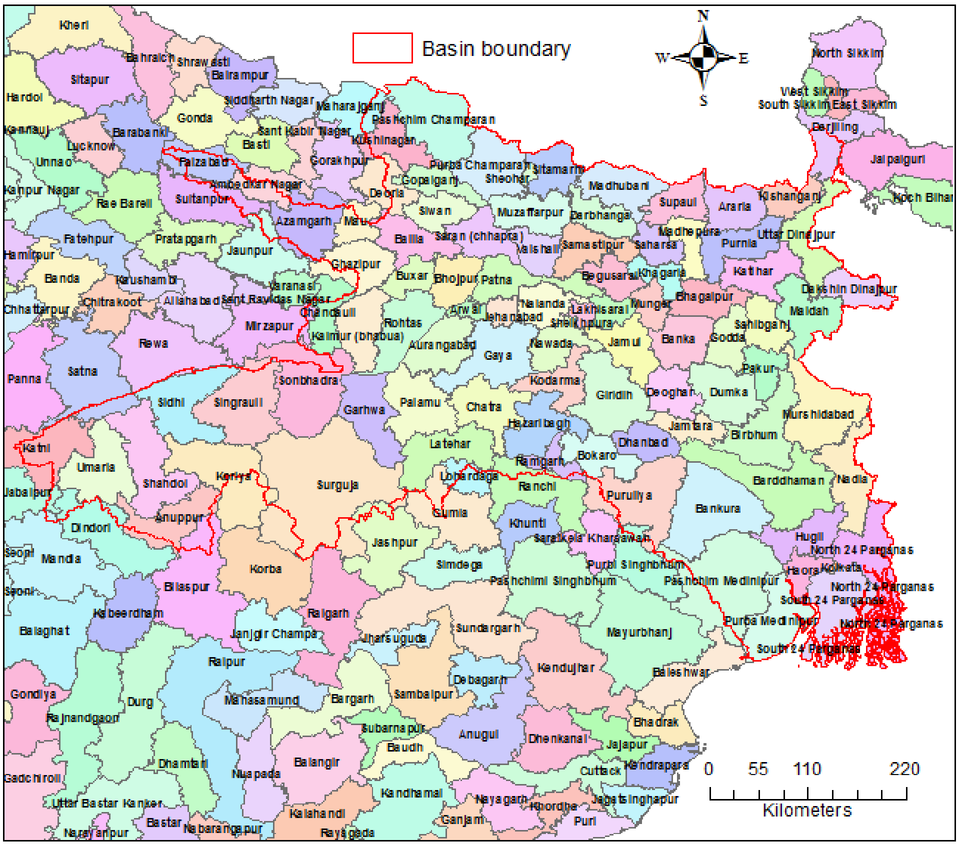


Figure 12.35 District boundaries in Lower Ganga sub-basin

12 (a).9.10 Evaporation from major/medium/minor reservoirs and other water bodies

Table - 12.7 provides annual evaporation values from each of sub-basins for the period of 1985-86 to 2014-15 (30 years). Hathidah and Chapra sub-basin have no significant reservoir evaporation. The average annual evaporation volume for the Lower Ganga sub-basin is worked out as 0.603 BCM.

Table - 12.7 Evaporation from reservoirs in Lower Ganga sub-basin

Year	Reservoir evaporation in each independent sub-basin (in BCM)							
	Chopan	Koelwar	Jamal-pur	Gandhi-ghat	Hanskhali	Farakka	Mohan-pur	Delta
1985-86	0.40	0.48	0.40	0.85	0.20	2.52	0.07	1.22
1986-87	0.45	0.48	0.41	0.84	0.21	2.33	0.08	1.28
1987-88	0.35	0.46	0.52	0.64	0.27	2.66	0.18	1.87
1988-89	0.39	0.46	0.38	0.82	0.23	2.37	0.07	1.26
1989-90	0.47	0.46	0.43	0.77	0.20	2.30	0.08	1.43
1990-91	0.46	0.45	0.38	0.72	0.19	2.17	0.08	1.19
1991-92	0.38	0.43	0.40	0.71	0.19	2.26	0.08	1.33
1992-93	0.34	0.41	0.30	0.80	0.21	2.27	0.09	1.72
1993-94	0.44	0.46	0.40	0.79	0.19	2.28	0.08	1.26
1994-95	0.45	0.49	0.41	0.79	0.17	1.89	0.07	1.22
1995-96	0.40	0.47	0.41	0.80	0.22	2.23	0.08	1.24
1996-97	0.38	0.43	0.39	0.87	0.20	2.27	0.07	1.39
1997-98	0.35	0.54	0.68	0.69	0.33	2.57	0.24	2.05
1998-99	0.39	0.47	0.43	0.75	0.21	2.30	0.07	1.30
1999-00	0.38	0.49	0.64	0.66	0.35	2.88	0.21	2.21
2000-01	0.41	0.46	0.41	0.74	0.20	2.38	0.07	1.28
2001-02	0.46	0.52	0.44	0.99	0.22	2.58	0.08	1.31
2002-03	0.32	0.44	0.36	1.31	0.24	2.65	0.12	1.77
2003-04	0.46	0.49	0.44	0.88	0.24	2.76	0.08	1.27
2004-05	0.31	0.39	0.35	1.05	0.21	2.65	0.12	1.75
2005-06	0.41	0.42	0.31	0.73	0.23	2.14	0.09	1.67
2006-07	0.39	0.54	0.39	0.87	0.24	2.27	0.07	0.46
2007-08	0.29	0.49	0.50	0.66	0.20	2.44	0.18	0.85
2008-09	0.33	0.40	0.39	1.00	0.28	3.22	0.10	0.56
2009-10	0.28	0.41	0.38	0.82	0.21	1.96	0.05	0.28
2010-11	0.27	0.46	0.38	0.55	0.15	2.12	0.03	0.49
2011-12	0.41	0.53	0.38	0.95	0.16	3.03	0.08	0.50
2012-13	0.38	0.46	0.38	0.85	0.13	2.48	0.08	0.47
2013-14	0.44	0.38	0.38	0.61	0.16	1.36	0.08	0.60
2014-15	0.31	0.39	0.38	1.20	0.55	3.23	0.21	0.97
Avg	0.38	0.46	0.41	0.82	0.23	2.42	0.10	1.21

12 (a).10 Previous Estimates

No separate assessment of water resources potential for Lower Ganga sub-basin had been done in the past. However, in respect of Ganga, the erstwhile Ganga Basin Water Studies Organisation of Central Water Commission carried out the assessment of water resources potential and had presented the details of the study in their report of 1986. Ganga basin was divided into ten sub-basins for the study and the assessment was based on the actual observed flow data available at several locations for durations ranging from 5 years to 20 -25 years. Simple rainfall-runoff regression analysis and multi-site data generation were resorted to wherever the observed flow data were found to be inadequate. As per 1993 studies for Reassessment of Water Resources Potential of India, the water resource potential was estimated as 525 BCM for the whole Ganga basin for a catchment area of 8,61,452 sq.km.

12 (a).11 Runoff Estimation

Tables - L.8 to L.18 (at Annexure L(b)) give calibrated discharge along with observed discharge, rainfall, ECII, etc during 30 years for the nine G&D sites and for the whole Lower Ganga sub-basin. Figures 12.36 to 12.45 show comparative graphs of calibrated and observed discharge at these sites.

Table L.18 at Annexure - L(b) gives calibrated runoff of the basin for 30 years. The mean annual calibrated runoff is about 84.48 BCM. The maximum annual calibrated runoff is 176.50 BCM during 1999-2000. The minimum annual calibrated runoff is 5.19 BCM during 2010 -11. The mean annual ECII is about 91.11 BCM. The maximum annual ECII is about 128.56 BCM during 2009-10. The minimum annual ECII is about 62.95 BCM during 1999-2000.

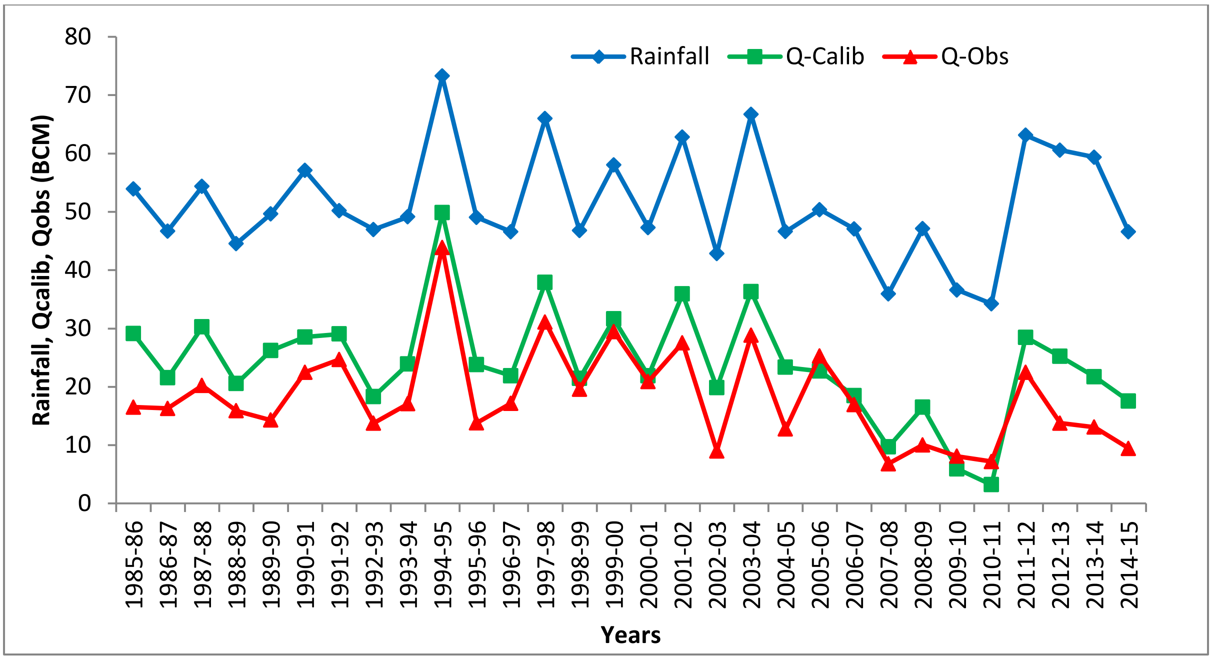


Figure 12.36 Calibrated runoff and observed discharge at Chopan on river Sone

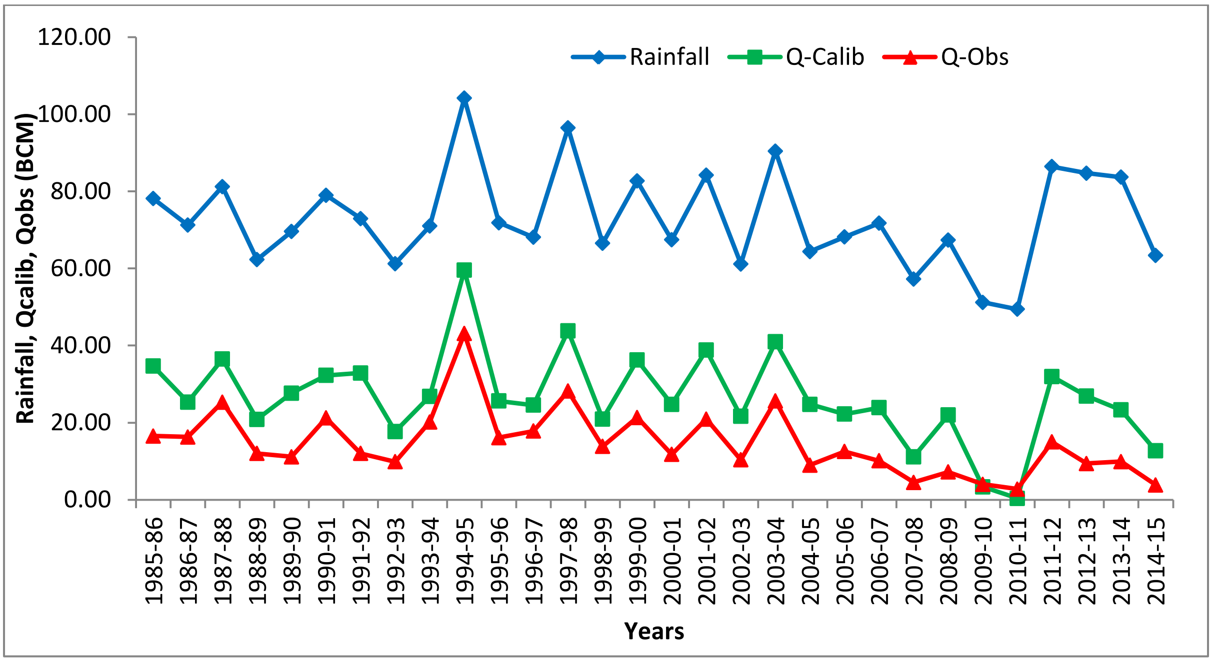


Figure 12.37 Calibrated runoff and observed discharge at Koelwar on river Sone

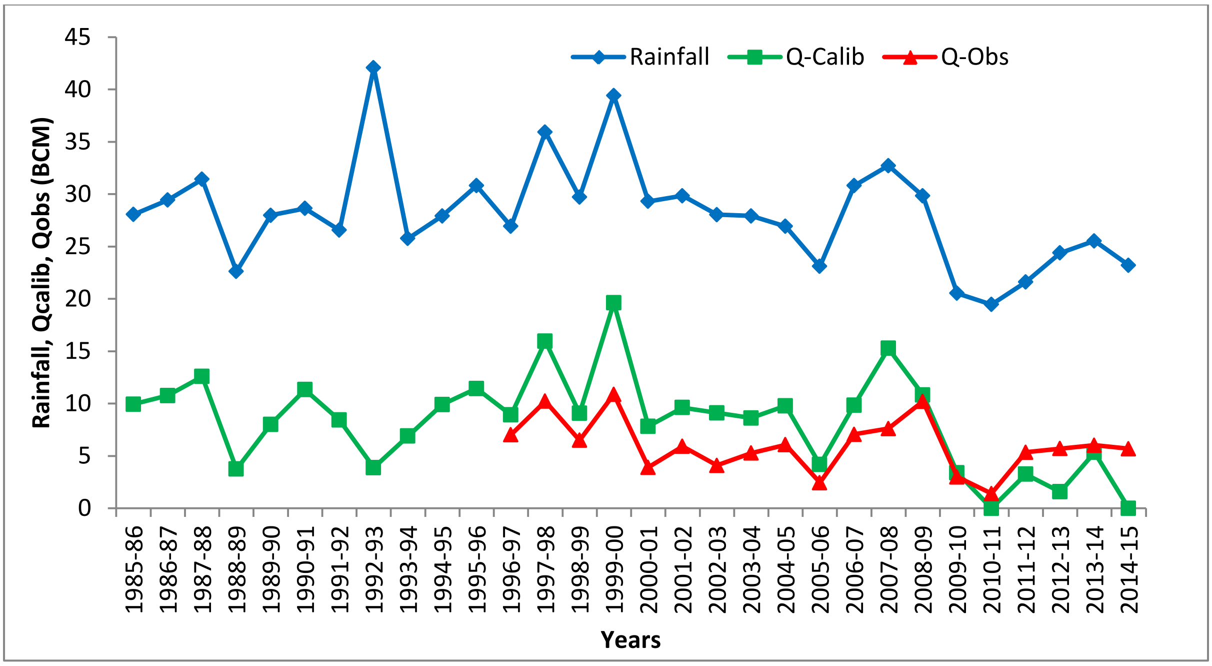


Figure 12.38 Calibrated runoff and observed discharge at Jamalpur on river Damodar

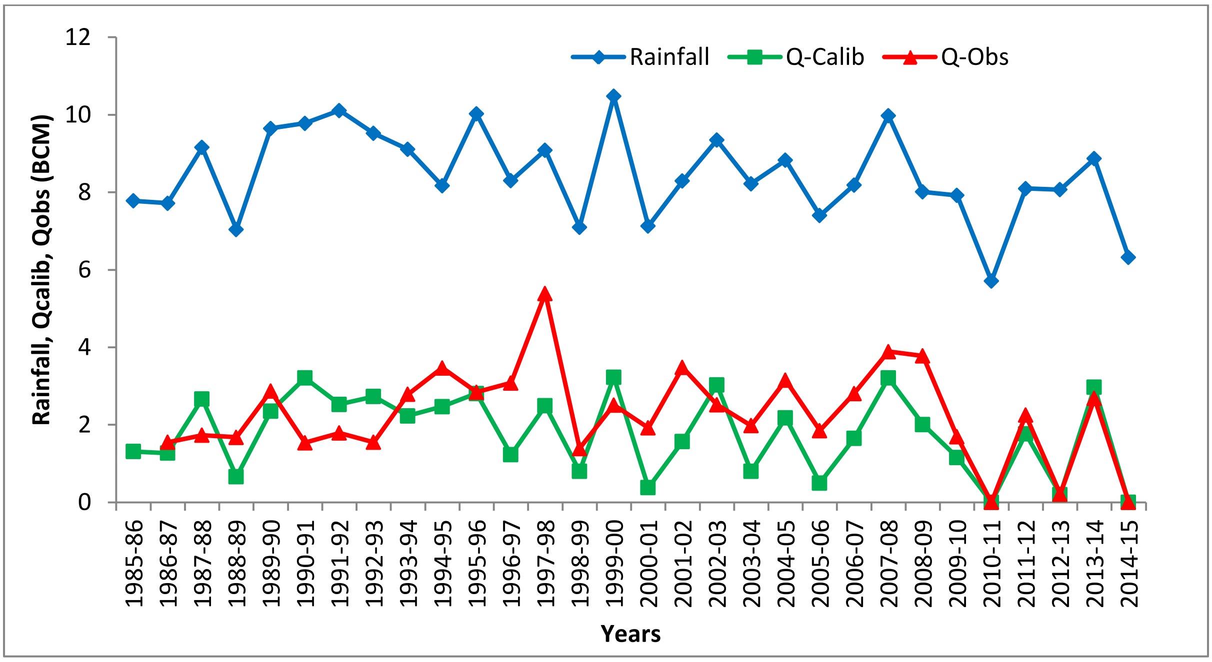


Figure 12.39 Calibrated runoff and observed discharge at Mohanpur on river Kangsabati

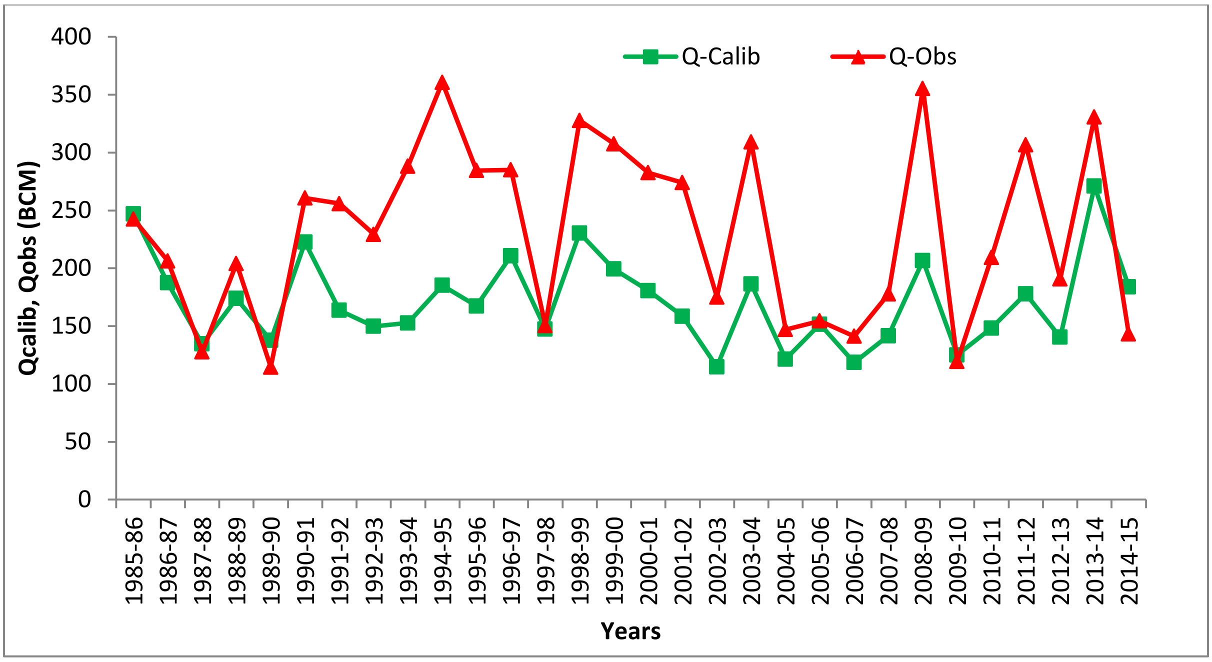


Figure 12.40 Calibrated runoff and observed discharge at Gandhighat

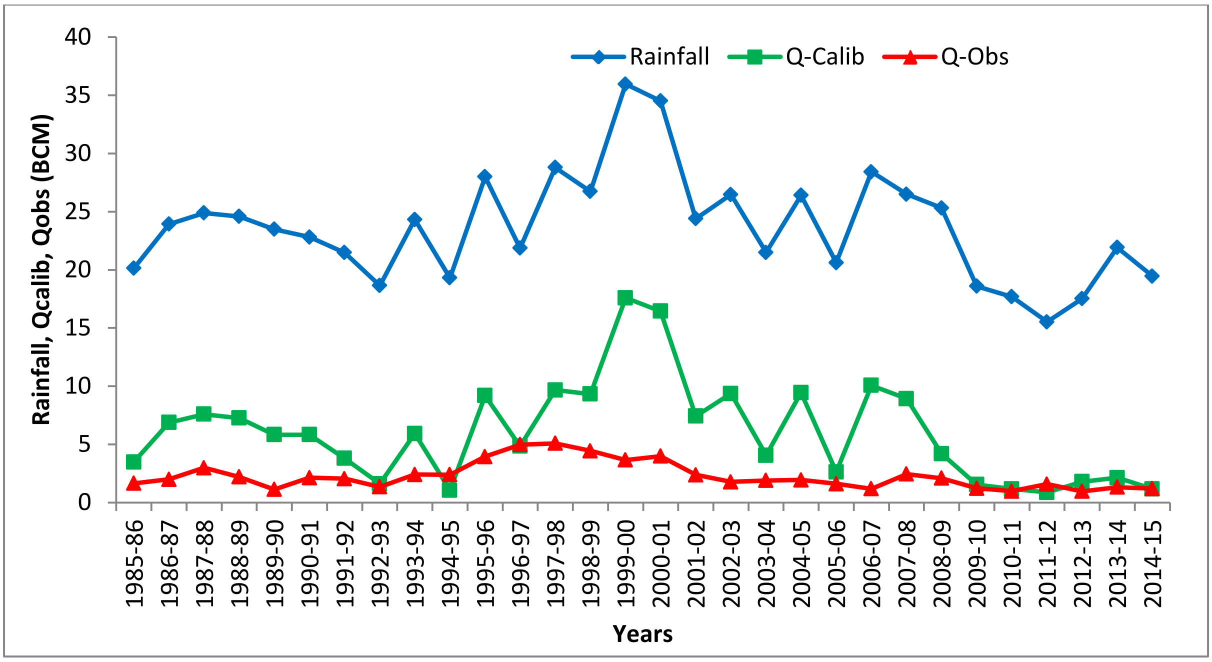


Figure 12.41 Calibrated runoff and observed discharge at Hanskhali on river Churni

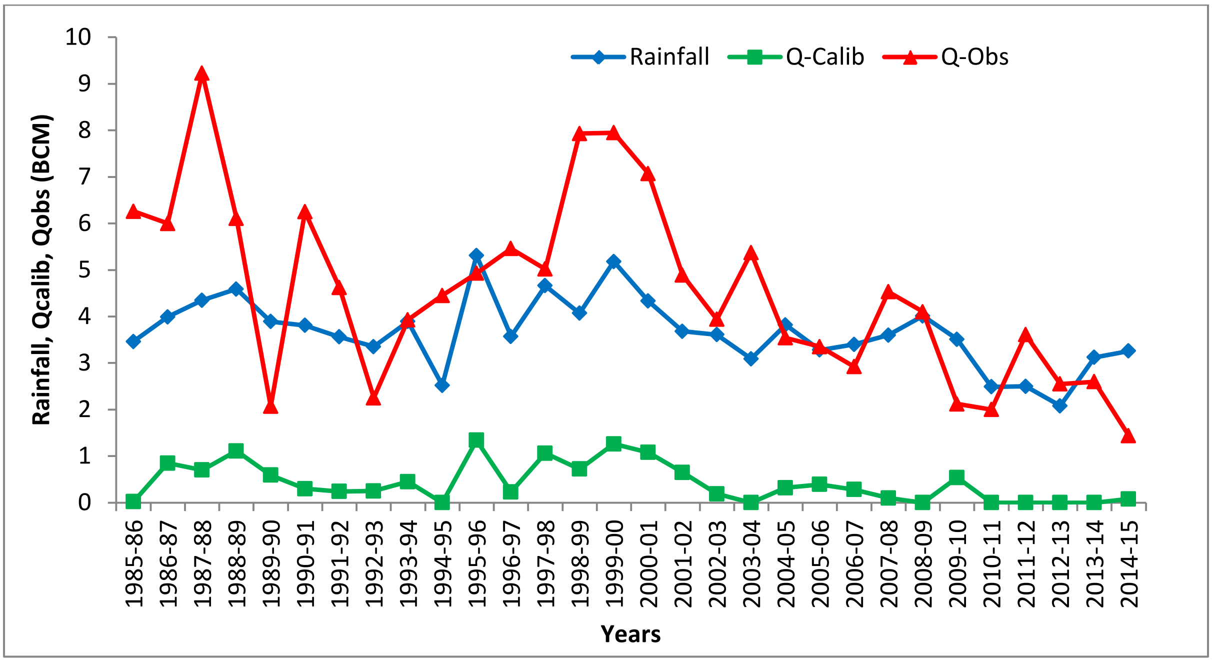


Figure 12.42 Calibrated runoff and observed discharge at Chapra on river Jalangi

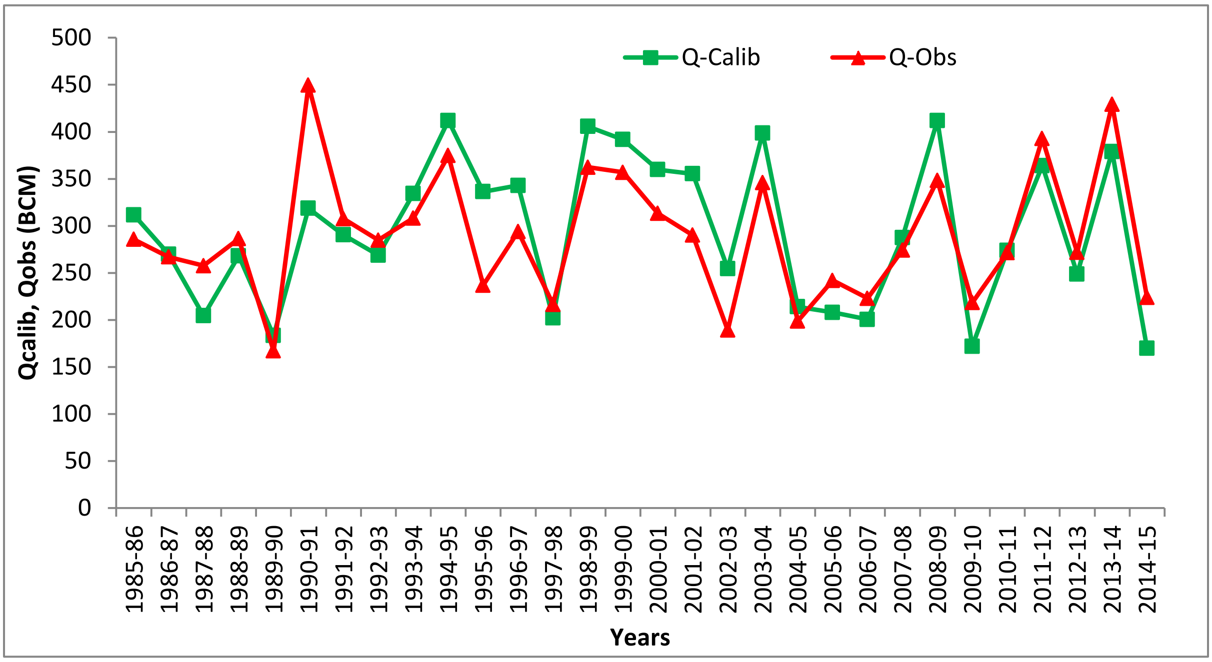


Figure 12.43 Calibrated runoff and observed discharge at Hathidah

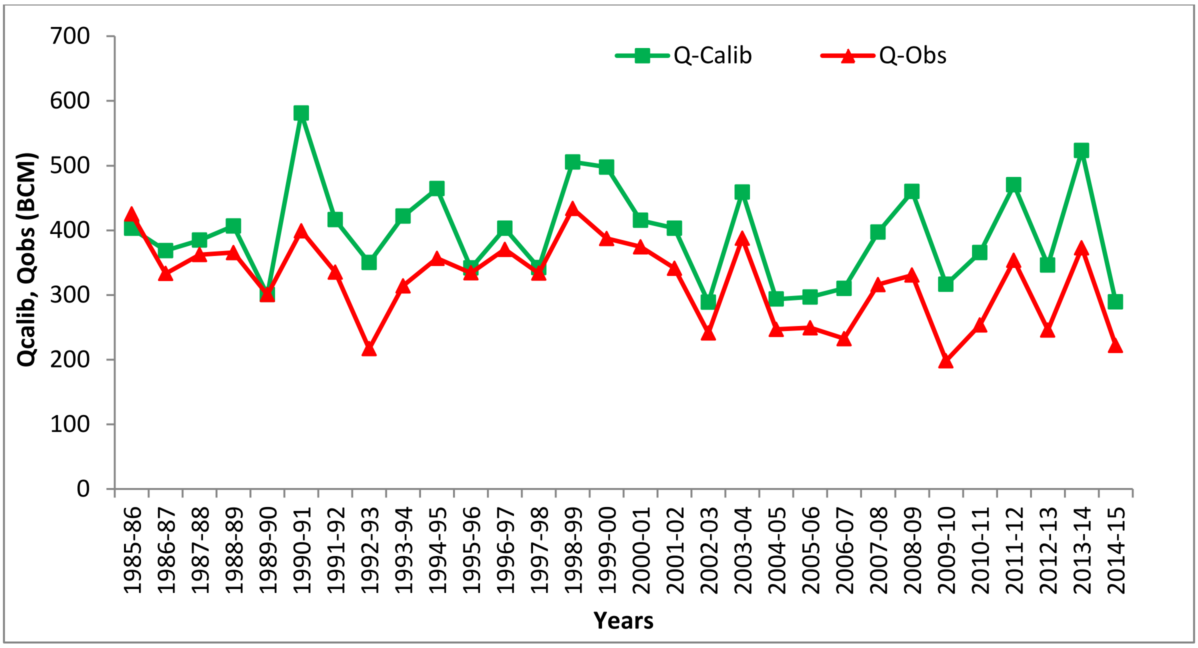


Figure 12.44 Calibrated runoff and observed discharge at Farakka

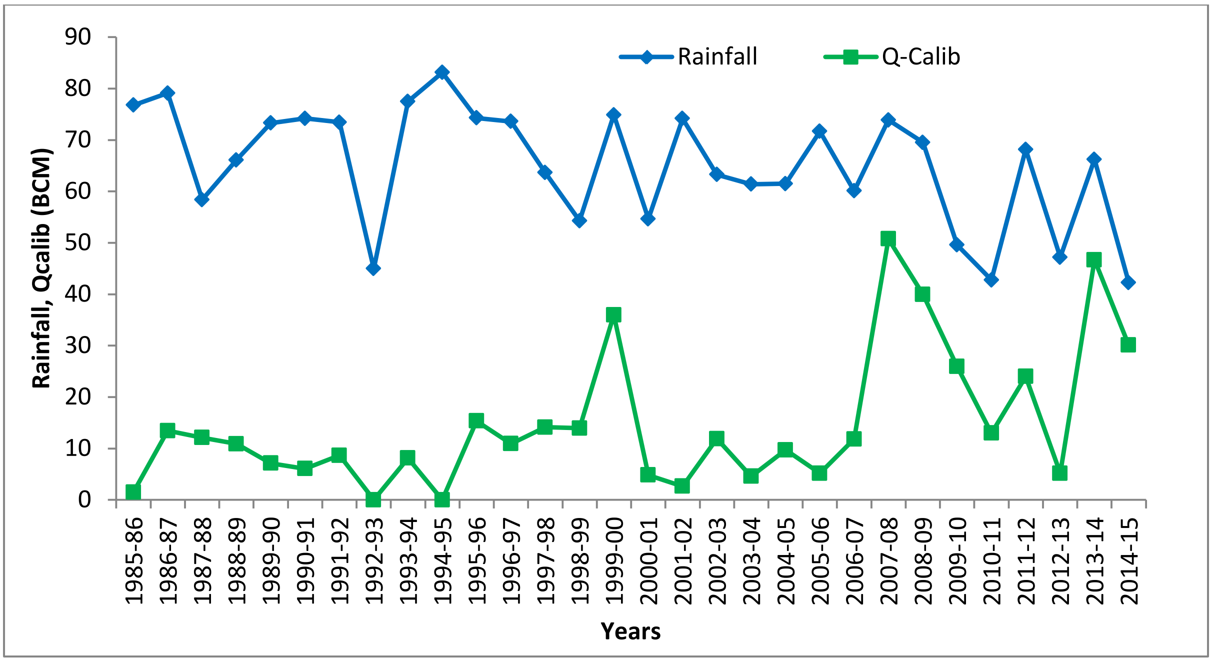


Figure 12.45 Calibrated runoff and rainfall for Delta

12 (a).12 Annual Water Resource Availability of Lower Ganga Sub-basin

Table - L.18 shows different components required to estimate the basin level water resources of Lower Ganga sub-basin for 30 years period. The maximum and minimum annual water resource availability is 266.45 BCM during 1999-2000 and 128.57 BCM during 2010 -11 respectively in the 30 years period.

The average annual water resource availability of Lower Ganga sub-basin is 192.60 BCM.

75% dependable flow of Lower Ganga sub-basin is 179.25 BCM.

The water resources availability of Lower Ganga sub-basin accounts for about 52.86% of mean annual rainfall during the period 1985-86 to 2014-15. The total population as per 2011 census is 240.63 million and hence average annual water availability per capita is about 800.39 cubic metres.

12 (a).12.1 Annual water resources of basin during extreme rainfall conditions

Out of the total 30 years of meteorological data base of study period, during the years 1999-2000 and 2010-11, extreme wet and dry rainfall conditions occurred in Lower Ganga sub-basin respectively. The annual water resources of Lower Ganga sub-basin during these two extreme rainfall conditions are 266.45 BCM and 128.57 BCM respectively as shown in Table 12.8. The water balance components during these years are presented in Figures 12.46 and 12.47.

Table - 12.8 Water resources availability in Lower Ganga sub-basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	1999-2000	459.76	266.45
Minimum Rainfall	2010-11	268.03	128.57

Water resources availability-rainfall ratio during the extreme maximum and minimum rainfall years is found to be 0.58 and 0.48 respectively, which shows that the higher the rainfall, the higher percentage of runoff. During higher rainfall years, potential evapotranspiration is less compared to the dry years. This will have cumulative effect in runoff. It is found that the ECII during 1999-2000 is less than the year 2010-11.

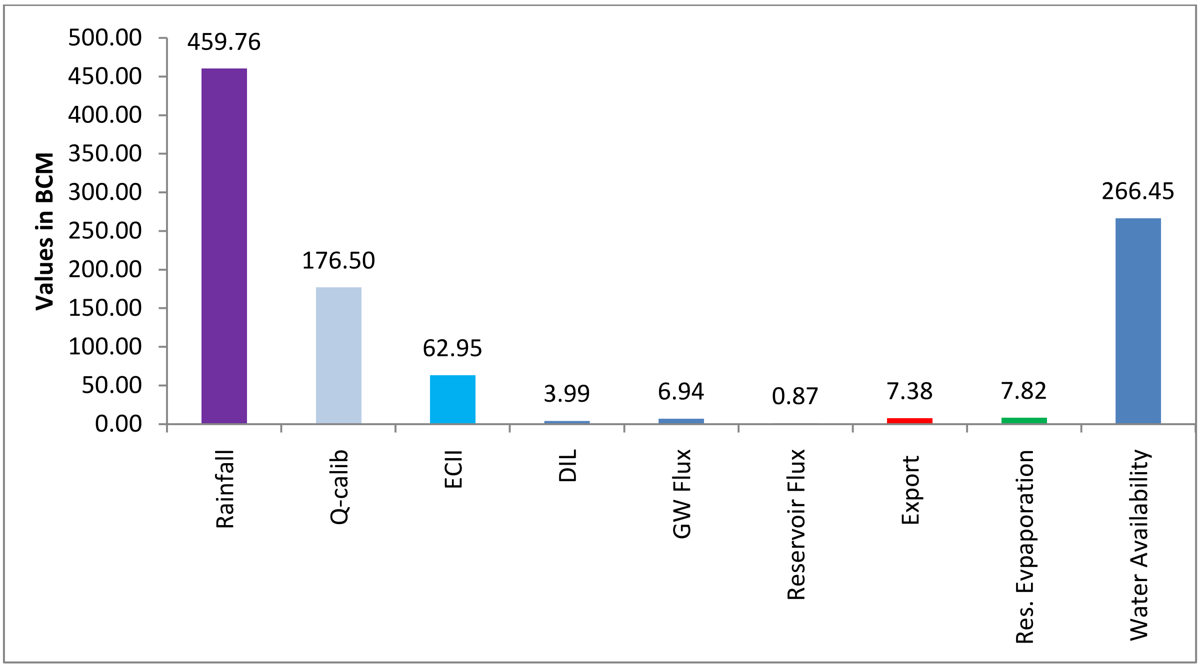


Figure 12.46 Water balance components of Lower Ganga sub-basin during extreme high rainfall (1999-2000)

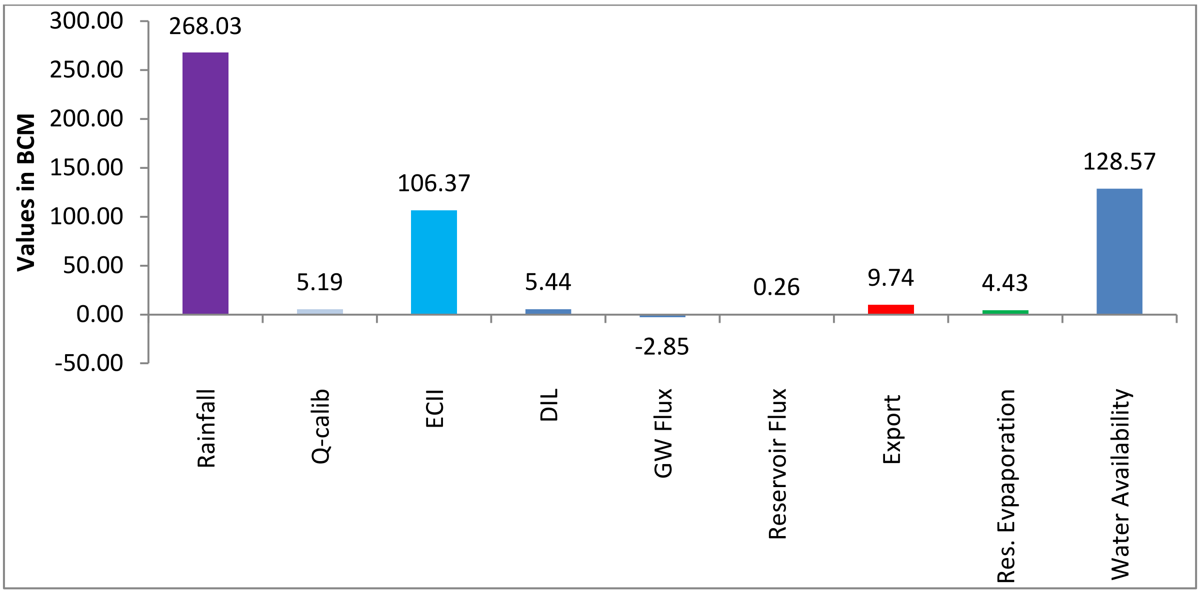


Figure 12.47 Water balance components of Lower Ganga sub-basin during extreme low rainfall (2010-2011)

12.12.2 Mean water resources of Lower Ganga sub-basin

The mean water resources of the basin is computed by taking the mean of the 30 years water balance components such as flow in the river at final outlet, upstream effective utilisations for irrigation, domestic and industrial, change in storage of groundwater, change in strorage of reservoirs and evaporation from reservoirs.

Mean water resources = Mean of (Calibrated Runoff + Estimated Consumptive Irrigation Input + Domestic, Industrial and Livestock consumption + Groundwater Flux + Reservoir Flux + Export from basin + Evaporation from Reservoirs)

= 84.48 + 91.11 + 4.05 - 0.41 + 0.26 + 7.08 + 6.03 = 192.60* BCM

**This includes contribution from Nepal.*

The mean available annual water resource of the Lower Ganga sub-basin is 192.60 BCM and 75% dependable flow is 179.25 BCM. Figure 12.48 shows the various water balance components averaged over a period of 30 years during 1985-86 to 2014-15.

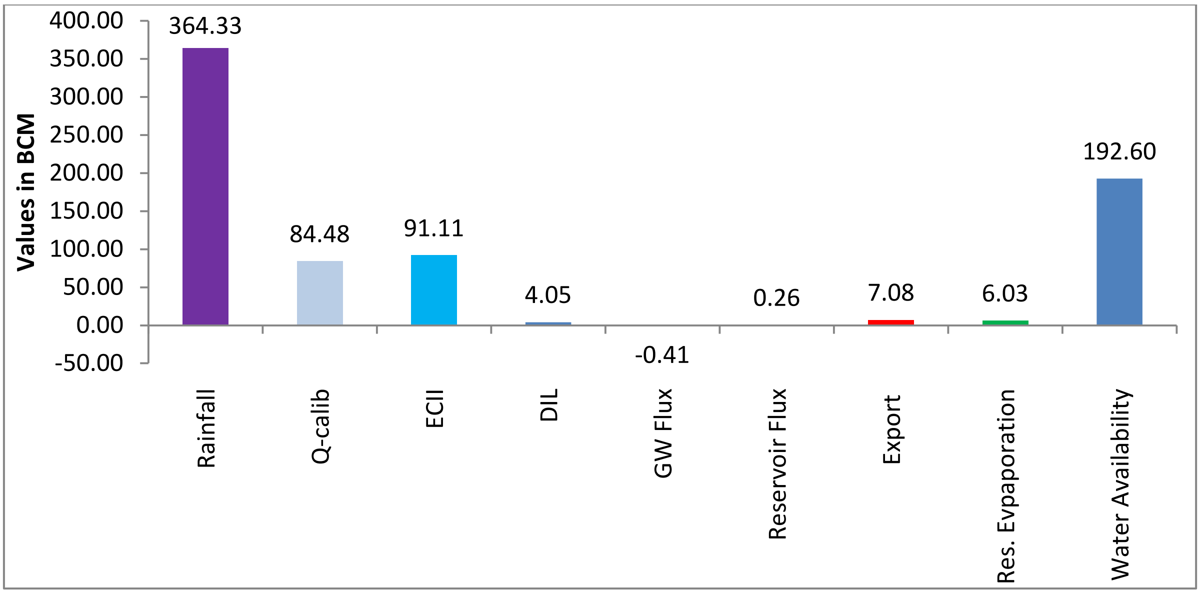


Figure 12.48 Mean water balance components of Lower Ganga sub-basin

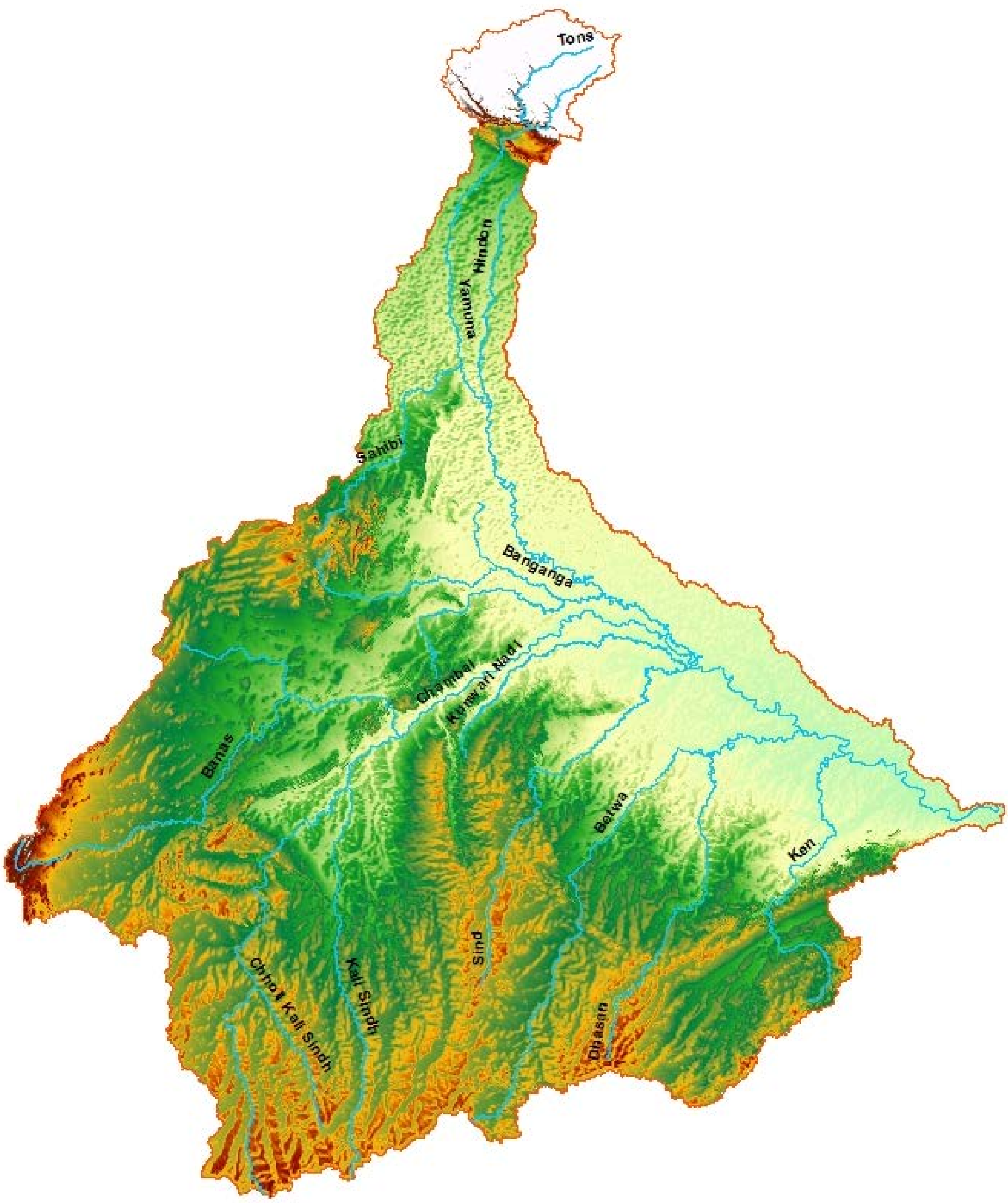
12 (a).13 Basin outward diversions/imports

Lower Ganga sub-basin exports water to Upper Ganga sub-basin. As shown in Table L.18 the average export is about 7.08 BCM. The export takes place from Chopan sub-basin (Bansagar dam) to Upper Ganga sub-basin.

HIGHLIGHTS

- *Mean annual available water resources of Lower Ganga Sub- basin is 192.60 BCM.*
- *Maximum annual water availability is 266.45 BCM during 1999-2000.*
- *Minimum annual water availability is 128.57 BCM during 2010-11.*
- *Annual rainfall in the basin varies from 244 mm to 3,782 mm during 1985-86 to 2014-15 and mean rainfall for these 30 years is 1,270 mm.*
- *Lower Ganga sub-basin is divided into ten sub-basins for the reassessment study viz. Chopan, Koelwar, Gandhighat, Hathidah, Farakka, Hanskhali, Chapra, Jamalpur, Mohanpur and combined Delta region as one sub-basin.*
- *Average annual domestic, industrial and livestock demand in the basin is 4.05 BCM.*
- *Average annual evaporation from water bodies in the basin is 6.03 BCM.*

YAMUNA SUB-BASIN



12 (a).14 Geo-Spatial Datasets

12 (a).14.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map of Yamuna sub-basin is shown in Figure 12.49. The map corresponds to the 2004-05 year and consists of sixteen different classes. Figure 12.50 shows distribution (in percentage) of LULC in the lower Ganga sub-basin for 2004-05. LULC analysis indicates Kharif (16.62%), Rabi (26.11%), Double/Triple (19.37%) and scrub/degraded forest are major classes in Yamuna sub-basin.

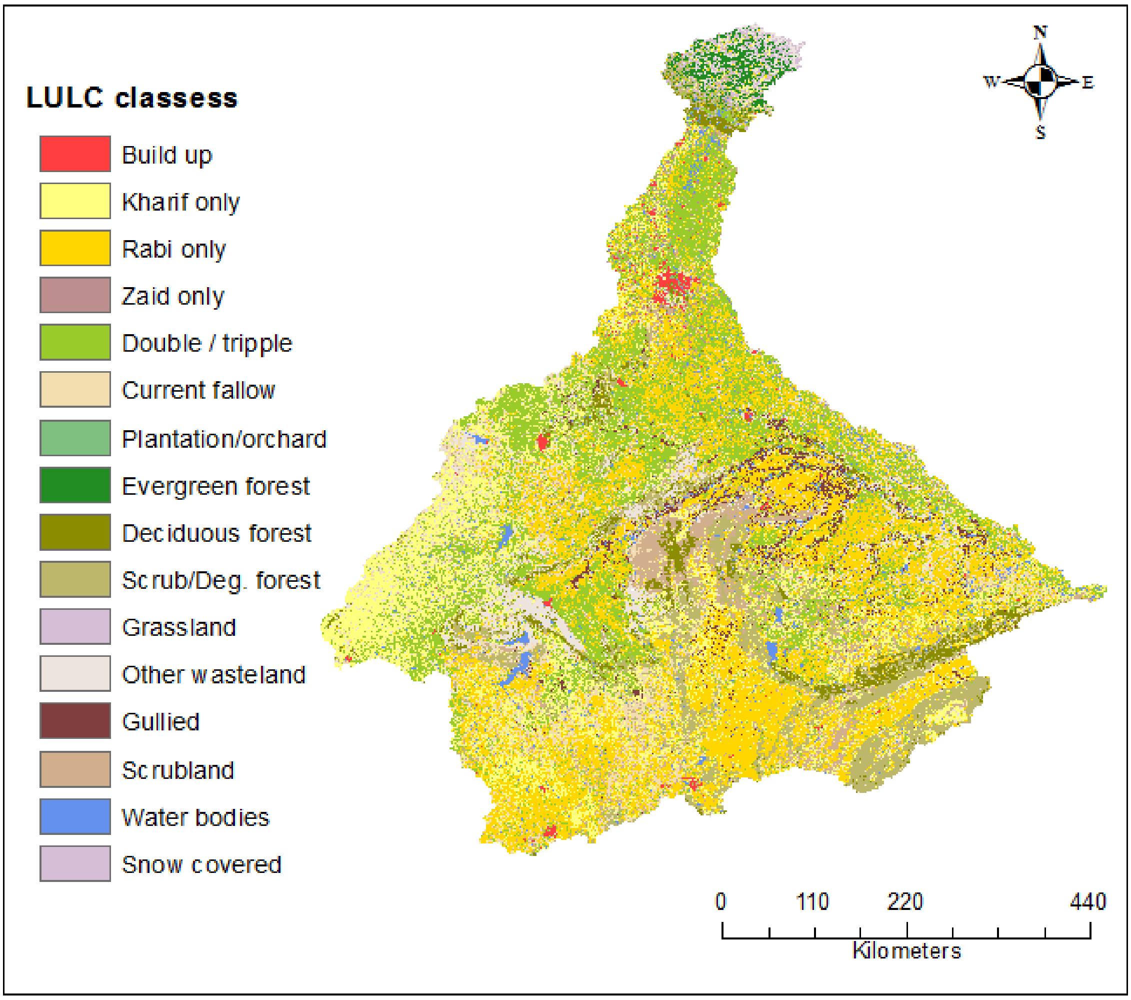


Figure 12.49 LULC map of Yamuna sub-basin (2004-05)

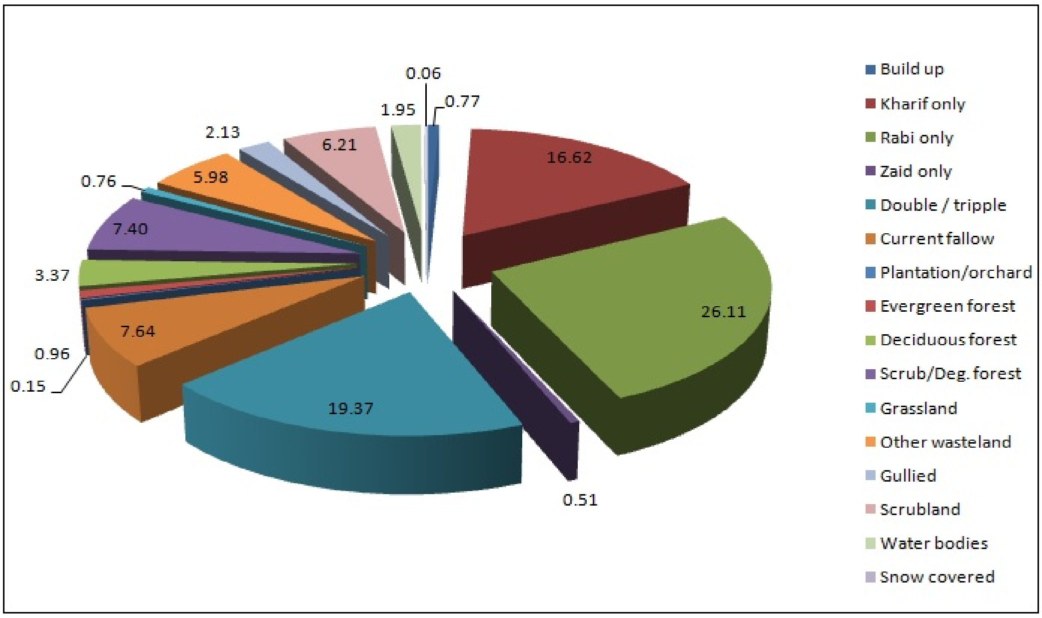


Figure 12.50 Distribution of LULC in Yamuna sub-basin (2004-05)

12 (a).14.2 Soil texture

The main soil types found in the basin are clayey, loamy and sandy. Figure 12.51 shows various categories of soil in the basin. The soils are classified as clayey, loamy, loamy skeletal, rock mountains, glaciers and rock outcrops, clayey skeletal and rocky outcrop based on the soil texture information.

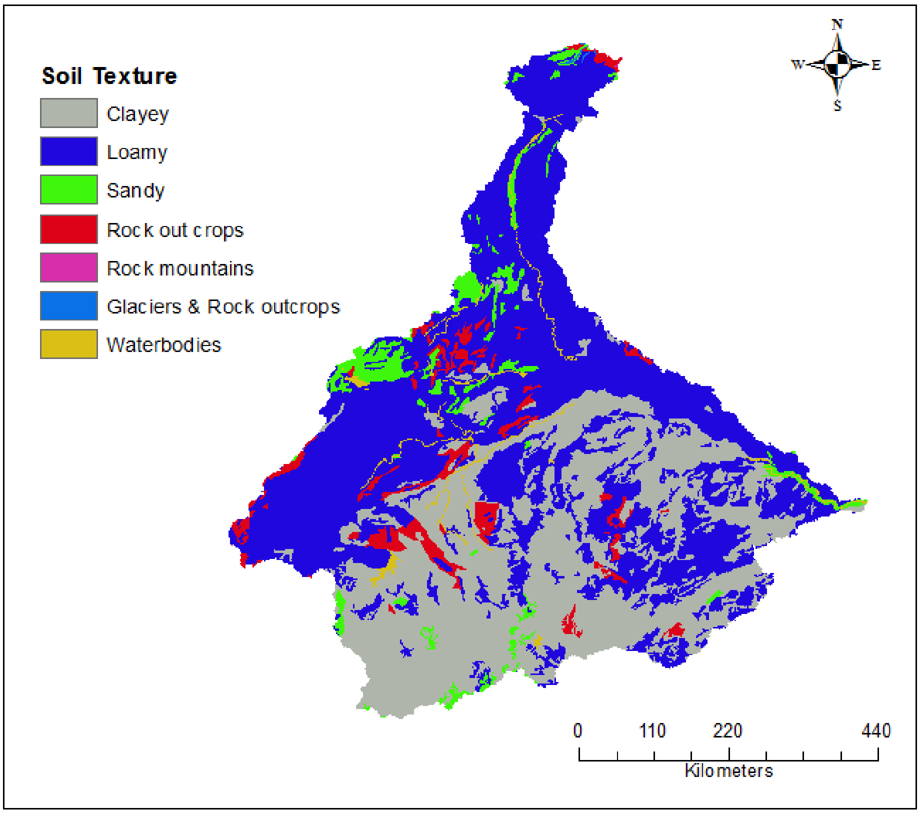


Figure 12.51 Soil texture map of Yamuna sub-basin

12 (a).14.3 Topography

The topography of the basin consists of forest areas and upper Gangetic plains. The upper regions of the basin are mostly hilly and forested. Yamuna joins the Ganga river near Sangam in Allahabad in mid Gangetic plains. Chambal is major tributary of the Yamuna and drains the arid area of Rajasthan and Madhya Pradesh. Figure 12.52 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the basin.

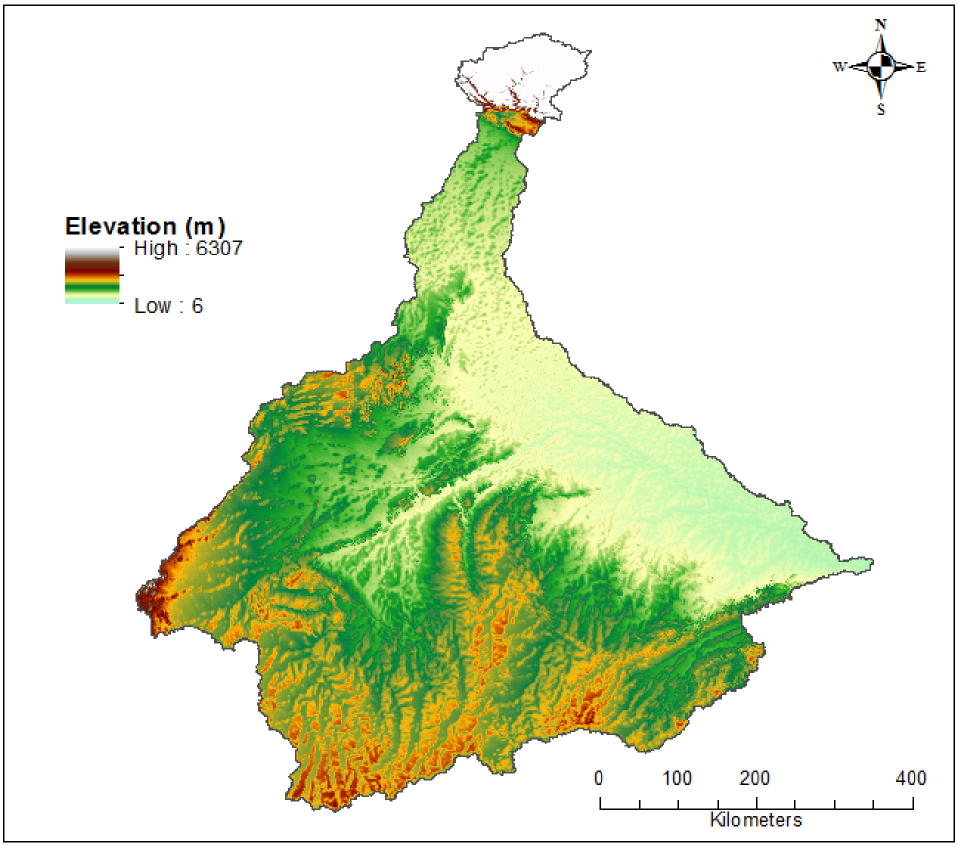


Figure 12.52 SRTM DEM map of Yamuna sub-basin

12 (a).15 Hydro-Meteorological and other Input Data

12 (a).15.1 Rainfall grids

Figure 12.53 shows gridded annual rainfall map of Yamuna sub-basin for year 2004-05. The variation in annual rainfall during study period of 30 years (1985-86 to 2014-15) is shown in Figure 12.54. Annual rainfall of the basin varies from 501 mm to 1,138 mm and mean rainfall of these 30 years is found to be 781 mm. Of the 30 years, for 15 years annual rainfall is higher than the mean rainfall and for remaining 15 years, it is lower than the mean rainfall.

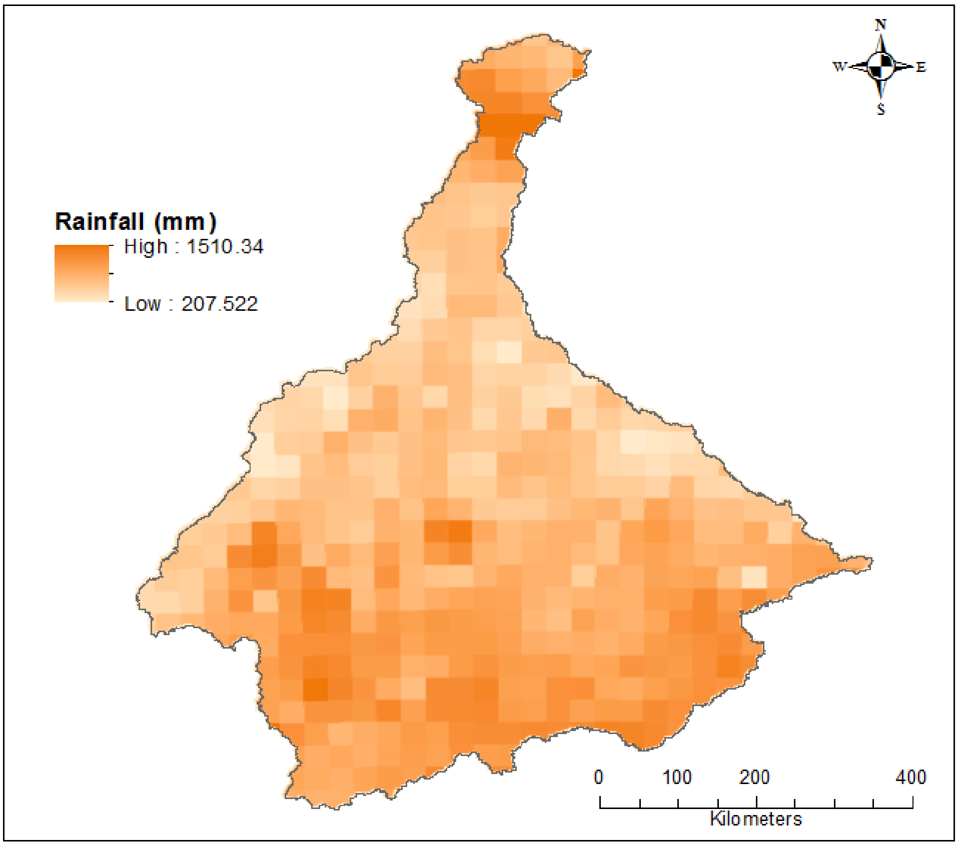


Figure 12.53 Gridded annual rainfall of Yamuna sub-basin (2004-05)

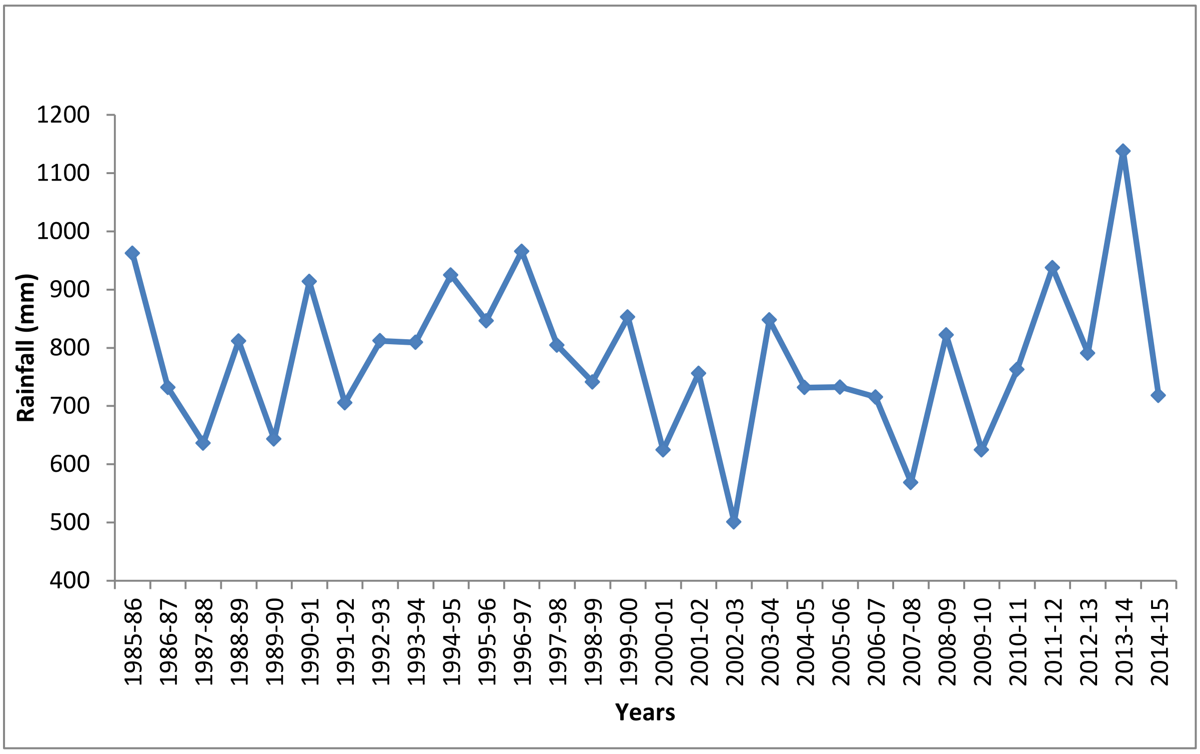


Figure 12.54 Annual rainfalls in Yamuna sub-basin (1985-86 to 2014-15)

12 (a).15.2 Temperature grids

Figure 12.55 shows mean annual temperature map of Yamuna sub-basin during 2004-05.

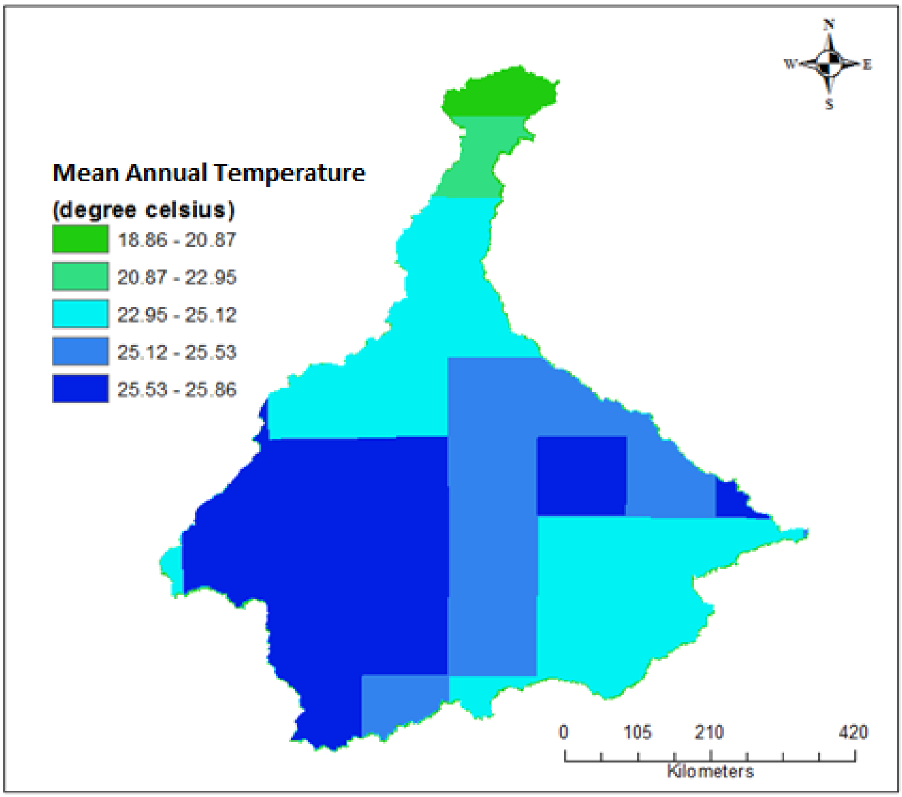


Figure 12.55 Gridded mean annual temperature of Yamuna sub-basin (2004-05)

12 (a).15.3 Sub-basins of Yamuna sub-basin

In the present study the Yamuna sub-basin has been divided into twelve sub-basins (Figure 12.56) viz. Bhagpat, Galeta, Seondha, Shahjina, Banda, Pali, Udi, Pratappur, Arnota, Sub-Basin_A, Sub-basin_B & Sub-basin_C. Table - 12.9 gives details of each sub-basin. The sub-basins are divided in such a way that the location of CWC discharge sites is taken as sub-basin terminal point except for Sub-basin_A, Sub-basin_B & Sub-basin_C.

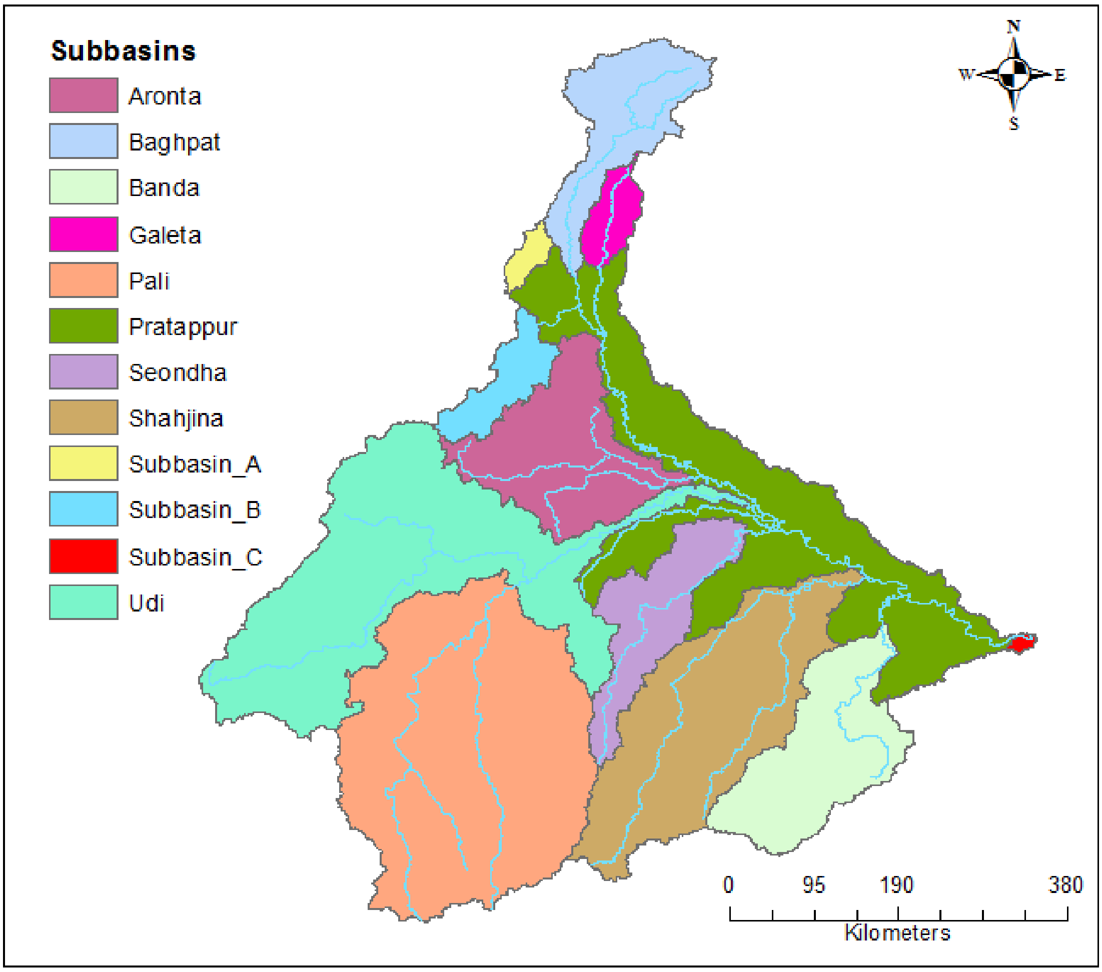


Figure 12.56 Sub-basins of Yamuna sub-basin

Table - 12.9 Sub-basin wise details of Yamuna sub-basin

S. No.	Sub-basin	River	Individual drainage area (sq.km)
1	Baghpat	Yamuna	16,798.6
2	Galeta	Hindon	4,458.18
3	Seondha	Sind	16,425.60
4	Shahjina	Betwa	43,753.20
5	Banda	Ken	25,357
6	Pali	Chambal	76,688.60
7	Udi	Chambal	65,314.80
8	Pratappur	Yamuna	59,711.30
9	Arnota	Uttangan	25,569.30
10	Sub-basin_A	-	1,879.63
11	Sub-basin_B	-	6,983.56
12	Sub-basin_C	Yamuna	39
		Total basin area	3,43,388

12 (a).15.4 River discharge

River discharge data i.e. observed flow are available at nine sites for the study period of 30 years. However, the discharge at Arnota site is negligible and hence it has not been considered for calibration. The daily discharge data have been aggregated to annual series and used for calibration and validation of model computed runoff at sub-basin level.

12 (a).15.5 Reservoir flux

Figure 12.57 shows the location of some of the major reservoirs in Yamuna sub-basin. The data of four major reservoirs namely Gandhisagar dam in Madhya Pradesh, Ranapratap sagar in Rajasthan, Matatila dam in Uttar Pradesh and Rajghat Dam in Madhya Pradesh/Uttar Pradesh have been considered for estimating storage fluxes changes for each water year during 30 years period.

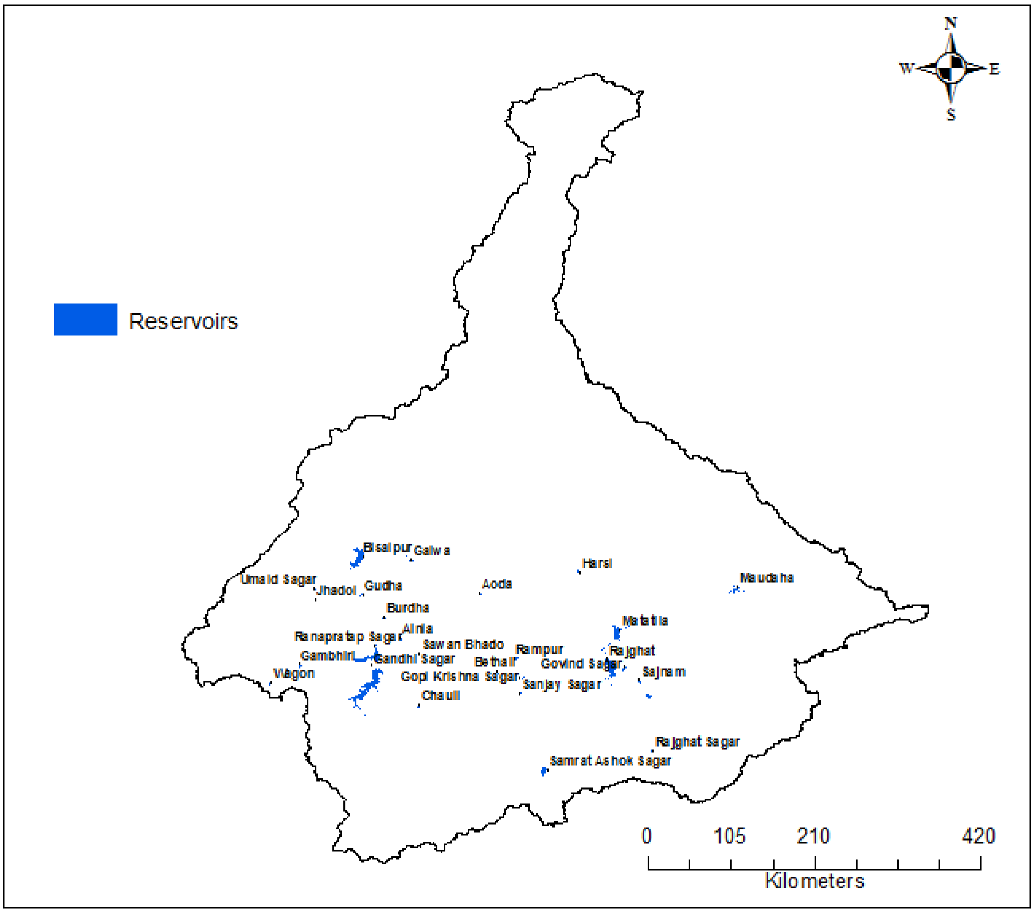


Figure 12.57 Major reservoirs in Yamuna sub-basin

12 (a).15.6 Groundwater flux

Spatial variation of annual groundwater flux in the Yamuna sub-basin for year 2004-05 is shown in Figure 12.58 and annual groundwater flux variation for study period (1985-86 to 2014-15) is shown in Figure 12.59. The annual groundwater flux in the sub-basin varies from 19.45 BCM to -21.44 BCM during the period 1984-85 to 2014-15. The mean annual groundwater flux from 1984-85 to 2014-15 of Yamuna sub-basin is estimated as -2.59 BCM.

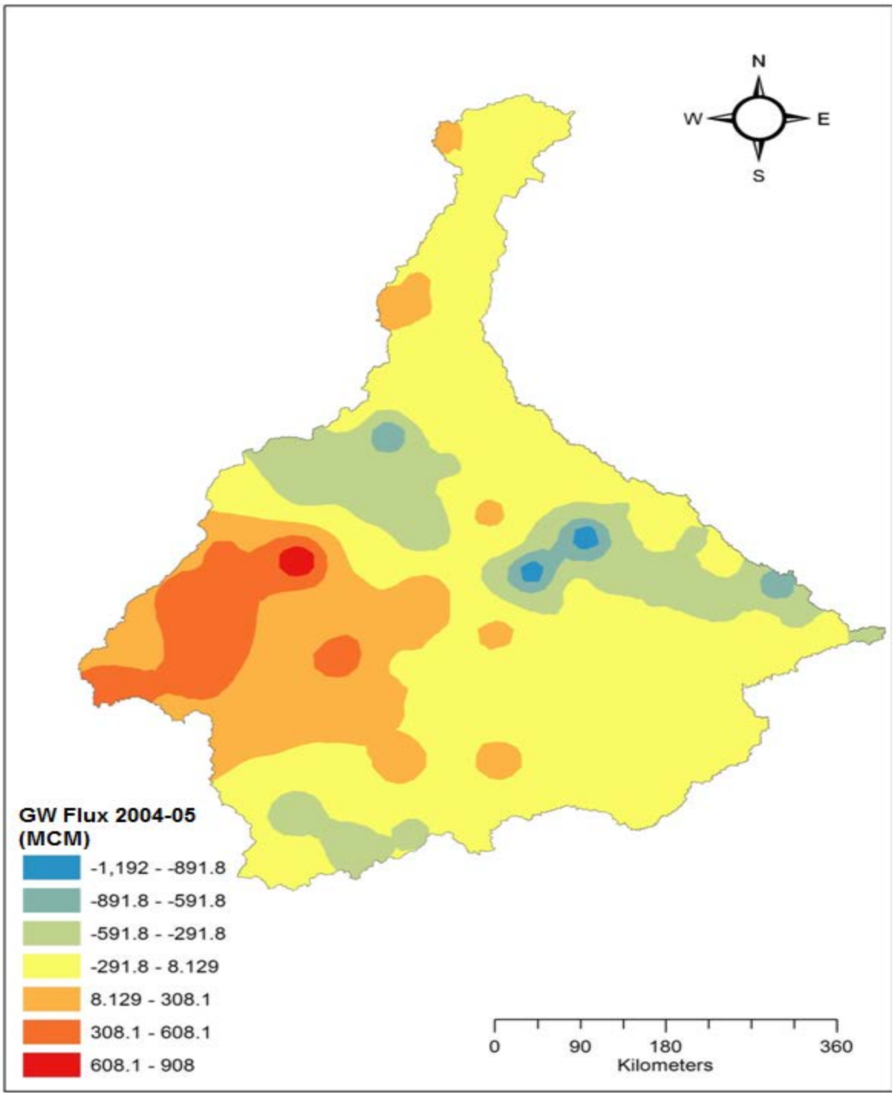


Figure 12.58 Groundwater flux (spatial data) estimated during 2004-05

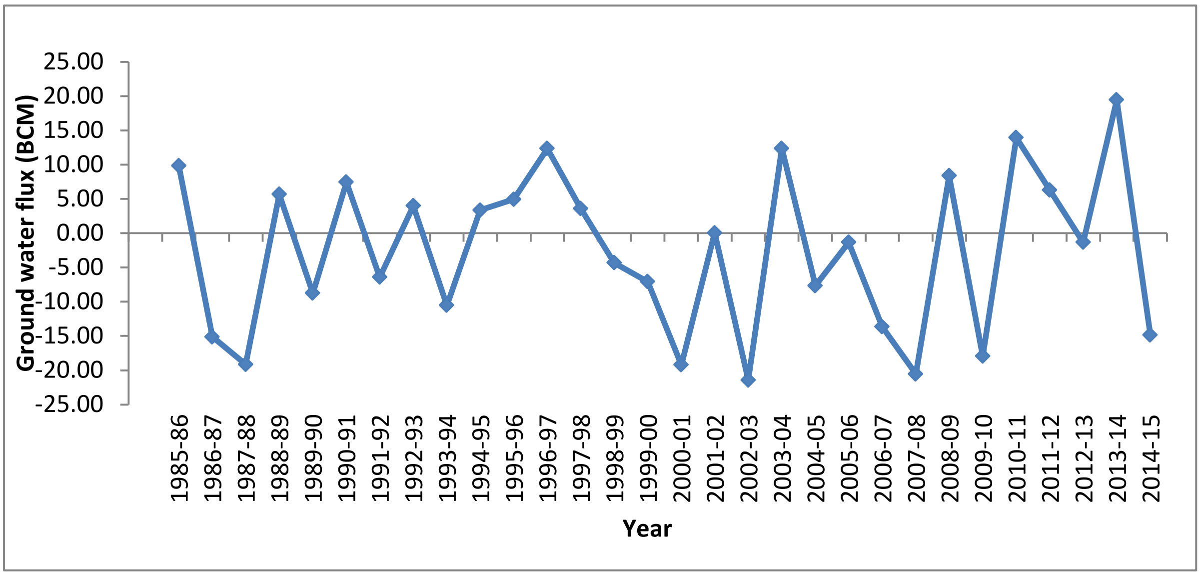


Figure 12.59 Annual groundwater flux of Yamuna sub-basin (1985-86 to 2014-15)

12 (a).15.7 Major crops in the basin

Based on the district-wise crop area statistics, district wise major crops for each crop season are identified. The sub-basin is divided in five regions based on the historic district-wise crop statistics collected from various sources (http://lus.dacnet.nic.in/dt_lus.aspx). Each region specifies a unique crop for each crop season both spatially and temporally within the basin. Hence, the coefficients are taken as per the crop in that particular region/district. On examining the cropping pattern within the basin, crop growing seasons are classified as Kharif only crop during 4 months (July to October), Rabi only crop during 4 months (November to February), Double/Triple crop during 8-12 months.

12 (a).15.8 Irrigation command area

Figure 12.60 shows location of irrigation command boundaries inside Yamuna sub-basin considered for the year 2014-15. Since annual command boundary maps are not available, command area has been selected from the year 2014-15 based on the completion of the project/dam. Hence, the command area in the basin considered during the year 2014-15 is worked out to be around 1,05,27,550 hectare. Basin outside command has been taken uniformly for all years while working out ECII from these areas.

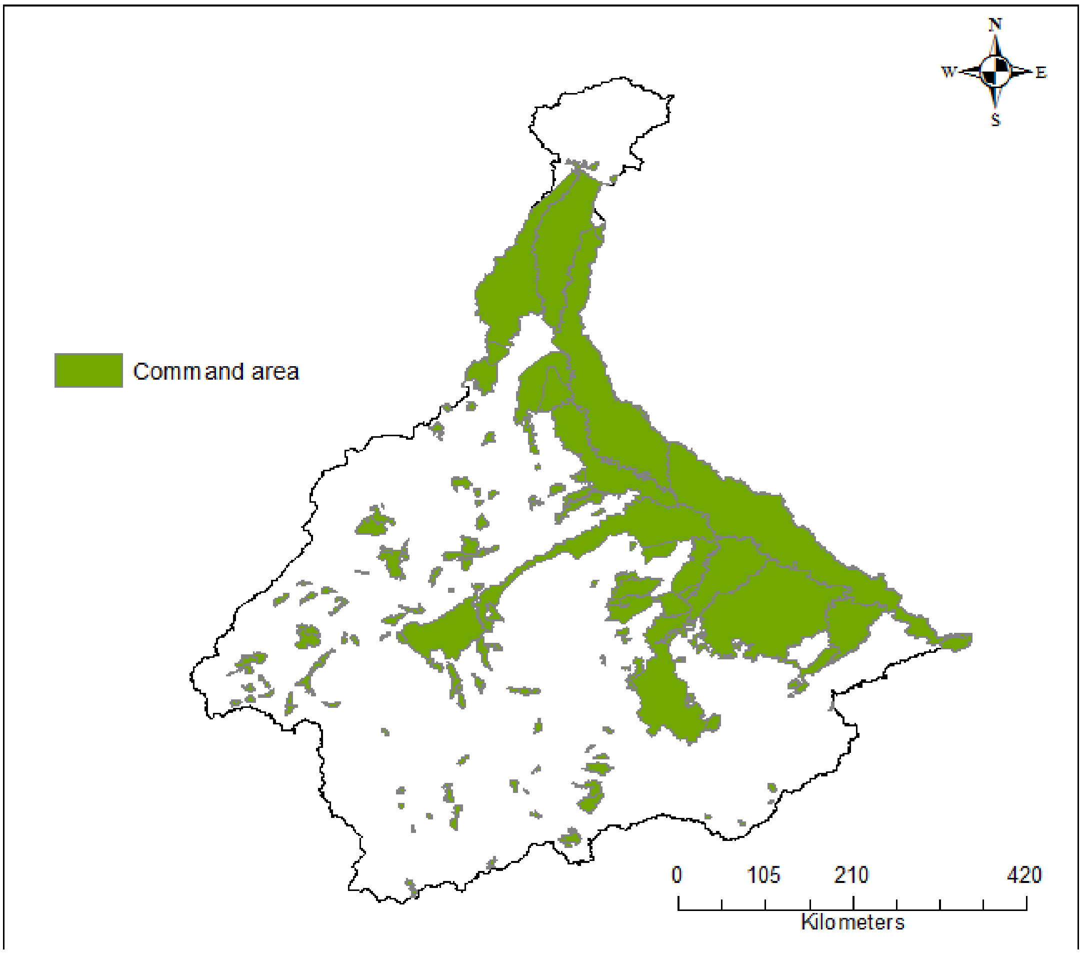


Figure 12.60 Irrigation command boundaries of Yamuna sub-basin

12 (a).15.9 Domestic, industrial and livestock demand

Figure 12.61 shows district boundaries layer for the Yamuna sub-basin for the year 2011 census. The mean annual domestic, industrial and livestock demands are estimated as 2.69 BCM in the Yamuna sub-basin.

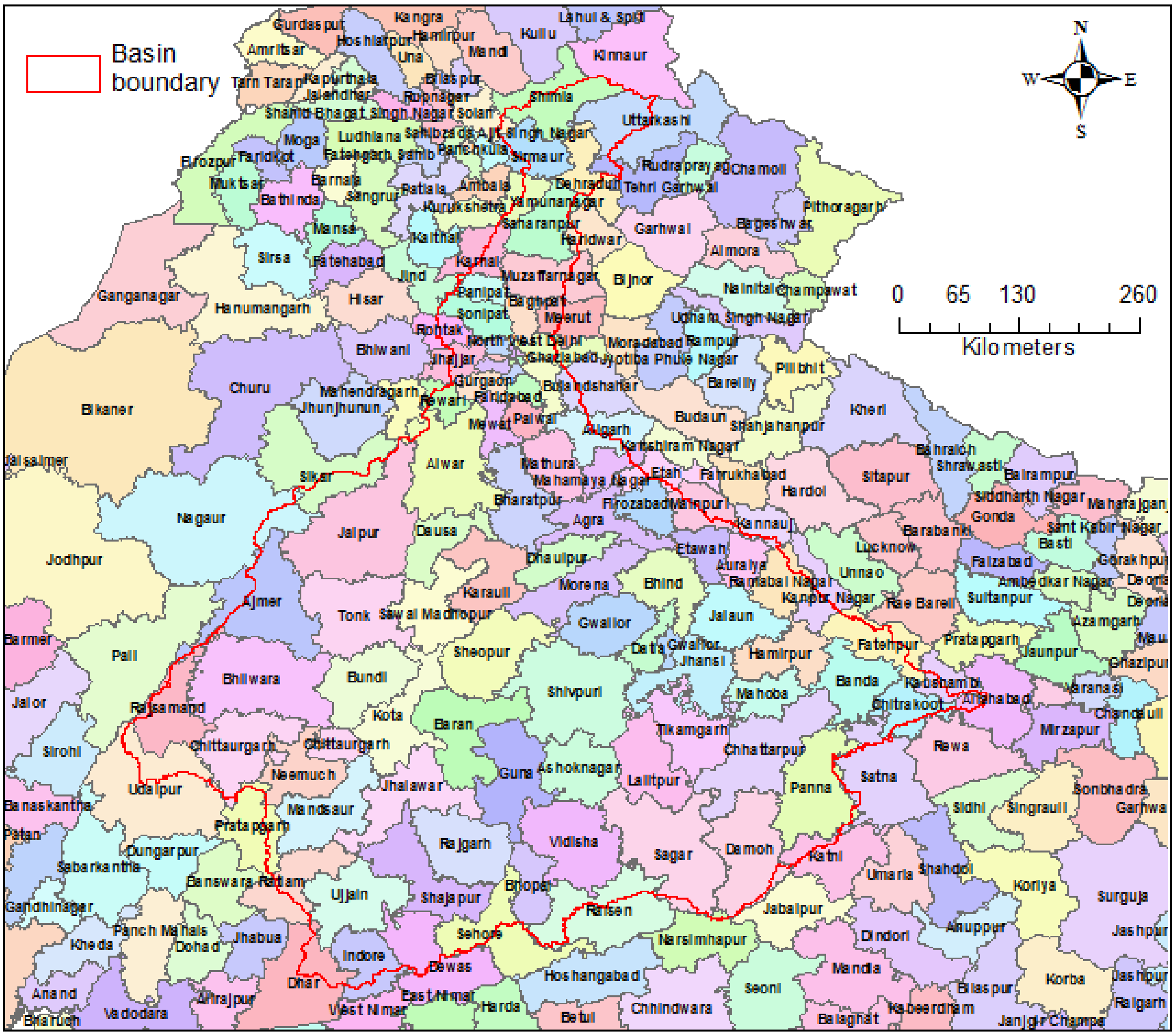


Figure 12.61 District boundaries in Yamuna sub-basin

12 (a).15.10 Evaporation from major/medium/minor reservoirs and other water bodies

Table - 12.10 provides annual evaporation values from each of sub-basins for the period of 1985-86 to 2014-15 (30 years). The average annual evaporation volume for total basin is worked out as 1.90 BCM.

12 (a).15.11 Previous Estimates

No separate assessment of water resources potential for Lower Ganga sub-basin had been done in the past. However, in respect of Ganga, the erstwhile Ganga Basin Water Studies Organisation of Central Water Commission carried out the assessment of water resources potential and had presented the details of the study in their report of 1986. Ganga basin was divided into ten sub-basins for the study and the assessment was based on the actual observed flow data available at several locations for durations ranging from 5 years to 20 -25 years. Simple rainfall-runoff regression analysis and multi-site data generation were resorted to wherever the observed flow data were found to be inadequate. As per 1993 studies for Reassessment of Water Resources Potential of India, the water resource potential was estimated as 525 BCM for the whole Ganga basin for a catchment area of 8,61,452 sq.km.

Table - 12.10 Evaporation in reservoirs of Yamuna sub-basin

	Reservoir Evaporation in each independent sub-basin (in BCM)							
Year	**Seondha**	**Shahjina**	**Banda**	**Pali**	**Udi**	**Pratappur**	**Arnota**	**Total**
1985-86	0.05	0.51	0.06	0.47	0.35	0.06	0.02	1.53
1986-87	0.14	0.43	0.08	0.57	0.53	0.04	0.05	1.84
1987-88	0.04	0.48	0.05	0.43	0.25	0.04	0.01	1.30
1988-89	0.05	0.45	0.05	0.63	0.70	0.05	0.04	1.97
1989-90	0.03	0.33	0.05	0.35	0.31	0.34	0.02	1.44
1990-91	0.04	0.44	0.05	0.50	0.36	0.06	0.02	1.47
1991-92	0.14	0.41	0.07	0.55	0.54	0.29	0.05	2.04
1992-93	0.05	0.41	0.05	0.55	0.78	0.06	0.04	1.93
1993-94	0.03	0.44	0.05	0.66	0.63	0.05	0.03	1.89
1994-95	0.05	0.42	0.06	0.66	1.15	0.00	0.02	2.36
1995-96	0.04	0.43	0.05	0.52	0.72	0.05	0.04	1.85
1996-97	0.06	0.45	0.06	0.60	1.25	0.06	0.04	2.50
1997-98	0.04	0.40	0.06	0.66	0.73	0.04	0.04	1.98
1998-99	0.04	0.31	0.04	0.45	0.48	0.05	0.06	1.43
1999-00	0.04	0.46	0.05	0.56	0.60	0.06	0.03	1.81
2000-01	0.03	0.39	0.05	0.34	0.49	0.05	0.02	1.37
2001-02	0.18	0.50	0.08	0.67	0.43	0.34	0.06	2.27
2002-03	0.03	0.22	0.04	0.37	0.35	0.03	0.01	1.04
2003-04	0.04	0.47	0.05	0.55	0.73	0.06	0.05	1.94
2004-05	0.12	0.44	0.09	0.57	0.48	0.30	0.02	2.03
2005-06	0.04	0.32	0.04	0.43	0.49	0.04	0.01	1.36
2006-07	0.04	0.29	0.04	0.62	0.84	0.04	0.05	1.92
2007-08	0.03	0.25	0.36	0.50	0.36	0.03	0.02	1.55
2008-09	0.05	0.52	0.06	0.63	0.82	0.06	0.05	2.18
2009-10	0.04	0.50	0.06	0.44	0.25	0.05	0.02	1.35
2010-11	0.05	0.42	0.05	0.48	1.02	0.04	0.03	2.08

2011-12	0.07	0.56	0.08	0.75	1.37	0.07	0.03	2.92
2012-13	0.05	0.39	0.06	0.54	1.29	0.05	0.03	2.41
2013-14	0.06	0.59	0.08	0.68	1.77	0.06	0.04	3.28
2014-15	0.03	0.24	0.06	0.21	1.48	0.04	0.02	2.08
Avg	0.06	0.42	0.07	0.53	0.72	0.08	0.03	1.90

12 (a).16 Runoff Estimation

Nine out of twelve sub-basins namely Bhagpat, Galeta, Arnota, Seondha, Shahjina, Banda, Pali, Udi and Pratappur have been delineated at the CWC G&D sites present in the Yamuna sub-basin. The model estimated runoff is calibrated against the observed discharge at these locations except Arnota (since it has negligible annual flow as per the observed data). The three sub-basins i.e. Sub-basin_A, Sub-basin_B & Sub-basin_C contain the remaining area of the Yamuna sub-basin. Since they have small area, the runoffs from the WRA tool for all these three sub-basins have been added to the calibrated runoff for all the remaining nine sub-basins for estimation of the water resources availability of Yamuna. Tables - L.19 to L.26 (at Annexure L(c)) give calibrated runoff along with observed discharge, rainfall, ECII, etc during 30 years for the eight G&D sites. Figure 12.62 to 12.69 show comparative graphs of calibrated runoff and observed discharge at all these eight G&D sites. Table - L.27 at Annexure - L(c) gives calibrated runoff of the basin for 30 years. The mean annual calibrated runoff is about 52.87 BCM. The maximum annual calibrated runoff is 138.51 BCM during 2013-14. The minimum annual calibrated runoff is 9.71 BCM during 1989-90. The mean annual ECII is about 97.23 BCM. The maximum annual ECII is about 119.19 BCM during 2009-10. The minimum annual ECII is about 82.86 BCM during 1993-1994.

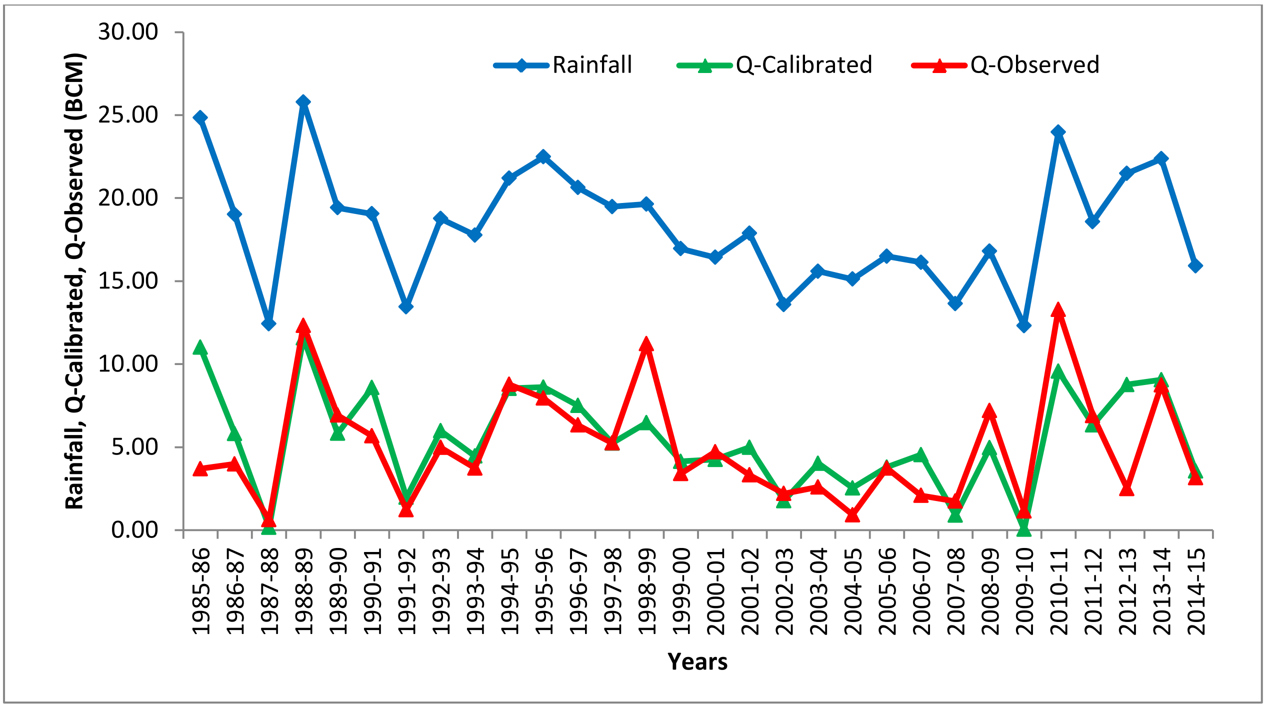


Figure 12.62 Calibrated runoff and observed discharge at Baghpat

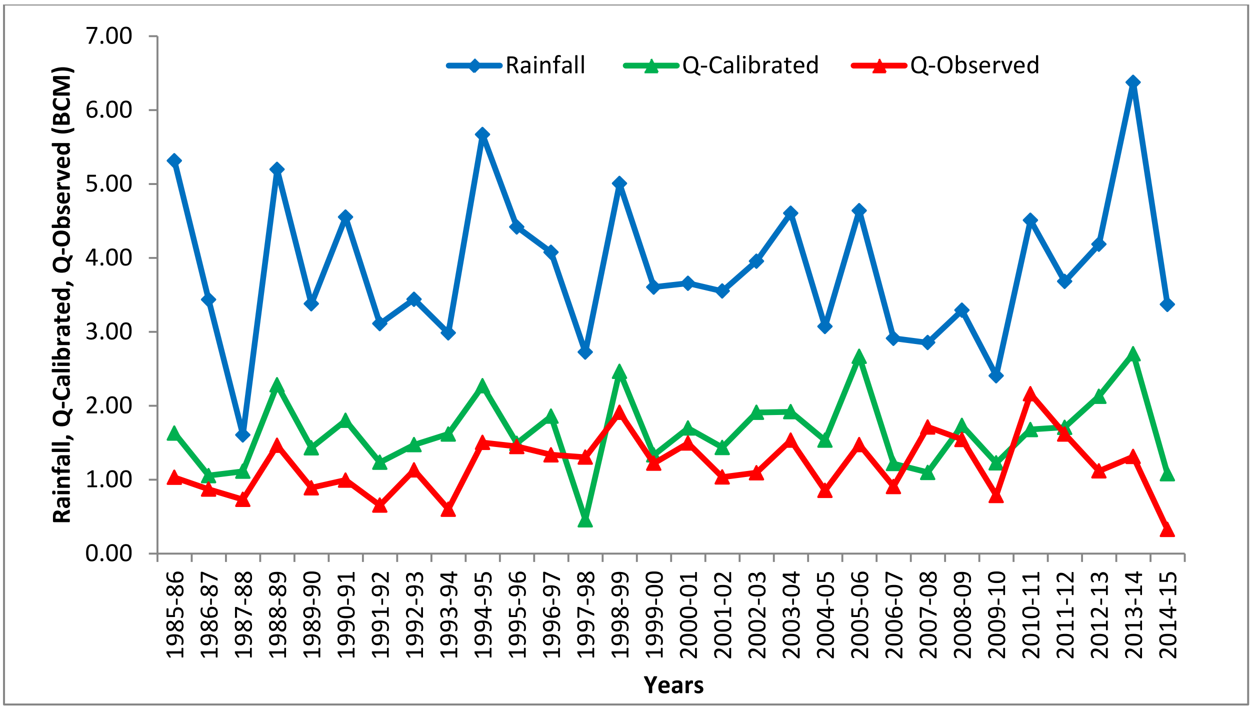


Figure 12.63 Calibrated runoff and observed discharge at Galeta on river Hindon

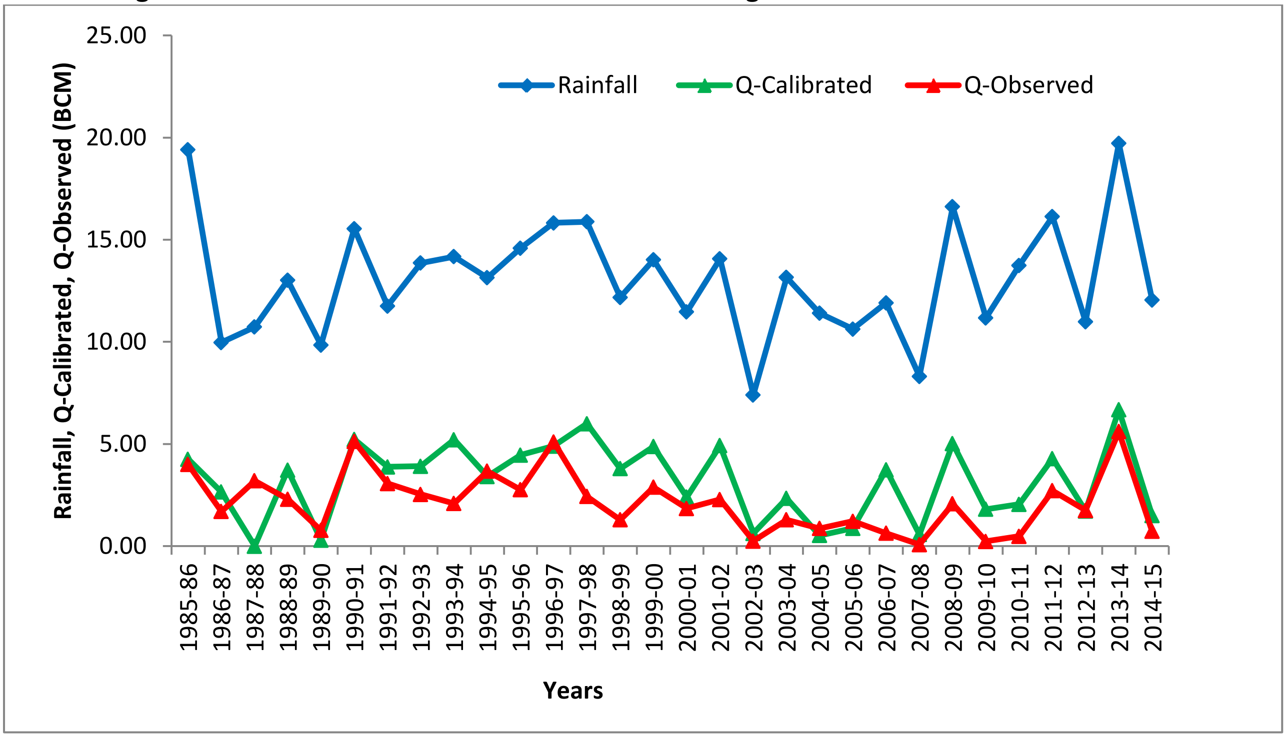


Figure 12.64 Calibrated runoff and observed discharge at Seondha on river Sind

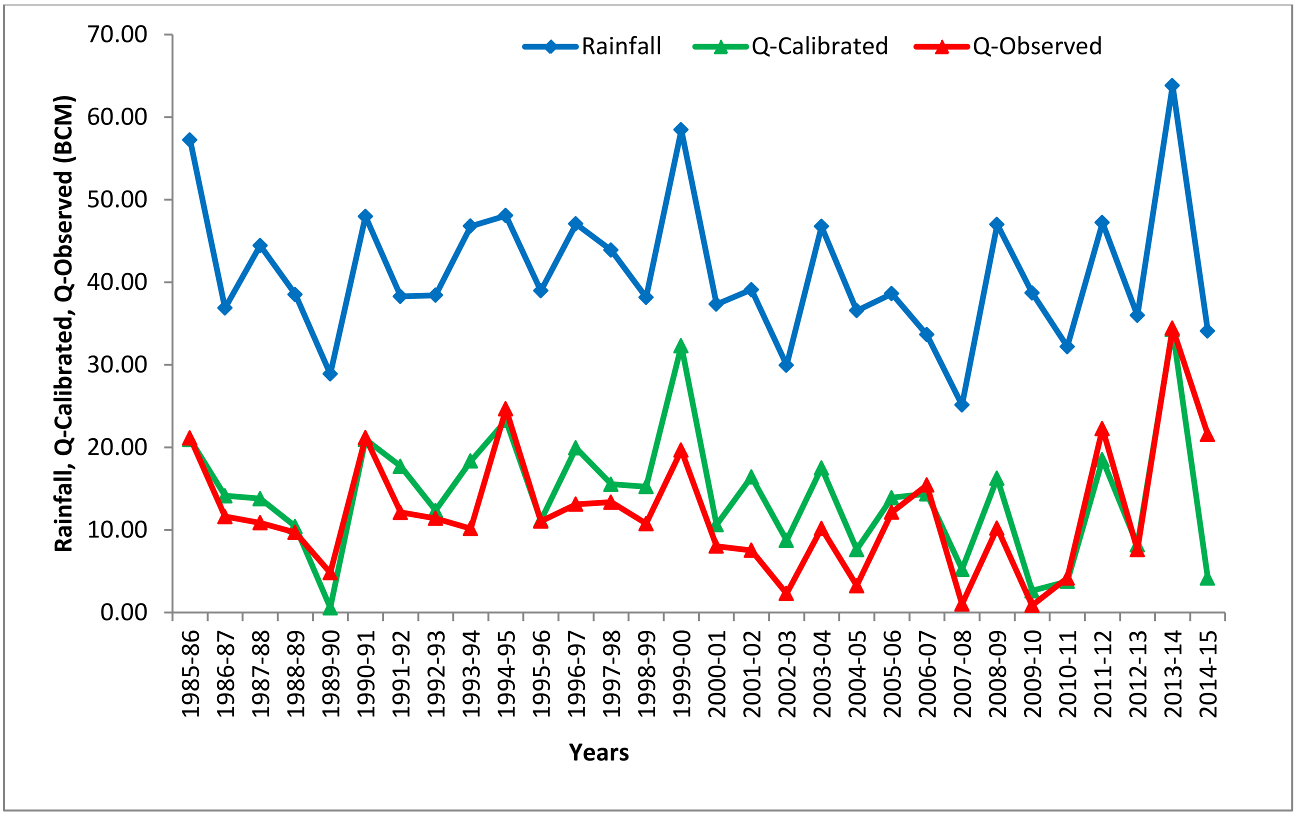


Figure 12.65 Calibrated runoff and observed discharge at Shahjina on river Betwa

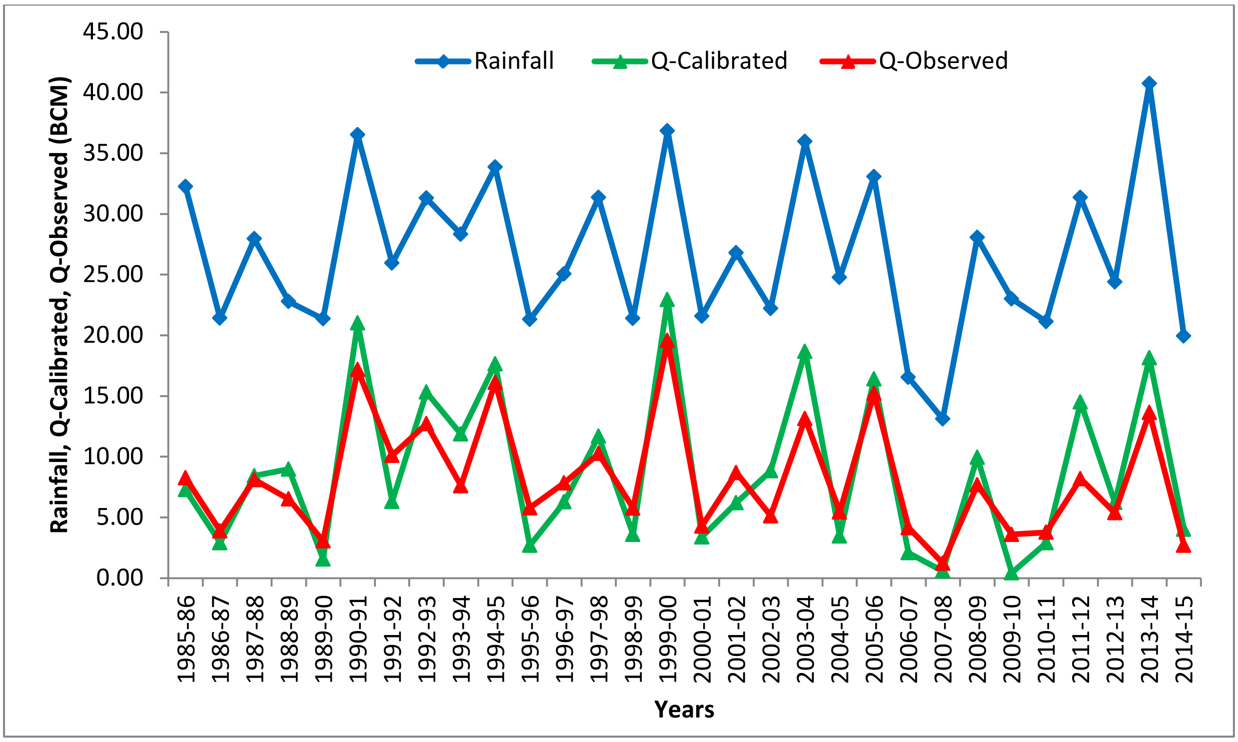


Figure 12.66 Calibrated runoff and observed discharge at Banda on river Ken

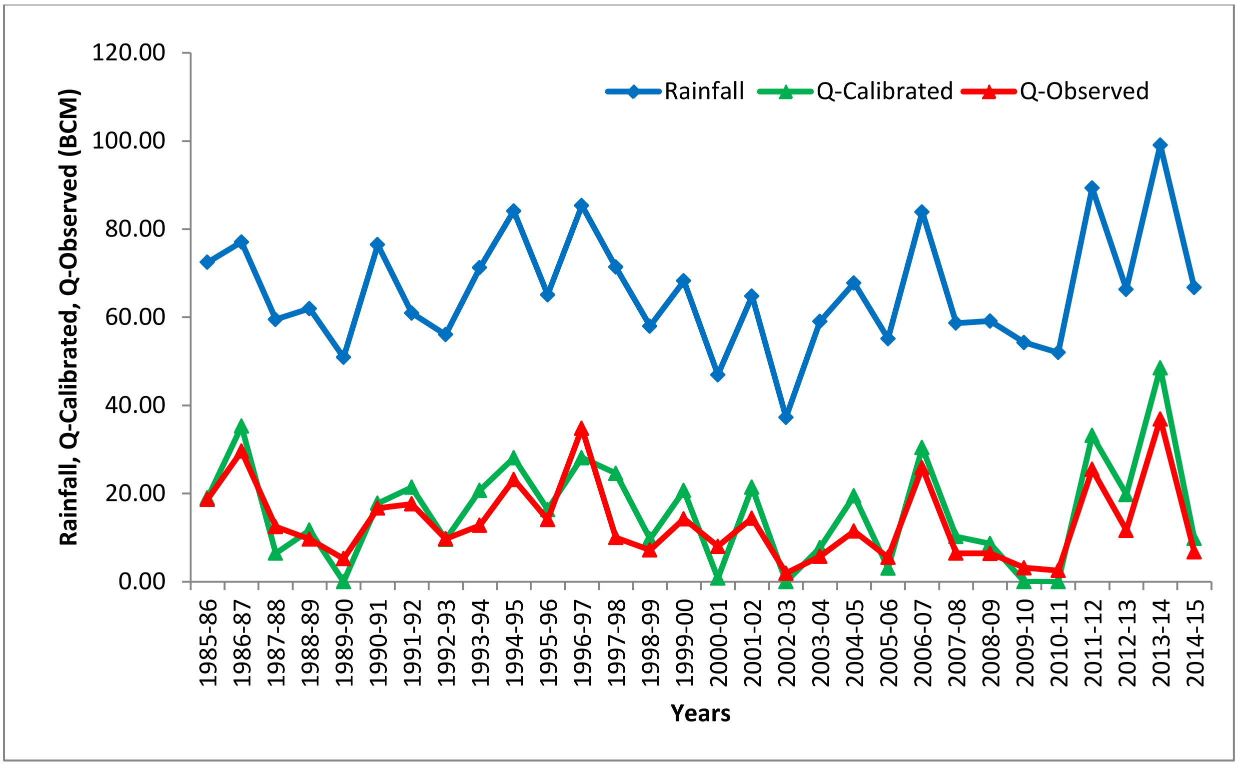


Figure 12.67 Calibrated runoff and observed discharge at Pali on river Chambal

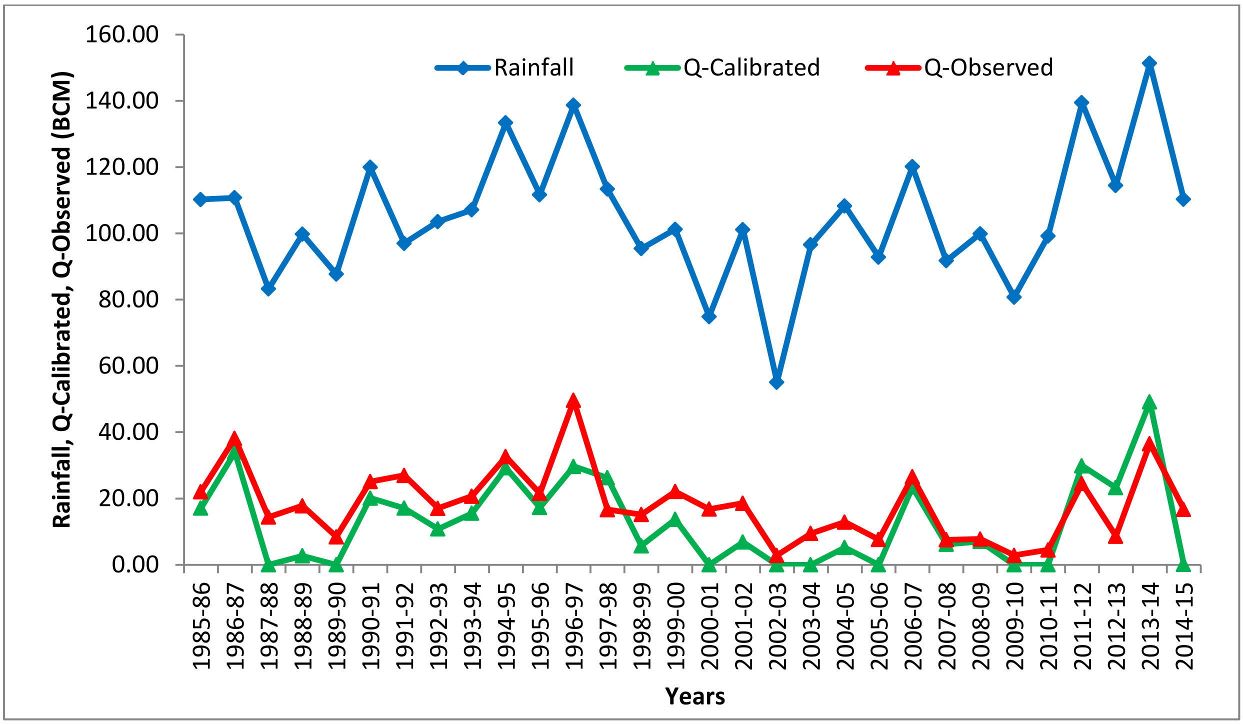


Figure 12.68 Calibrated runoff and observed discharge at Udi on river Chambal

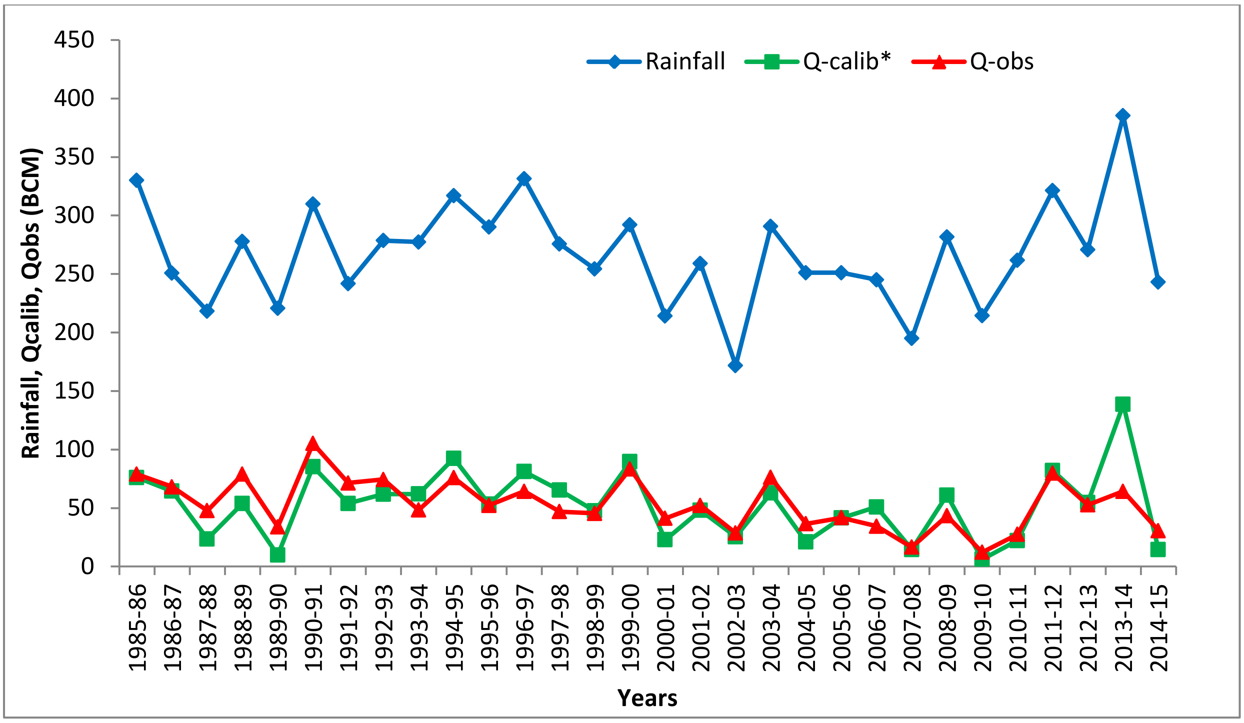


Figure 12.69 Calibrated runoff and observed discharge at Pratappur

12 (a).17 Annual Water Resources Availability of Yamuna Sub-basin

Table - L.27 shows the different components required to estimate water resources availablility of Yamuna sub-basin for 30 years. The maximum and minimum annual water resource availability is 238.93 BCM during 2013-14 and 70.33 BCM during 2007-08 reapectively.

The average annual available basin water resource is 136.94 BCM and 75% dependable flow is 118.83 BCM. The average available water resources of Yamuna sub-basin accounts about 51.09% of mean annual rainfall during 1985-86 to 2014-15.

12 (a).17.1 Annual water resources of Yamuna sub-basin during extreme rainfall conditions

Out of the total 30 water years of study period, during the years 2013-14 and 2002-03, extreme wet and dry rainfall conditions occurred in Yamuna sub-basin. The annual water resources of Yamuna sub-basin during these two extreme rainfall conditions are 238.93 BCM and 91.01 BCM, respectively as shown in Table - 12.11. The water balance components during these years are presented in the Figures 12.70 and 12.71.

Table - 12.11 Water resources availability in Yamuna sub-basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	2013-14	387.03	238.93
Minimum Rainfall	2002-03	173.25	91.01

Water resources availability - rainfall ratio during the extreme maximum and minimum rainfall years is found to be 0.62 and 0.52 respectively, this shows that the higher the rainfall, the higher percentage of runoff. During higher rainfall years, potential evapotranspiration is less compared to the dry years. This will have cumulative effect in runoff. The total population in the basin for 2014-15 as per 2011 census is estimated as 142.11 million and hence water availability per capita in the basin is 963.62 cubic metres.

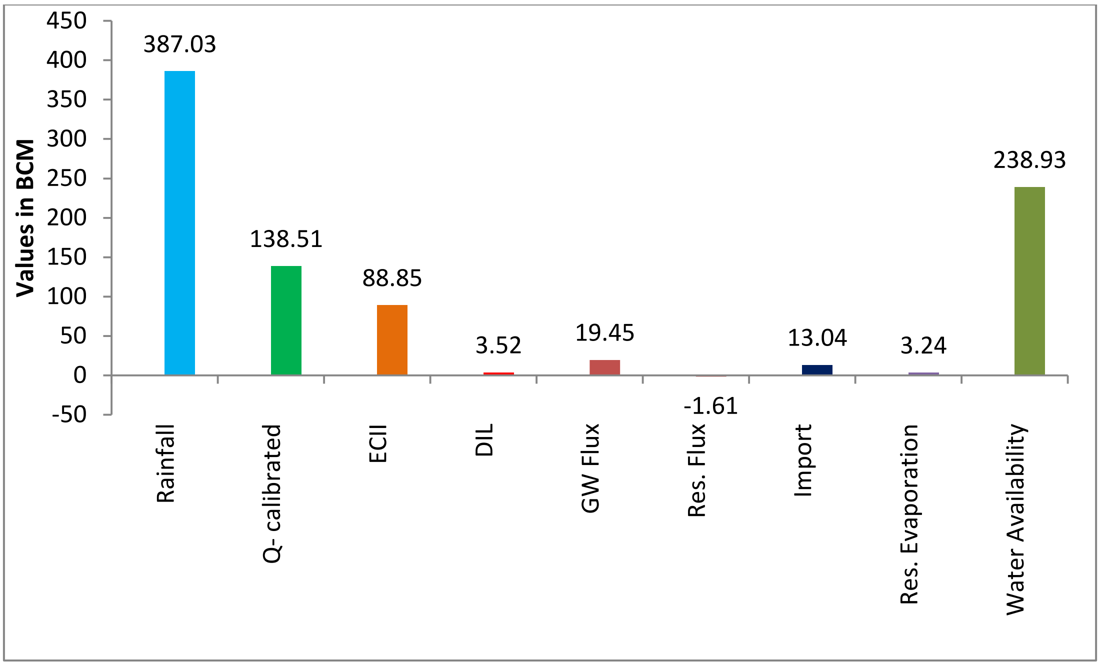


Figure 12.70 Water balance components of Yamuna sub-basin during extreme high rainfall (2013-14)

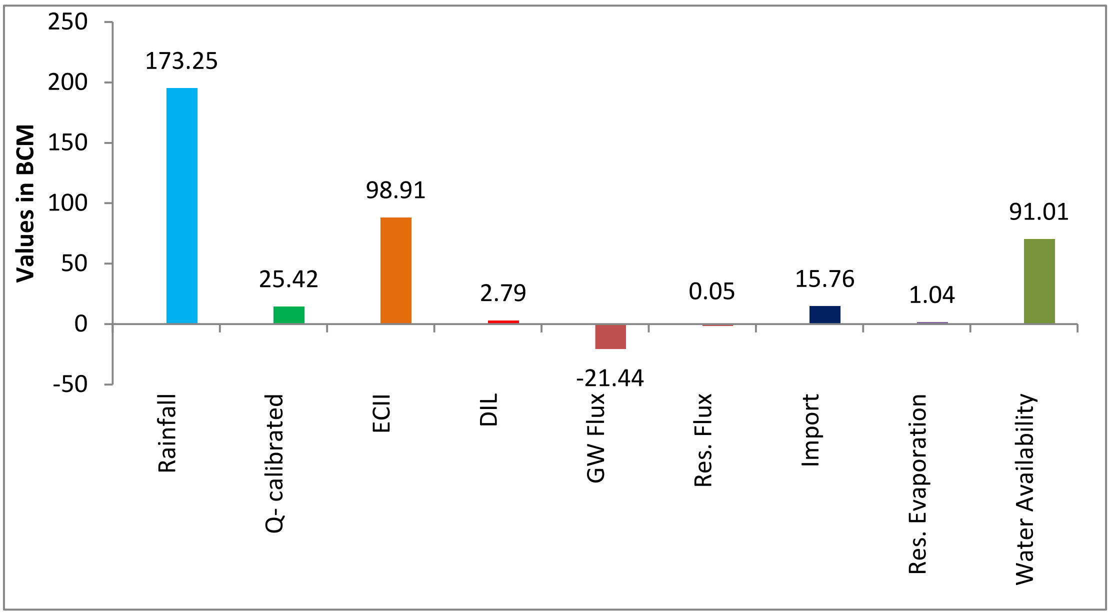


Figure 12.71 Water balance components of Yamuna of sub-basin during extreme low rainfall (2002-03)

12 (a).17.2 Mean water resources of Yamuna sub-basin

The mean water resources of the basin is computed by taking the mean of the 30 years water balance components such as flow in the river at final outlet, upstream effective utilisations for irrigation, domestic and industrial, change in storage of groundwater, change in strorage of reservoirs and evaporation from reservoirs.

Mean water resources = Mean of (Calibrated Runoff + Estimated Consumptive Irrigation Input + Domestic, Industrial and Livestock consumption + Groundwater Flux +

Reservoir Flux + Export from basin - Import from basin + Evaporation from Reservoirs)

= 52.87 + 97.23 + 2.69 + (-2.59) + 0.01 + 0 – 15.14 + 1.87 = 136.94 BCM

The mean available annual water resource of Yamuna sub-basin is 136.94 BCM and 75% dependable flow of Yamuna sub-basin is 118.83 BCM. Figure 12.72 shows the various water balance components averaged over a period of 30 years during 1985-86 to 2014-15.

It is observed that the computed runoff factors varies from 0.03 (737 mm rainfall) to 0.36 (1325 mm rainfall). The mean runoff factor for 30 year period is 0.19.

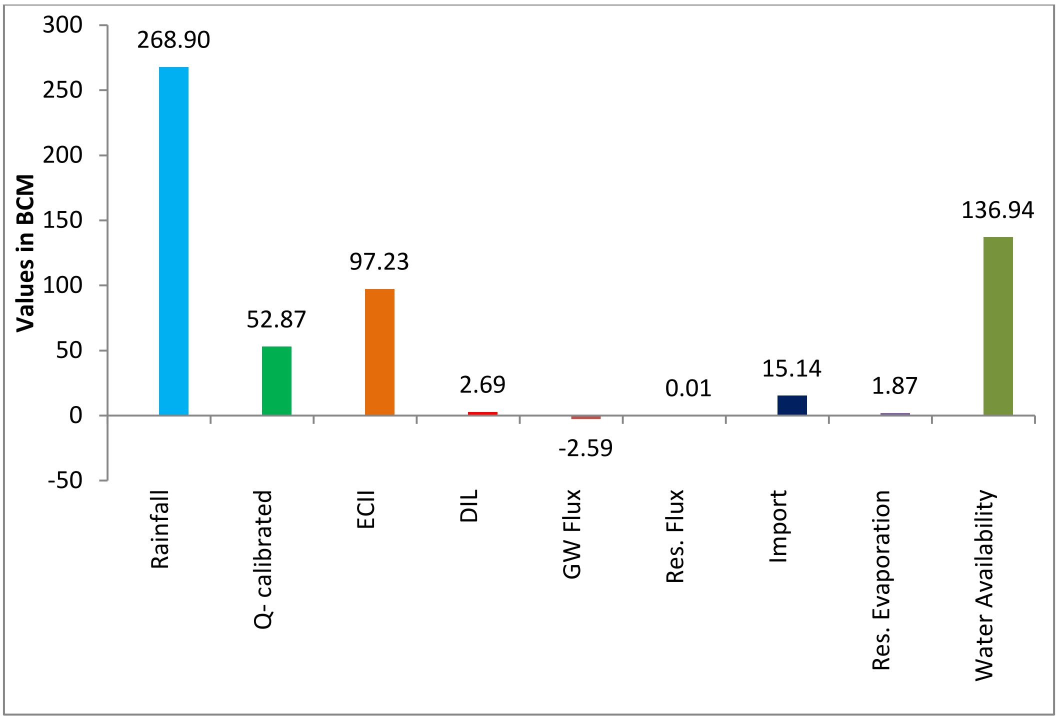


Figure 12.72 Mean water balance components of Yamuna sub-basin

12 (a).18 Basin Outward Diversions/Imports

Yamuna sub-basin receives water from the Upper Ganga sub-basin mainly through Upper Ganga Canal (UGC) and Lower Ganga Canal (LGC) i.e. irrigation water is being imported from Upper Ganga sub-basin to Yamuna sub-basin. In the present study, the import has been estimated using ERDAS Imagine software and the AET and rainfall image file generated by the WRA tool in the output for the Pratappur and Galeta sub-basin (Table 12.12).

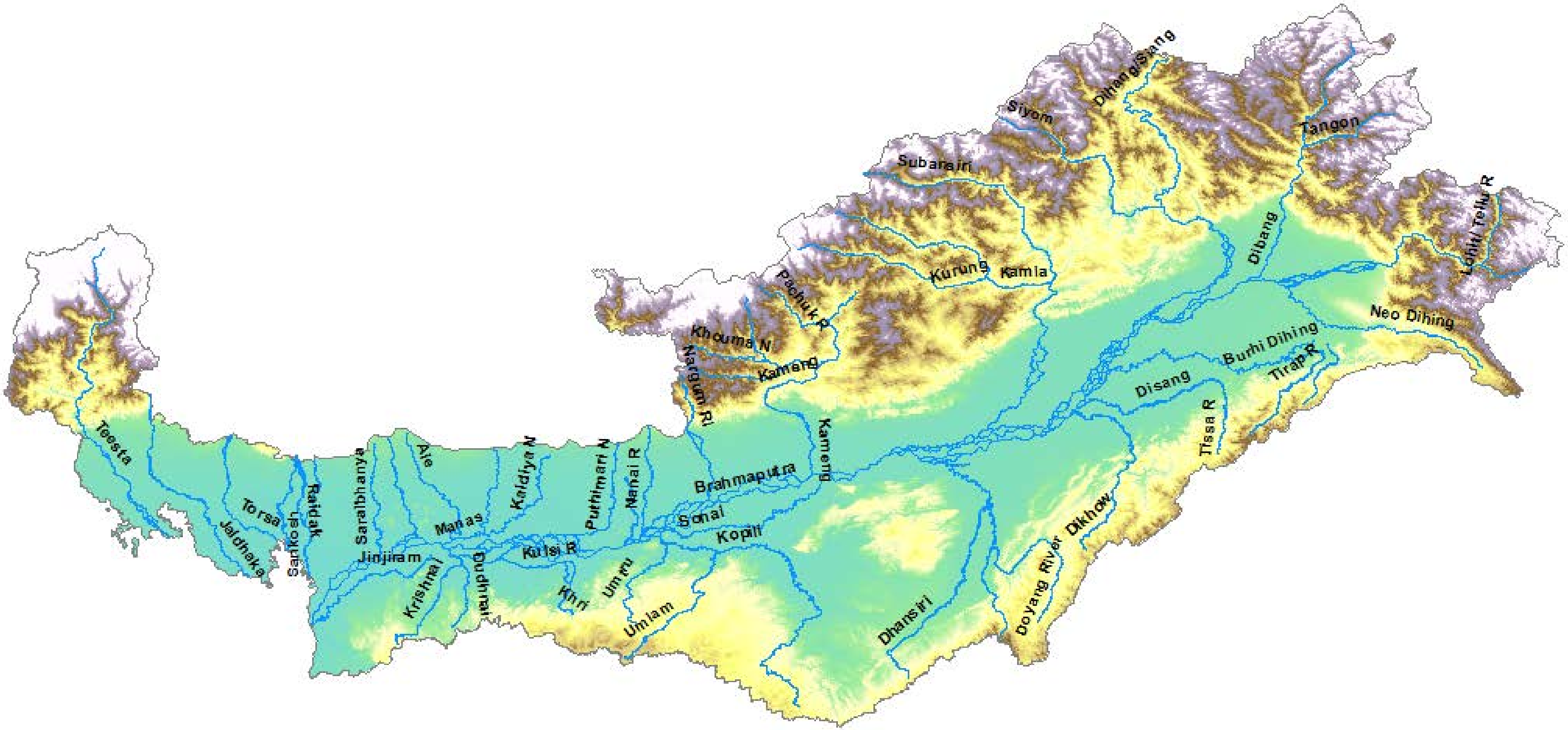
Table - 12.12 Details of diversions considered for the study

S.No.	Name of Projects	Import in (BCM)	Remarks
1	Upper Ganga Canal Project , Haridwar and Lower Ganga Canal	15.14	The diversions takes place through Upper Ganga Canal and Lower Ganga Canal

HIGHLIGHTS

- *Mean annual available water resources of Yamuna basin is 136.94 BCM.*
- *Maximum annual water availability is 238.93 BCM during 2013-14.*
- *Minimum annual water availability is 70.33 BCM during 2007-08.*
- *Annual rainfall in the basin varies from 501 mm to 1138 mm during 1985-86 to 2014-15 and mean rainfall of these 30 years is 781 mm.*
- *Yamuna sub-basin has been divided into twelve sub-basins for the reassessment study viz. Bhagpat, Galeta, Seondha, Shahjina, Banda, Pali, Udi, Pratappur, Arnota, Sub-Basin_A, Sub-basin_B and Sub-basin_C.*
- *Average annual domestic, industrial and livestock demand in the basin is 2.69 BCM.*
- *Average annual evaporation from water bodies in the basin is 1.87 BCM.*

BRAHMAPUTRA BASIN



12 (b).19 Geo-Spatial Datasets

12 (b).19.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map of Brahmaputra basin corresponding to 2004-05 year is shown in Figure 12.73 which shows 17 different classes. Forest land is the predominant land use in the Brahmaputra basin accounting for more than 50% (including evergreen forest, deciduous forest) of the basin area. This extent varies slightly from year to year. Next dominating class is Kharif only and plantation. Tea, banana, rubber plantation are the main crops in the basin. Distribution (in percentage) of LULC in the Brahmaputra basin during 2004-05 is given in the Figure 12.74.

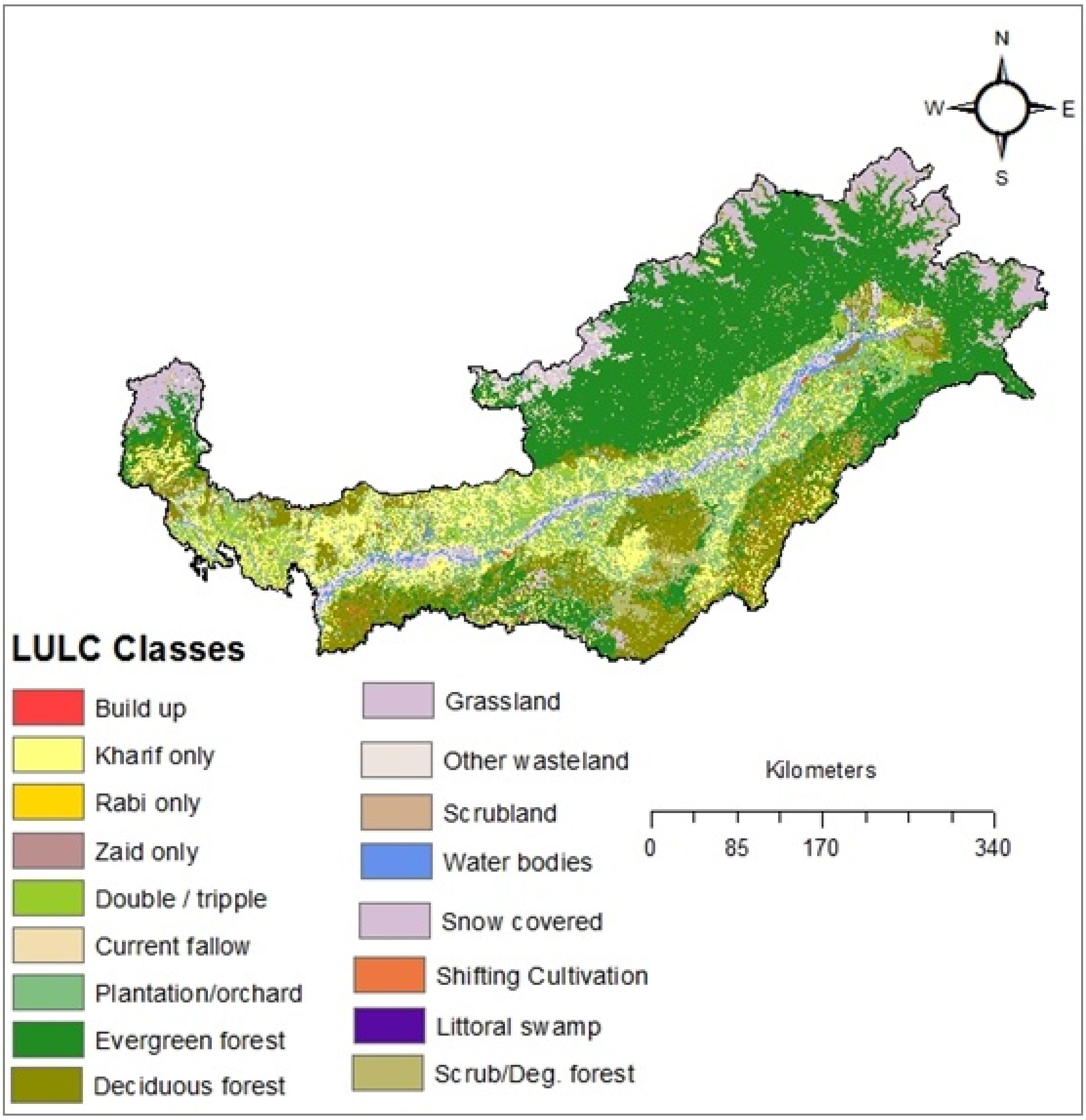


Figure 12.73 LULC map of Brahmaputra basin (2004-05)

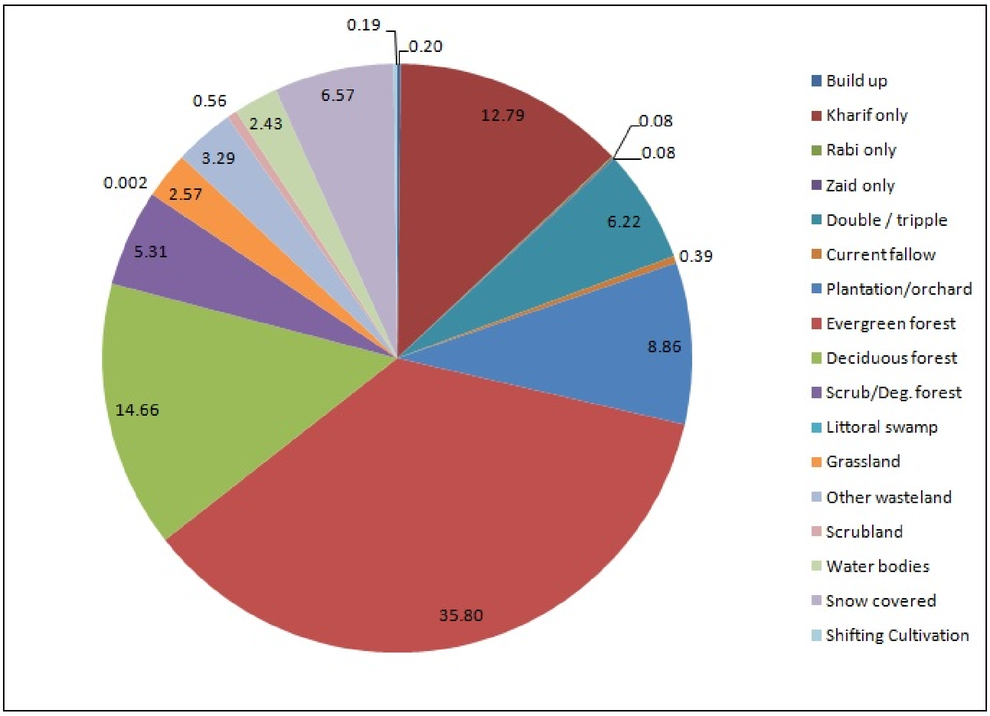


Figure 12.74 Distribution of LULC in Brahmaputra basin (2004-05)

12 (b).19.2 Soil texture

Loamy and clayey are the main soil textural classes in the study basin. Predominant soil textures in the study area is loamy that accounts for low infiltration rate and more runoff in the basin. Soil texture classes in the study area are shown in the Figure 12.75.

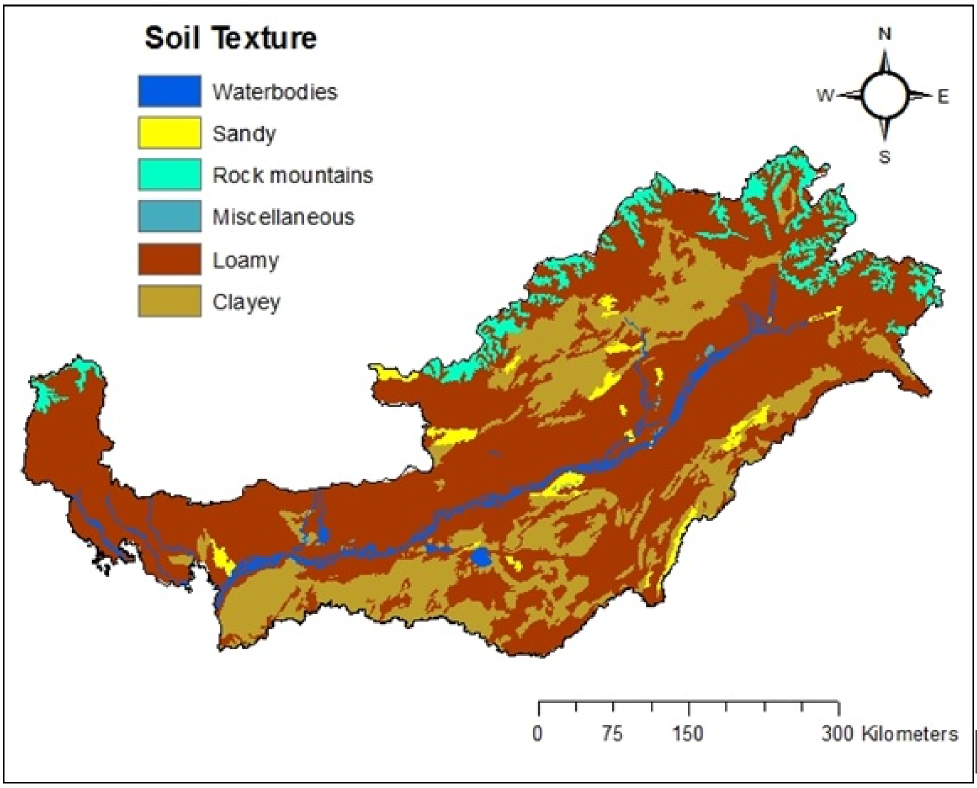


Figure 12.75 Soil texture map of Brahmaputra basin

12 (b).19.3 Topography

The topography of the basin consists of hills. The upper regions of the basin are mostly hilly and snow covered. The lower region of the basin is covered with forests. Figure 12.76 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the basin. From DEM it is observed that elevation ranges from 0 m to 8,022 m.

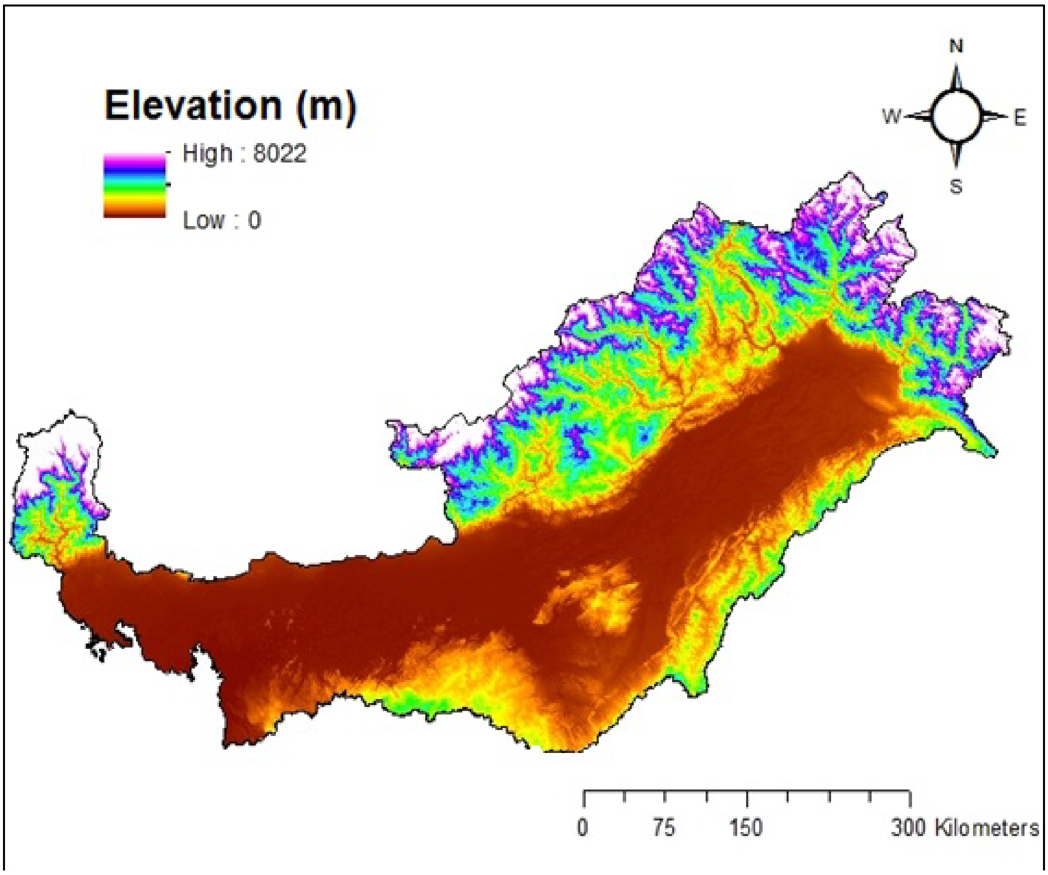


Figure 12.76 SRTM DEM map of Brahmaputra basin

12 (b).20 Hydro-Meteorological and other Input Data

12 (b).20.1 Rainfall grids

Figure 12.77 shows gridded annual rainfall map (IMD rainfall) of Brahmaputra basin for year 2004-05. The variation in the annual rainfall (IMD rainfall) during study period of 30 years (1985-86 to 2014-15) is shown in the Figure 12.78. Annual rainfall varies from 2,105 mm to 3,083 mm in the basin and mean of these rainfalls (30 years) is 2,330 mm.

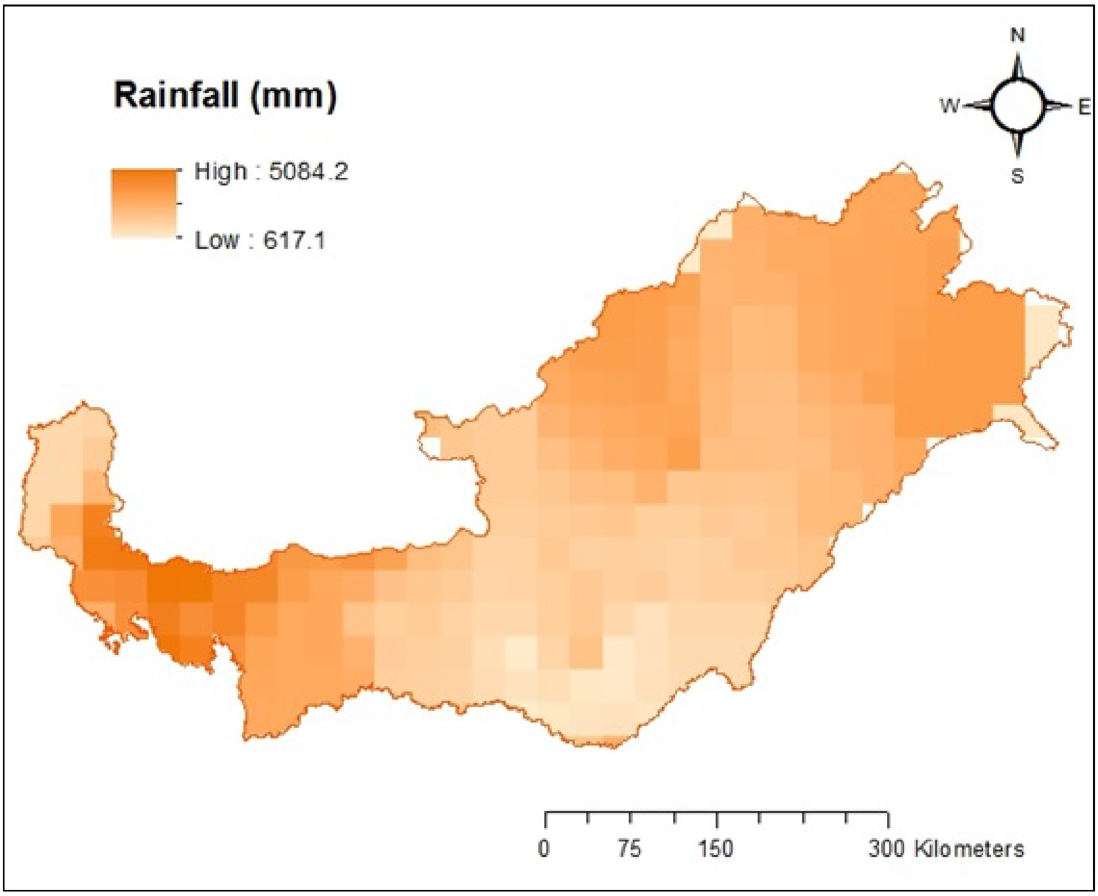


Figure 12.77 Gridded rainfall of Brahmaputra basin (2004-05)

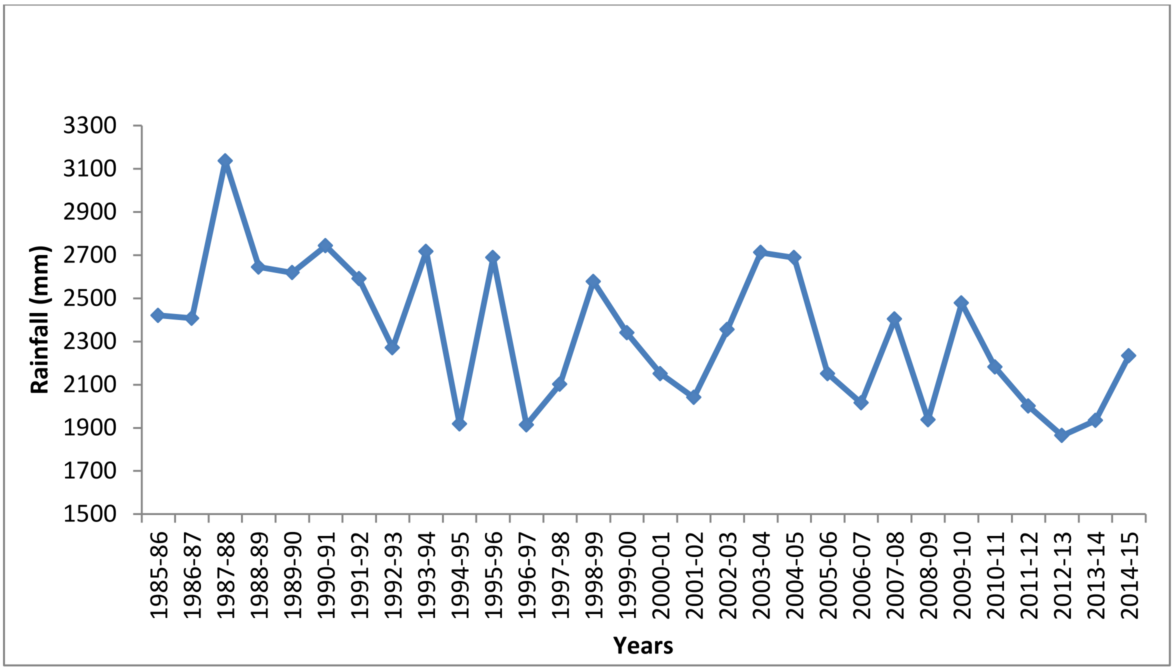


Figure 12.78 Annual rainfalls in Brahmaputra basin (1985-86 to 2014-15)

12 (b).20.2 Temperature grids

Gridded temperature datasets for India prepared by India Meteorological Department (IMD) along with Global Ensemble Forecast System (GEFS) temperature data have been used in this study. The mean annual temperature map of the basin during 2004-05 (based on IMD data) is shown in Figure 12.79.

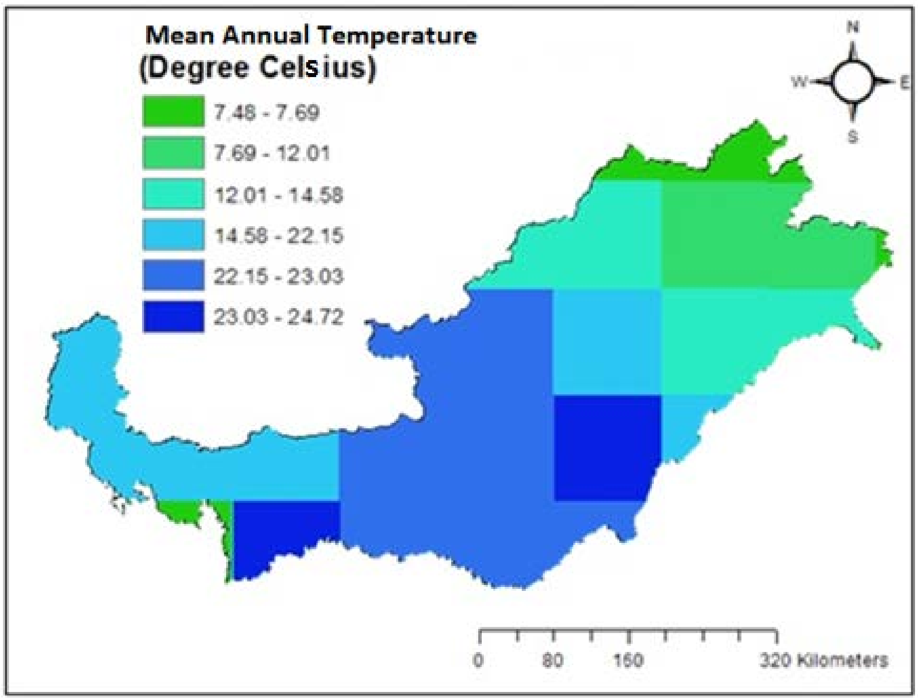


Figure 12.79 Gridded mean annual temperature of Brahmaputra basin (2004-05)

12 (b).20.3 Sub-basins of Brahmaputra basin

The Brahmaputra basin has been divided into thirteen sub-basins as shown in Figure 12.80. The details of the sub-basins are given in Table - 12.13.

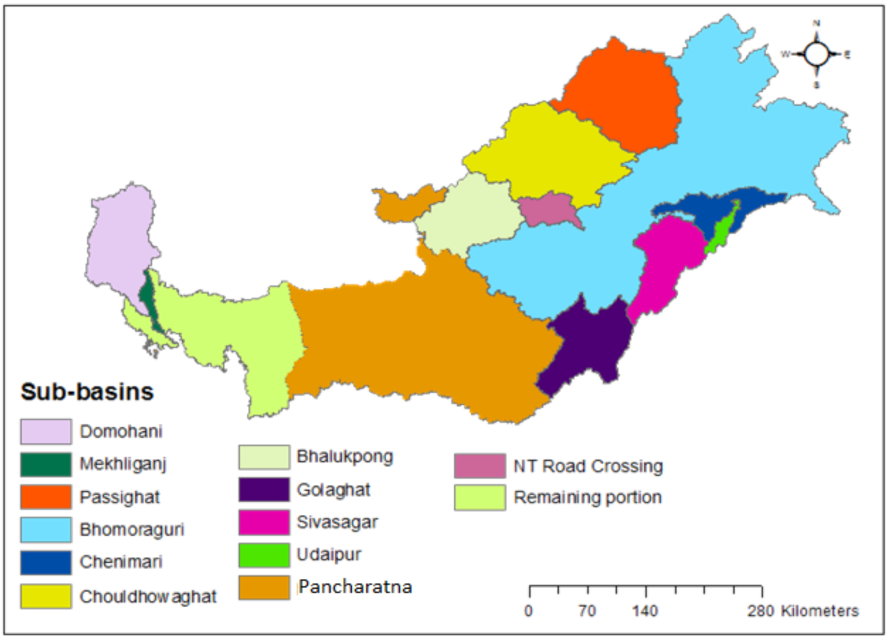


Figure 12.80 Sub-basins of Brahmaputra basin

Table - 12.13 Sub-basin wise details of Brahmaputra basin

Sl. No.	Sub-basin	River	Individual drainage area (sq.km)
1.	Passighat	Siang	14,070
2.	Chouldhowaghat	Subansiri	16,027
3.	NT Road Crossing	Pagladiya	2,282
4.	Bhalukpong	Jiabharali	8,680
5.	Chenimari	Buridehing	4,145
6.	Udaipur	Buridehing/Tirap	875
7.	Sivasagar	Dikhow	6,892
8.	Golaghat	Dhansiri(South)	8,234
9.	Bhomoraguri	Brahmaputra	56,987
10.	Pancharatna	Brahmaputra	47,067
11.	Domohani	Teesta	9,070
12.	Mekhliganj	Teesta	785
13.	Remaining portion	Sankosh	18,138
		Total basin area	1,93,252

12 (b).20.4 River discharge

River discharge data are taken at Passighat, Chouldhowaghat, NT Road Crossing, Bhalukpong, Chenimari, Udaipur, Sivasagar,Golaghat, Bhomoraguri, Pancharatna, Domohani and Mekhliganj discharge sites.

12 (b).20.5 Reservoir flux

No reservoir flux has been considered during the study of Brahmaputra basin as there is no storage scheme present in this basin. All projects are Run-of-the-River type.

12 (b).20.6 Groundwater flux

Spatial groundwater flux map for year 2004-05 and annual variations in groundwater flux (1985-86 to 2014-15) in the basin are shown in Figures 12.81 and 12.82 respectively.

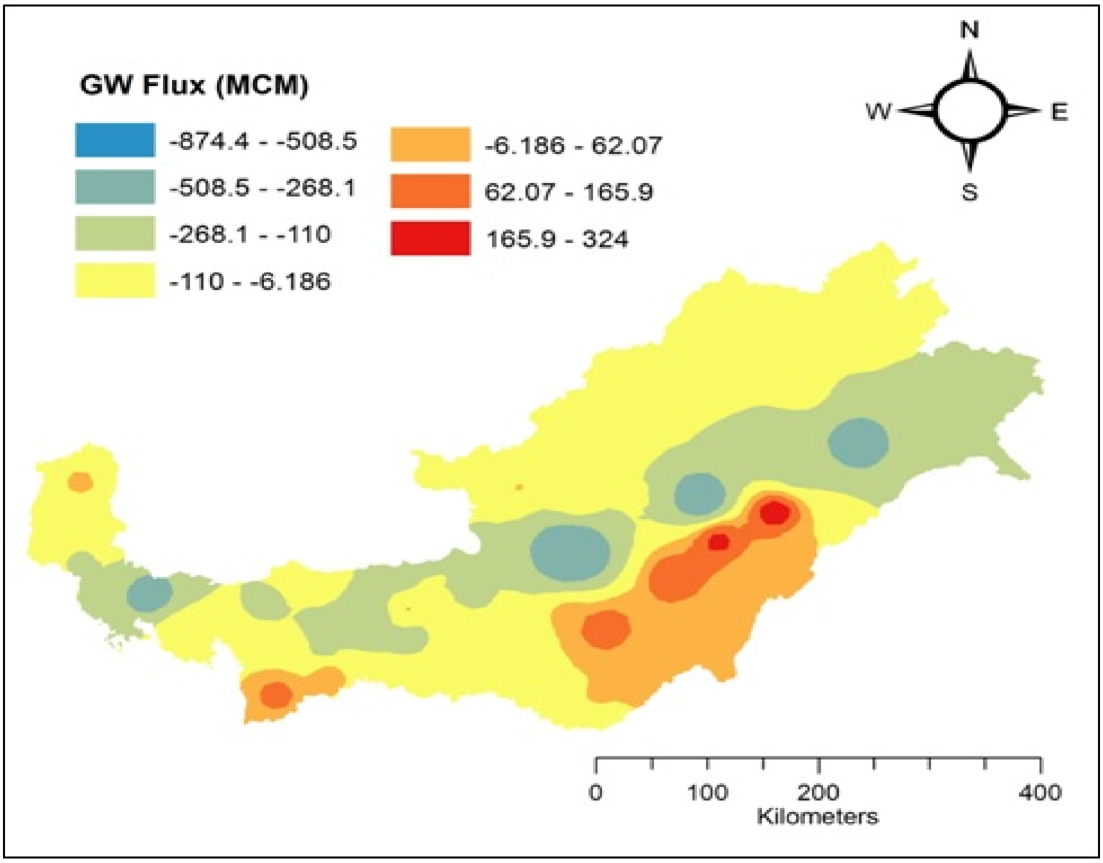


Figure 12.81 Groundwater flux (spatial data) estimated during 2004-05

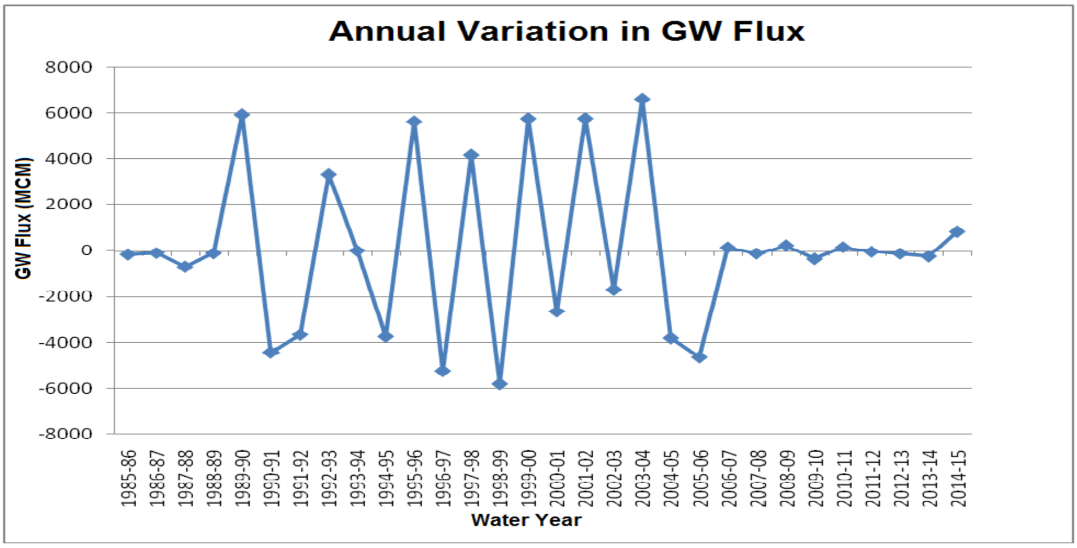


Figure 12.82 Annual groundwater flux of Brahmaputra basin (1985-86 to 2014-15)

12 (b).20.7 Major crops in the basin

Based on the district-wise crop area statistics, district wise major crops for each crop season are identified. One region is taken for the whole basin based on the historic district-wise crop statistics collected from various sources (http://lus.dacnet.nic.in/ dt_lus.aspx). The region specifies a dominant crop for each crop season both spatially and temporally within the basin. On examining the cropping pattern within the basin, crop growing seasons are decided as Kharif only crop for the whole year.

12 (b).20.8 Irrigation command area

Figure 12.83 shows location of irrigation command boundaries in the Brahmaputra basin considered for the year 2014-15.

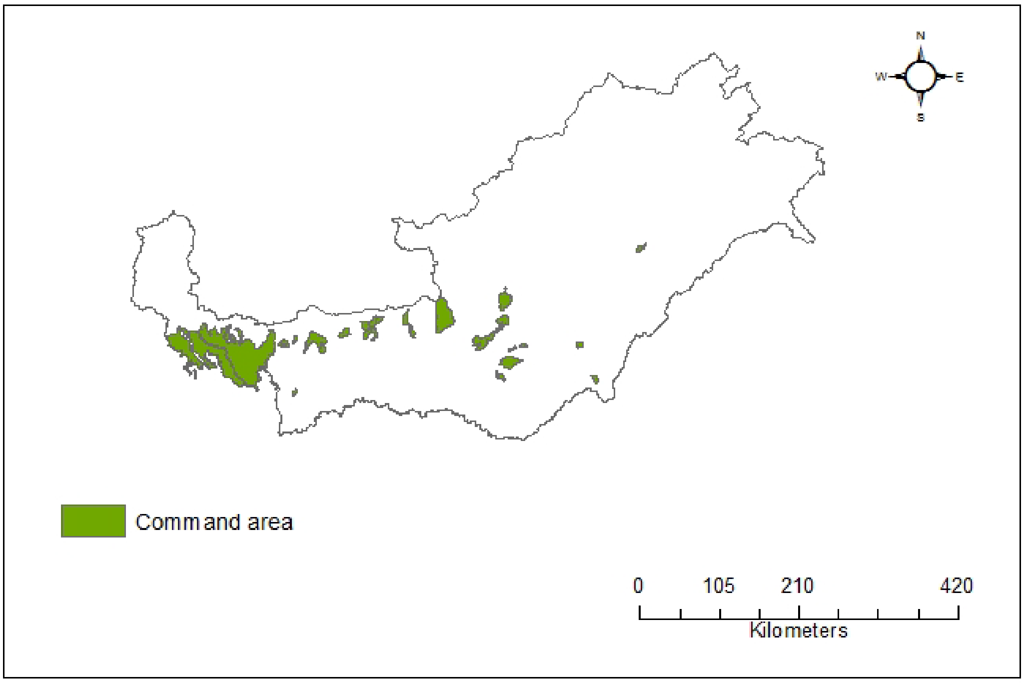


Figure 12.83 Irrigation command boundaries of Brahmaputra basin

12 (b).20.9 Domestic, industrial and livestock demand

Figure 12.84 shows district boundaries layer of the Brahmaputra basin for 2011 census. The mean annual domestic, industrial and livestock demands are estimated as 0.70 BCM in the basin.

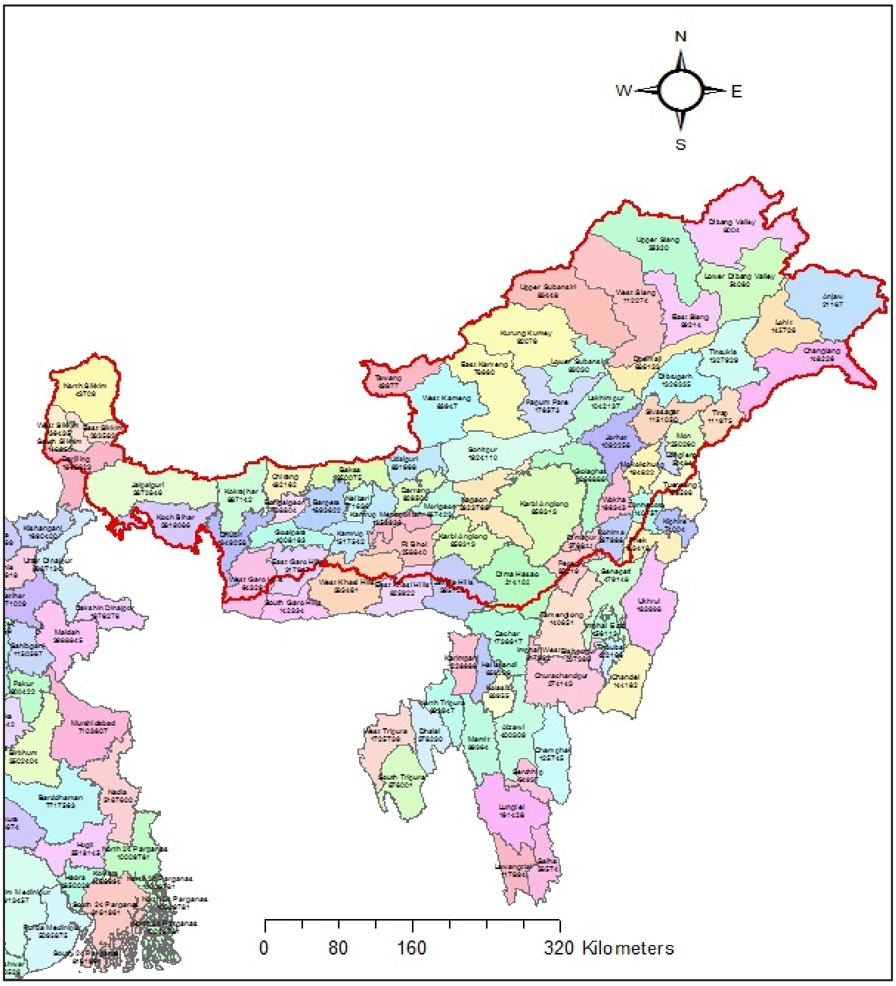


Figure 12.84 District boundaries in Brahmaputra basin

12(b).20.10 Evaporation from major/medium/minor reservoirs and other water bodies

No evaporation was considered during the study of Brahmaputra basin as there is no storage scheme present in this basin.

12(b).20.10 Previous Estimates

During 1993 study, no separate assessment was made for estimating water resources of the Brahmaputra basin. The Brahmaputra Board in their report of 1987 on “Master Plan of Brahmaputra Basin: Part 1 Main Stem” has reported the average annual flow at Jogighopa (Pancharatna) on Brahmaputra as 537.067 BCM.

12(b).21 Runoff Estimation

Tables L.28 to L.41 (at Annexure L(d)) show model runoff, calibrated discharge, rainfall, ECII, etc. during 28 years for 13 locations (including 12 G&D sites) sites and for the whole Brahmaputra basin. Figure 12.85 to 12.97 show comparative graphs of model runoff/calibrated discharge and rainfall at these locations.

Model runoff (except for Domohani and Mekhliganj sub-basin) has been used for estimating the water availability (Q_{model} = Water availability) of the sub-basins because of the following reasons:

i) For Bhomoraguri and Chouldhowaghat sub-basins, annual observed discharge is found to be greater than the annual rainfall received in the subbbasin, as measured by different sources like IMD and GEFS (Global Ensemble Forecasting System). However, the adjacent sub-basins have fairly good co-relation between respective annual rainfall and annual discharge. Also, discharge data is available for only 6-7 years for these sub-basins. So, calibration could not be carried out for these sub-basins.

ii) Further, in Passighat sub-basin the annual observed discharge is greater than the annual IMD rainfall in the subbbasin. However, GEFS rainfall is giving acceptable co-relation. Hence, GEFS rainfall has been used for the assessment of water potential of the Passighat sub-basin.

iii) For remaining sub-basins (downstream of Bhomoraguri), parameters of the adjacent sub-basins have been adopted and IMD rainfall has been used for the assessment of water potential.

The GEFS data is available from 1986 to 2014 only. Hence, the water availability for the whole Brahmaputra basin has been estimated based on only 28 years (1986-87 to 2013-14) period.

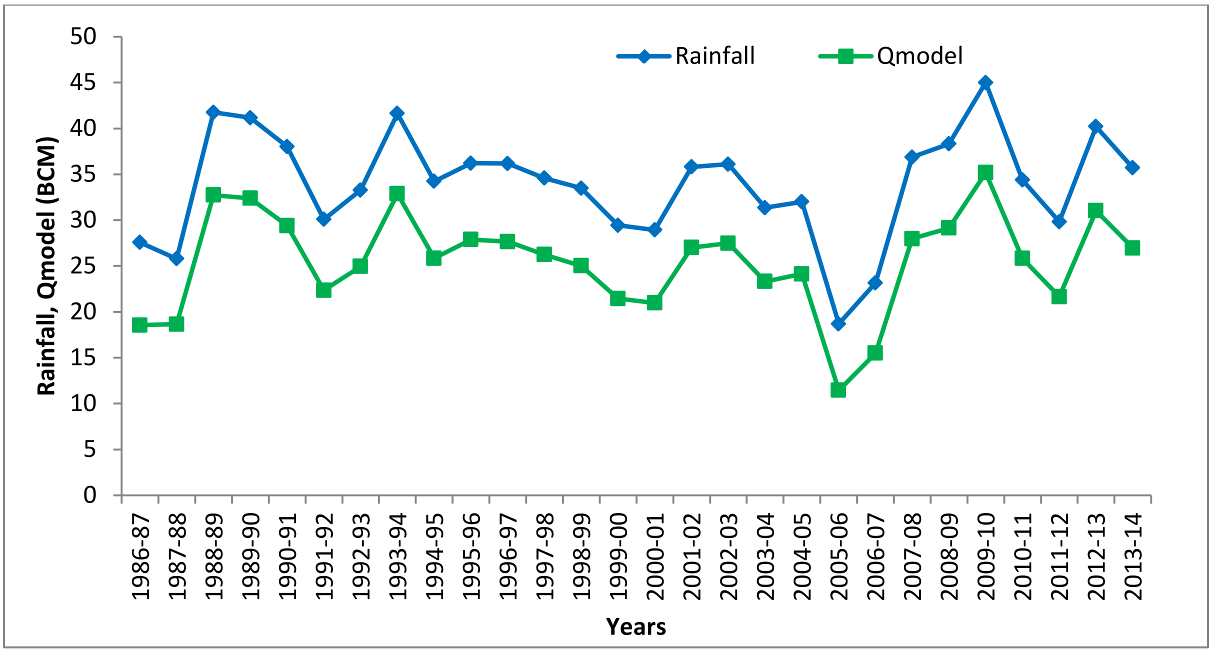


Figure 12.85 Model runoff and rainfall at Bhalukpong

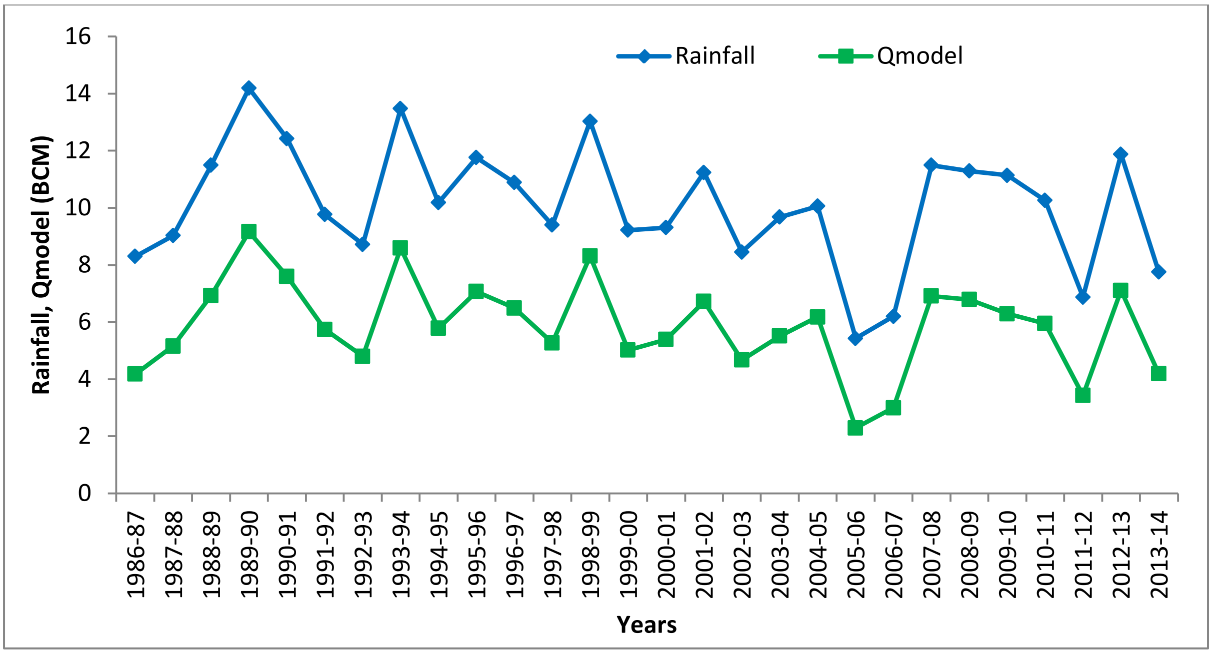


Figure 12.86 Model runoff and rainfall at Chenimari

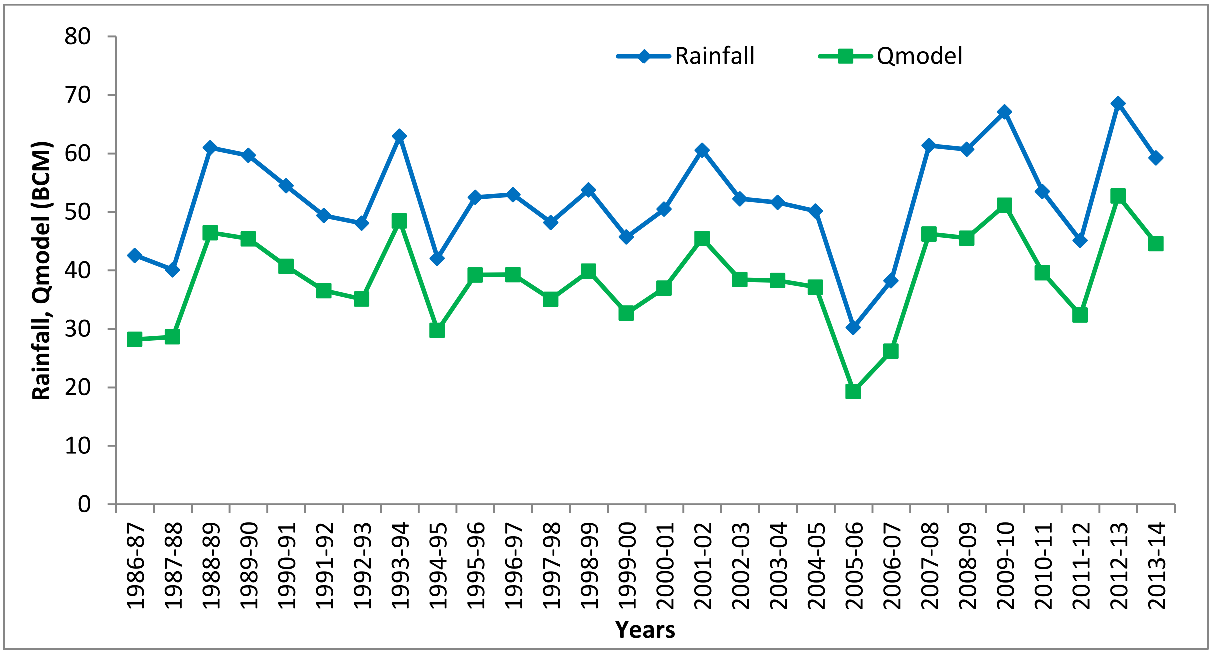


Figure 12.87 Model runoff and rainfall at Passighat

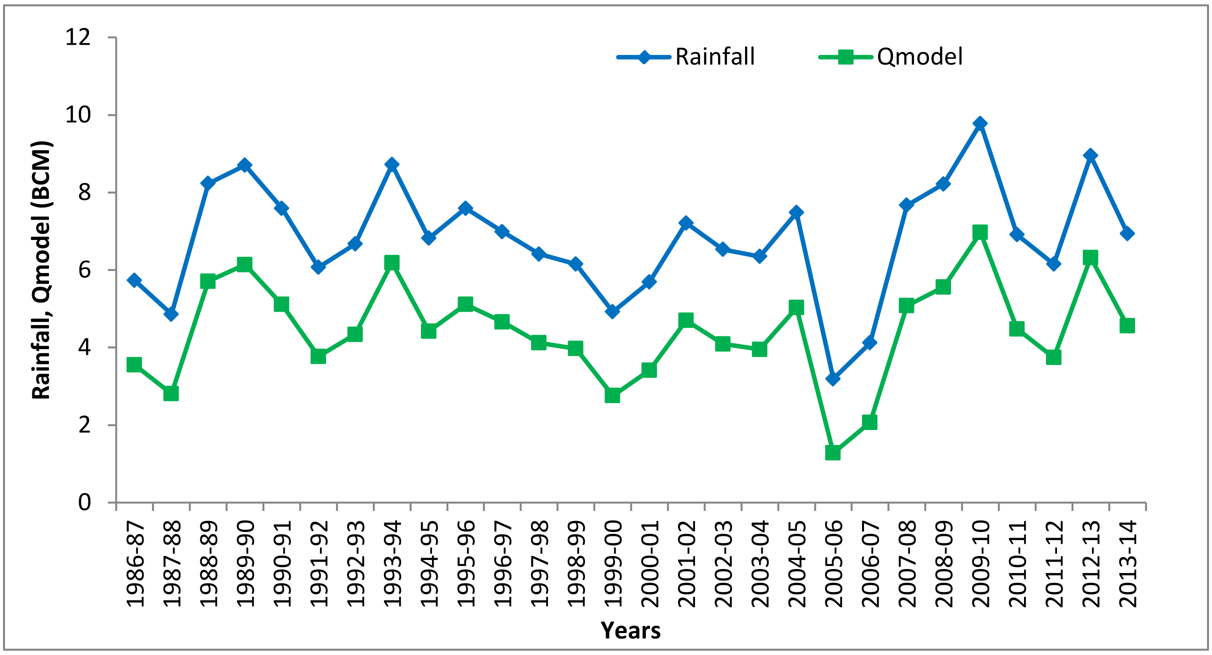


Figure 12.88 Model runoff and rainfall at NT Road Crossing

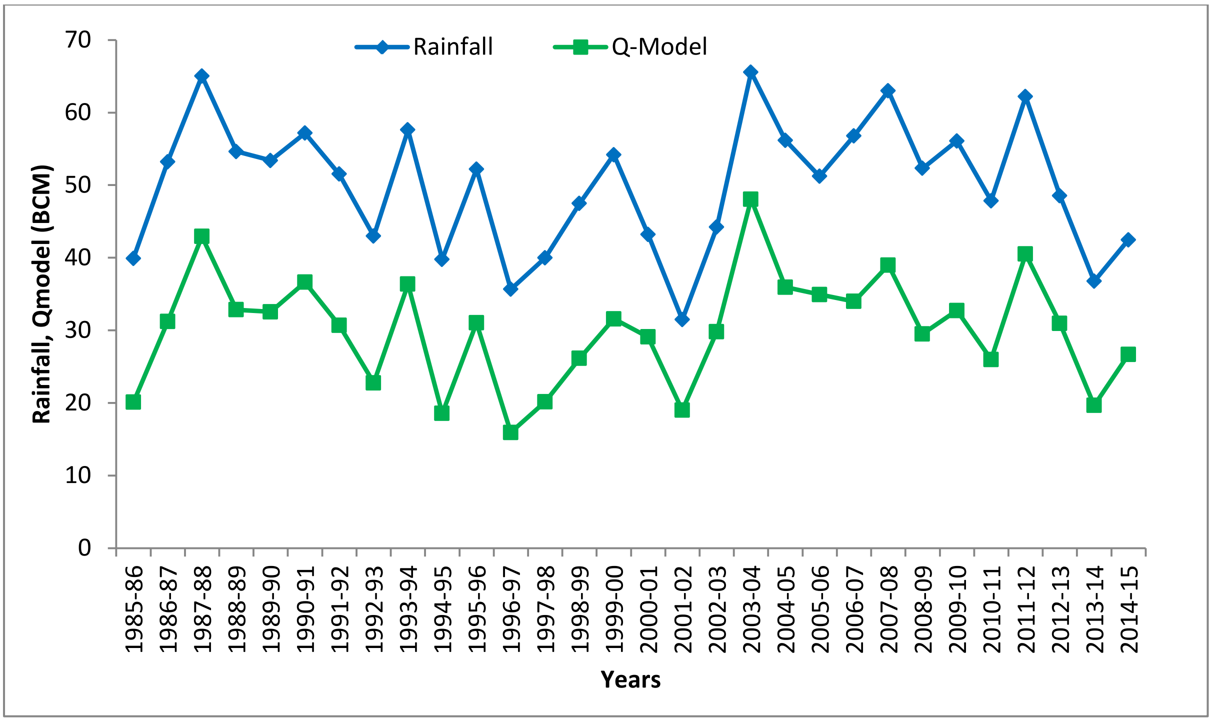


Figure 12.89 Model runoff and rainfall at Chouldhowaghat

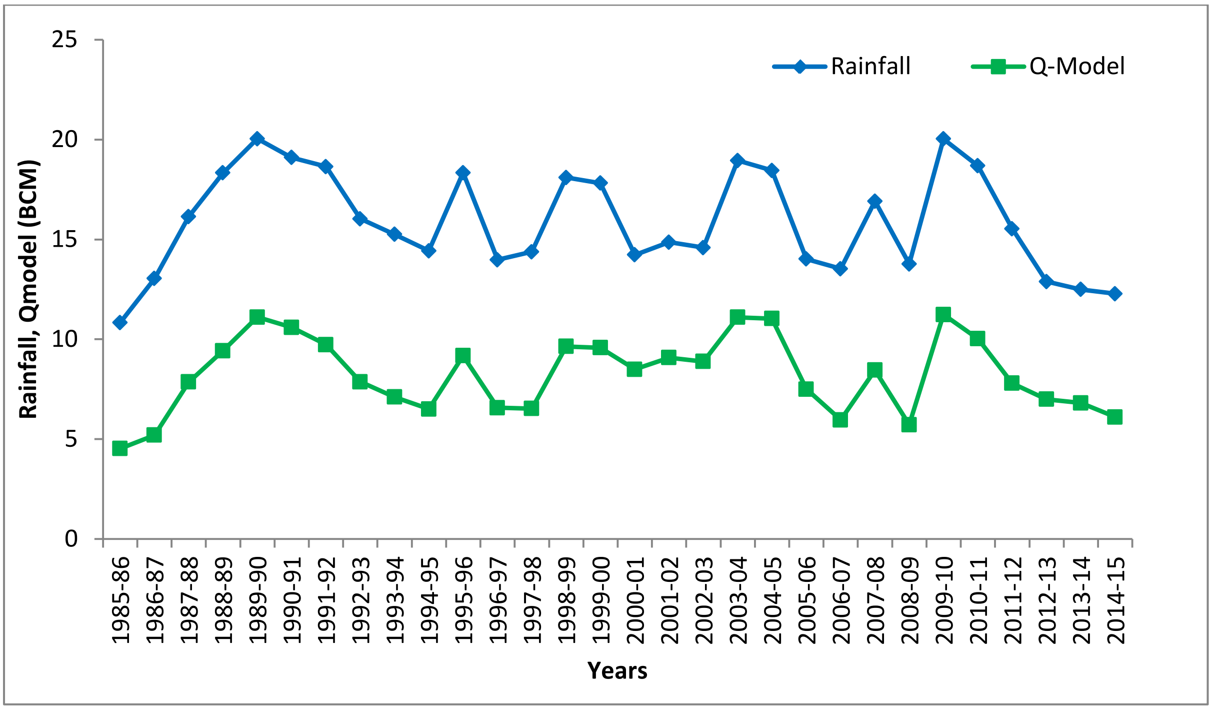


Figure 12.90 Model runoff and rainfall at Sivasagar

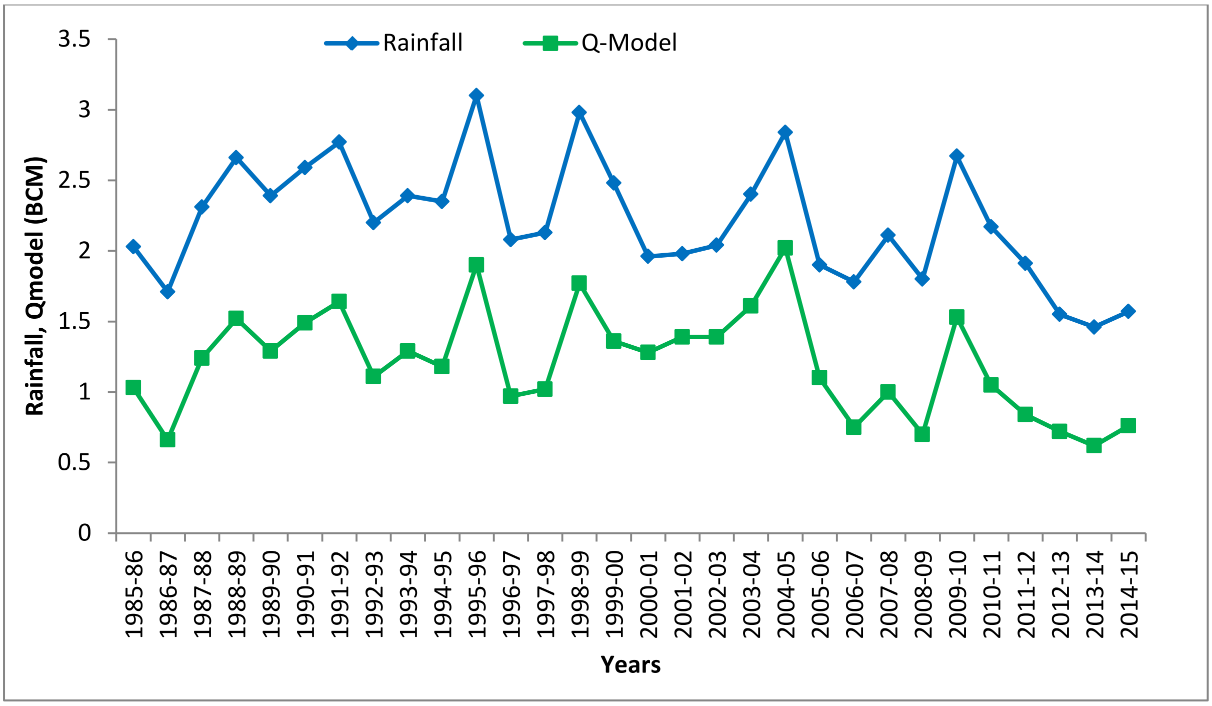


Figure 12.91 Model runoff and rainfall at Udaipur

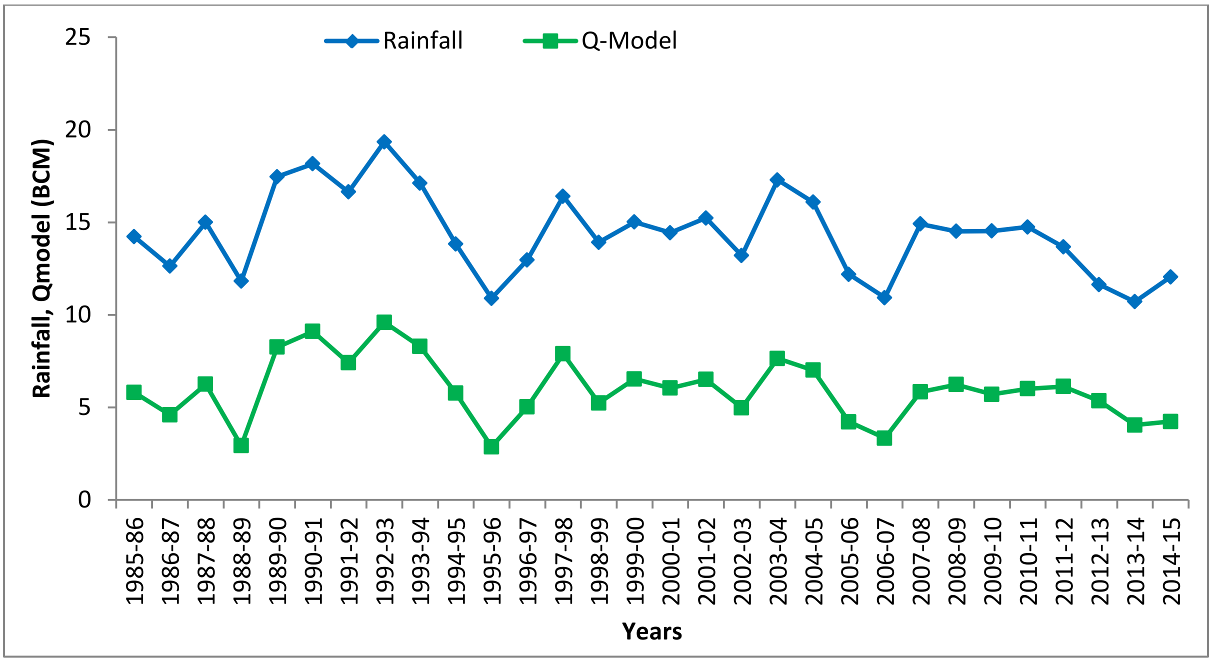


Figure 12.92 Model runoff and rainfall at Golaghat

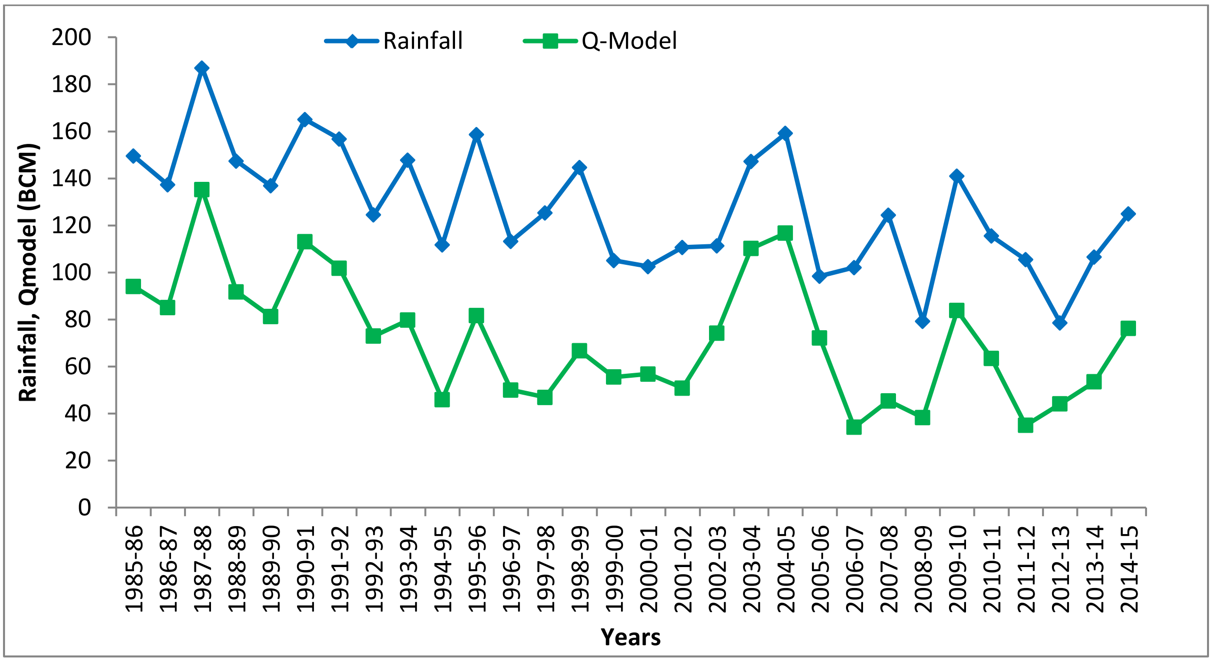


Figure 12.93 Model runoff and rainfall at Bhomoraguri

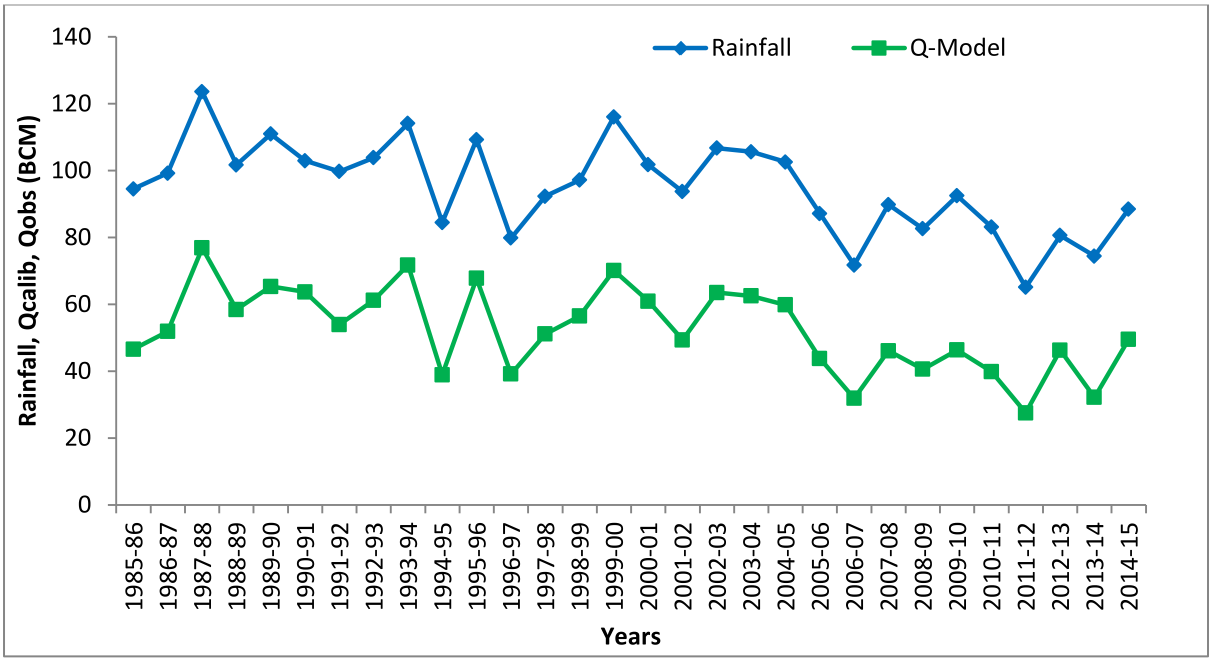


Figure 12.94 Model runoff and rainfall at Pancharatna

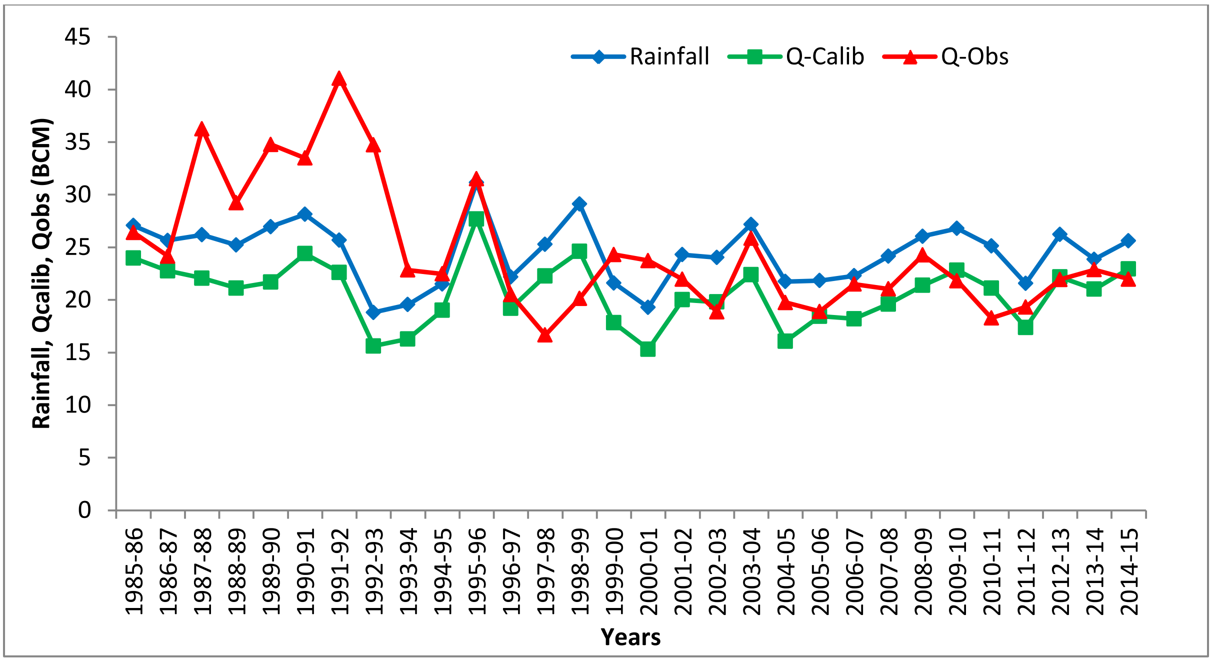


Figure 12.95 Calibrated runoff and observed discharge at Domohani

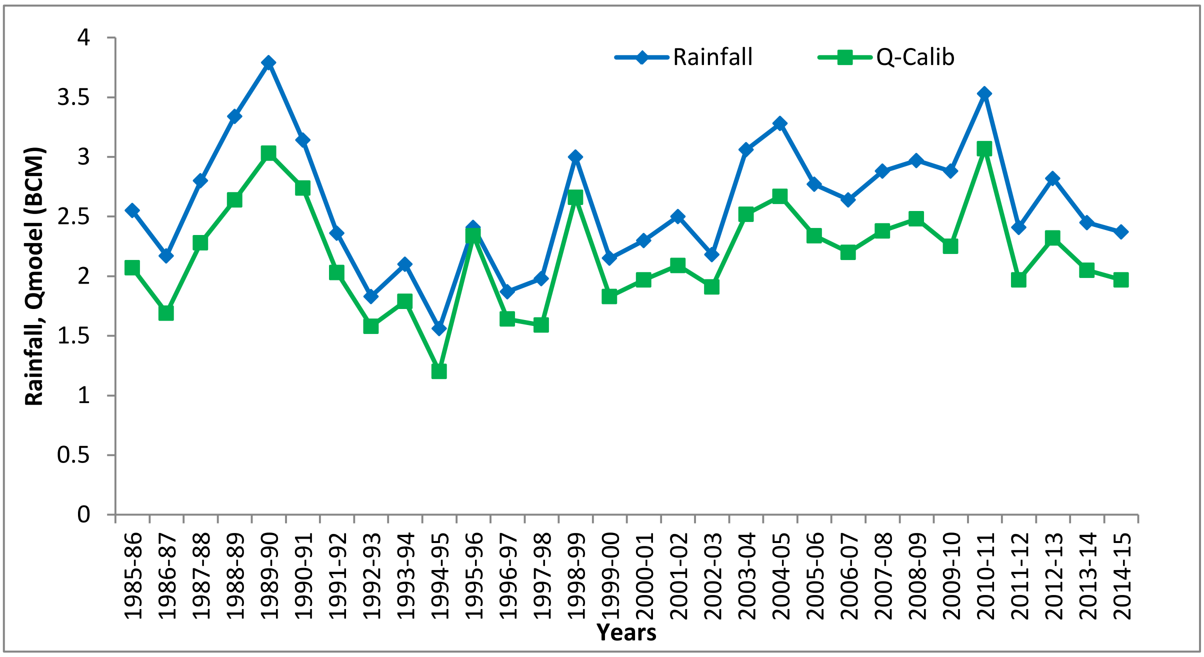


Figure 12.96 Model runoff and rainfall at Mekhliganj

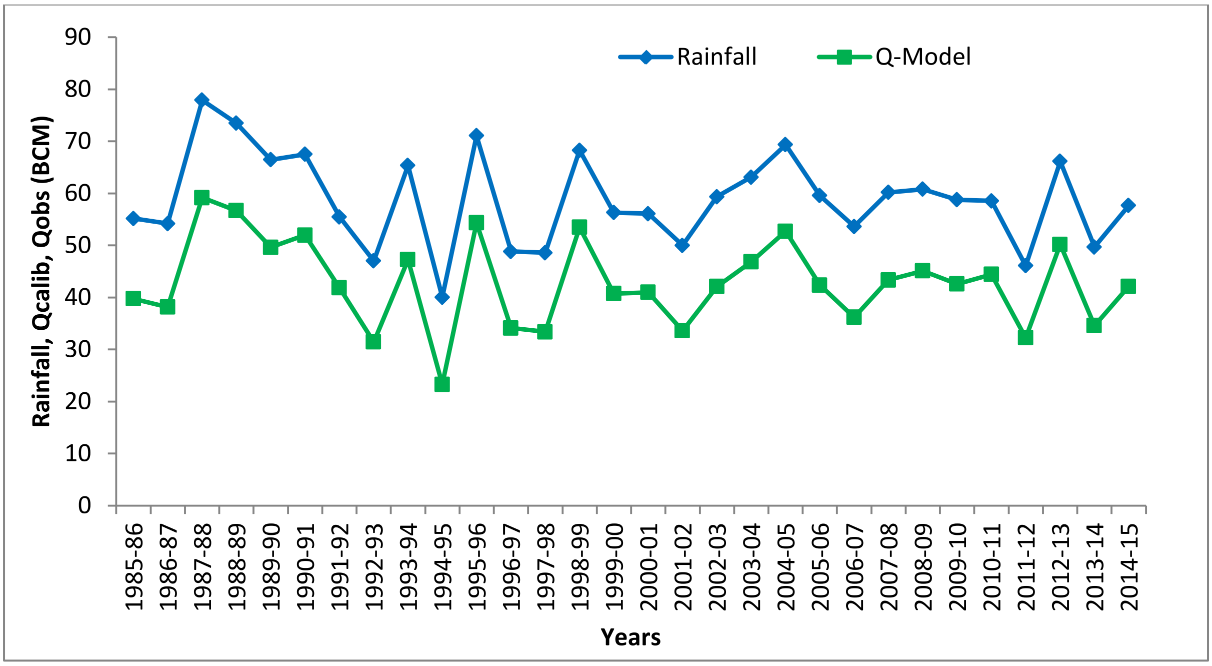


Figure 12.97 Model runoff and rainfall of remaining portion

12 (b).22 Annual water resources availability of Brahmaputra basin

Table L.41 at Annexure L(d) shows the different components required to estimate the basin level water resources of Brahmaputra basin for 28 years. The observed discharge data are available for 8 years (from 2007-08 to 2014-15) in respect of Kibitu, Lemeking and Tuting sites, which are measured entry points for the water entering India boundary. Hence, the maximum and minimum annual water resources availability has been calculated considering the above three sites for 8 years. The maximum annual water resources availability is 461.17 BCM during 2009-10 in the 8 years. The minimum annual water resources availability is 351.61 BCM during 2011-12 which is the driest year in the 8 years.

12 (b).22.1 Annual water resources of Brahmaputra basin during extreme rainfall conditions

Out of the total 8 years of meteorological data base of study period, during the years 2009-10 and 2011-12, extreme wet and dry rainfall conditions occurred in Brahmaputra basin river basin. The annual water resources of Brahmaputra basin during these two extreme rainfall conditions are 461.17 BCM and 351.61 BCM, respectively as shown in Table 12.14. The water balance components during these years are presented in Figures 12.98 and 12.99.

Runoff-rainfall ratios during the extreme maximum and minimum rainfall years are found to be 0.84 and 0.83 respectively, which shows that the higher the rainfall, the higher percentage of runoff.

Table - 12.14 Water resources availability in Brahmaputra basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability* (BCM)
Maximum Rainfall	2009-10	548.23	461.17
Minimum Rainfall	2011-12	421.86	351.61

** Maximum and minimum WRA in the basin include discharge at Kibutu, Lemeking and Tuting sites, which are the measured entry points at India boundary.*

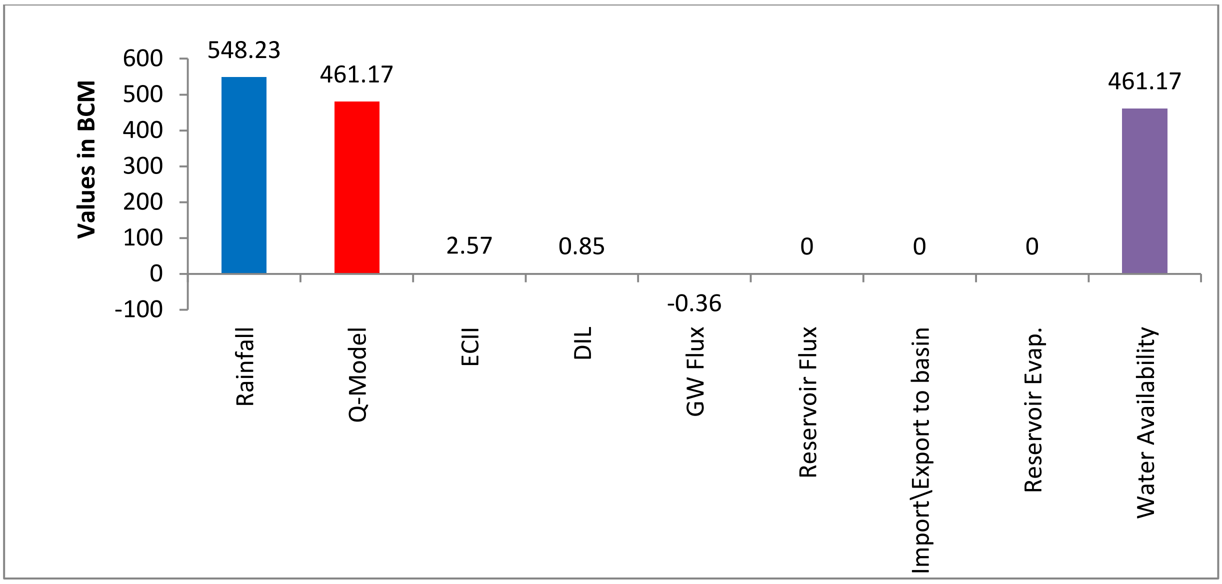


Figure 12.98 Water balance components of Brahmaputra basin during extreme high rainfall (2009-10)

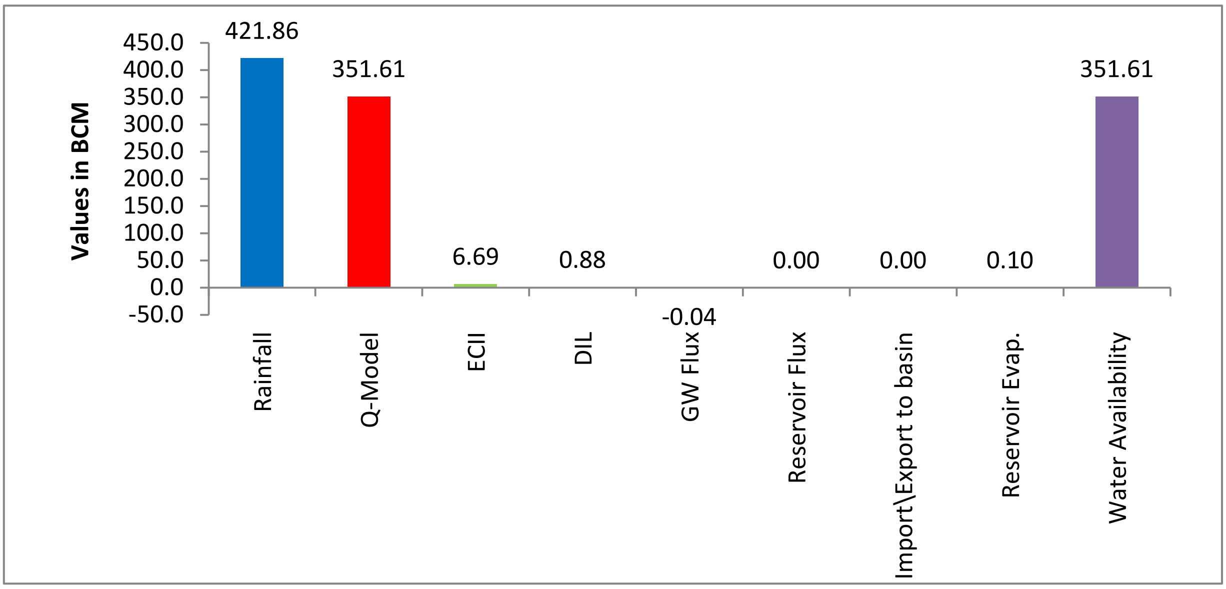


Figure 12.99 Water balance components of Brahmaputra basin during extreme low rainfall (2011-12)

12 (b).22.2 Mean water resources of Brahmaputra basin

Mean Water Resources Availability = Mean of Modelled Runoff + Export from basin + Evaporation from Reservoirs + Average observed discharge at Kibitu + Average observed discharge at Lemeking + Average observed discharge at Tuting

= (310.14) + 0.00 + 0.00 + 36.08 + 5.78 + 89.68

= 441.68 BCM

The mean available annual water resource of the Brahmaputra basin is 441.68 BCM.

75% dependable flow of Brahmaputra basin = 385 BCM

Figure 12.100 shows the various water balance components averaged over a period of 28 years during 1986-87 to 2013-14.

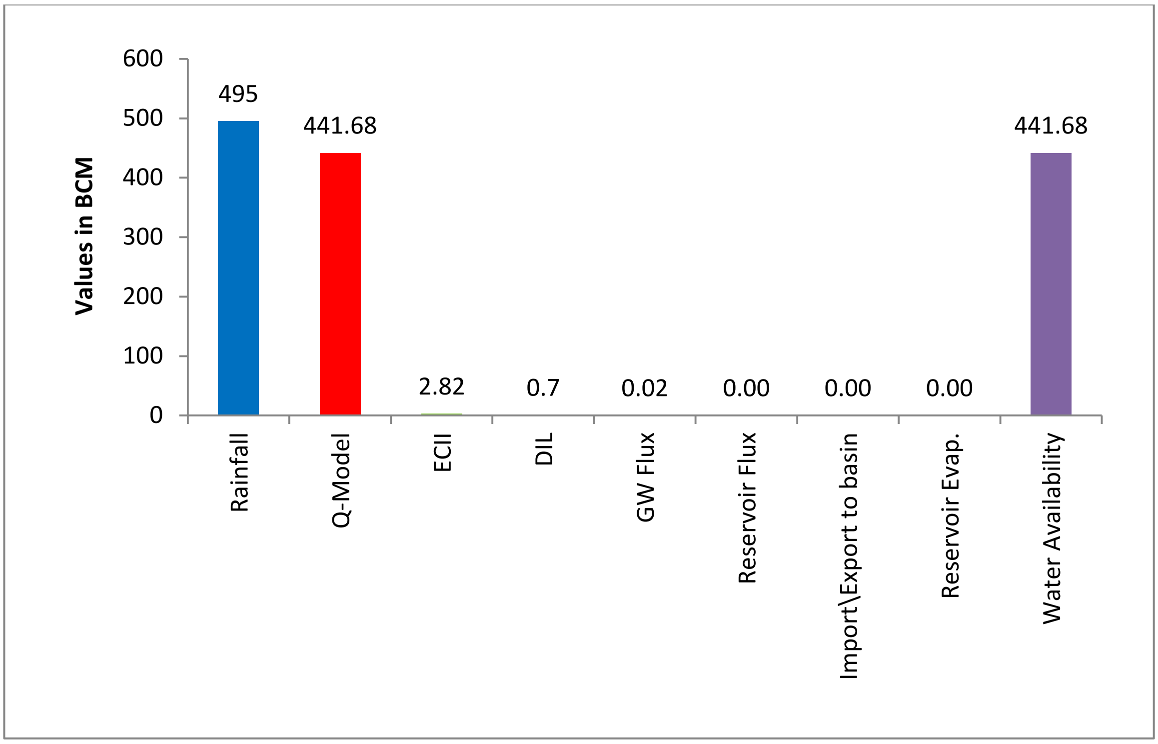
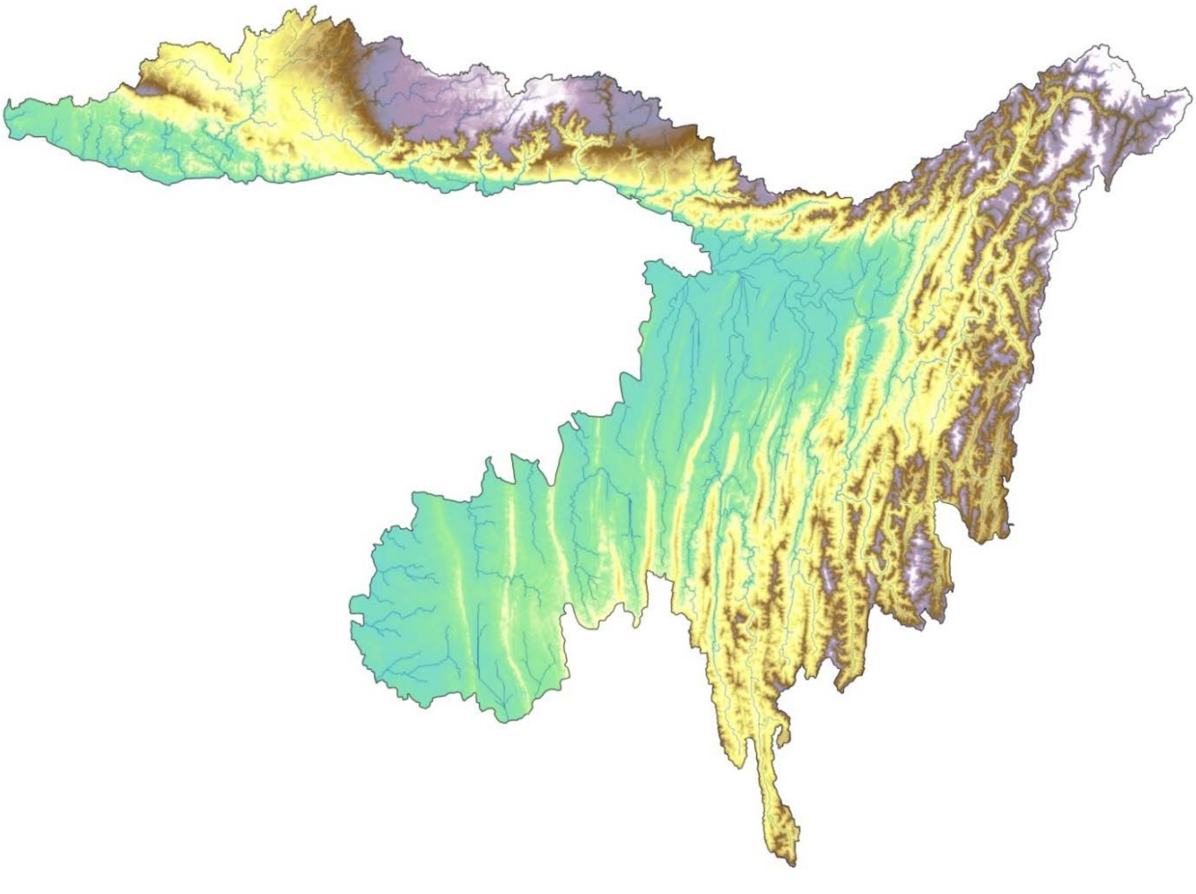


Figure 12.100 Mean water balance components of Brahmaputra basin

HIGHLIGHTS

- *Mean annual available water resources of Brahmaputra basin is 441.68 BCM.*
- *Maximum annual water availability is 461.17 BCM during 2009-10.*
- *Minimum annual water availability is 351.61 BCM during 2011-12.*
- *Annual rainfall in the basin varies from 2,105 mm to 3,083 mm during 1985-86 to 2014-15 and mean rainfall for these 30 years is 2,330 mm.*
- *The Brahmaputra basin has been divided into thirteen sub-basins for the reassessment study viz. Passighat, Chouldhowaghat, NT Road Crossing, Bhalukpong, Chenimari, Udaipur, Sivasagar, Golaghat, Bhomoraguri, Pancharatna, Domohani, Mekhliganj and Remaining portion.*
- *Mean annual domestic, industrial and livestock demand in the basin is 0.70 BCM.*

BARAK & OTHERS BASIN



12(c).23 Geo-Spatial Datasets

12 (c).23 .1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map of Barak & others basin is shown in Figure 12.101. Figure 12.102 shows distribution (in percentage) of LULC in the basin for 2004-05. The LULC analysis indicates that deciduous forest (40%), evergreen forest (28%), scrub/degraded forest (13%), Kharif only (8%) and Double/Triple crop (5%) are the major classes in Barak & others basin.

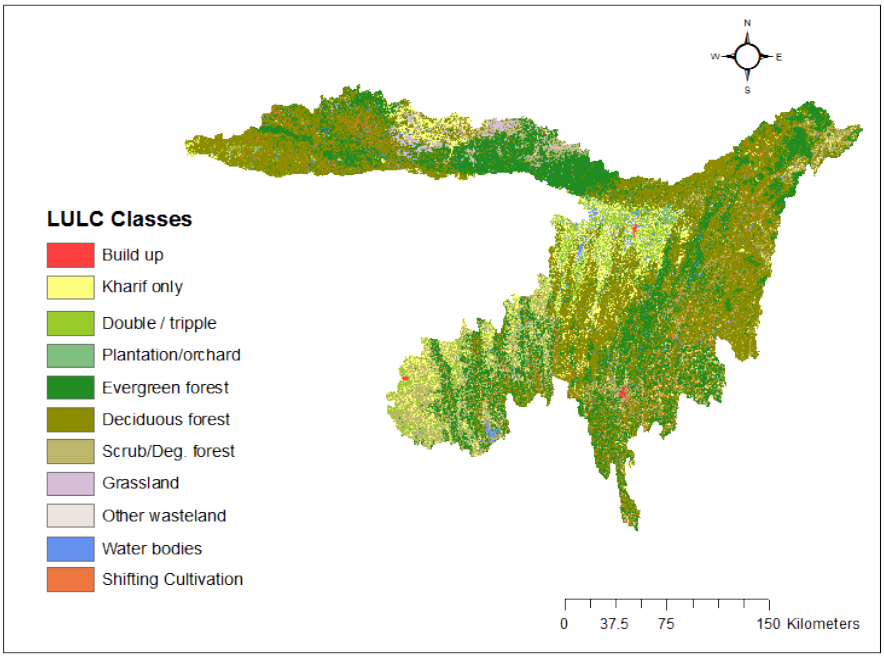


Figure 12.101 LULC map of Barak & others basin (2004-05)

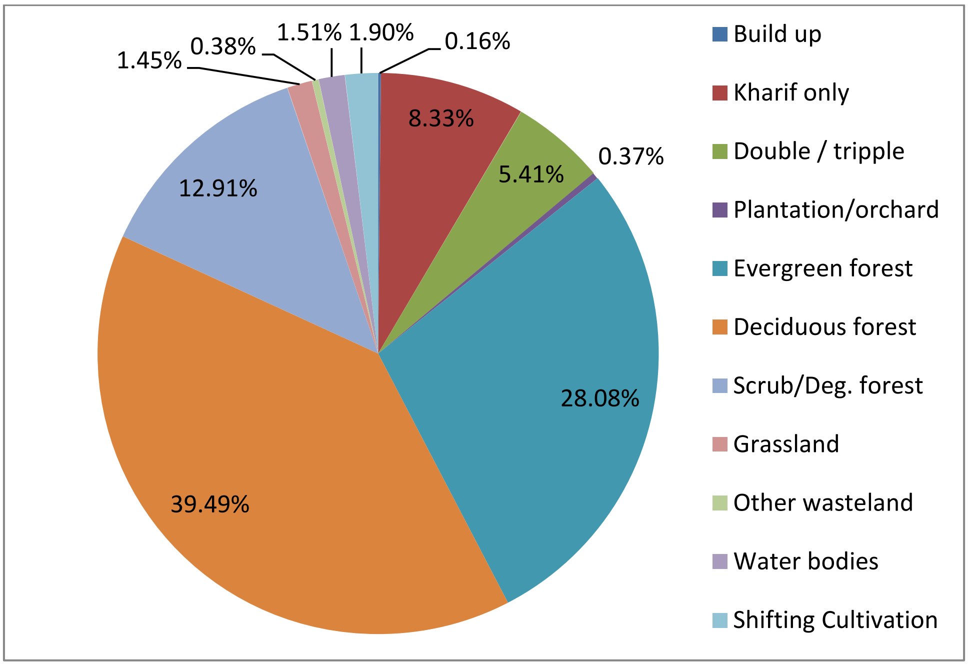


Figure 12.102 Distribution of LULC in Barak & others basin (2004-05)

12 (c).23.2 Soil texture

The main soil types found in the basin are sandy, clay and loamy soils. The coastal plains consist of fertile delta area highly suited for intensive cultivation. Figure 12.103 shows various categories of soils in the basin. The soils are classified as sandy, loamy, clayey and rock outcrops based on the soil textural information.

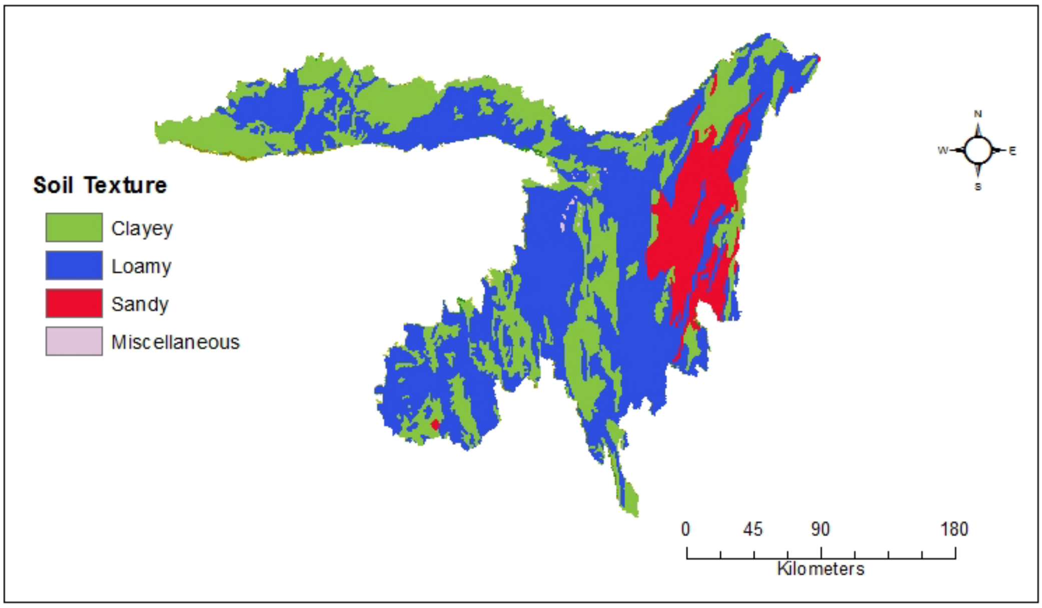


Figure 12.103 Soil texture map of Barak & others basin

12 (c).23.3 Topography

The topography of the basin consists of mountainous areas, hills and the reverine plains. The major portions of the basin are hilly and forested. The border area of the basin near Bangladesh is riverine plains. The elevation values ranges from a minimum of 0 m to a maximum of 3,011 m. Figure 12.104 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the basin.

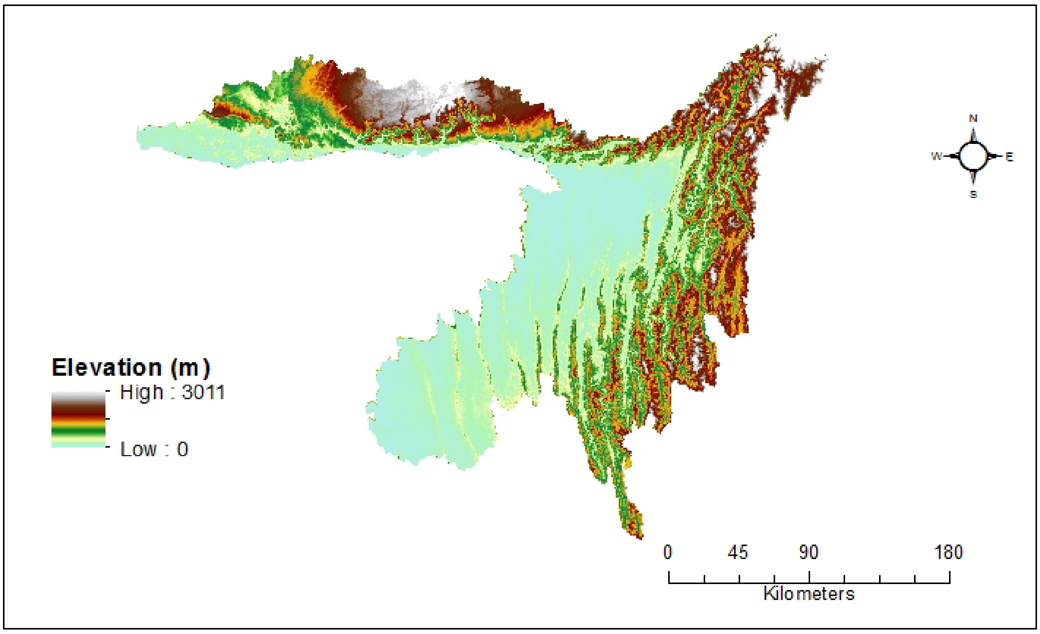


Figure 12.104 SRTM DEM map of Barak & others basin

12 (c).24 Hydro-Meteorological and other Input Data

12 (c).24.1 Rainfall grids

Figure 12.105 shows gridded annual rainfall map of Barak & others basin for year 2004-05. The annual variations in the rainfall during study period of 30 years (1985-86 to 2014-15) are shown in Figure 12.106. Annual rainfall of the basin varies from 1975 mm to 3,518 mm and mean rainfall of these 30 years is found to be 2625 mm. Rainfall analysis at sub-basin level during the study period reveals that minimum annual rainfall of around 1,340 mm is observed in Fulertal sub-basin while highest annual rainfall of 8,072 mm is observed in Ranikor sub-basin. North eastern part of the basin receives less rainfall. Of the 30 years, for 16 years annual rainfall is higher than the mean rainfall and for remaining 13 years it is lower than the mean rainfall. However, there is a decreasing trend of rainfall towards recent years.

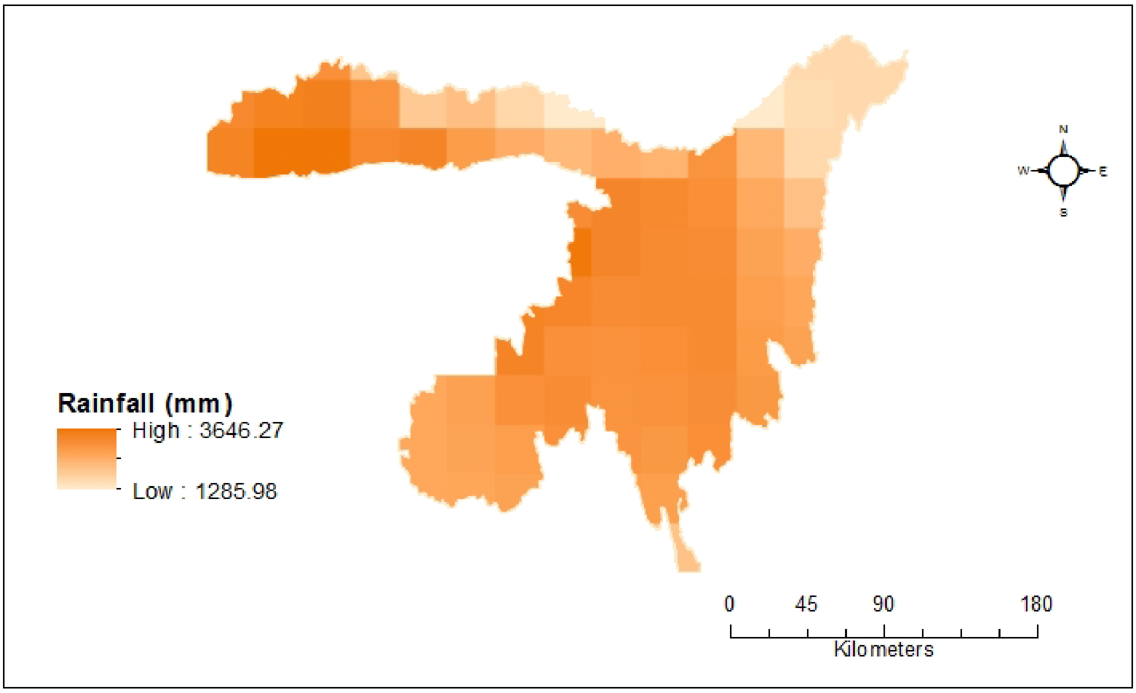


Figure 12.105 Gridded rainfall of Barak and others basin (2004-05)

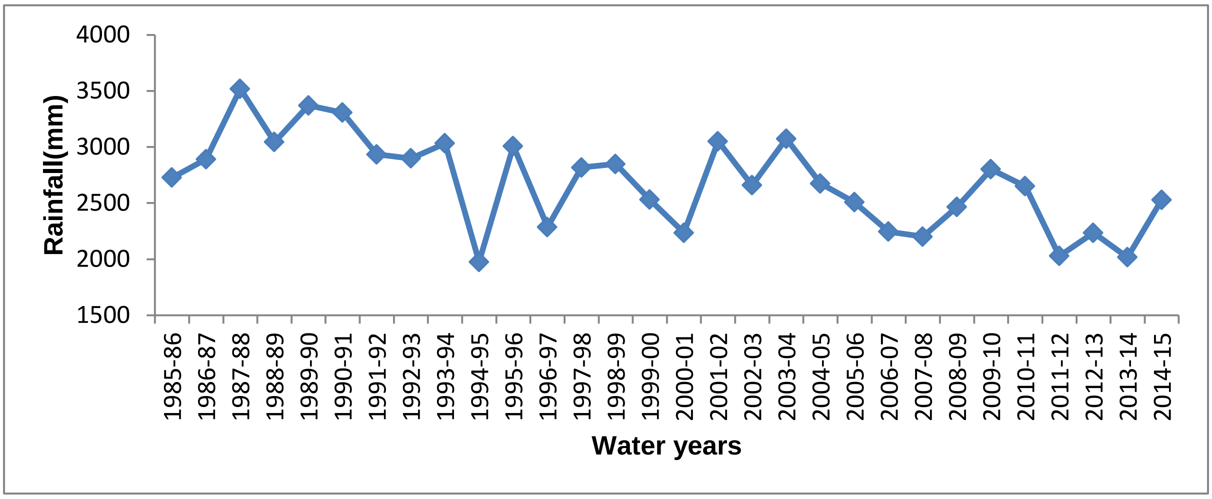


Figure 12.106 Annual rainfalls in Barak & others basin (1984-85 to 2014-15)

12 (c).24.2 Temperature grids

Gridded mean annual temperature map of Barak and Others basin for 2004-05 year is shown in Figure 12.107.

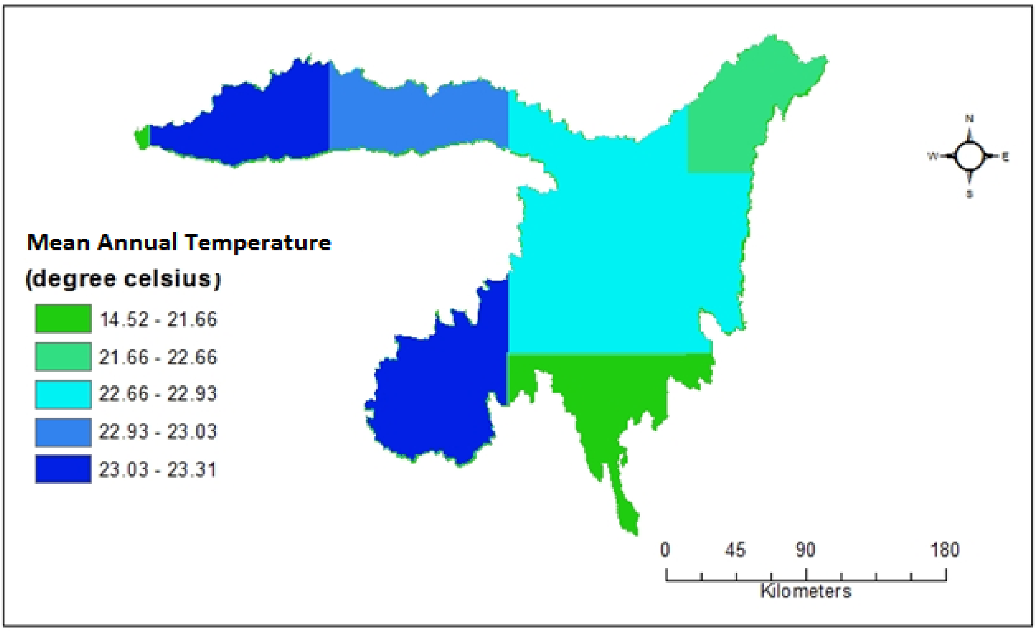


Figure 12.107 Gridded mean annual temperature of Barak & others basin (2004-05)

12 (c).24.3 Sub-basins of Barak & others basin

The Barak and Others basin is divided into nine sub-basins (Figure 12.108) viz. Fulertal, A. P. Ghat, B. P. Ghat, Tulargram, Matijuri, Ranikor, Baghmara, Kailashahar and combined other region as one sub-basin. Table 12.15 gives details of each sub-basin. The sub-basins are divided in such a way that the locations of CWC discharge sites are taken as sub-basin terminal point.

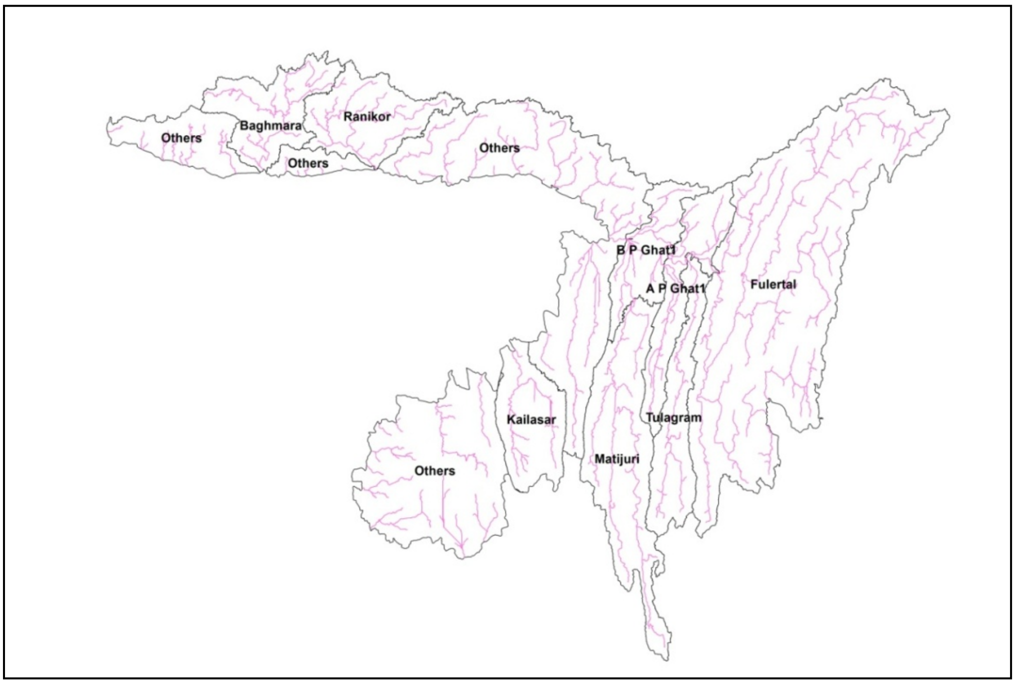


Figure 12.108 Sub-basins of Barak & others basin

Table - 12.15 Sub-basin wise details of Barak & others basin

S. No.	Sub-basin	River	Individual drainage area (sq.km)
1	Fulertal	Barak	13,923
2	A. P. Ghat	Barak	18,285
3	B. P. Ghat	Barak	24,482
4	Tulargram	Sonai	2,261
5	Matijuri	Dhaleshwari	4,447
6	Ranikor	Jadukata	2,493
7	Baghmara	Someswari	2,305
8	Kailashahar	Manu	2,218
9	Other	Other	15,921
		Total basin area	86,335

12 (c).24.4 River discharge

The river discharge data are available at six sites (Fulertal, A. P. Ghat and B. P. Ghat located on river Barak, Tulargram on river Sonai and Matijuri on river Dhaleswari, both are on left flank tributary of Barak and Kailashahar on river Manu) for the study period of 30 years. The river discharge data of two sites (Ranikor and Baghmara) is available only for 10 years from 1981 to 1990. In this study, these two sites have been considered to represent the eastern part of basin.

12 (c).24.5 Reservoir flux

Figure 12.109 shows the location of major reservoir in Barak & others basin. There is only one major reservoir i.e Gumati. The data of Gumati reservoir maintained by CWC is considered for estimating storage flux changes for each water year wise for 30 year period.

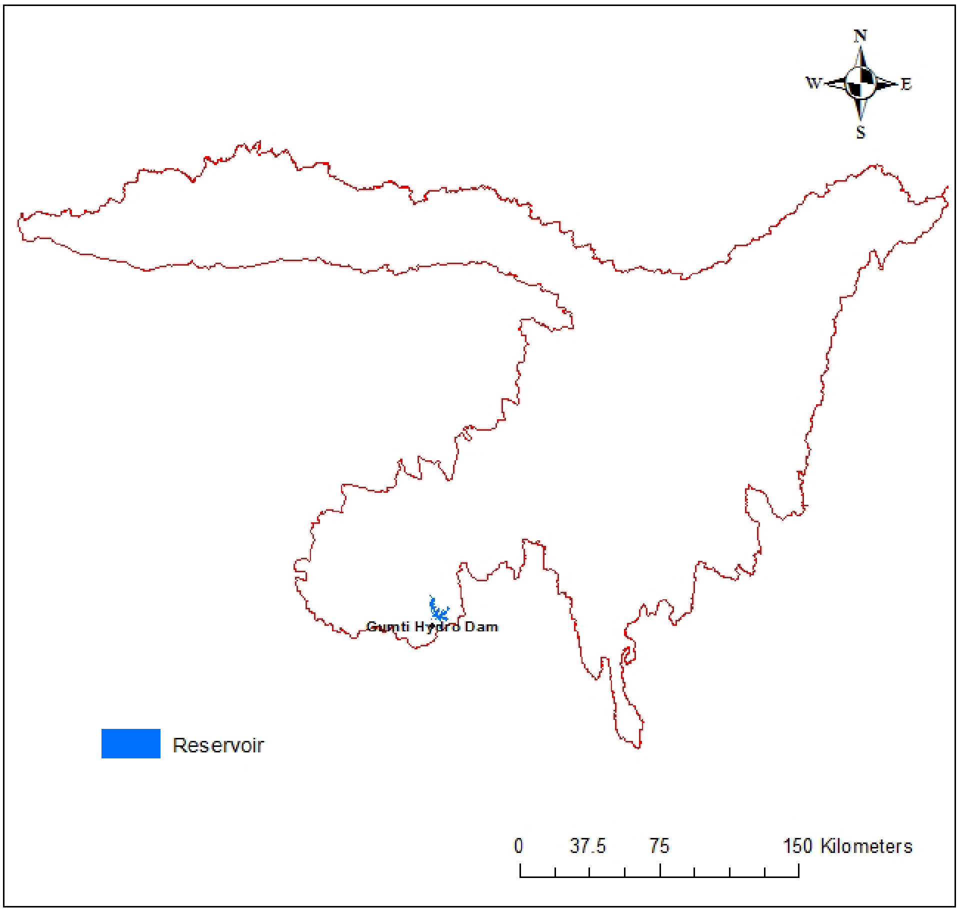


Figure 12.109 Major reservoirs in Barak & others basin

12 (c).24.6 Groundwater flux

The spatial variation of groundwater flux for year 2004-05 is shown in Figure 12.110. Annual variations in the flux for the study period of 30 years (1985-86 to 2014-15) are shown in Figure 12.111.

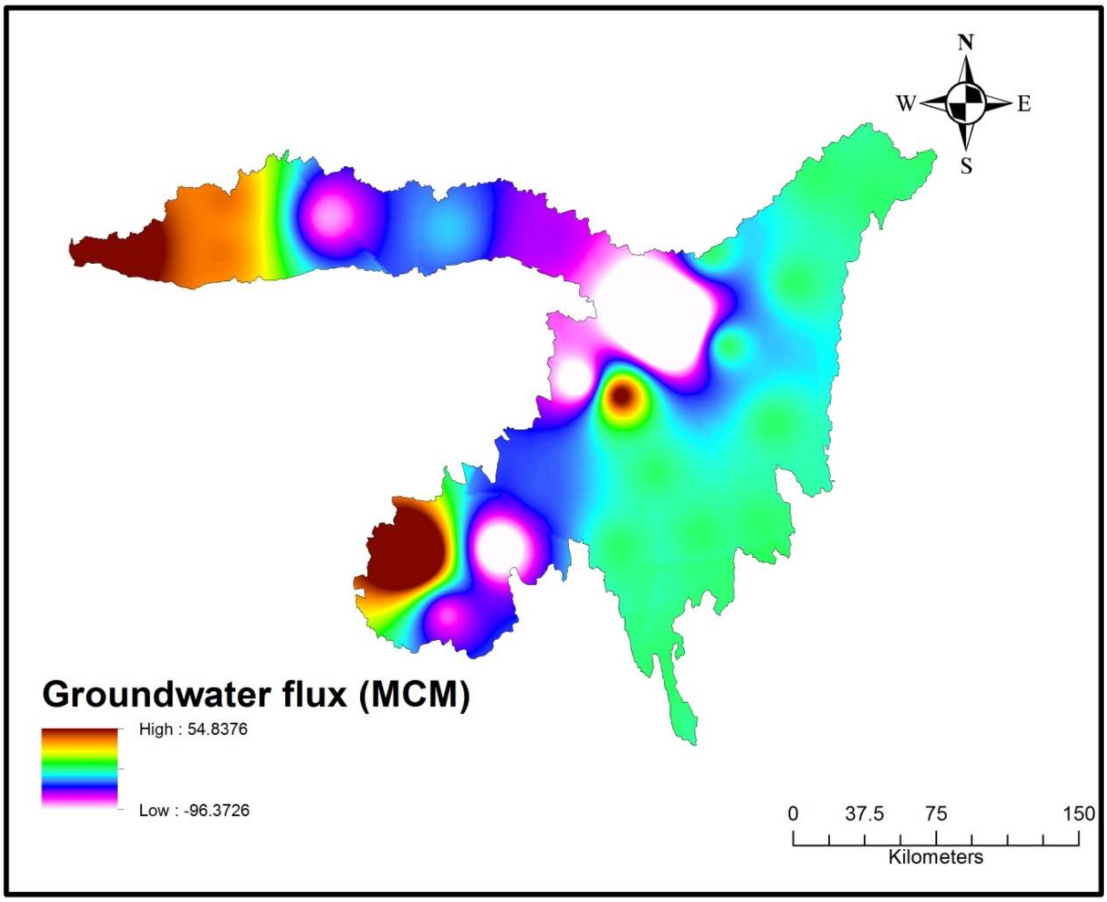


Figure 12.110 Groundwater flux (spatial data) estimated during 2004-05

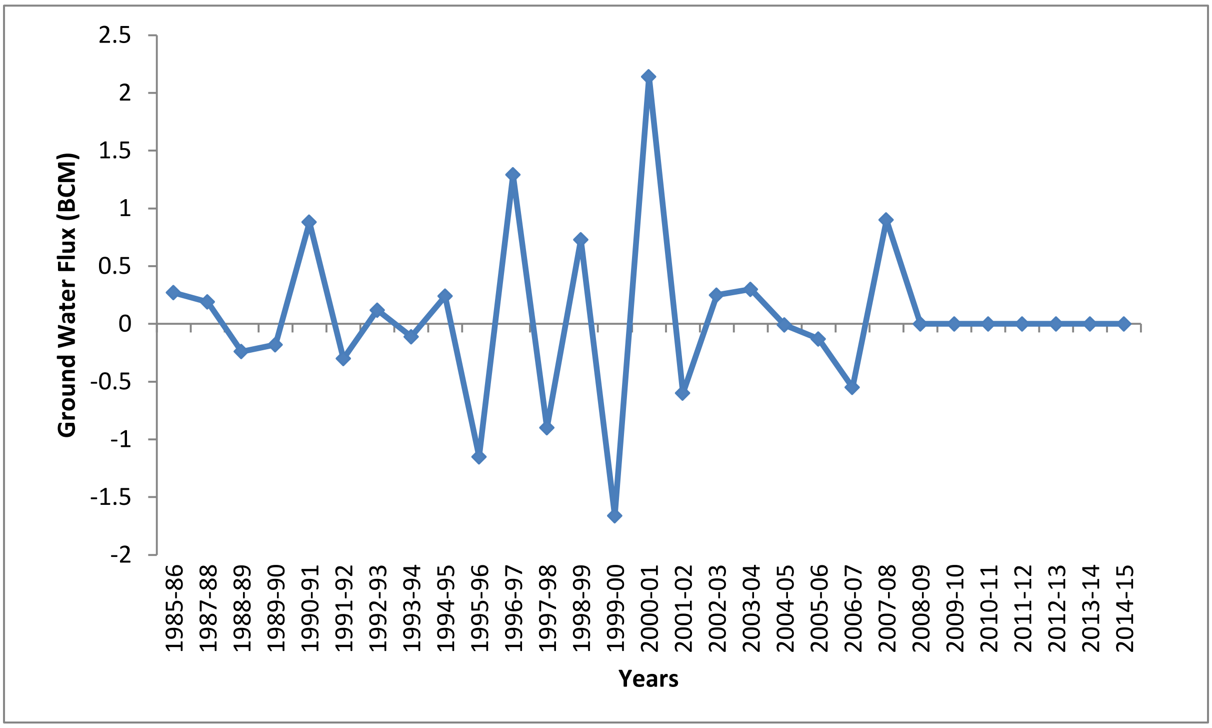


Figure 12.111 Annual groundwater flux of Barak & others basin (1985-86 to 2014-15)

12 (c).24.7 Major crops in the basin

Barak & others basin has more than 75% of forested area and hence major land-use class is forest. The Barak & others basin has been divided in six regions based on forest cover. Each region has specific canopy of forest cover.

12 (c).24.8 Irrigation command area

Figure 12.112 shows location of irrigation command boundaries in the basin considered for year 2014-15.

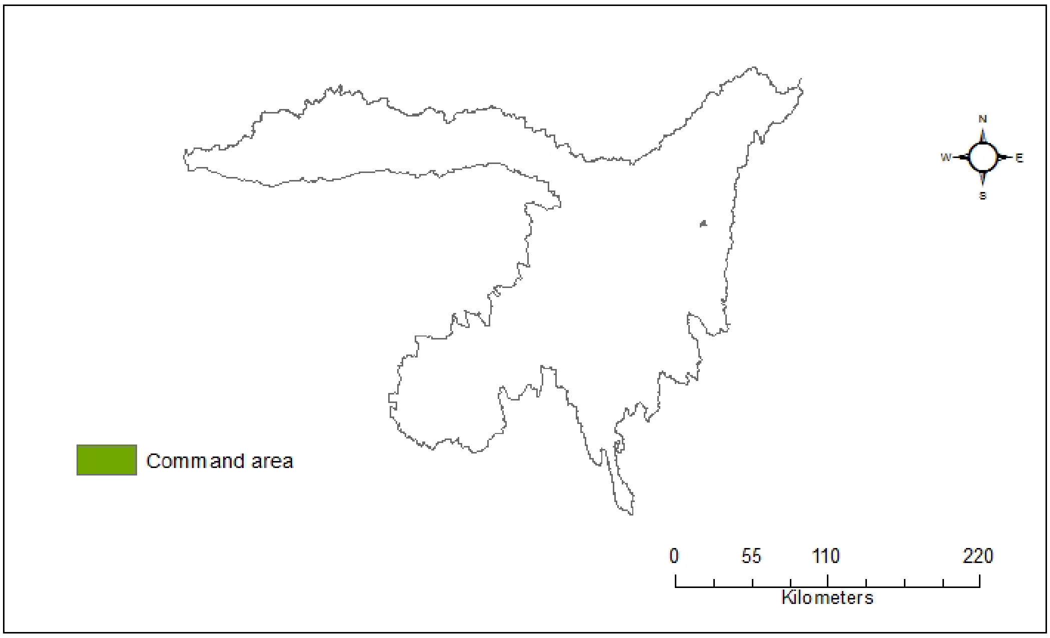


Figure 12.112 Irrigation command boundaries of Barak & others basin

12 (c).24.9 Domestic, industrial and livestock demand

Figure 12.113 shows district boundaries layer for the year 2011 census. The mean annual domestic, industrial and livestock demands are estimated as 0.15 BCM in the basin.

12 (c).25 Previous Estimates

In 1993 estimate, water resources up to Badarpurghat (Catchment area = 25,070 sq.km) were directly taken from report on Master Plan for Barak sub basin-1988 submitted by Brahmaputra Board. The total catchment area of Barak in India was considered as 41,723 sq.km. For rest of the region (Meghalaya and Tripura) no direct estimate was available. A proportionate approach was adopted to estimate the water resources of the remaining basin area. Accordingly, the potential was estimated as 48.36 BCM.

Figure 12.113 District boundaries in Barak & others basin

12 (c).26 Runoff Estimation

The model estimated runoff is calibrated against the observed discharge at eight locations. Those regions where either discharge data are not available or catchment areas are smaller than cell size 0.25^0 x 0.25^0 were clubbed into one sub-basin namely “Other sub-basin”. Summation of water assessments of the sub-basins namely, 1) B P Ghat; 2) Kailashahar; 3) Ranikor; 4) Baghmara & 5) Other give the final water assessment of the basin.

Tables L.42 to L.50 (at Annexure L (e)) give calibrated runoff along with observed discharge, rainfall, ECII, etc. during 30 years for the seven G&D sites for the sub-basins and for the whole basin. Figures 12.114 to 12.121 show comparative graphs of calibrated runoff and observed discharge at these discharge stations. From the graphs, it may be observed that model estimated runoff and observed discharge are matching well for the 30 year period at almost all the sites. The results matched well in case of B P Ghat for almost all the years except for the years 2007-08, 2008-09, 2010-11 & 2013-14. In some years it is observed that the observed discharge at some G&D sites in the basin overrides the rainfall value. This may be due to i) baseflow contribution to the river because of steep slopes in the basin ii) normalization of rainfall grids in the hilly regions of the basin.

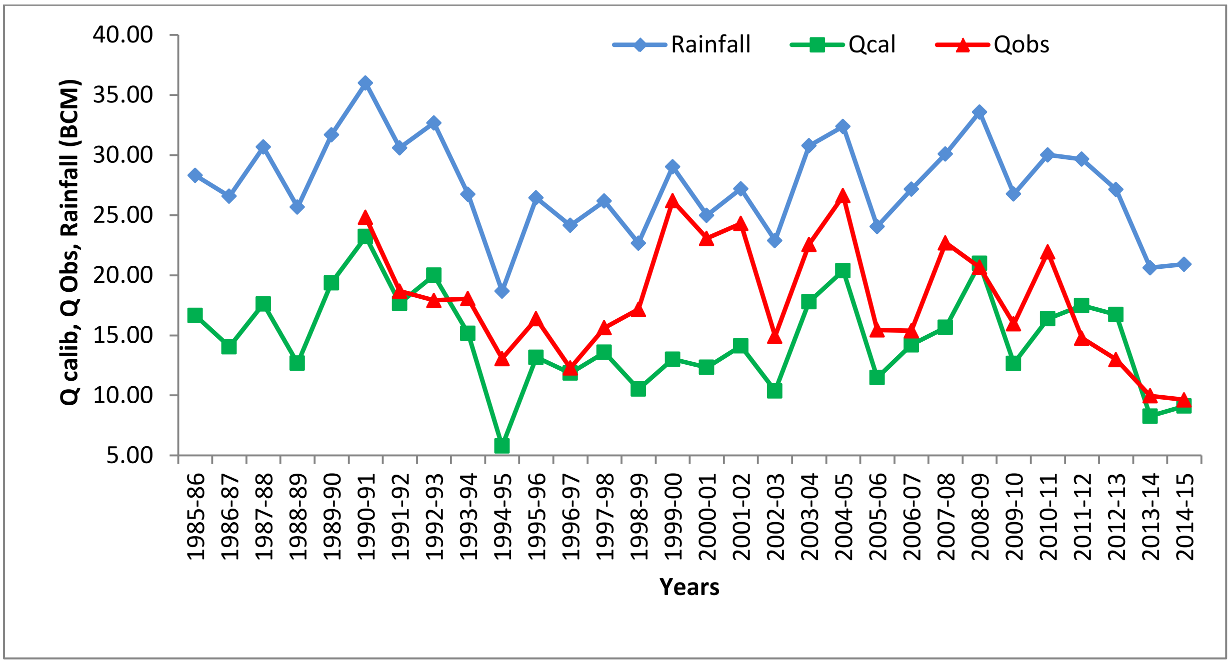


Figure 12.114 Calibrated runoff and observed discharge at Fulertal

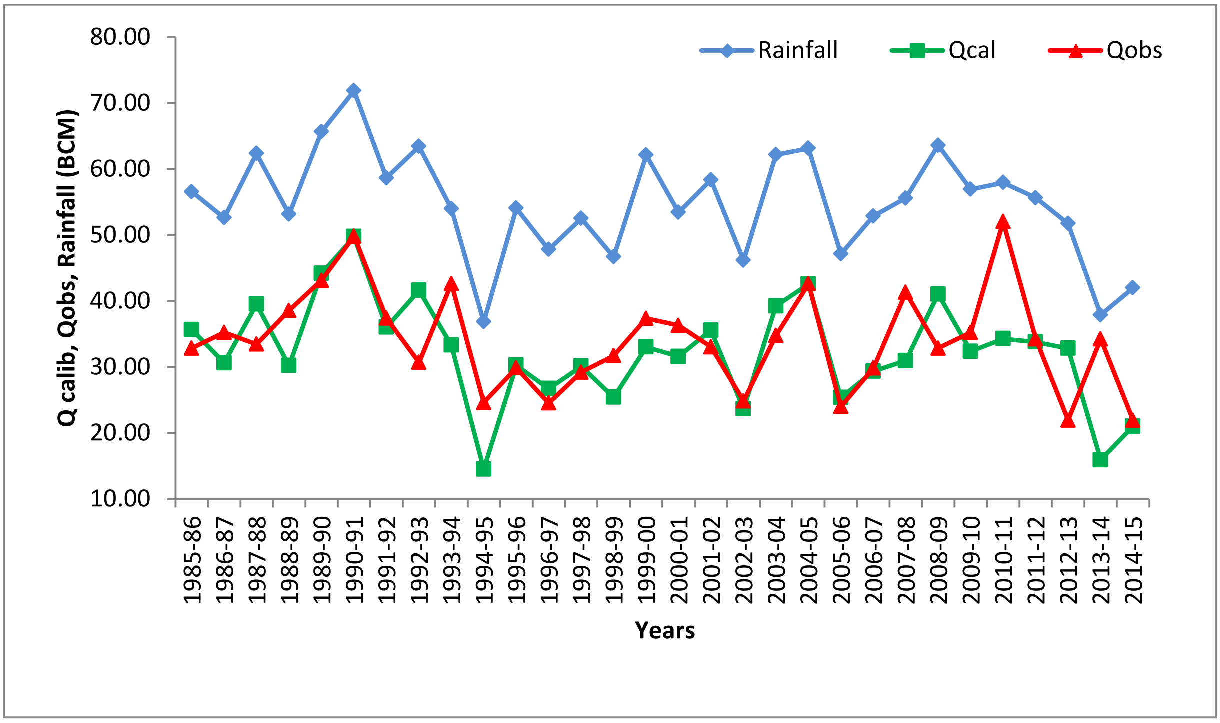


Figure 12.115 Calibrated runoff and observed discharge at BP Ghat

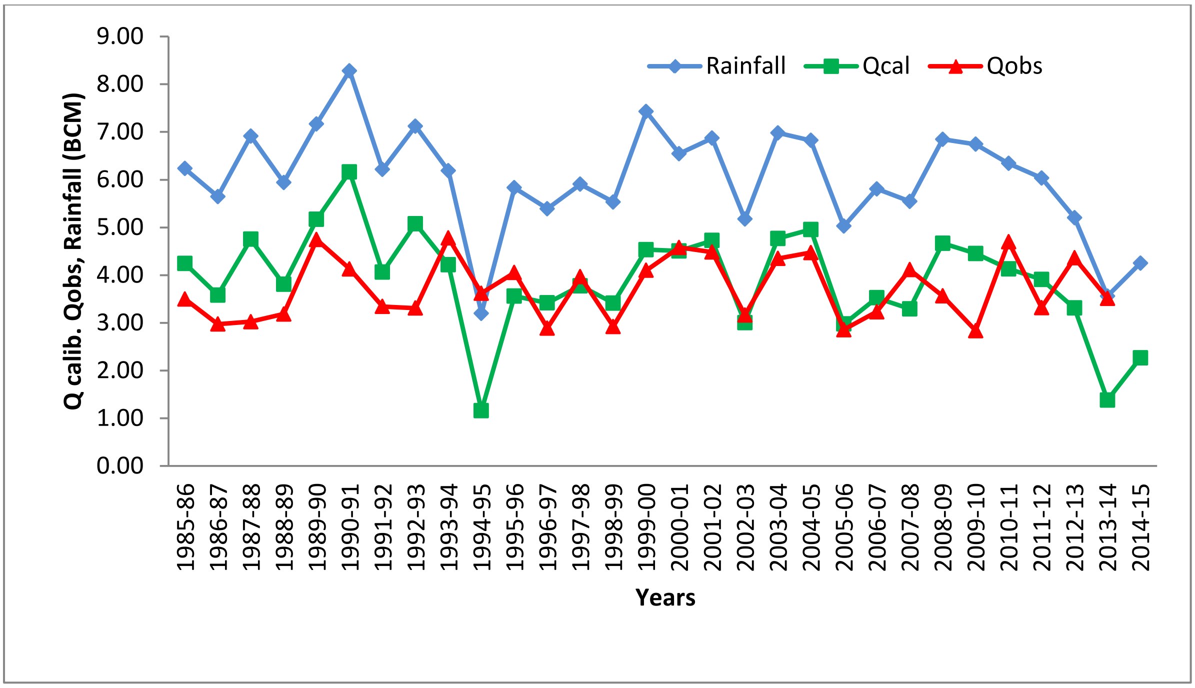


Figure 12.116 Calibrated runoff and observed discharge at Tulargram

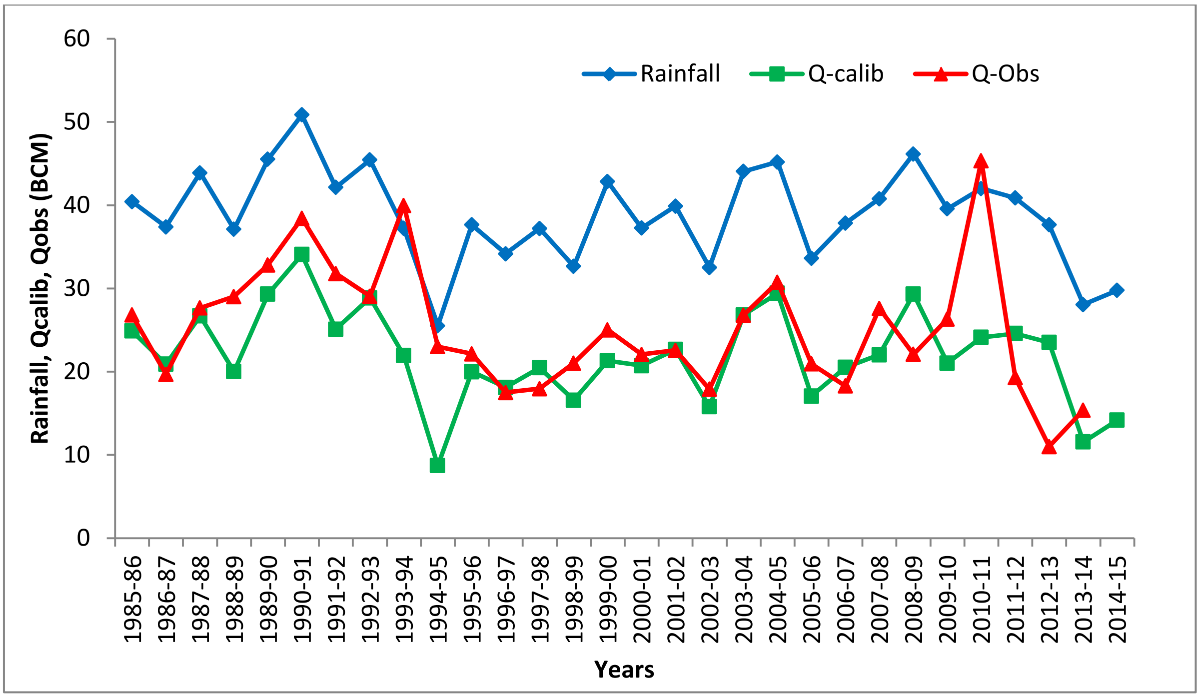


Figure 12.117 Calibrated runoff and observed discharge at AP Ghat

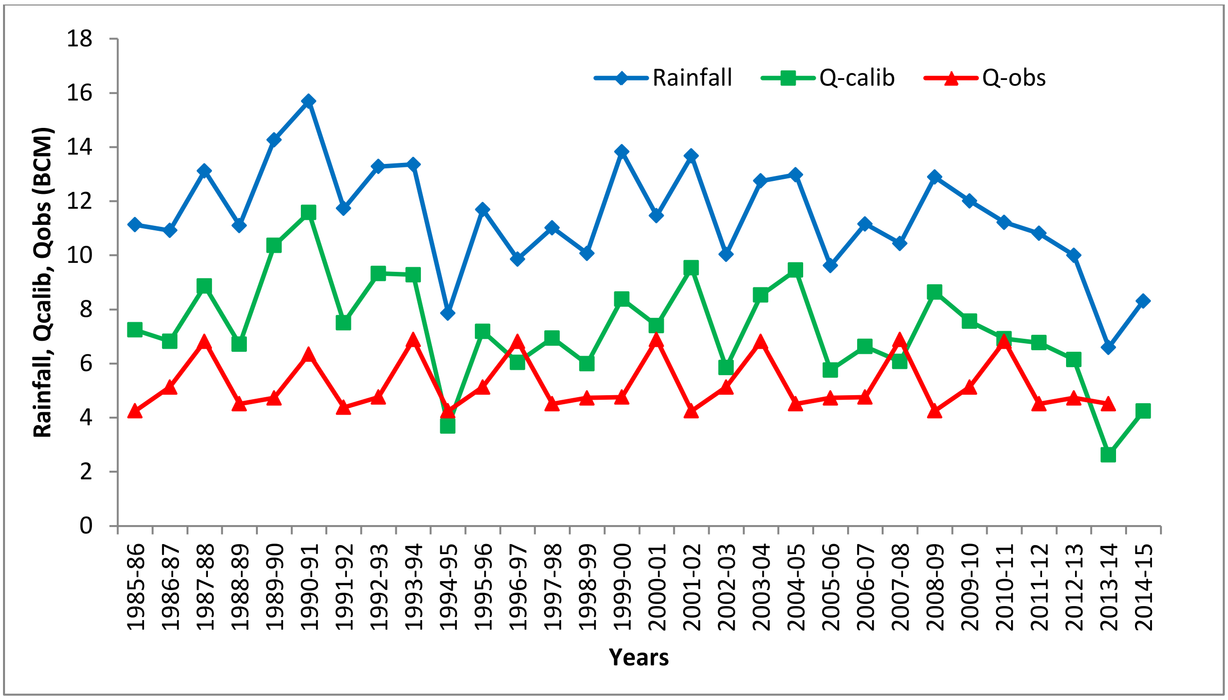


Figure 12.118 Calibrated runoff and observed discharge at Matijuli

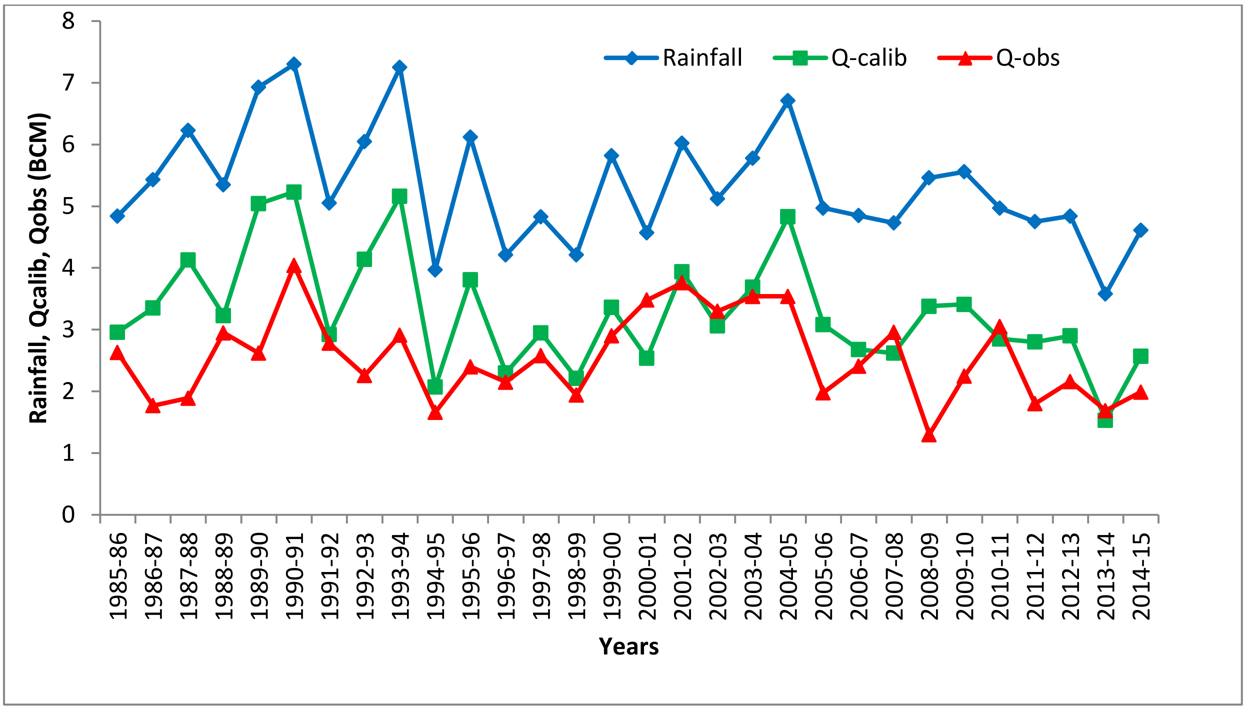


Figure 12.119 Calibrated runoff and observed discharge at Kailashar

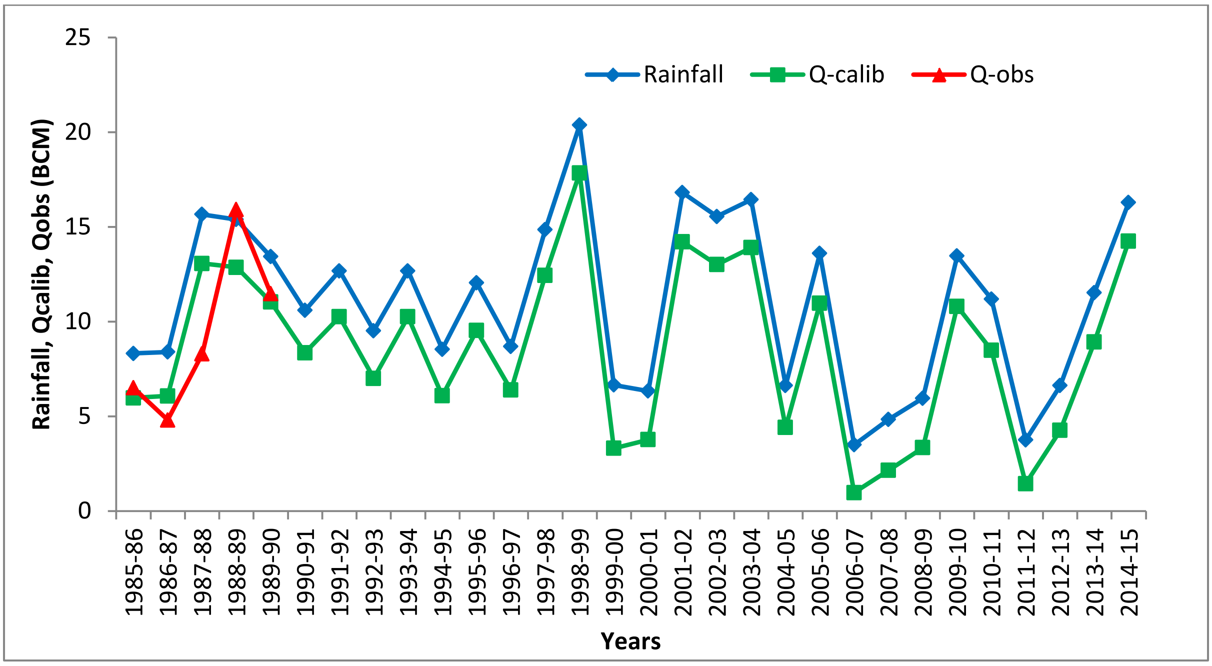


Figure 12.120 Calibrated runoff and observed discharge at Ranikor

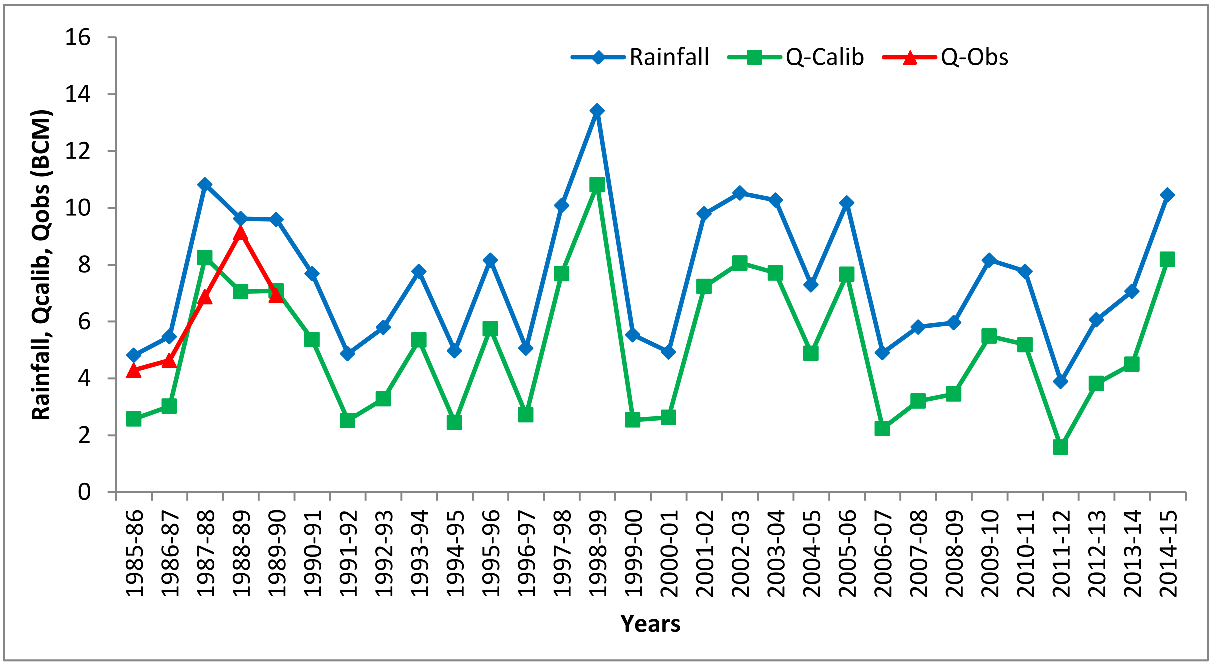


Figure 12.121 Calibrated runoff and observed discharge at Baghmara

12 (c).27 Annual water resources availability of Barak & others basins

Table L.50 shows the different components required to estimate the basin level water resources of Barak & others for 30 years. The maximum and minimum annual water resource availability is 127.74 BCM during 1987-88 and 52.02 BCM during 1994-95 respectively in 30 years.

The mean annual available basin water resource is 86.67 BCM and 75% dependable flow is 68.58 BCM. The average available water resources of Barak & others basin accounts about 67% of mean annual rainfall during 1985-86 to 2014-15.

12 (c).27.1 Annual water resources of Barak & others basin during extreme rainfall conditions

Out of the total 30 years of meteorological database of study period, during the years 1987-88 and 1994-95, extreme wet and dry rainfall conditions occurred in Barak & others river basin. The annual water resources of Barak & others basin during these two extreme rainfall conditions are shown in Table 12.16. The water balance components during these years are presented in the Figure 12.122 and 12.123.

Table - 12.16 Water resources availability in Barak & others basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	1987-88	176.36	127.74
Minimum Rainfall	1994-95	98.51	52.02

Runoff-rainfall ratio during the extreme maximum and minimum rainfall years is found to be 0.72 and 0.53 respectively. This shows that the higher the rainfall, the higher percentage of runoff. During higher rainfall years, potential evapo-transpiration is less as compared to the dry years, which will have cumulative effect in runoff.

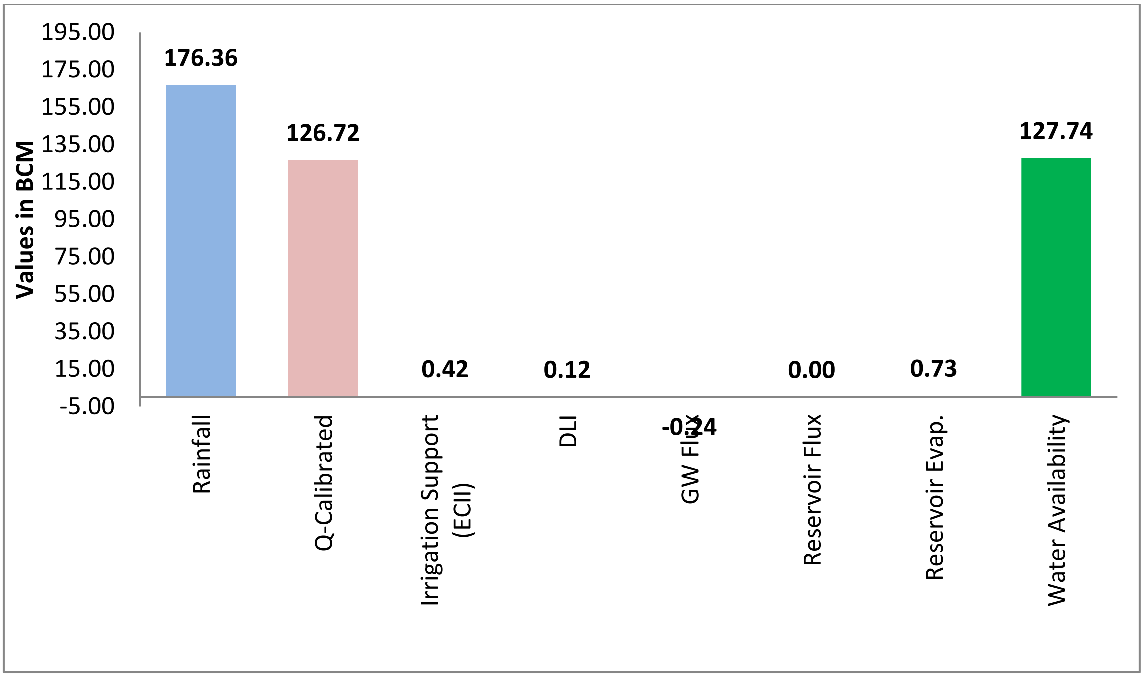


Figure 12.122 Water balance components of Barak & others basin during extreme high rainfall (1987-88)

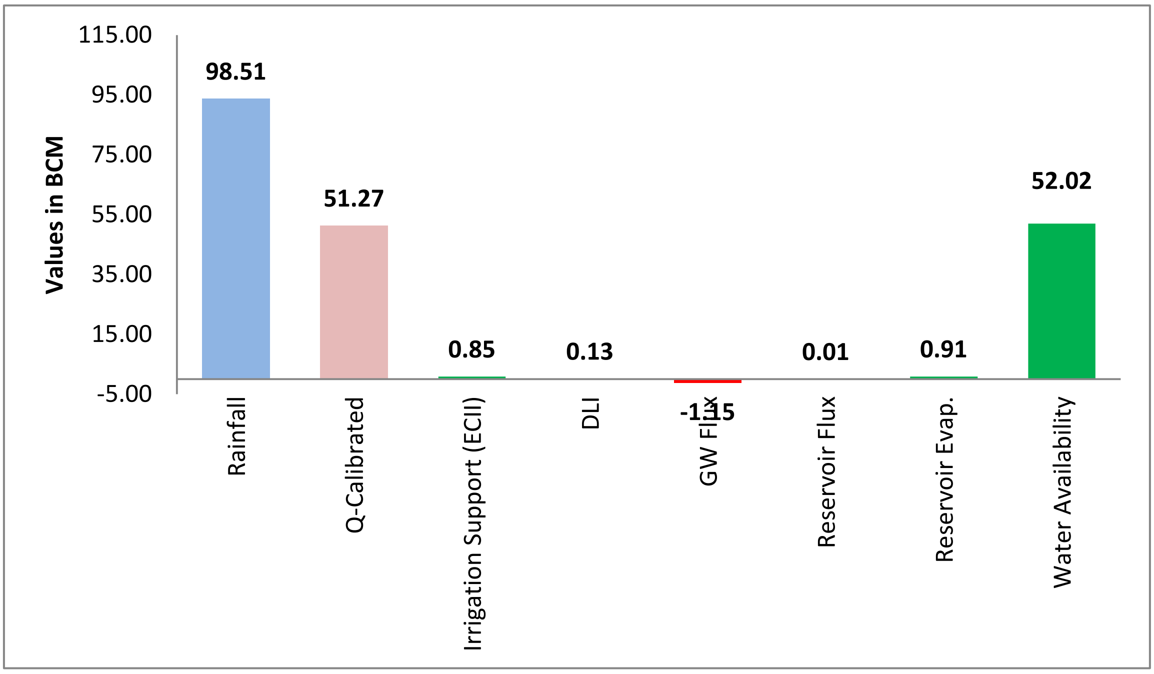


Figure 12.123 Water balance components of Barak & others basin during extreme low rainfall (1994-95)

12 (c).27.2 Mean water resources of Barak & others basin

Mean water resources = Mean of (Calibrated Runoff + Estimated Consumptive Irrigation Input + Domestic, Industrial and Livestock consumption + Groundwater Flux + Reservoir Flux + Export from basin+ Evaporation from Reservoirs)

= 84.96 + 0.61 + 0.15 + 0.05 + 0.09 + 0.00 + 0.81 = 86.67 BCM

The mean available annual water resource of the Barak & others basin is 86.67 BCM and 75% dependable flow is 68.58 BCM. Figure 12.124 shows the various water balance components averaged over a period of 30 years during 1985-86 to 2014-15.

It is observed that the computed runoff factors varies from 0.48 (2,245 mm rainfall) to 0.76 (3,518 mm rainfall). The mean runoff factor for 30 year period is 0.66.

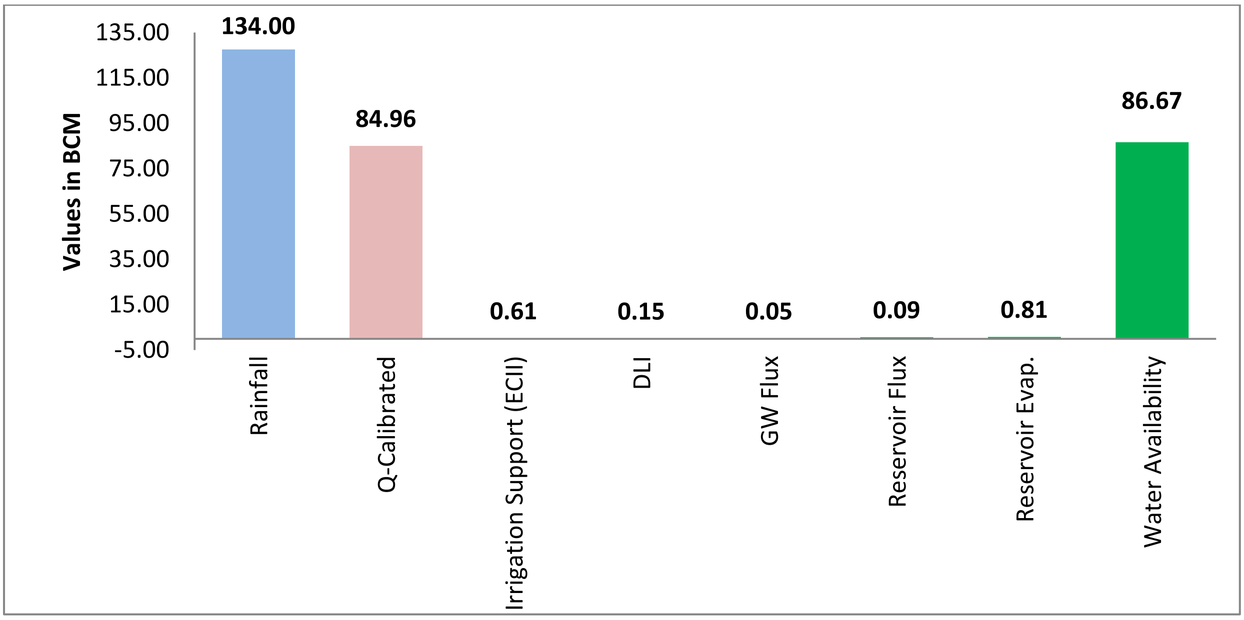
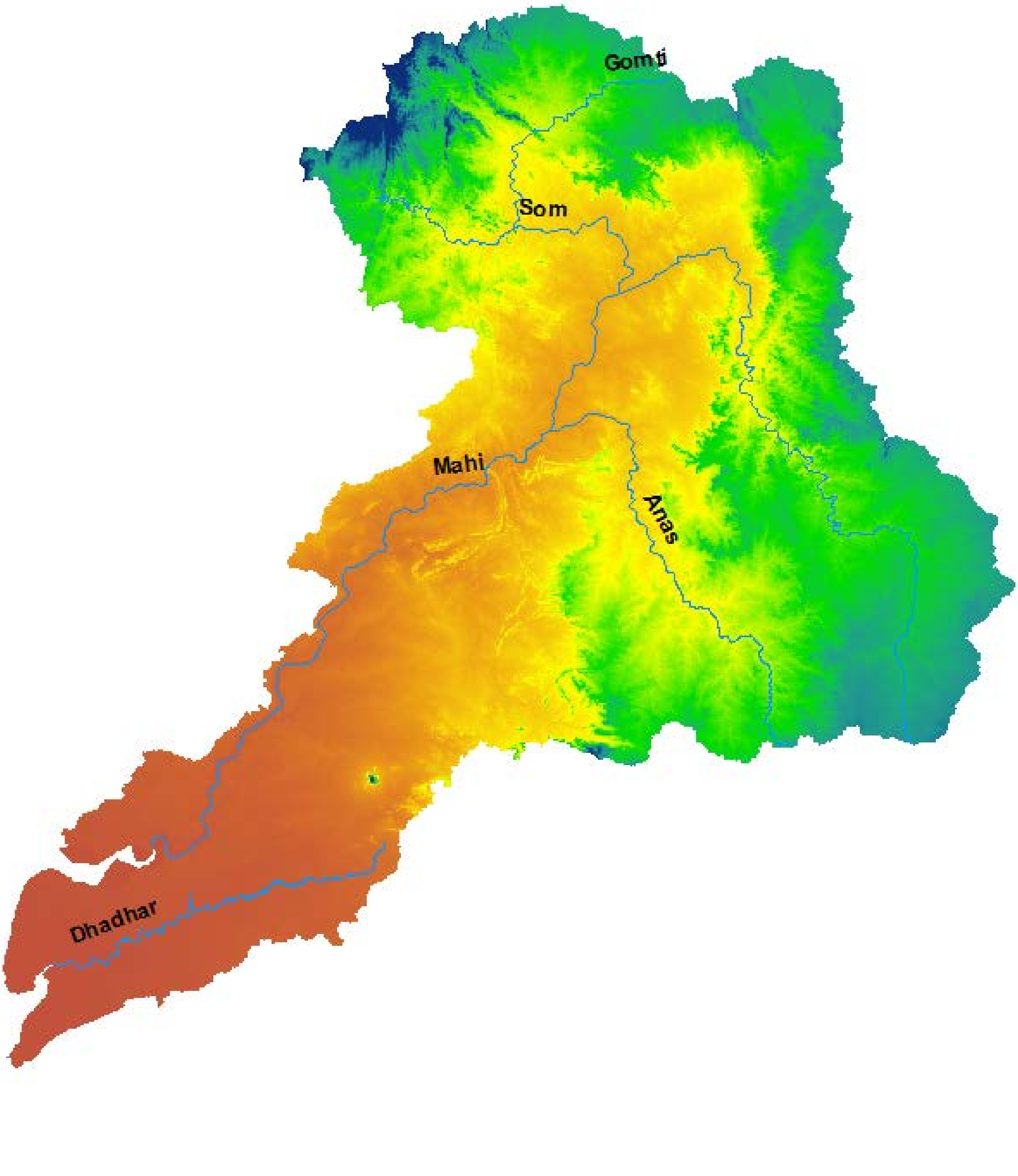


Figure 12.124 Mean water balance components of Barak & others basin

HIGHLIGHTS

- *Mean annual available water resources of Barak & Others basin is 86.67 BCM.*
- *Maximum annual water availability is 127.74 BCM during 1987-88.*
- *Minimum annual water availability is 52.02 BCM during 1994-95.*
- *Annual rainfall in the basin varies from 1975 mm to 3,518 mm during 1985-86 to 2014-15 and mean rainfall for these 30 years is 2,625 mm.*
- *The Barak & Others basin is divided into nine sub-basins for the reassessment study viz. Fulertal, A.P.Ghat, B.P.Ghat, Tulargram, Matijuri, Ranikor, Baghmara, Kailashahar and combined other region as one sub-basin.*
- *Average annual domestic, industrial and livestock demand in the basin is 0.15 BCM.*
- *Average annual evaporation from water bodies in the basin is 0.81 BCM.*

MAHI BASIN



13.1 Geo-Spatial Datasets

13.1.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map of Mahi basin for year 2004-05 is shown in Figure 13.1. From the LULC map, it is found that thirteen land use classess exist in the study area. Agriculture land is the predominant land use in the basin accounting for more than 50% (including fallow) of the basin area. This extent varies slightly from year to year. Next dominant class in the study area is wasteland and deciduous forest land. The LULC analysis of 2004-05 indicates that Kharif only (31.64%), Double/Triple crop (20.97%) and current fallow (12.37%) are the major classes in Mahi basin as shown at Figure 13.2.

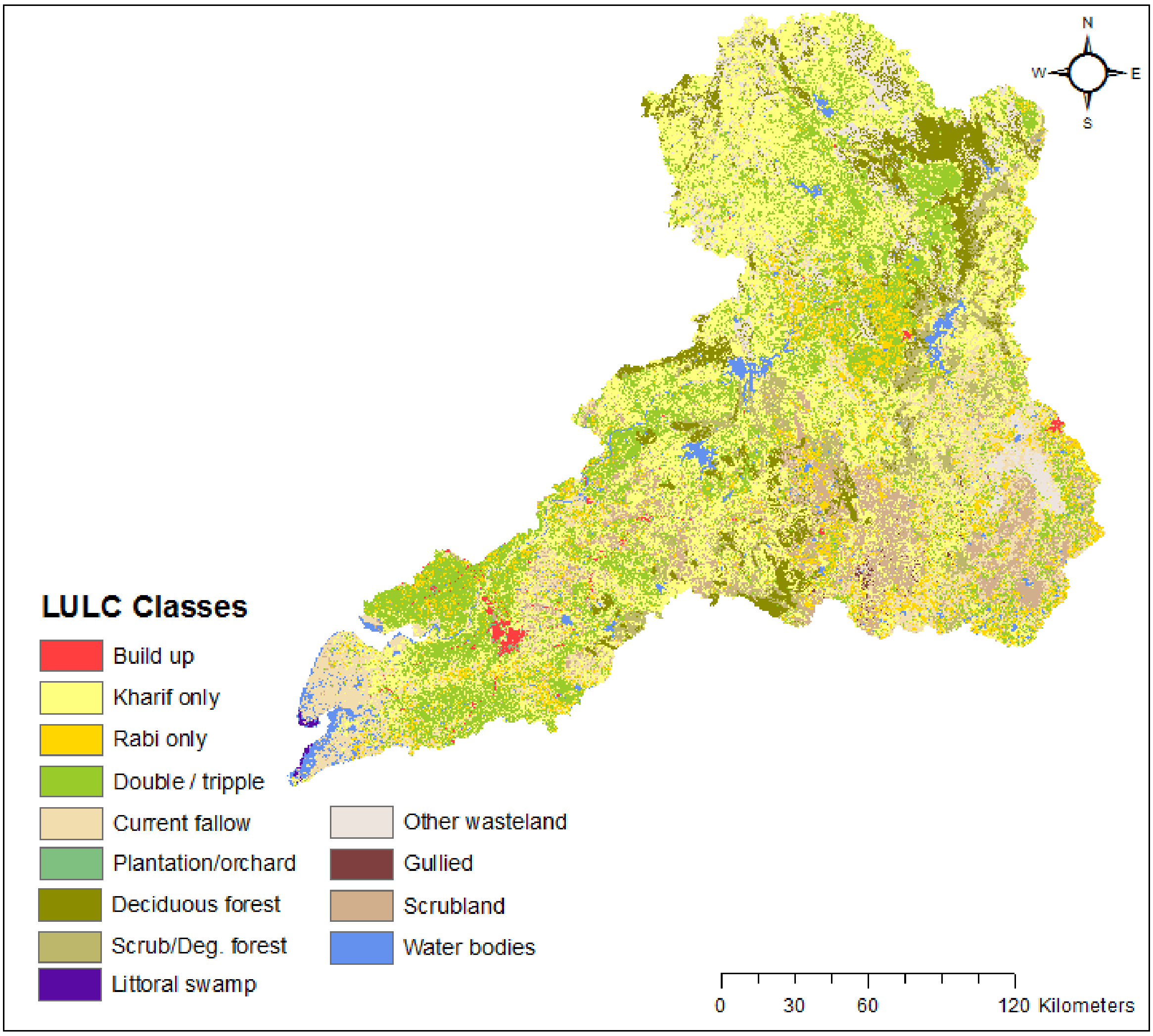


Figure 13.1 LULC map of Mahi basin (2004-05)

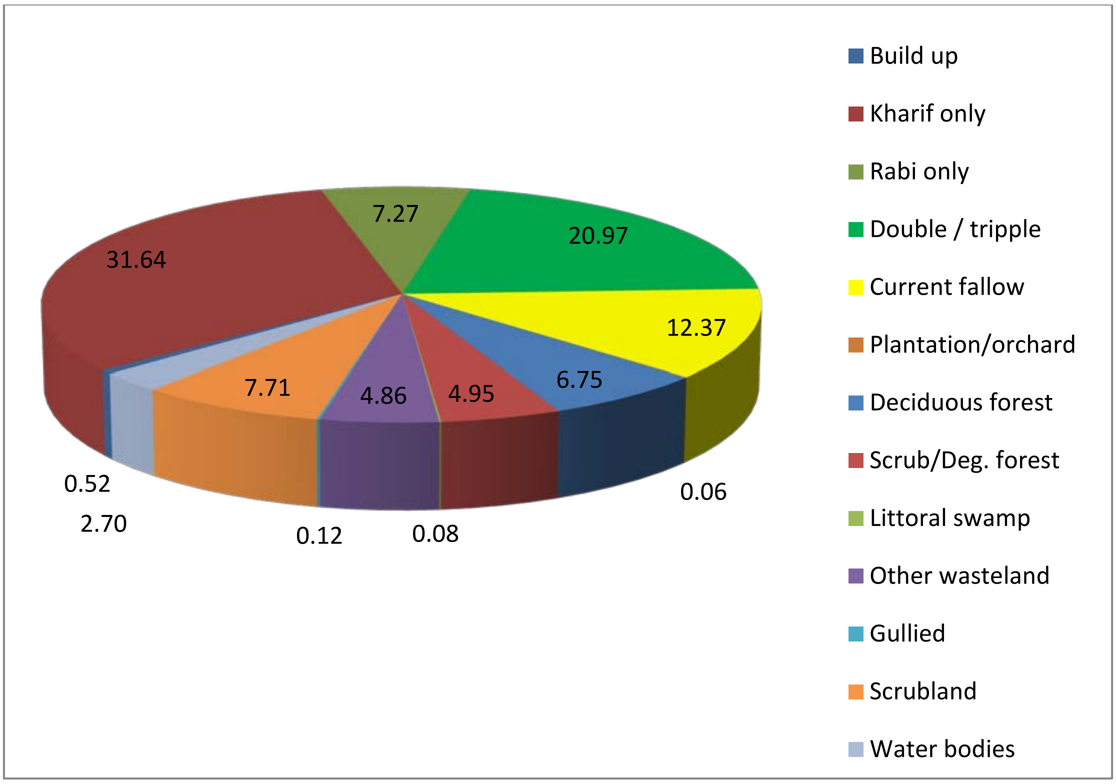


Figure 13.2 Distribution of LULC in Mahi basin (2004-05)

13.1.2 Soil texture

Sandy, clayey, loamy, loamy skeletal, clayey skeletal, rocky outcrop are the main soil texture classes in the basin. The coastal plains consist of fertile delta and highly suited for intensive cultivation. Figure 13.3 shows soil texture map of the basin. The larger part of the basin falls under fine texture category i.e. clayey and loamy that accounts for low infiltration rate and more runoff in the basin.

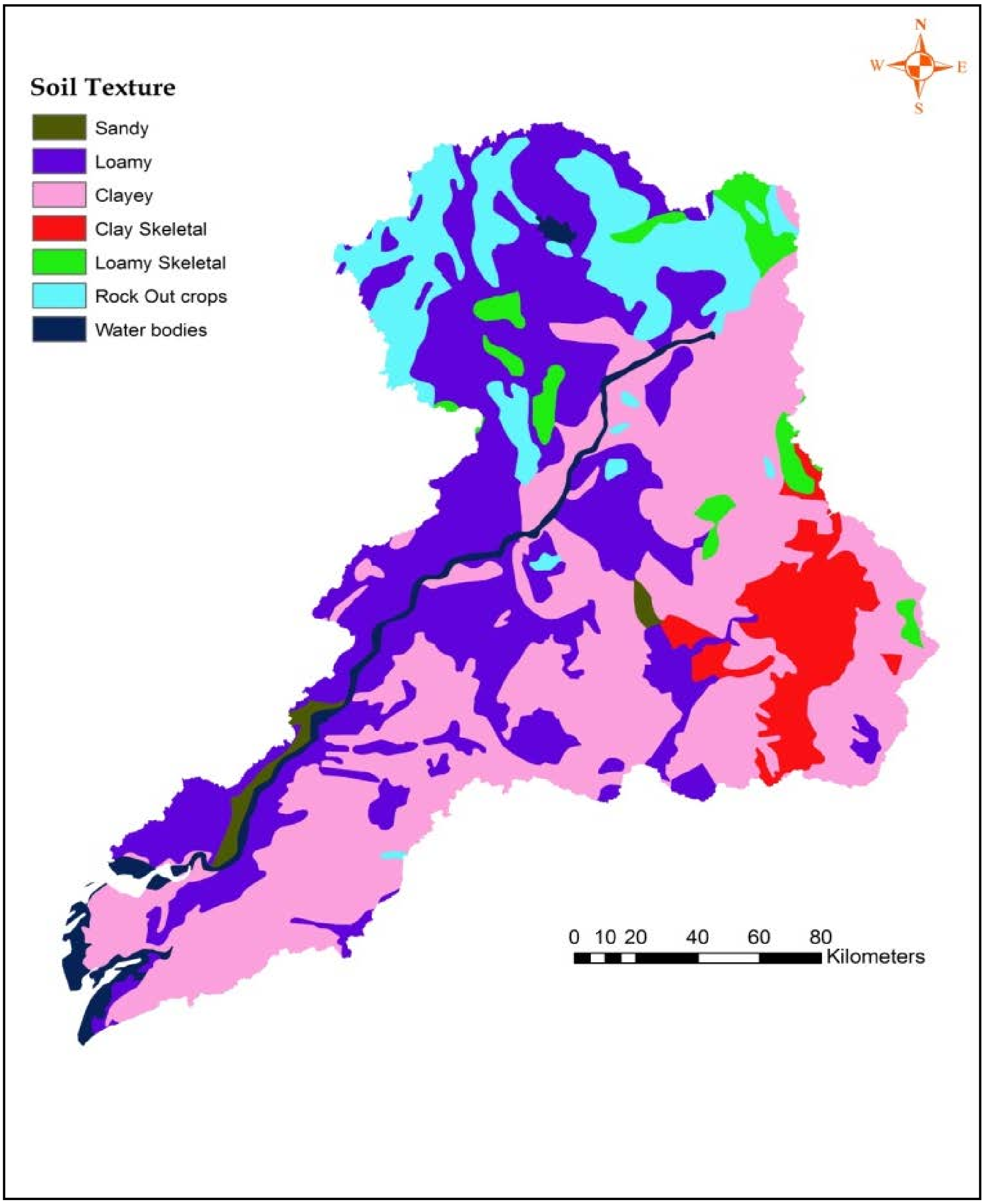


Figure 13.3 Soil texture map of Mahi basin

13.1.3 Topography

The topography of the basin consists of Ghat areas, plateau and the coastal plains. The districts of Rajasthan are under Central plateau and hills region. The districts of Madhya Pradesh fall under Western plateau and hills region. The elevation values ranges from a minimum of 0 m to a maximum of 1,011 m. Figure 13.4 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the basin.

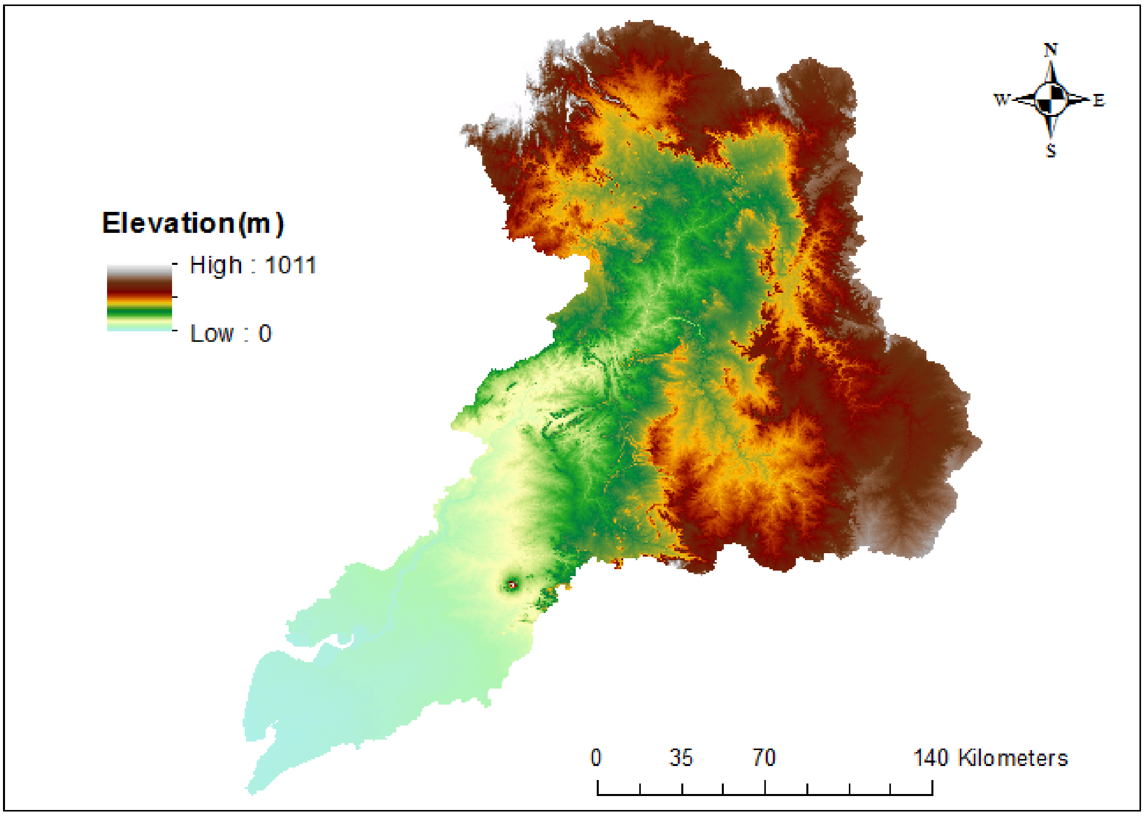


Figure 13.4 SRTM DEM map of Mahi Basin

13.2 Hydro-Meteorological and other Input Data

13.2.1 Rainfall grids

Figure 13.5 shows gridded annual rainfall map of Mahi basin for year 2004-05. The variations in the annual rainfall during study period of 30 years (1985-86 to 2014-15) are shown in the Figure 13.6. Rainfall varies both spatially and temporally in Mahi basin. The mean rainfall of these 30 years is found to be 811 mm. When spatial variations are considered, some areas receive 405 mm and some other areas receive 1,366 mm annual rainfall for year 2004-05. Major part of the basin receives an annual rainfall of 500 mm to 1,000 mm. During the last 30 years (1984-85 to 2014-15) maximum rainfall was recorded as 1,506 mm in 2006-07 (which has not been considered for estimating water resources availability of Mahi basin) and minimum as 411.32 mm in 2000-01. Hence, these two are considered as meteorologically wet and dry periods respectively during these 30 years period. Out of 29 years (excluding 2006-07), for 14 years annual rainfall is higher than the mean rainfall and for the remaining 15 years it is lower than the mean rainfall.

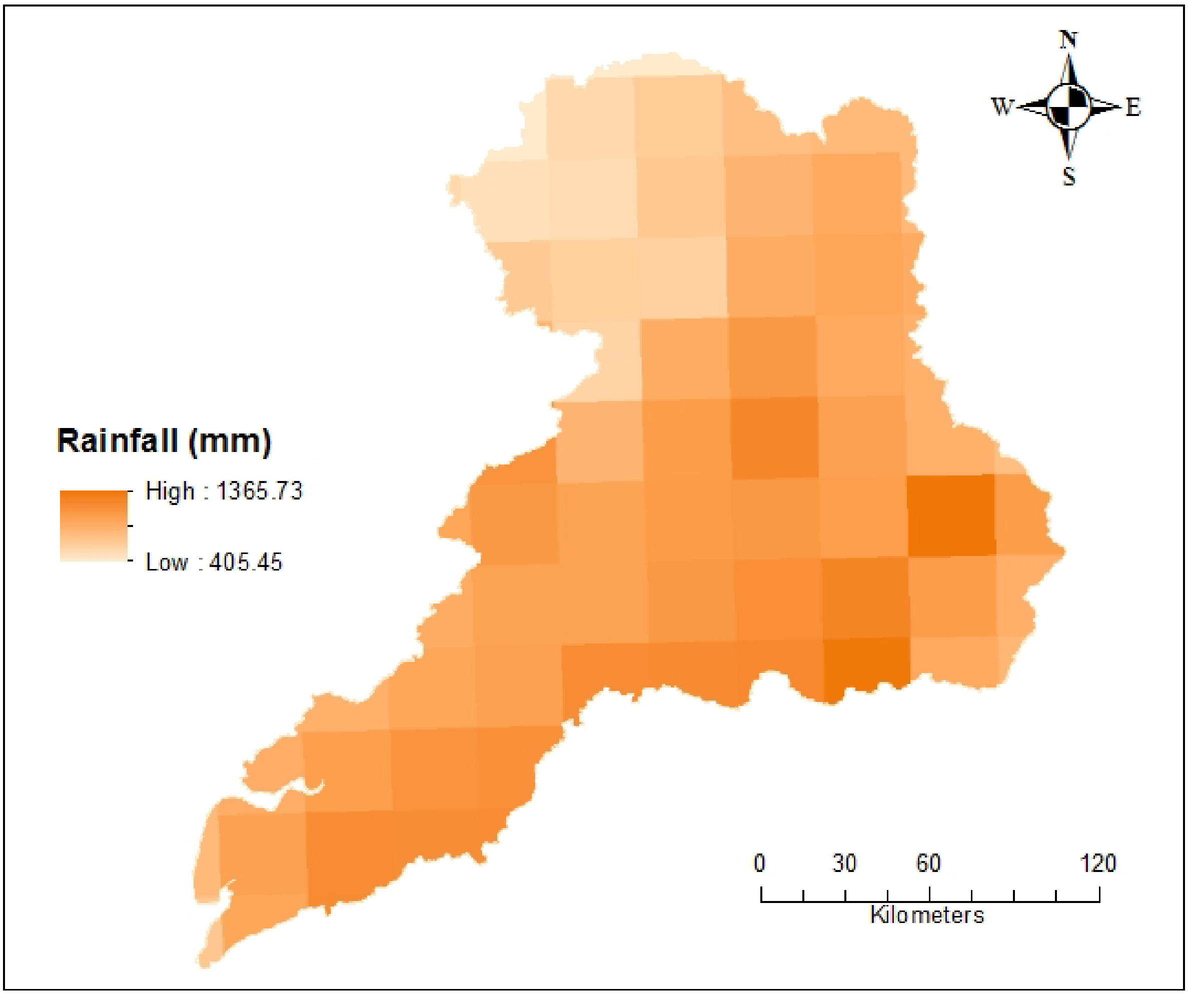


Figure 13.5 Gridded rainfall of Mahi basin (2004-05)

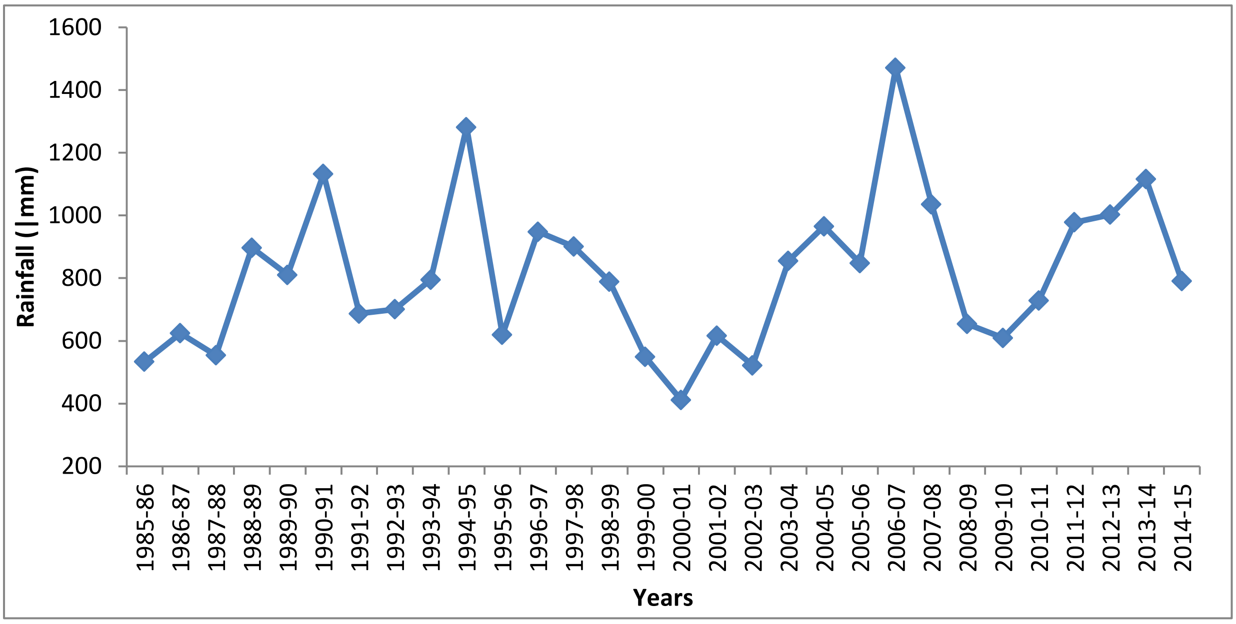


Figure 13.6 Annual rainfall in Mahi basin (1985-86 to 2014-15)

13.2.2 Temperature grids

Gridded mean annual temperature of Mahi Basin in 2004-05 is shown in Figure 13.7. The mean annual temperature in Mahi basin varied from 25.00°C to 27.44°C in 2004-05.

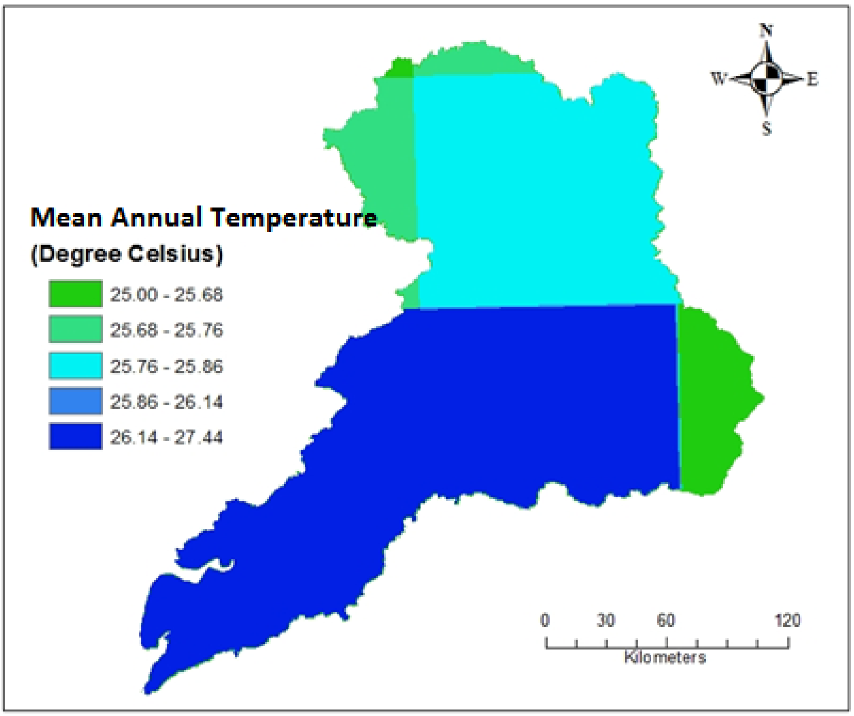


Figure 13.7 Gridded mean annual temperature of Mahi basin (2004-05)

13.2.3 Sub-basins of Mahi basin

Mahi basin is divided into four sub-basins namely, Mataji, Paderdibadi, Khanpur and below Khanpur as shown in Figure 13.8. The sub-basins are divided in such way that the locations of CWC discharge stations are at sub-basin outlets. Further, the sub-basin below Khanpur is delineated separately due to one independent west flowing river namely Dhadhar as shown in Figures 13.9 and 13.10. The drainage area of each sub-basin is given at Table - 13.1. SRTM DEM of 90 m resolution is used to delineate the watershed and sub-watershed boundaries of the Mahi basin.

Table - 13.1 Sub-basin wise details of Mahi basin

S. No.	Sub-basin	River	Individual drainage area (sq.km)
1	Mataji	Mahi	3,733
2	Paderdibadi	Mahi	12,650
3	Khanpur	Mahi	16,635
4	Below Khanpur	Mahi & Dhadhar	6,548
		Total basin area	39,566
	Pingalwada	Dhadhar	4,131*

** This drainage area is included in the sub-basin below Khanpur*

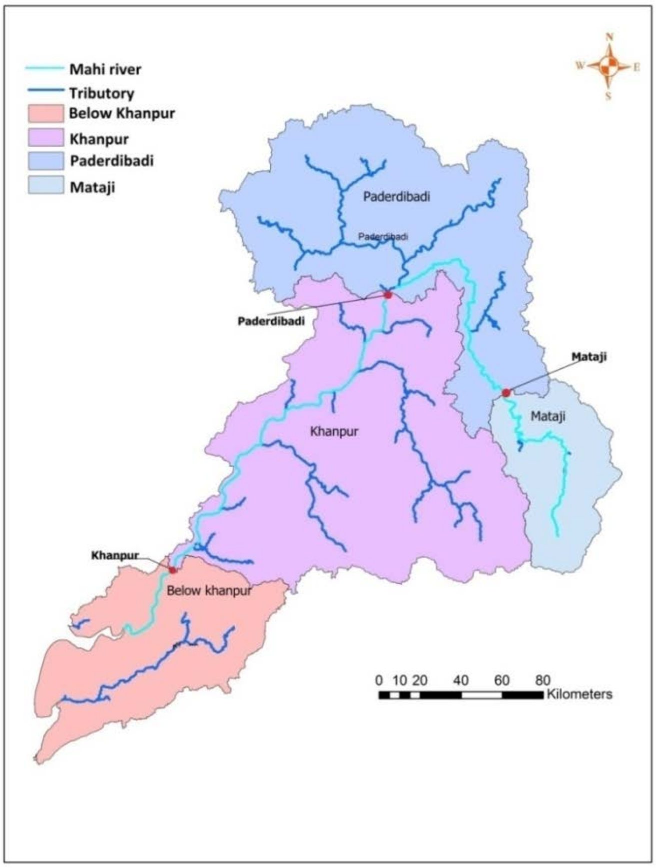


Figure 13.8 Sub-basins of Mahi basin

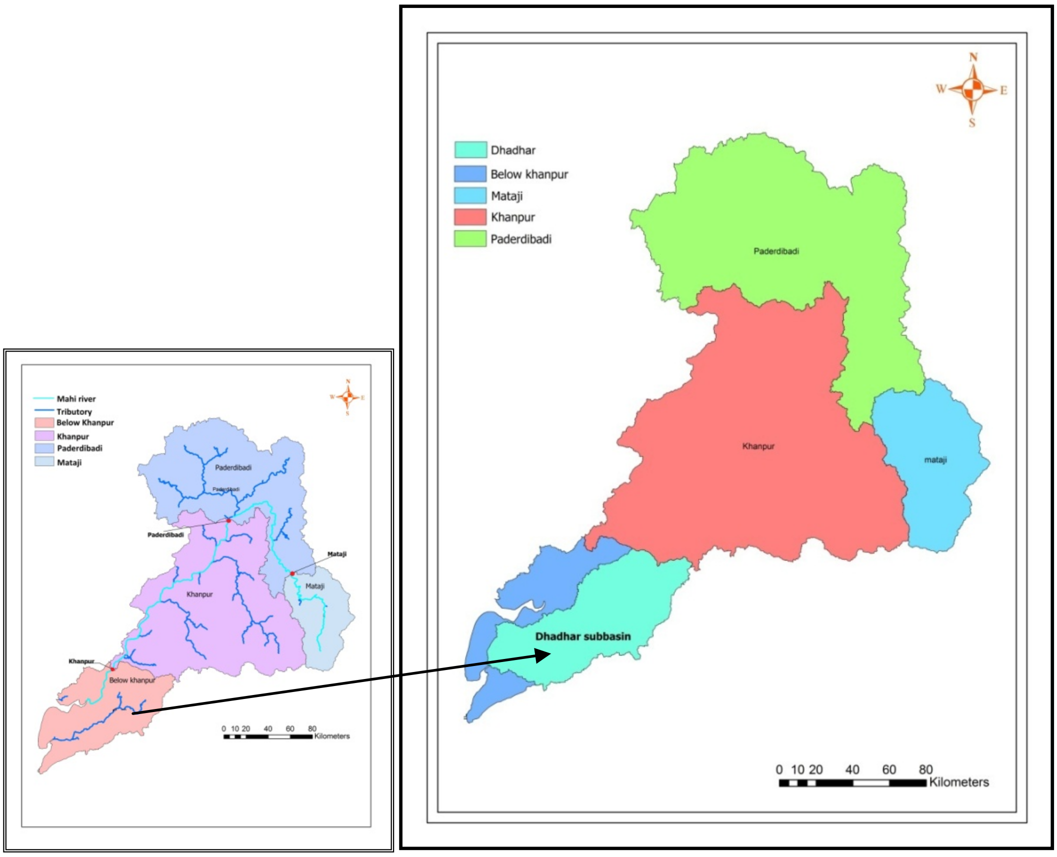


Figure 13.9 Dhadhar sub-basin

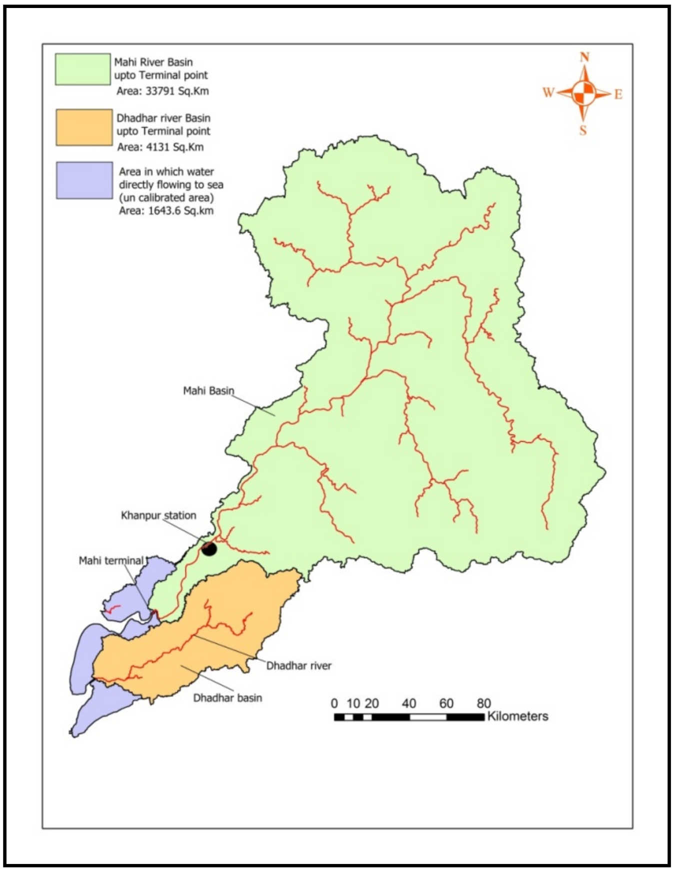


Figure 13.10 Mahi river basin and Dhadhar river sub-basin

13.2.4 River discharge

River discharge data for 30 years are available at all three sites (Mataji, Paderdibadi and Khanpur) located on main river Mahi and data for 25 years is available for Pingalwada site on river Dhadhar which is an independent west flowing river.

13.2.5 Reservoir flux

Reservoir flux data of 5 (five) major and medium reservoirs are considered for estimating reservoir fluxes for each water year for 30 years period. Figure 13.11 shows the location of reservoirs used for this study. The mean annual flux of reservoirs of Mahi river basin from 1984-85 to 2014-15 is estimated as 0.09 BCM.

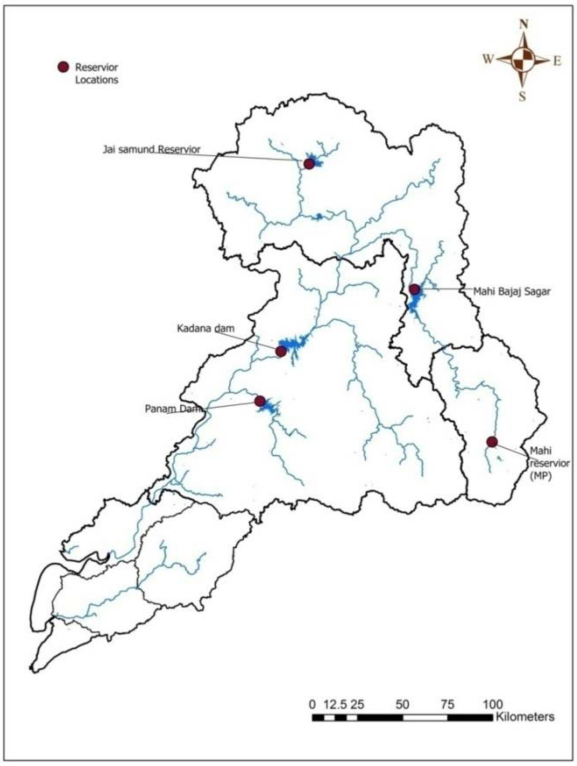


Figure 13.11 Major & medium reservoirs in Mahi basin

13.2.6 Groundwater flux

The spatial annual groundwater flux in the basin varies from 531.47 MCM to -695.93 MCM during year 2014-15 as shown Figure 13.12. Annual variation in the flux for 30 years (1985-86 to 2014-15) is shown in Figure 13.13. The mean annual groundwater flux from 1984-85 to 2014-15 of Mahi river basin is estimated at -0.24 BCM (drawdown).

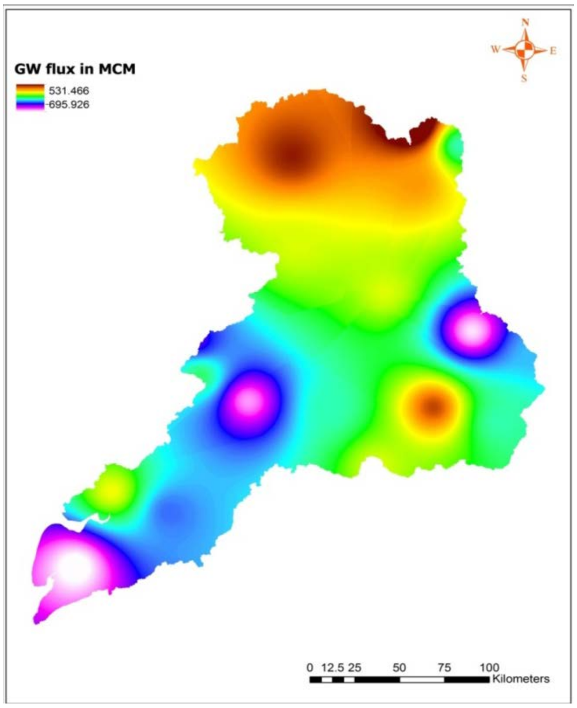


Figure 13.12 Groundwater flux (spatial data) in Mahi basin (2014-15)

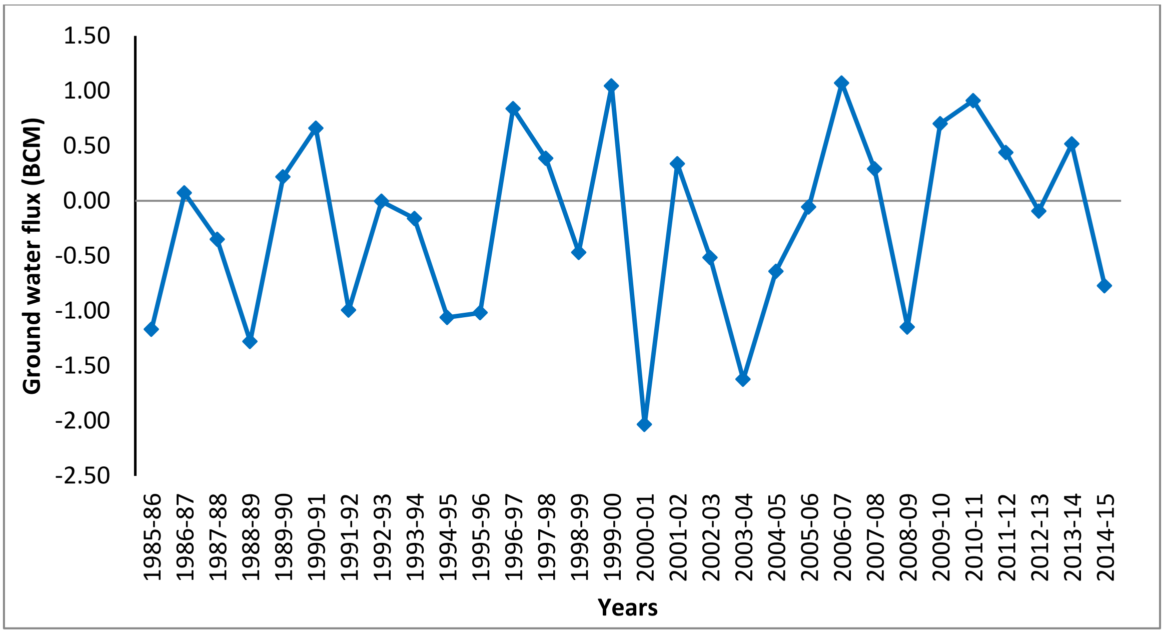


Figure 13.13 Annual groundwater flux of Mahi basin (1985-86 to 2014-15)

13.2.7 Major crops in the basin

Mahi basin is subdivided into 5 to 6 regions based on predominant crops identified in each district. Each region specifies a unique crop for each crop season both spatially and temporally within the basin. For example, (spatial variation) in Kharif only season in a district, if rice is a major crop, it may be jowar or bajra in the neighbouring district. Similarly, temporal variation indicates for example during 2004-05, if rice is a major crop in Kharif only season, it may be jowar or bajra during 2005-06.

13.2.8 Irrigation command area

Figure 13.14 shows location of irrigation command boundaries of the Mahi basin considered for the year 2014-15. Since annual command boundary maps are not available, command area has been selected from the year 2014-15 based on the completion of the project/dam. Hence the command area considered during the year 1985-86 is worked out to be around 7,47,870 hectare, while it is 12,67,830 hectare in 2014-15 (excluding the basin outside command). Basin outside command has been taken uniformly for all years while working out ECII from these areas.

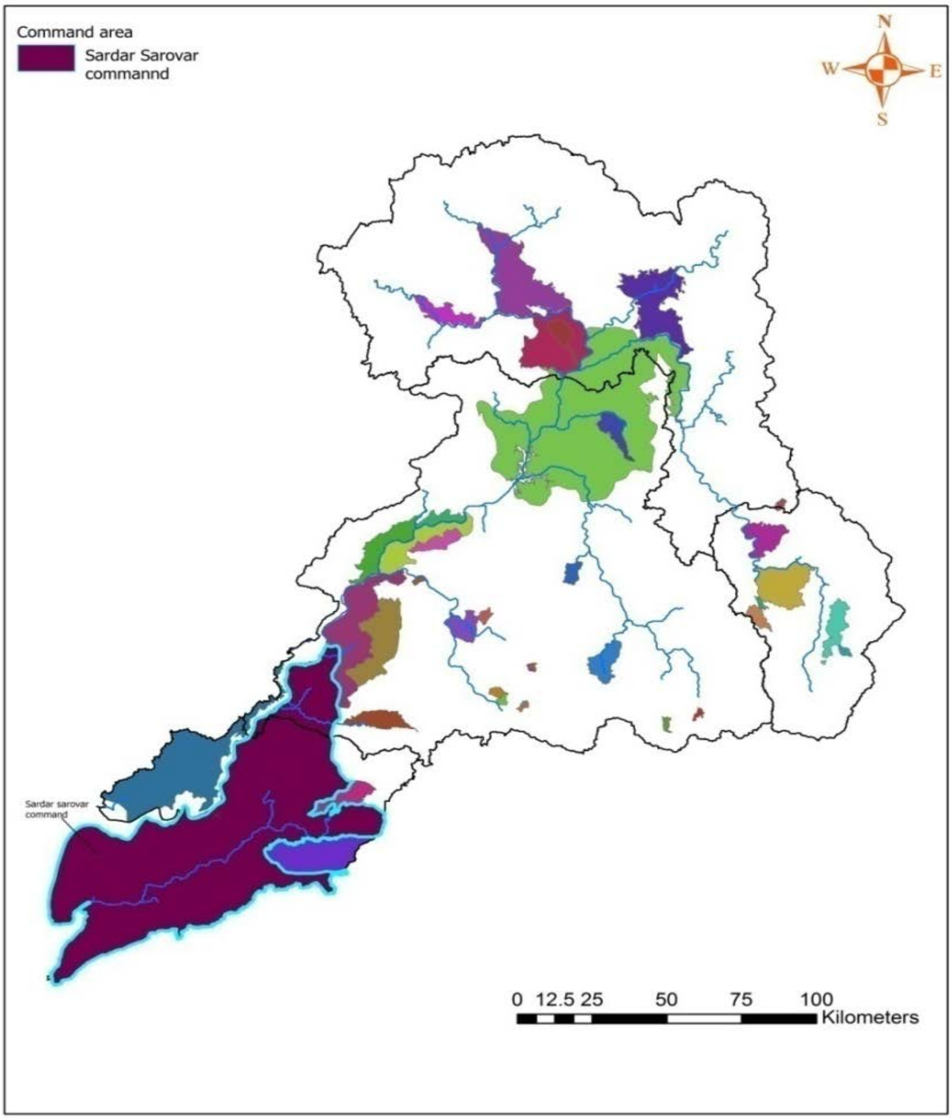


Figure 13.14 Irrigation command boundaries of Mahi basin

13.2.9 Domestic, industrial and livestock demand

Figure 13.15 shows the district boundaries in the basin used for DIL demand estimation.The mean annual domestic, industrial and livestock demands are estimated as 0.24 BCM during the period 1985-86 to 2014-15 in the Mahi river basin.

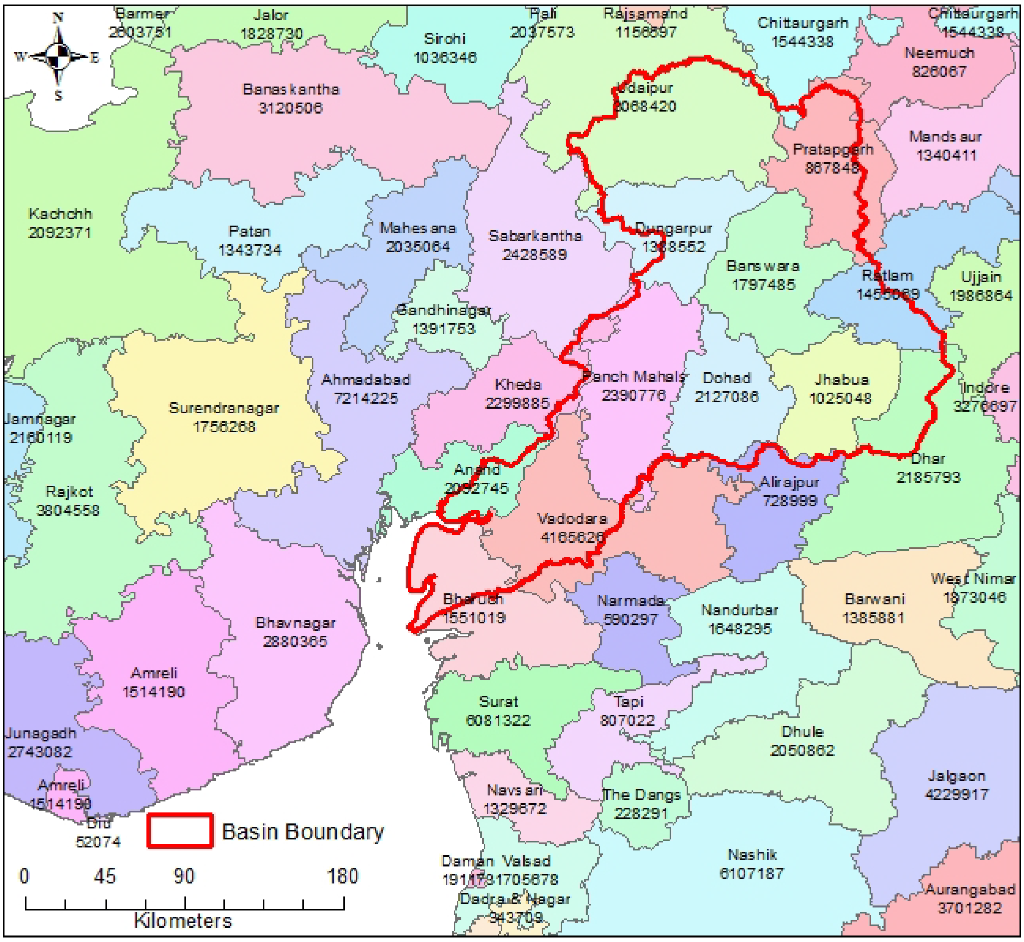


Figure 13.15 District boundaries in Mahi basin

13.2.10 Evaporation from major/medium/minor reservoirs and other water bodies

This has been worked out based on the yearly reservoir masks prepared from LULC layers from the year 2004-05 to 2014-15 considering the area of water bodies of more than 1 hectare and excluding flowing water in the river. For the water bodies prior to the year 2004-05 (since LULC layers prior to 2004-05 are not available), water bodies area of respective dams were removed based on the year of completion of the dam.

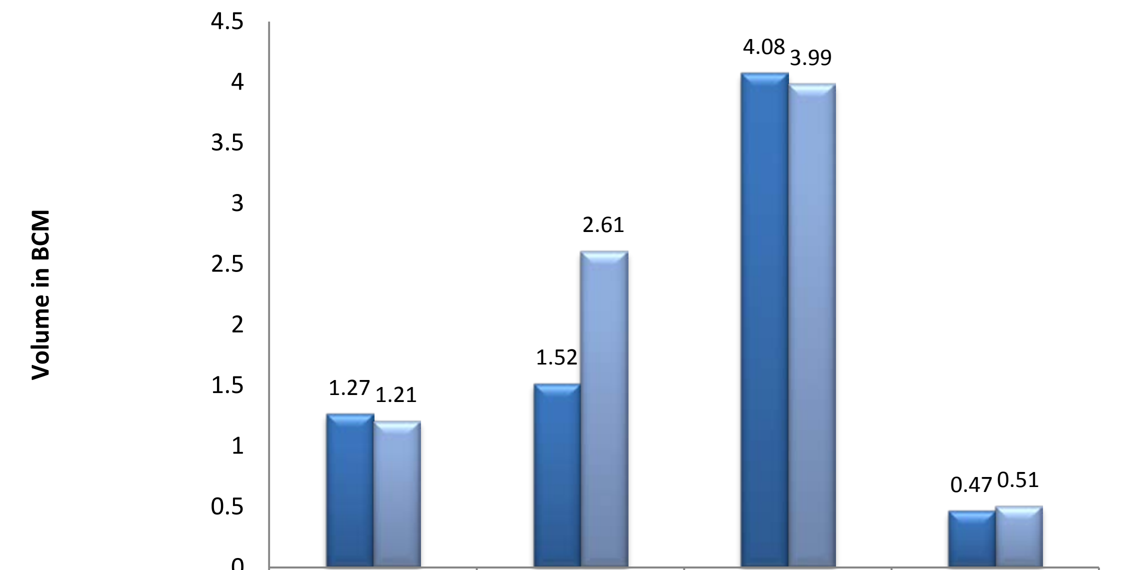
13.3 Previous Estimates

The previous CWC (1993) estimate of available water resources of the total basin was 11.02 BCM while in present study (1985 to 2015) available water resources of the total basin is 14.96 BCM. Observed discharges were taken into account for arriving the natural flow at Khanpur in the 1993 study after accounting all other abstractions.

13.4 Runoff Estimation

Discharge stations namely Mataji, Paderdibadi and Khanpur are selected on Mahi River and the model estimated runoff is calibrated against the observed discharge at all the three locations. Dhadhar river is flowing in Khanpur sub-basin. For Dhadhar sub-basin, model runoff is calibrated with discharge data at Pingalwada. Figure 13.16 shows comparison between mean observed discharge and mean calibrated runoff at various gauge stations.

Rainfall, ECII, DIL, calibrated discharge, etc. at the different G&D sites in Mahi basin are shown in Table - M.1 to M.4 (Annexure - M). Figures 13.17 to 13.20 show comparative graphs of calibrated runoff and observed discharge at these gauging stations. From the graphs, it may be observed that model estimated runoff and observed discharge are matching very well for 30 year period except Paderdibadi. At the Khanpur station (terminal station for Mahi Basin), the observed discharge and calibrated runoff are in good agreement for almost all the years except for 3-4 years. Tables M.1 to M.4 (at Annexure - M) give rainfall, ECII, calibrated discharge, observed discharge, DIL flux, GW flux, reservoir flux, reservoir evaporation and water availability for the sub-basins of Mahi. Table - M.5 at Annexure - M gives calibrated runoff of Mahi basin for the period 1985-86 to 2014-15. The mean annual calibrated runoff is about 4.09 BCM. The maximum annual calibratd runoff is 20.45 BCM during 1994-95. The minimum annual calibrated runoff is 0.24 BCM during 2009-10. The mean annual ECII is about 8.19 BCM. The maximum annual ECII is about 13.99 BCM during 2012-13. The minimum annual ECII is about 3.60 BCM during 2002-03.



	Mataji	Paderdibadi	Khanpur	Pingalwada
Mean Obs. Runoff	1.27	1.52	4.08	0.47
Mean Cal. runoff	1.21	2.61	3.99	0.51

Figure 13.16 Calibrated runoff and observed discharge at various gauge stations

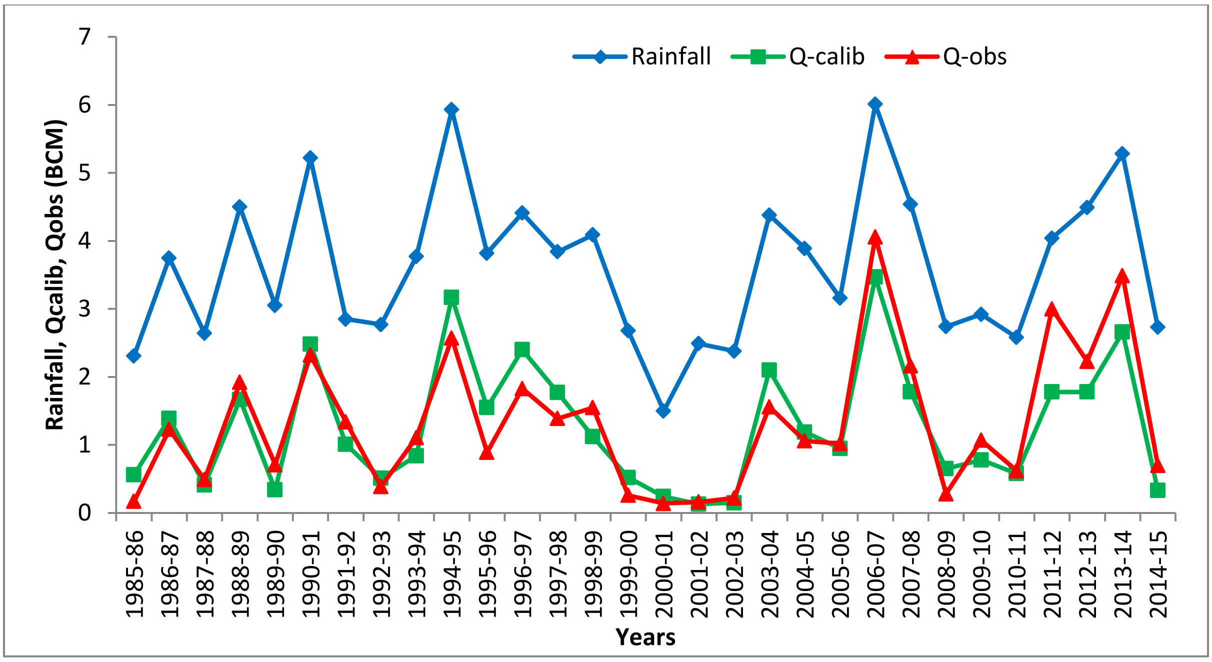


Figure 13.17 Calibrated runoff and observed discharge at Mataji

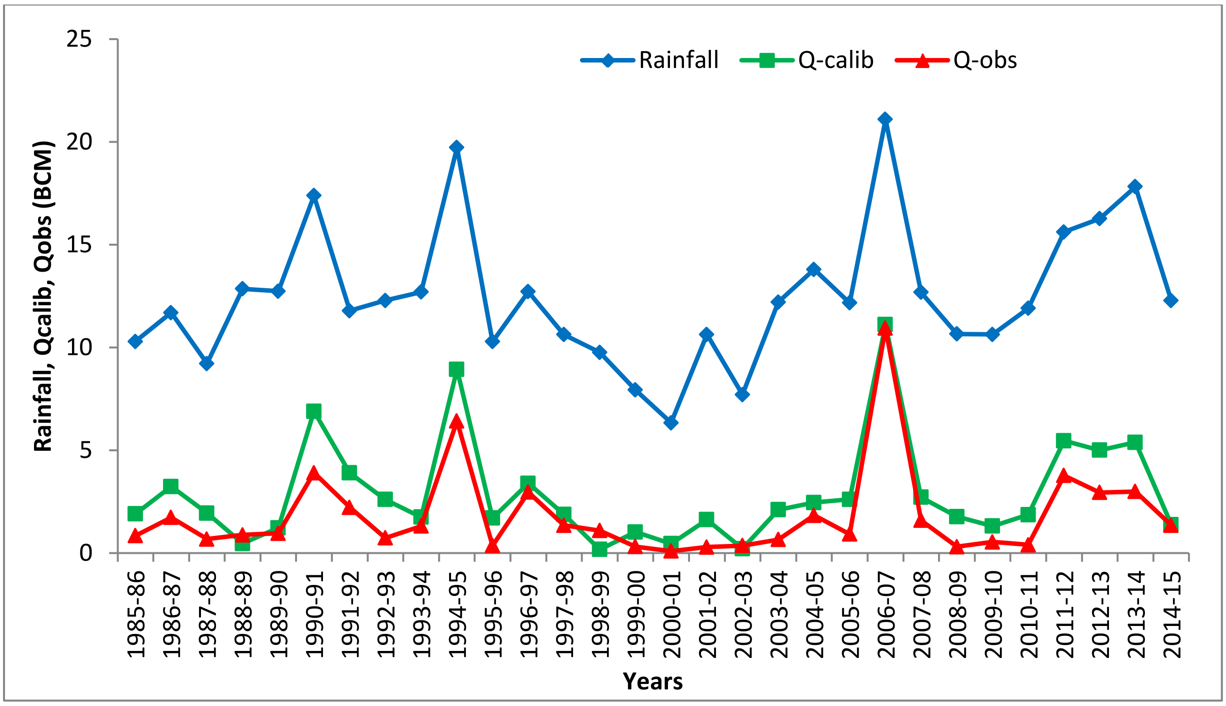


Figure 13.18 Calibrated runoff and observed discharge at Paderdibadi

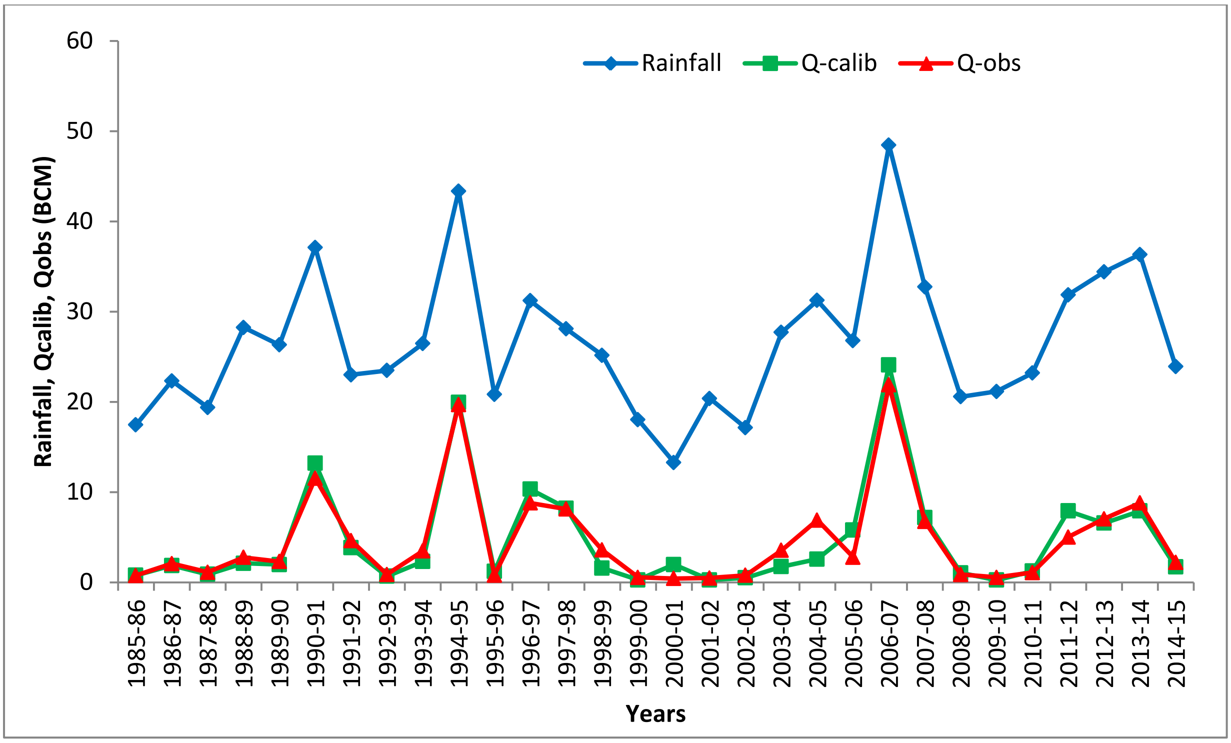


Figure 13.19 Calibrated runoff and observed discharge at Khanpur

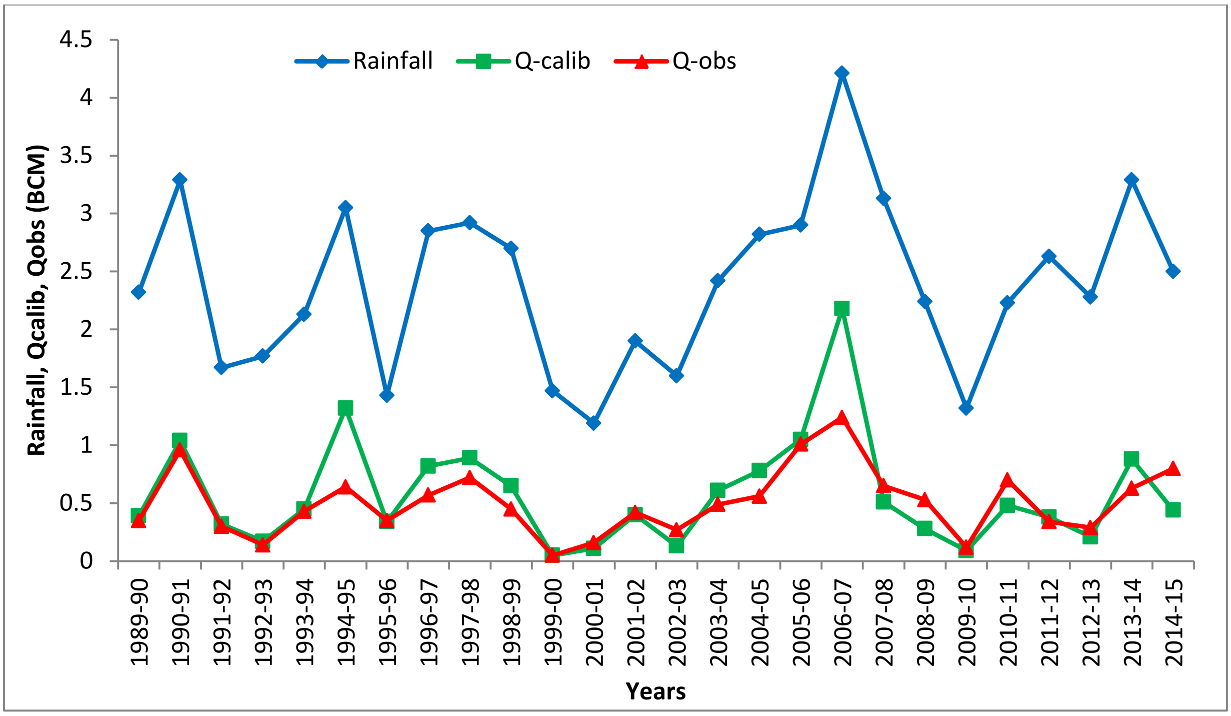


Figure 13.20 Calibrated runoff and observed discharge at Pingalwada

13.5 Annual Water Resources Availability of Mahi Basin

Table - M.5 at Annexure - M shows the different components required to estimate the basin level water resources of Mahi River basin (up to Merging into sea) for 30 years. The maximum annual water availabiliy is 33.35 BCM during 2006-07 and minimum annual water resource is 4.01 BCM during 2000-01 which is the driest year in the 30 years.

Mean water resources of Mahi sub-basin	= Mean of (Calibrated Runoff + Estimated Consumptive Irrigation Input (ECII) + Domestic, Industrial & Livestock consumption + Groundwater Flux + Evaporation from reservoirs+ Reservoir Flux + Export from basin + Import to Basin)
	= 4.09 + 8.19 + 0.24 + (-0.24) + 0.75 + 0.09 + 0.00 + 0.00 = 13.12 BCM

Water resources availability (WRA) calculation of Mahi basin (Mahi river sub-basin+ Dhadhar river sub-basin) is shown below:

Annual Mean WRA in Mahi river sub-basin (33,791 sq. km)	13.12 BCM
Annual Mean WRA in Dhadhar river sub-basin (4,131 Sq Km)	1.22 BCM
Area: (33,791 + 4131)	37,922 sq.km
Water Resource Availability: (13.12 + 1.22)	14.34 BCM
Annul Mean Water resources availability for un-calibrated area (area = 39,565.6 - 37,922 = 1643.6) = (14.34*1,643.6)/37,922)	0.62 BCM
WRA for Mahi basin (Mahi sub-basin + Dhadhar + uncalibrated area)	14.96 BCM

The mean average water resource of of Mahi river basin is 14.96 BCM and 75% dependable flow is 9.135 BCM. The mean water potential is 42.74 % of the mean annual rainfall during the 30 years (1985-86 to 2014-15).

13.5.1 Annual water resources of Mahi basin during extreme rainfall conditions

Out of the total 30 years of meteorological database of study period, during the years 2006-07 and 2000-01, extreme wet and dry rainfall conditions occurred in Mahi basin. Table - 13.2 shows the water availability and rainfall during these years. The annual water resources of Mahi basin during these two extreme rainfall conditions are 35.35 BCM and 4.01 BCM respectively. The water balance components during these years are presented in the Figures 13.21 and 13.22.

Table - 13.2 Water resources availability of Mahi basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	2006-07	64.15	35.35
Minimum Rainfall	2000-01	17.57	4.01

Water resource availability-rainfall ratio during the extreme maximum and minimum rainfall years is found to be 0.55 and 0.23 respectively, this shows that the higher the rainfall, the higher percentage of runoff. During higher rainfall years potential evapotranspiration is less as compared to the dry years, which has cumulative effect in runoff.

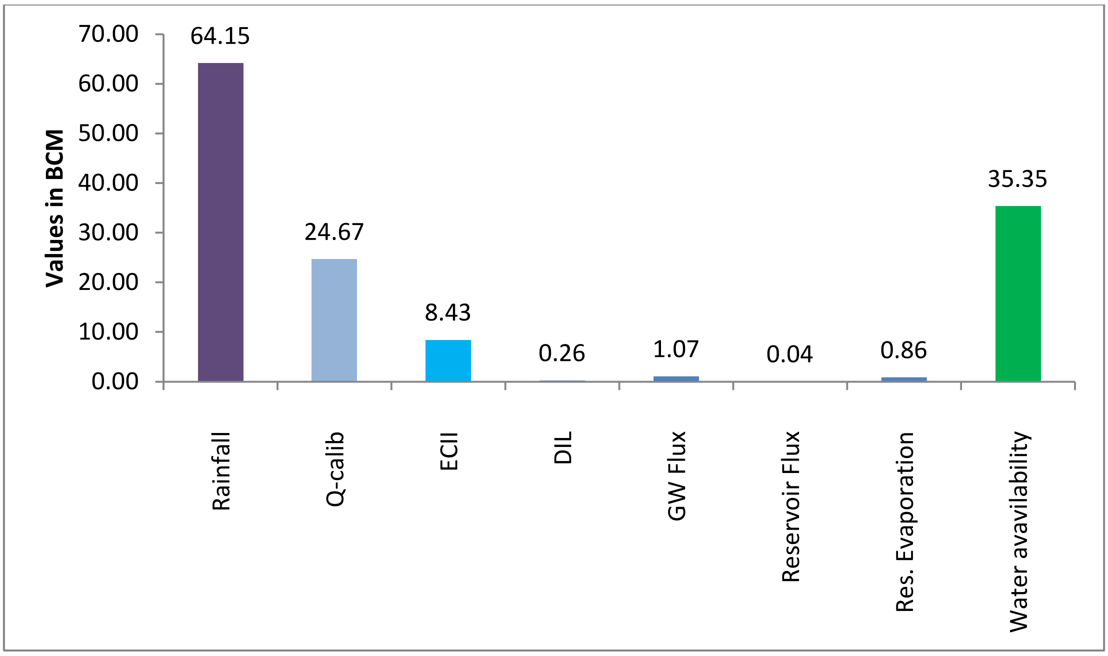


Figure 13.21 Water balance components of Mahi basin during extreme high rainfall (2006-07)

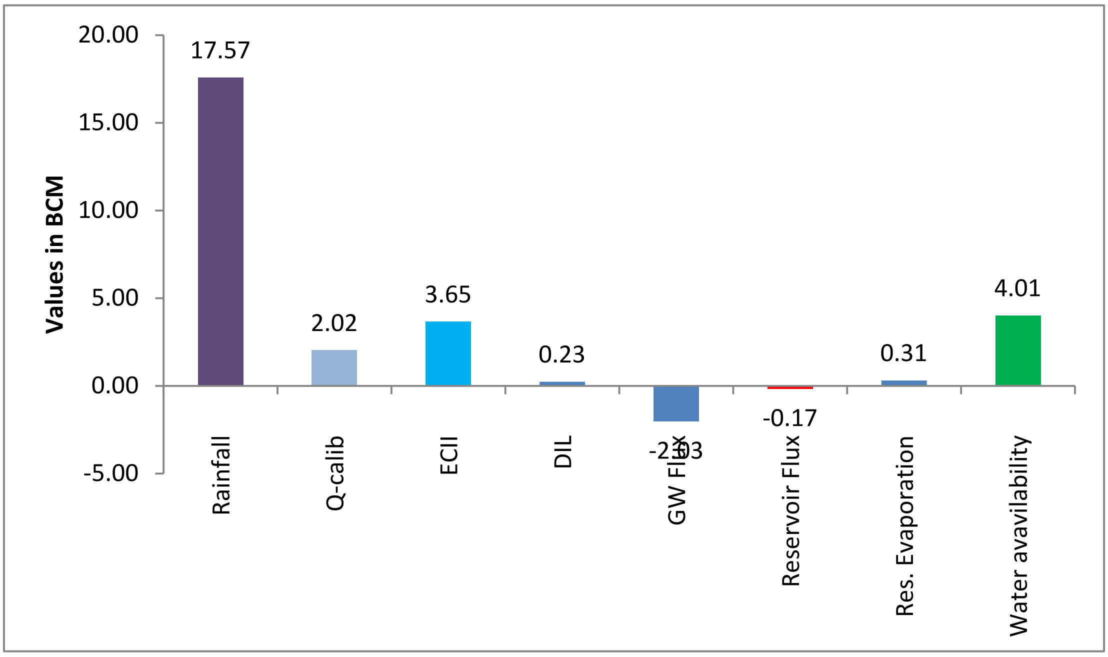


Figure 13.22 Water balance components of Mahi basin during extreme low rainfall (2000-01)

13.5.2 Mean water resources of Mahi basin

Figure 13.23 shows the various water balance components of Mahi basin averaged over a period of 30 years during 1985-86 to 2014-15 (excluding the year 2006-07).

The mean available annual water resources potential of the Mahi Basin (Mahi river sub-basin + Dhadhar sub-basin + uncalibrated area) is 14.96 BCM.

75% dependable flow of Mahi basin = 9.13 BCM

It is observed that the computed runoff factors varies from 0.01 (657 mm rainfall) to 0.50 (1,506 mm rainfall). The mean runoff factor for 30 year period is 0.14.

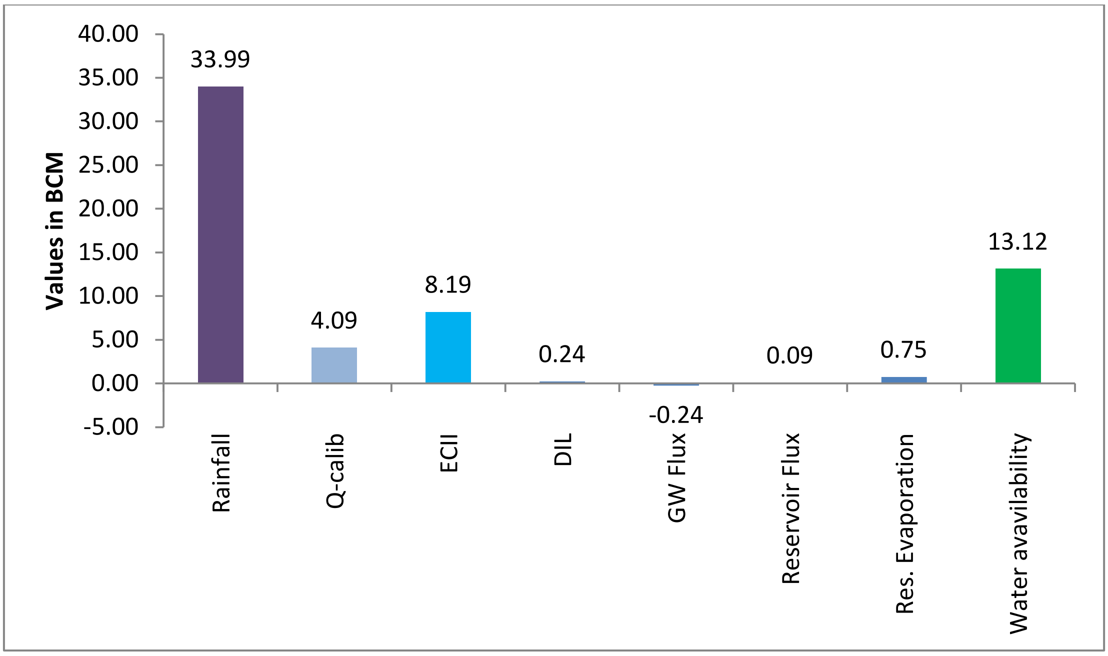
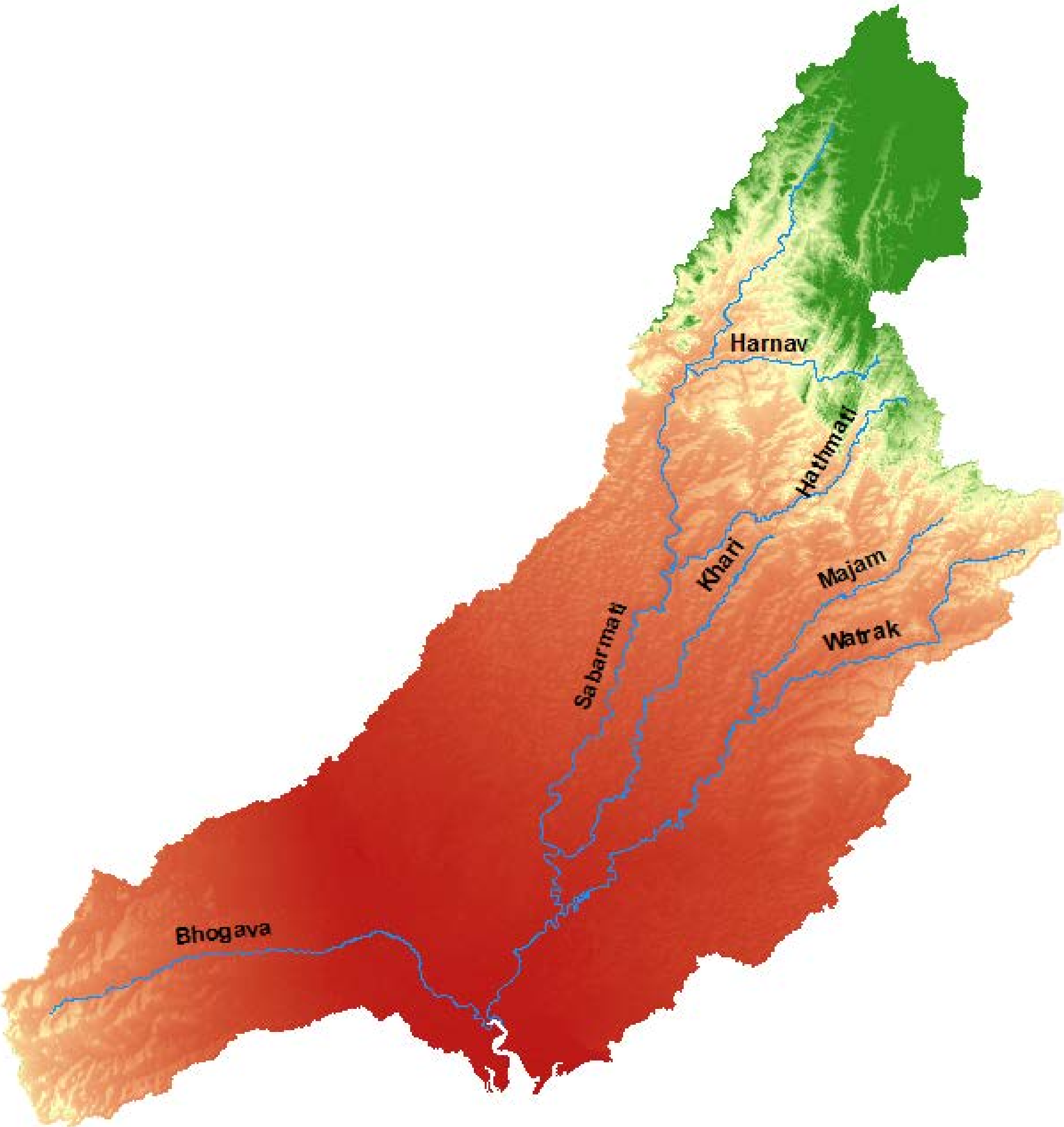


Figure 13.23 Mean water balance components of Mahi basin (excluding Dhadhar sub-basin and uncalibrated area)

HIGHLIGHTS

- *Mean available water resources of Mahi basin is 14.96 BCM.*
- *Maximum annual water availability is 35.35 BCM during 2006-07.*
- *Minimum annual water availability is 4.01 BCM during 2000-01.*
- *Annual rainfall in the basin varies from 405 mm to 1366 mm during 1985-86 to 2014-15 and mean rainfall for these 30 years is 811 mm.*
- *Mahi basin is divided into four sub-basins for the reassessment study viz. Mataji, Paderdibadi, Khanpur and below Khanpur.*
- *Average annual domestic, industrial and livestock demand in the basin is 0.24 BCM.*
- *Average annual evaporation from water bodiesin the basin is 0.75 BCM.*

SABARMATI BASIN



14.1 Geo-Spatial Datasets

14.1.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map of Sabarmati basin for year 2004-05 is shown in Figure 14.1. Agriculture land is predominant land use in the Sabarmati basin accounting for more than 50% (including current fallow) of the basin area. This extent varies slightly from year to year. Next dominant classes in the study area are wasteland and deciduous forest land. Figure 14.2 shows the distribution (in percentage) of LULC in the basin for 2004-05. The land cover analysis indicates that kharif only (28.21%), Double/Triple crop (26.84%), fallow (15.44%) and deciduous forest (8.34%) are the major LULC classes in Sabarmati basin.

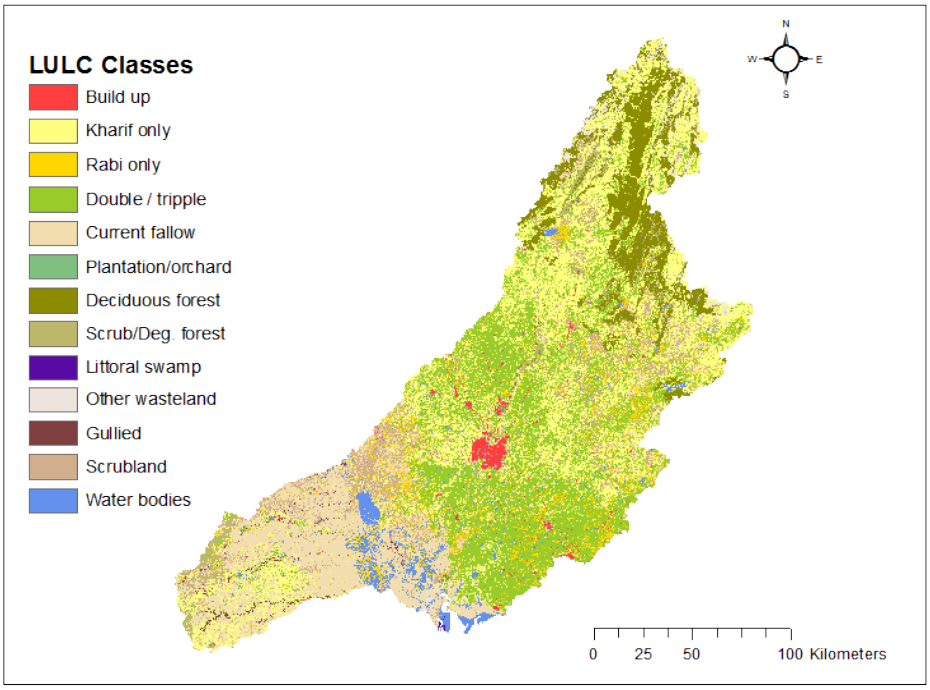


Figure 14.1 LULC map of Sabarmati basin (2004-05)

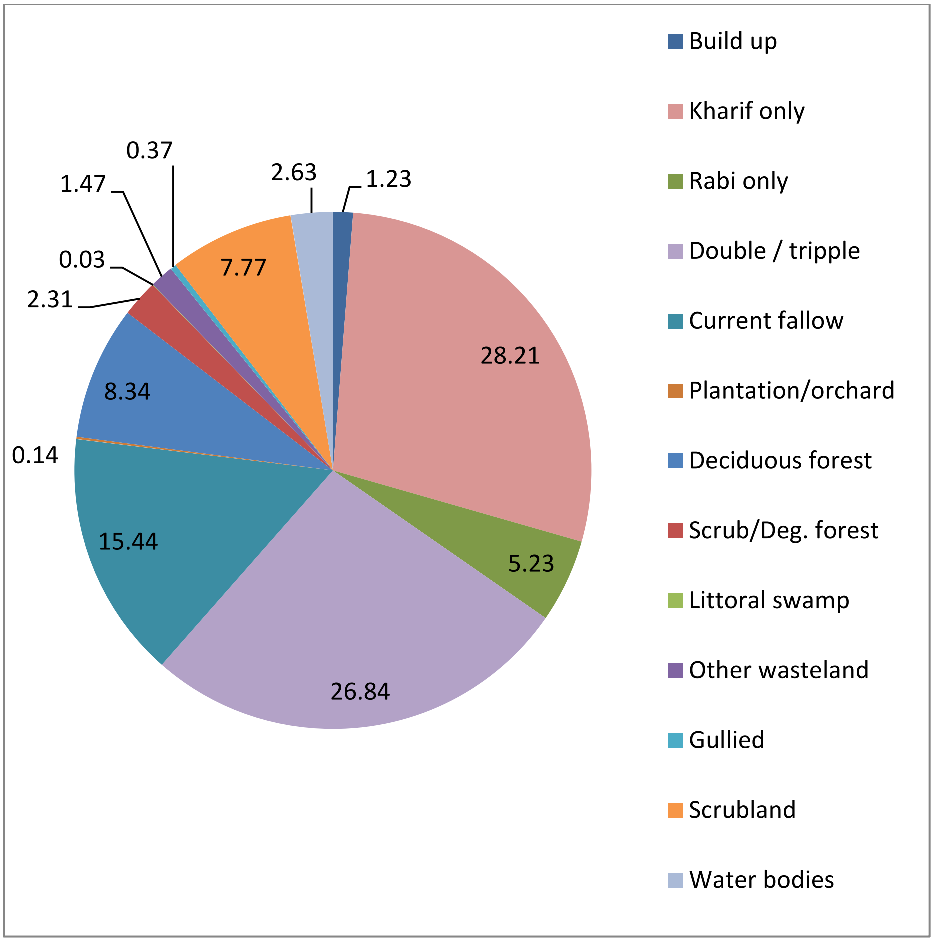


Figure 14.2 Distribution of LULC in Sabarmati basin (2004-05)

14.1.2 Soil texture

Sandy, clayey, loamy and rocky outcrop are the main soil texture classes in the study basin. The coastal plains consist of fertile delta area highly suited for intensive cultivation. Figure 14.3 shows various categories of soil in the basin. The larger part of the basin (study area) falls under fine texture category i.e. clayey and loamy that accounts for low infiltration rate and more runoff in the basin based.

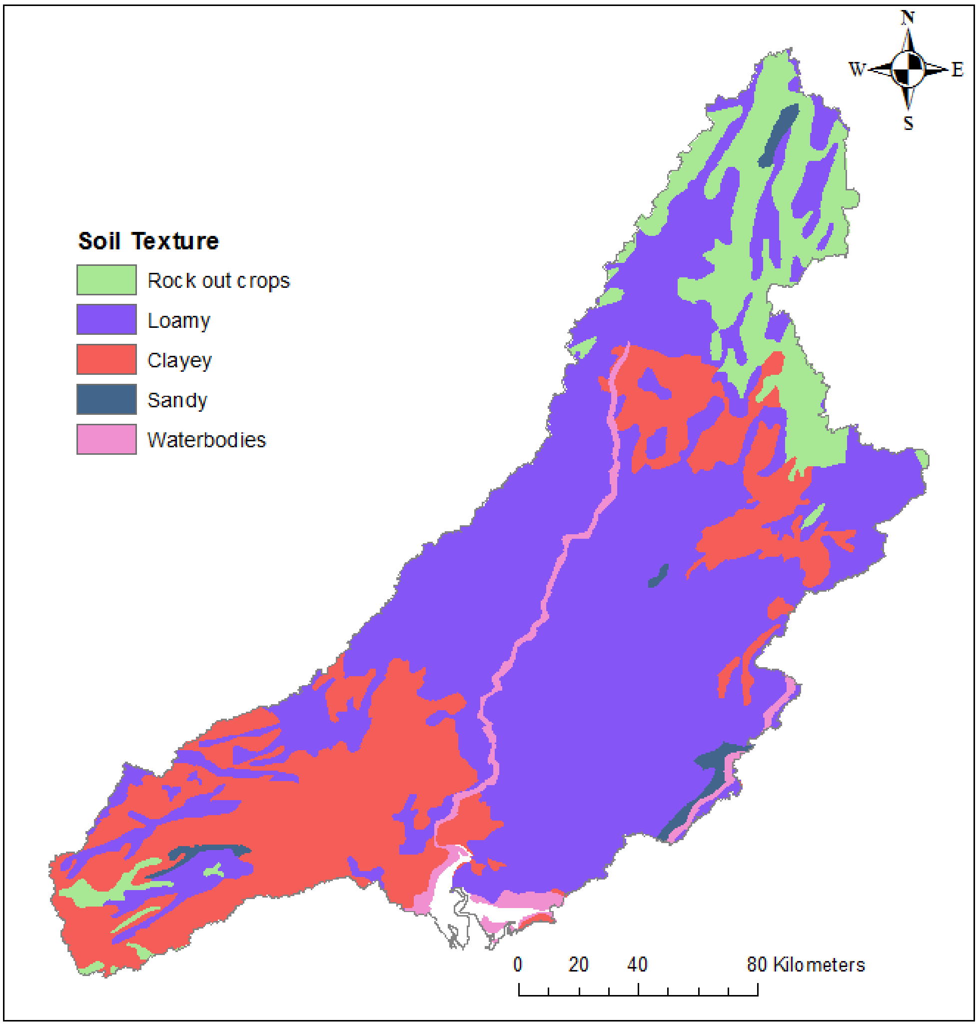


Figure 14.3 Soil texture map of Sabarmati basin

14.1.3 Topography

The topography of the basin consists of Ghat areas, plateau and the coastal plains. The districts of Rajasthan are under Central plateau and hills region. The districts of Madhya Pradesh fall under Western plateau and hills region. The elevation values ranges from a minimum of 0 m to a maximum of 1,173 m in the basin. Larger part of the basin is plains, mountain parts lie in districts of Rajasthan and Madhya Pradesh. Figure 14.4 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of Sabarmati basin. The DEM was used for delineating sub-basin boundaries of Sabarmati basin.

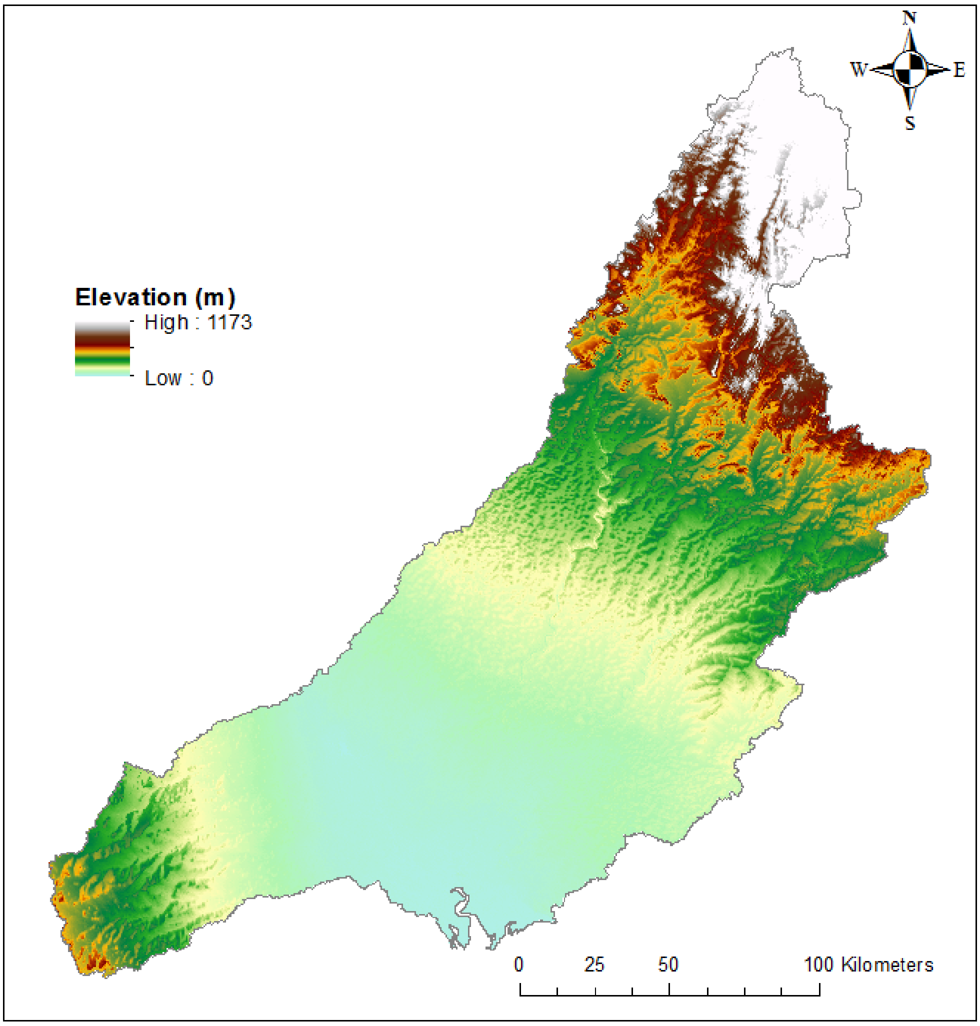


Figure 14.4 SRTM DEM map of Sabarmati basin

14.2 Hydro-Meteorological and other Input Data

14.2.1 Rainfall grids

Figure 14.5 shows gridded annual rainfall map of Sabarmati basin for year 2004-05. The variations in the annual rainfall during study period of 30 years (1985-86 to 2014-15) are shown in the Figure 14.6. Rainfall varies both spatially and temporally in Sabarmati basin. The mean rainfall of 30 years is found to be 727 mm. When spatial variations are considered, some areas received 375.66 mm and some other areas received 1,148.45 mm annual rainfall for year 2014-15. Major part of the basin receives annual rainfall of 500 mm to 1,000 mm. During the last 30 years (1984-85 to 2014-15) maximum rainfall was recorded as 1,283 mm in 2006-07 and minimum as 262.16 mm in 1987-88. Hence these two are considered as meteorologically wet and dry periods respectively during these 30 years span. Out of the 30 years, for 16 years annual rainfall is higher than the mean rainfall and for remaining 14 years it is lower than the mean rainfall.

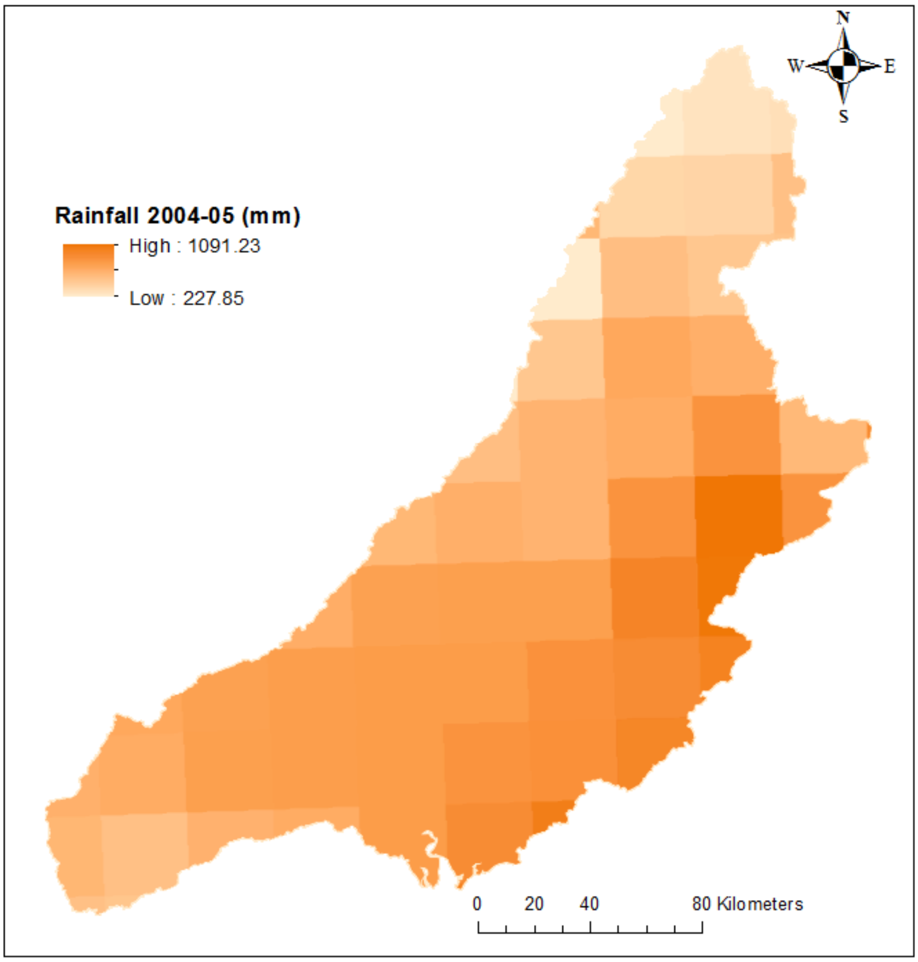


Figure 14.5 Gridded rainfall of Sabarmati basin (2004-05)

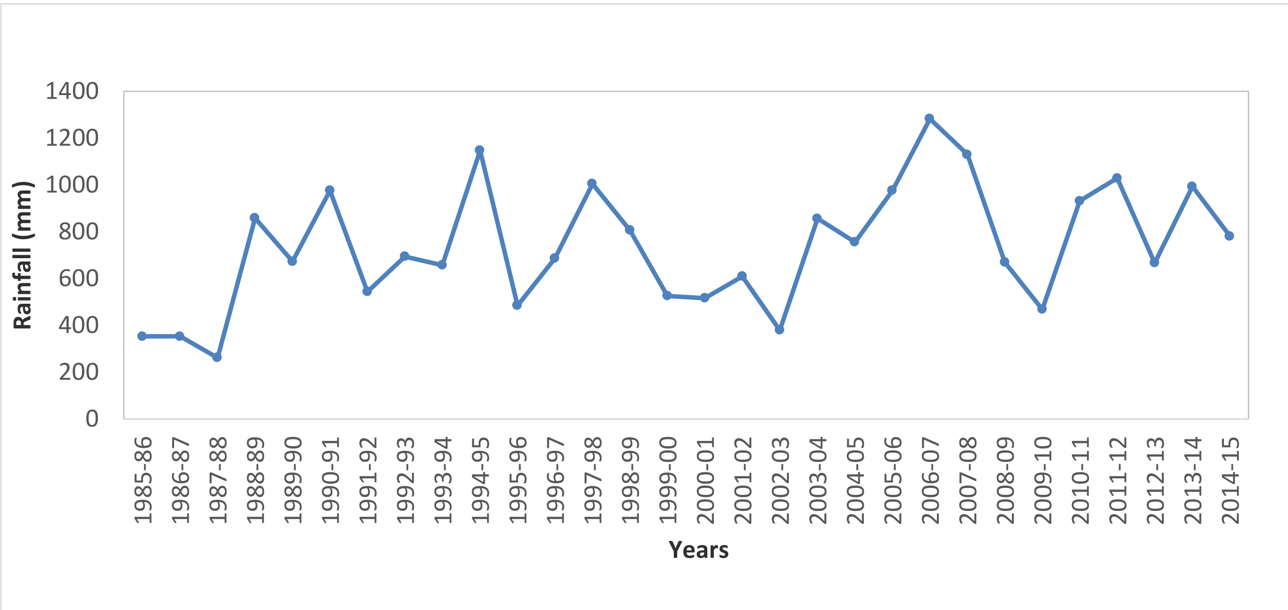


Figure 14.6 Annual rainfall in Sabarmati basin (1985-86 to 2014-15)

14.2.2 Temperature grids

Gridded mean annual temperature of Sabarmati basin in 2004-05 is shown in Figure 14.7. The mean annual temperature in Sabarmati basin varied from 25°C to 27.44°C during 2004-05.

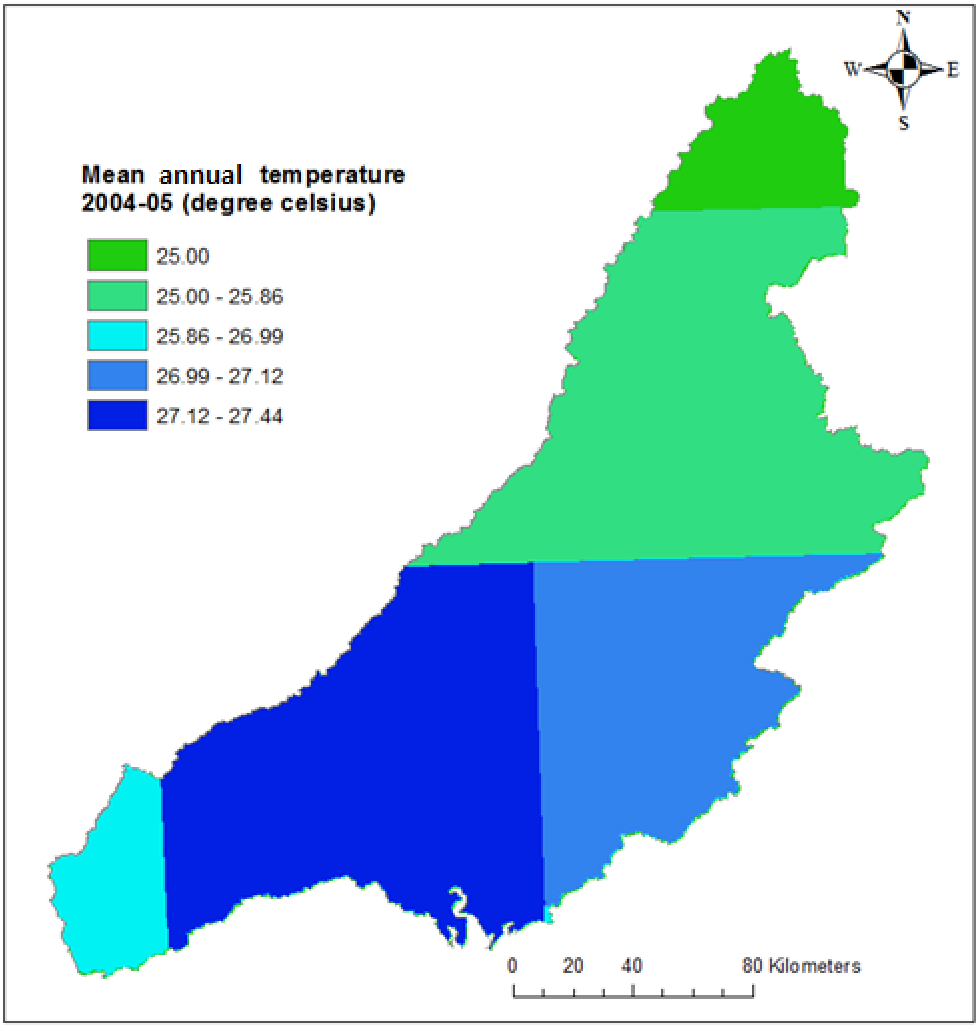


Figure 14.7 Gridded mean annual temperature of Sabarmati basin (2004-05)

14.2.3 Sub-basins of Sabarmati basin

Sabarmati basin is divided into four sub-basins namely Derol Bridge, Kheda, Voutha and others (Bhogavo) as shown in Figure 14.8. The sub-basins are divided in such way that the locations of CWC discharge stations are taken as sub-basin terminal point. The drainage area of each sub-basin is given at Table 14.1. SRTM DEM of 90 m resolution is used to delineate the basin and sub-basin boundaries of the Mahi basin.

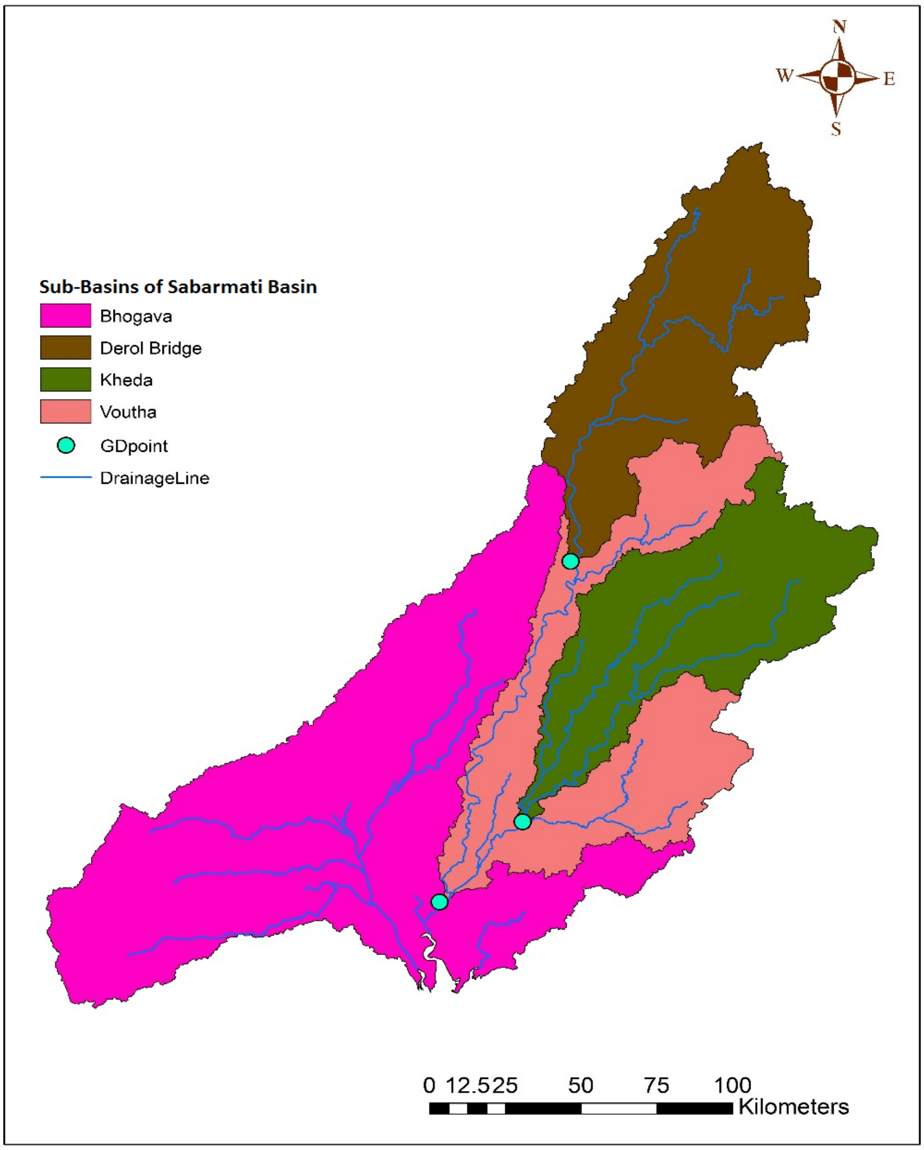


Figure 14.8 Sub-basins of Sabarmati basin

Table - 14.1 Sub-basin wise details of Sabarmati basin

S. No.	Sub-basin	River	Individual drainage area (sq.km)
1	Derol Bridge	Sabarmati	6,221
2	Kheda	Sabarmati	5,759
3	Voutha	Sabarmati	6,200
4	Others (Bhogavo)	Bhogavo & Others	13,721
		Total basin area	31,901

14.2.4 River discharge

The discharge data for three sub-basins namely Derol Bridge, Kheda and Voutha are available from 1989-90, 1992-93 and 2001-02 onwards respectively. The data for Others (Bhogavo) region is not available.

14.2.5 Reservoir flux

Figure 14.9 shows the location of reservoirs/dams considered for the estimation of reservoir flux in the basin.

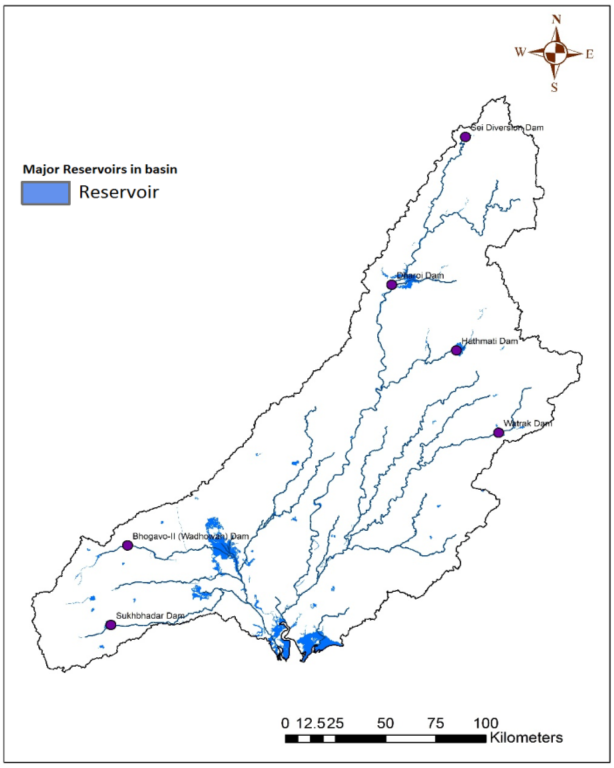


Figure 14.9 Major reservoirs in Sabarmati basin

14.2.6 Groundwater flux

The spatial annual groundwater flux in the basin varies from 635.1 MCM to -1,403.44 MCM during year 2014-15 as shown Figure 14.10. Annual variation in the groundwater flux for the study period of 30 years (1985-86 to 2014-15) is shown in Figure 14.11. The mean annual groundwater flux from 1984-85 to 2014-15 of Sabarmati basin is estimated at -0.56 BCM (drawdown).

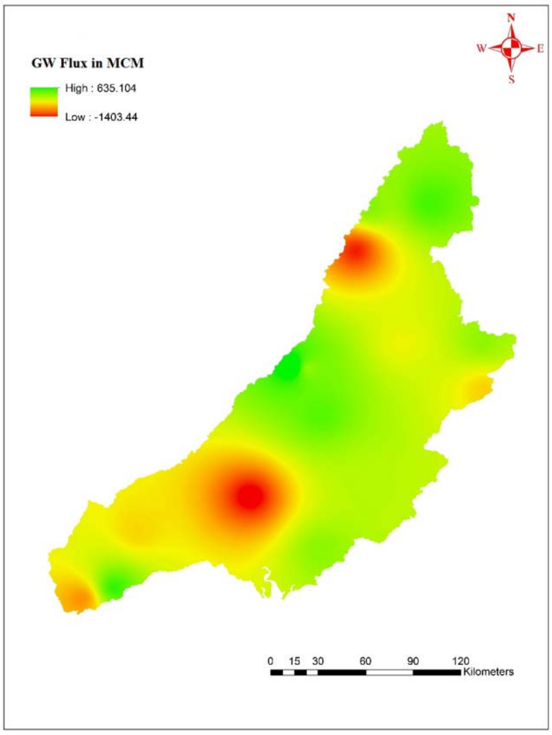


Figure 14.10 Groundwater flux (spatial data) estimated during 2014-15

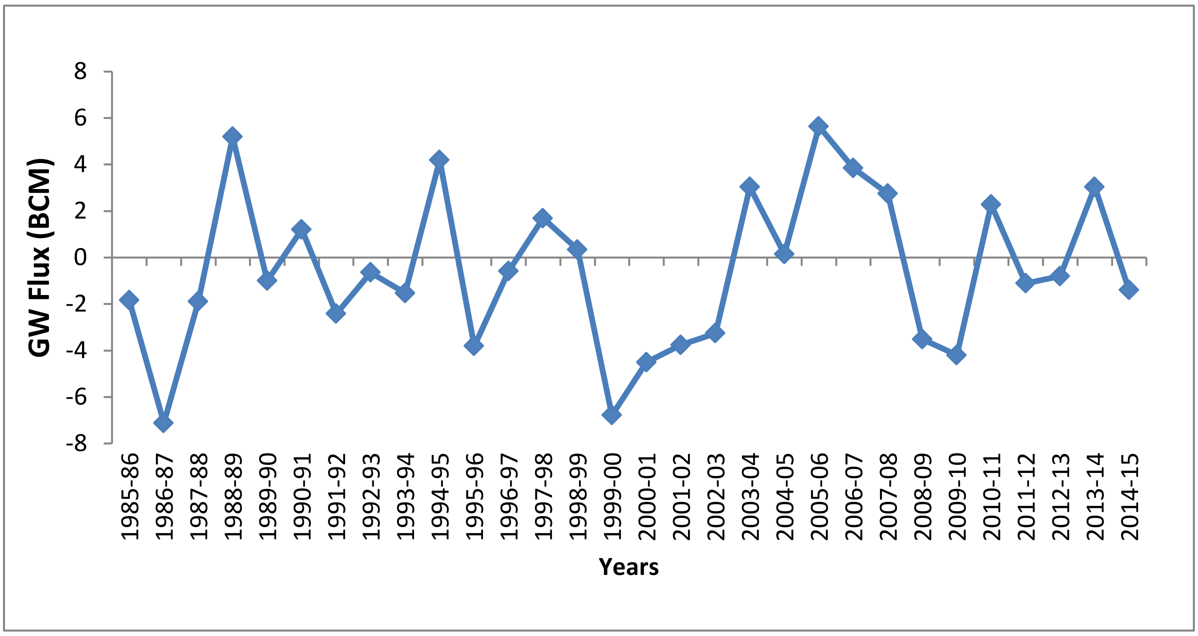


Figure 14.11 Annual groundwater flux of Sabarmati basin (1985-86 to 2014-15)

14.2.7 Major crops in the basin

Sabarmati basin is subdivided into six (6) regions based on predominant crops identified in each district. Each region specifies a unique crop for each crop season both spatially and temporally within the basin. For example (spatial variation) in Kharif only season in a district, if rice is a major crop, it may be cotton or castor in the neighbouring district. Similarly, temporal variation indicates for example during 2004-05, if cotton is a major crop in Kharif only season, it may be rice or castor during 2005-06.

14.2.8 Irrigation command area

Figure 14.12 shows location of irrigation command boundaries of the Sabarmati basin considered for the year 2014-15. Since annual command boundary maps are not available, command area has been selected from the year 2014-15 based on the completion of the project/dam. Basin outside command has been taken uniformly for all years while working out ECII from these areas.

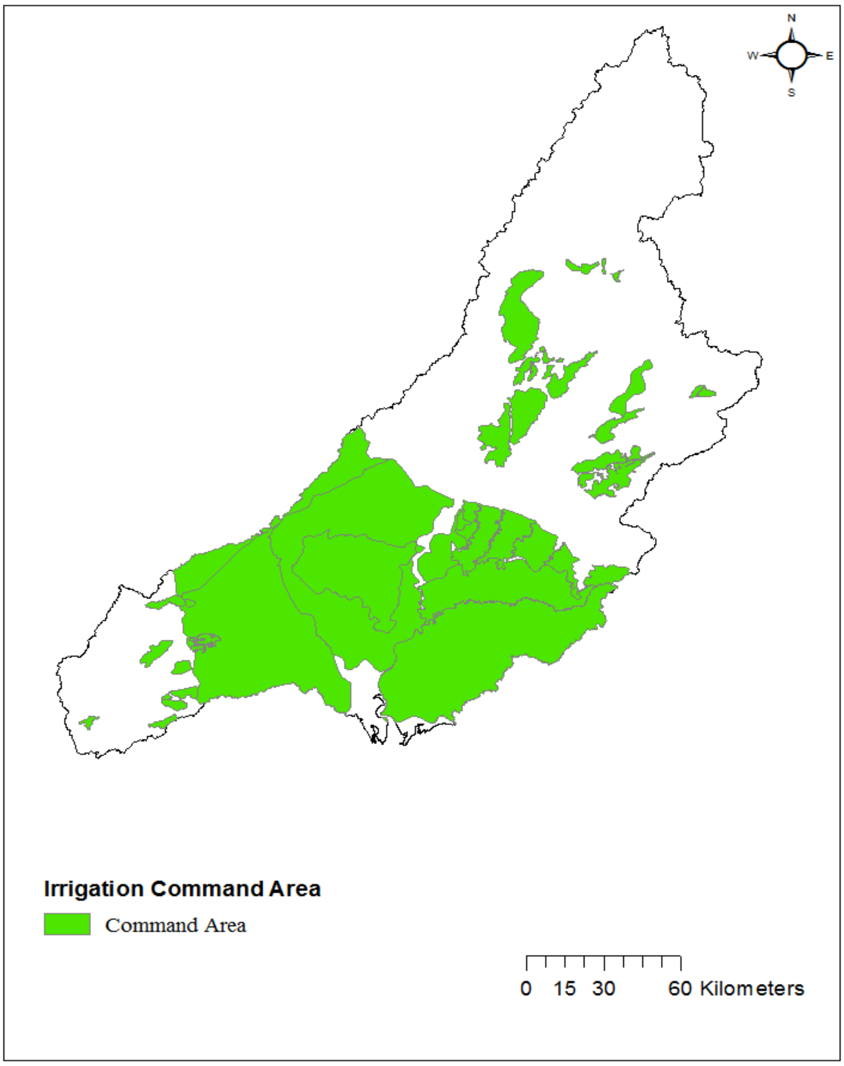


Figure 14.12 Irrigation command boundaries of Sabarmati basin

14.2.9 Domestic, industrial and livestock demand

Figure 14.13 shows the district boundaries in the basin used for DIL demand estimation. The mean annual domestic, industrial and livestock (DIL) demands are estimated as 0.33 BCM during the period 1985-86 to 2014-15 in Sabarmati basin.

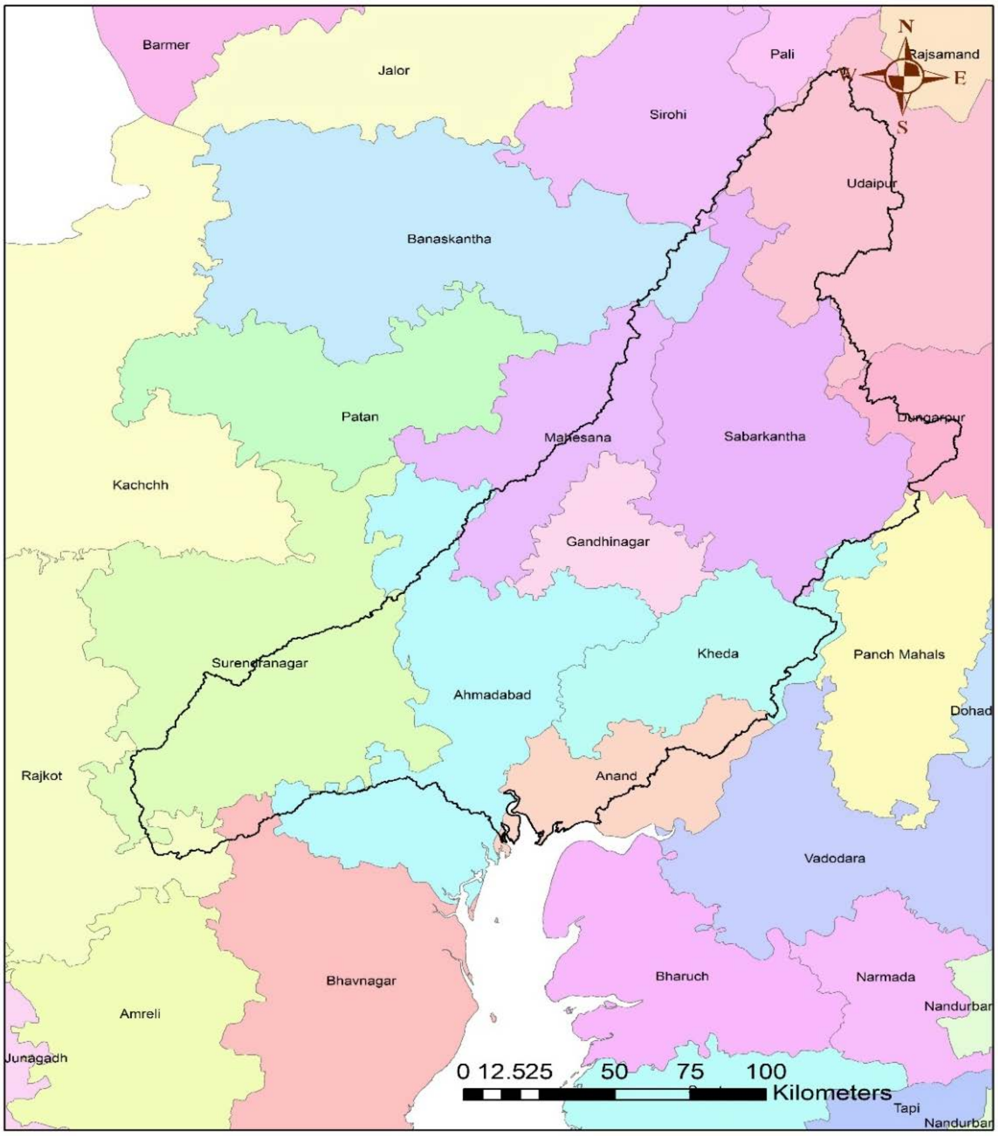


Figure 14.13 District boundaries in Sabarmati basin

14.2.10 Evaporation from major/medium/minor reservoirs and other water bodies

The annual evaporation from the reservoirs and other water bodies in the basin is shown in Table - 14.2.

Table - 14.2 Evaporation in reservoirs of Sabarmati basin

Year	Reservoir Evp BCM	Year	Reservoir Evp BCM	Year	Reservoir Evp BCM
1985-86	0.173	1995-96	0.167	2004-05	0.172
1986-87	0.135	1996-97	0.986	2005-06	1.108
1987-88	0.098	1997-98	1.070	2006-07	0.232
1988-89	0.207	1998-99	0.224	2007-08	0.447
1989-90	0.916	1999-00	0.183	2008-09	0.821
1990-91	0.924	2000-01	0.153	2009-10	0.150
1991-92	0.139	2001-02	0.874	2010-11	0.240
1992-93	0.201	2001-02	0.874	2011-12	0.171
1993-94	0.769	2002-03	0.132	2012-13	0.135
1994-95	0.464	2003-04	0.213	2013-14	0.245
				2014-15	0.266
				Avg	0.41

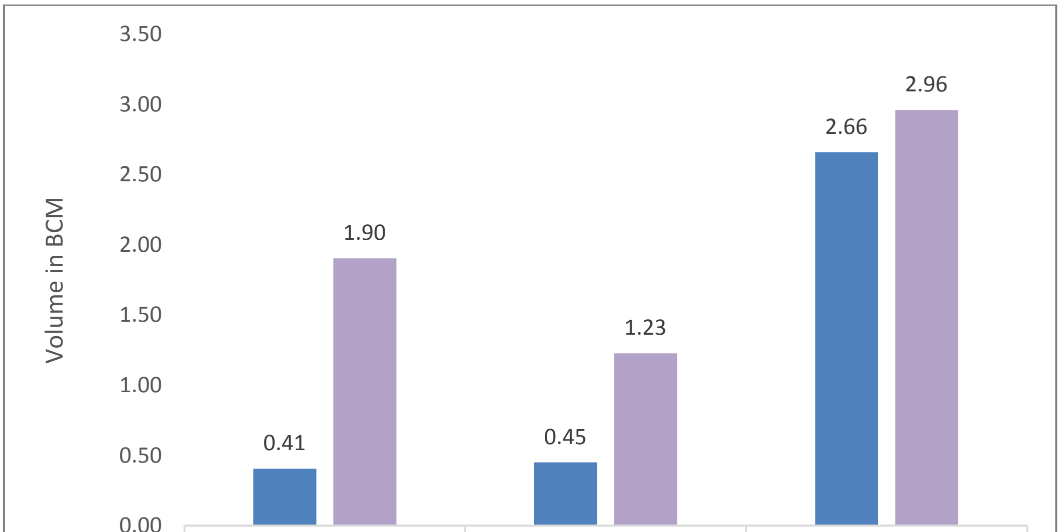
14.3 Previous Estimates

In 1949 when the basinwise assessment of the water resources of the country was made on the basis of Khosla's empirical formula, the annual runoff of Sabarmati basin had been assessed as 4.663 BCM. In 1960, the Central Water & Power Commission, while conducting irrigation potential studies, assessed the average annual runoff of Sabarmati as 3.663 BCM, which was subsequently revised to 4.079 BCM in CWC's Publication No 30/88 "Water Resources of India", April 1988.

The CWC (1993) estimate of available water resources of the total basin was 3.81 BCM. Observed discharges were taken into account for arriving at the natural flow at Ahmedabad in the 1993 study after accounting all other abstractions.

14.4 Runoff Estimation

Discharge stations namely Derol Bridge, Kheda and Voutha are selected on Sabarmati river and the model estimated runoff is calibrated against the observed discharge at all the three locations. Tables N.1 to N.3 (at Annexure - N) give calibrated runoff along with observed discharge, rainfall, ECII, etc during 30 years for the 3 discharge stations. Figure 14.14 shows comparison between mean observed discharge and mean calibrated runoff at various gauge stations. Figures 14.15 to 14.17 show comparative graphs of calibrated runoff and observed discharge at these discharge stations. At the Voutha station (terminal station for Sabarmati Basin), the observed discharge and calibrated runoff are matching well for almost all the years except for 3-4 years. Table N.4 at Annexure - N gives calibrated runoff of Sabarmati basin for 30 years. The mean annual calibrated runoff is about 4.14 BCM. The maximum annual calibrated runoff is 12.855 BCM during 1994-95. The minimum annual calibrated runoff is 0 BCM during 1987-88, 1989-90 and 1996-97. The mean annual ECII is about 8.64 BCM. The maximum annual ECII is about 14.64 BCM during 1993-94. The minimum annual ECII is about 2.54 BCM during 2005-06.



	Derol bridge	Kheda	Voutha
Observed	0.41	0.45	2.66
Calibrated	1.90	1.23	2.96

Figure 14.14 Calibrated runoff and observed discharge at various gauge stations

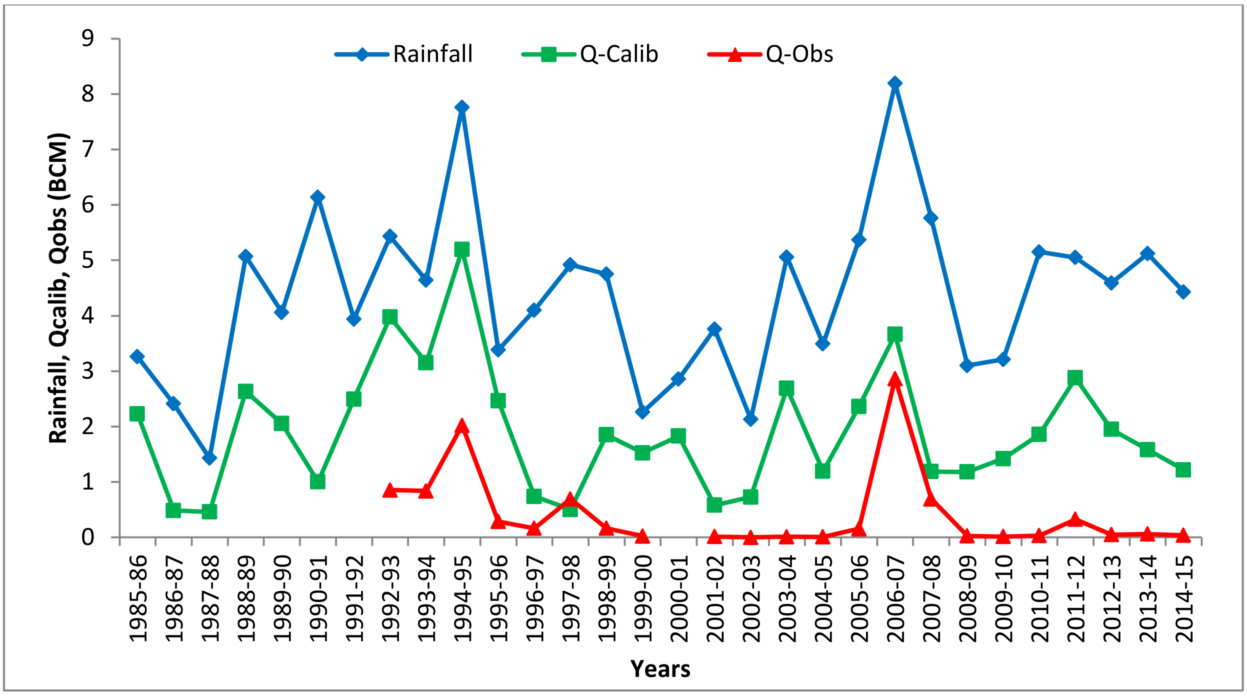


Figure 14.15 Calibrated runoff and observed discharge at Derol Bridge

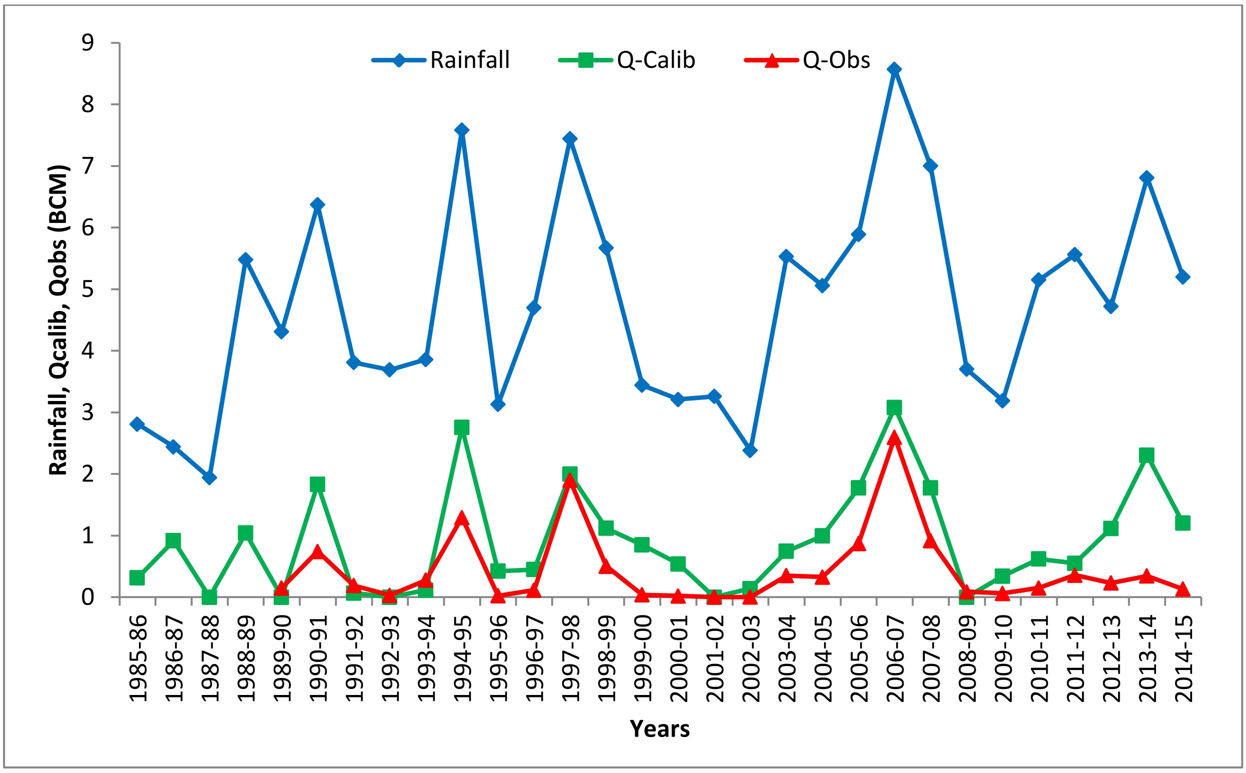


Figure 14.16 Calibrated runoff and observed discharge at Kheda

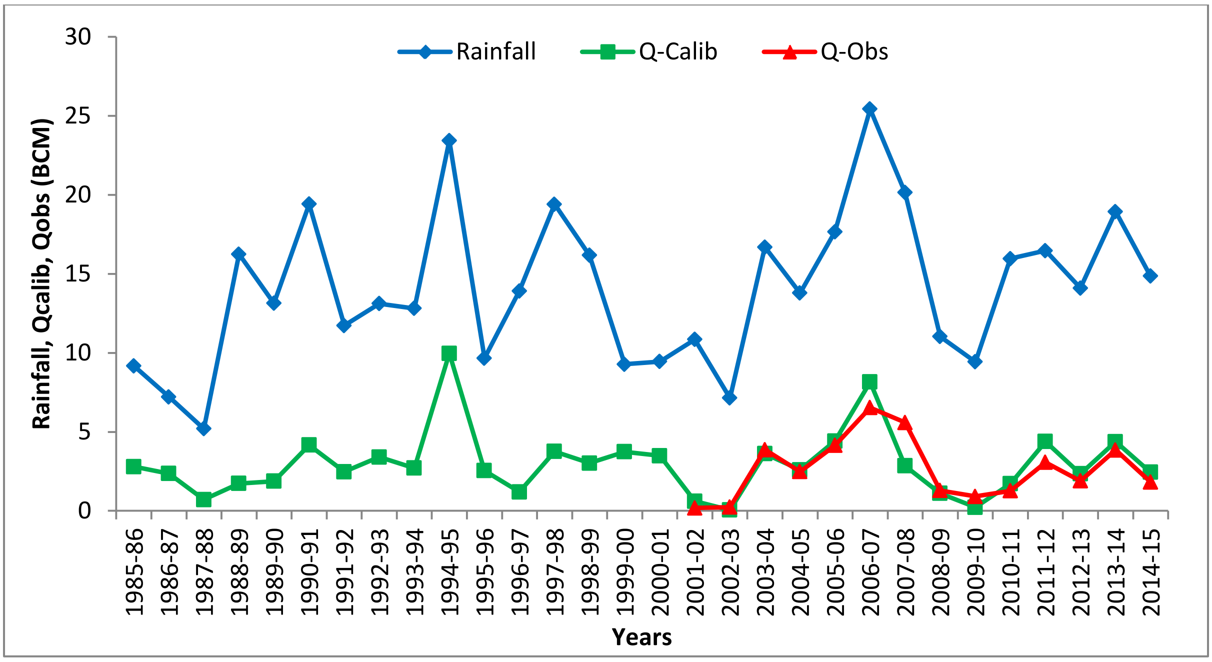


Figure 14.17 Calibrated runoff and observed discharge at Voutha

14.5 Annual Water Resources Availability of Sabarmati Basin

The Sabarmati basin includes the drainage area of Sabarmati river, Bhogavo river and other small streams. Drainage area of total Sabarmati basin is 31,901 sq.km. As said earlier Voutha site is terminal station for calibration of runoff of Sabarmati basin. Drainage area/catchment area up to Voutha site is 18,180 sq.km, which is 57% of the total drainage area of Sabarmati river.

Table N.4 (at Annexure - N) shows the different components required to estimate the basin level water resources of Sabarmati basin for 30 years. The maximum annual water resource is 27.21 BCM during 2006-07 in the 30 years. The minimum annual water resource is 3.56 BCM during 1986-87.

The mean annual available basin water resource is 12.96 BCM and 75% dependable flow is 8.92 BCM. The mean water potential is 51.84 % of the mean annual rainfall during the 30 years (1985-86 to 2014-15).

14.5.1 Annual water resources of Sabarmati basin during extreme rainfall conditions

Out of the total 30 years of meteorological database of study period, during the years 2006-07 and 1987-88, extreme wet and dry rainfall conditions occurred in Sabarmati river basin respectively. The annual water resources of Sabarmati basin during these two extreme rainfall conditions are 27.21 BCM and 4.41 BCM respectively as shown in Table - 14.3. The water balance components during these years are shown in Figure 14.18 and 14.19.

Table - 14.3 Water resources availability in Sabarmati basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	2006-07	43.95	27.21
Minimum Rainfall	1987-88	8.74	4.41

Water Resources availability-rainfall ratio during the extreme maximum and minimum rainfall years is found to be 0.61 and 0.50 respectively. This shows that the higher the rainfall, the higher percentage of runoff. During higher rainfall years potential evapotranspiration is less compared to the dry years, which will have cumulative effect in runoff.

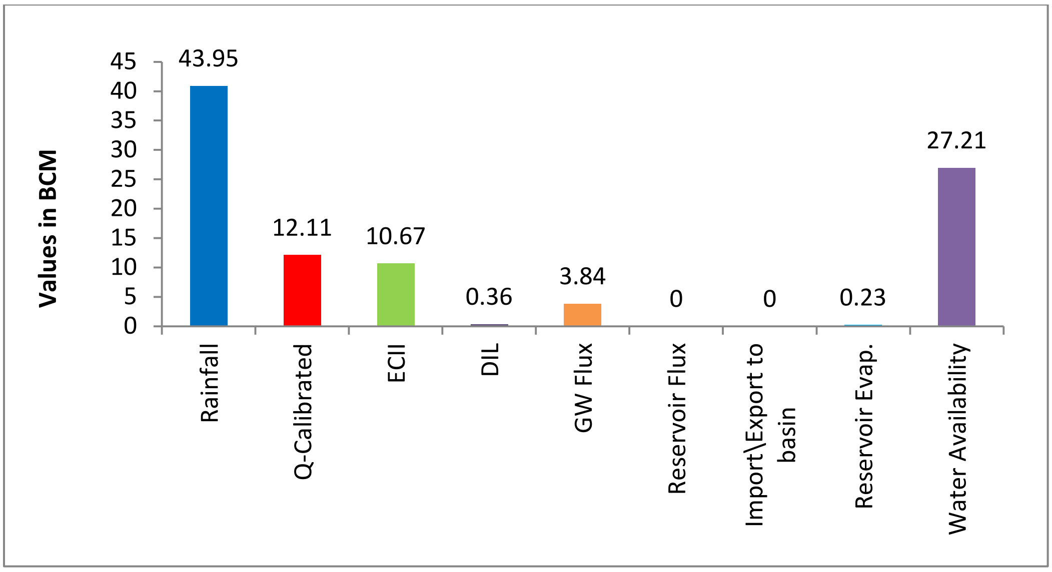


Figure 14.18 Water balance components of Sabarmati basin during extreme high rainfall (2006-07)

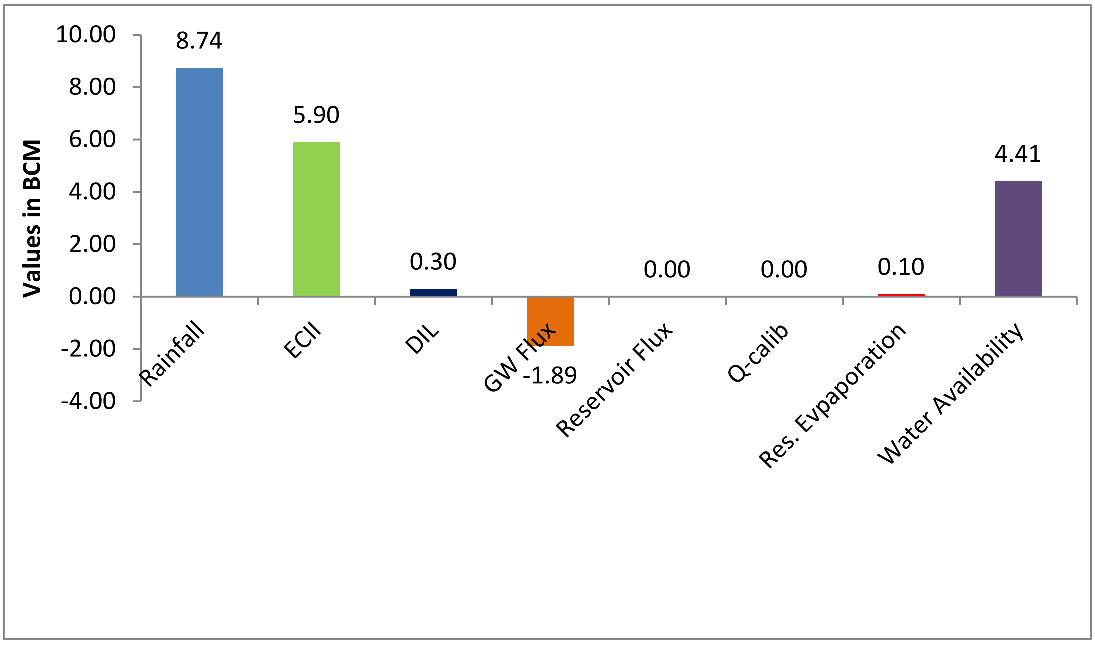


Figure 14.19 Water balance components for Sabarmati basin during extreme low rainfall (1987-88)

14.5.2 Mean water resources of Sabarmati basin

The mean water resources of the basin is computed by taking the mean of the 30 years water balance components such as flow in the river at final outlet, upstream effective utilisations for irrigation, domestic and industrial, change in storage of groundwater,change in strorage of reservoirs and evaporation from reservoirs.

Mean water resources = Mean of (Calibrated Runoff + Estimated Consumptive Irrigation Input + Domestic, Industrial and Livestock consumption + Groundwater Flux + Reservoir Flux + Export from basin+ Evaporation from Reservoirs)

= 4.14 + 8.64 + 0.33 + (-0.56) + 0 + 0 + 0.41 = 12.96 BCM

The mean water resource of the basin is 12.96 BCM and 75% dependable flow is 8.92 BCM. Figure 14.20 shows the mean water balance components for the basin.

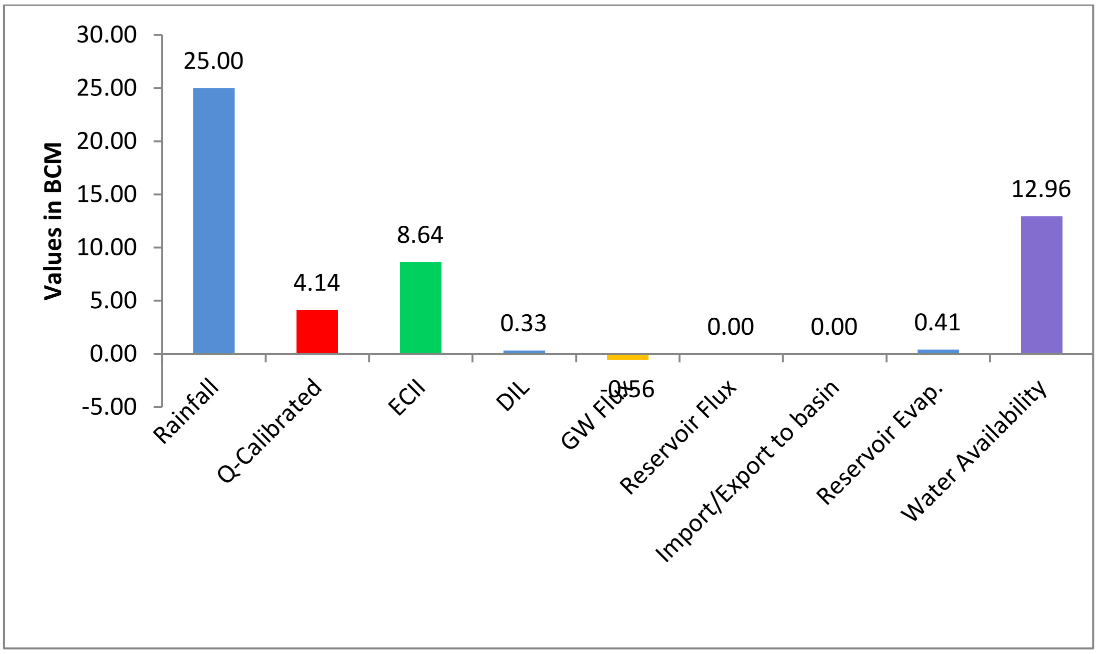
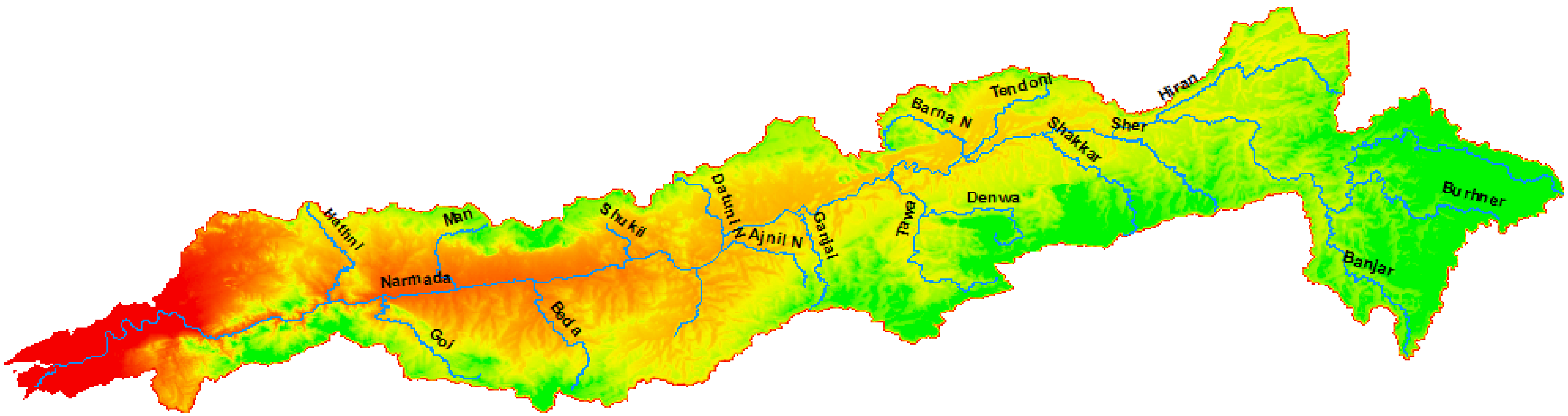


Figure 14.20 Mean water balance components of Sabarmati basin

HIGHLIGHTS

- *Mean annual available water resources of Sabarmati basin is 12.96 BCM.*
- *Maximum annual water availability is 27.21 BCM during 2006-07.*
- *Minimum annual water availability is 3.56 BCM during 1986-87.*
- *Annual rainfall in the basin varies from 375.66 mm to 1,148.45 mm during 1985-86 to 2014-15 and mean rainfall for these 30 years is 727 mm.*
- *Sabarmati basin is divided into four sub-basins for the reassessment study viz. Derol Bridge, Kheda, Voutha and Others (Bhogavo).*
- *Average annual domestic, industrial and livestock demand in the basin is 0.33 BCM.*
- *Average annual evaporation from water bodies in the basin is 0.41 BCM.*

NARMADA BASIN



15.1 Geo-Spatial Datasets

15.1.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map of Narmada basin for year 2004-05 is shown in Figure 15.1. Distribution (in percentage) of LULC in the basin for 2004-05 is shown in Figure 15.2. The LULC analysis indicates that Kharif (18.15%), Rabi (15.76%), fallow (14.95%), Double/Triple crop (10.31%), deciduous forest (11.98%) and scrub/degraded forest (17.59%) are the major classes in Narmada basin.

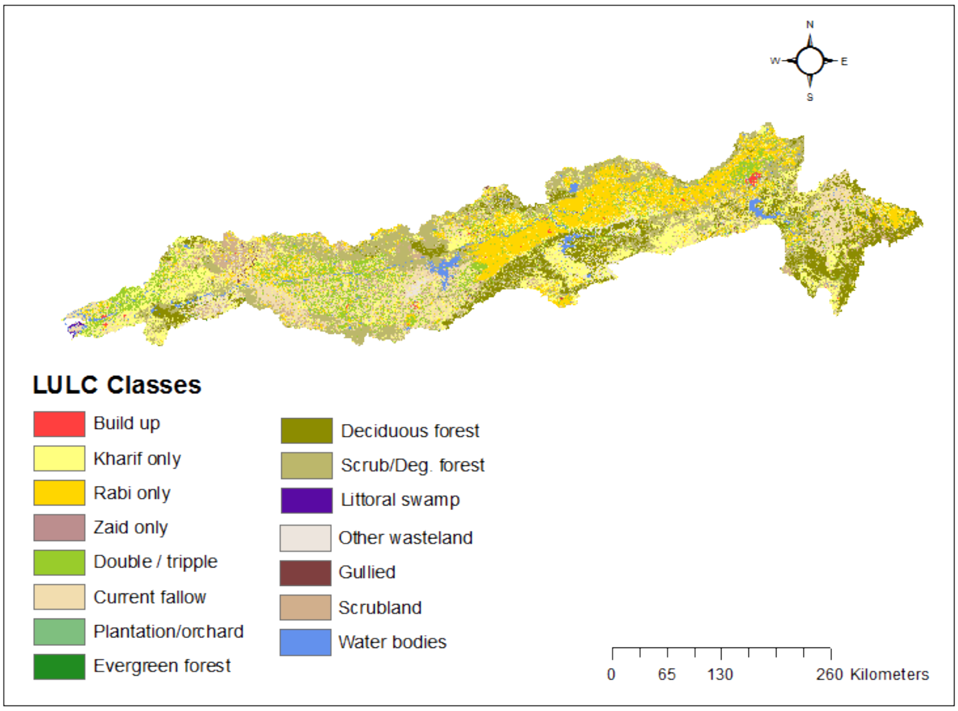


Figure 15.1 LULC map of Narmada basin (2004-05)

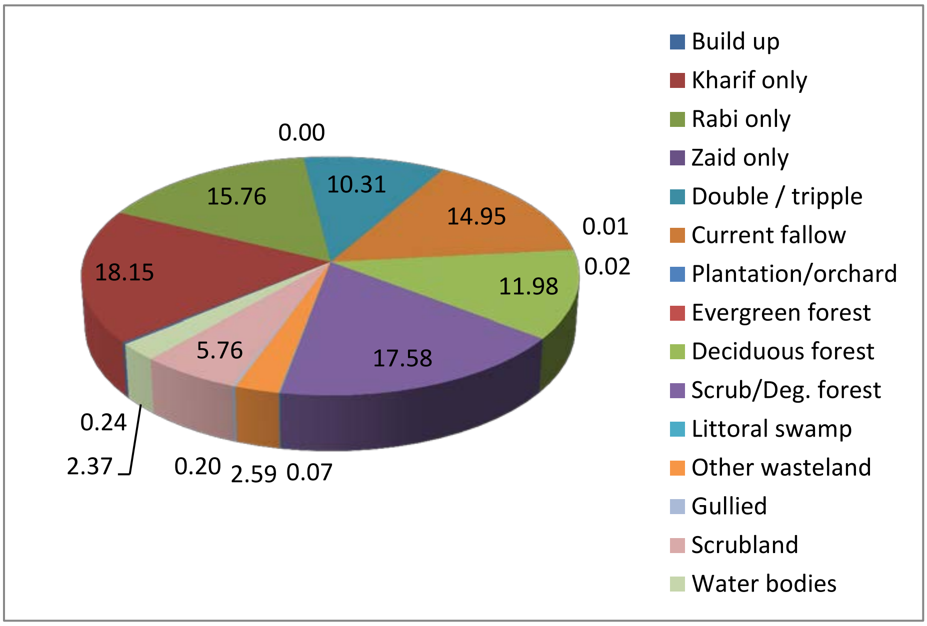


Figure 15.2 Distribution of LULC in Narmada basin (2004-05)

15.1.2 Soil texture

The main soil types found in the basin are clayey, loamy, sandy and rocky outcrop. Figure 15.3 shows various categories of soil in the basin. The soils are classified as clayey, loamy, loamy skeletal, clayey skeletal and rocky outcrop based on the soil texture information.

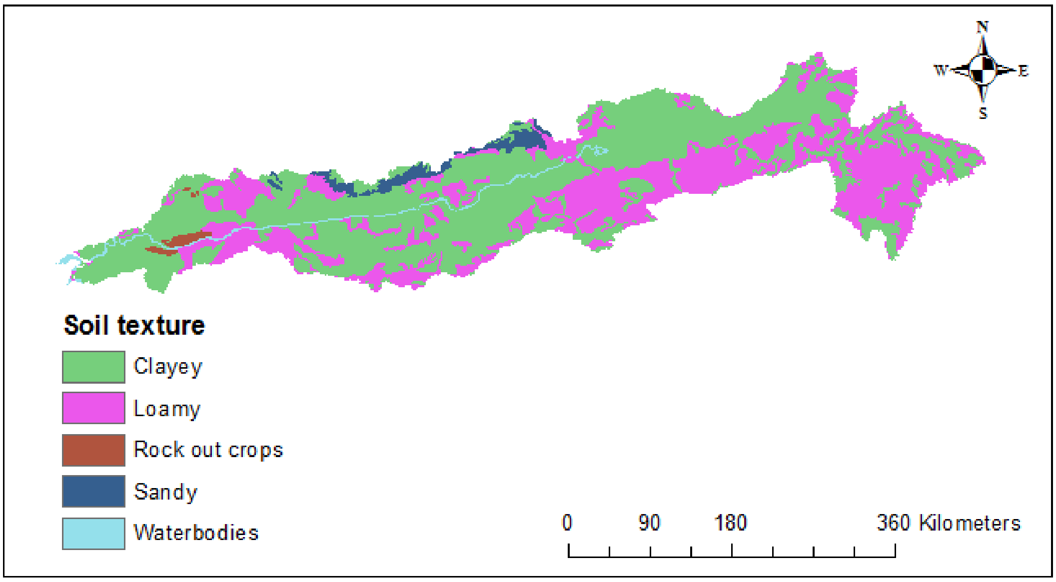


Figure 15.3 Soil texture map of Narmada basin

15.1.3 Topography

The topography of the basin consists of forest areas and plateau. The upper regions of the basin are mostly hilly and forested. The lower region of the basin is deltaic plains. The elevation values ranges from a minimum of 0 m to a maximum of 1,317 m. The average elevation is about 409 m in the basin. Figure 15.4 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the basin.

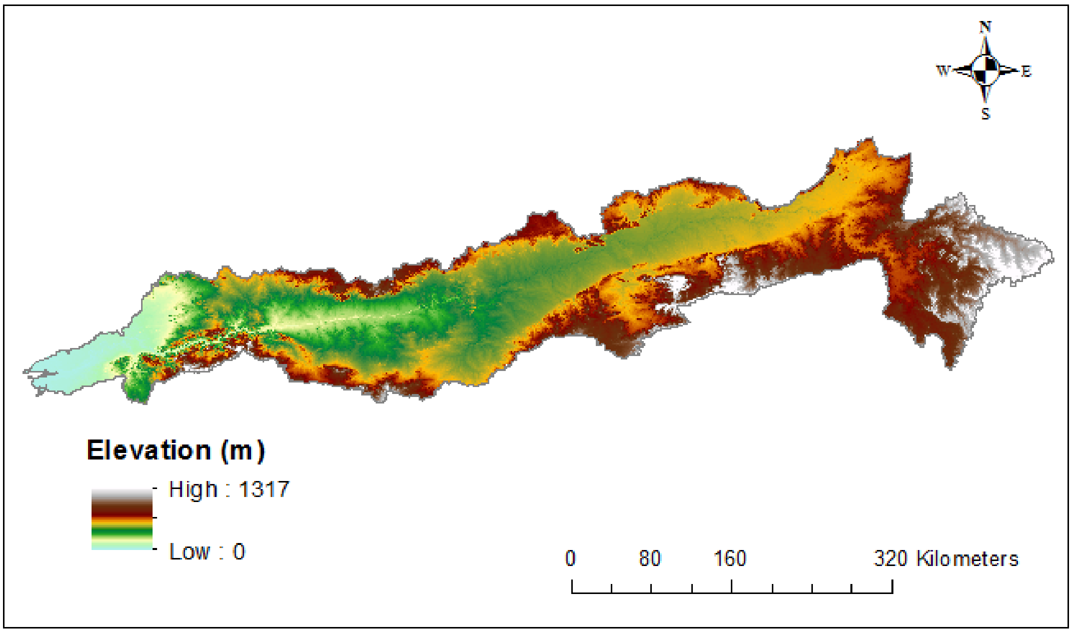


Figure 15.4 SRTM DEM map of Narmada basin

15.2 Hydro - Meteorological and other Input Data

15.2.1 Rainfall grids

Figure 15.5 shows gridded annual rainfall map of Narmada basin for year 2004-05. The annual variations in the annual rainfall during study period of 30 years (1985-86 to 2014-15) are shown in the Figure 15.6. Annual rainfall of the basin varies from 693 mm to 1,588 mm and mean rainfall of these 30 years is found to be 1,045 mm. Of the 30 years, for 13 years annual rainfall is higher than the mean rainfall and for remaining 17 years, it is lower than the mean rainfall.

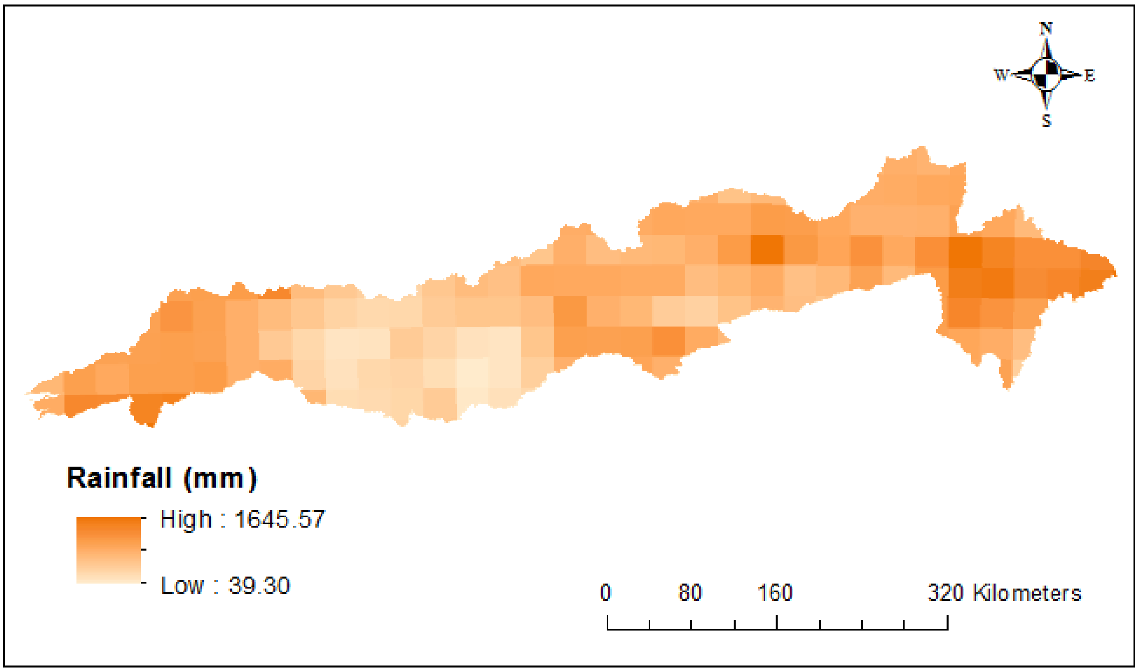


Figure 15.5 Gridded rainfall of Narmada basin (2004-05)

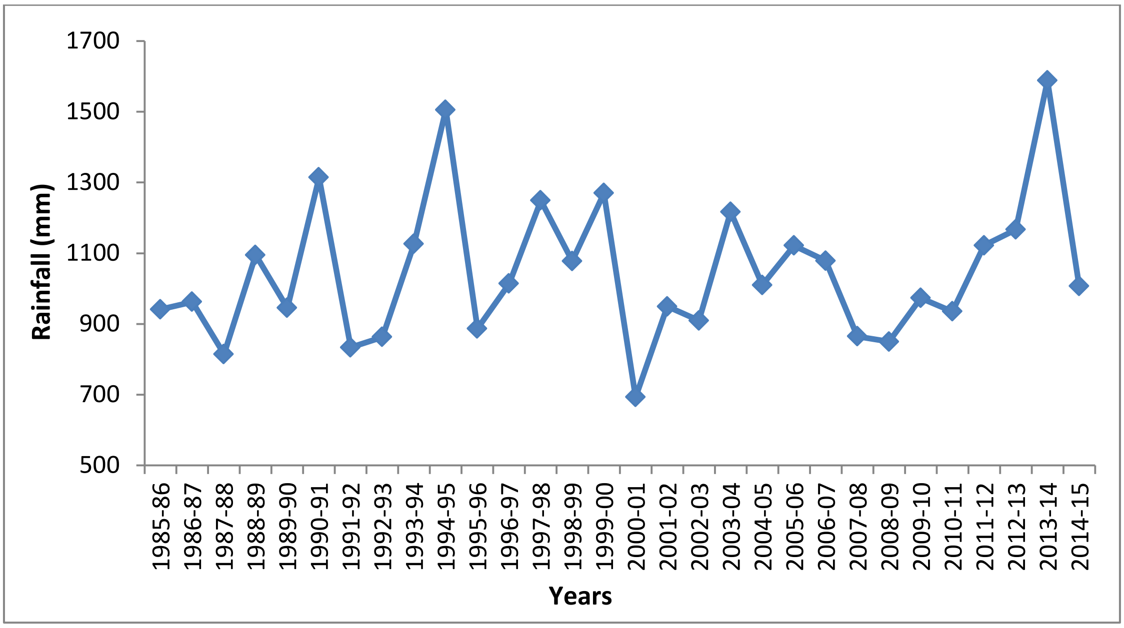


Figure 15.6 Annual rainfall in Narmada basin (1985-86 to 2014-15)

15.2.2 Temperature grids

Figure 15.7 shows gridded mean annual temperature map of Narmada basin for 2004-05.

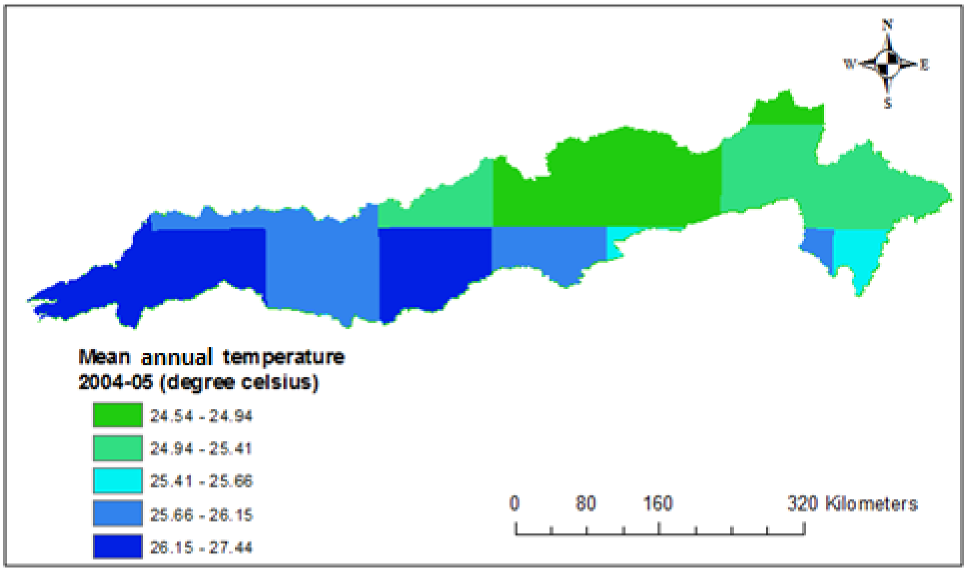


Figure 15.7 Gridded mean annual temperature of Narmada basin (2004-05)

15.2.3 Sub-basins of Narmada basin

The Narmada basin is divided into seven sub-basins (Figure 15.8) viz. Manot, Barmanghat, Handia, Hoshangabad, Mandleshwar, Garudeshwar and Outlet to Sea. Table 15.1 gives details of each sub-basin. The sub-basins are divided in such a way that the locations of CWC discharge sites are taken as sub-basin terminal point. Outlet to sea sub-basin drains directly into sea.

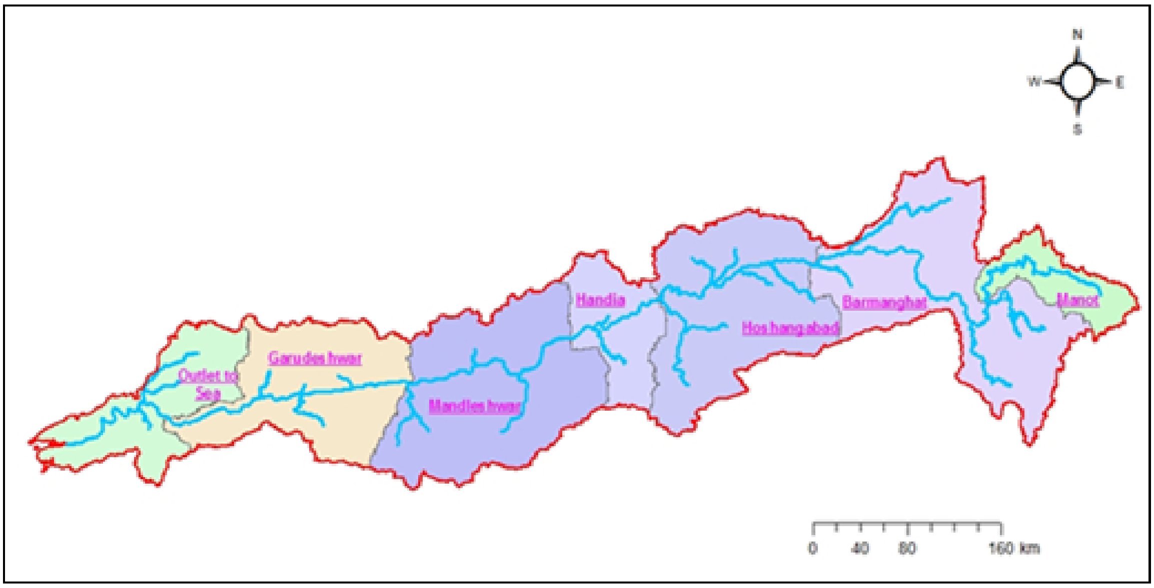


Figure 15.8 Sub-basins of Narmada basin

Table - 15.1 Sub-basin wise details of Narmada basin

S. No.	Sub-basin	River	Individual drainage area (sq.km)
1	Manot	Narmada	4840.987
2	Barmanghat	Narmada	21182.39
3	Hoshangabad	Narmada	18614.983
4	Handia	Narmada	6861.866
5	Mandleshwar	Narmada	20428.948
6	Garudeshwar	Narmada	14786.454
7	Outlet to Sea	Narmada	9944.162
		Total basin area	96659.79

15.2.4 River discharge

The river discharge data is available at all the six sites (Manot, Barmanghat, Handia, Hoshangabad, Mandleshwar and Garudeshwar) for the study period of 30 years.

15.2.5 Reservoir flux

Figure 15.9 shows the location of some of the major reservoirs in Narmada basin. The data of six major reservoirs namely Bargi, Tawa, Barna, Indira Sagar, Sardar Sarovar and Karjan have been considered for estimating reservoirs fluxes for each water year for 30 year period. These reservoir fluxes have been used for calibration and validation purpose of computed runoff.

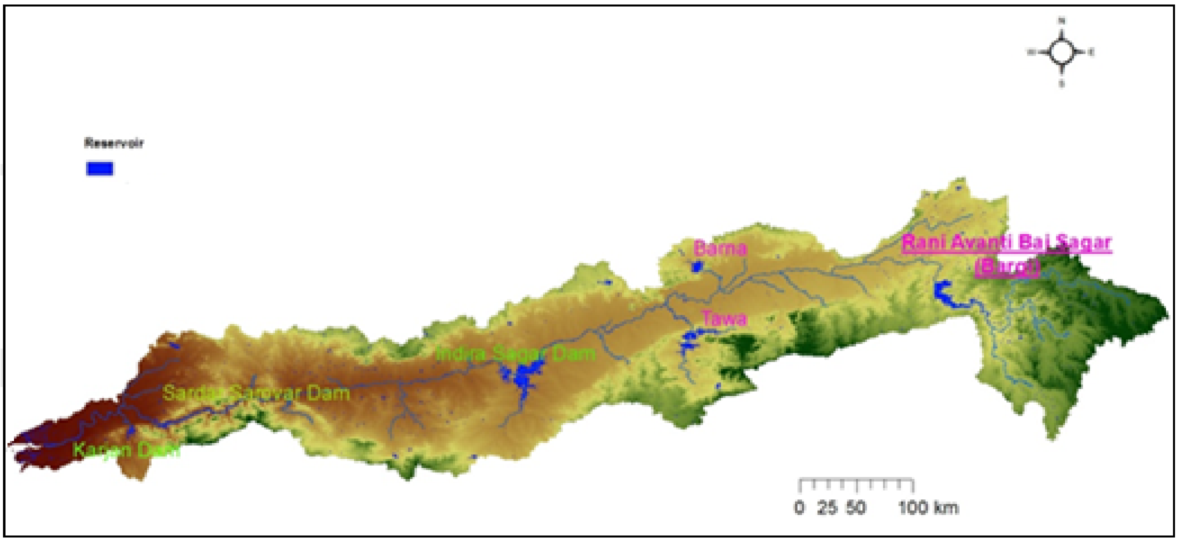


Figure 15.9 Major reservoirs in Narmada basin

15.2.6 Groundwater flux

The spatial annual groundwater flux for the year 2004-05 is shown in Figure 15.10 and annual variations of the flux is shown in Figure 15.11.

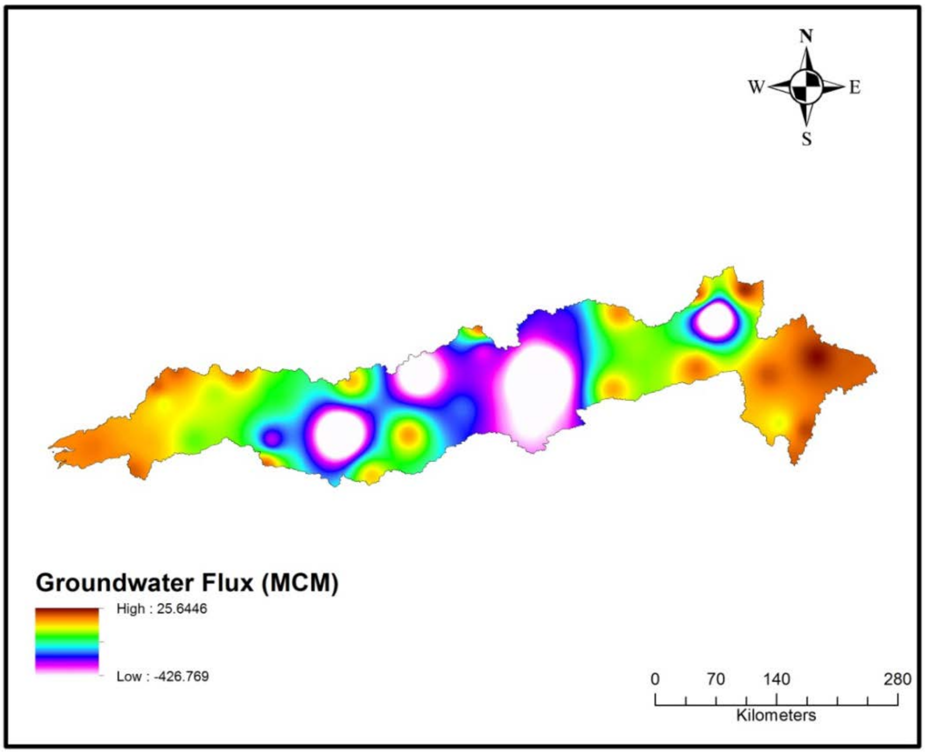


Figure 15.10 Groundwater flux (spatial data) estimated during 2004-05

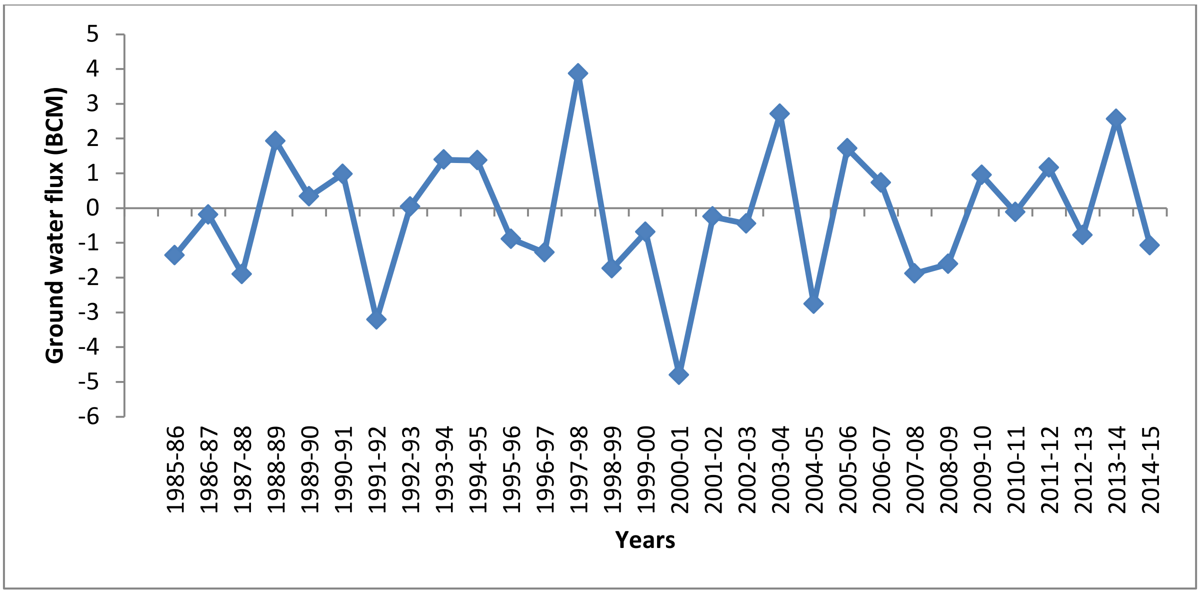


Figure 15.11 Annual groundwater flux of Narmada basin (1985-86 to 2014-15)

15.2.7 Major crops in the basin

Based on the district-wise crop area statistics, district wise major crops for each crop season are identified. The basin was divided in seven regions based on the historic district-wise crop statistics collected from various sources (http://lus.dacnet.nic.in/ dt_lus.aspx). Each region specifies a unique crop for each crop season both spatially and temporally within the basin. Hence, the coefficients have been taken as per the crop in that particular region/district.

On examining the cropping pattern within the basin, crop growing seasons are decided as Kharif only crop during 4 months (June to September), Rabi only crop during 5 months (October to February) and Double/Triple crop during 8 months (July to October. Considering all the above factors land use coefficients are taken based on the FAO 56, other sources and earlier studies carried out in the basin.

15.2.8 Irrigation command area

Figure 15.12 shows location of irrigation command boundaries inside the basin considered for the year 2014-15. The command area considered during the year 1985-86 has been estimated as 3,63,200 hectare, while it is 23,22,000 hectare in 2014-15. Basin outside command has been taken uniformly for all years while working out ECII from these areas.

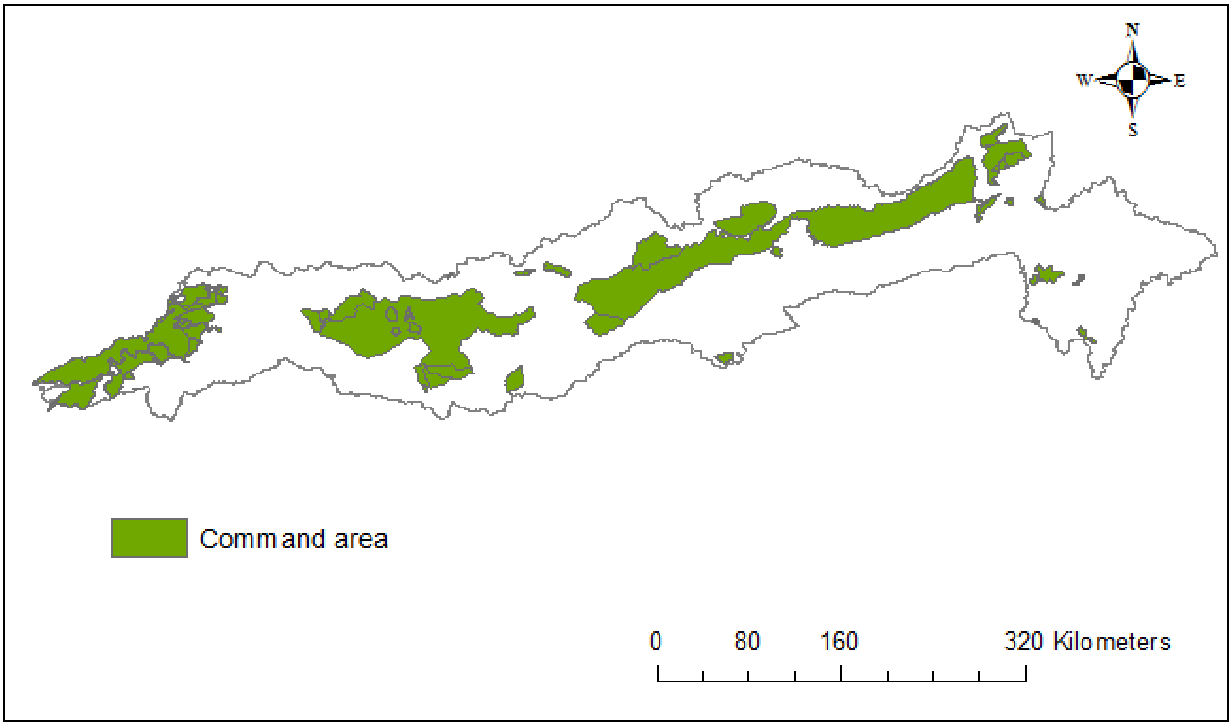


Figure 15.12 Irrigation command boundaries of Narmada basin

15.2.9 Domestic, industrial and livestock demand

Figure 15.13 shows district boundaries layer in Narmada basin for year 2011 census. The mean annual domestic, industrial and livestock demands are estimated at 0.25 BCM in the basin.

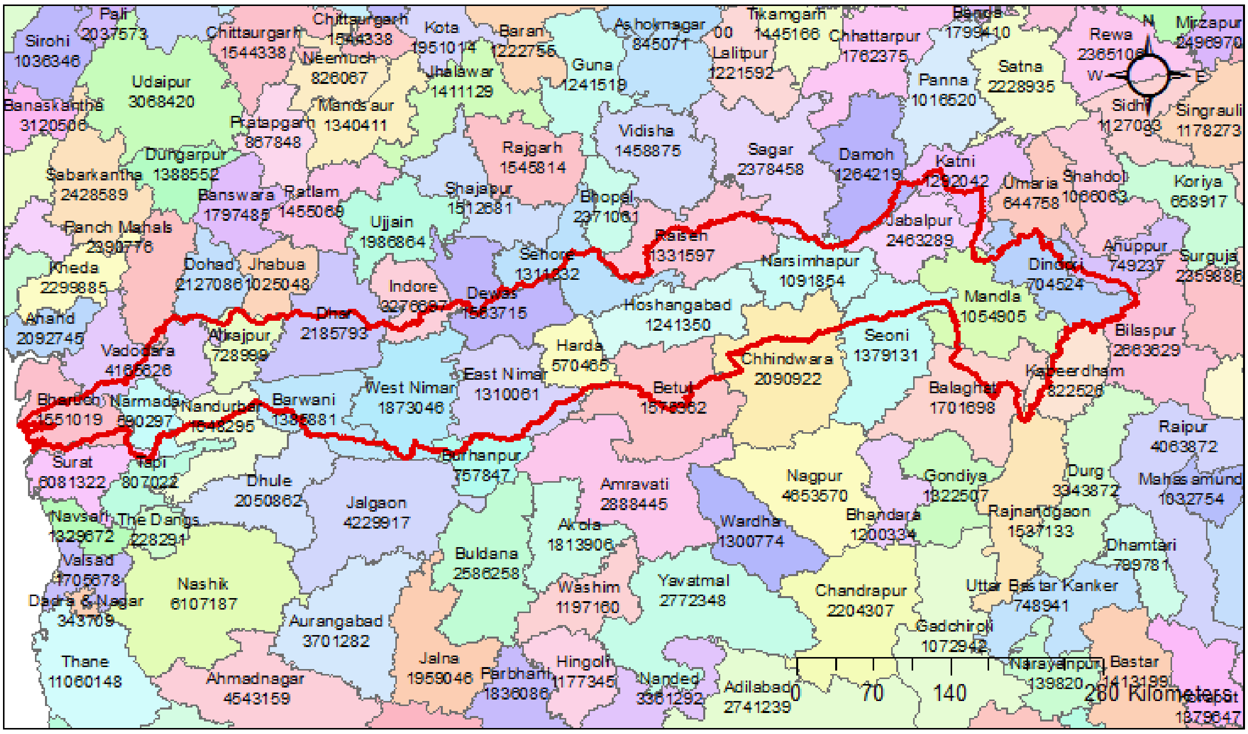


Figure 15.13 District boundaries in Narmada basin

15.2.10 Evaporation from major/medium/minor reservoirs and other water bodies

Table 15.2 provides annual evaporation values from each of sub-basins for the period of 1985-86 to 2014-15 (30 years). The average annual evaporation volume for total basin is worked out as 0.49 BCM.

15.3 Previous Estimates

During 1993 study, no separate assessment was made for estimating water resources of the Narmada basin. The potential of Narmada basin was worked out on the basis of catchment area proportion from the potential assessed at Garudeswar (Catchment Area = 89,345 sq.km) as given in the report of Narmada Water Disputes Tribunal with its decision (1979).

Table - 15.2 Evaporation in reservoirs of Narmada basin

Year	Reservoir Evaporation in each independent sub-basin (in BCM)						
	Manot	Barmanghat	Handia	Hoshangabad	Mandleshwar	Garudeshwar	Outlet to Sea
1985-86	0.00	0.00	0.00	0.13	0.00	0.00	0.00
1986-87	0.00	0.00	0.00	0.14	0.00	0.00	0.00
1987-88	0.00	0.00	0.00	0.13	0.00	0.00	0.00
1988-89	0.00	0.00	0.00	0.13	0.00	0.00	0.00
1989-90	0.00	0.20	0.00	0.13	0.00	0.00	0.00
1990-91	0.00	0.23	0.00	0.14	0.00	0.00	0.00
1991-92	0.00	0.15	0.00	0.09	0.00	0.00	0.00
1992-93	0.00	0.19	0.00	0.11	0.00	0.00	0.00
1993-94	0.00	0.22	0.00	0.13	0.00	0.00	0.00
1994-95	0.00	0.24	0.00	0.15	0.00	0.00	0.00
1995-96	0.00	0.21	0.00	0.12	0.00	0.00	0.00
1996-97	0.00	0.22	0.00	0.10	0.00	0.00	0.00
1997-98	0.00	0.25	0.00	0.14	0.00	0.00	0.00
1998-99	0.00	0.22	0.00	0.13	0.00	0.00	0.00
1999-00	0.00	0.19	0.00	0.14	0.00	0.00	0.00
2000-01	0.00	0.18	0.00	0.10	0.00	0.00	0.00
2001-02	0.00	0.21	0.00	0.12	0.00	0.00	0.00
2002-03	0.00	0.18	0.00	0.15	0.00	0.00	0.02
2003-04	0.00	0.22	0.00	0.16	0.00	0.00	0.02
2004-05	0.00	0.29	0.00	0.16	0.22	0.00	0.02
2005-06	0.00	0.23	0.00	0.17	0.32	0.07	0.03
2006-07	0.00	0.15	0.00	0.14	0.36	0.07	0.02
2007-08	0.00	0.09	0.00	0.16	0.39	0.07	0.02
2008-09	0.00	0.22	0.00	0.17	0.43	0.06	0.02
2009-10	0.00	0.21	0.00	0.19	0.48	0.06	0.01
2010-11	0.00	0.20	0.00	0.15	0.39	0.07	0.02
2011-12	0.00	0.23	0.00	0.17	0.46	0.06	0.02
2012-13	0.00	0.24	0.00	0.15	0.41	0.06	0.02
2013-14	0.00	0.27	0.00	0.18	0.55	0.09	0.02
2014-15	0.00	0.12	0.00	0.10	0.12	0.00	0.00
Avg	0.00	0.18	0.00	0.14	0.14	0.02	0.01
Average for basin: 0.49 BCM							

15.4 Runoff Estimation

Manot, Barmanghat, Handia, Hoshangabad, Mandleshwar and Garudeshwar discharge sites are located on river Narmada and the model estimated runoff is calibrated against the observed discharge at all the six locations. Computed runoff of Outlet to Sea sub-basin is added with the calibrated runoff for the six sub-basins. Tables O.1 to O.6 at Annexure - O give calibrated runoff along with observed discharge, rainfall, ECII, etc during 30 years for the six G&D sites. Table - O.7 (at Annexure O) give calibrated discharge, rainfall, ECII, etc during 30 years for the Outlet to Sea sub-basin. The Figures 15.14 to 15.19 show comparative graphs of calibrated runoff and observed discharge at all these six discharge stations, whereas Figure 15.20 shows calibrated runoff graph only for Outlet to Sea sub-basin. From the graphs, it could be observed that the comparison of model estimated runoff with observed runoff (Manot, Barmanghat, Handia, Hoshangabad, Mandleshwar and Garudeshwar) is matching very well for the 30 year period at almost all the sites. Table O.8 at Annexure - O gives calibrated runoff of Narmada basin for 30 years. The mean annual calibrated runoff is about 41.39 BCM. The maximum annual calibrated runoff is 91.36 BCM during 1994-95. The minimum annual calibrated runoff is 15.93 BCM during 1987-88. The mean annual ECII is about 14.28 BCM. The maximum annual ECII is about 20.51 BCM during 2000-01. The minimum annual ECII is about 9.52 BCM during 2013-14.

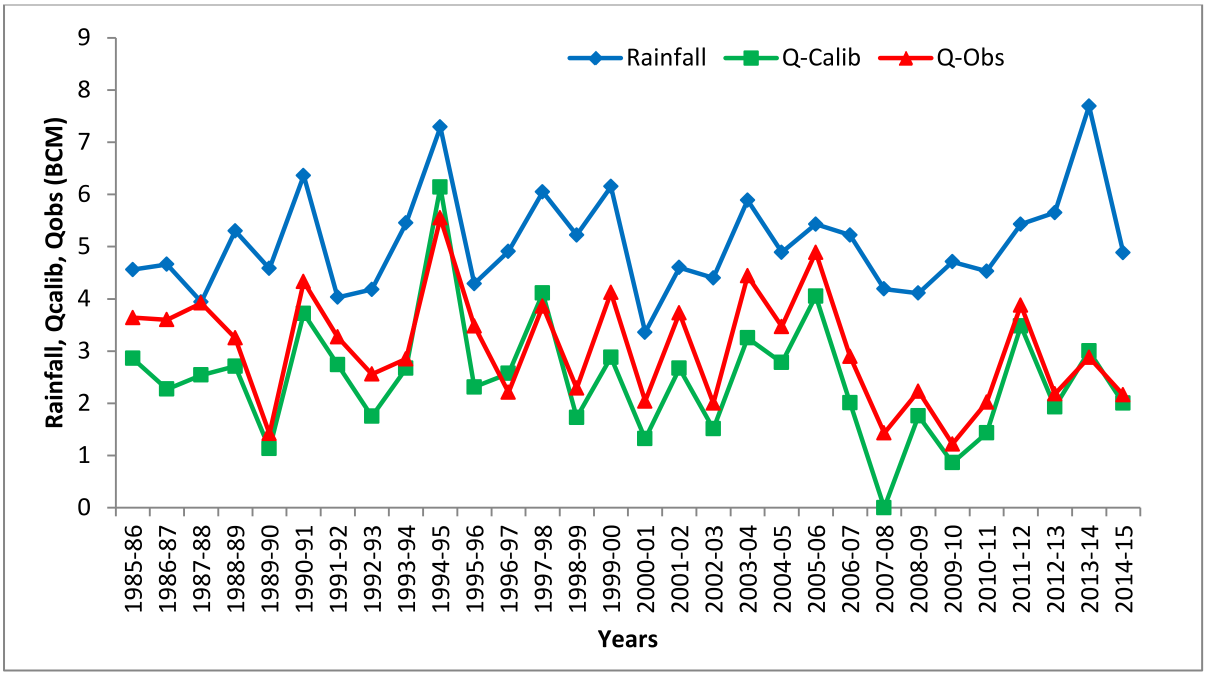


Figure 15.14 Calibrated runoff and observed discharge at Manot

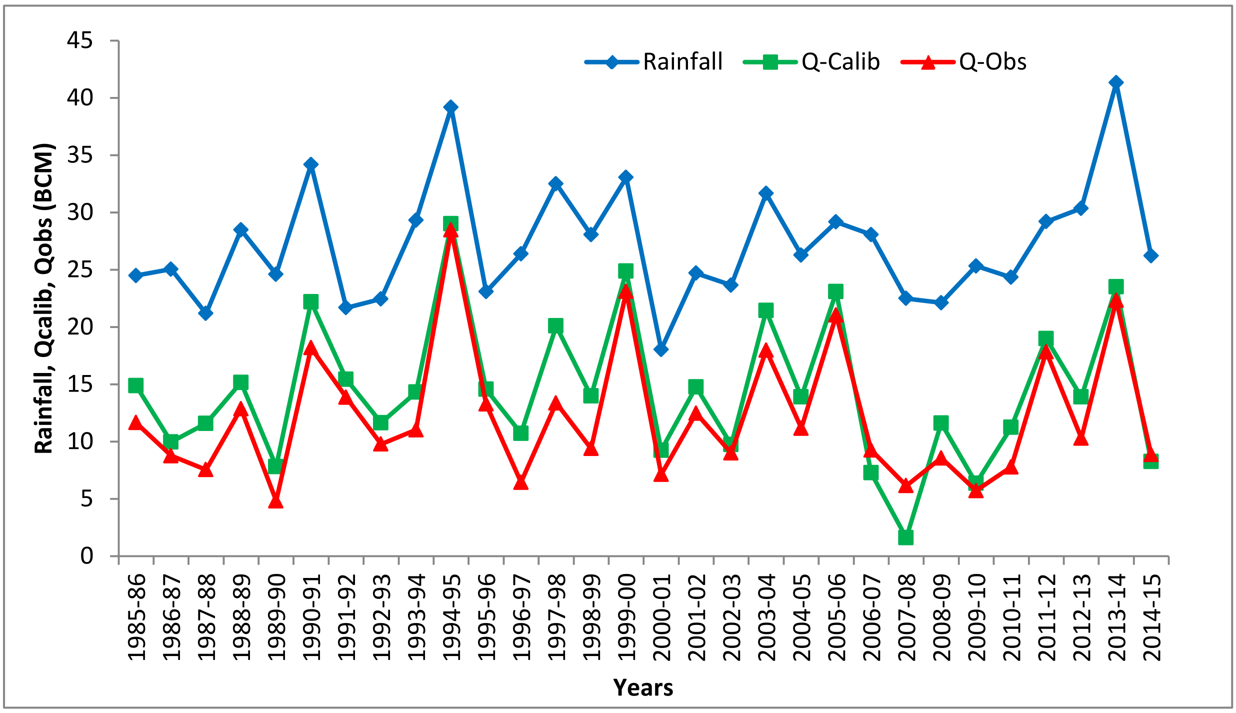


Figure 15.15 Calibrated runoff and observed discharge at Barmanghat

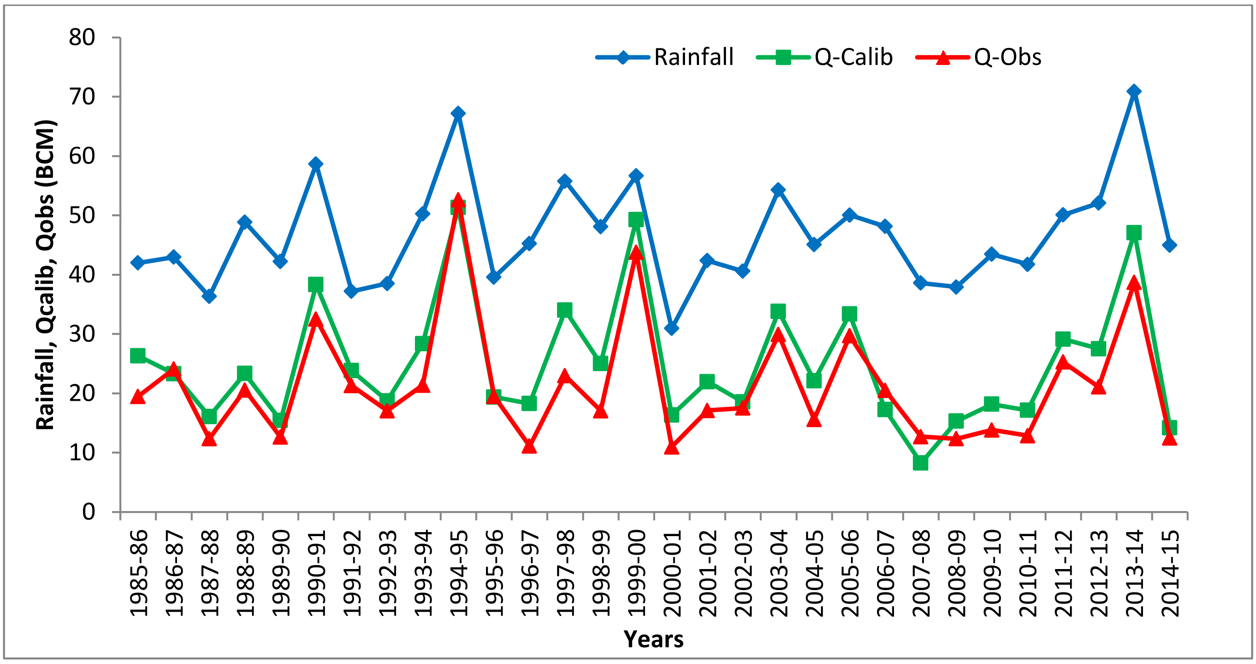


Figure 15.16 Calibrated runoff and observed discharge at Hoshangabad

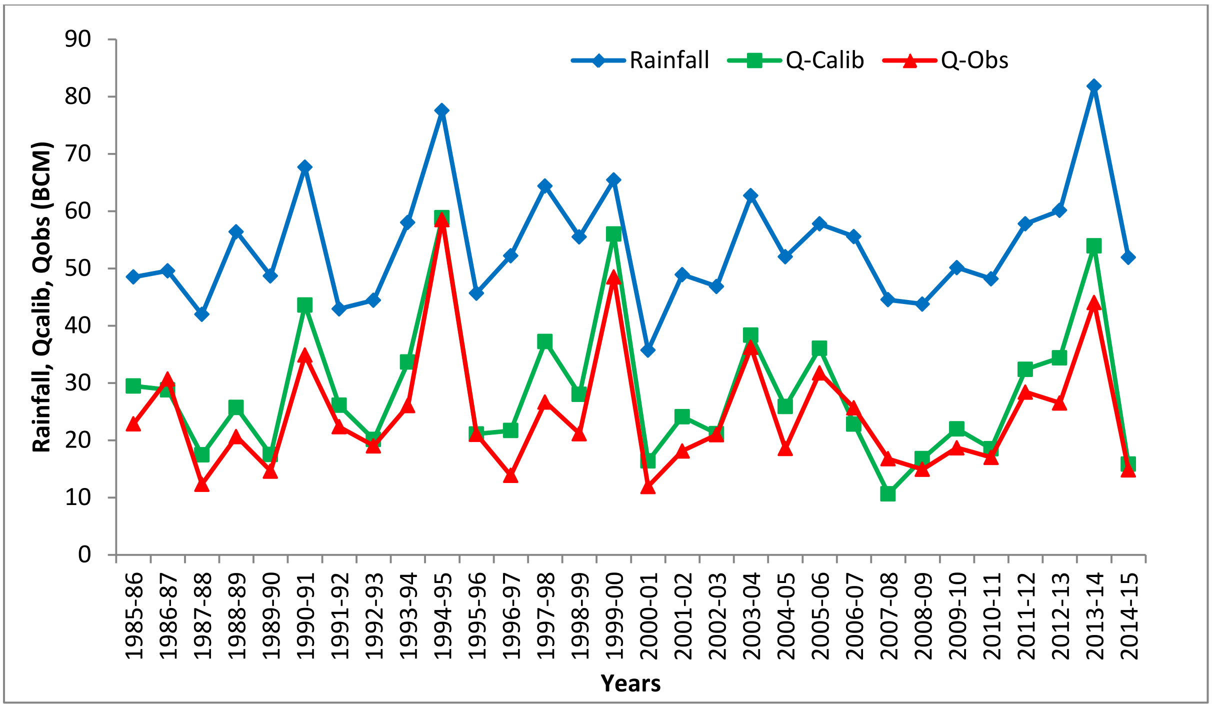


Figure 15.17 Calibrated runoff and observed discharge at Handia

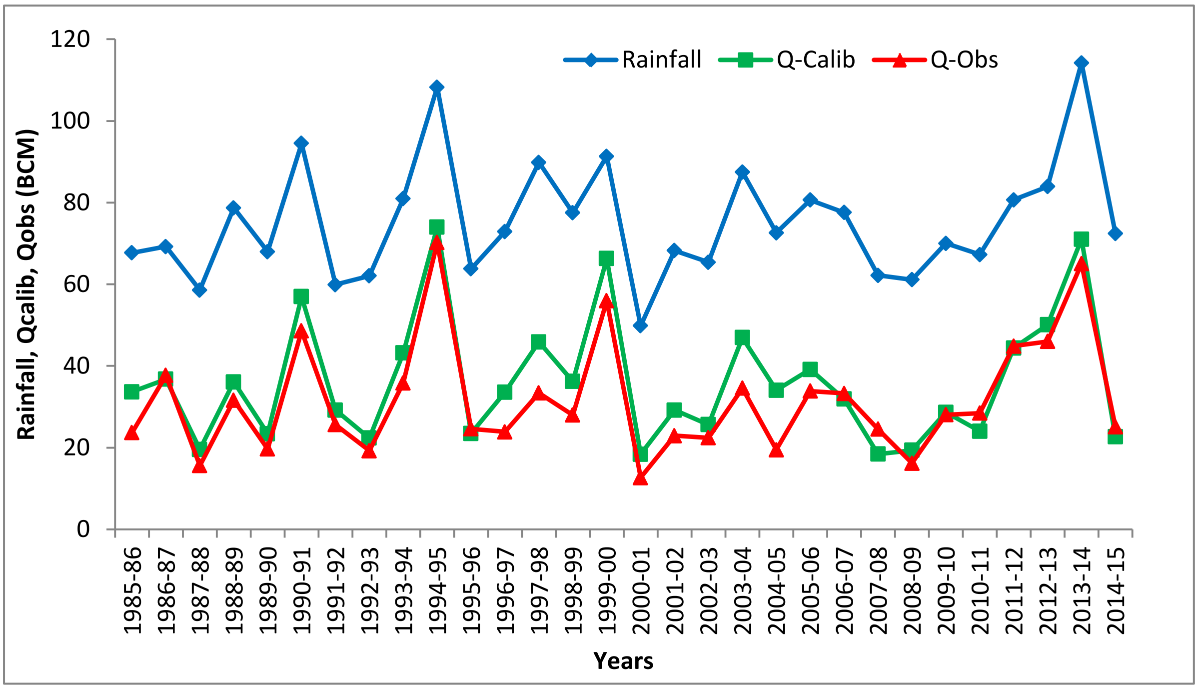


Figure 15.18 Calibrated runoff and observed discharge at Mandleshwar

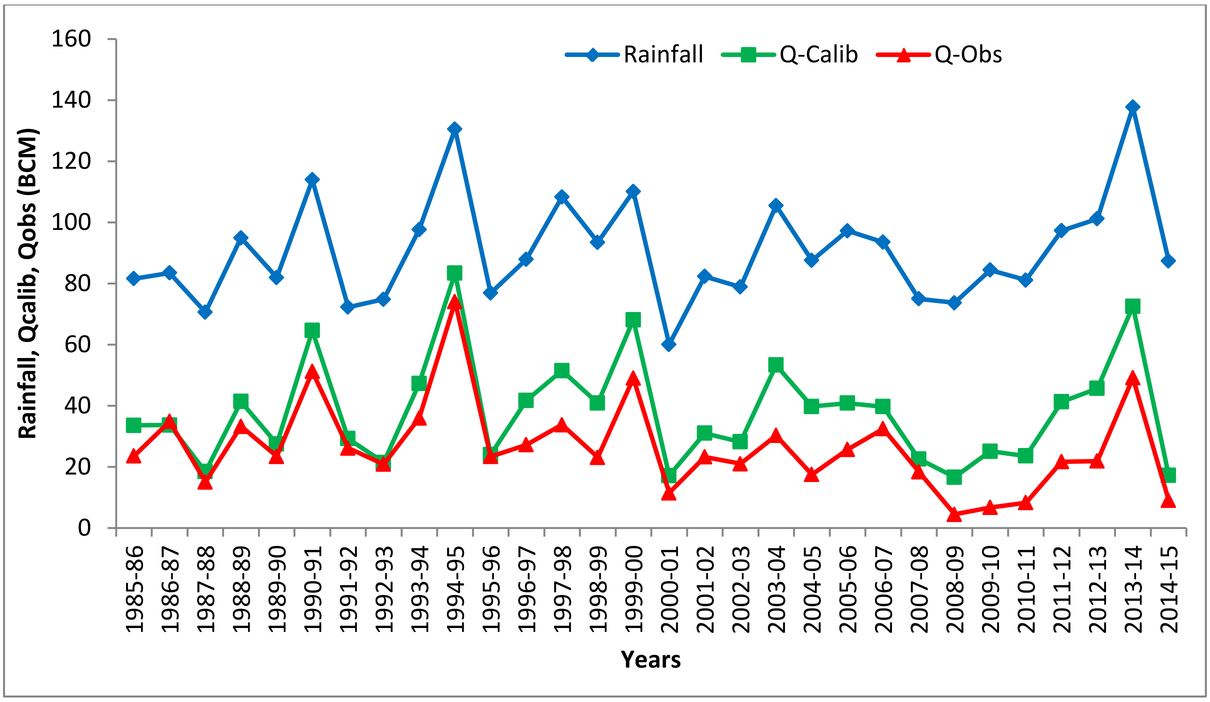


Figure 15.19 Calibrated runoff and observed discharge at Garudeshwar

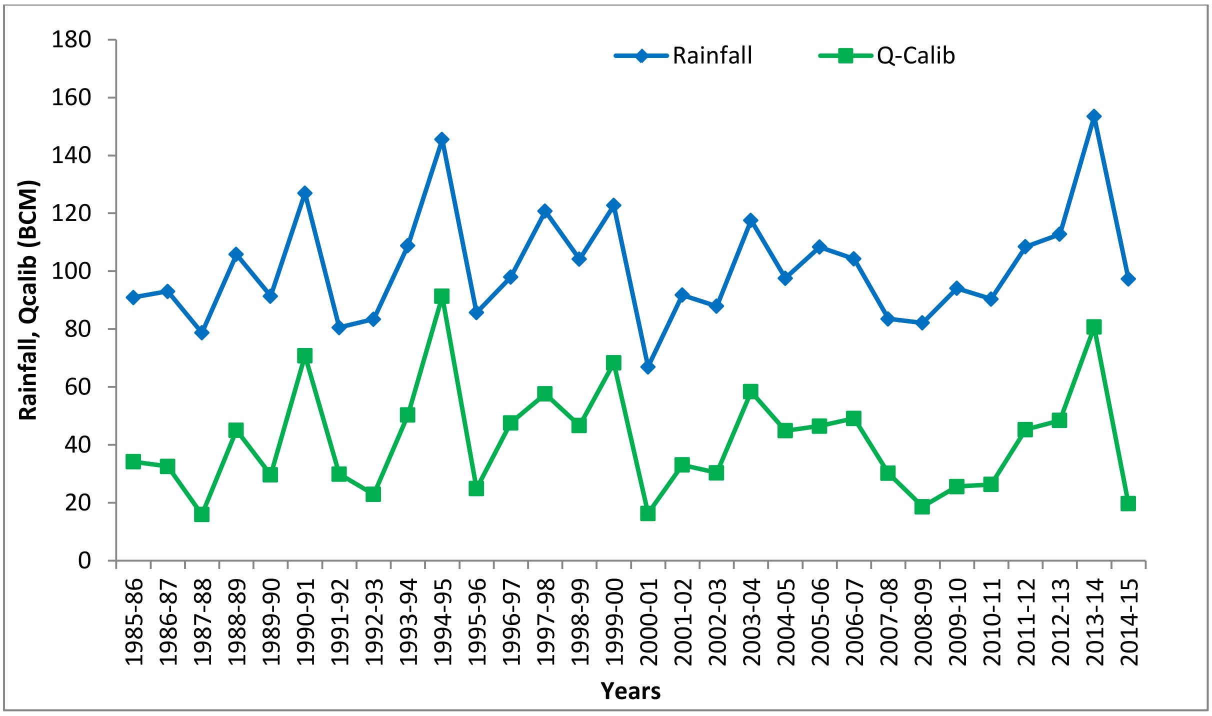


Figure 15.20 Calibrated runoff and rainfall at outlet to Sea

15.5 Annual Water Resources Availability of Narmada Basin

Table - O.8 (at Annexure - O) shows the different components required to estimate the basin level water resources of Narmada for 30 years. The maximum annual water resource is 105.75 BCM during 1994-95 in the 30 years. The minimum annual water resource is 31.46 BCM during 1987-88.

The mean available annual water resource of the Narmada basin is 58.21 BCM and 75% dependable flow of Narmada basin is 45.24 BCM. The mean available water resources of Narmada basin accounts for about 53.89% of mean annual rainfall during 1985-86 to 2014-15.

15.5.1 Annual water resources of Narmada basin during extreme rainfall conditions

Out of the total 30 years of meteorological database of study period, during the years 2013-14 and 2000-01, extreme wet and dry rainfall conditions occurred in Narmada river basin. The annual water resources of Narmada basin during these two extreme rainfall conditions are 103.76 BCM and 32.48 BCM, respectively as shown in Table 15.3. The water balance components during these years are presented in the Figures 15.21 and 15.22.

Table - 15.3 Water resources availability in Narmada basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	2013-14	163.69	103.76
Minimum Rainfall	2000-01	71.30	32.48

Water resources availability-rainfall ratio during the extreme maximum and minimum rainfall years is found to be 0.63 and 0.45 respectively. It is found that the ECII during 2013-14 is less than the year 2000-01.

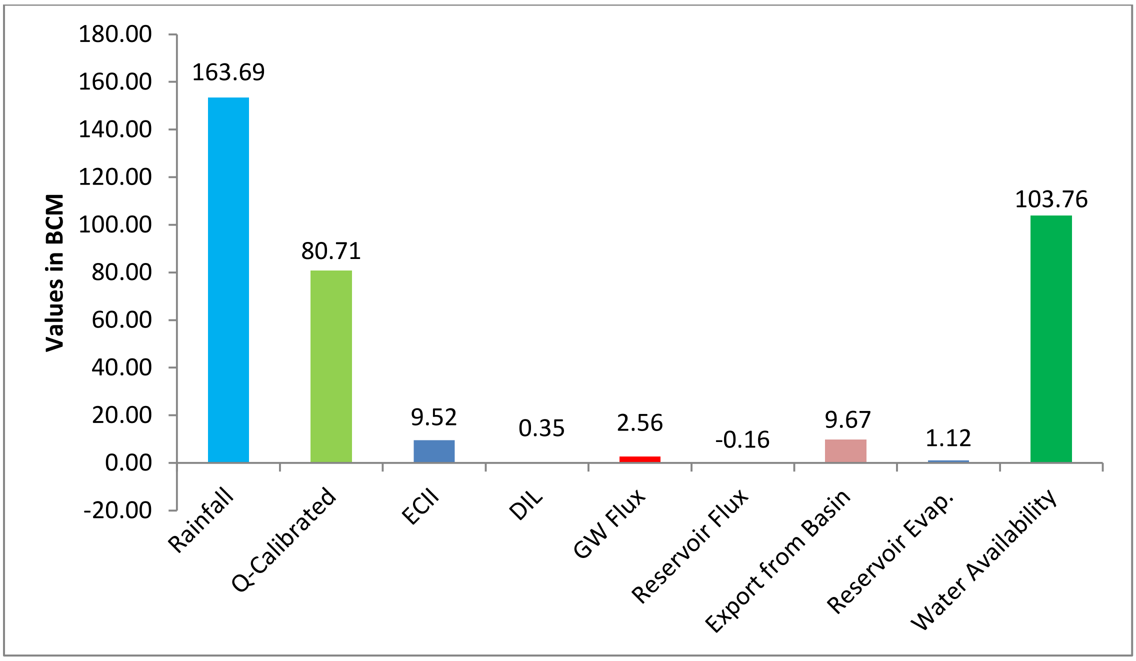


Figure 15.21 Water balance components of Narmada basin during extreme high rainfall (2013-14)

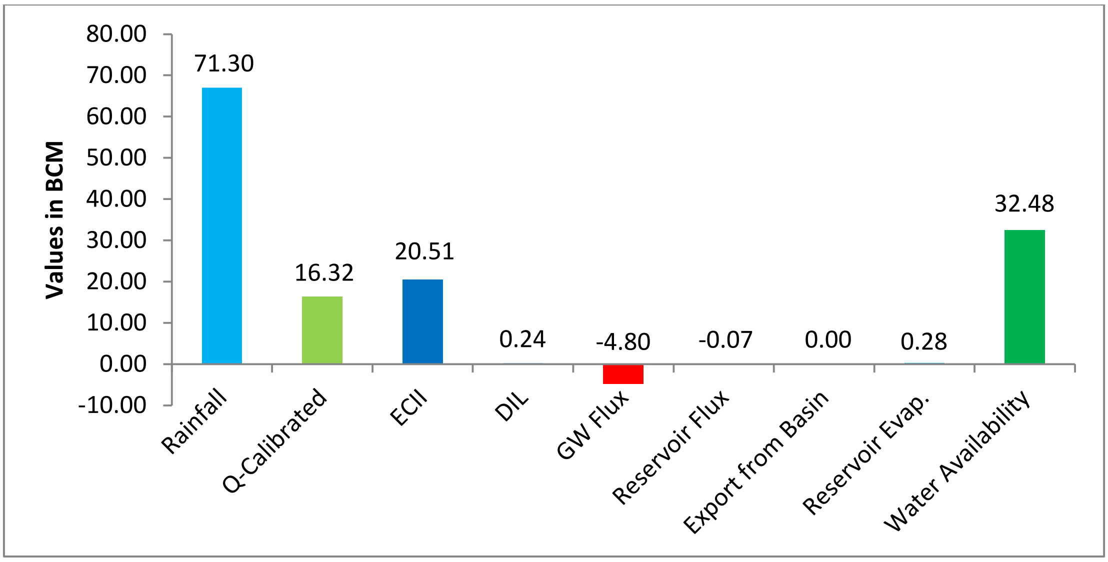


Figure 15.22 Water balance components of Narmada basin during extreme low rainfall (2000-01)

15.5.2 Mean water resources of Narmada basin

The mean water resources of the basin is computed by taking the mean of the 30 years water balance components such as flow in the river at final outlet, upstream effective utilisations for irrigation, domestic and industrial, change in storage of groundwater, change in storage of reservoirs and evaporation from reservoirs.

Mean water resources = Mean of (Calibrated Runoff + Estimated Consumptive Irrigation Input + Domestic, Industrial and Livestock consumption + Groundwater Flux + Reservoir Flux + Export from basin + Evaporation from the Reservoirs)

= 41.39 + 14.28 + 0.25 + (-0.18) + 0.12 + 1.86 + 0.49 = 58.21 BCM

Mean available annual water resource of Narmada basin is 58.21 BCM and 75% dependable flow 45.24 BCM. Figure 15.23 shows the various water balance components averaged over a period of 30 years during 1985-86 to 2014-15.

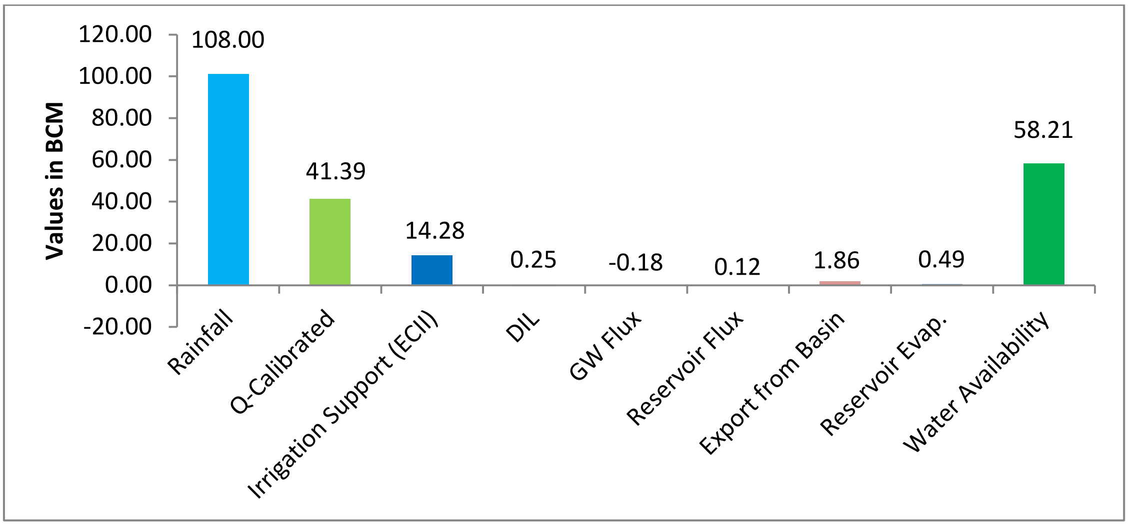


Figure 15.23 Mean water balance components of Narmada basin

15.6 Basin Outward Diversions/Imports

In Narmada basin, diversion occurs from Sardar Sarovar dam to Mahi basin. Table 15.4 gives the details of water diverted out of basin.

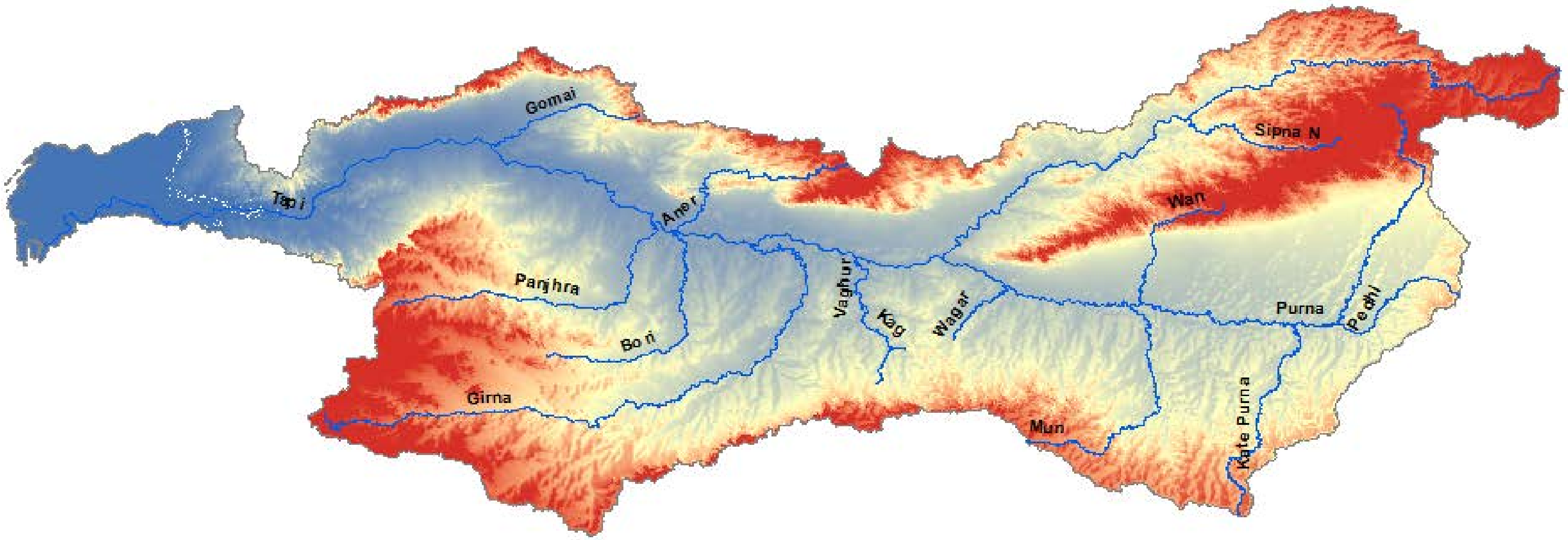
Table - 15.4 Details of diversions considered for the study

Name of Projects	Quantity of Diverted Water (BCM)	Remarks
Sardar Sarovar Dam	1.86 (Avg. annual outflow from basin for 30 years)	The diversions take place to Mahi basin.

HIGHLIGHTS

- *Mean annual available water resources of Narmada basin is 58.21 BCM.*
- *Maximum annual water availability is 105.75 BCM during 1994-95.*
- *Minimum annual water availability is 31.46 BCM during 1987-88.*
- *Annual rainfall in the basin varies from 693 mm to 1,588 mm during 1985-86 to 2014-15 and mean rainfall for these 30 years is 1,045 mm.*
- *Narmada basin is divided into seven sub-basins for the reassessment study viz. Manot, Barmanghat, Handia, Hoshangabad, Mandleshwar, Garudeshwar and Outlet to sea.*
- *Average annual domestic, industrial and livestock demand in the basin is 0.25 BCM.*
- *Average annual evaporation from water bodiesin the basin is 0.48 BCM.*

TAPI BASIN


Gomai
Tapi
Aner
Panjhra
Bori
Girna
Vaghur
Kag
Wagar
Sipna N
Wan
Purna
Pedhi
Mun
Kate Purna

16.1 Geo-Spatial Datasets

16.1.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map of Tapi basin for year 2004-05 is shown in Figure 16.1. Agriculture land is the predominant land use in Tapi basin accounting for more than 50% (including current fallow) of the basin area. This extent varies slightly from year to year. Next dominant class in the study area is wasteland and deciduous forest land. The LULC analysis of 2004-05 indicates that Kharif only (34%), Double/Triple crop (14%) current fallow (9%) and wasteland (11%) are the major classes in Tapi basin as shown in Figure 16.2.

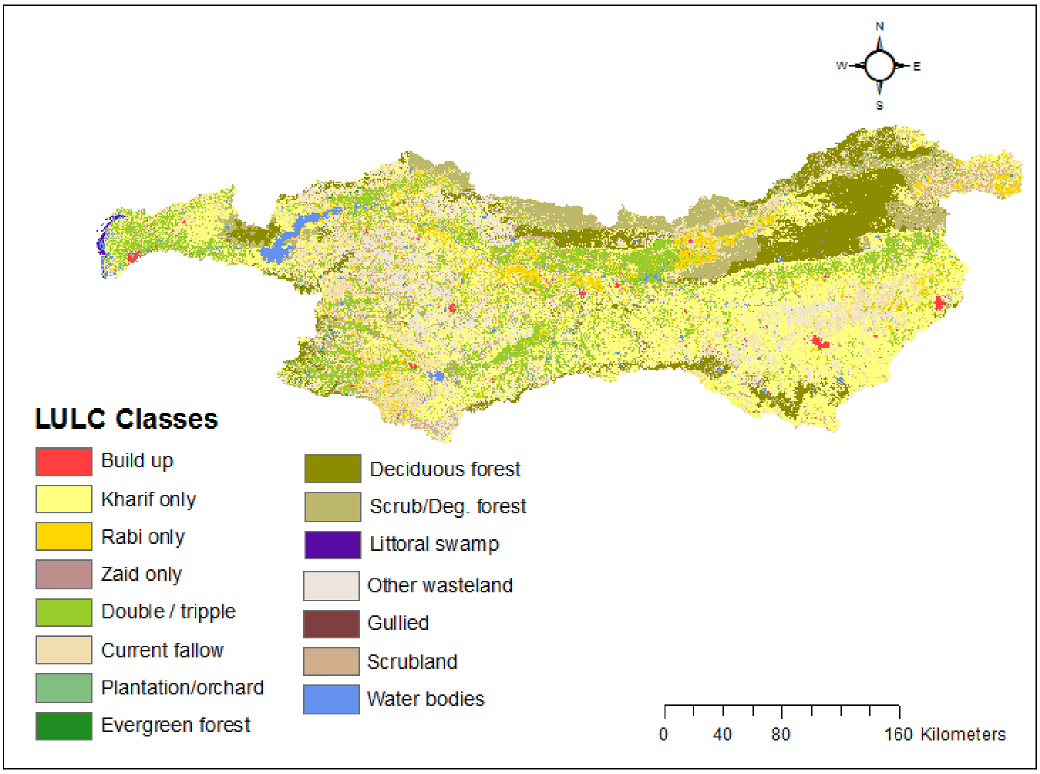


Figure 16.1 LULC Map of Tapi basin (2004-05)

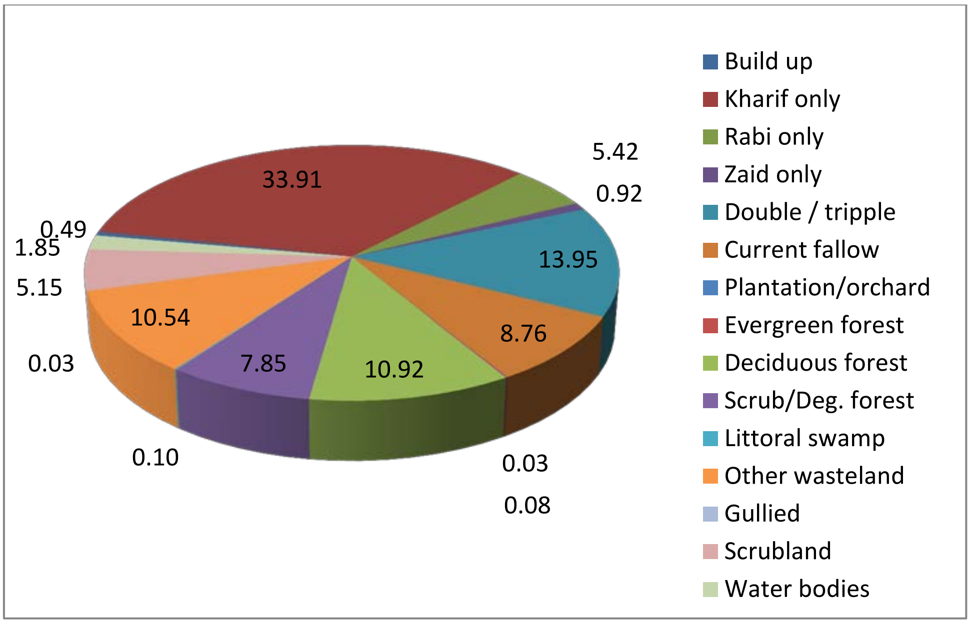


Figure 16.2 Distribution of LULC in Tapi basin (2004-05)

16.1.2 Soil texture

Sandy, clayey and loamy are the main soil textural classes in the study basin. The fertile delta area of the coastal plains is suited for intensive cultivation. Figure 16.3 shows various categories of soil in the basin. The larger part of the basin falls under fine texture category i.e. clayey and loamy that accounts for low infiltration rate and more runoff in the basin.

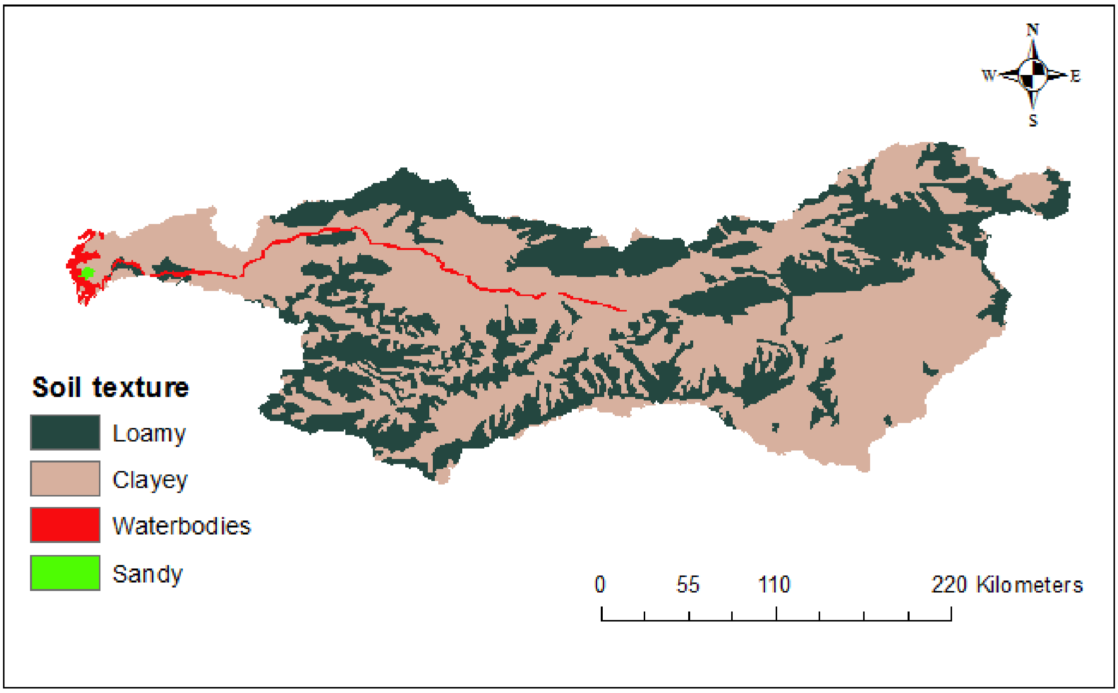


Figure 16.3 Soil texture map of Tapi basin

16.1.3 Topography

The topography of the basin consists of Ghat areas, plateau and the coastal plains. Deccan plateau, Western plateau and hills regions cover the districts of Maharashtra and Madhya Pradesh. Elevation value ranges from a minimum of 0 m to a maximum of 1,338 m. Figure 16.4 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the basin. Larger part of the basin is in plains, while mountaneous part lies in districts of Maharashtra and Madhya Pradesh.

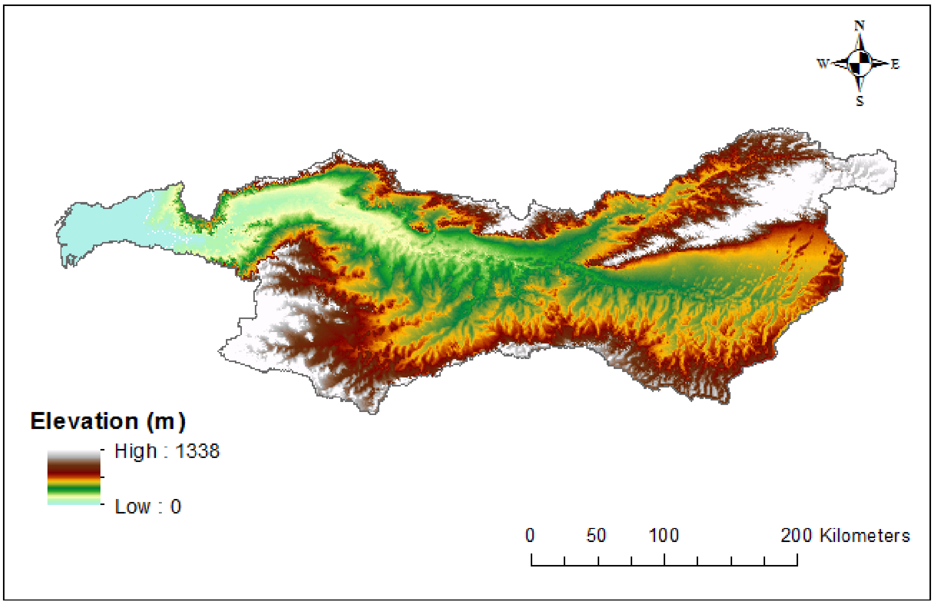


Figure 16.4 SRTM DEM map of Tapi basin

16.2 Hydro-Meteorological and other Input Data

16.2.1 Rainfall grids

Figure 16.5 shows gridded annual rainfall of Tapi Basin for the year 2004-05. The variation in annual rainfall during study period of 30 years (1985-86 to 2014-15) is shown in Figure 16.6. Rainfall varies both spatially and temporally in Tapi basin. Mean rainfall for 30 years of the basin is 839 mm. Annual rainfall of the basin varies from 584.31 mm to 1,327.77 mm over the 30 years period. Major part of the basin receives annual rainfall of 550 mm to 900 mm. Hence, these two years are considered as meteorologically wet and dry years respectively during these 30 years span.

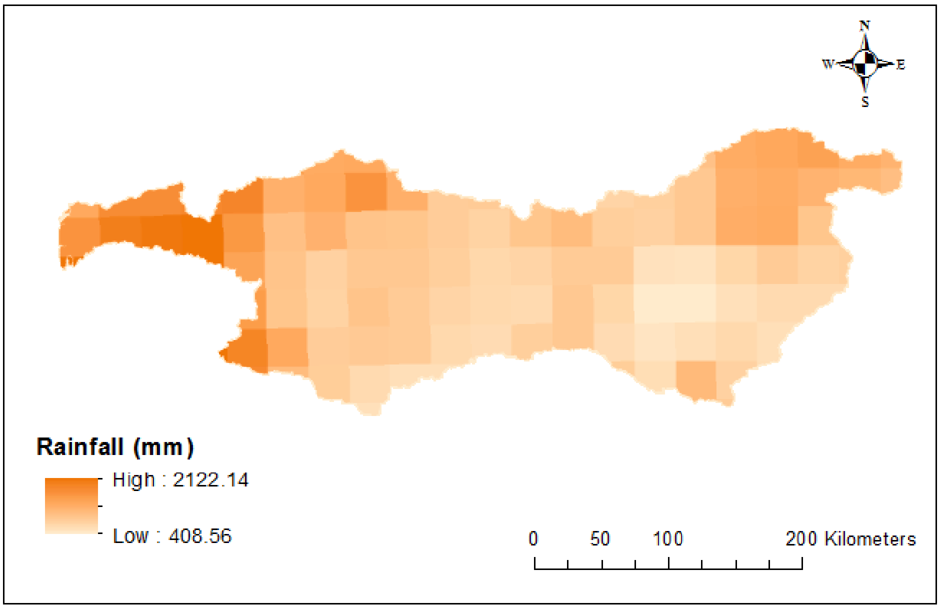


Figure 16.5 Gridded rainfall of Tapi basin (2004-05)

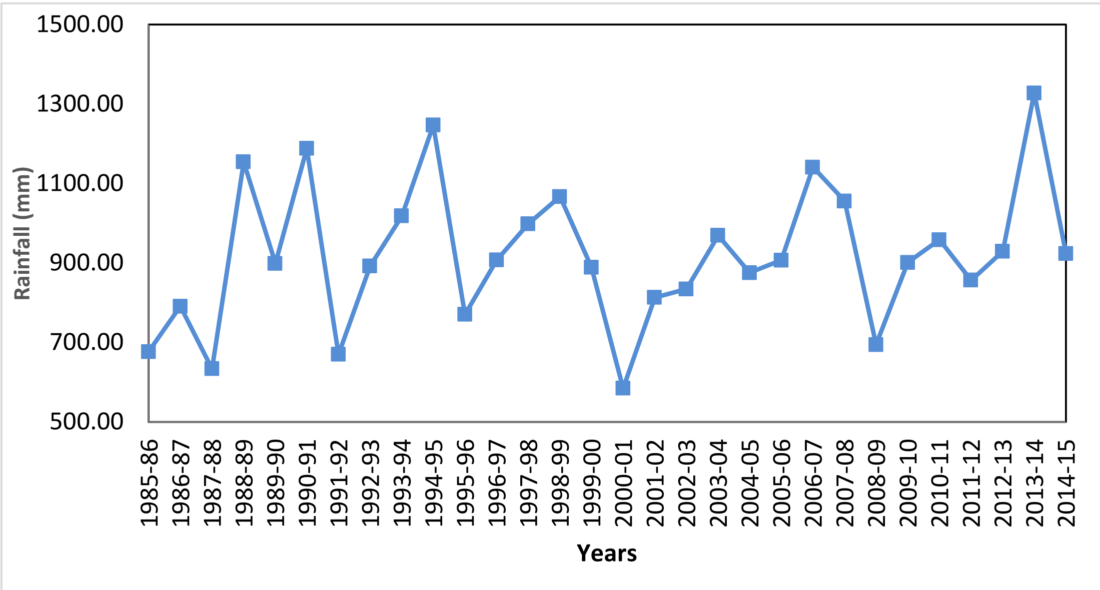


Figure 16.6 Annual rainfall in Tapi basin (1984-85 to 2014-15)

16.2.2 Temperature grids

Gridded mean annual temperature of Tapi basin is shown in Figure 16.7. The mean annual temperature during 2004-05 varied from 25.59^{0}C to 27.49^{0}C.

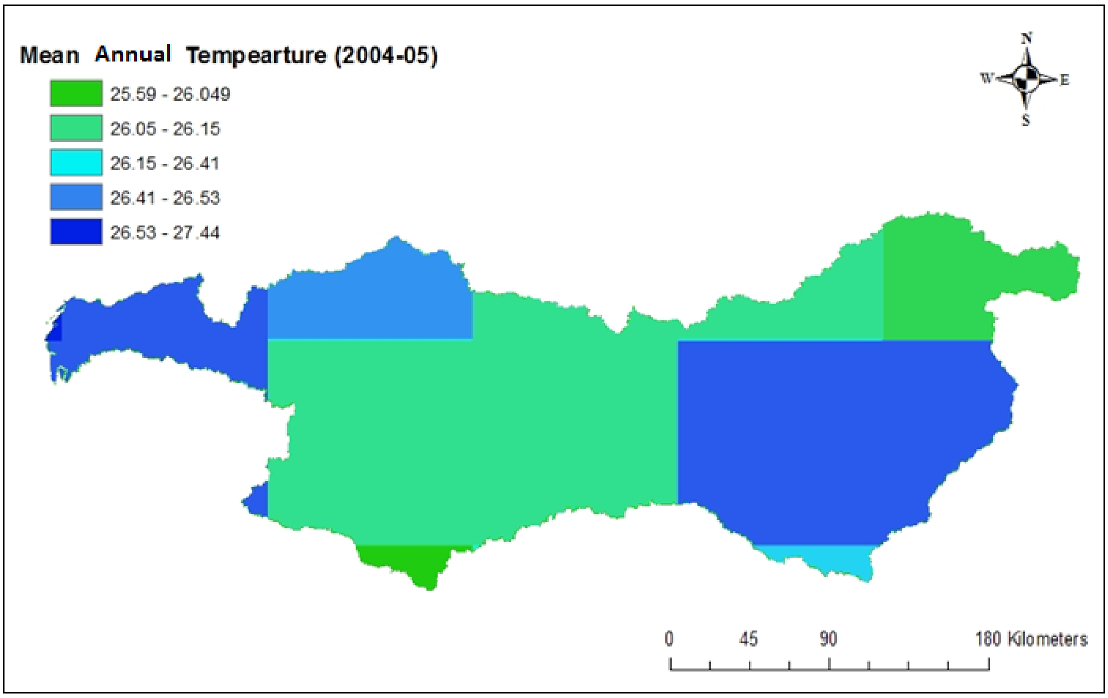


Figure 16.7 Gridded mean annual temperature of Tapi basin (2004-05)

16.2.3 Sub-basins of Tapi basin

Tapi basin is divided into five sub-basins as shown in Figure 16.8 viz. Upper Tapi, Purna, Middle Tapi, Lower Tapi and Delta. The sub-basins are divided in such a way that the locations of CWC discharge stations are taken as sub-basin terminal points. The drainage area of each sub-basin is given at Table - 16.1.

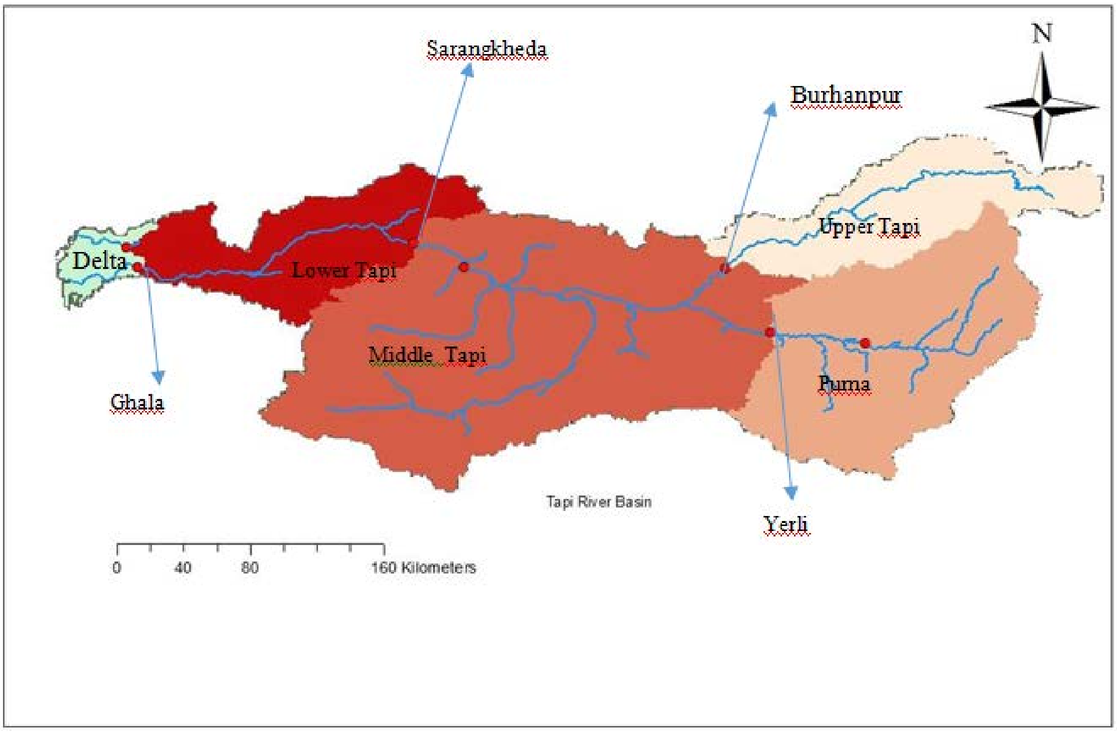


Figure 16.8 Sub-basins of Tapi basin

Table - 16.1 Sub-basin wise details of Tapi basin

S. No.	Sub-basin	River	Discharge site	Individual drainage area (sq.km)
1	Upper Tapi	Tapi	Burhanpur	8,970
2	Purna	Purna	Yerli	15,846
3	Middle Tapi	Tapi	Sarangkheda	30,729
4	Lower Tapi	Tapi	Ghala	8,605
5	Delta	Tapi	--	1,655.75
			Total basin area	65,805.75

16.2.4 River discharge

River discharge data for the study period 30 years is available at all the four sites (Burhanpur, Yerli, Sarangkheda and Ghala) located on main river Tapi.

16.2.5 Reservoir flux

Figure 16.9 shows the location of some of major reservoirs in Tapi basin. The data of three Major reservoirs such as Hathnur, Girna and Ukai have been considered for estimating storage fluxes changes for each water year during 30 year period. The mean annual flux of reservoirs of Tapi river basin from 1984-85 to 2014-15 is estimated 0.04 BCM.

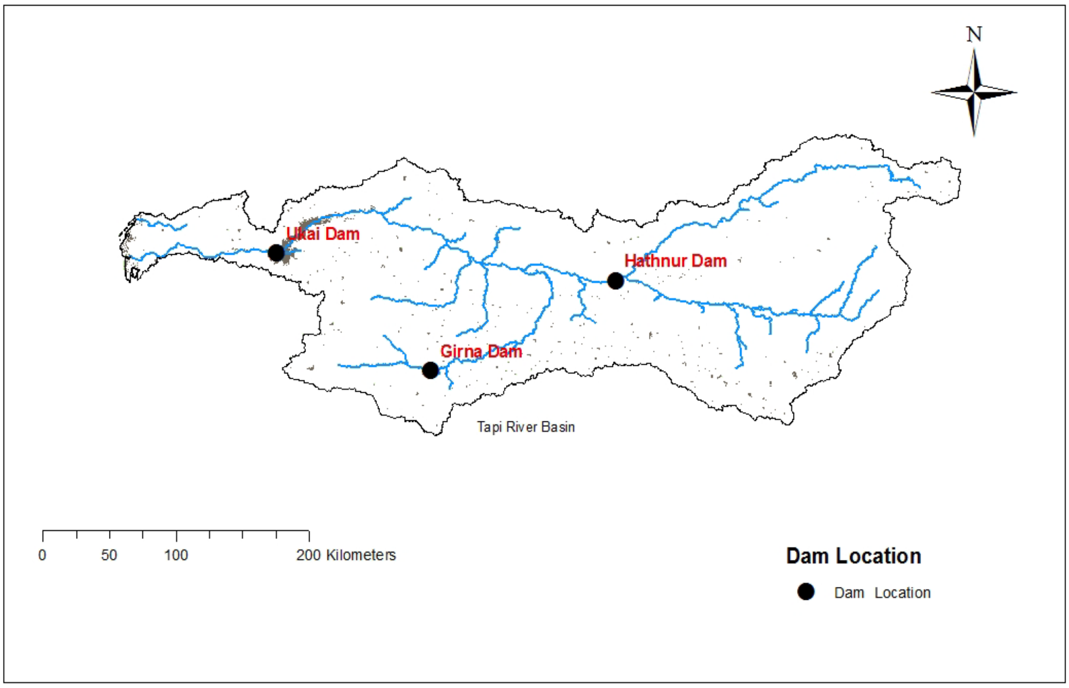


Figure 16.9 Major and medium reservoirs in Tapi basin

16.2.6 Groundwater flux

The spatial annual groundwater flux in the basin varies from -315.07 MCM to 21.22 MCM during year 2004-05 as shown Figure 16.10. The annual variation in groundwater flux during the 30 years (1985-86 to 2014-15) is shown in Figure 16.11. The mean annual groundwater flux from 1984-85 to 2014-15 of Tapi river basin is estimated at -0.08 BCM (drawdown).

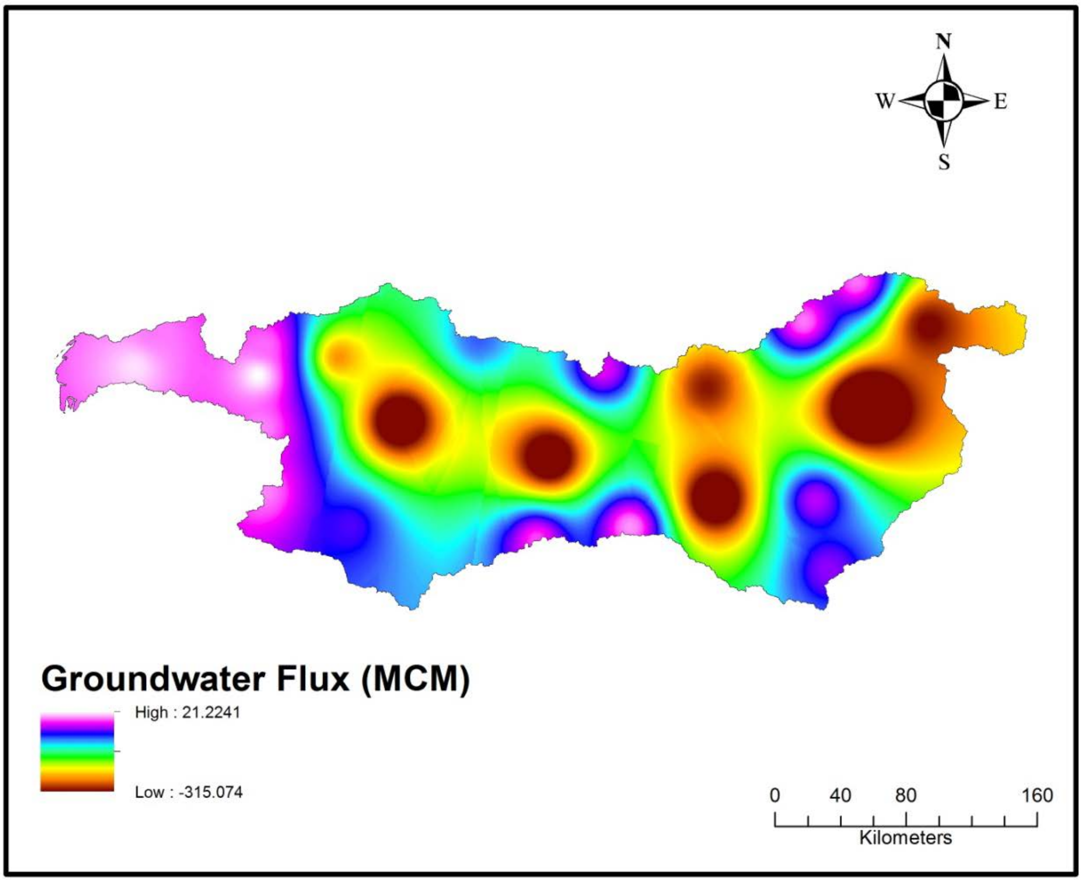


Figure 16.10 Groundwater flux (spatial data) estimated during 2004-05

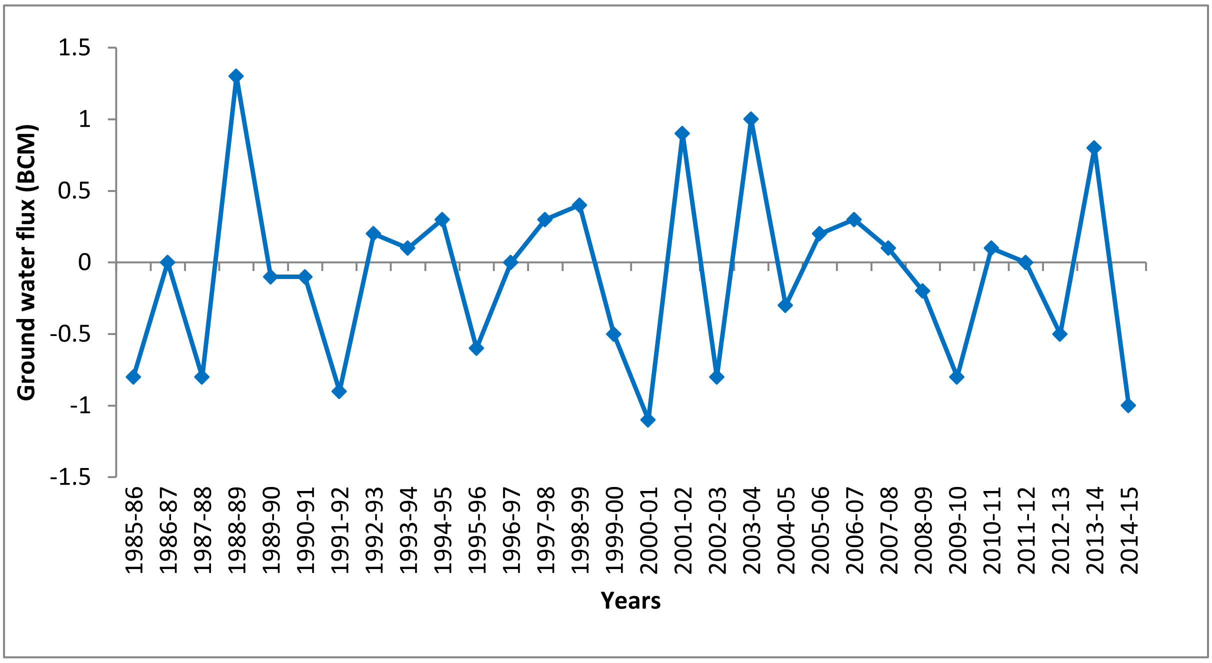


Figure 16.11 Annual groundwater flux of Tapi basin (1985-86 to 2014-15)

16.2.7 Major crops in the basin

Tapi basin was subdivided into five (5) regions based on predominant crops identified in each district. Each region specifies a unique crop for each crop season both spatially and temporally within the basin. For example (spatial variation) in Kharif only season in a district, if rice is a major crop, it may be jowar or bajra in the neighbouring district. Similarly, temporal variation indicates for example during 2004-05, if rice is a major crop in Kharif only season, it may be jowar or bajra during 2005-06.

16.2.8 Irrigation command area

Figure 16.12 shows location of irrigation command boundaries of the Tapi basin considered for the year 2014-15. The command area considered during the year 1985-86 has been estimated as 7,478.70 hectare and it has increased to 12,678.30 hectare in 2014-15. Basin outside command has been taken uniformly for all years while working out ECII from these areas.

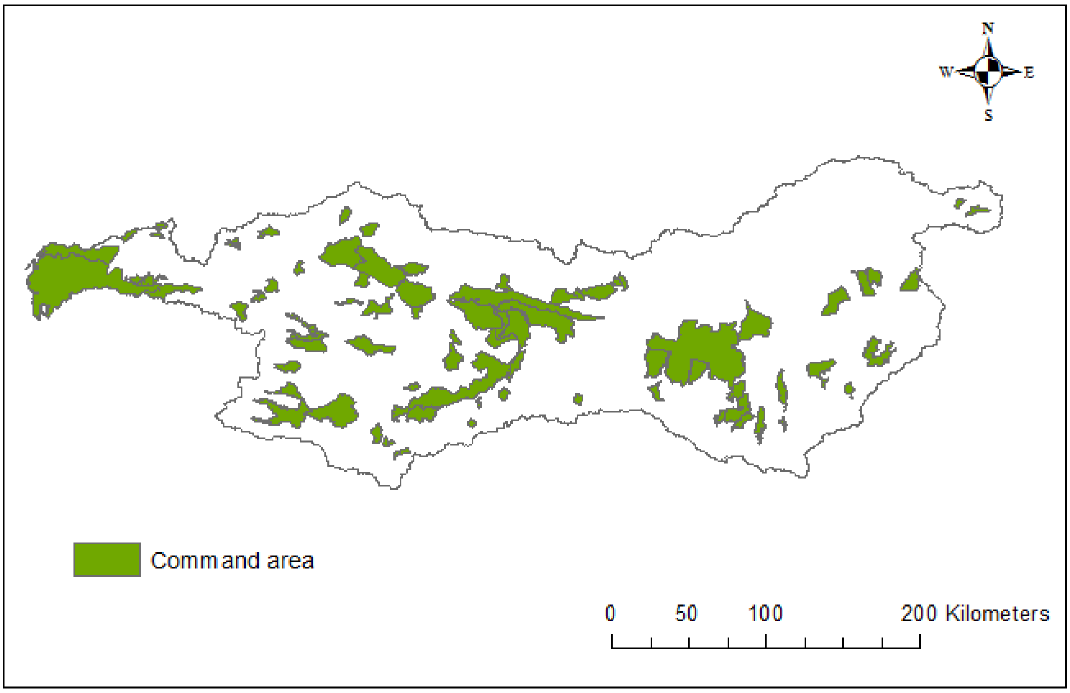


Figure 16.12 Irrigation command boundaries of Tapi basin

16.2.9 Domestic, industrial and livestock demand

Figure 16.13 shows the district boundaries layer with district population for 2011 census. The mean annual domestic, industrial and livestock consumption flux is estimated as 0.24 BCM during the period 1985-86 to 2014-15.

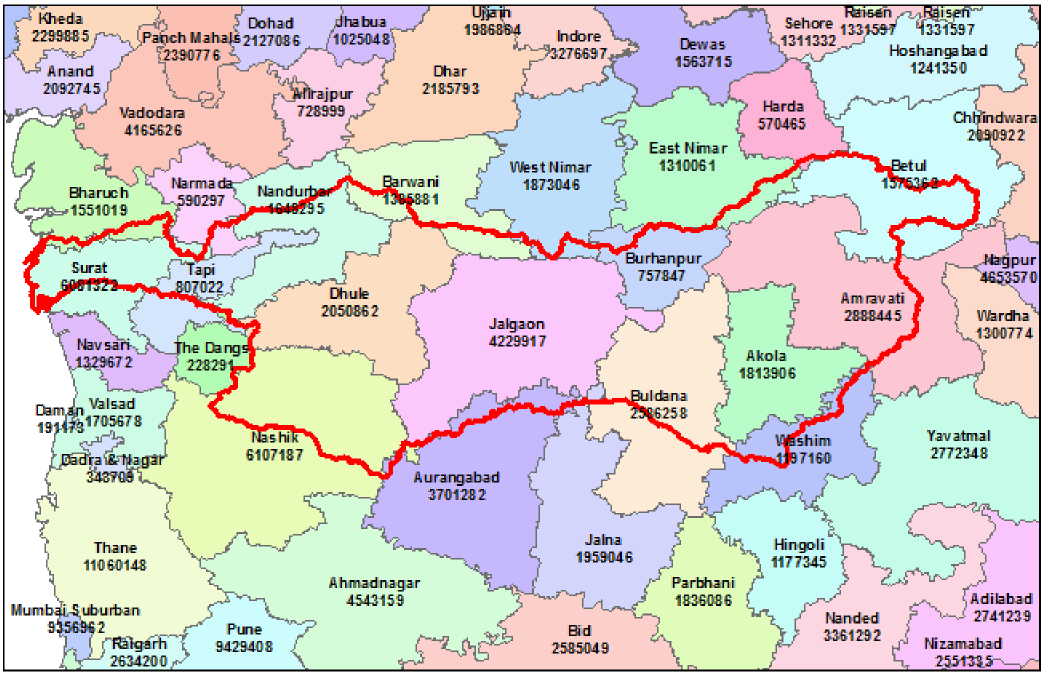


Figure 16.13 District boundaries in Tapi basin

16.2.10 Evaporation from major/medium/minor reservoirs and other water bodies

The average reservoir evaporation in the basin during the period 1985-2015 is estimated as 0.78 BCM as shown in the Table - 16.2.

Table - 16.2 Eavaporation in reservoirs of Tapi basin

Year	Reservoir Evaporation (BCM)	Year	Reservoir Evaporation (BCM)	Year	Reservoir Evaporation (BCM)
1985-86	0.64	1995-96	0.69	2005-06	0.98
1986-87	0.69	1996-97	0.81	2006-07	0.76
1987-88	0.74	1997-98	0.82	2007-08	0.79
1988-89	0.79	1998-99	0.9	2008-09	0.74
1989-90	0.77	1999-00	0.99	2009-10	0.59
1990-91	0.71	2000-01	0.63	2010-11	0.78
1991-92	0.6	2001-02	0.72	2011-12	0.63
1992-93	1.06	2002-03	0.83	2012-13	0.64
1993-94	0.77	2003-04	0.85	2013-14	1.05
1994-95	0.79	2004-05	0.75	2014-15	0.86
				Avg.	0.78

16.3 Previous Estimates

In 1949 when the assessment of the basinwise water resources of the country was worked out on the basis of Khosla's empirical formula, the annual runoff of the Tapi river system was estimated as

9.128 BCM. In 1960 when the irrigation potential studies of the country were made by the CW&PC, the total annual runoff of the Tapi river system was assessed at 19.736 BCM, which was revised to 18.387 BCM in the CWC study done subsequently based on 10 years of observed flows extended to 30 years by rainfall-runoff regression analysis. The flow data for Kathore (State Government. gauging station) on Tapi was used for the study. Review of the study indicates that the average annual flow at Sarangkheda (C.A. 58,400 sq.km) in the upstream was 11.8 BCM, whereas that at Kathore (C.A. 62,750 sq.km) was 18.0 BCM. It indicates an increase of 52.5% in runoff for an increase of only 7.4% in catchment area. This does not appear realistic.

In 1993 estimate by CWC, available water resource of the total basin was 14.88 BCM. In this study, rainfall-runoff regression modelling has been resorted to in order to extend the flow record to period of 22 years, because the flow record was available only for a period of 7 years at Ghala site, which is terminal station for Tapi basin. The total catchment areas considered for Tapi basin in 1993 study and present study are 65,145 sq.km and 65,806 sq. km respectively.

16.4 Runoff Estimation

Burhanpur, Yerli, Sarangkheda and Ghala discharge sites are located on river Tapi. The model estimated runoff is calibrated against the observed discharge at all the four locations. Deltaic region computed runoff is added to the whole basin without any calibration, since it does not have any observed discharge. Figure 16.14 shows comparison between mean observed discharge and mean calibrated runoff at various gauge stations. Tables P.1 to P.4 (at Annexure - P) give calibrated runoff along with observed discharge, rainfall, ECII, etc. during 30 years for the four G&D sites. Figure 16.15 to 16.18 shows comparative graphs of calibrated runoff and observed discharge at these discharge stations. From the graphs, it may be observed that the model estimated runoff with observed discharge is matching very well for the 30 year period. At the Ghala G&D site (terminal station for Tapi Basin), the observed runoff and calibrated discharge are matching well for almost all years except for 3-4 years. Table - P.5 at Annexure - P gives calibrated runoff of Tapi basin (up to Ghala) for 30 years. The mean annual calibrated runoff is about 9.33 BCM. The maximum annual calibrated runoff is 24.79 BCM during 2006-07. The minimum annual calibrated runoff is 1.01 BCM during 2000-01. The mean annual ECII is about 15.28 BCM. The maximum annual ECII is about 23.69 BCM during 1994-95. The minimum annual ECII is about 3.20 BCM during 2014-15.

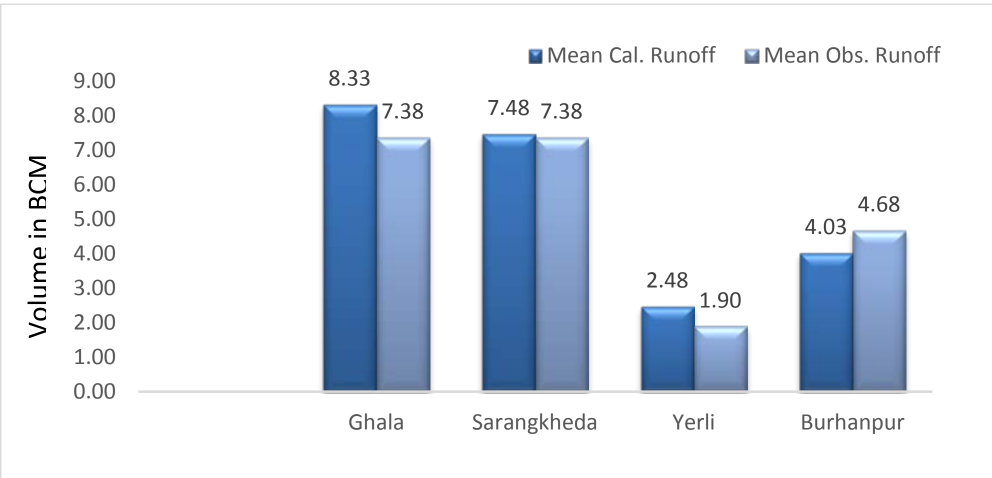


Figure 16.14 Calibrated runoff and observed discharge (mean) at various gauge stations

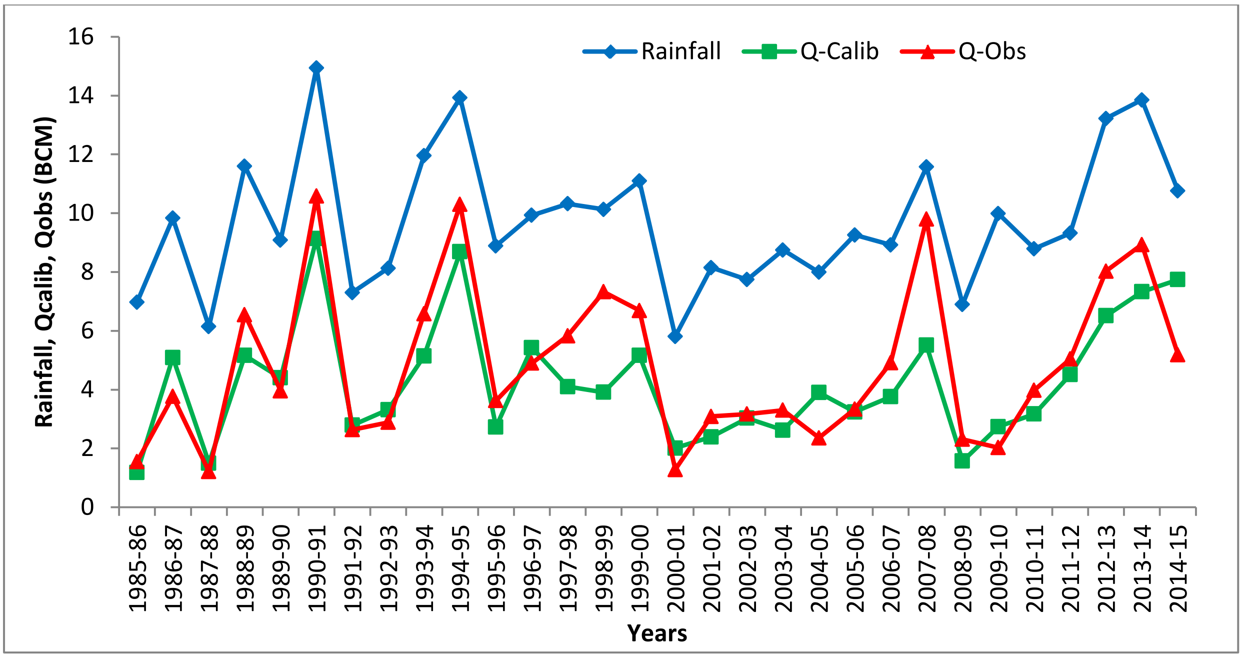


Figure 16.15 Calibrated runoff and observed discharge at Burhanpur

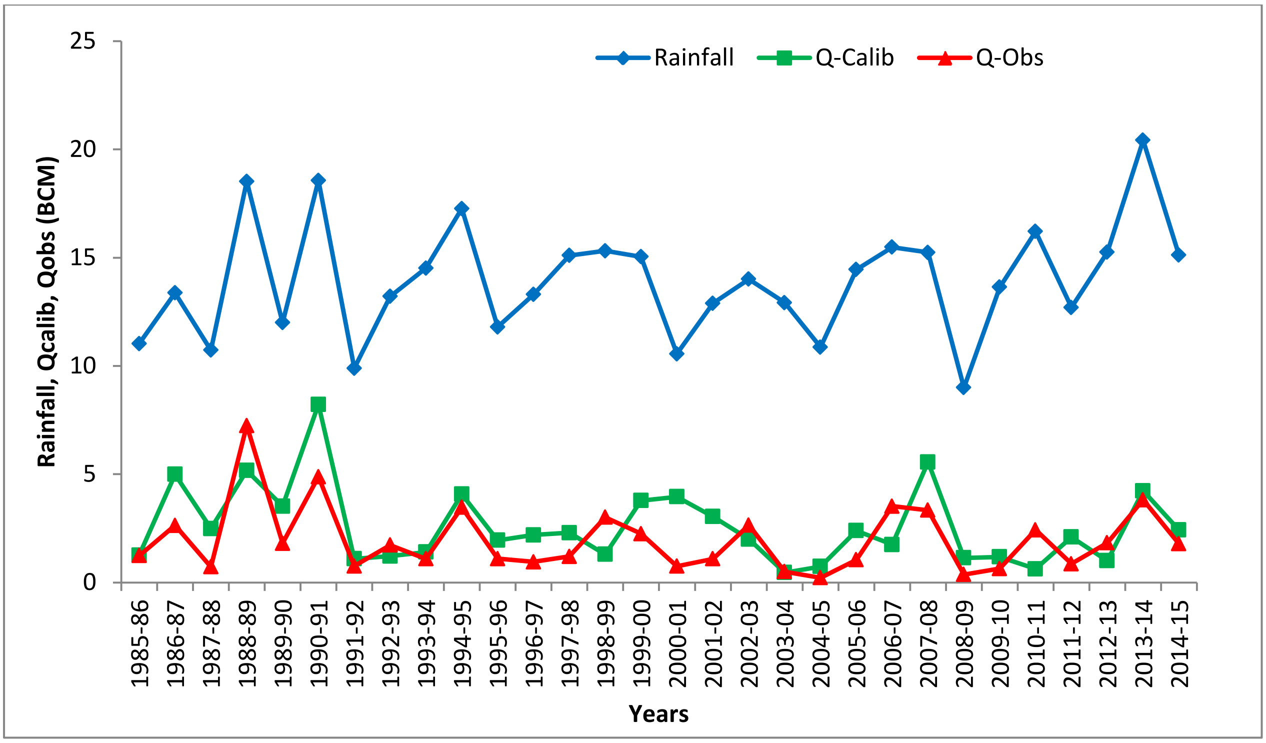


Figure 16.16 Calibrated runoff and observed discharge at Yerli

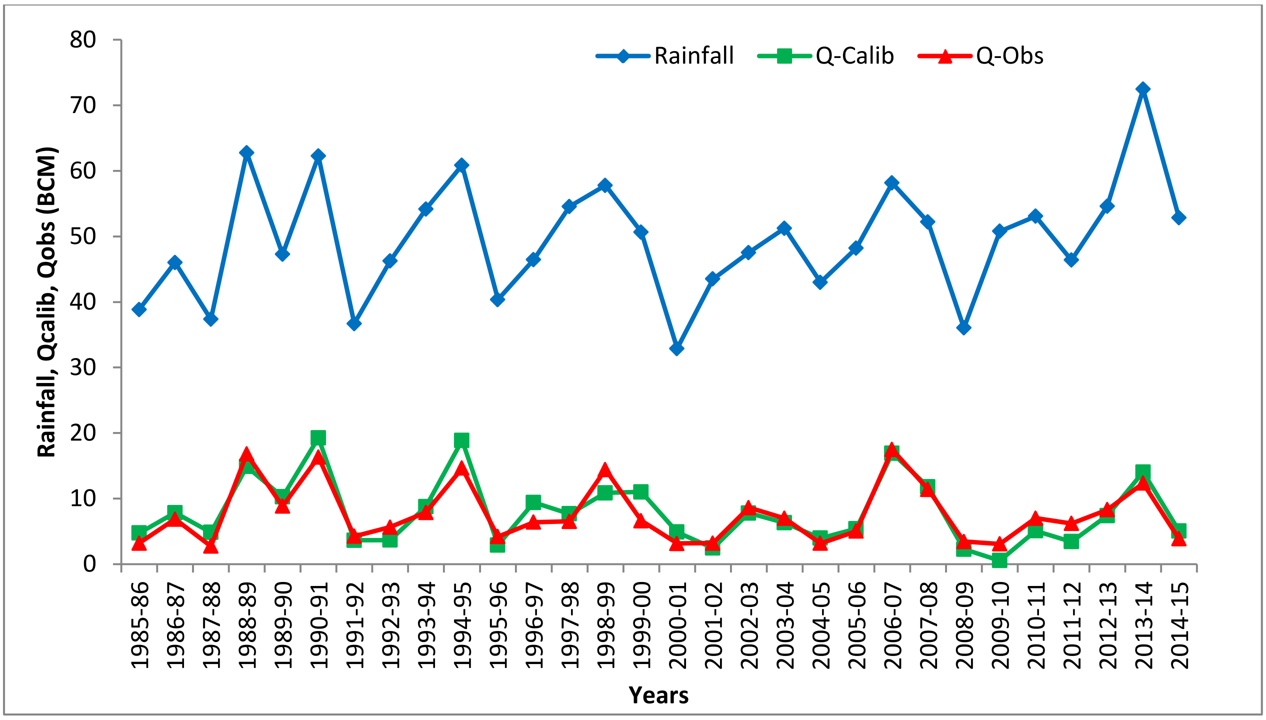


Figure 16.17 Calibrated runoff and observed discharge at Sarangkheda

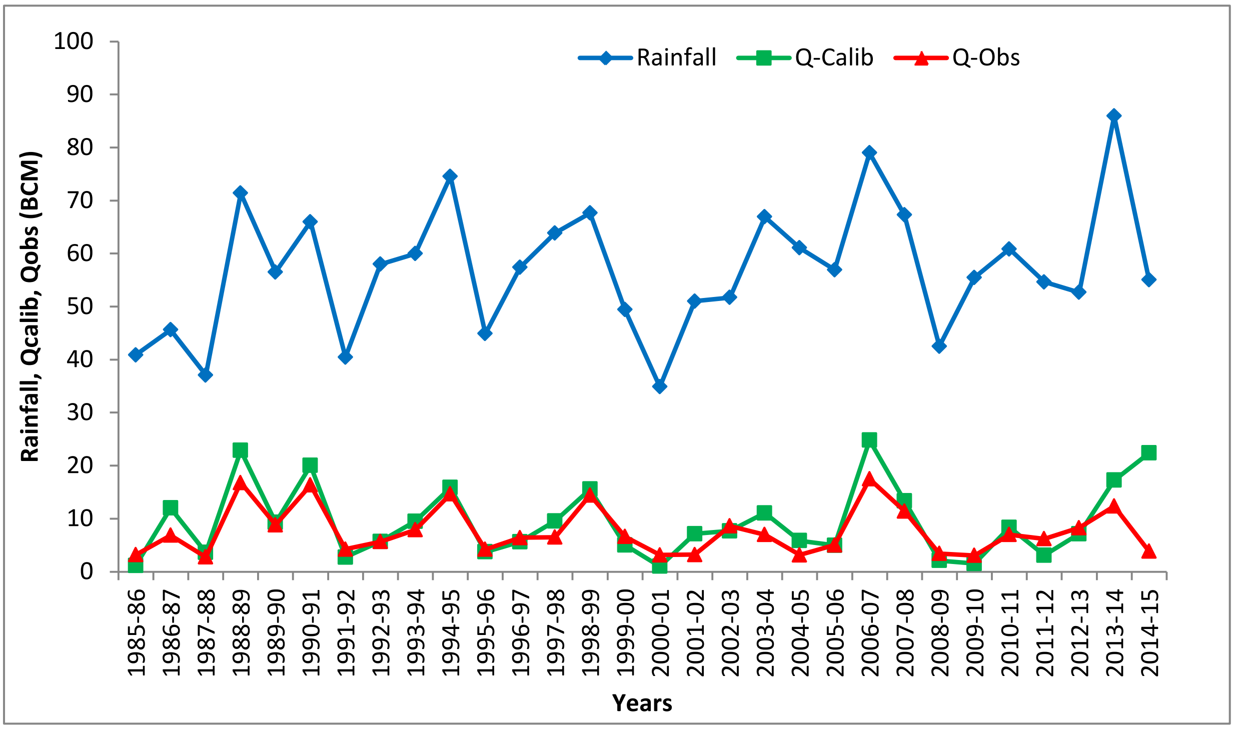


Figure 16.18 Calibrated runoff and observed discharge at Ghala

16.5 Annual Water Resources Availability of Tapi Basin

Total drainage area of Tapi basin is 65,805.75 sq.km as per the geospatial dataset. Ghala site is the terminal station for calibration of discharge of Tapi basin. Drainage area upto Ghala site is 64,150 sq.km, which is 97.48 % of total drainage area of Tapi basin.

Mean water resources of Tapi river basin (up to Ghala)	=	Mean of (Calibrated Runoff + Estimated Consumptive Irrigation Input (ECII) + Domestic, Industrial & Livestock consumption + Groundwater Flux + Evaporation from reservoirs (reservoirs evaporation) + Reservoir Flux + Export from basin + Import to Basin)
		= 9.33 + 15.28 + 0.24 + (-0.08) + 0.78 + 0.03 + 0.00 + 0.00 = 25.58

Annual Mean Water resources availability in Tapi river basin at Ghala (64150 sq. km)	25.58 BCM
Annul Mean Water resources availability for un-calibrated area (Delta) (65805.75 – 64150 = 1655.75) = (25.58 * 1655.75) / 64150	0.66 BCM
Total for Tapi basin (Tapi river basin upto Ghala + Delta)	26.24 BCM

The mean available annual water resources potential of the Tapi Basin is 26.24 BCM and 75% dependable flow of Tapi river basin is 21.23 BCM.

Table - P.5 (at Annexure - P) shows the different components that are required to estimate the basin level water resource of Tapi basin (up to Ghala site) for 30 years. The maximum and minimum annual water resource availability is 44.37 BCM during 2006-07 and 14.70 BCM during 1987-88 respectively. The annual average water potential of Tapi basin is 26.24 BCM. This is about 44.47% of mean annual rainfall during 1985-86 to 2014-15.

16.5.1 Annual water resources of Tapi basin during extreme rainfall conditions

Out of the total 30 years of meteorological data base of study period, during the years 2013-14 and 2000-01, extreme wet and dry rainfall conditions occurred in Tapi river basin. The annual water resources of Tapi river basin during these two extreme rainfall conditions are 40.35 BCM and 14.85 BCM respectively as shown in Table - 16.3. The water balance components during these years are presented in the Figures 16.19 and 16.20.

Table - 16.3 Water resources availability of Tapi basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	2013-14	82.08	40.35
Minimum Rainfall	2000-01	39.45	14.85

Water resources availability-rainfall ratio during the extreme maximum and minimum rainfall years is found to be 0.49 and 0.38 respectively. This shows that the higher the rainfall, the higher percentage of runoff. During higher rainfall years potential evapotranspiration is less compared to the dry years, which will have cumulative effect in runoff.

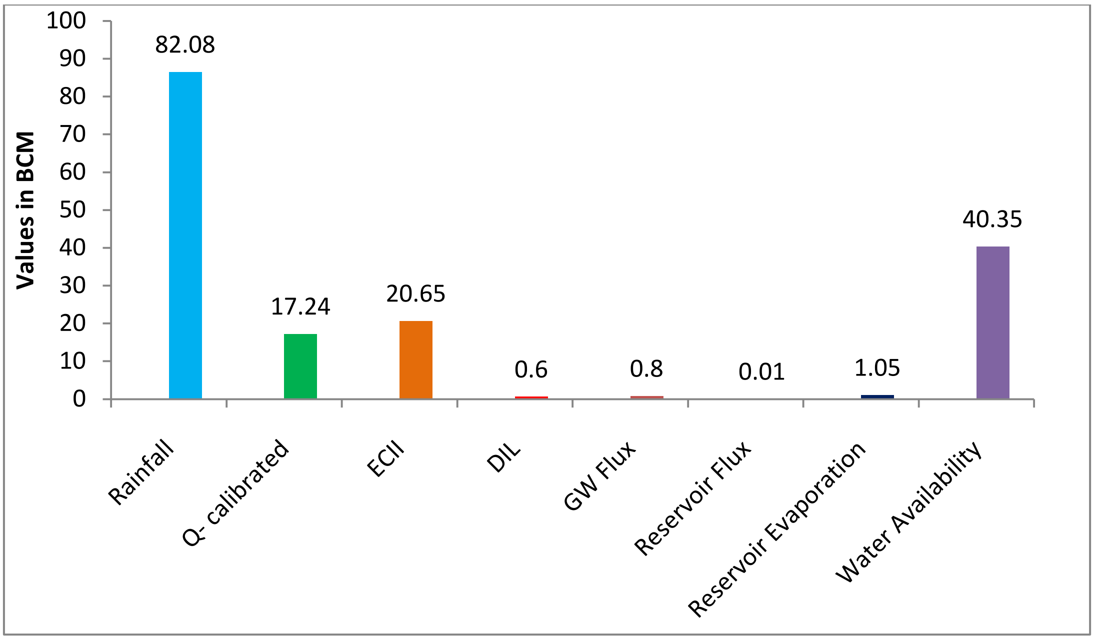


Figure 16.19 Water balance components of Tapi basin during extreme high rainfall (2013-14)

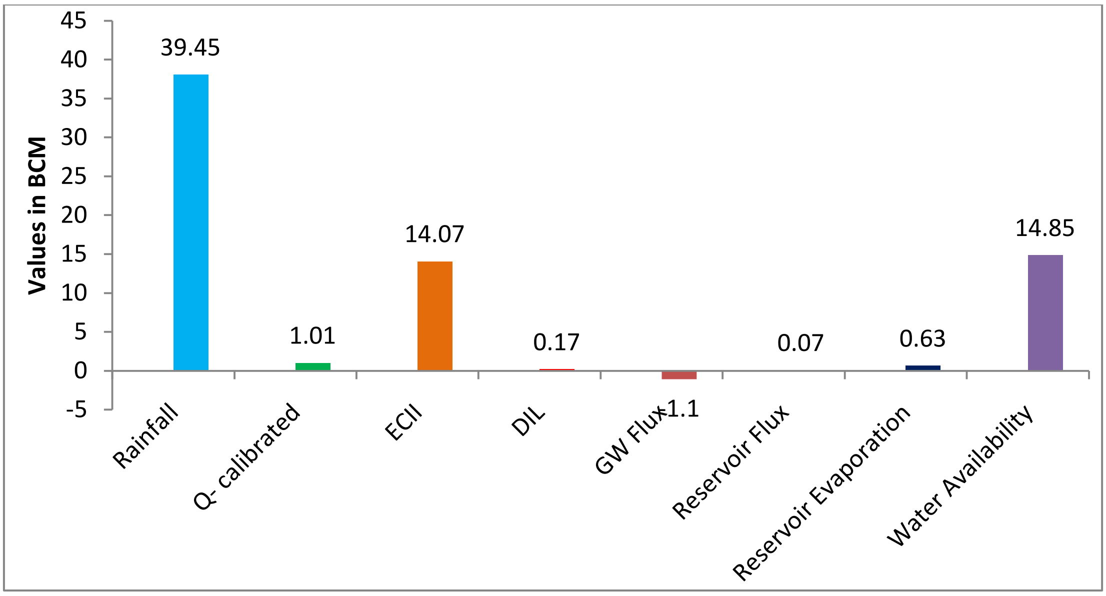


Figure 16.20 Water balance components of Tapi basin during extreme low rainfall (2000-01)

16.5.2 Mean water resources of Tapi basin

The mean available annual water resources potential of the Tapi Basin is 26.24 BCM and 75% dependable flow of the basin is 21.23 BCM. It is observed that the computed runoff factors varies from 0.03 (901.24 mm rainfall) to 0.37 (923.68 mm rainfall). The mean runoff-factor for 30 year period is 0.14.

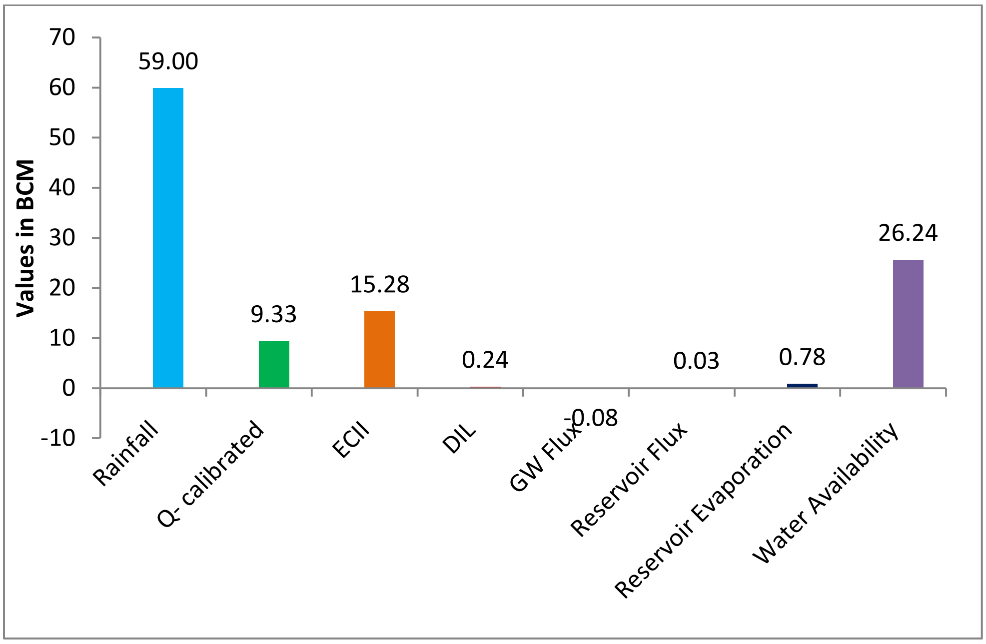
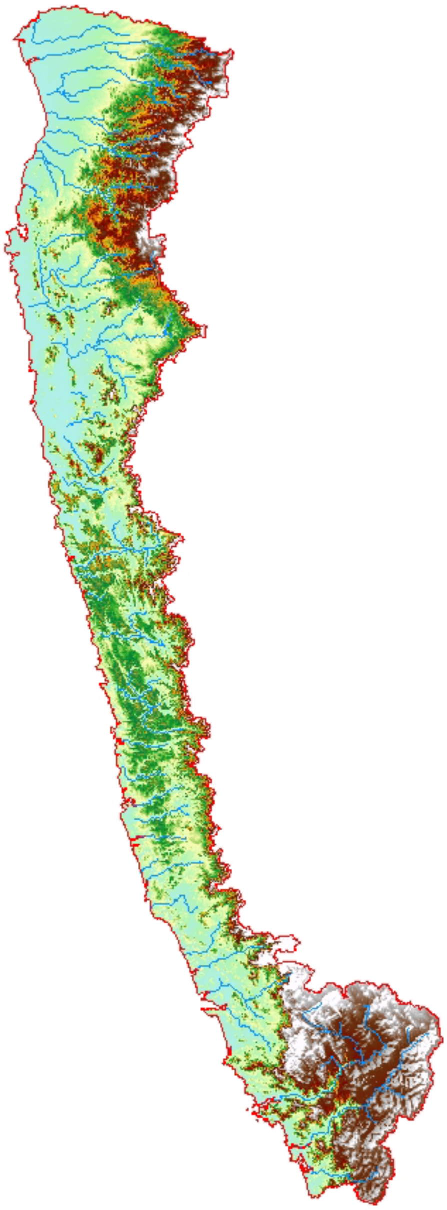


Figure 16.21 Mean water balance components of Tapi basin

HIGHLIGHTS

- *Mean annual available water resources of Tapi basin is 26.24 BCM.*
- *Maximum annual water availability is 44.37 BCM during 2006-07.*
- *Minimum annual water availability is 14.70 BCM during 1987-88.*
- *Annual rainfall in the basin varies from 584.31 mm to 1,327.77 mm during 1985-86 to 2014-15 and mean rainfall for these 30 years is 839 mm.*
- *Tapi basin is divided into four sub-basins for the reassessment study viz. Burhanpur, Yerli, Sarangkheda and Ghala.*
- *Average annual domestic, industrial and livestock demand in the basin is 0.24 BCM.*
- *Average annual evaporation from water bodies in the basin is 0.78 BCM.*

WEST FLOWING RIVERS FROM TAPI TO TADRI BASIN



17.1 Geo-Spatial Datasets

17.1.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map and its distribution for West flowing rivers (WFR) from Tapi to Tadri basin for year 2004-05 is shown in Figures 17.1 and 17.2 respectively. The major LULC classess are Deciduous forest (21%), Kharif only (16.5%) and Evergreen forest (14%).

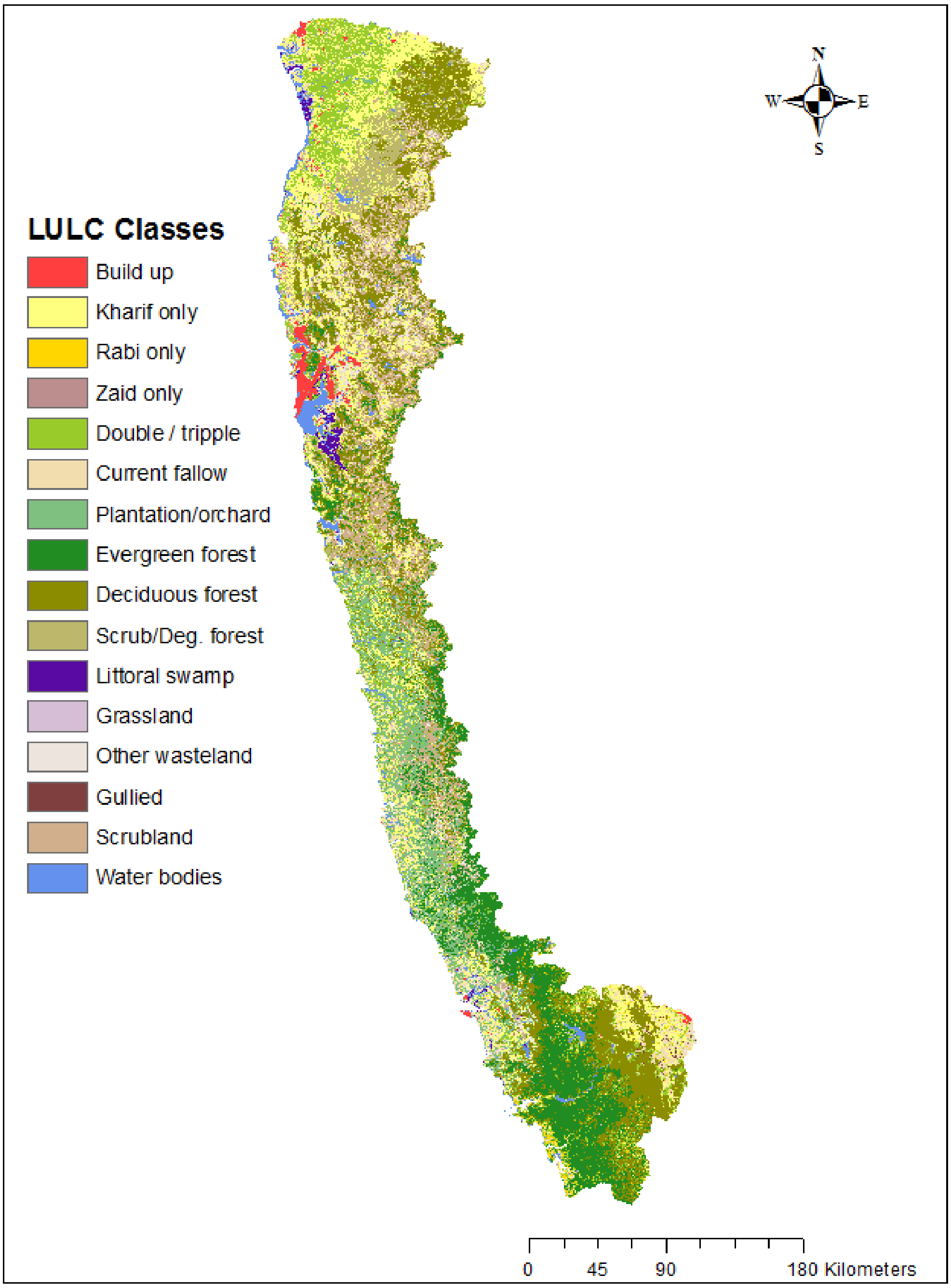


Figure 17.1 LULC Map of WFR from Tapi to Tadri basin (2004-05)

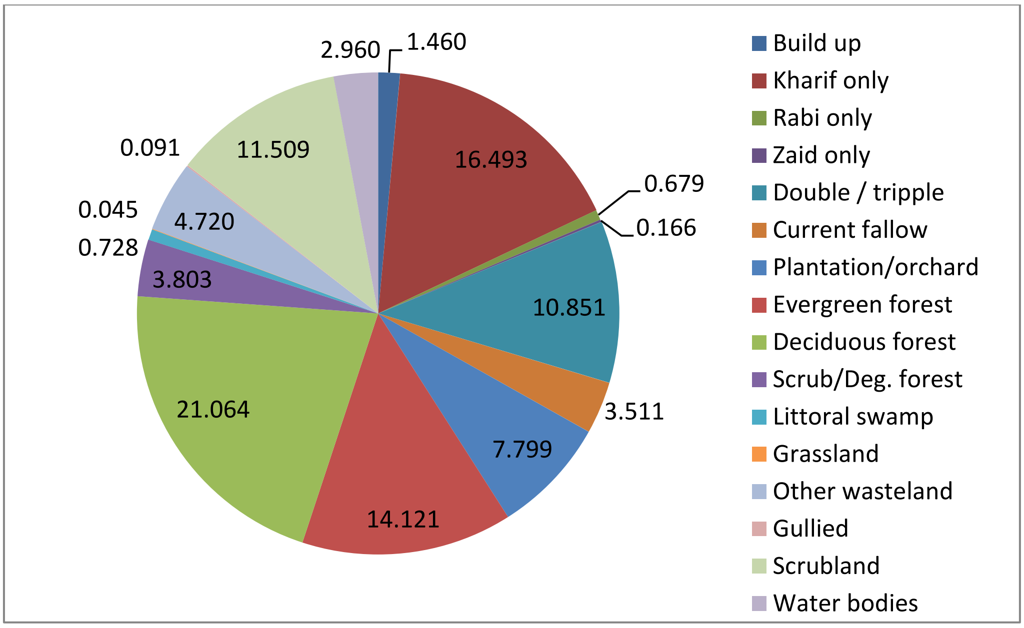


Figure 17.2 Distribution of LULC in WFR from Tapi to Tadri basin (2004-05)

17.1.2 Soil texture

The main soil types based on the soil textural information found in the basin are loamy, clayey, sandy and rock out crops. Figure 17.3 shows various texture classes of soils in the basin.

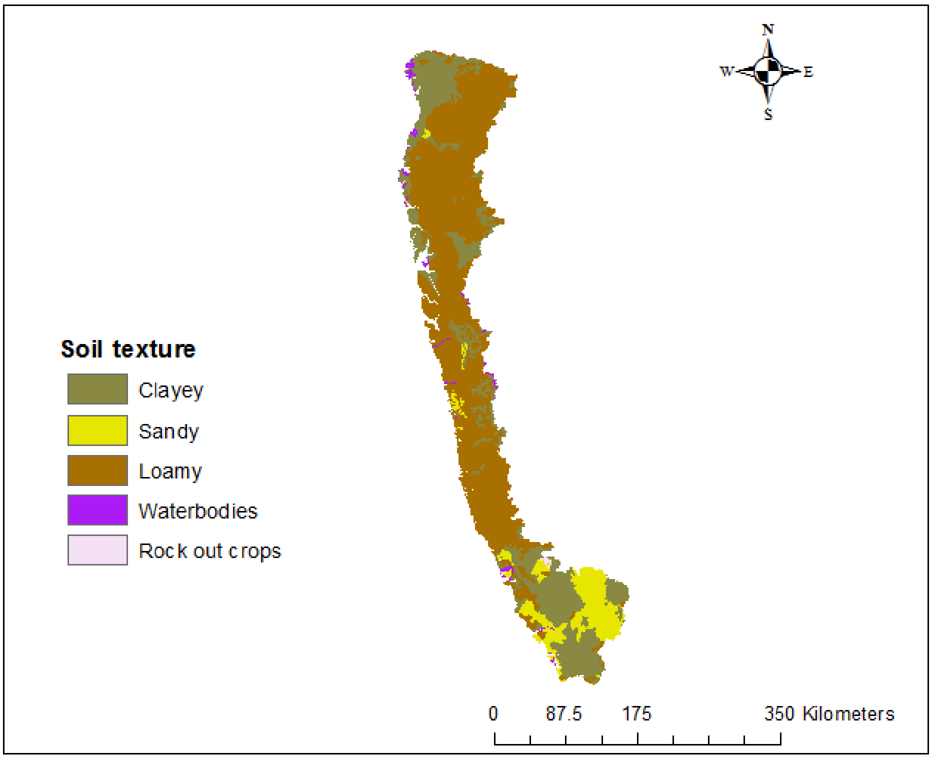


Figure 17.3 Soil texture map of WFR from Tapi to Tadri basin

17.1.3 Topography

The topography of the basin consists of sandy beaches, coastal sand dunes or mud flats, alluvial tracts along rivers or lagoons or estuary, laterite platforms, erosional surfaces in the hard basement rock or the residual hills. The parallel running Sahaydris and undulating lowlands of the Konkan are some of the major features. Lofty hills and elevated plateaus, intersected by numerous creeks and navigable streams, are found close to the coast. The elevation values ranges from a minimum of 0 m to a maximum of 1,396 m. The average elevation is about 219.6 m in the basin. Figure 17.4 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the basin used for delineating sub-basin boundaries of WFR from Tapi to Tadri basin.

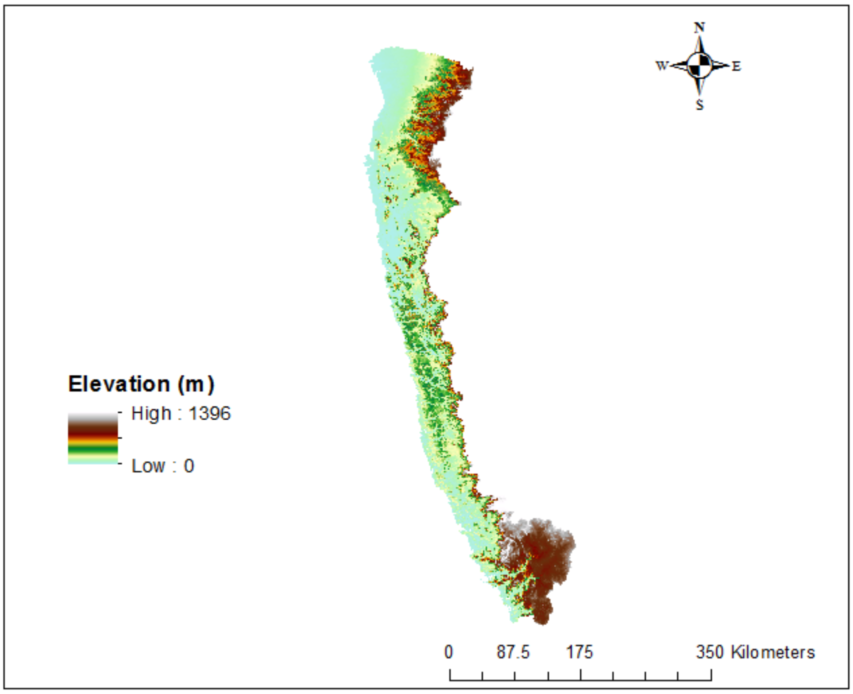


Figure 17.4 SRTM DEM map of WFR from Tapi to Tadri basin

17.2 Hydro-Meteorological and other Input Data

17.2.1 Rainfall grids

Figure 17.5 shows gridded rainfall of WFR from Tapi to Tadri basin for year 2004-05. The variations in the annual rainfall during study period of 30 years (1985-86 to 2014-15) are shown in the Figure 17.6. Annual rainfall of the basin varies from 1,947 mm to 3,420 mm and mean rainfall of 30 years is found to be 2,661 mm. Out of 30 years, 13 years annual rainfall is higher than the mean rainfall and that of remaining 17 years is lower than the mean rainfall.

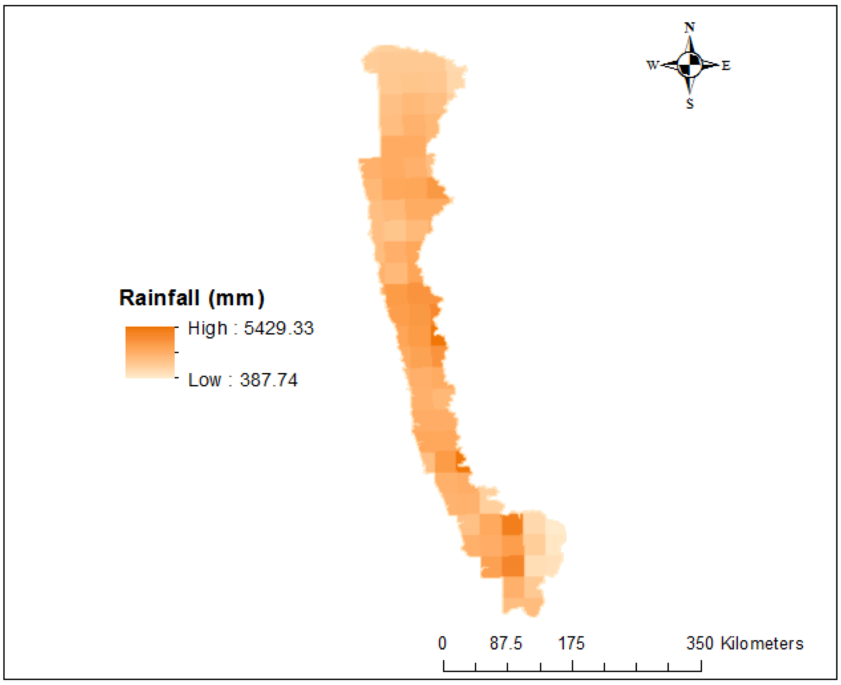


Figure 17.5 Gridded rainfall of WFR from Tapi to Tadri basin (2004-05)

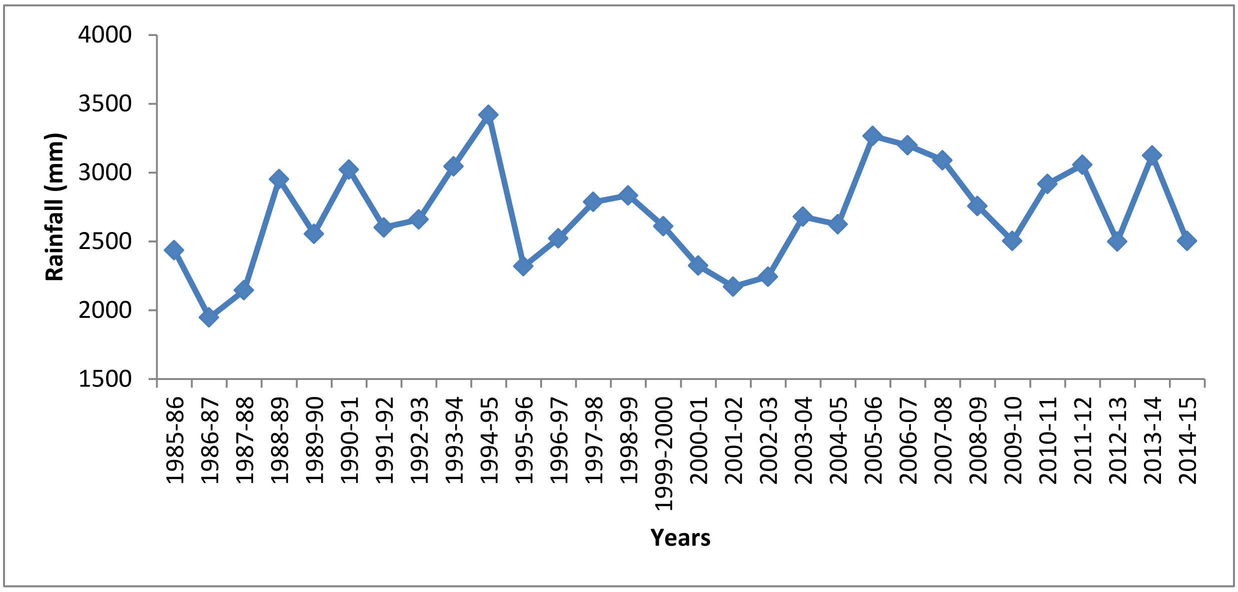


Figure 17.6 Annual rainfall in WFR from Tapi to Tadri basin (1985-86 to 2014-15)

17.2.2 Temperature grids

Figure 17.7 represents the gridded mean annual temperature for year 2004-05 in the basin.

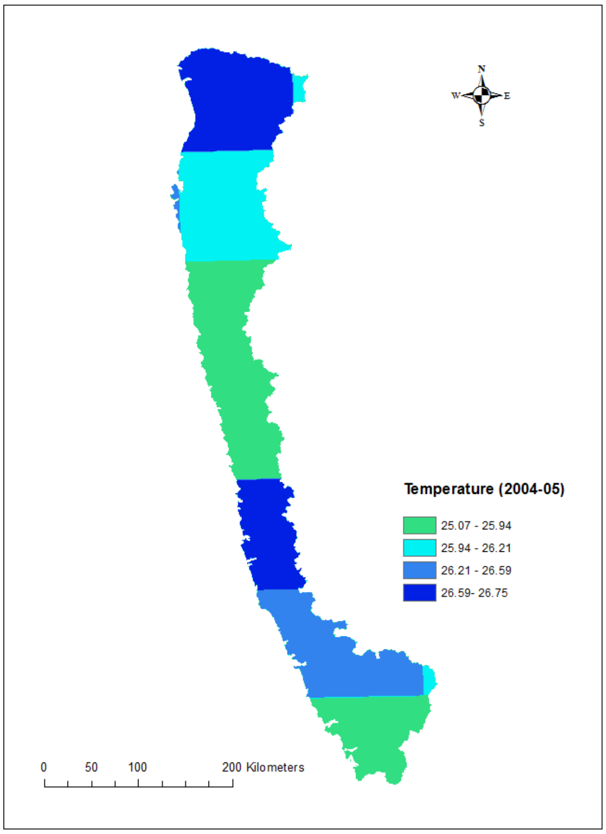


Figure 17.7 Gridded mean annual temperature of WFR from Tapi to Tadri basin (2004-05)

17.2.3 Sub-basins of WFR from Tapi to Tadri basin

WFR from Tapi to Tadri basin was initially divided into seven sub-basins (Figure 17.8) viz. Gadat, Mahuwa, Durvesh, Badlapur, Santeguli, Ganjim and remaining region as one sub-basin. The sub-basins have been named based on the name of the G&D sites. Out of these, the discharges at Badlapur, Ganjim and Santeguli sites were coming greater than the mean annual rainfall calculated in these sub-basins. Hence, these sites were not selected for calibration and hence merged with the remaining area. Also, these sites have very small catchment area (less than 1000 sq.km only). Table 17.1 depicts the drainage area of each sub-basin.

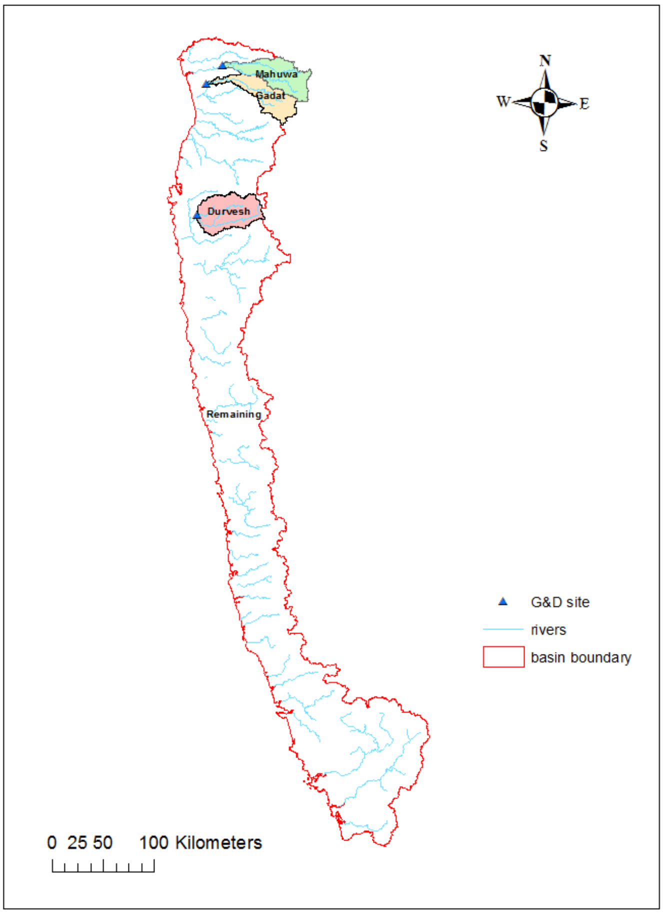


Figure 17.8 Sub-basins of WFR from Tapi to Tadri basin

Table - 17.1 Sub-basin wise details of WFR from Tapi to Tadri basin

S. No.	Sub-basin	River	Individual drainage area (sq.km)
1	Gadat	Ambica	1,471
2	Mahuwa	Purna	1,701
3	Durvesh	Vaitarana	1,887
4	Remaining	-	53,301
		Total basin area	58,360

17.2.4 River discharge

The river discharge data are available at six sub-basins having catchment area more than 625 sq.km (outlet points at Gadat, Mahuwa, Durvesh, Ganjim, Badlapur and Santeguli) for the study period of 30 years. As mentioned earlier, the discharges at Badlapur, Ganjim and Santeguli have not been used for calibration. The daily discharge data have been aggregated to annual scale and used for calibration and validation of model computed runoff at sub-basin level.

17.2.5 Reservoir flux

Figure 17.9 shows the location of some of the major reservoirs in the basin. Reservoir flux data (1986-2015) of Upper Vaitarana reservoir has been used in the calibration of Durvesh sub-basin while that of Bhatsa reservoir (2002-2015) and Damanganga reservoir (1990-2015) have been used for the calculation of calibrated discharge (Q_{calib}) for remaining area of the basin.

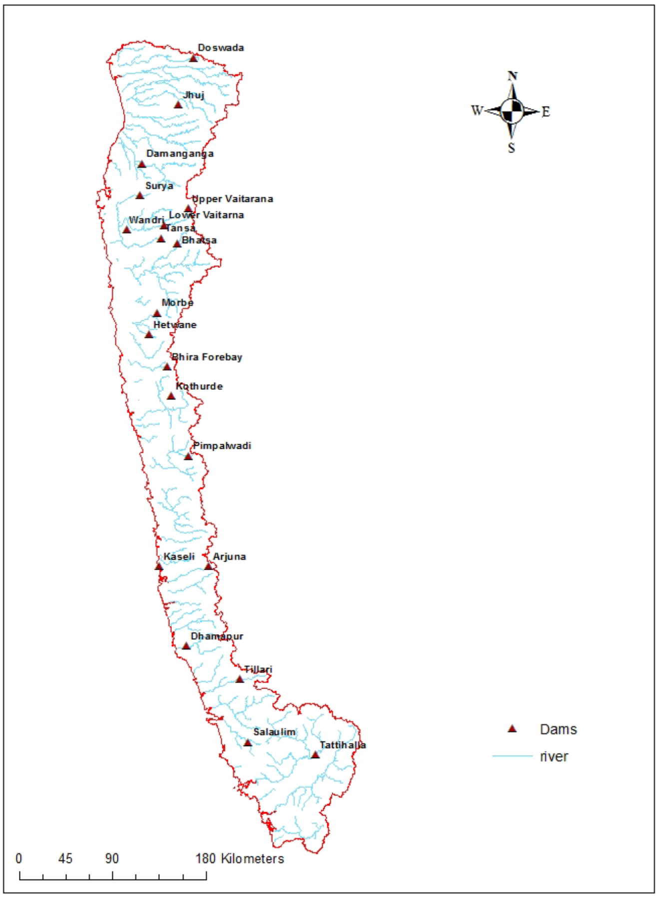


Figure 17.9 Major reservoirs in WFR from Tapi to Tadri basin

17.2.6 Groundwater flux

The spatial annual groundwater flux for the year 2004-05 is shown in Figure 17.10. The annual variation in groundwater flux for the duration 1985-2015 is shown in Figure 17.11.

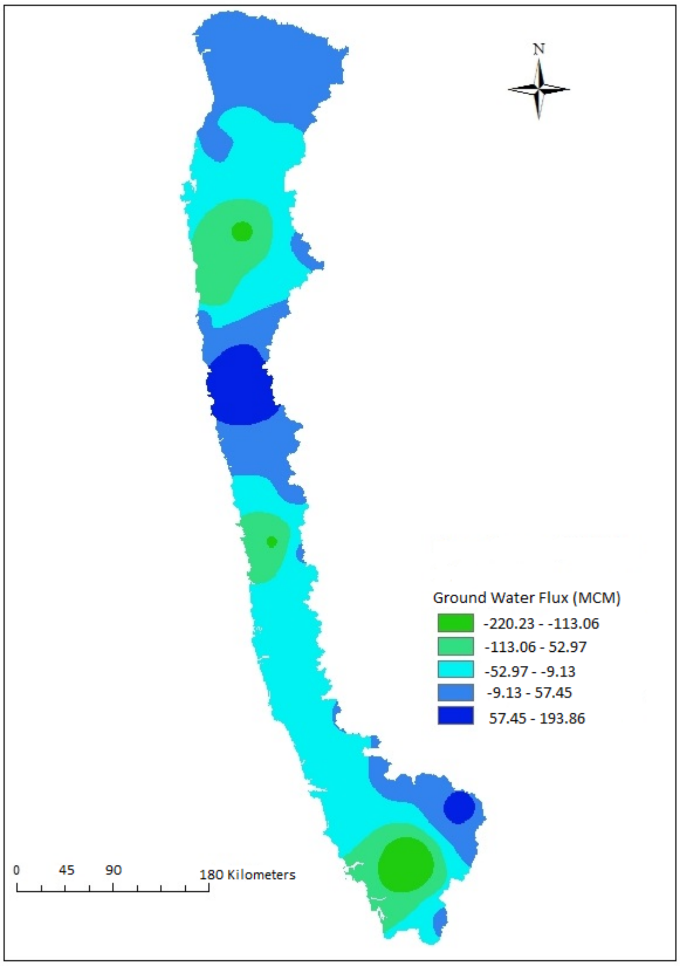


Figure 17.10 Groundwater flux (spatial data) estimated during 2004-05

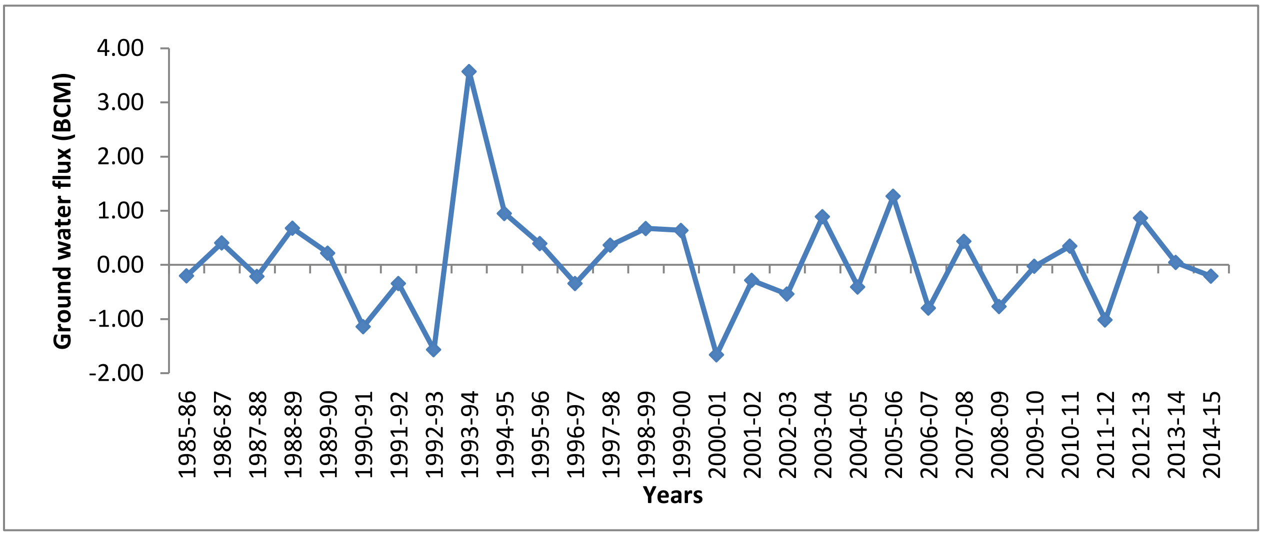


Figure 17.11 Annual groundwater flux of WFR from Tapi to Tadri basin (1985-86 to 2014-15)

17.2.7 Major crops in the basin

Based on the district-wise crop area statistics, district wise major crops for each crop season are identified. The basin is divided in seven regions based on the historic district-wise crop statistics collected from various sources (http://lus.dacnet.nic.in/ dt_lus.aspx). Each region specifies a unique crop for each crop season both spatially and temporally within the basin. Hence, the coefficients have been taken as per the crop in that particular region/district. On examining the cropping pattern within the basin, crop growing seasons have been decided as Kharif only crop during 4 months (July to October), Rabi only crop during 4 months (November to February), Double/Triple crop during 8-12 months.

17.2.8 Irrigation command area

Figure 17.12 shows location of irrigation command boundaries inside the WFR from Tapi to Tadri basin considered for the year 2014-15. Since annual command boundary maps are not available, command area has been selected from the year 2014-15 based on the completion of the project/dam. Hence, the command area in the basin considered during the year 1985-86 is worked out to be around 3, 75,622.58 hectare while it is 54,86,89.86 hectare in 2014-15. Basin outside command has been taken uniformly for all years while working out ECII from these areas.

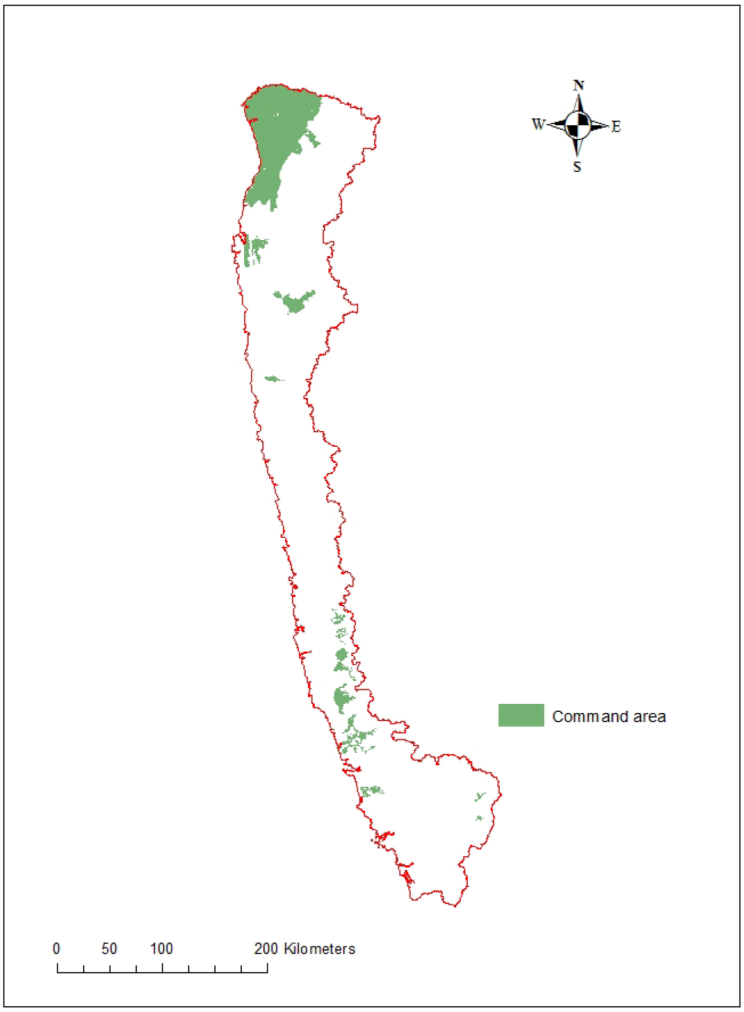


Figure 17.12 Irrigation command boundaries of WFR from Tapi to Tadri basin

17.2.9 Domestic, industrial and livestock demand

Figure 17.13 shows district boundaries layer with population as per 2011 census. The mean annual domestic, industrial and livestock demands are estimated as 0.655 BCM in the basin.

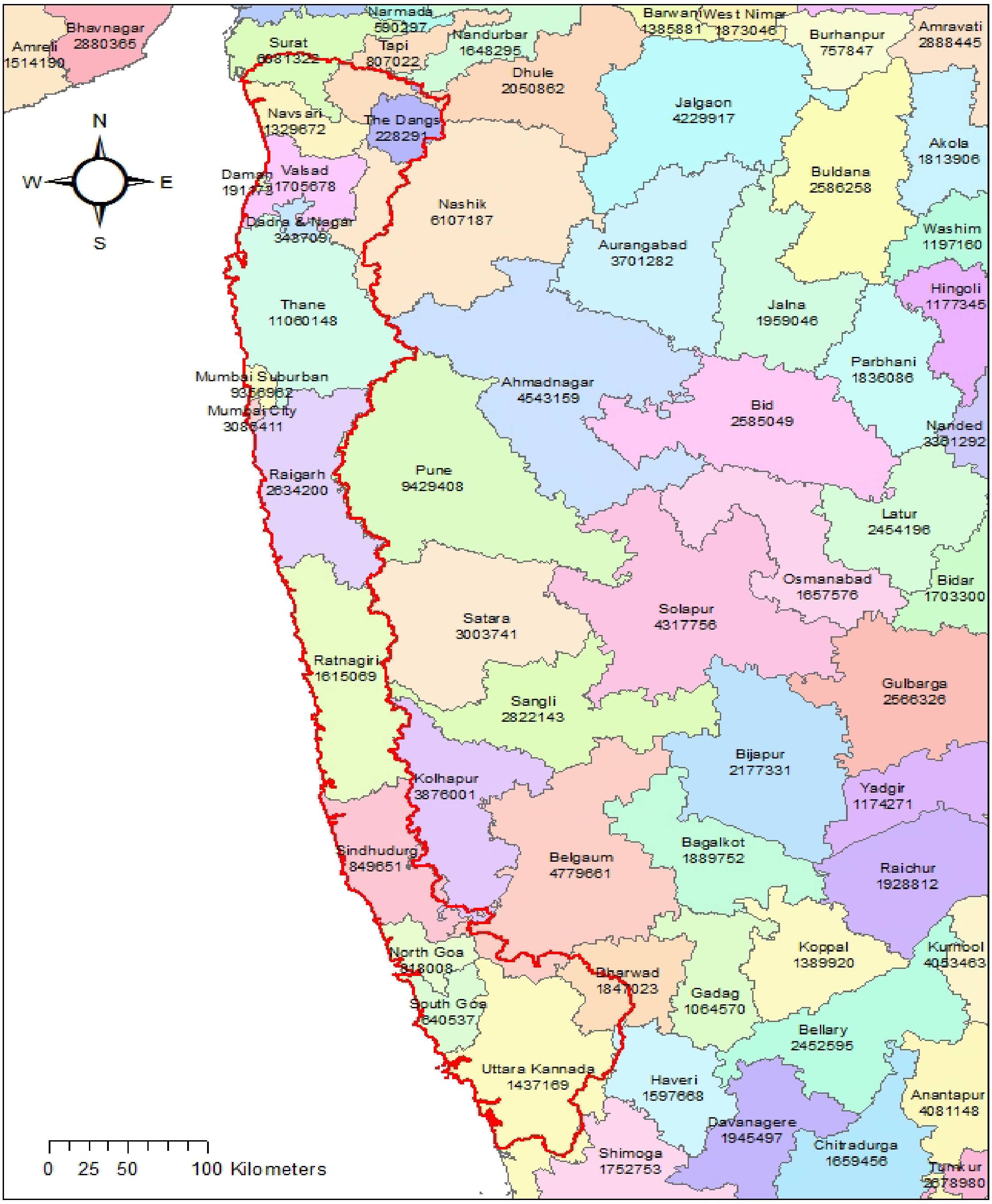


Figure 17.13 District boundaries in WFR from Tapi to Tadri basin

17.2.10 Evaporation from major/medium/minor reservoirs and other water bodies

Table 17.2 provides annual evaporation values from each of sub-basins for the period of 1985-86 to 2014-15 (30 years). Mahuwa sub-basin has no significant reservoir evaporation. The average annual evaporation volume for the basin is worked out as 1.29 BCM.

Table - 17.2 Evaporation in reservoirs of WFR from Tapi to Tadri basin

Year	Reservoir Evaporation in each independent sub-basin (in BCM)		
	Durvesh	Gadat	Remaining
1985-86	0.020	0.012	1.046
1986-87	0.016	0.009	0.956
1987-88	0.018	0.011	1.107
1988-89	0.020	0.011	1.138
1989-90	0.021	0.015	1.227
1990-91	0.020	0.014	1.352
1991-92	0.016	0.017	0.890
1992-93	0.020	0.010	1.151
1993-94	0.022	0.015	1.515
1994-95	0.018	0.021	1.293
1995-96	0.017	0.018	1.217
1996-97	0.021	0.017	1.165
1997-98	0.020	0.013	1.154
1998-99	0.025	0.012	1.376
1999-00	0.015	0.014	1.352
2000-01	0.016	0.014	1.180
2001-02	0.019	0.017	1.051
2002-03	0.019	0.011	1.039
2003-04	0.018	0.012	1.160
2004-05	0.019	0.013	1.043
2005-06	0.020	0.013	1.516
2006-07	0.020	0.020	1.301
2007-08	0.022	0.014	1.295
2008-09	0.023	0.023	1.376
2009-10	0.018	0.026	1.538
2010-11	0.026	0.020	1.622
2011-12	0.024	0.012	1.464
2012-13	0.029	0.012	1.679
2013-14	0.030	0.012	1.651
2014-15	0.028	0.022	0.885
Avg	0.021	0.015	1.258

17.3 Previous Estimates

The previous estimates were made for the combined basin from Tapi to Kanyakumari. The first assessment of the water resources potential was made by the Irrigation Commission (1901-03) which estimated the annual runoff of this basin as 230.78 BCM for a catchment area of 93,805 sq. km. In 1949, when the basin wise water assessment of resources of the country was made on the basis of the Khosla's empirical formula, the annual runoff of the west flowing rivers basin was estimated at 229.02 BCM. In 1960, the CW&PC while conducting irrigation potential studies assessed the total annual runoff of the basin as 217.89 BCM based on the available observed data and Strange's Coefficients of rainfall and runoff. Later in 1982 the committee for assessment of water resources of rivers flowing into Arabian Sea and its utilisation assessed the potential of the basin as 198.854 BCM.

In 1993, CWC had undertaken reassessment of water resources potential of India. First time separate assessment was made for Tapi to Tadri basin. The total water resource available was estimated as 87.411 BCM in the basin and 75 % dependable flow for whole basin as 65.663 BCM. (1993)

17.4 Runoff Estimation

Tables - Q.1 to Q.4 (at Annexure - Q) give calibrated discharge along with observed discharge, rainfall, ECII, etc. during 30 years for the three G&D sites and remaining basin. Figures 17.14 to 17.17 show comparative graphs of calibrated and observed discharge at these G&D sites.

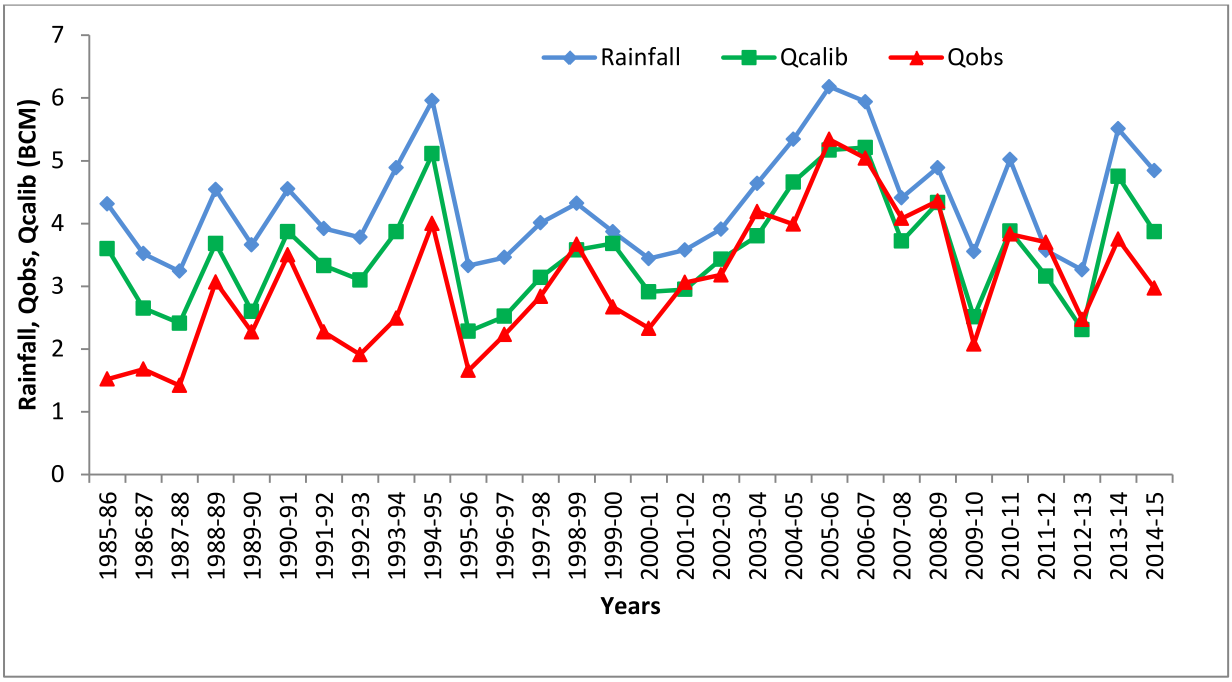


Figure 17.14 Calibrated runoff and observed discharge at Durvesh on river Vaitarana

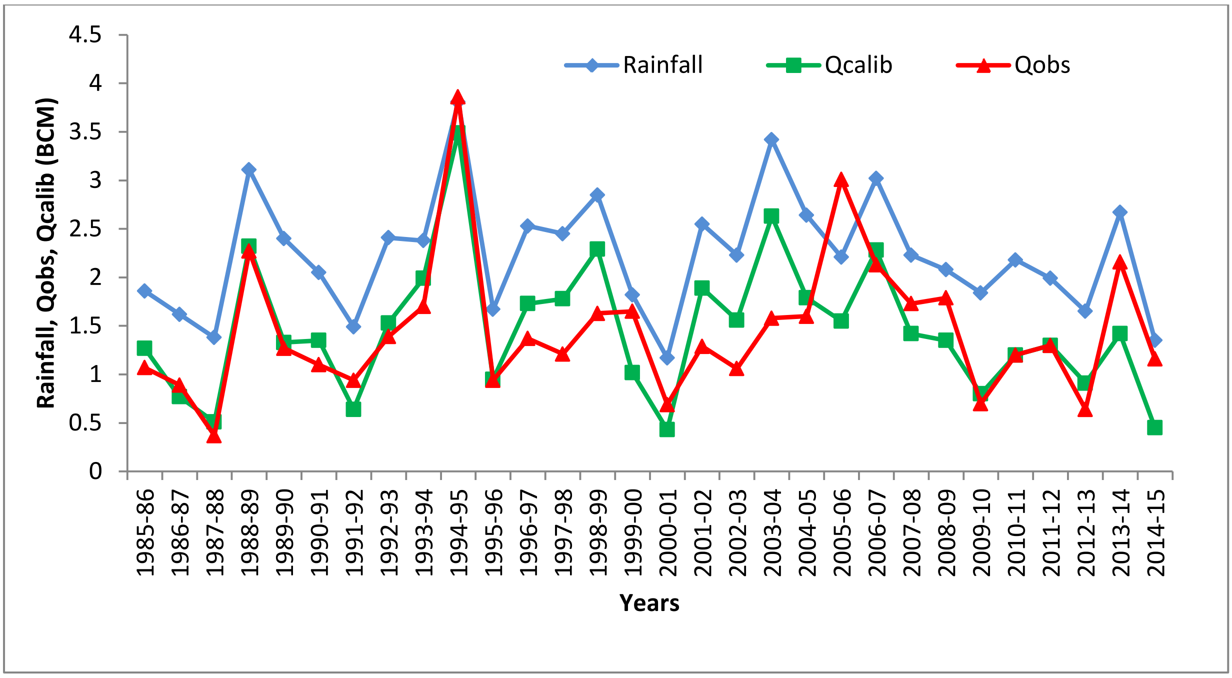


Figure 17.15 Calibrated runoff and observed discharge at Gadat on river Ambica

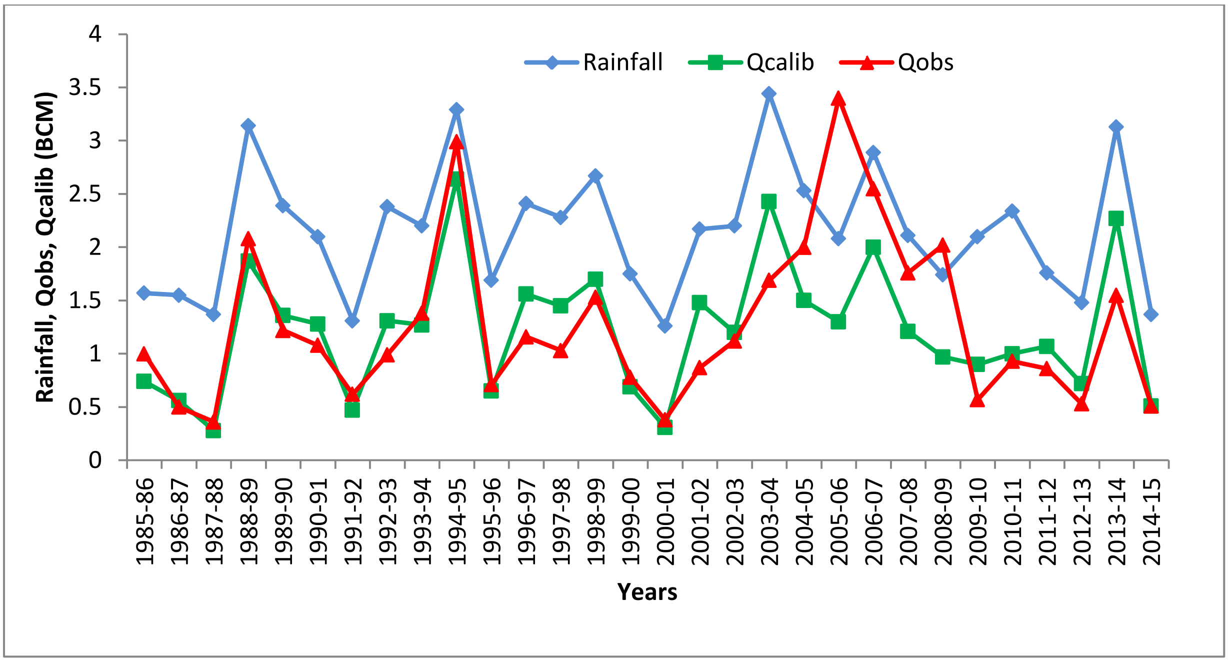


Figure 17.16 Calibrated runoff and observed discharge at Mahuwa on river Purna

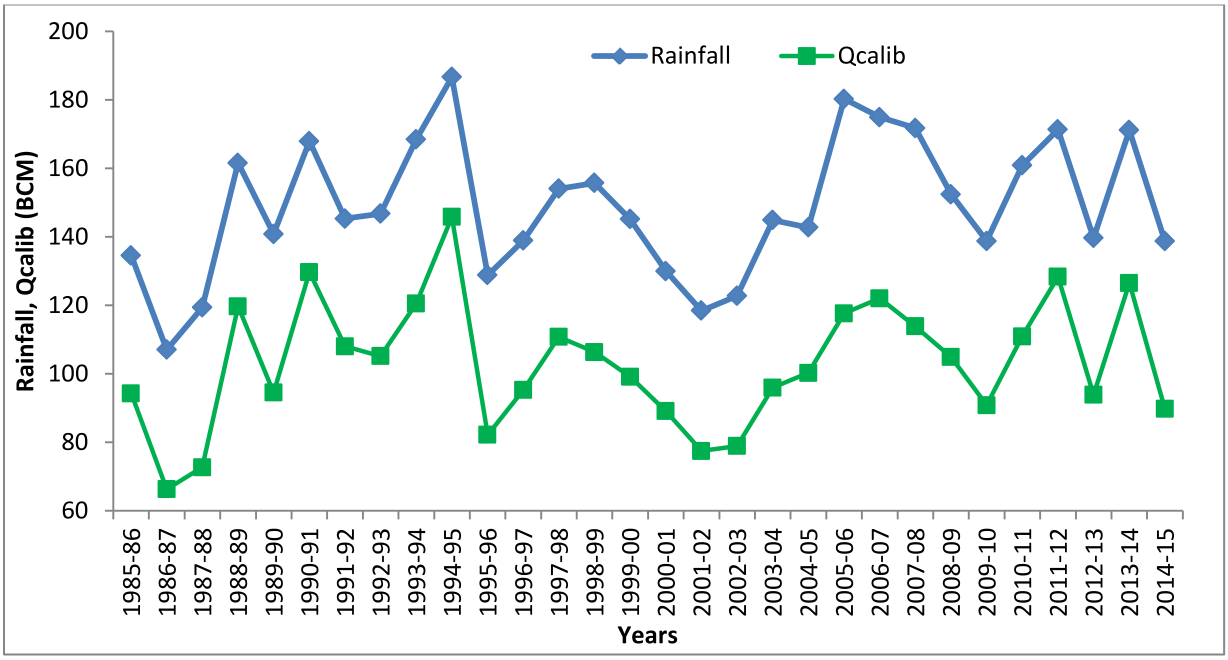


Figure 17.17 Calibrated runoff and rainfall of remaining area of WFR from Tapi to Tadri basin

The remaining ungauged area of the basin has been calibrated with the help of MODIS AET values obtained from TERRA satellite. TERRA satellite was launched by National Aeronautics and Space Administration (NASA) in Dec, 1999 with multiple sensors on-board. MODIS is one sensor on-board of TERRA using which global ET was estimated at 1 sq.km spatial resolution. ET was estimated using improved ET algorithm developed by Mu et al (2011) based on the Penmann-Monteith equation. The AET for the remaining sub-basin of Tapi to Tadri have been compared with the MODIS AET values and found to be comparable.

Table Q.5 at Annexure - Q gives calibrated runoff of WFR from Tapi to Tadri basin. The average calibrated runoff is about 109.05 BCM annually. The maximum annual calibrated runoff is 157.10 BCM during 1994-95. The minimum annual calibrated runoff occurred as 70.07 BCM during 1986-87. The average annual ECII is about 7.27 BCM. The maximum annual ECII is about 9.50 BCM during 1986-87. The minimum annual ECII is about 4.58 BCM during 1998-99.

17.5 Annual Water Resources Availability of WFR from Tapi to Tadri Basin

Table - Q.5 at Annexure - Q shows the different components required to estimate the basin level water resources of WFR Tapi to Tadri basin for 30 years period. The mean available annual water resource of WFR from Tapi to Tadri basin is 118.35 BCM and 75% dependable flow is 106.81 BCM. The maximum annual water resource is 166.10 BCM during 1994-95 in the 30 years period. The minimum annual water resource is 81.42 BCM during 1986-87 which is the driest year during the 30 years period. The mean available water resources of WFR from Tapi to Tadri basin accounts about 73.50% of mean annual rainfall during 1985-86 to 2014-15.

17.5.1 Annual water resources of WFR from Tapi to Tadri basin during extreme rainfall conditions

Out of the total 30 years of meteorological database of study period, extreme wet and dry rainfall conditions occurred in WFR from Tapi to Tadri basin during the years 1994-95 and 1986-87 respectively. The annual water resources of the basin during these two extreme rainfall conditions are 166.30 BCM and 81.61 BCM, respectively as shown in Table 17.3. The water balance components during these years are presented in Figures 17.18 and 17.19.

Table - 17.3 Water resources availability in WFR from Tapi to Tadri basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	1994-95	207.44	166.10
Minimum Rainfall	1986-87	116.74	81.42

Water resources availability-rainfall ratio during the extreme maximum and minimum rainfall years is found to be 0.80 and 0.70 respectively, this shows that the higher the rainfall, the higher percentage of runoff. The average runoff factor for the whole basin is 0.68 during the period between 1985-86 and 2014-15. During higher rainfall years, potential evapotranspiration is less as compared to the dry years. This has cumulative effect in runoff. It is found that the ECII during 1994-95 is less than the year 1986-87.

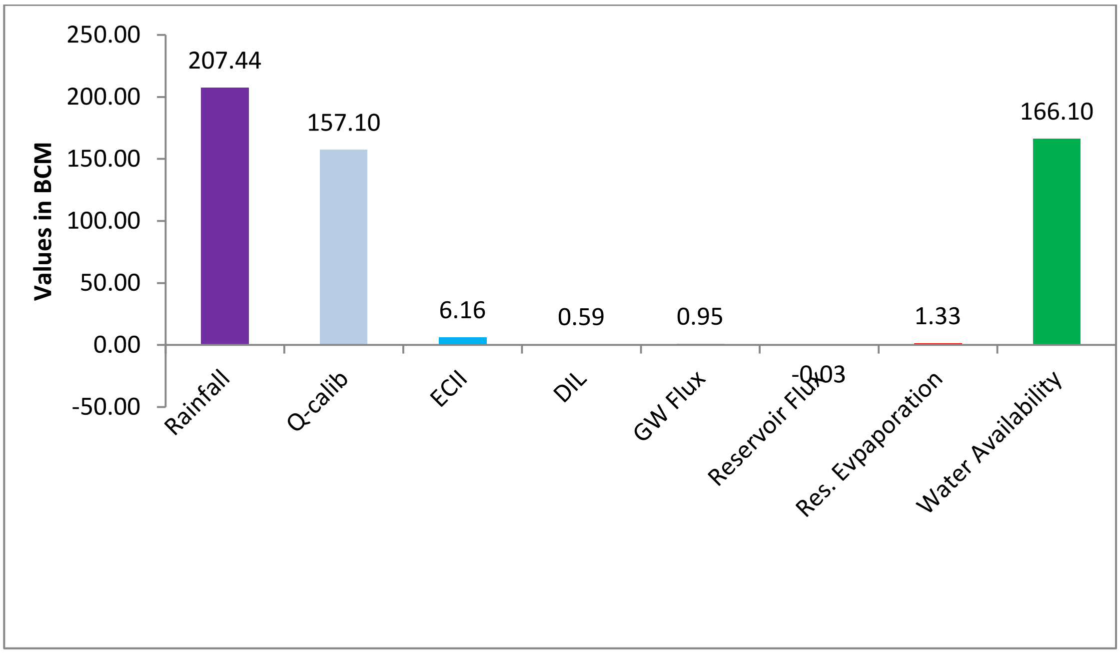


Figure 17.18 Water balance components of WFR from Tapi to Tadri basin during extreme high rainfall (1994-95)

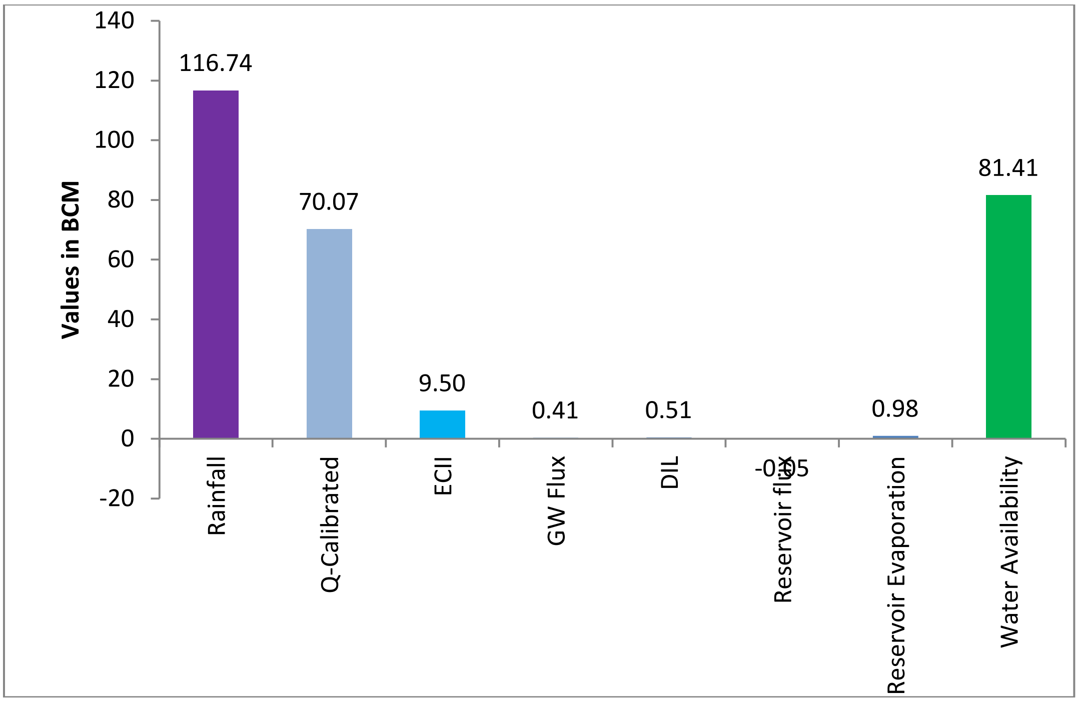


Figure 17.19 Water balance components of WFR from Tapi to Tadri basin during extreme low rainfall (1986-87)

17.5.2 Mean water resources of WFR from Tapi to Tadri basin

The mean water resources of the basin is computed by taking mean of the 30 years water balance components such as flow in the river at final outlet, upstream effective utilisations for irrigation, domestic and industrial, change in storage of groundwater, change in storage of reservoirs and evaporation from reservoirs.

Mean water resources = Mean of (Calibrated Runoff + Estimated Consumptive Irrigation Input + Domestic, Industrial and Livestock consumption + Groundwater Flux + Reservoir Flux + Export from basin + ET Reservoirs)

$$=109.05 + 7.27 + 0.66 + 0.07 + 0.01 + 0.00 + 1.29 = 118.35 \text{ BCM}$$

The mean available annual water resource of WFR from Tapi to Tadri is 118.35 BCM.

75% dependable flow of WFR Tapi to Tadri basin = 106.81 BCM

Figure 17.20 shows the various water balance components averaged over a period of 30 years during 1985-86 to 2014-15. It is observed that the computed runoff factors varies from 0.61 (2,142 mm rainfall) to 0.79 (3,420 mm rainfall). The mean runoff factor for 30 year period is 0.68. The high values of runoff factors are mainly attributed to the steep slopes of Western Ghat region.

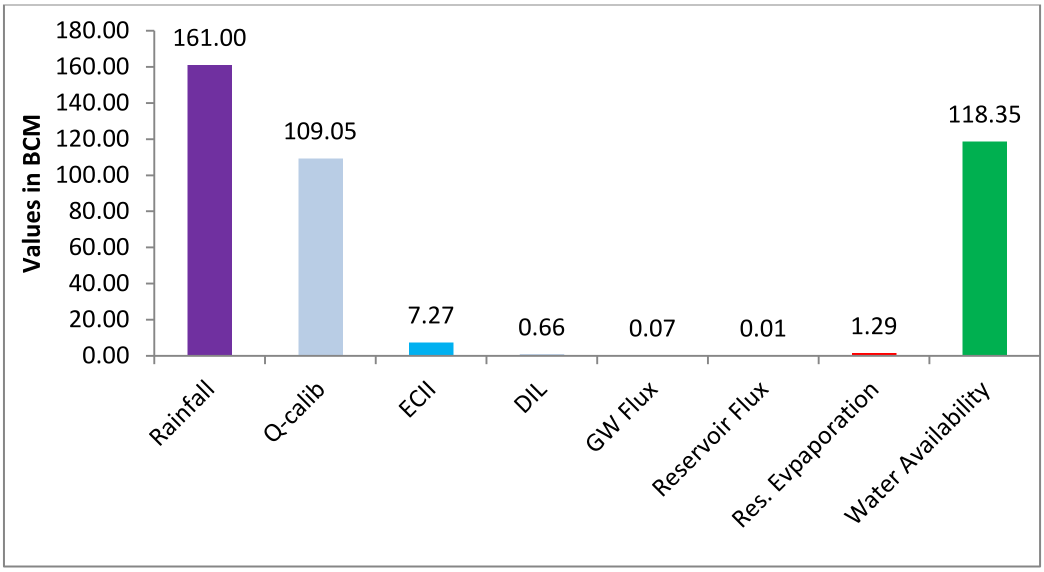
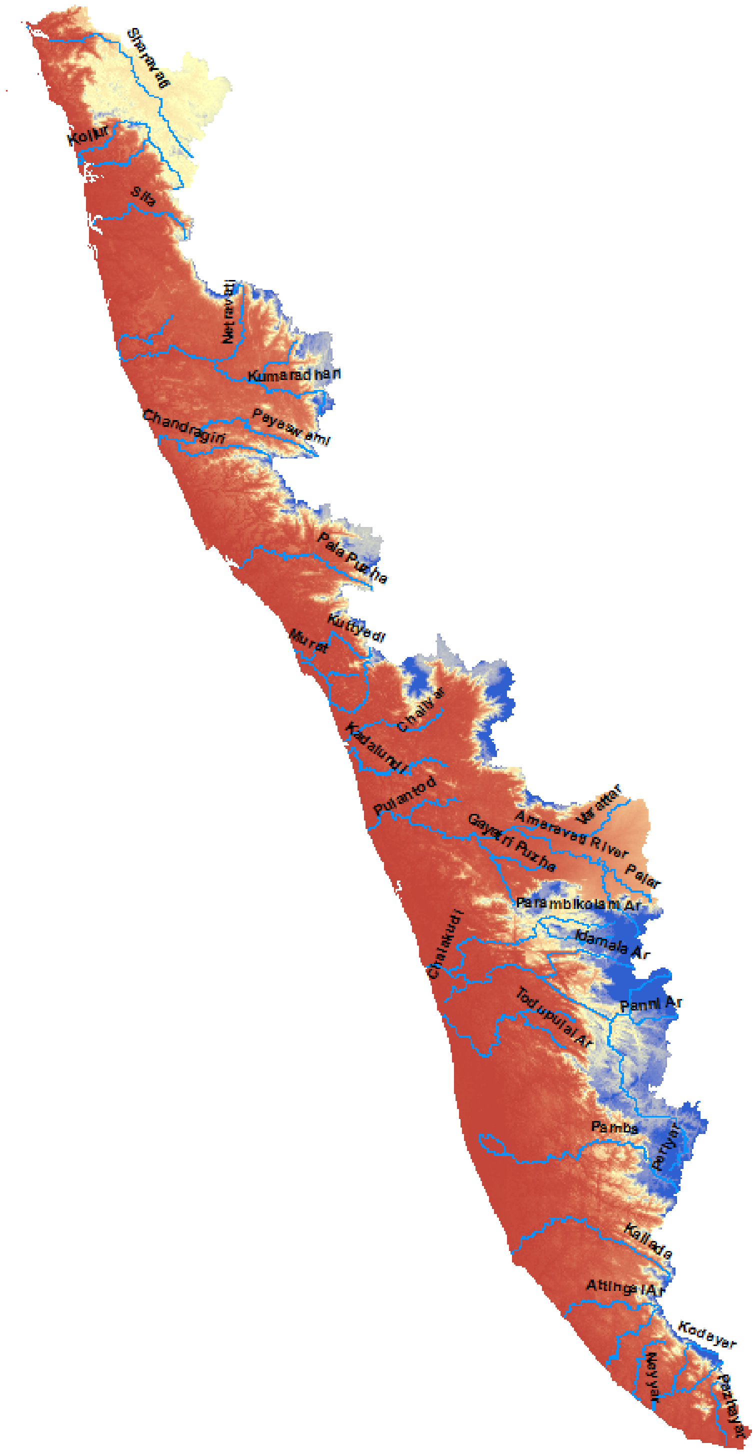


Figure 17.20 Mean water balance components of WFR Tapi to Tadri basin

HIGHLIGHTS

- *Mean annual available water resources of Tapi to Tadri basin is 118.35 BCM.*
- *Maximum annual water availability is 166.10 BCM during 1994-95.*
- *Minimum annual water availability is 81.41 BCM during 1986-87.*
- *Annual rainfall in the basin varies from 1,947 mm to 3,420 mm during 1985-86 to 2014-15 and mean rainfall for these 30 years is 2,661 mm.*
- *WFR Tapi to Tadri basin is divided into four sub-basins for the reassessment study viz. Gadat, Mahuwa, Durvesh, and remaining.*
- *Average annual domestic, industrial and livestock demand in the basin is 0.66 BCM.*
- *Average annual evaporation from water bodies in the basin is 1.29 BCM.*

WEST FLOWING RIVERS FROM TADRI TO KANYAKUMARI



18.1 Geo-Spatial Datasets

18.1.1 Land Use and Land Cover

West Flowing Rivers (WFR) from Tadri to Kanyakumari basin basin holds a variety of Land Use and Land Cover (LULC) classes. Figure 18.1 shows the LULC map for year 2004-05 and its distribution is given in Figure 18.2. The major landuse is plantation or orchard covering about 33.78% of the basin area. The deciduous forest exists in 13.02% and evergreen forests in 22.97%. The irrigated agriculture in Rabi and Double/Triple cropped areas are 3.94% and 4.45% respectively, whereas Kharif crops, which are predominantly rain-fed, occupy 9.54% of the basin area.

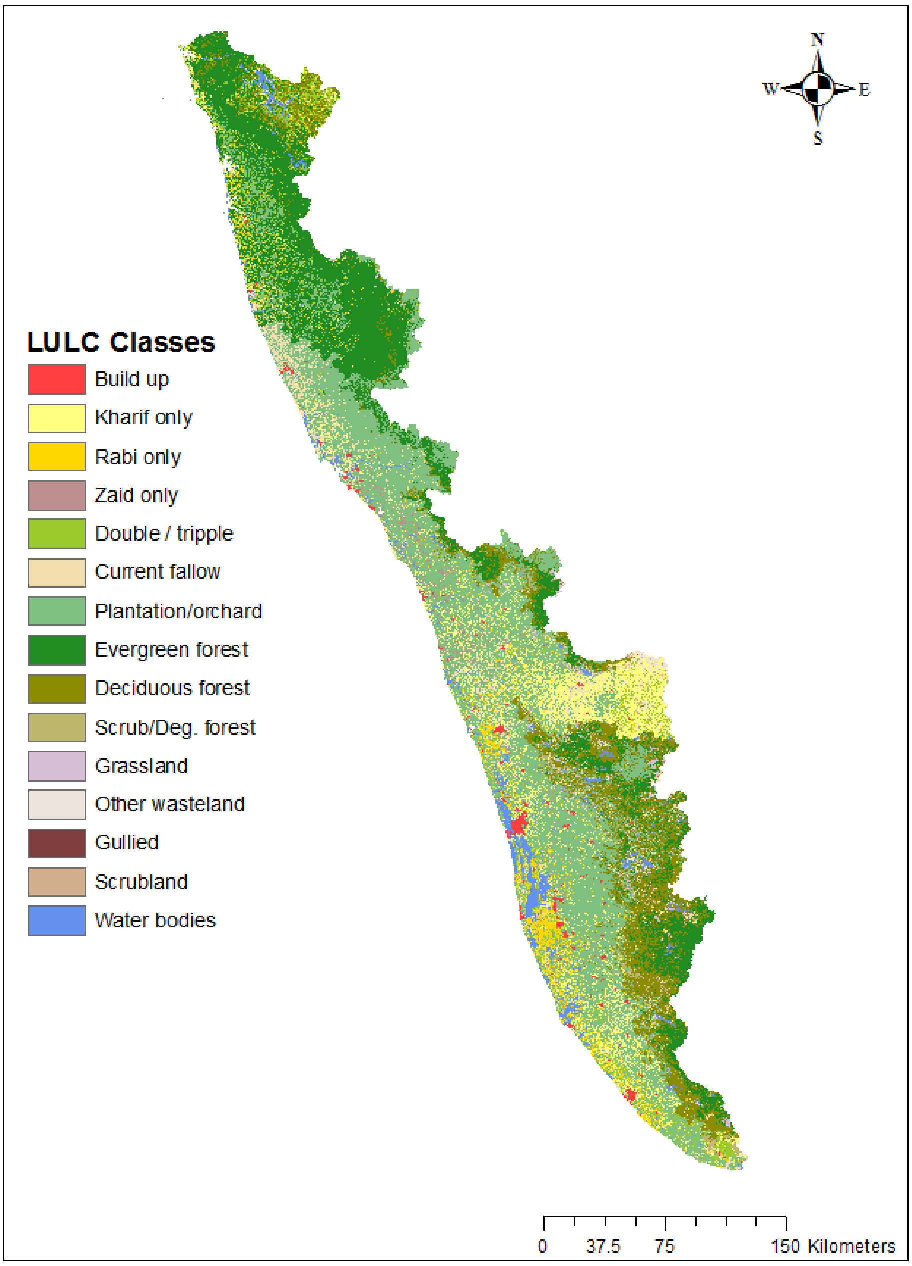


Figure 18.1 LULC map of WFR from Tadri to Kanyakumari basin (2004-05)

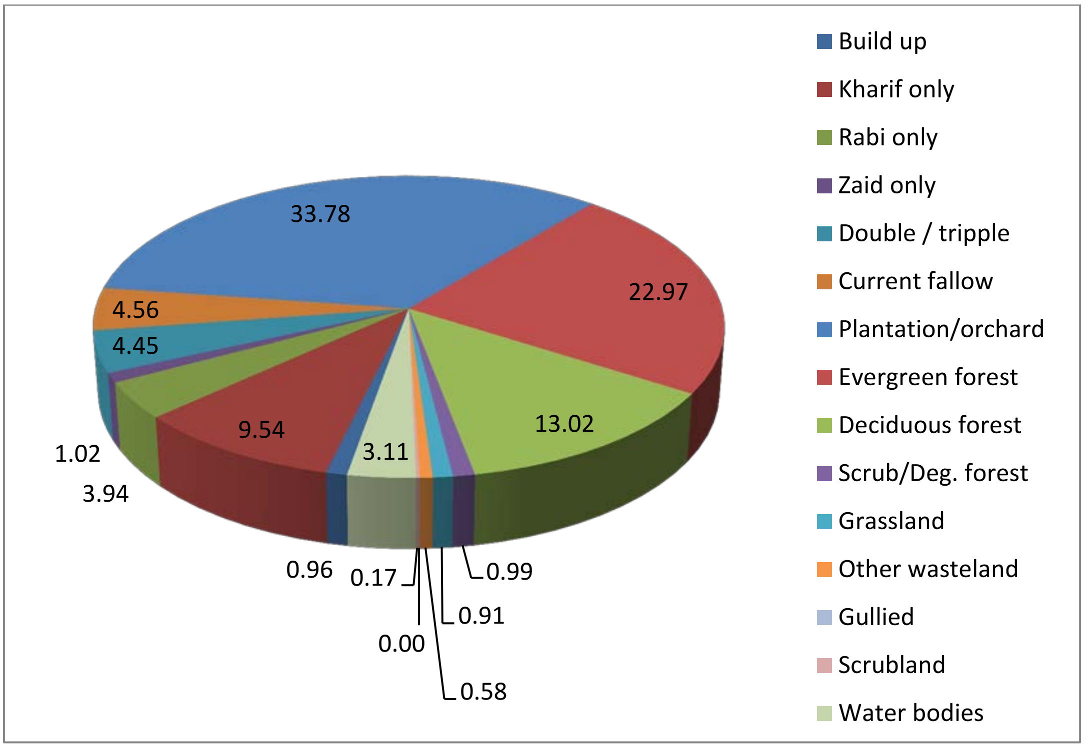


Figure 18.2 Distribution of LULC in WFR from Tadri to Kanyakumari basin (2014-15)

18.1.2 Soil texture

Soils in the basin are composed of minerals, mixed with some organic matter, which differ from its parent materials in terms of its texture, structure, consistency, colour, chemical, biological and other characteristics. The main soil types found in the basin are clayey and clay skeletal type of soils. The coastal plains consist of fertile delta area highly suited for intensive cultivation of rice and coconut. Figure 18.3 shows various categories of soil in the basin. The soils are classified as sandy, loamy, clayey, and rock outcrops based upon the soil textural information.

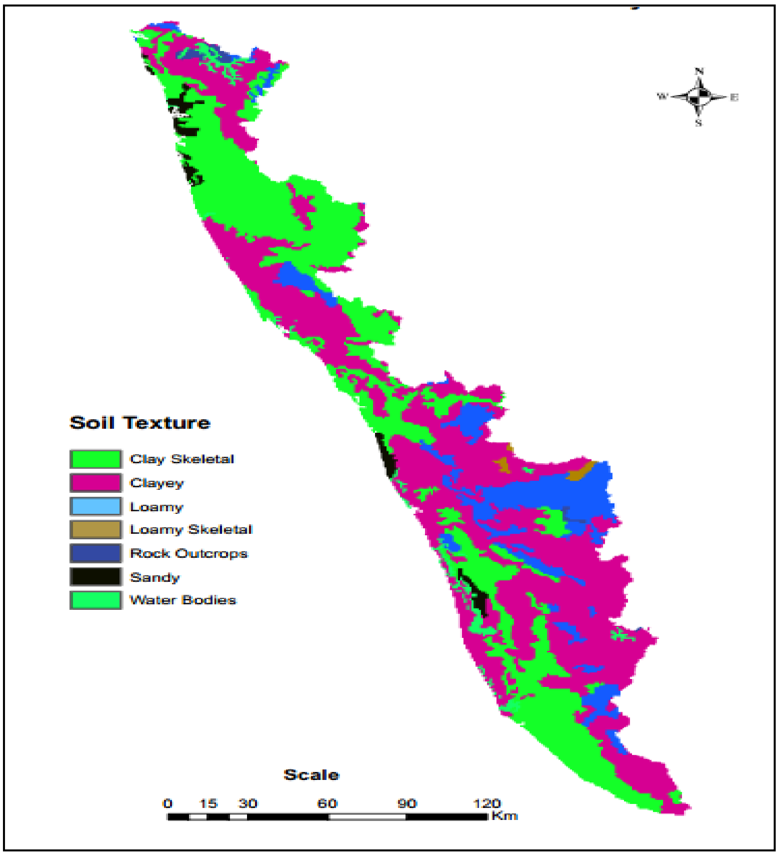


Figure 18.3 Soil texture map of WFR from Tadri to Kanyakumari basin

18.1.3 Topography

The topography of the basin can be divided into hilly and plain regions. The hilly regions are in the upper part of the basin, as well as in the lower middle reaches. The plain regions in between the hilly tracts and in the lower reaches are broad and fertile which are well suited for cultivation. The basin is an almost unbroken line formed by the Sahyadri range of the Western Ghats, ranging from 600 to 2,700 m in height. Basin is very rugged in the north-eastern part and flat towards sea. Major area (23.09%) falls under 10-50 m elevation zone followed by 50-100 m elevation zone (19.55%). Highest elevation is 2,674 m. Figure 18.4 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the basin.

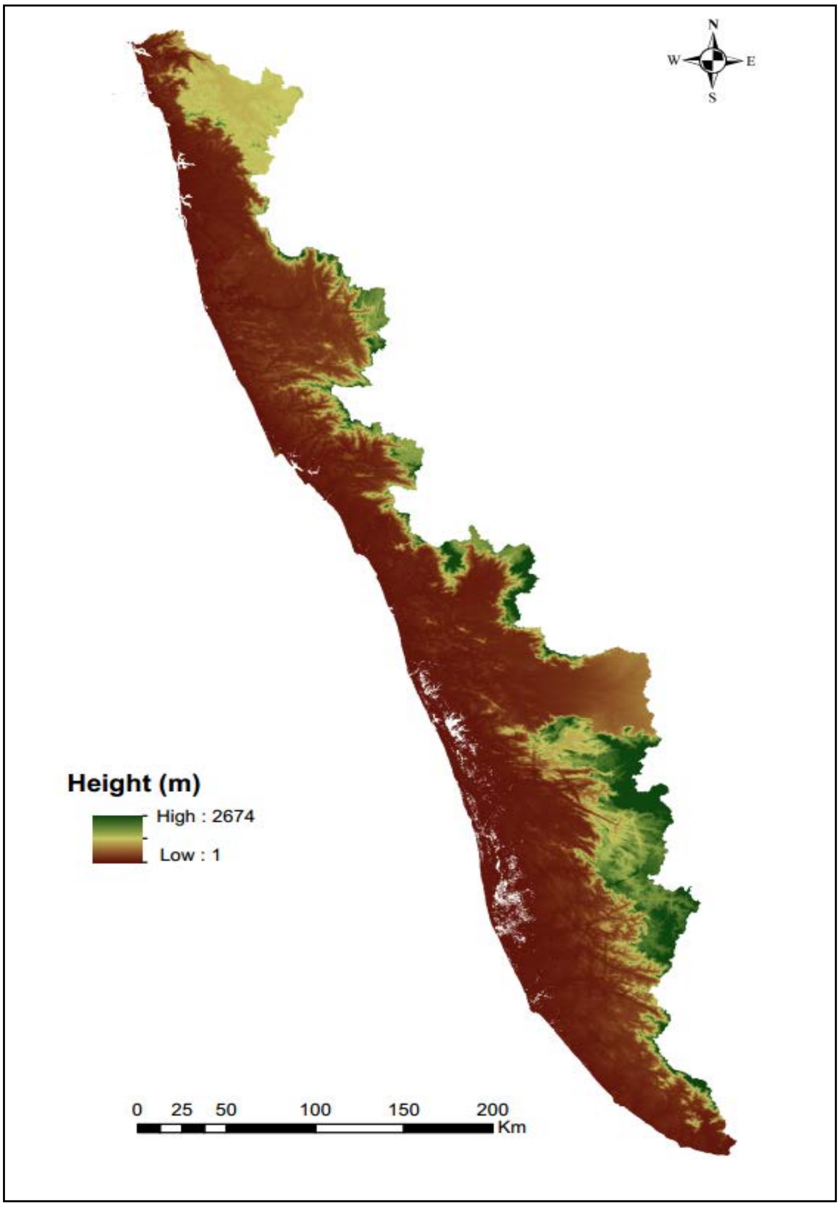


Figure 18.4 SRTM DEM map of WFR from Tadri to Kanyakumari basin

18.2 Hydro-Meteorological and other Input Data

18.2.1 Rainfall grids

The rainfall is uniformly high in the basin. The composite basin, consisting of West Flowing Rivers from Tadri to Kanyakumari, comes under the direct influence of South-West monsoon and receives heavy rainfall between June and August. The rainfall gradually decreases from northern part of Kerala to southern part of Kerala. In Kerala, the period of South-West monsoon is from June to September and the period of north-east monsoon from September to November. The South-West monsoon rainfall is usually very heavy (about two-third of the annual rainfall). Gridded annual rainfall for the year 2004-05 in the basin is shown in Figure 18.5. Most of the basin receives annual rainfall greater than 2,500 mm. Ninety percent of the rainfall occurs from June to November. During this season the sky is cloudy, the air humid and there is gusty and squally rain. During the study period of 30 years (1985-2015), maximum annual rainfall recorded in the entire composite basin is around 3,663 mm in 1994-95 and minimum annual rainfall is 2,181 mm in 2002-03. The mean rainfall in the composite basin during 1985-2015 is 2,773 mm. The annual rainfall shows a rising trend during the study period of 1985 to 2015 as shown in Figure 18.6.

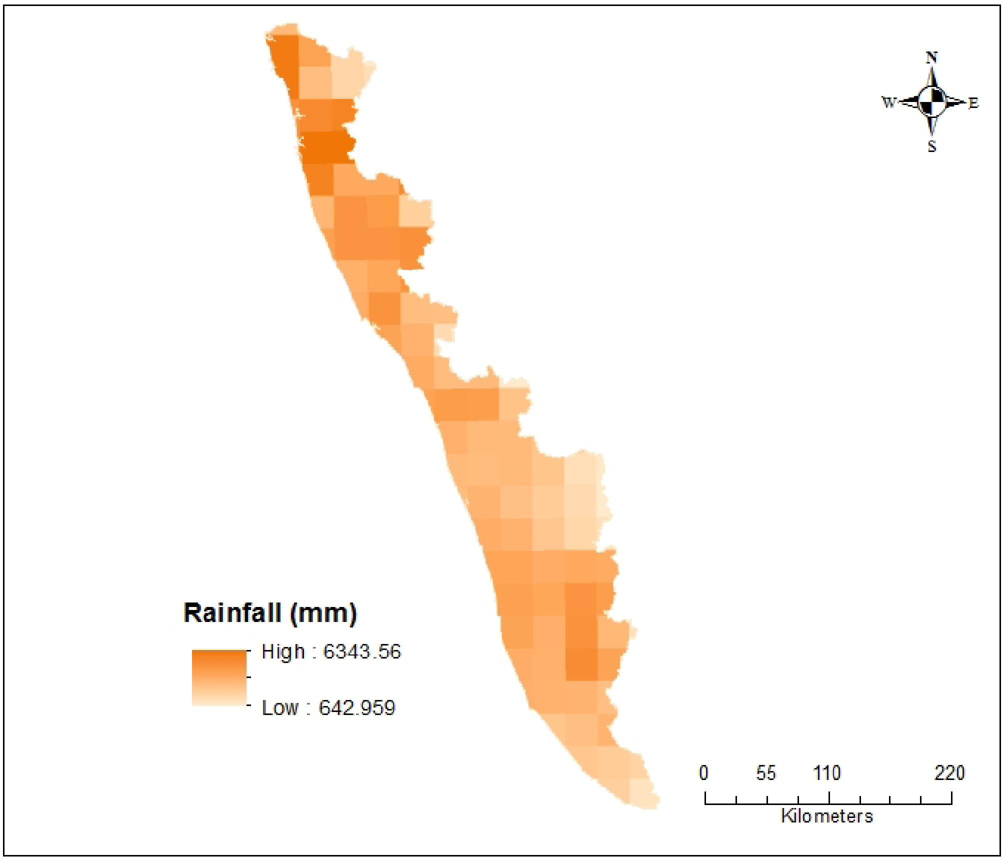


Figure 18.5 Gridded rainfall of WFR from Tadri to Kanyakumari basin (2004-05)

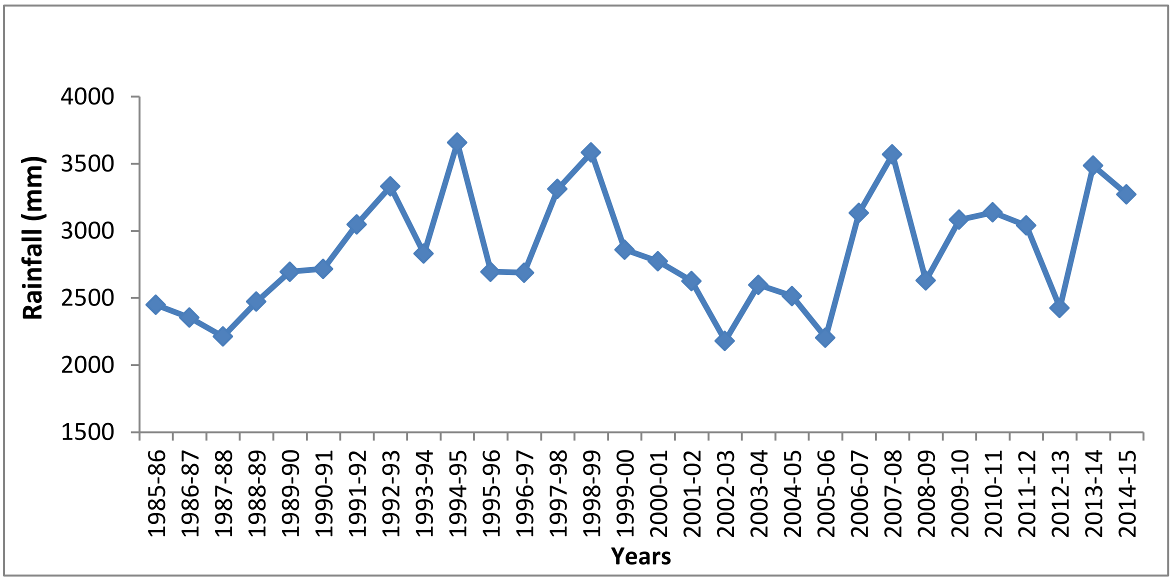


Figure 18.6 Annual rainfall in WFR from **Tadri to Kanyakumari basin (1985-86 to 2014-15)**

18.2.2 Temperature grids

Temperature in the basin generally varies with an average minimum temperature of 18°C in January to average maximum temperature 33°C in April. In the monsoon and post-monsoon seasons, temperatures are moderate and in the range of 25°C to 27.5°C. The northern part of the basin experiences lower temperatures than its southern part. Temperatures are higher in the plains (lower reaches) than in the hills (upper reaches). Gridded mean annual temperature for the basin for 2004-05 is shown in Figure 18.7.

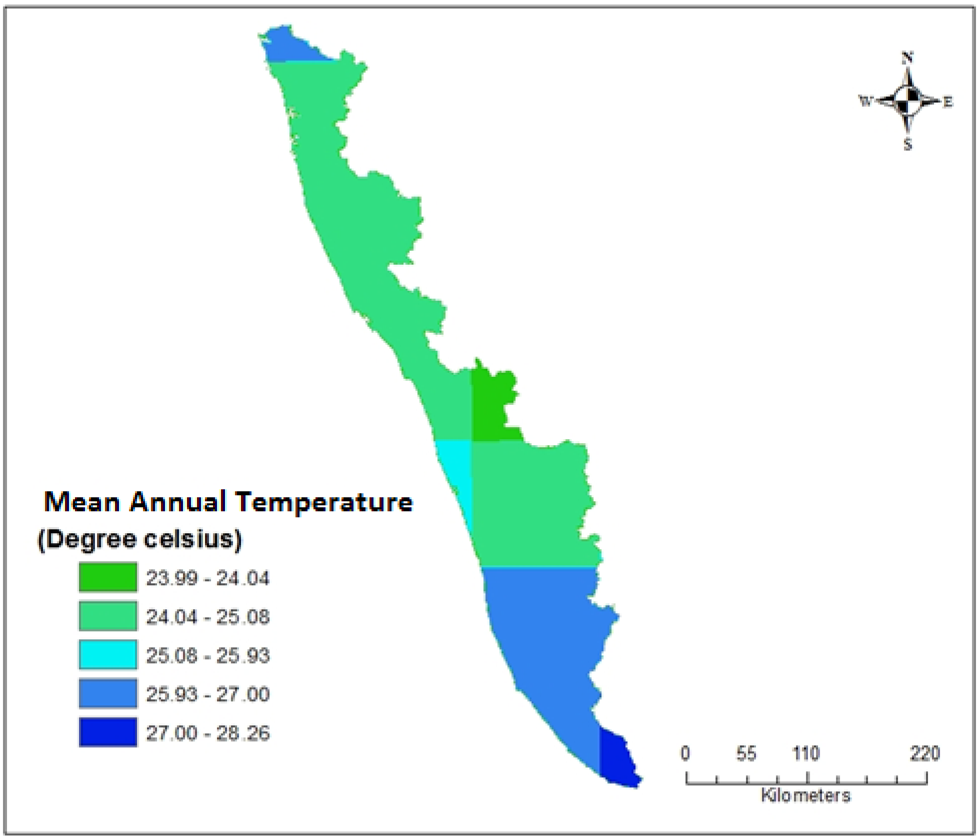


Figure 18.7 Gridded mean annual temperature of WFR from Tadri to Kanyakumari basin (2004-05)

18.2.3 Sub-basins of WFR from Tadri to Kanyakumari basin

The composite basin consisting of West Flowing Rivers (Tadri to Kanyakumari) has been divided into nine sub-basins based on the drainage pattern. The eight sub-basins have been delineated using outlets at CWC's gauging stations. These are Gurpur, Netravati, Valapatanam, Chaliyar, Bharathapuzha, Periyar, Pamba, and Kallada (Figure 18.8). However, the sub-basins, which did not have CWC gauging data for the study period of 1985-2015, have been clubbed into one as "Others". Thus, there are total nine sub-basins considered in this composite basin i.e. eight sub-basins wherein CWC data is available for the study period, and one ungauged sub-basin named as "Others". The basin boundary is same as that of India WRIS. The details of sub-basins have been presented in Table - 18.1.

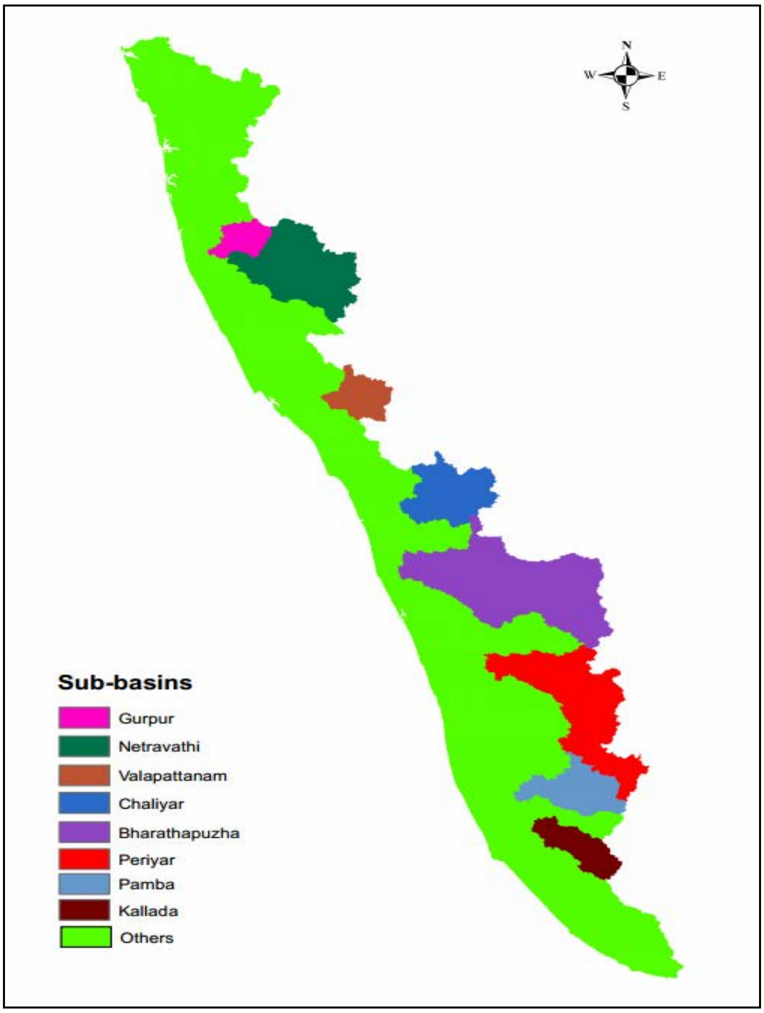


Figure 18.8 Sub-basins of WFR from Tadri to Kanyakumari basin

Table -18.1 Sub-basin wise details of WFR Tadri to Kanyakumari basin

S. No.	River /Sub-basin	CWC G&D Site	Individual drainage area (sq.km)
1	Gurpur	Addoor	690
2	Netravati	Bantwal	3,202
3	Valapatnam	Perumannu	1,019
4	Chaliyar	Kuniyil	1,992
5	Bharathapuzha	Kumbidi	5,783
6	Periyar	Neeleswaram	4,033
7	Pamba	Malakkara	1,620
8	Kallada	Pattazhy	1,138

9	Others	-	34,754
		Total basin area	54,231

18.2.4 River discharge

The river discharge data were selected by considering the drainage pattern and spatial distribution of G&D sites. Discharge data were available at all the sites for the study period of 30 years except for Addoor, wherein the data was available only for 2003 to 2015. The daily discharge data have been aggregated to annual scale and used for calibration and validation of model computed discharge at sub-basin level. Eight CWC G&D stations were chosen for model calibration and validation are:

18.2.5 Reservoir flux

Reservoir flux data from 16 major and medium reservoirs have been obtained from CWC. Reservoir locations in the basin are shown in Figure 18.9. Annual flux during all the 30 years is calculated and used in the assessment of water resources of the basin.

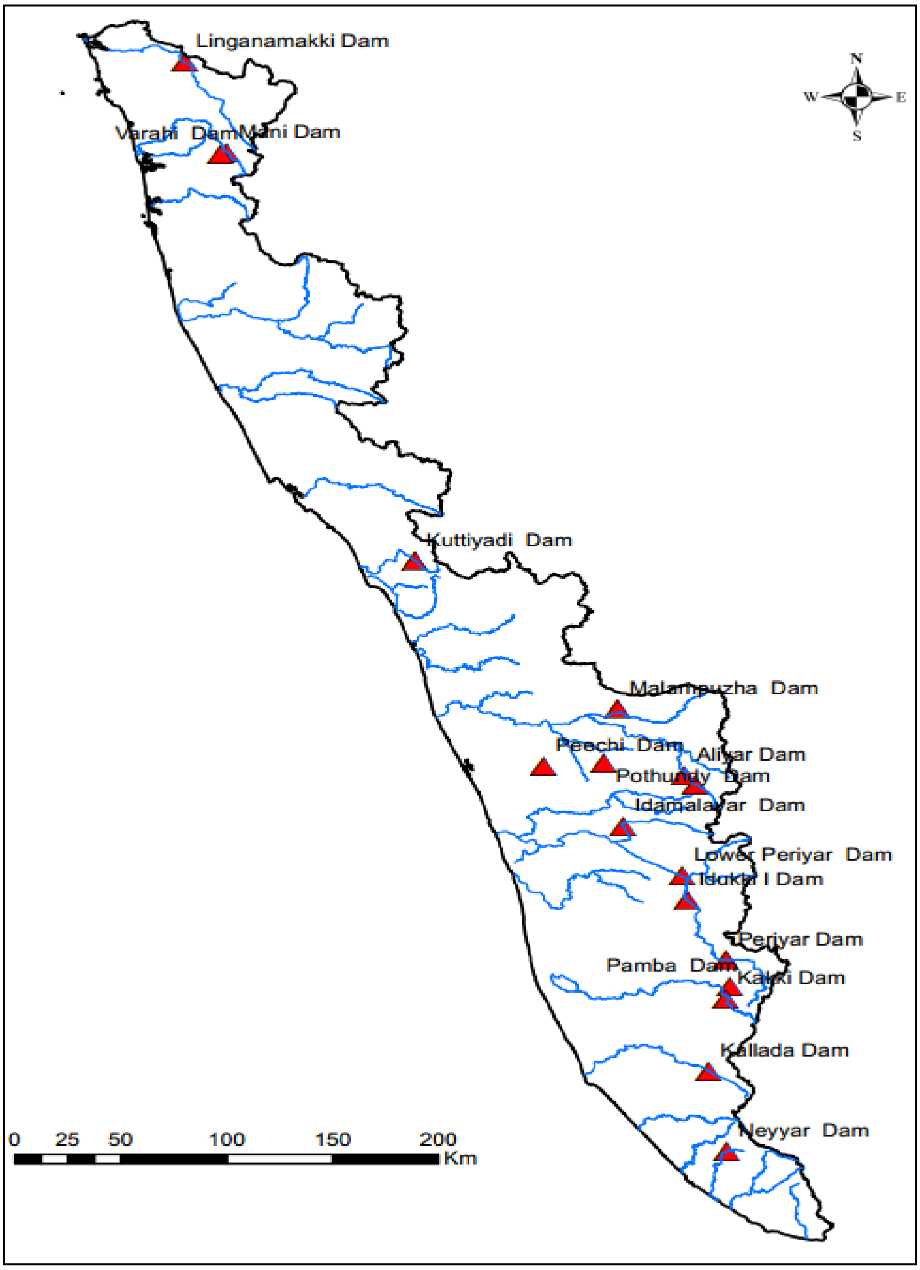


Figure 18.9 Major and medium reservoirs in WFR from Tadri to Kanyakumari basin

18.2.6 Groundwater flux

The basin receives high rainfall, therefore, the groundwater recharge is also good. As the southern part of the basin has two monsoon seasons: SW monsoon, as well as NE monsoon, the area has sufficient soil moisture and groundwater availability. Figure 18.10 presents spatial groundwater flux map for the year 2004-05. The cumulative change in groundwater storage in MCM for the period 1985-2015 is shown in Figure 18.11. It can be seen that there is no permanent depletion of groundwater table, indicating no over-exploitation of groundwater.

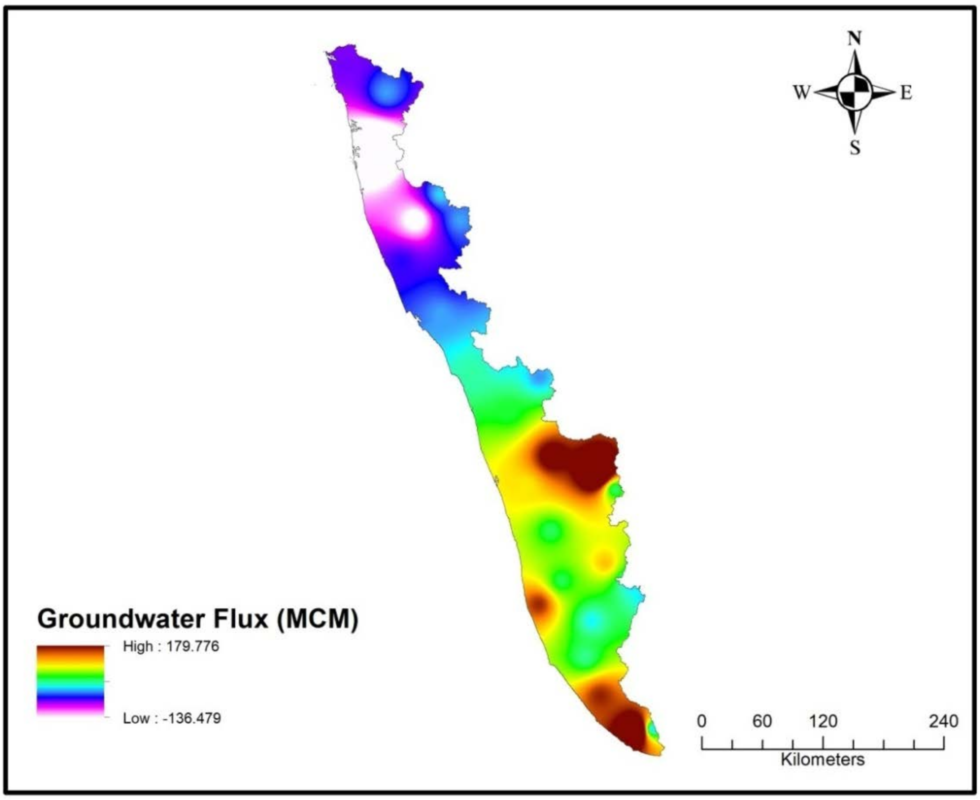


Figure 18.10 Groundwater flux (spatial data) estimated during 2004-05

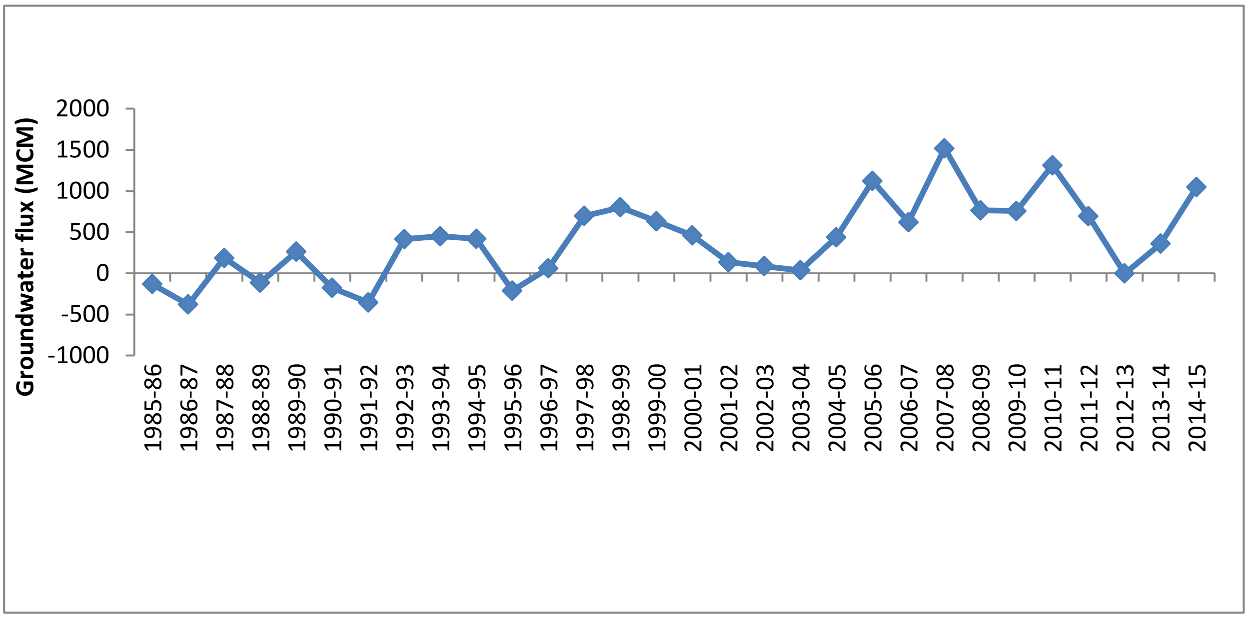


Figure 18.11 Annual cumulative groundwater flux of WFR from Tadri to Kanyakumari basin (1985-86 to 2014-15)

18.2.7 Major crops in the basin

The entire basin is divided in four regions based on the historic district-wise crop statistics collected from various sources (http://lus.dacnet.nic.in/dt_lus.aspx). Each region specifies a unique crop for each crop-season, both spatially and temporally, within the basin. The crop coefficients are calibrated so that the model discharge matches, more or less, with the observed discharge at eight G&D sites in the basin.

18.2.8 Irrigation command area

Figure 18.12 shows the location of irrigation command boundaries inside the basin and outside the basin considered for the year 2014-15. The command area is about 24% of the total basin area. In case of Kharif only crop, irrigation support is provided only to the cropped area located within the command boundary. For Double/Triple crop, irrigation support is provided irrespective of whether the area is located within or outside the surface command boundary. If the Double/Triple cropped area is outside the surface command, it is logical to assume that the area might be under irrigation from either the groundwater or surface water lift schemes. Hence, the command area during the year 2014-15 is worked out to be around 13,00,947 hectare (excluding the basin outside command).

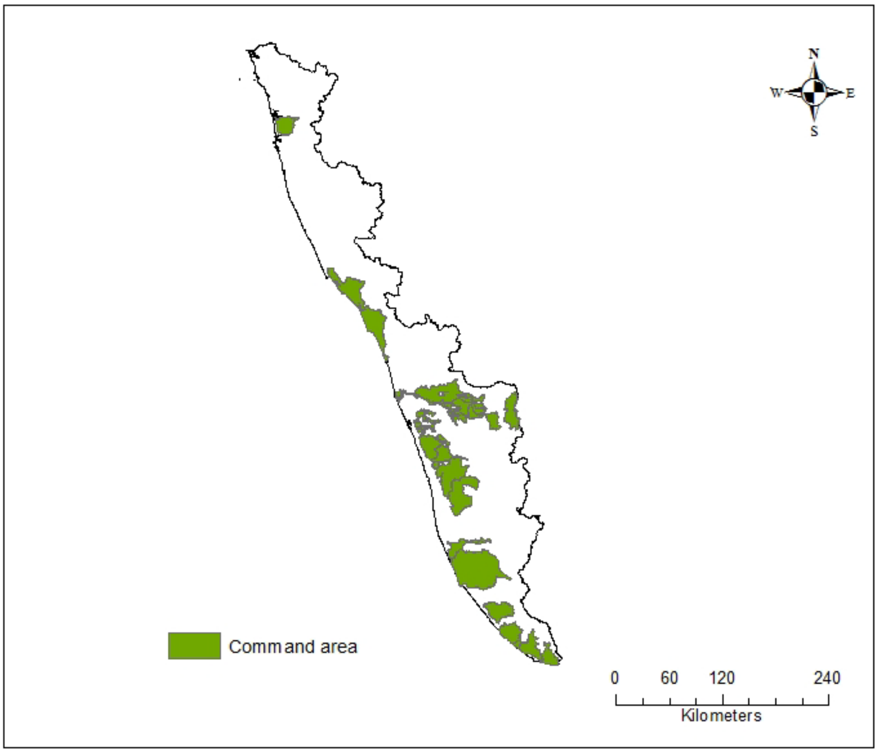


Figure 18.12 Irrigation command boundaries of WFR from Tadri to Kanyakumari basin

18.2.9 Domestic, Industrial and livestock demand

Figure 18.13 shows district boundaries layer for the year 2011 census. The mean annual domestic, industrial, and livestock demands are estimated as 0.79 BCM in the basin.

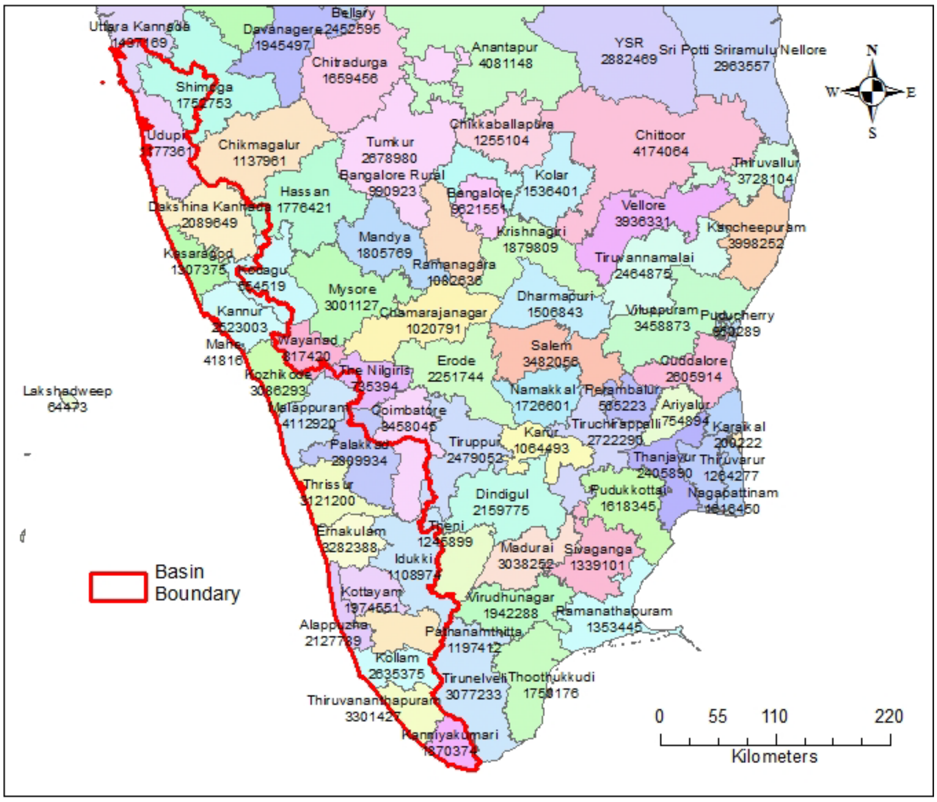


Figure 18.13 District boundaries in WFR Tadri to Kanyakumari basin

18.2.10 Evaporation from major/medium/minor reservoirs and other water bodies

Table 18.2 provides annual evaporation values from each of sub-basins for the period of 1985-86 to 2014-15 (30 years). The average annual evaporation volume for the basin is worked out as 1.27 BCM.

Table - 18.2 Evaporation in reservoirs of WFR Tadri to Kanyakumari basin

Year	Reservoir Evaporation (BCM)	Year	Reservoir Evaporation (BCM)
1985-86	1.33	2000-01	1.62
1986-87	1.32	2001-02	1.43
1987-88	0.42	2002-03	1.40
1988-89	0.50	2003-04	1.43
1989-90	1.41	2004-05	1.53
1990-91	1.43	2005-06	1.00
1991-92	1.41	2006-07	1.42
1992-93	1.47	2007-08	0.49
1993-94	0.44	2008-09	1.21
1994-95	1.09	2009-10	1.41
1995-96	1.35	2010-11	1.42
1996-97	1.43	2011-12	1.70
1997-98	1.45	2012-13	1.54
1998-99	1.65	2013-14	1.12
1999-00	1.48	2014-15	1.31
		Avg	1.27

18.3 Previous Estimates

As per 1993 report, this basin has 54 minor river systems of which five rivers had observed flow records for 12 to 16 years. As explained above these flow records along with the flow records for two river systems in the basin containing west flowing rivers from Tapi to tadri were analysed and a relationship was developed between average annual catchment rainfall and runoff. Using this relationship and knowing the catchment rainfall, the runoff in the remaining river systems was estimated. The previous CWC (1993) estimate of available water resources of the total basin was 113.5 BCM.

18.4 Runoff Estimation

Tables - R.1 to R.9 (at Annexure - R) give calibrated runoff along with observed discharge, rainfall, ECII, etc. during 30 years for the three G&D sites and remaining basin. Figures 18.15 to 18.23 show comparative graphs of calibrated runoff and observed discharge at these G&D sites.

Table - R.10 at Annexure - R gives calibrated runoff of WFR from Tadri to Kanyakumari basin. The average annual calibrated runoff is about 111.68 BCM. The maximum annual calibrated runoff is 134.66 BCM during 1992-93. The minimum annual calibrated runoff occurred as 81.16 BCM during 1987-88. The average annual ECII is about 5.22 BCM. The maximum annual ECII is about 7.90 BCM during 2011-12. The minimum annual ECII is about 1.09 BCM during 1988-89.

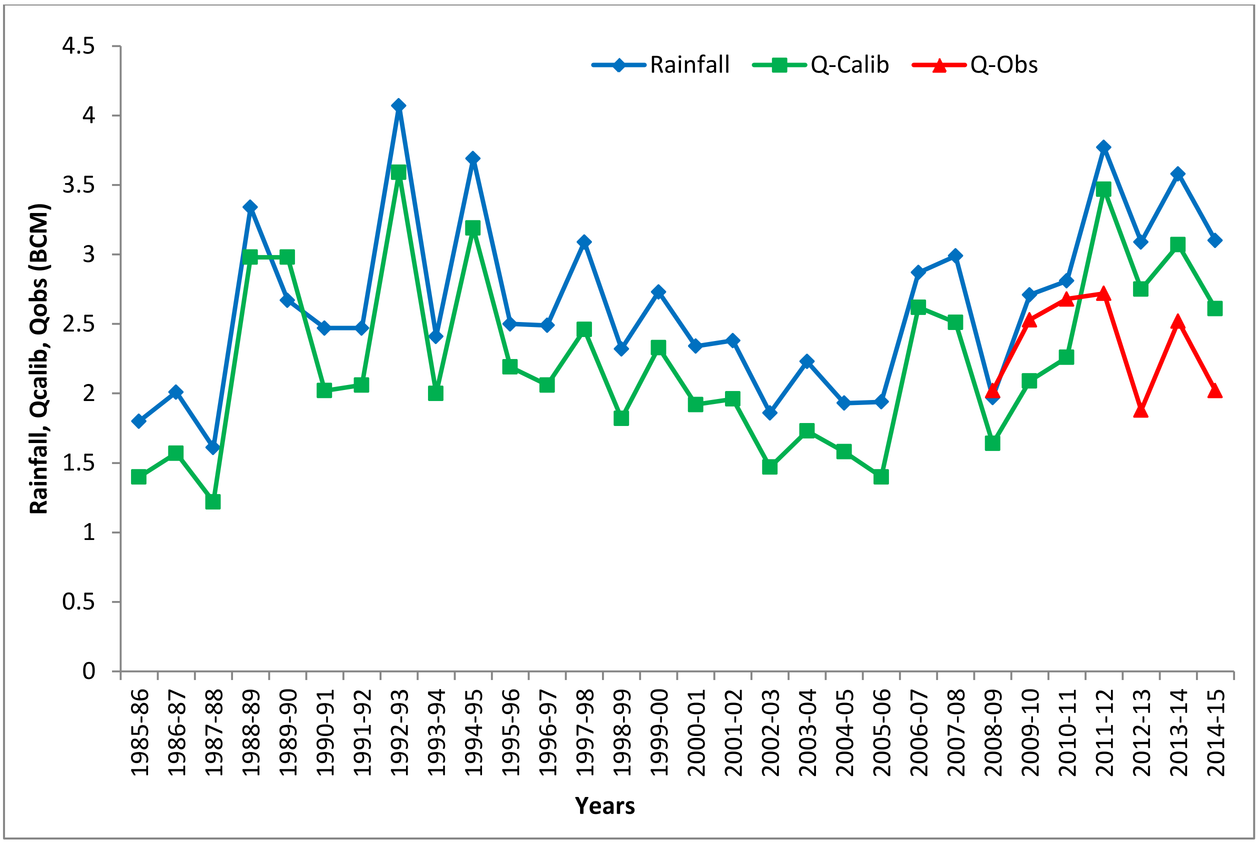


Figure 18.15 Calibrated runoff and observed discharge at Adoor

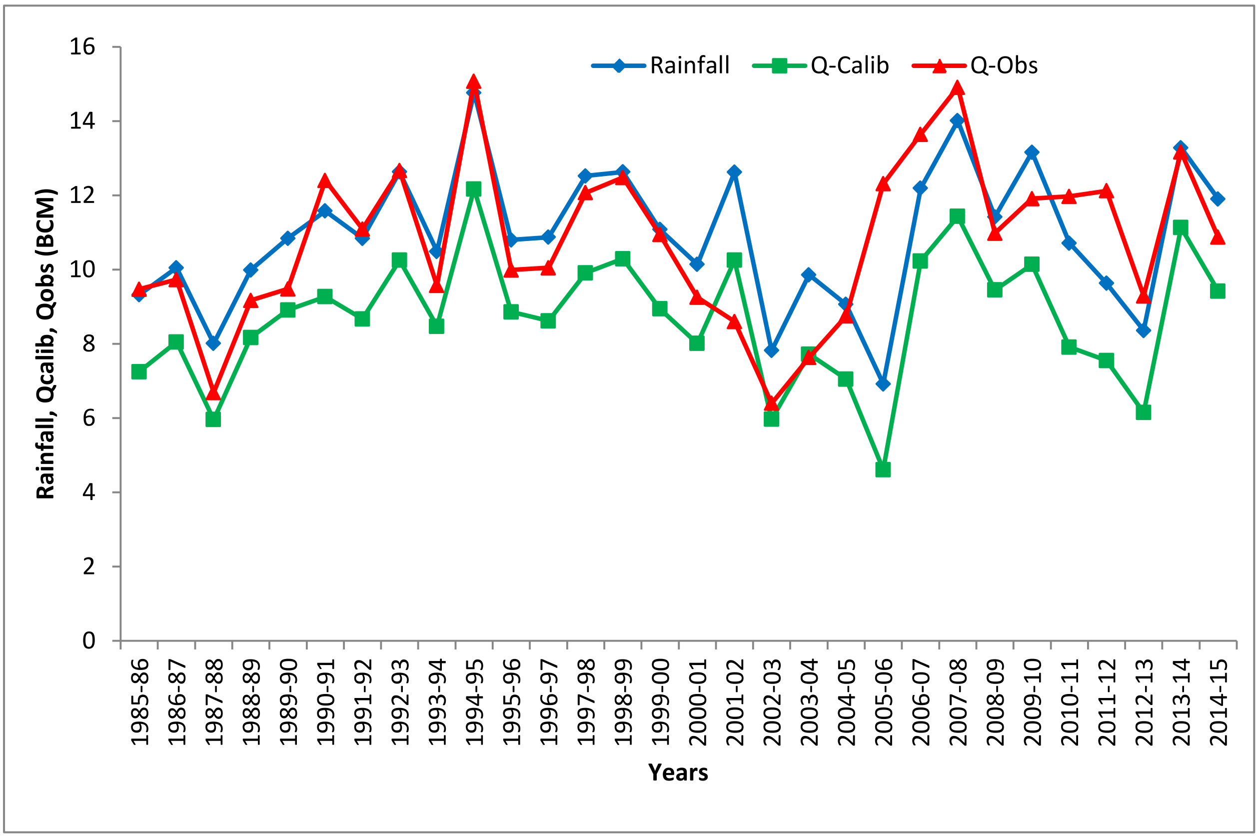


Figure 18.16 Calibrated runoff and observed discharge at Bantwal

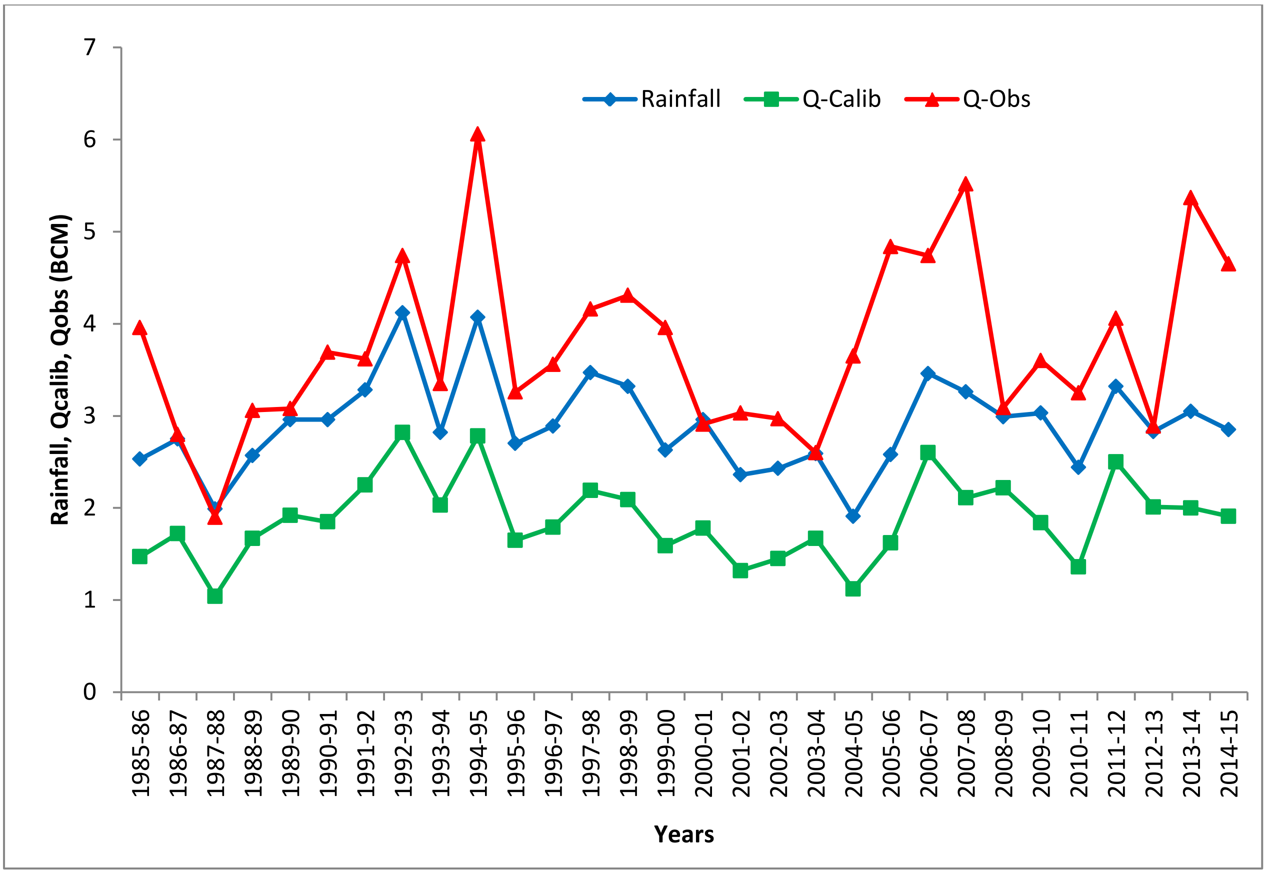


Figure 18.17 Calibrated runoff and observed discharge at Perumannu

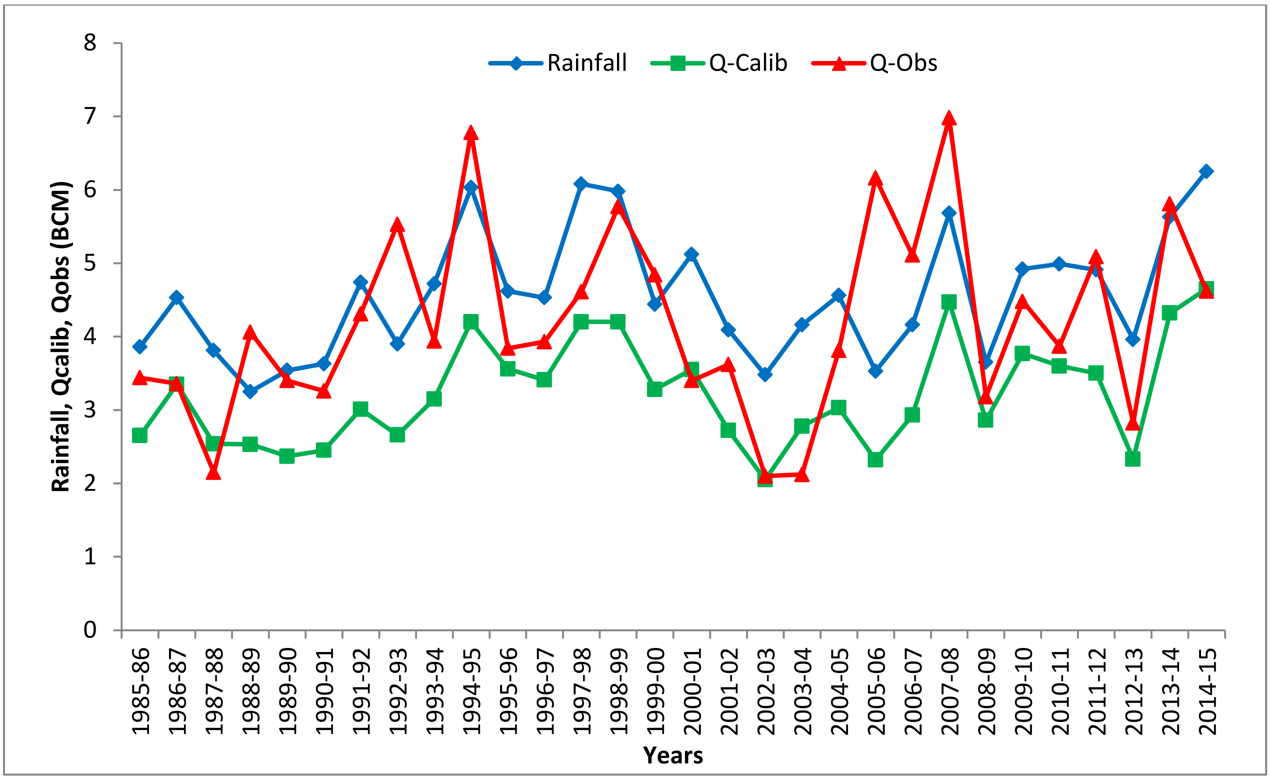


Figure 18.18 Calibrated runoff and observed discharge at Kuniyil

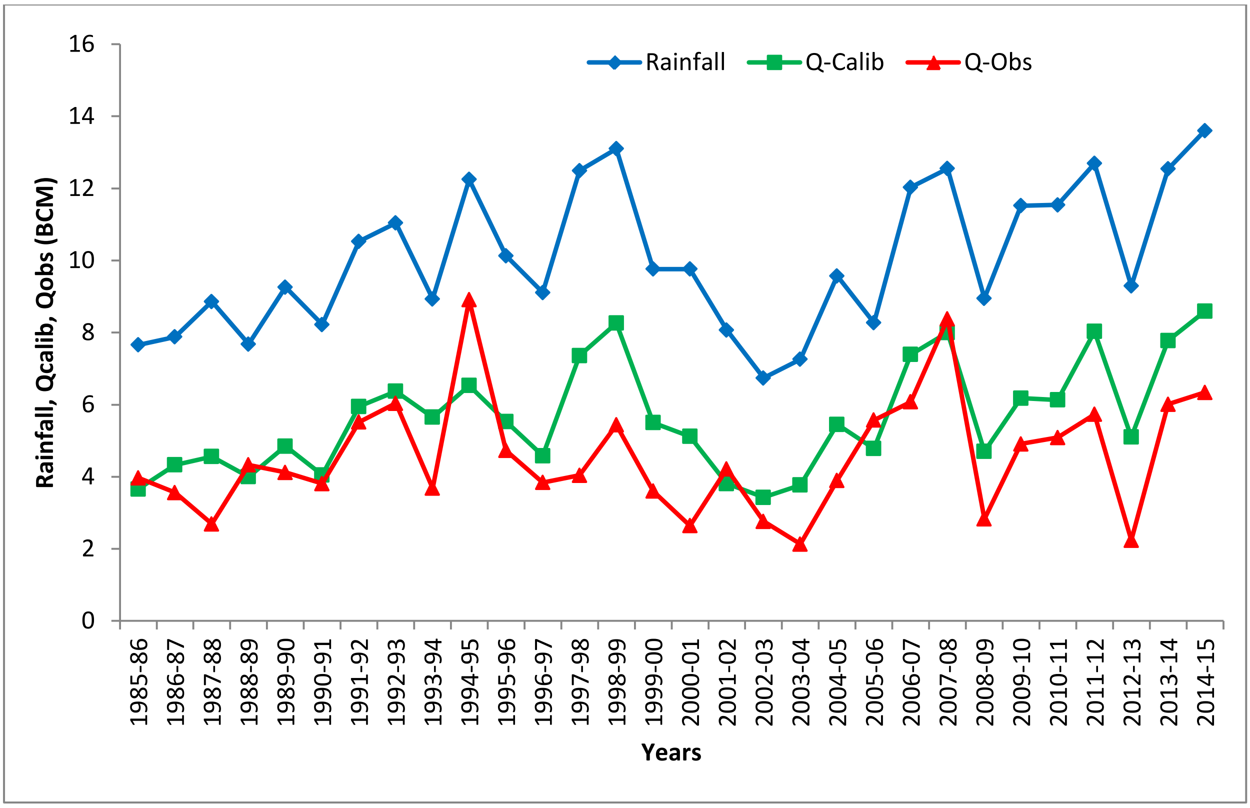


Figure 18.19 Calibrated runoff and observed discharge at Kumbidi

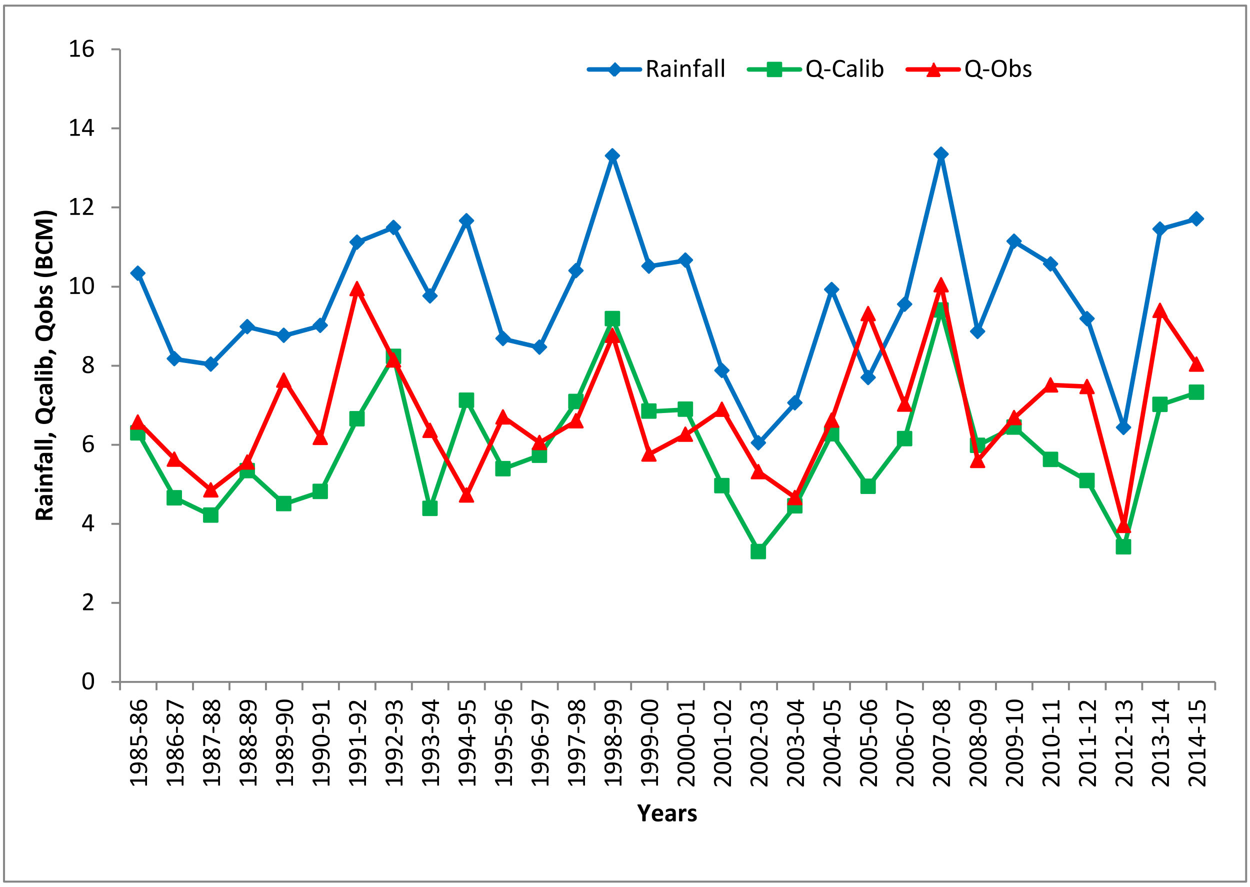


Figure 18.20 Calibrated runoff and observed discharge at Neeleshwaram

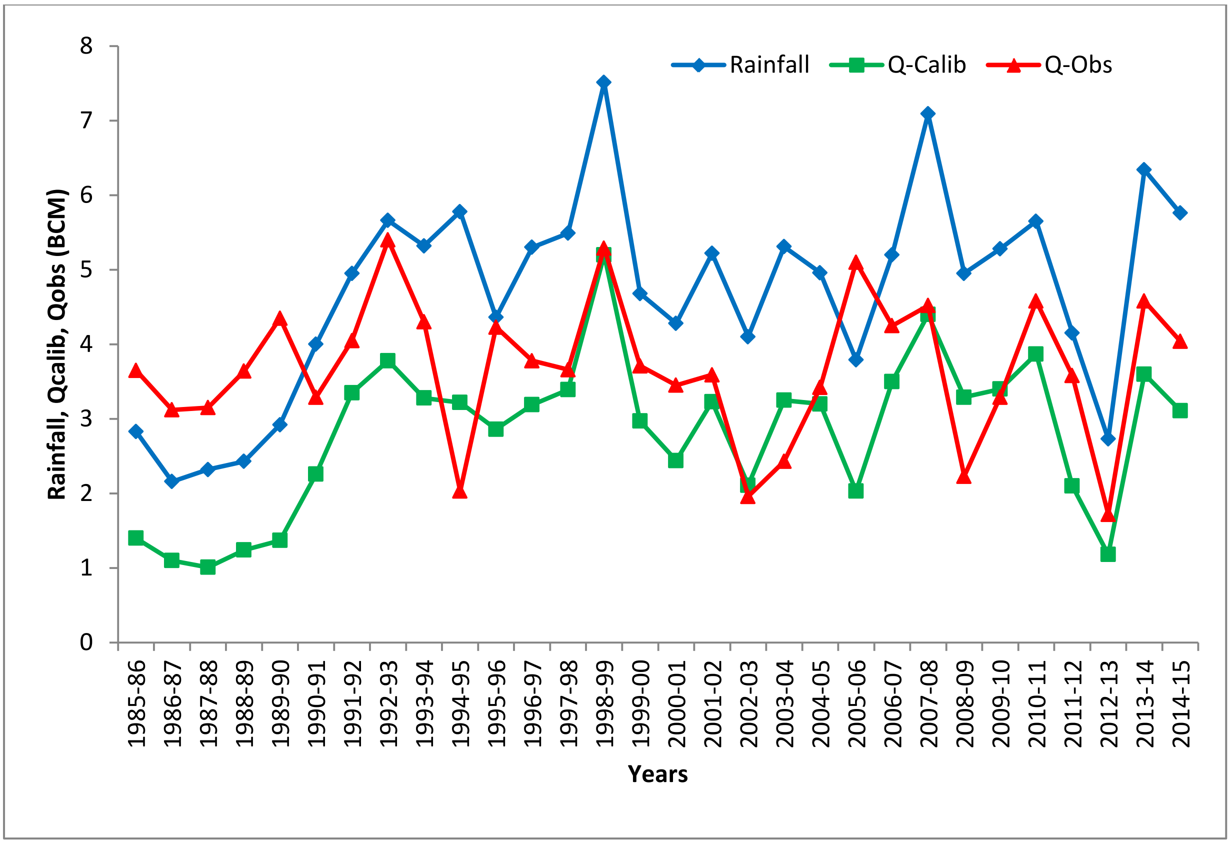


Figure 18.21 Calibrated runoff and observed discharge at Malakkara

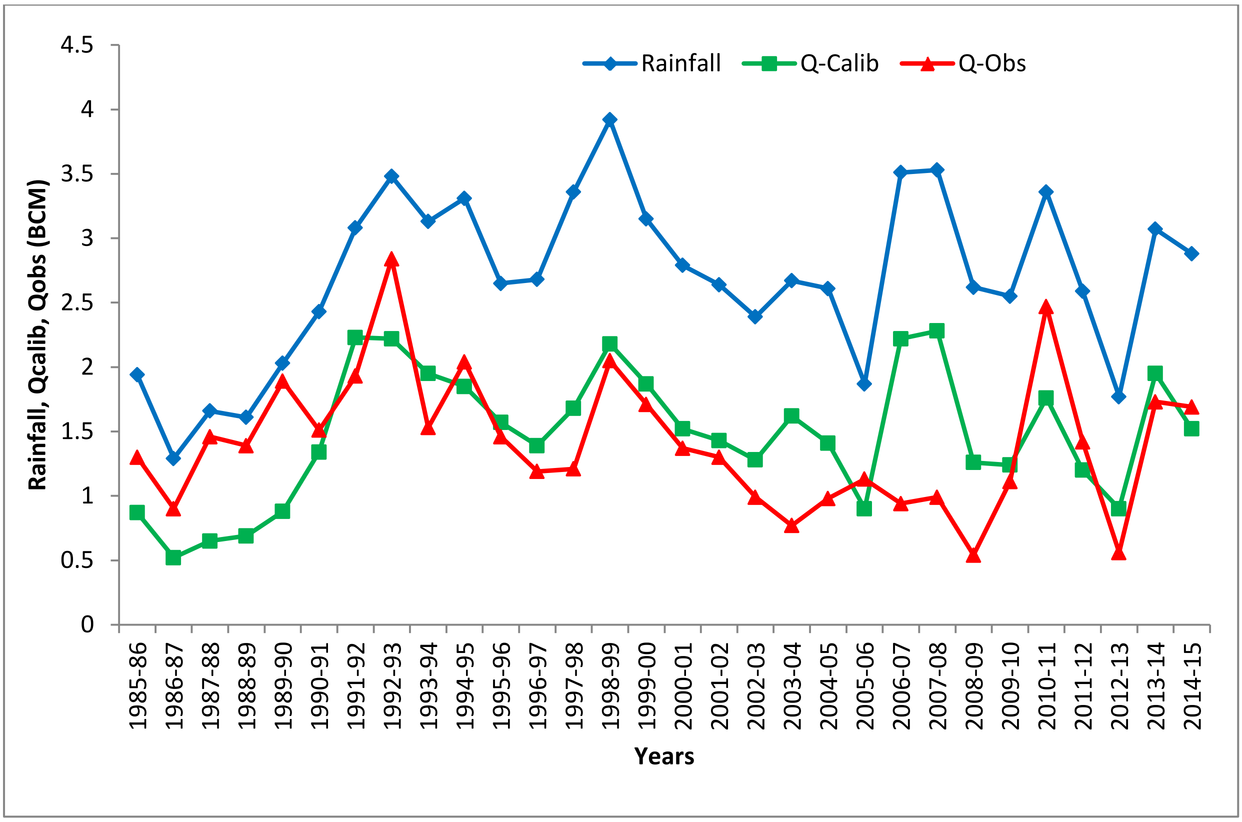


Figure 18.22 Calibrated runoff and observed discharge at Pattazhy

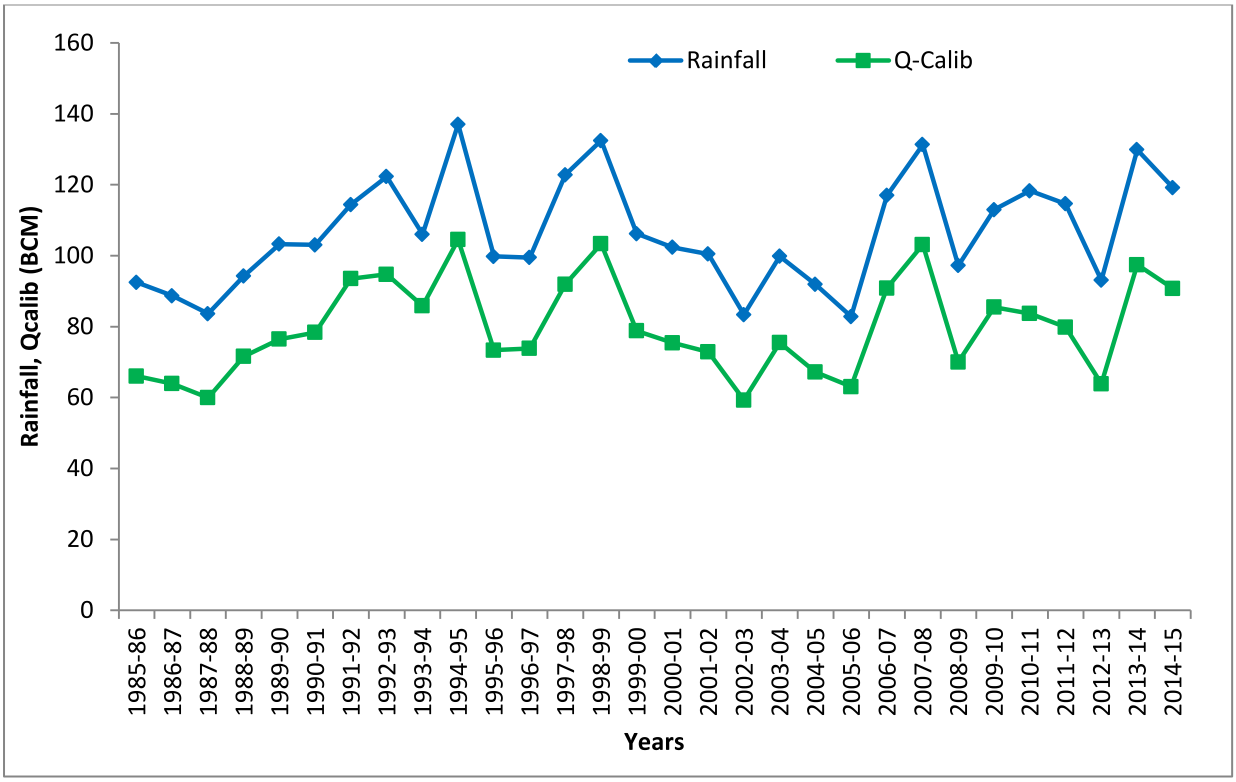


Figure 18.23 Calibrated runoff and rainfall in Ungauged catchment

18.4 Annual Water Resources Availability of WFR Tadri to Kanyakumari Basin

Table - R.10 at Annexure - R shows the different components required to estimate the basin level water resources of WFR from Tapi to Tadri basin for 30 years period. The mean available annual water resource of the Tadri to Kanyakumari is 119.06 BCM.

The mean water potential is 78.85% of the mean annual rainfall during the 30 years (1985-86 to 2014-15).

Various results of the study in respect of the basin comprising are as follows:

Average annual water availability	119.06 BCM
75% Dependable water availability	106.13 BCM

18.4.1 Annual water resources of WFR from Tadri to Kanyakumari basin during extreme rainfall conditions

Out of the total 30 years of meteorological data base of study period, the driest year is 2002-03 and the wettest year is 1994-95. The annual water resources of the basin during the wettest and the driest year are 151.21 BCM and 86.77 BCM respectively as shown in Table - 18.3. The water balance components during these years are presented in the Figures 18.24 and 18.25.

Table - 18.3 Water resources availability in WFR from Tadri to Kanyakumari basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum rainfall	1994-95	193.63	151.21
Minimum rainfall	2002-03	114.23	86.77

Runoff-rainfall ratio during the wettest and driest years is found to be 0.78 and 0.76 respectively; this shows that the higher the rainfall, higher is the runoff factor. The AET due to rain is 47.30 BCM in the wettest year and 31.47 BCM in the driest year. The mean AET due to rain is 35.72 BCM.

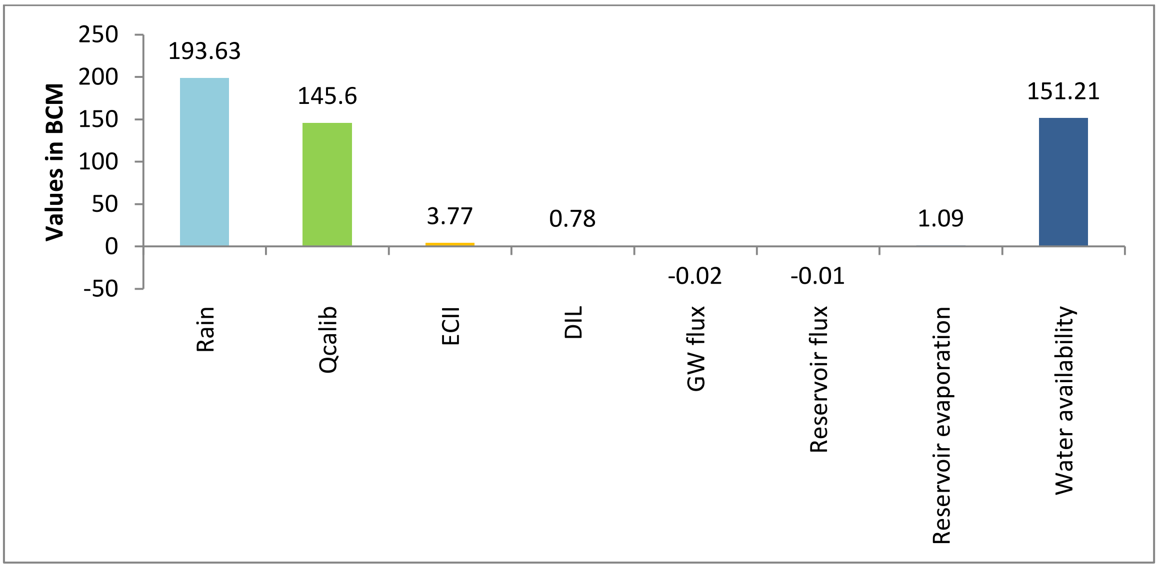


Figure 18.24 Water balance components of WFR from Tadri to Kanyakumari basin during extreme high rainfall (1994-95)

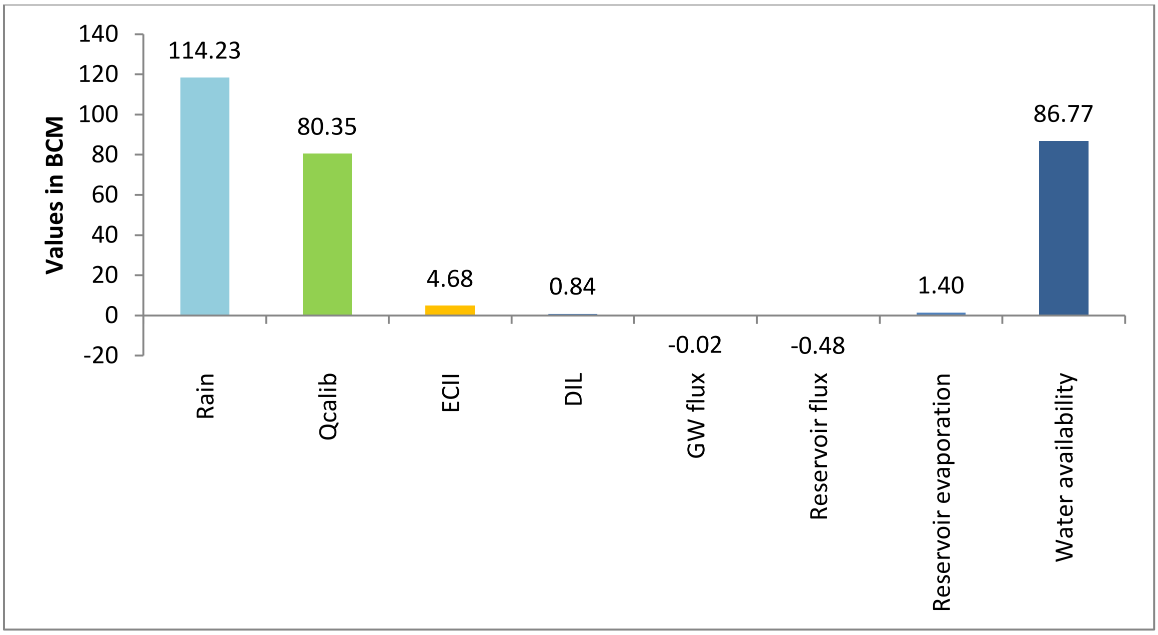


Figure 18.25 Water balance components of WFR from Tadri to Kanyakumari basin during extreme low rainfall (2002-03)

18.4.2 Mean water resources of WFR from Tadri to Kanyakumari basin

The mean water resources of the basin is computed by taking mean of the 30 years water balance components such as flow in the river at final outlet, consumptive use in the basin for irrigation, domestic and industrial, change in storage of groundwater, change in storage of reservoirs and evaporation from reservoirs.

Mean Water Resources Availability = Mean of (Calibrated discharge + ECII + domestic, industrial and livestock consumption + groundwater flux + reservoir flux + export from basin + Evaporation from reservoirs)

= 111.68 + 5.22 + 0.79 + 0.05 + 0.05 + 0 + 1.27 = 119.06 BCM

The mean available annual water resource of the Tadri to Kanyakumari is 119.06 BCM.

75% dependable flow of WFR from Tadri to Kanyakumari basin = 106.13 BCM.

Figure 18.26 shows the various water balance components averaged over a period of 30 years during 1985-86 to 2014-15.

It is observed that the computed runoff factors varies from 0.67 (2,426 mm rainfall) to 0.77 (3,051 mm rainfall). The mean runoff factor for 30 year period is 0.72. The high values of runoff factors are mainly attributed to the steep slopes of Western Ghat region.

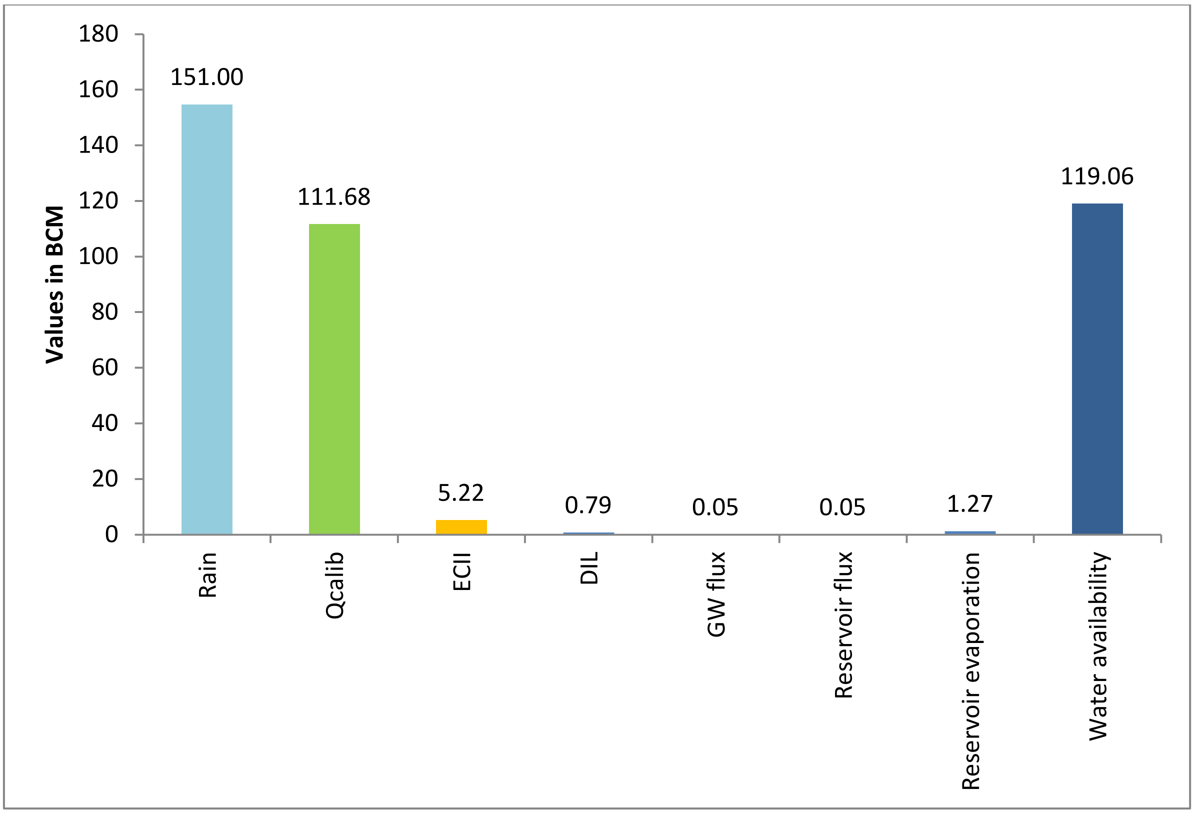
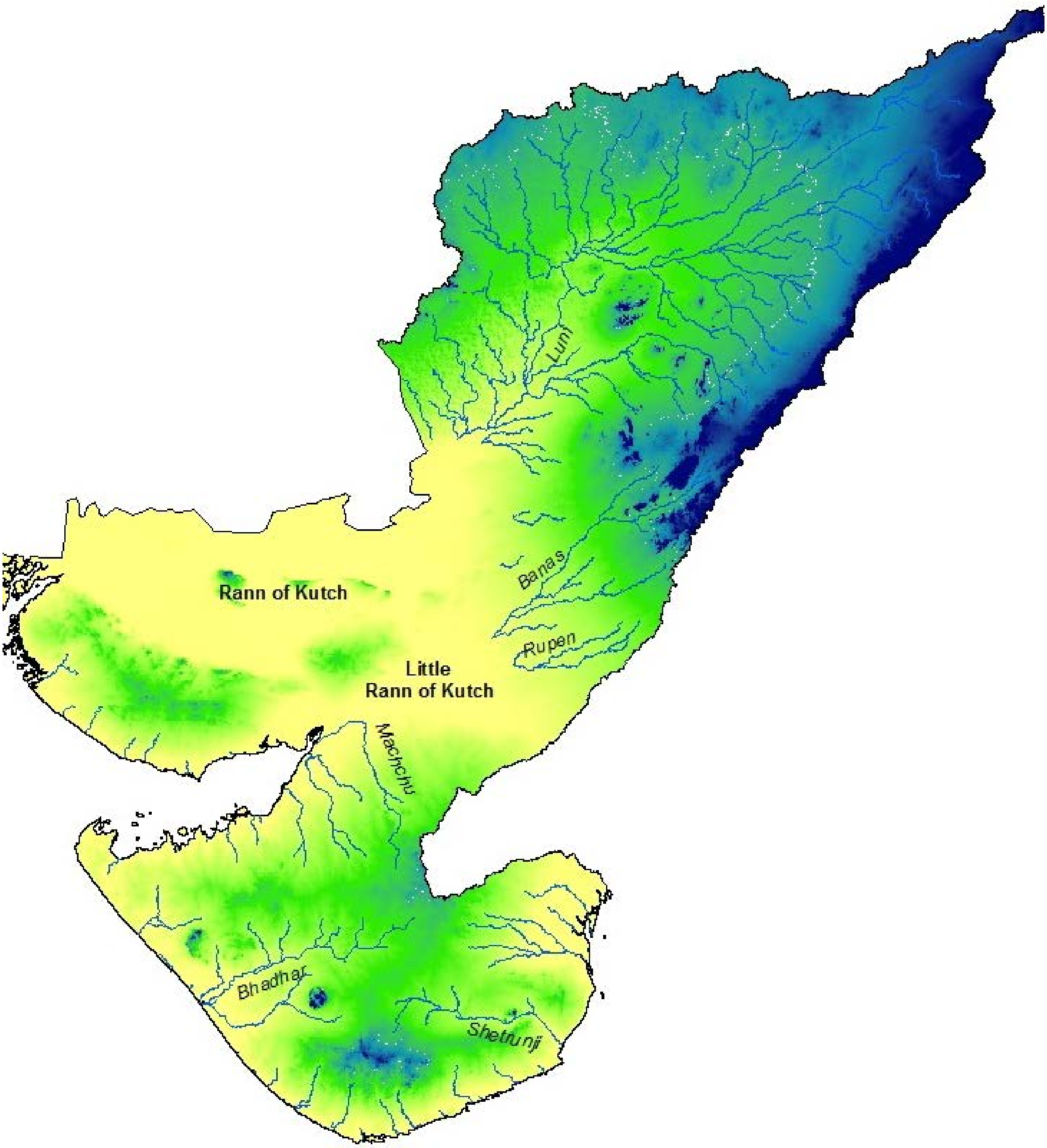


Figure 18.26 Mean water balance components of WFR from Tadri to Kanyakumari basin

HIGHLIGHTS

- *Mean annual available water resources of WFR Tadri to Kanyakumari basin is 119.06 BCM.*
- *Maximum annual water availability is 154.96 BCM during 1998-99.*
- *Minimum annual water availability is 86.77 BCM during 2002-03.*
- *Annual rainfall in the basin varies from 2,181 mm to 3,663 mm during 1985-86 to 2014-15 and mean rainfall for these 30 years is 2,773 mm.*
- *WFR Tadri to Kanyakumari basin is divided into nine sub-basins for the reassessment study viz. Gurpur, Netravati, Valapatanam, Chaliyar, Bharathapuzha, Periyar, Pamba ,Kallad and Others.*
- *Average annual domestic, industrial and livestock demand in the basin is 0.79 BCM.*
- *Average annual evaporation from water bodies in the basin is 1.27 BCM.*

WEST FLOWING RIVERS OF KUTCH & SAURASHTRA INCLUDING LUNI



19.1 Geo-Spatial Datasets

19.1.1 Land Use and Land Cover

The Land Use and Land Cover of WFR of Kutch & Saurashtra including Luni basin for year 2004-05 is shown in Figure 19.1. From the LULC map it is found that thirteen land use classes exist in the study area. Agriculture land is the predominant land use in the basin accounting for more than 58% (including current fallow) of the basin area. This extent varies slightly from year to year. The land cover analysis of 2004-05 indicates Kharif only (21.73%), Double/Triple crop (7.92%), current fallow (25.33%), wasteland (17.71%), and scrubland (14.63%) are the major classes in the basin as shown at Figure 19.2.

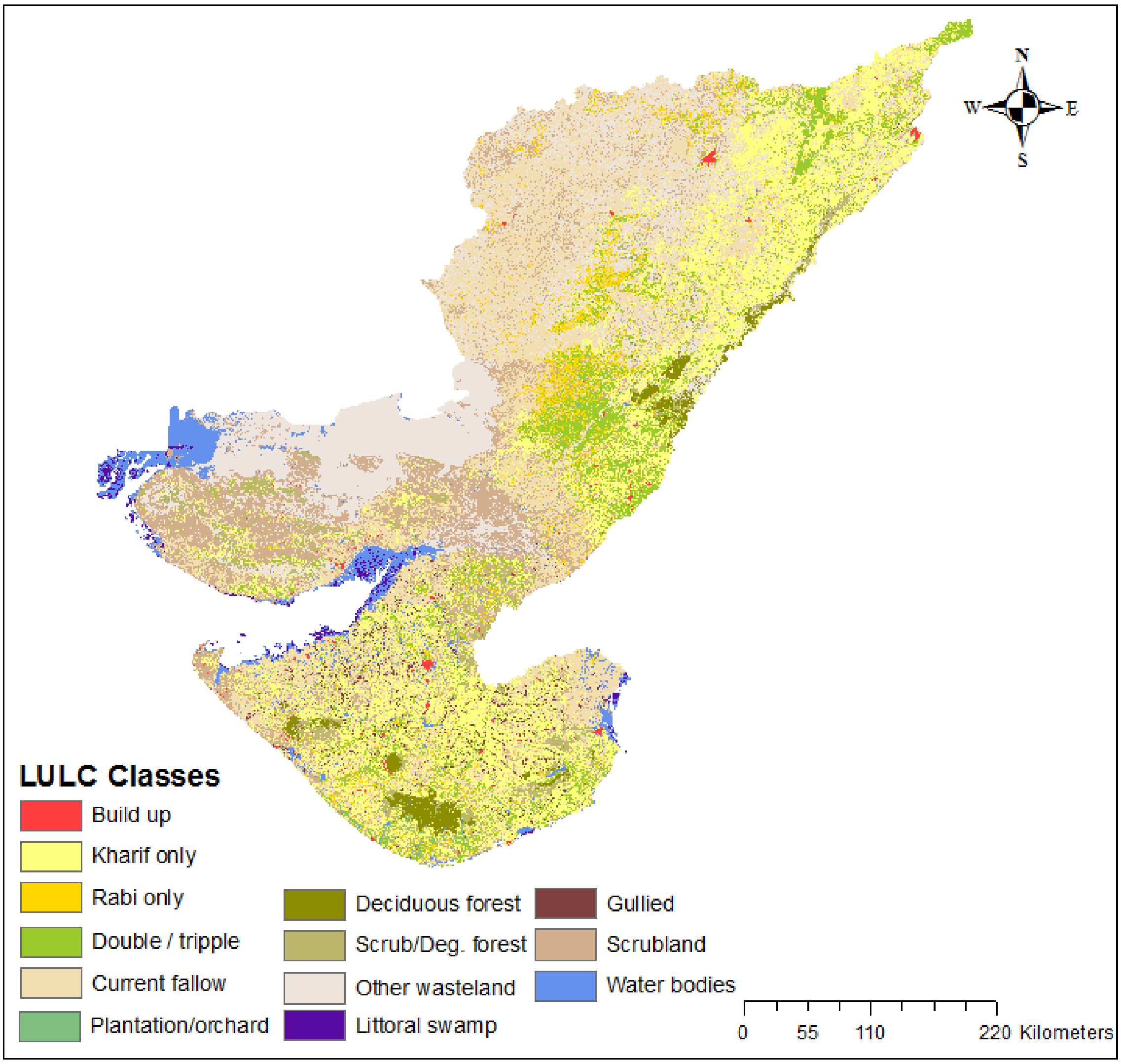


Figure 19.1 LULC map of WFR of Kutch & Saurashtra including Luni basin (2004-05)

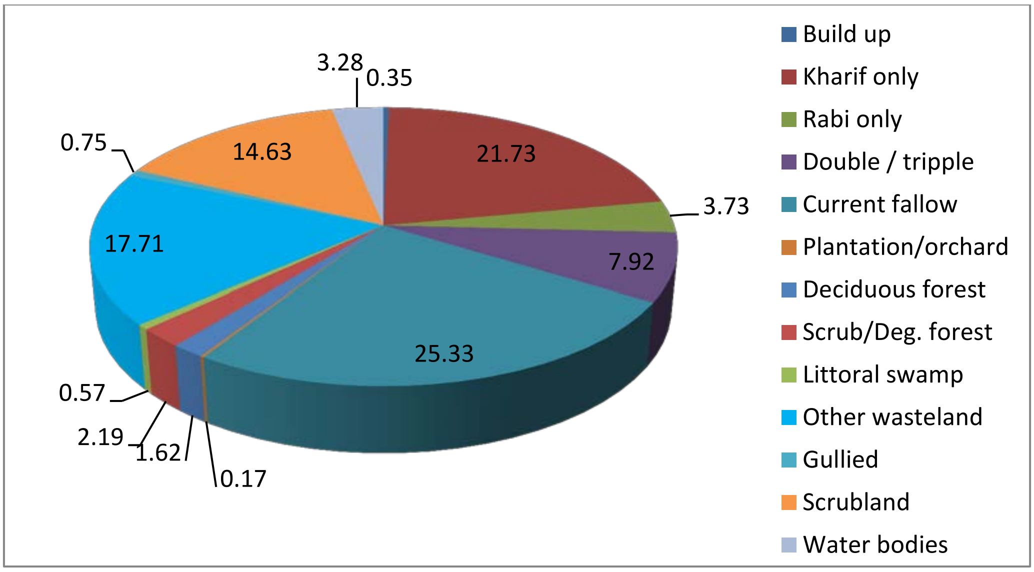


Figure 19.2 Distribution of LULC in WFR of Kutch & Saurashtra including Luni basin (2004-05)

19.1.2 Soil texture

Sandy, clayey, loamy, loamy skeletal, clayey skeletal, rocky outcrop and saline soil of Rann of Kutch are the main soil textural classes in the study basin. The coastal plains consist of fertile delta area highly suited for intensive cultivation. Figure 19.3 shows various categories of soil in the basin. The larger part of the basin (study area) falls under fine texture category i.e. clayey, sandy and loamy that accounts for low infiltration rate and more runoff in the basin based on texture.

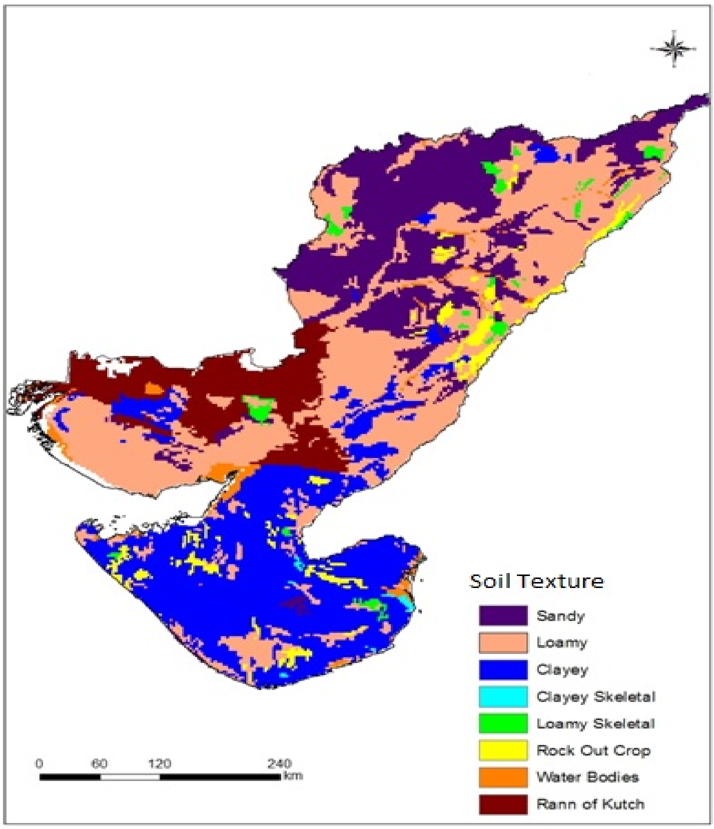


Figure 19.3 Soil texture map of WFR of Kutch & Saurashtra including Luni basin

19.1.3 Topography

The topography of the basin consists of Ghat areas, plateau, coastal plains and the Rann of Kutch, and deciduous forests of Southern Rajasthan. The districts of Rajasthan are under Central plateau and hills region. The elevation values ranges from a minimum of 0 m to a maximum of 1,698 m. Figure 19.4 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the basin. The DEM has been used for delineating sub-basin boundaries of Luni, Banas, Bhadar, Machu and Shetrunji sub-basins. After delineating these boundaries large part of basin remains without any definite drainage pattern. This part has been dealt separately in two parts namely other rivers of Kutch and other rivers of Saurashtra. Larger part of these sub-basins of other rivers of Kutch and Saurashtra is in plains. Many small rivers flow and end into these plains. Most of these rivers are part of inland type of drainage in the area.

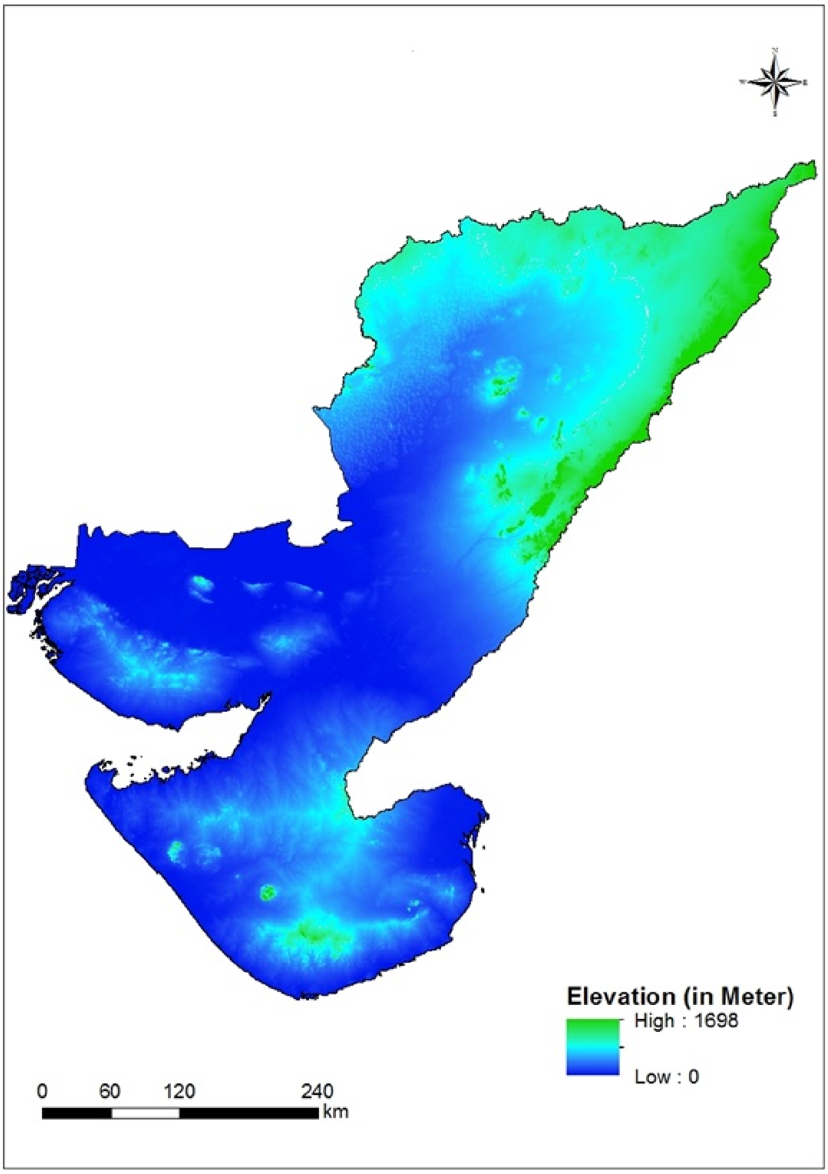


Figure 19.4 SRTM DEM map of WFR of Kutch & Saurashtra including Luni basin

19.2 Hydro-Meteorological and other Input Data

19.2.1 Rainfall grids

Figure 19.5 shows gridded rainfall of the basin for year 2004-05. The annual variations in the rainfall during study period of 30 years (1985-86 to 2014-15) are shown in the Figure 19.6. Rainfall varies both spatially and temporally in the basin. The mean rainfall of the basin for 30 years is 479 mm. Annual rainfall of the basin varies from 99 mm to 861.60 mm. When spatial variations are considered, some areas receive 5.55 mm and some other areas receive 963.74 mm annual rainfall in the year 2004-05. Major part of the basin receives an average rainfall of 99 mm to 861 mm. During the last 30 years (1984-85 to 2014-15) maximum rainfall was recorded as 2,361.40 mm in 2011-12 and minimum as 53.38 mm in 1987-88.

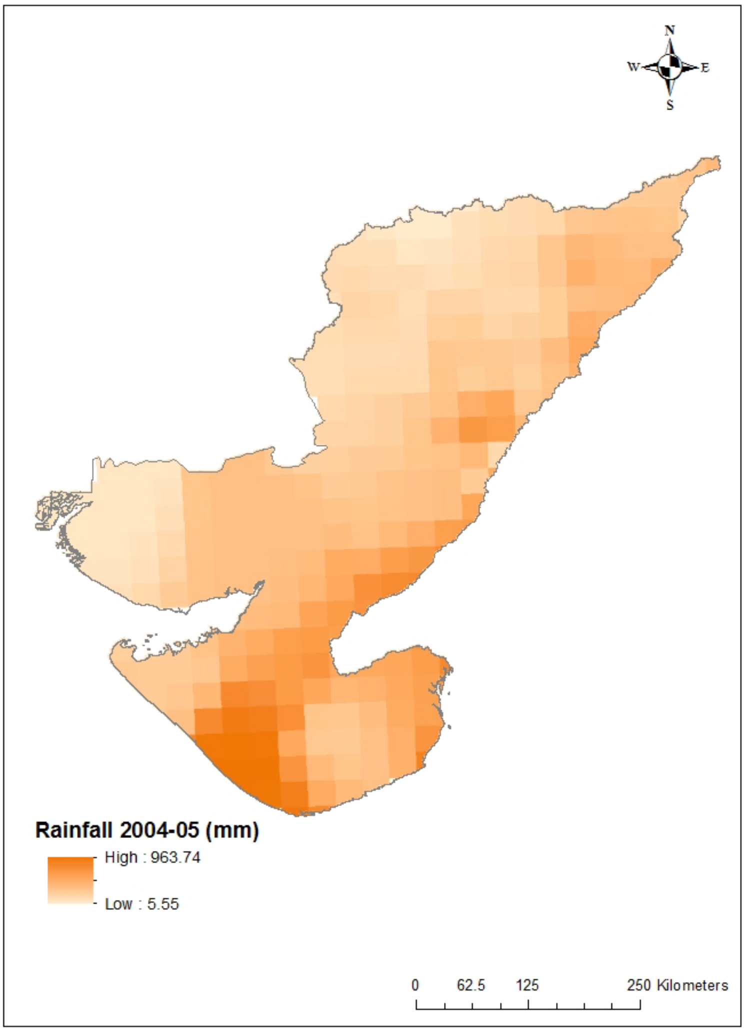


Figure 19.5 Gridded rainfall of WFR of Kutch & Saurashtra including Luni basin (2004-05)

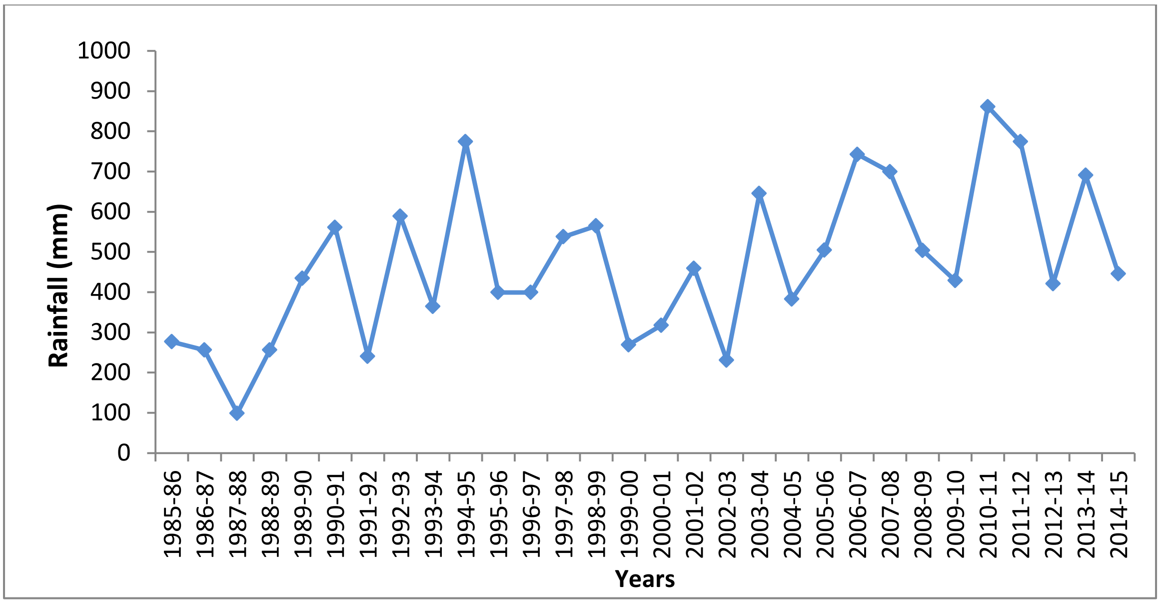


Figure 19.6 Annual rainfall in WFR of Kutch & Saurashtra including Luni basin (1985-86 to 2014-15)

19.2.2 Temperature grids

Gridded mean annual temperature of the basin is shown in Figure 19.7. The mean annual temperature during 2004-05 varies from 24.64°C to 27.44°C.

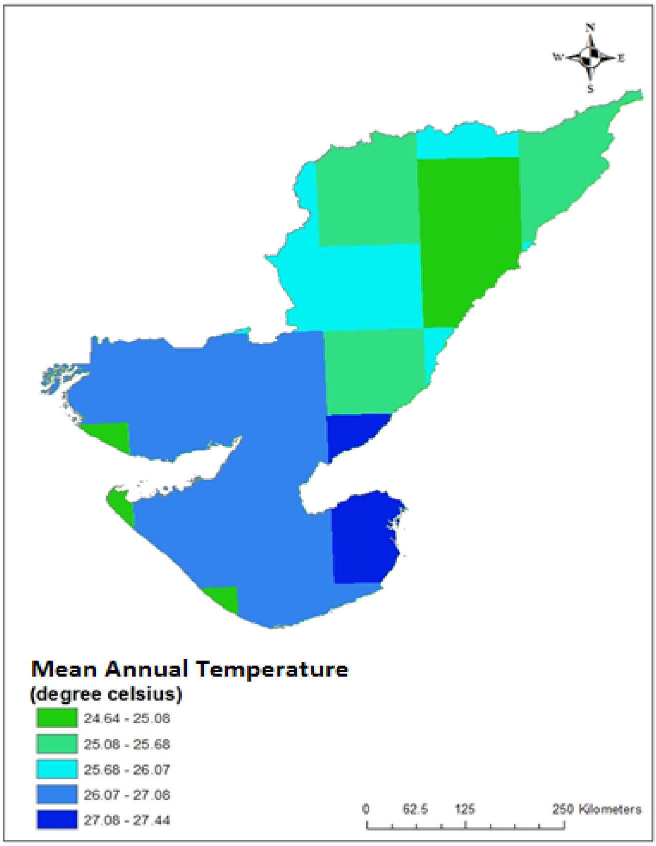


Figure 19.7 Gridded mean annual temperature of WFR of Kutch & Saurashtra including Luni basin (2004-05)

19.2.3 Sub-basins of WFR of Kutch & Saurashtra including Luni basin

The sub-basin wise area of WFR of Kutch & Saurashtra including Luni basin is shown in Table-19.1. Figure 19.8 shows the location of the sub-basins in the basin.

1. **Luni sub-basin**: Luni sub-basin is located in South-West Rajasthan. The sub-basin is delineated using outlet at Gandhav, CWC's G&D site of Luni.
2. **Banas sub-basin**: Banas sub-basin consists of Banas river and its major tributaries. The sub-basin is delineated using outlet at Kamalpur, CWC's terminal G&D site of Banas. The area of this sub-basin is about 6,112.81 sq.km.
3. **Bhadar sub-basin**: Bhadar river is a major river in Saurashtra and this sub-basin is delineated using the CWC's G&D site Ganod as sub-basin outlet. It covers an area of 5,489.36 sq.km. The remaining part of the basin is considered as ungauged (5,730.78 sq.km.) since there is no other G&D site is available.
4. **Machchu sub-basin**: Machchu river flows in Saurashtra region draining to Little Rann-of-Kutch. The sub-basin is delineated using outlet at CWC's G&D site Gungan. An area of 106.99 sq. km is treated as ungauged.
5. **Shetrunji sub-basin**: Shetrunji river sub-basin has been delineated based on the State Govt G&D site Talaja, which is maintained by the state Government.
6. **Other rivers of Kutch sub-basin**: The entire area of upper parts of Gujarat except Luni river sub-basin and Banas sub-basin has been considered in this sub-basin. It covers Rann-of-Kutch and most part of Gujarat above Tropic of Cancer as shown in Figure 19.8.
7. **Other rivers of Saurashtra sub-basin**: The entire area of Gujarat below Tropic of Cancer except the Shetrunji, Macchu and Bhadar sub-basins have been considered in this sub-basin.

The WFR of Kutch & Saurashtra basin boundary is kept same as that of the India WRIS delineated boundary.

Table - 19.1 Sub-basin wise details of WFR of Kutch & Saurashtra including Luni basin

S. No.	River /Sub-basin	CWC G&D Site	Individual drainage area (sq.km)
1	Luni	Gandhav	62,066.80
2	Banas	Kamalpur	6,112.81
3	Bhadar	Ganod	5,489.36
4	Machchu	Gungan	2,305.08
5	Shetrunji	-	5,365.84
6	Other rivers of Kutch	-	73,895.80
7	Other rivers of Saurashtra	-	30,774.20
8	Ungauged area of Bhadar	-	5,730.78

9	Ungauged area of Machchu	-	106.99
10	Uncalibrated Area of Shetrunji	-	264.34
		Total basin area	1,92,112

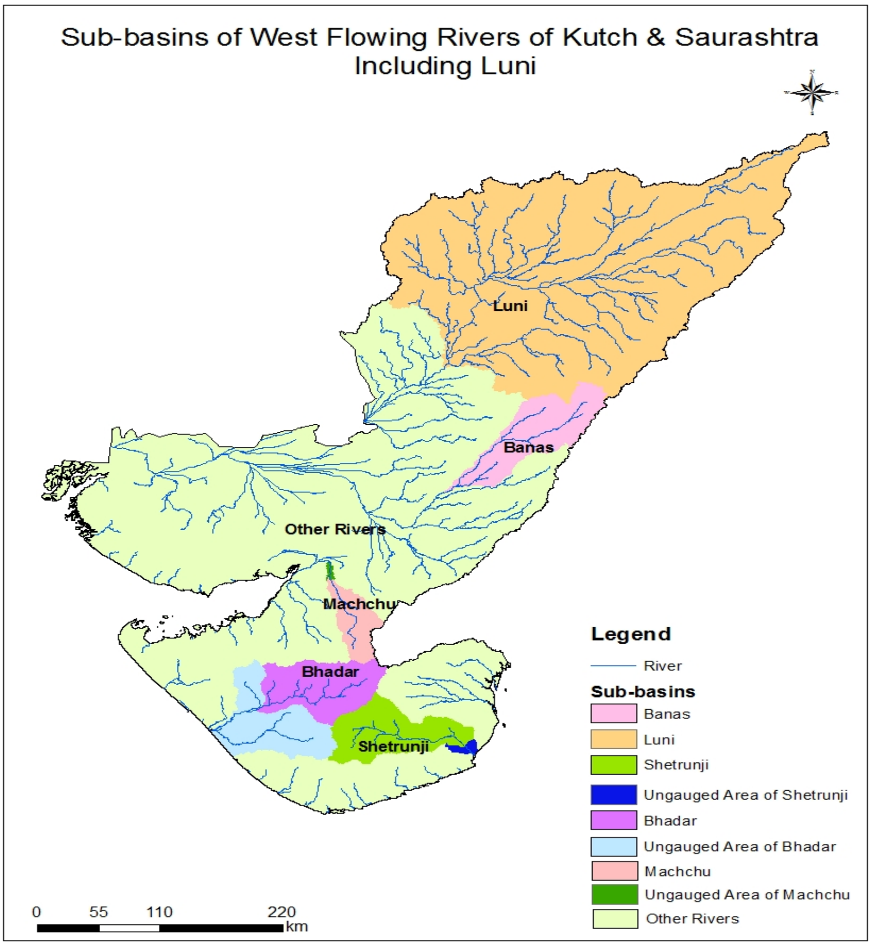


Figure 19.8 Sub-basins of WFR of Kutch & Saurashtra including Luni basin

19.2.4 River discharge

The river discharge data have been selected by considering the drainage pattern and spatial distribution of G&D sites. Four CWC G&D sites have been chosen for model calibration and validation as mentioned earlier. Daily discharge data on river Shetrunji is not available. The daily discharge data aggregated to annual scale have been used for calibration and validation of model computed runoff at sub-basin level.

19.2.5 Reservoir flux

Reservoir flux data of three major and medium of projects have been considered for estimating reservoir fluxes for each water year for 30 years period. In Banas sub-basin, the reservoir flux of Dantiwada reservoir is available from 1988-2015, and the mean annual reservoir flux is estimated -

0.0001 BCM. The reservoir flux of about -0.0004 BCM from Bhadar reservoir is used to estimate the mean annual reservoir flux for the sub-basin. The location of major and medium reservoirs in the basin is shown in the Figure 19.9.

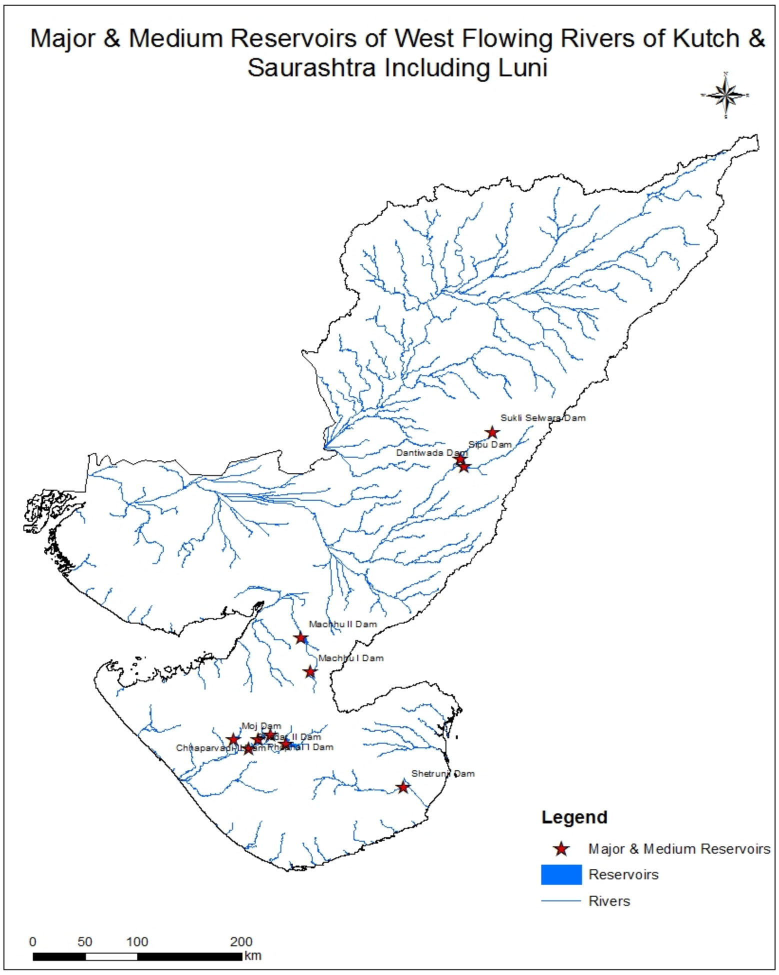


Figure 19.9 Major and medium reservoirs in WFR of Kutch & Saurashtra including Luni basin

19.2.6 Groundwater flux

The spatial variation in groundwater flux during year 2004-05 is shown Figure 19.10. Annual groundwater flux in the basin varies from 547.15 MCM to -768.25 MCM during year 1984-85 to 2014-15. The mean annual groundwater flux from 1984-85 to 2014-15 is estimated at -101.29 MCM (drawdown).

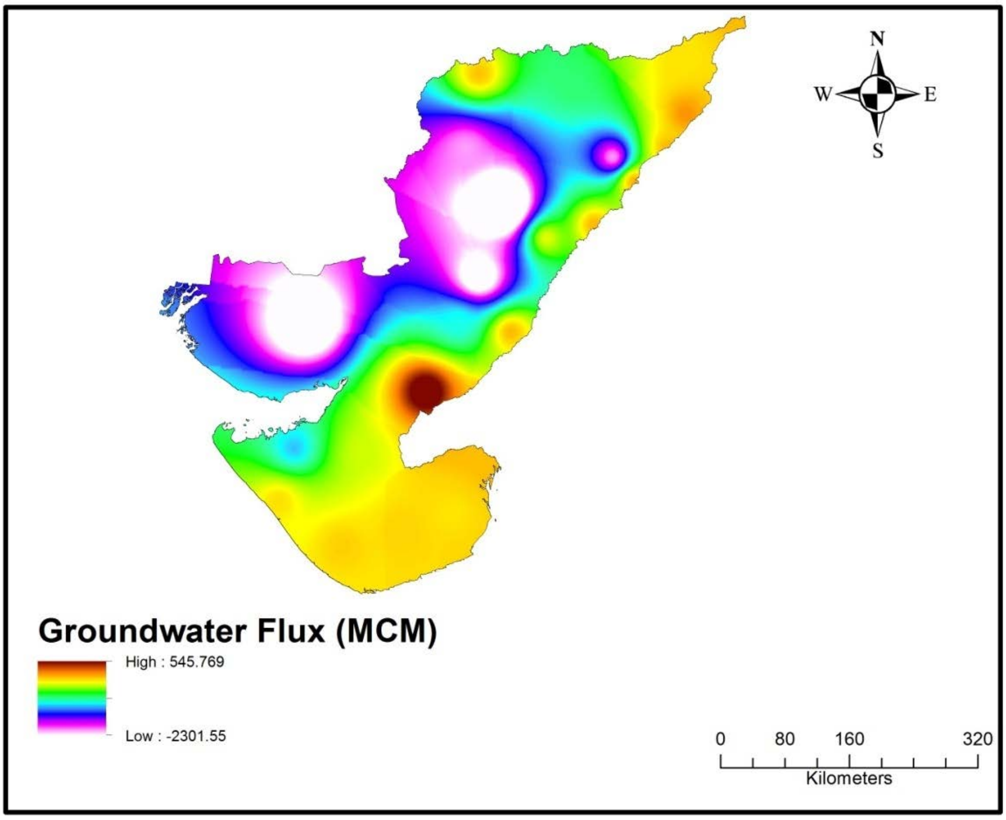


Figure 19.10 Groundwater flux (spatial data) estimated during 2004-05

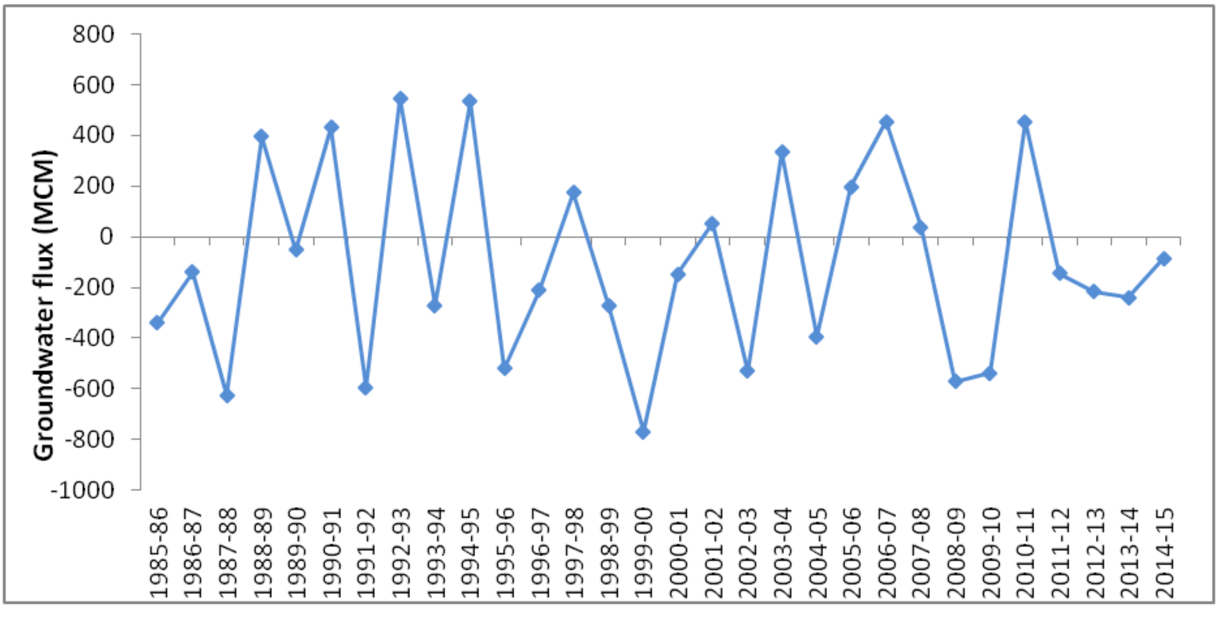


Figure 19.11 Annual groundwater flux of WFR of Kutch & Saurashtra including Luni basin (1985-86 to 2014-15)

19.2.7 Major crops in the basin

Different major crops for each season are emerged and the crop coefficients are taken as per the crop in that particular region/district. On examining the cropping pattern within the basin, crop growing seasons are decided as Kharif only crop during 4 months (July to October), Rabi only crop during 4 months (November to February), Zaid only crop during 4 months (February to May), Double/Triple crop during 8 to 10 months (July to April). Accordingly basin is subdivided into regions.

19.2.8 Irrigation command area

Figure 19.12 shows location of irrigation command boundaries of West Flowing Rivers of Kutch & Saurashtra including Luni basin considered for the year 2014-15. Since annual command boundary maps are not available, command area has been selected from the year 2014-15 based on the completion of the project/dam. Hence, the command area considered during the year 1985-86 is worked out to be 9,37,787 hectare, while it is 22,79,987 hectare in 2014-15 (excluding the basin outside command). Basin outside command has been taken uniformly for all years while working out ECII from these areas.

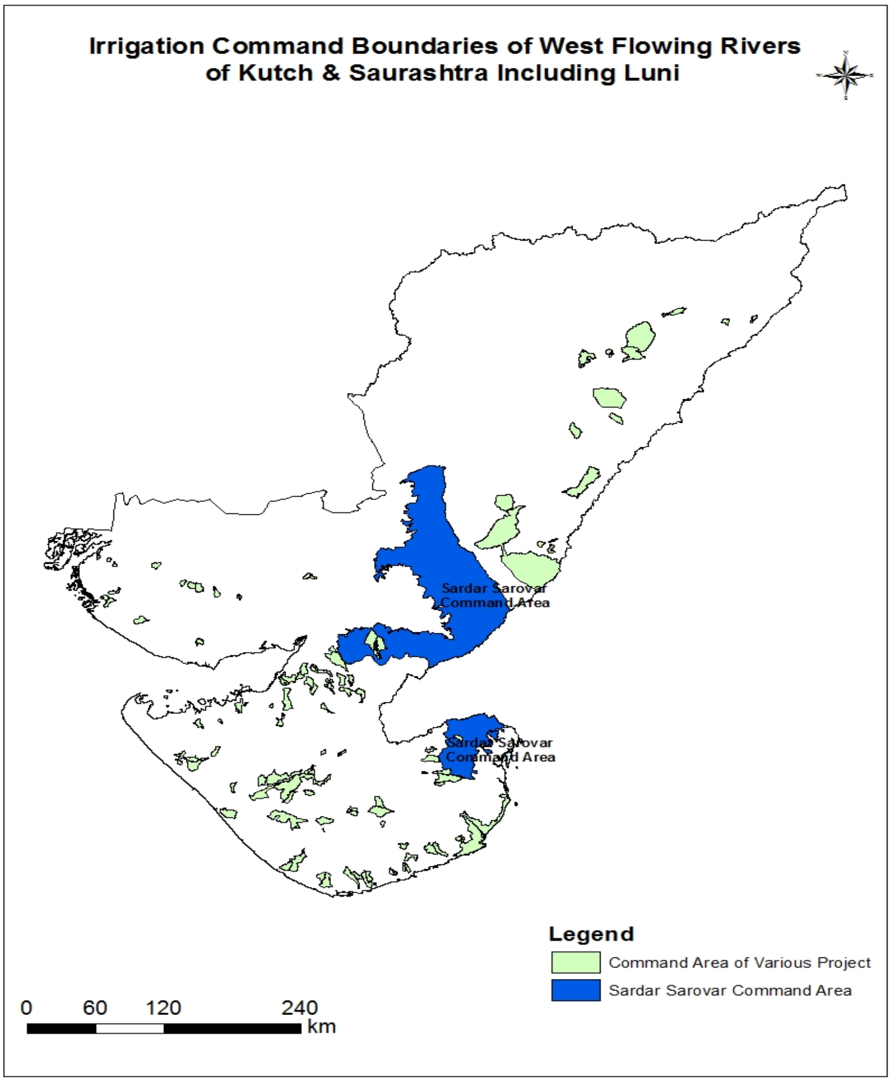


Figure 19.12 Irrigation command boundaries of WFR of Kutch & Saurashtra including Luni basin

19.2.9 Domestic, industrial and livestock demand

The district boundaries of the year 2011 for estimation of DIL flux is shown in Figure 19.13. The average (for 30 years) domestic, industrial and livestock demand for the basin is estimated as 0.15 BCM.

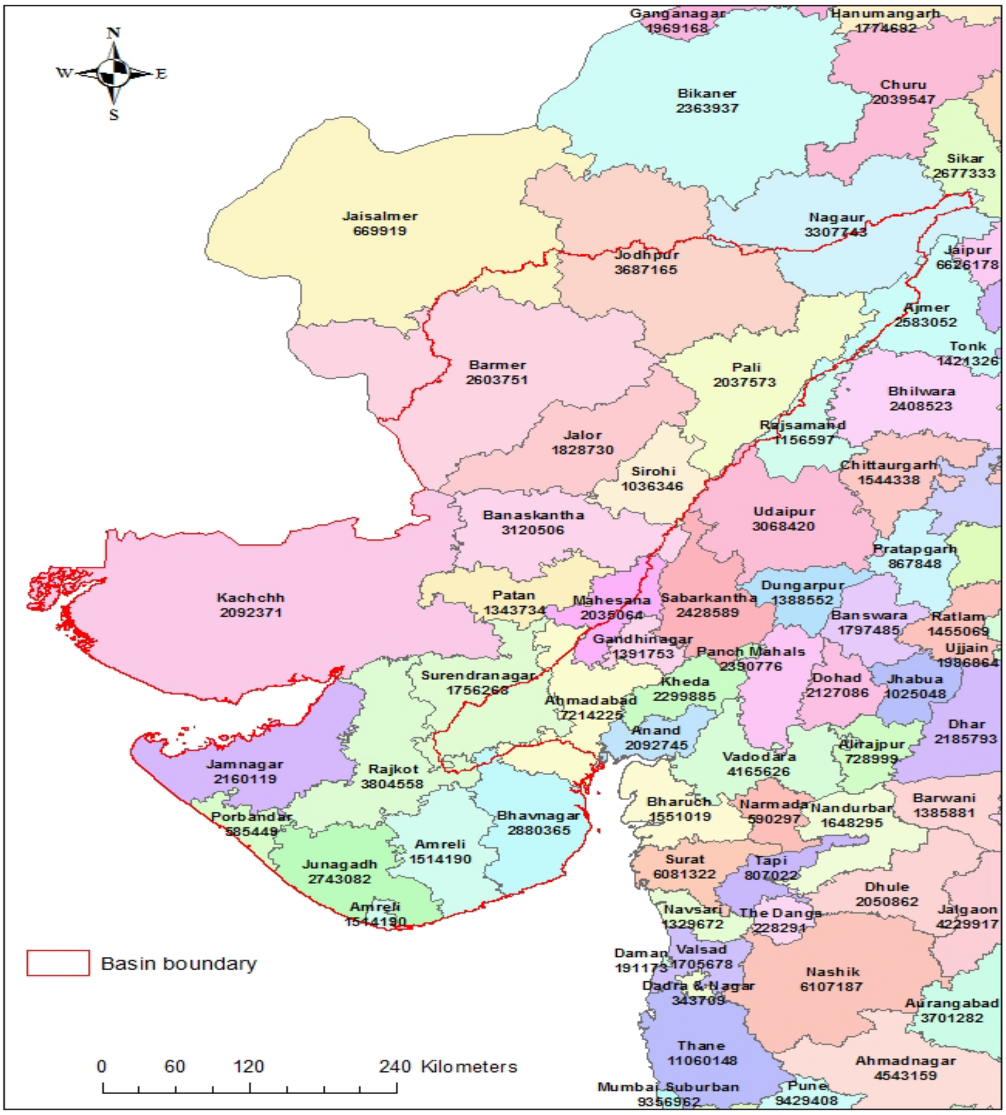


Figure 19.13 District boundaries in WFR of Kutch & Saurashtra including Luni basin

19.2.10 Evaporation from major/medium/minor reservoirs and other water bodies

For the water bodies prior to the year 2004-05 (since LULC layers prior to 2004-05 are not available), same reservoir mask based on the nearest mean value of rainfall have been used in the model run. Water spread area of respective dams has been removed based on the year of completion of the dam. For WFR of Kutch & Saurashtra including Luni basin the average evaporation from reservoirs has been estimated as negligible.

19.3 Previous Estimates

The reassessment study of this composite basin was not performed in 1993. The results from the CWC Publication No. 30/88 "Water Resources of India", 1988 were reproduced in the 1993 report, where in the methodology adopted in 1988 studies has not been mentioned.

19.4 Runoff Estimation

Tables - S.1 to S.5 (at Annexure - S) give calibrated runoff along with observed discharge, rainfall, ECII, etc. during 30 years for sites at Gandhav, Kamalpur, Gunjan, Ganod and Shetrunji sub-basin. Figures 19.14 to 19.18 show comparative graphs of calibrated runoff and observed discharge at G&D sites.

19.5 Annual Water Resources Availability of WFR of Kutch & Saurashtra including Luni basin

The estimated runoff for each sub-basin is calibrated with observed discharge at annual scale. For the ungauged Shetrunji sub-basin values of AET to rainfall (RF) ratio has been considered as calibration parameter. For ungauged areas of Kutch and Saurashtra, water availability has been calculated based on the rainfall and area proportions of the nearby sub-basins.

19.5.1 Water resources availability of Luni sub-basin

Luni river sub-basin is the significant sub-basin in western Rajasthan, which forms the bulk of arid zone. Luni river originates from western slopes of the Aravalli ranges at an elevation of 772 m above Mean Sea Level. Flowing in south-west direction Near Ajmer and traversing a course of 511 km in Rajasthan, it finally drains into the Rann-of-Kutch. Most of its tributaries drain the steep north-west of Aravalli hills and join it on left side. Its whole catchment area falls in Rajasthan. The peculiarity of this river is that it tends to increase its width rather than deepening the bed because the banks are of soils, which are easily erodible, whereas beds are of sand. The Aravalli ranges form its east boundary whereas main course of River in Barmer district forms north boundary and majorily Banas and initial reach of Chambal River form its southern boundary.

Luni has ten tributories namely Lilari, Guhiya, Bandi (Hemawas), Sukri (Hemawas), Sukri, Mithri, Jawai, Khari Bandi, SukriBandi and Sugi. Luni receives all the main tributaries from its left bank except one i.e. Jojari (Mithri) which joins it from the rightbank. Drainage on the leftbank of Luni is, therefore, more extensive than on right bank. In Luni basin, the tail end of the river is at Rann-of-Kutch, which is a delta region and therefore the water spreads out and does not contribute any runoff.

The isohyets (50 cm) approximately follow Aravalli range and are dividing line between arid and semi-arid areas in the west and sub-humid areas in the east and south east. The rainfall is erratic and its distribution is uneven in the basin. During 2014-15, maximum and minimum temperature recorded in the Luni sub-basin is 44^{o}C and 8^{o}C repectively.

19.5.2 Water resources availability of Banas sub-basin

Banas rises near Pindwara of Sirohi district of Rajasthan at an elevation of 372.51 m above M.S.L. Little Rann-of-Kutch is the outfall of Banas River. Sipu is the only right bank tributary of Banas, which drains into the main channel. There are six tributaries on the left bank of Banas river namely, the Batria, the Sukli, the Sewaran, the Suket, the Balaram and the Khari, which drain into the main channel. Hence, the draining system on the left bank of the Banas River is more extensive as compared to the right bank. Average rainfall in Banas basin is 669.760 mm. Maximum and minimum temperature recorded in the Banas sub-basin are 44.5^{o}C and 8^{o}C during year 2014-15 respectively.

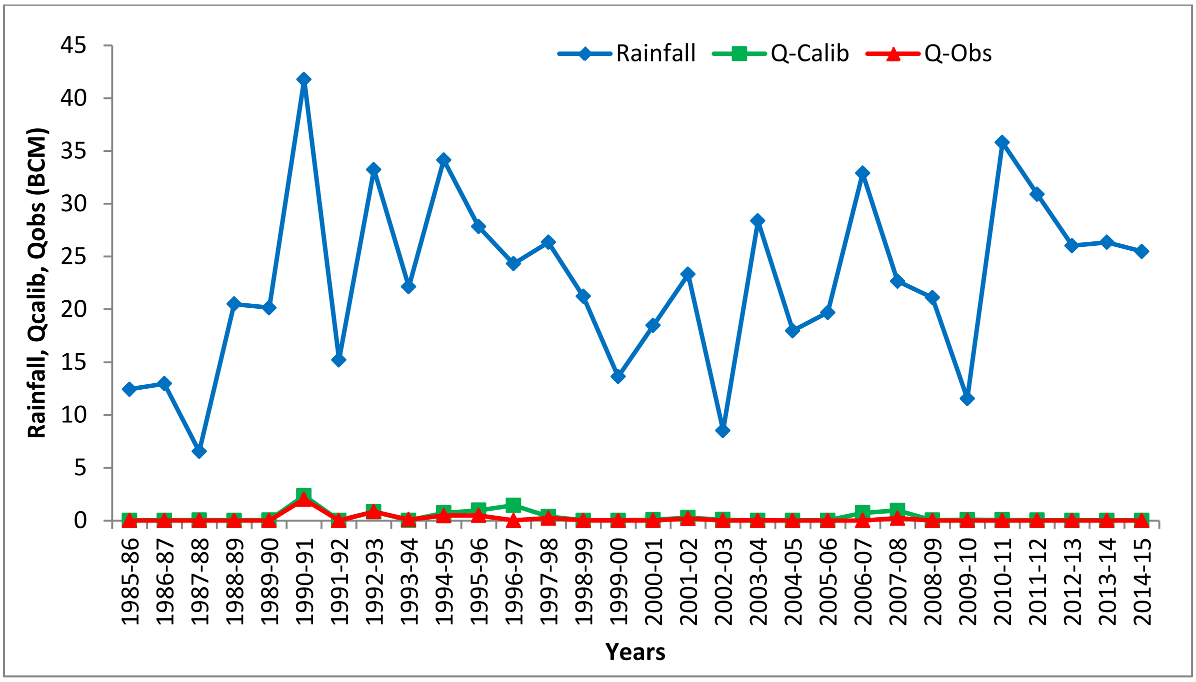


Figure 19.14 Calibrated runoff and observed discharge at Gandhav

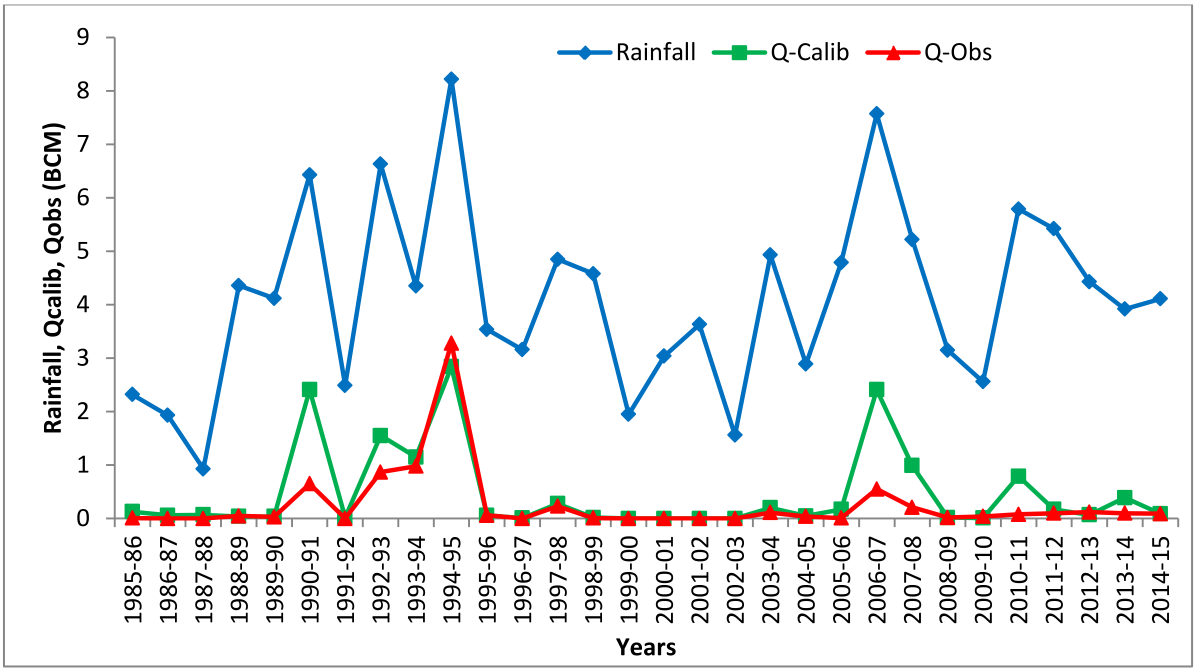


Figure 19.15 Calibrated runoff and observed discharge at Kamalpur

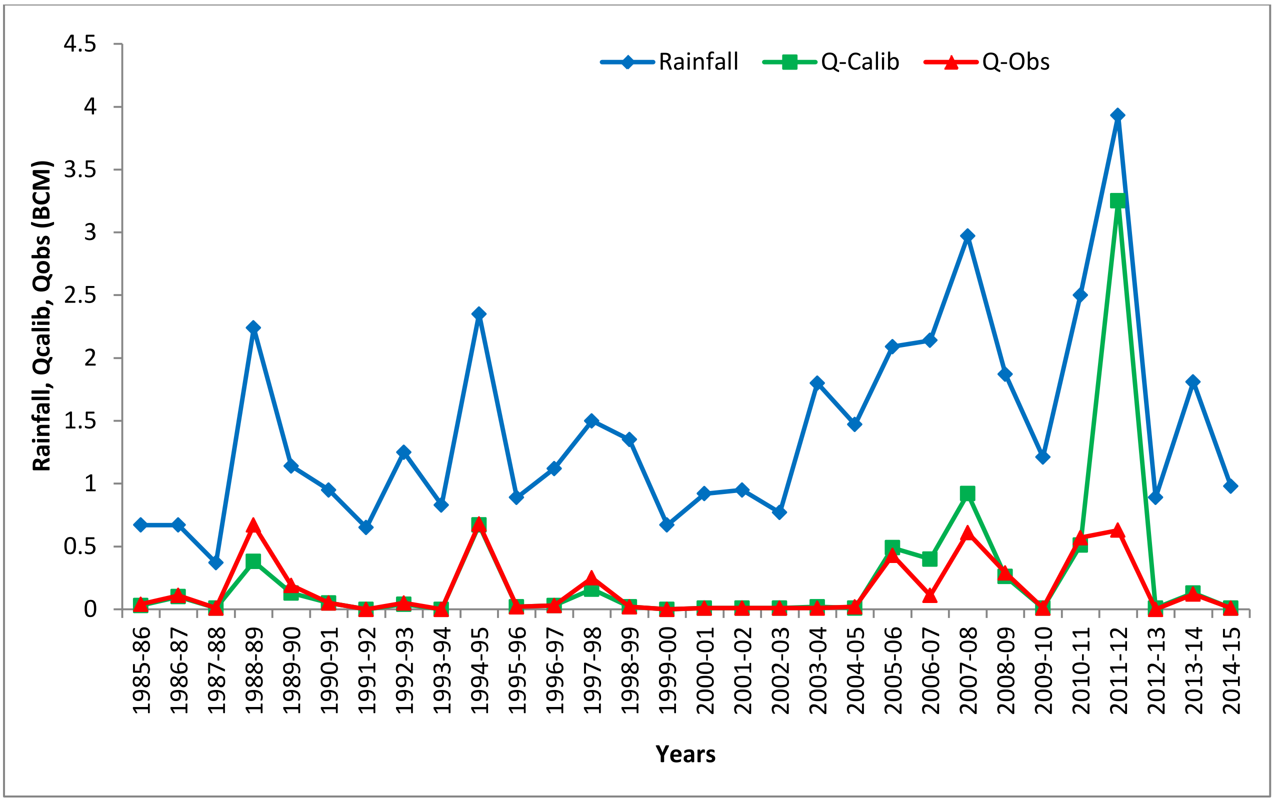


Figure 19.16 Calibrated runoff and observed discharge at Gungan

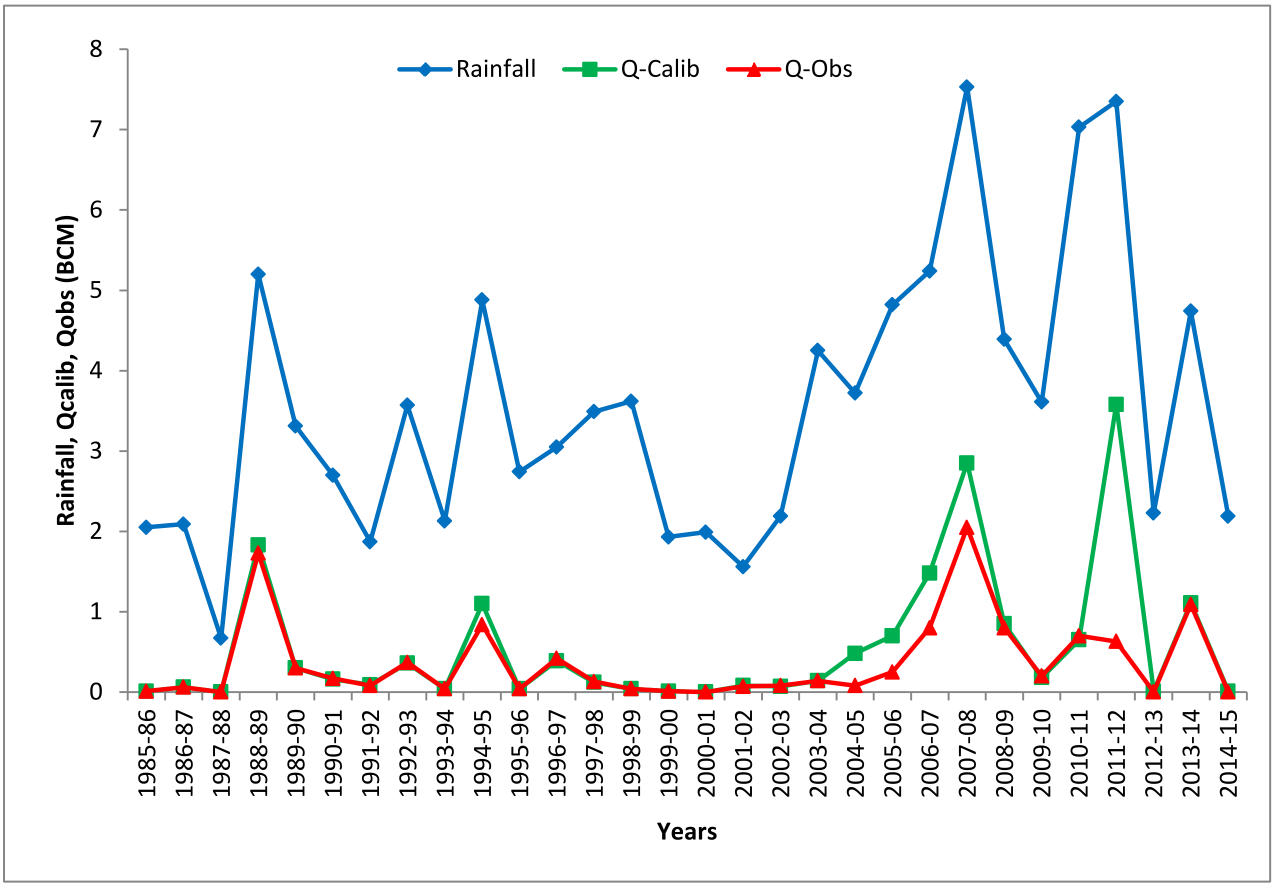


Figure 19.17 Calibrated runoff and observed discharge at Ganod

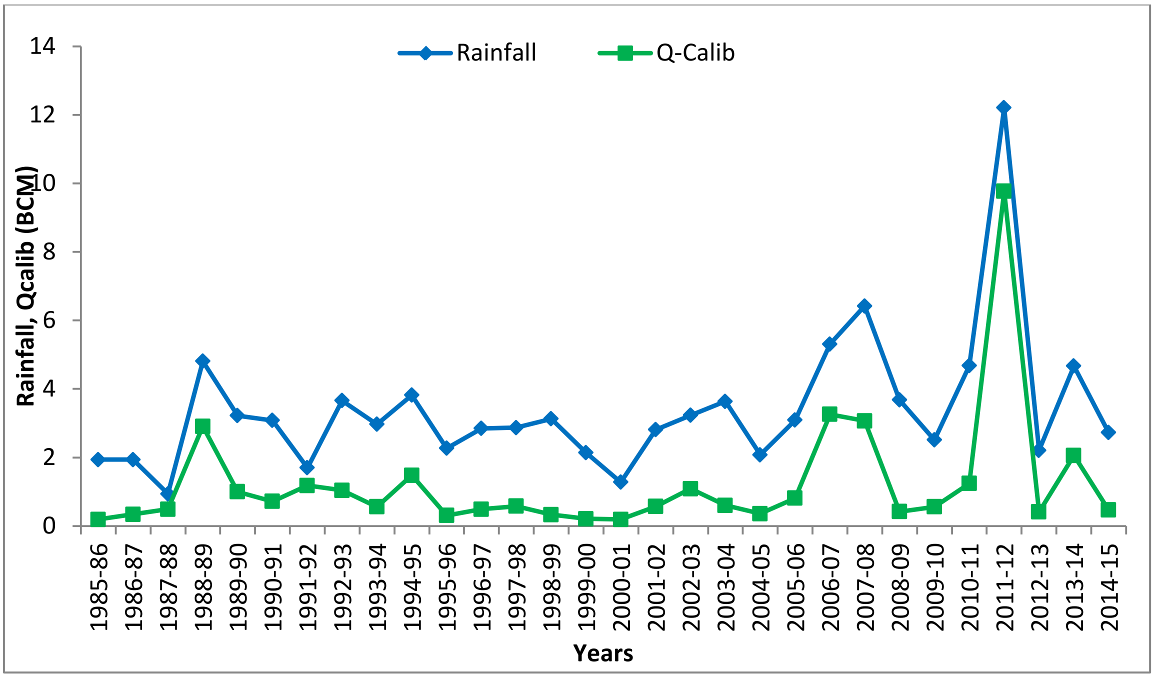


Figure 19.18 Calibrated runoff and rainfall of Shetrunji sub-basin

19.5.3 Water resources availability of Bhadar sub-basin

There are nine major tributaries out of which six tributaries viz, Gondali, Chapparwadi, Phopal, Utawali, Moj and Venu join from right and the remaining 3 tributaries viz, Vasavadi, Surwa and Galolia from left. The average rainfall in Bhadar Basin is 625 mm. The South-West monsoon sets in by the middle of June and withdraws by the first week of October. About 90% of total rainfall is received during July and August. Owing to the topographical characteristics, climate is variable. The Bhadar irrigation scheme is on the river Bhadar in Rajkot, which has gross storage capacity of 238 MCM.

19.5.4 Water resources availability of Macchu sub-basin

Machhu along with its tributaries flows 52% in the hilly area and 48% in plain region. More than 75% area of Machchu sub-basin lies in Rajkot district. The total length of this north flowing river from its origin to its outfall into the little Rann-of-Kutch is 141.75 km. Machhu receives several tributaries on both the banks. There are six major tributaries having length more than 25 km, out of which four tributaries namely Jamburi, Benia, Machhori and Maha join from the right and the remaining two tributaries namely Beti and Asoi join from the left. The drainage system on the right bank of Machhu is more extensive as compared to the left bank. The average rainfall in the Machhu Basin is 620.72 mm. The South West Monsoon sets in by the middle of June and withdraws by the first week of October. Owing to the topographical characteristics, the climate is variable. Maximum and minimum temperature recorded in the Machchu basin are 41^{o} and 11^{o} Celsius during year 2014-15.

19.5.5 Water resources availability of Shetrunji sub-basin

The Shetrunji is one of the major rivers of Saurastra. The river Shetrunji originates at Chachai Hills in Gir forest of Junagarh district at 380 m above MSL and flows towards east direction till it drains in the Gulf of Khambhat near Santhrampur port. The total length of this east flowing river from its origin to the outfall into the Gulf of Khambhat is 182 km. This river receives tidal influence for a length of 5 km from the mouth.

The Shetrunji receives several tributaries on both banks. There are nine tributaries having length more than 15 km. The climate of the basin is characterised by low rainfall, high humidity, and oppressive weather in the hot season. The hot season from March to May is followed by the South-West monsoon from June to September. October and November constitute the retreating monsoon or post monsoon season. Maximum and minimum temperatures recorded in the Shetrunji basin are 42°C and 12°C during year 2014-15.

The Shetrunji irrigation scheme comprises construction of masonry dam in the river portion and earthen dam on both the banks. It has gross capacity of 350 MCM with live storage of 309 MCM. Major crops of the basin are cotton, wheat, bajra and pulses.

Being a region of less rainfall and high evaporation losses, K_c values and root zone depth values are adopted based on the major crops in the area and calibration has been done based on the values of rainfall to AET ratio. The rainfall-AET ratio varies from 50 to 95.

19.5.6 Water resources availability of Other rivers of Kutch sub-basin

This part comprises of entire Kutch and parts of Gujarat above Tropic of Cancer area other than Luni and Banas sub-basins. West part of this sub-basin mostly lies in Runn-of-Kutch. Total area of this part is 73,895.8 sq.km. Initially, same crop coefficients and root zone depth values were taken for model run as this area is having similar climatic conditions as that of Luni sub-basin. But, the results were not satisfactory. Hence, the water availability is estimated on the basis of rainfall and area proportion of Luni sub-basin. This part is entirely un-calibrated as there is no CWC discharge measuring site in this area.

The average annual water availability during 1985-2015 in Other rivers of Kutch sub-basin is about 7.37 BCM. Table - 19.2 gives the water availability of Other rivers of Kutch sub-basin.

Table - 19.2 Water resources availability of Other rivers of Kutch sub-basin

Name of sub-basin	Average Rainfall (mm)	Area (sq.km)	Ratio of RF	Ratio of Area	Water availability (BCM)
Luni	366.09	62,066.80			6.19
Other rivers	463.03	73,895.8	1.265	1.1906	9.32
Runn of Kutch		19,612.80		0.2654	-2.08
Total water availability in Other rivers of Kutch basin					7.25

**Water availability of Other rivers of Kutch 1.265*1.1906*6.19= 9.32 BCM*

**Similarly, for Rann of Kutch available water which is subtracted due to saline nature = 1.265*0.2654*6.19 = 2.08*

19.5.7 Water resources availability of Other rivers of Saurashtra sub-basin

The area of this un-gauged sub-basin is 36,871.9 sq.km which is about 19.19% of the total basin area. In the absence of any G&D site, the calibration and validation exercise for this sub-basin could not be carried out. Model run for this area was carried out using Shetrunji basin co-efficients. But, the desired results could not be achieved. Hence, water availability has been calculated using rainfall and area proportion of the Shetrunji sub-basin. Table - 19.3 gives the water availability of Other rivers of Kutch sub-basin.

The average annual water availability during 1985-2015 in Other rivers of Saurashtra sub-basin is about 6.95 BCM.

Table - 19.3 Water resources availability of Other rivers of Saurashtra

Name of sub-basin	Average Rainfall(mm)	Area (sq.km)	Ratio of RF	Ratio of Area	Water availability (BCM)
Shetrunji	661.72	5,629.86			1.30
Other rivers Saurashtra	646.93	30,774.20	0.9776	5.47	6.95

* *Water availability of Other rivers of Saurashtra= 0.9776*5.47*1.30 = 6.95 BCM*

19.6 Annual Water Resources Availability of WFR of Kutch & Saurashtra including Luni Basin

Water resources availability calculation of West flowing rivers of Kutch & Saurashtra including Luni basin is shown in Figure 19.4.

Table - 19.4 Water resources availability of WFR of Kutch & Saurashtra Basin

Sub- basin name	Annual Mean Water availability (BCM)
Luni river basin (62,066.8 sq.km)	6.19
Banas river basin (6,112.8 sq.km)	1.71
Bhadar river basin (5,489.36 sq.km)	1.44
Machchu river basin (2,305.08 sq.km)	0.57
Shetrunji river basin (5,365.84 sq.km)	1.24
Other rivers of Kutch basin (73,895.80 sq.km)	7.25
Other rivers of Saurashtra (30,774.20 sq.km)	6.95
Un-calibrated area in Bhadar basin (5,730.78 sq.km)= (1.44*5730.78)/5,489.36)	1.50
Un-calibrated area in Machchu Basin (106.992sq.km) = (0.57*106.992)/2,305.08	0.026
Un-calibrated area in Shetrunji basin (264.025 sq.km) = (1.24*264.025)/5,365.84)	0.06
Total water availability	26.93

75% dependable flow of Composite basin = 14.59 BCM

The mean available annual water resources potential for composite basin of WFR of Kutch & Saurashtra including Luni is 26.93 BCM. The mean annual ET due to rainfall is 21.81 BCM. The mean available water resources of the basin accounts for about 26.93% of mean annual rainfall during 1985-86 to 2014-15.

Various results of the study in respect of the basin are as follows.

i)	Average annual water availability	26.93 BCM
ii)	75% Dependable water availability	14.59 BCM

19.6.1 Annual water resources of WFR of Kutch & Saurashtra including Luni basin during extreme rainfall conditions

Out of the total 30 years of meteorological database of study period, during the years 2010-11 and 1988-89, extreme wet and dry rainfall conditions occurred in the basin. The annual water resources of the composite basin in these sub-basins during these two extreme rainfall conditions are 74.99 BCM and 5.63 BCM respectively as shown in Table - 19.5. The water balance components during these years are presented in the Figures 19.19 and 19.20.

Table - 19.5 Water resources availability of WFR of Kutch & Saurashtra including Luni basin during extreme rainfall conditions

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	2010-11	165.52	74.99
Minimum Rainfall	1987-88	19.04	5.63

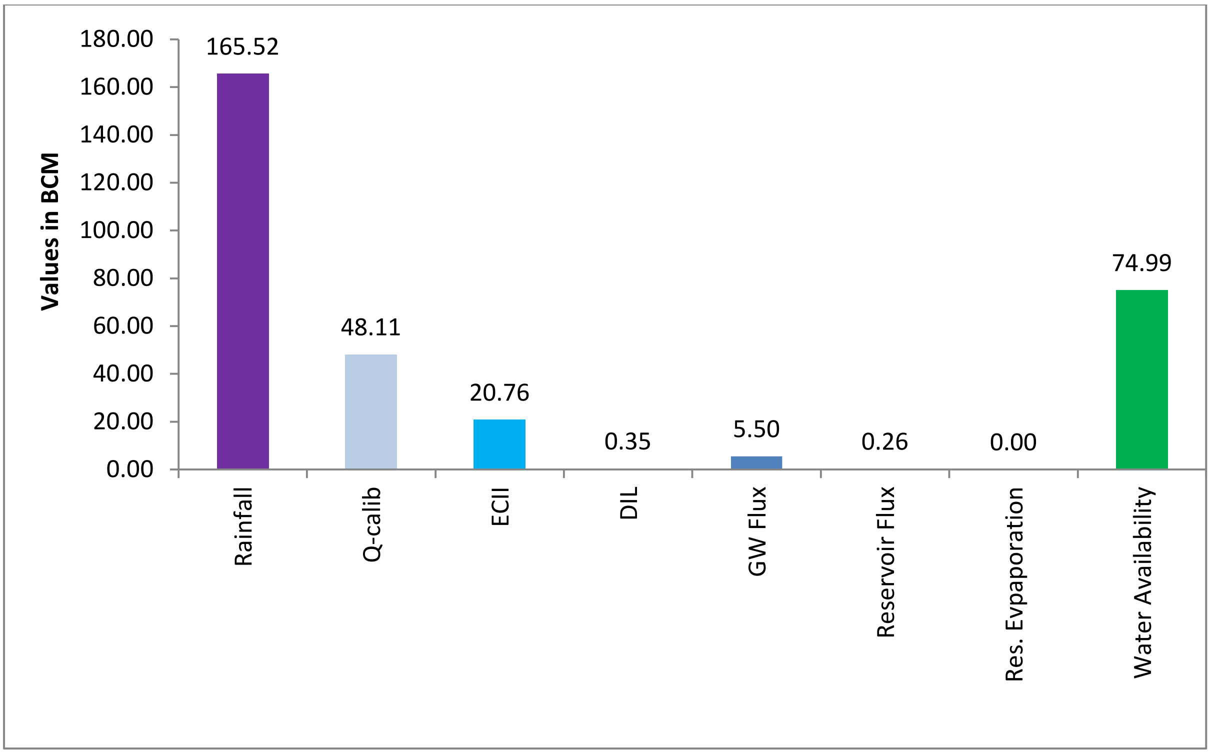


Figure 19.19 Water water balance components for composite basin of west flowing rivers of Kutch & Saurashtra including Luni during extreme high rainfall (2010-11)

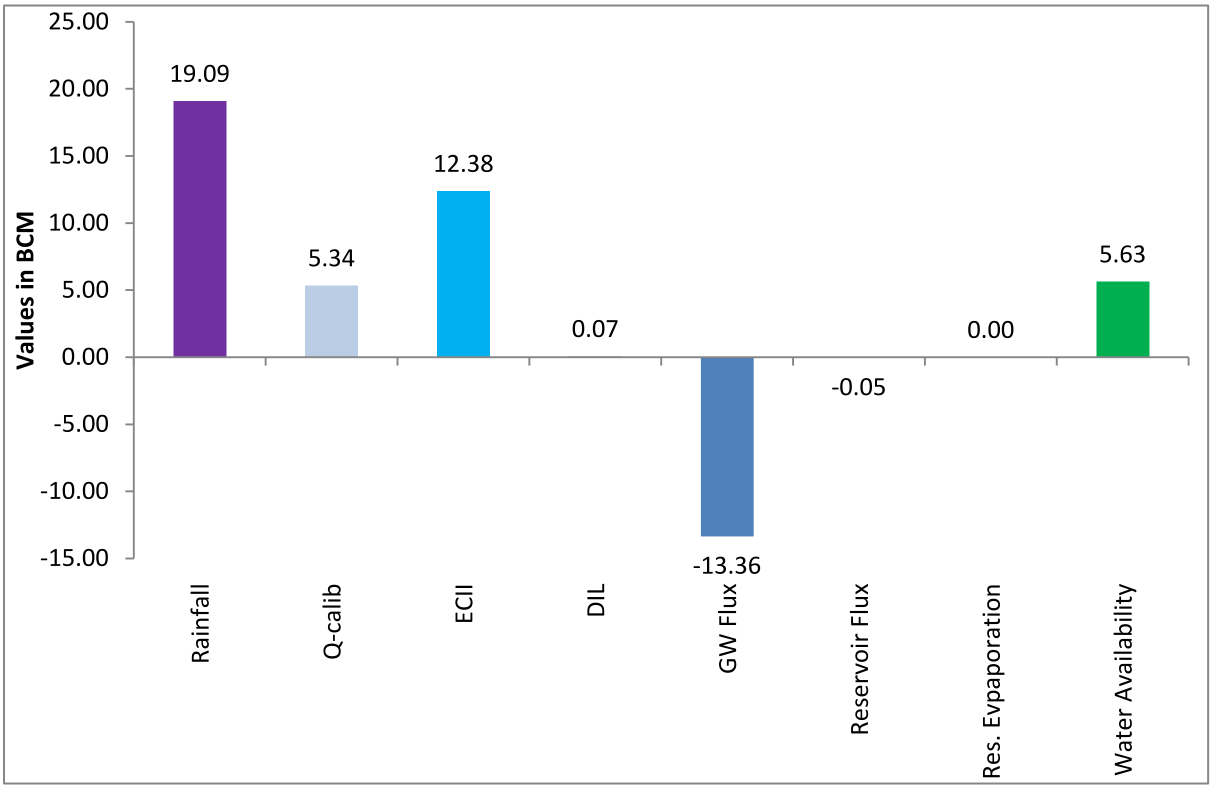


Figure 19.20 Water balance components for composite basin of west flowing rivers of Kutch & Saurashtra including Luni during extreme low rainfall (1987-88)

19.6.2 Mean water resources of WFR of Kutch & Saurashtra including Luni basin

The total annual average water resources availability of the composite basin for the study period of 1985-2015 has been assessed as 26.93 BCM. The 75% dependable annual water availability of the composite basin is assessed as 14.59 BCM. Figure 19.21 shows the various water balance components of the basin averaged over a period of 30 years during 1985-86 to 2014-15.

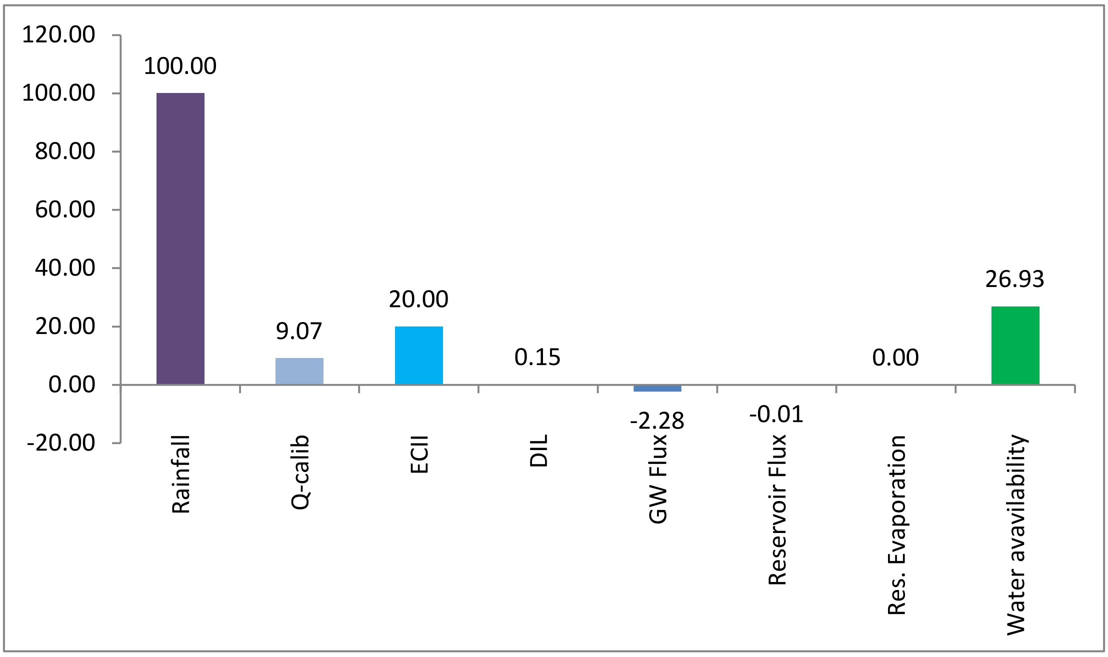
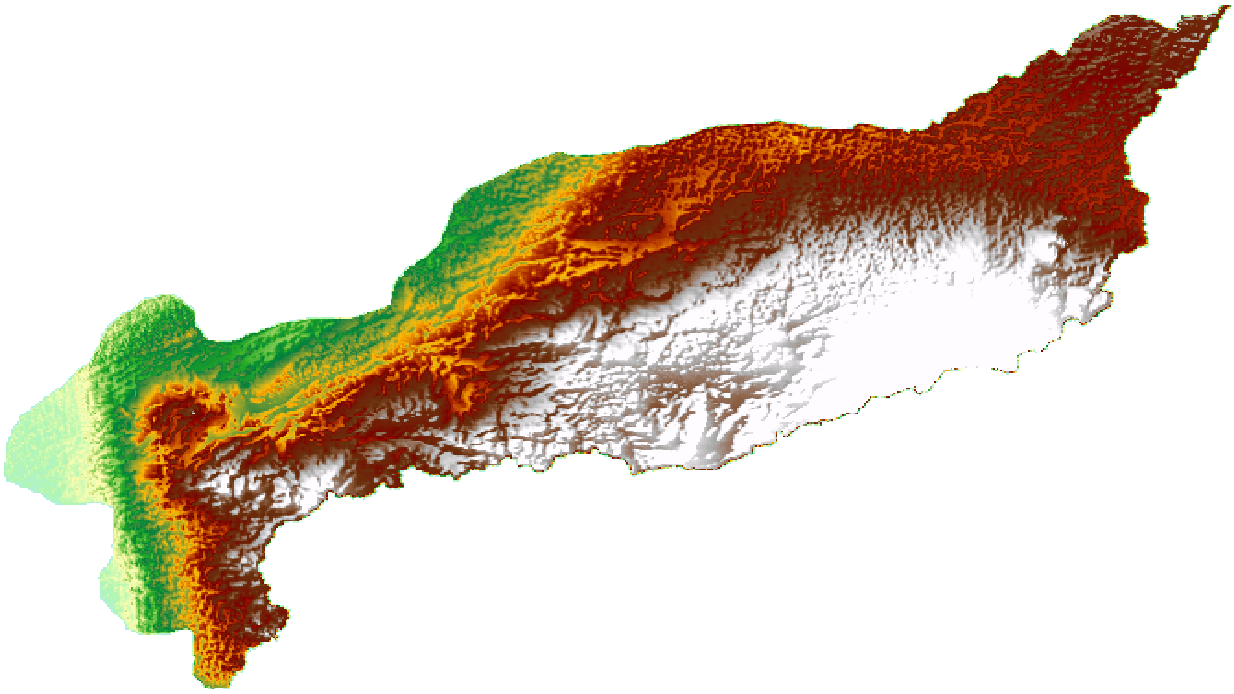


Figure 19.21 Mean water balance components for composite basin of west flowing rivers of Kutch & Saurashtra including Luni (1985-86 to 2014-15)

HIGHLIGHTS

- *Mean annual available water resources of WFR of Kutch & Saurashtra including Luni basin is 26.93 BCM.*
- *Maximum annual water availability is 74.99 BCM during 2010-11.*
- *Minimum annual water availability is 5.63 BCM during 1987-88.*
- *Annual rainfall of the basin varies from 99 mm to 861.60 mm from 1985-86 to 2014-15 and mean rainfall of these 30 years is 479 mm.*
- *WFR of Kutch & Saurashtra including Luni basin is divided into ten sub-basins for the reassessment study viz. Luni, Banas, Bhadar, Machchu, Shetrunji, Other rivers of Kutch, Other rivers Saurahtra, Ungauged area of Bhadar, Ungauged area of Machchu and Uncalibrated area of Shetrunji.*
- *Average annual domestic, industrial and livestock demand in the basin is 0.15 BCM.*

AREA OF INLAND DRAINAGE IN RAJASTHAN DESERT



20.1 Geo-Spatial Datasets

20.1.1 Land Use and Land Cover

The Land Use and Land Cover (LULC) map of Area of Inland Drainage in Rajasthan Desert basin for year 2004-05 is shown in Figure 20.1. From the LULC map it could be seen that wasteland, fallow and scrubland are the major LULC classes in the basin as shown at Figure 20.2 (distribution in percentage).

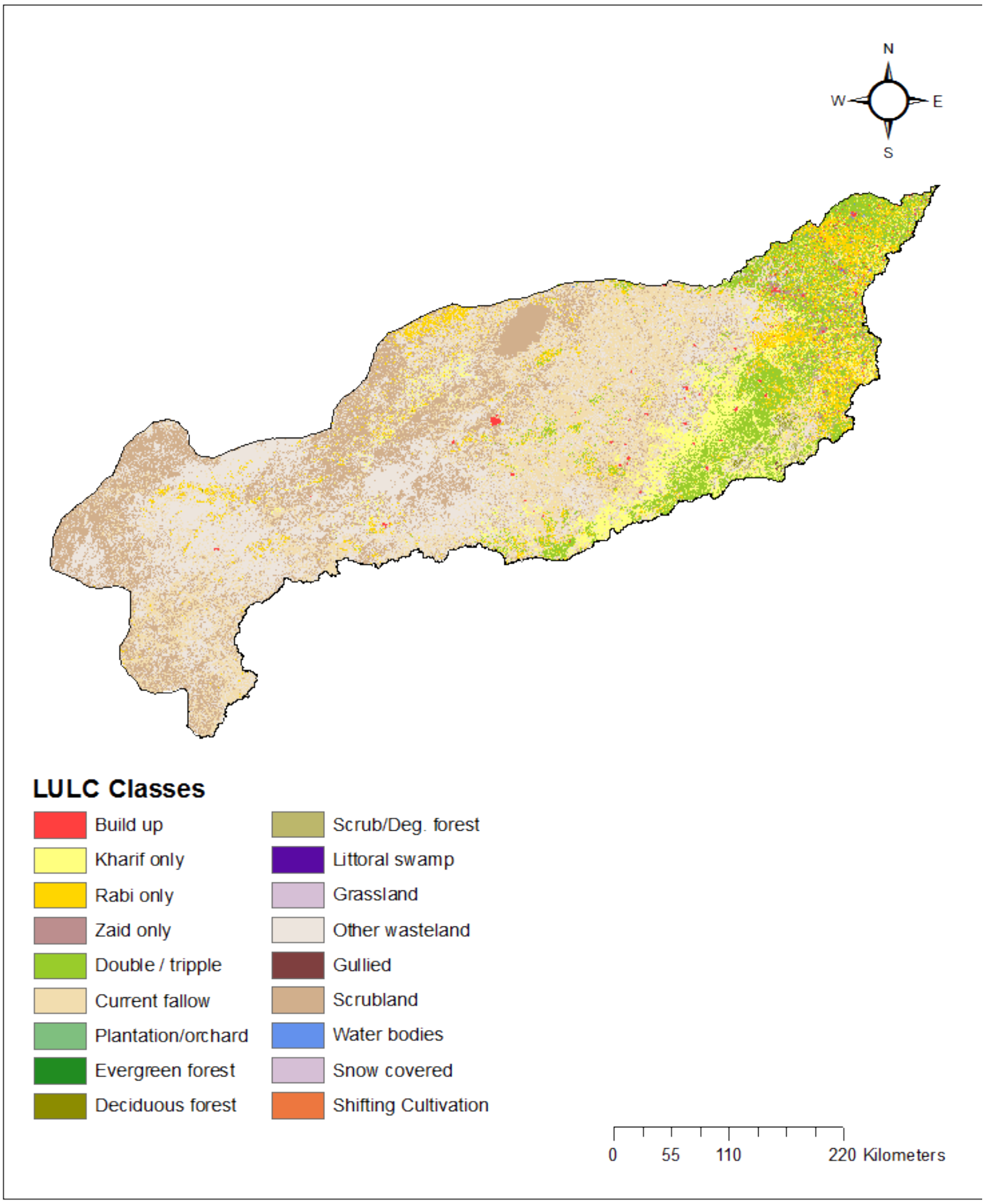


Figure 20.1 LULC map of Area of Inland Drainage in Rajasthan Desert basin (2004-05)

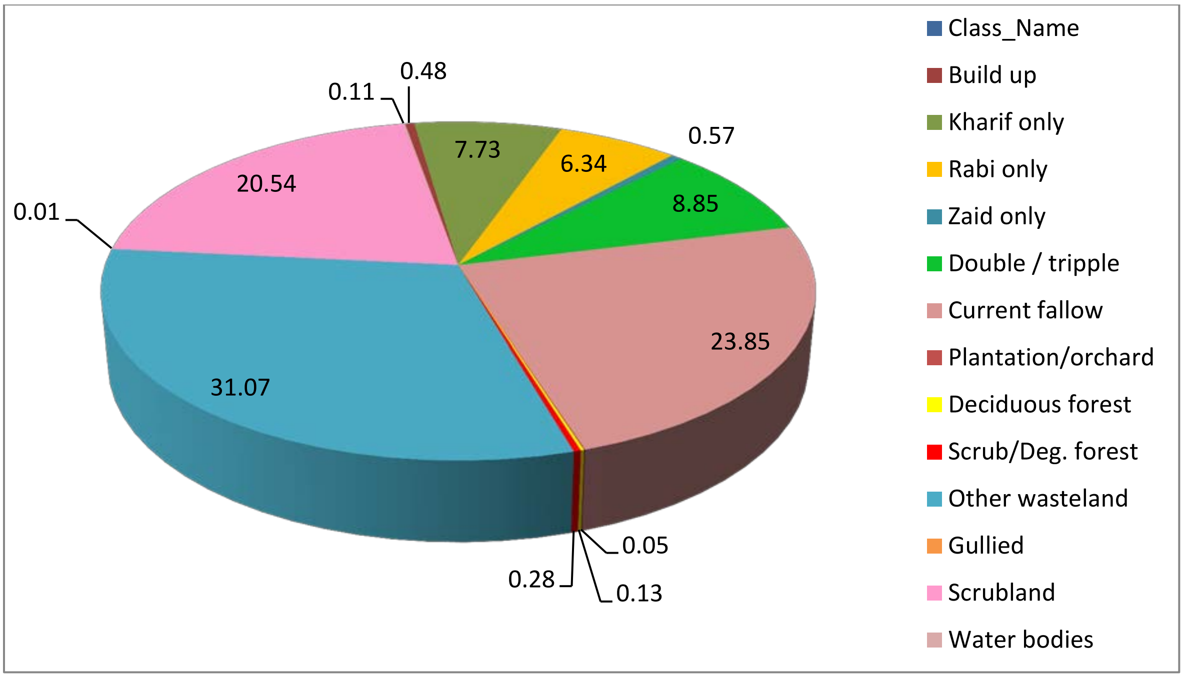


Figure 20.2 Distribution of LULC in Area of Inland Drainage in Rajasthan Desert basin (2004-05)

20.1.2 Soil texture

Sandy, loamy, rock outcrop and clayey are the main soil texture classes in the basin. Figure 20.3 shows various categories of soils in the basin.

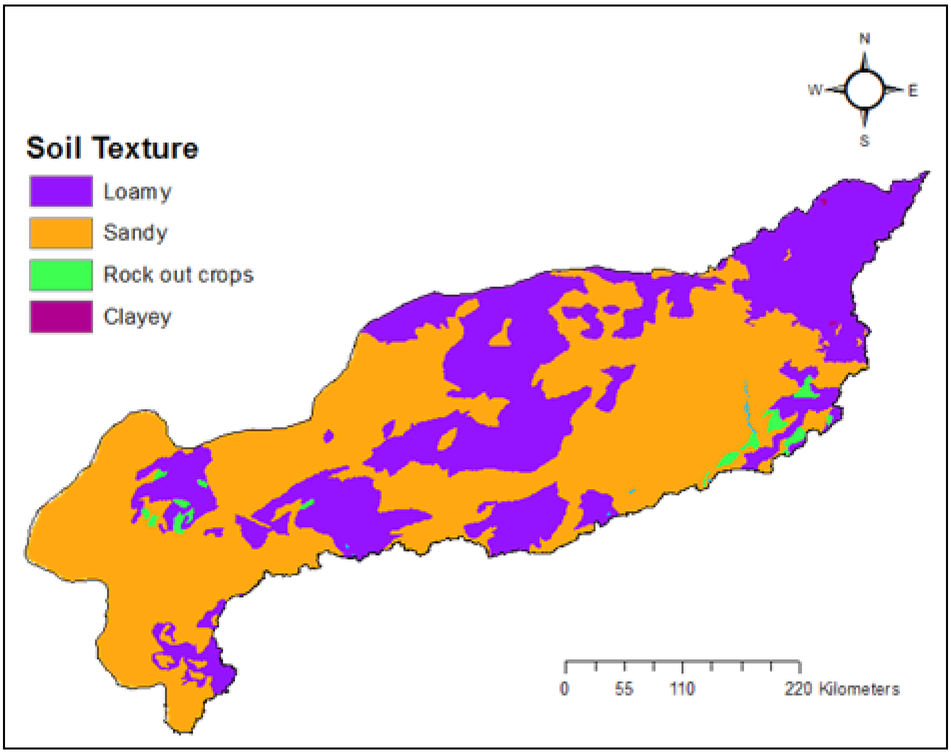


Figure 20.3 Soil texture map of Area of Inland Drainage in Rajasthan Desert basin

20.1.3 Topography

Figure 20.4 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the basin. Elevation varies from 23 m to 1,041 m in the basin.

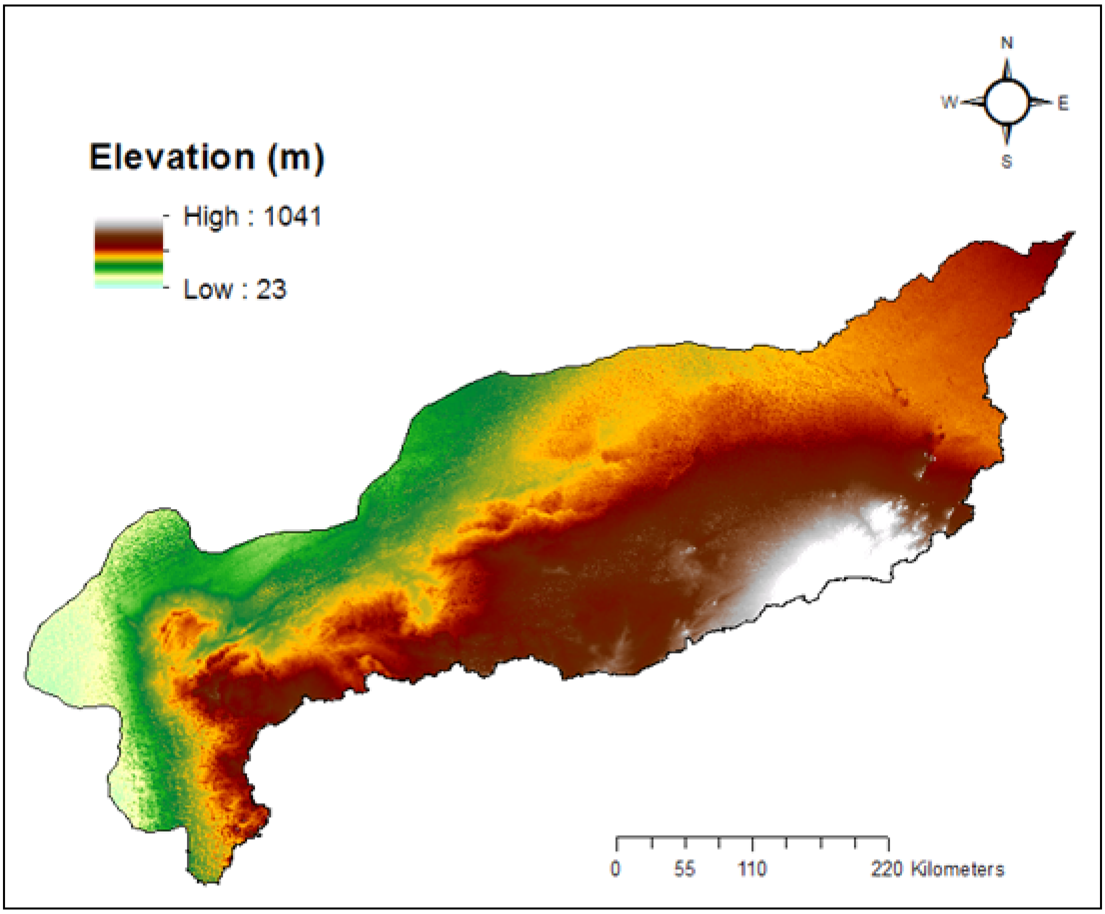


Figure 20.4 SRTM DEM map of Area of Inland Drainage in Rajasthan Desert basin

20.2 Hydro-Meteorological and Other Input Data

20.2.1 Rainfall grids

Figure 20.5 shows gridded rainfall of the basin for year 2004-05. The variations in annual rainfall during the period of 30 years (1985-86 to 2014-15) are shown in the Figure 20.6. Mean rainfall for 30 years (1985-2015) has been estimated as 302 mm in the basin.

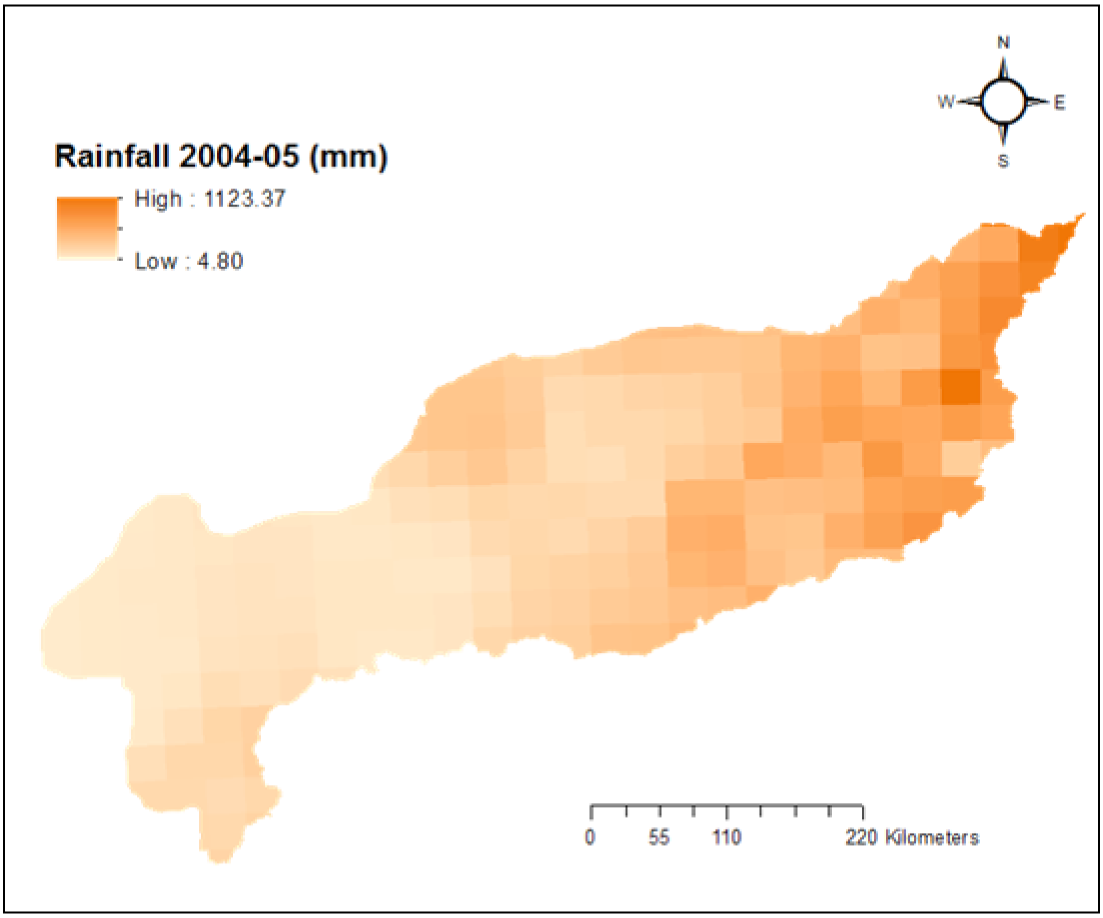


Figure 20.5 Gridded rainfall of Area of Inland Drainage in Rajasthan Desert basin (2004-05)

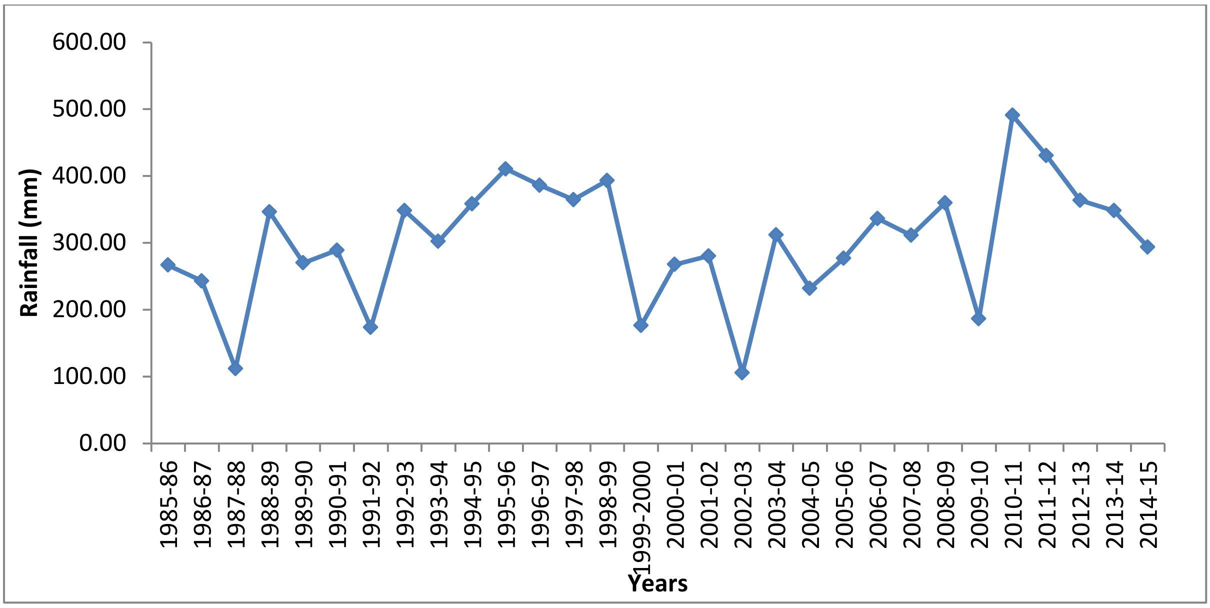


Figure 20.6 Annual rainfalls in Area of Inland Drainage in Rajasthan Desert basin (1985-86 to 2014-15)

20.2.2 Temperature grids

The mean annual temperature during 2004-05 varies from 24.64°C to 27.44°C as shown in Figure 20.7.

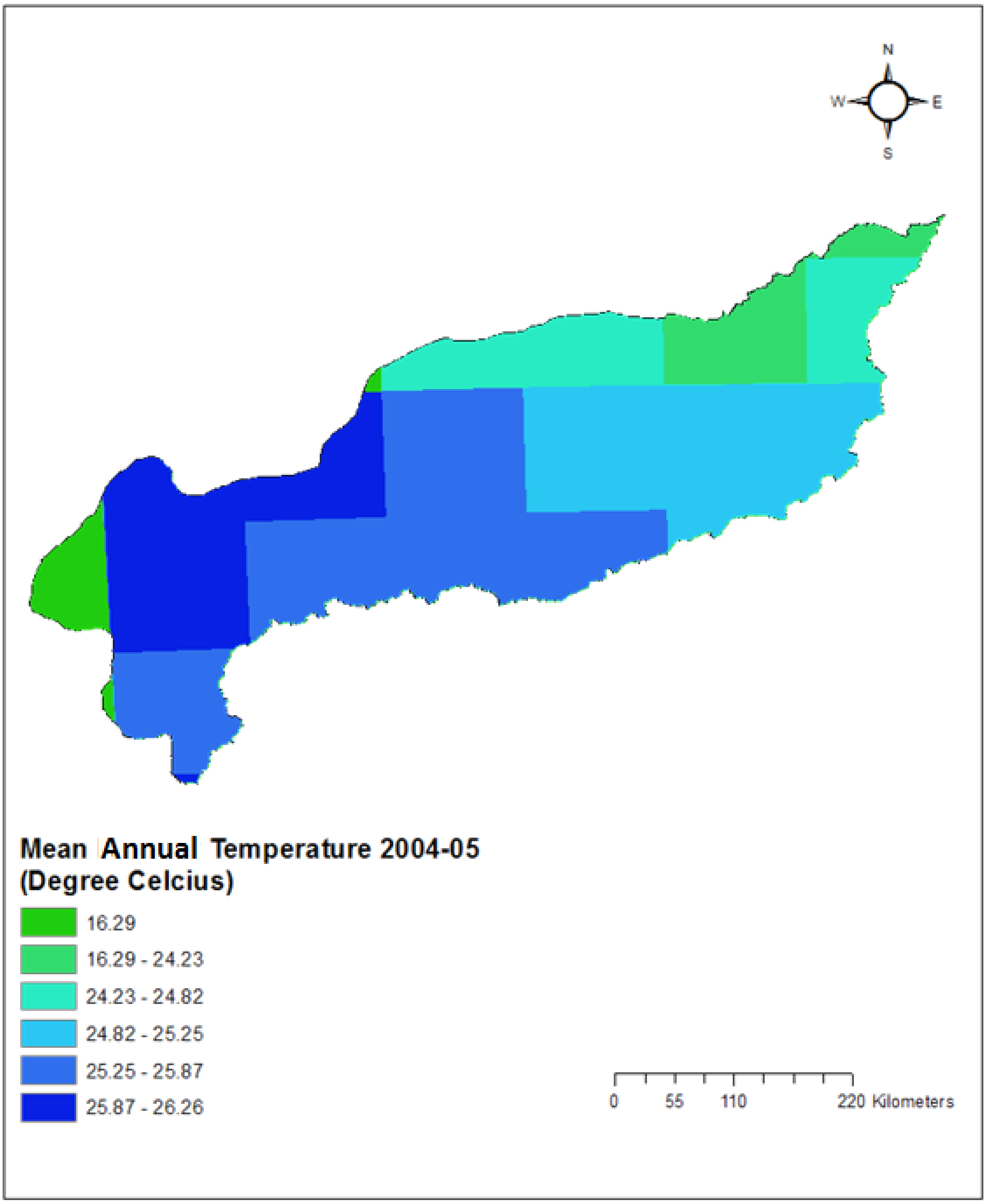


Figure 20.7 Gridded mean annual temperature of Area of Inland Drainage in Rajasthan Desert basin (2004-05)

20.2.3 Groundwater flux

The spatial variation in groundwater flux during 2004-05 is shown in Figure 20.8. The annual variation in ground water flux (1985-86 to 2014-15) in the basin is shown in Figure 20.9.

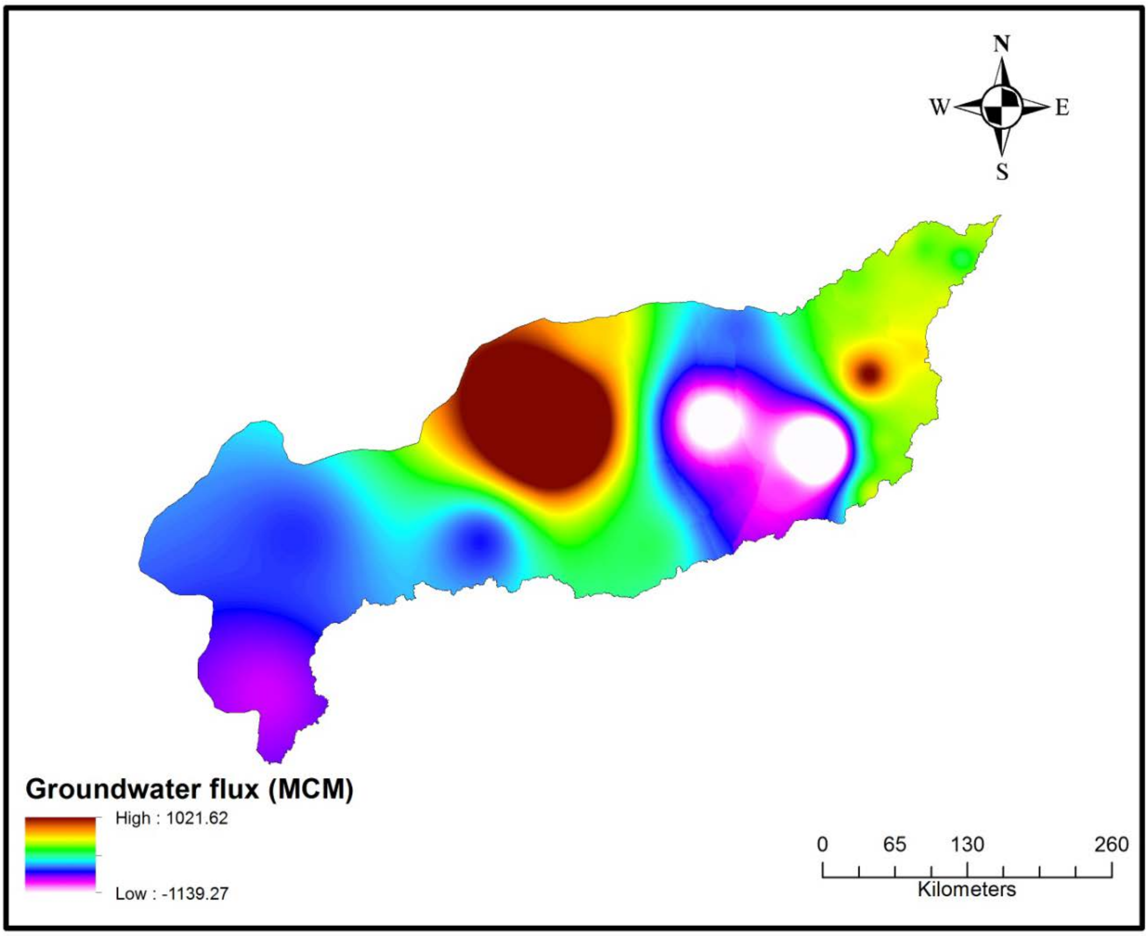


Figure 20.8 Groundwater flux (spatial data) estimated during 2004-05

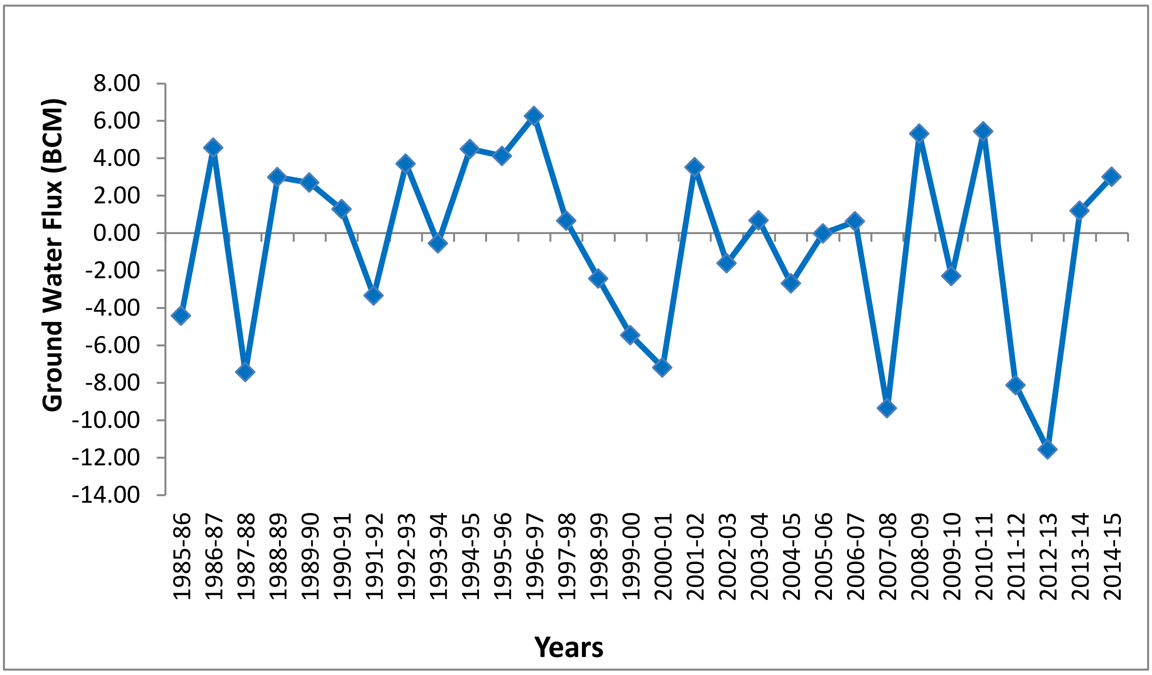


Figure 20.9 Annual groundwater flux of Area of Inland Drainage in Rajasthan Desert basin (1985-86 to 2014-15)

20.3 Annual Water Resources Availability of Area of Inland Drainage in Rajasthan Desert Basin

In the present study the water resource assessment of Area of Inland Drainage in Rajasthan Desert basin has not been carried out due to it negligible water potential.

ANNEXURES

ANNEXURE – K

INDUS BASIN

Table - K.1 Water availability at Akhnoor

Year	Rainfall		ECII	DIL	GW Flux	Snowmelt	Q-calib	Q-obs	Water availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	1344	30.63	0.003	0.0070	0.004	5.99	28.03	27.81	34.03
1986-87	1476	33.64	0.001	0.0072	0.002	6.59	31.03	31.15	37.63
1987-88	1231	28.05	0.013	0.0074	-0.024	7.31	27.95	28.65	35.26
1988-89	1549	35.30	0.007	0.0076	0.019	6.84	32.78	34.17	39.65
1989-90	1310	29.85	0.006	0.0077	-0.002	9.54	31.19	29.56	40.74
1990-91	1304	29.72	0.003	0.0079	0.014	8.89	30.13	32.32	39.04
1991-92	1139	25.96	0.002	0.0081	0.004	8.37	26.09	30.23	34.47
1992-93	1375	31.33	0.001	0.0084	-0.015	6.97	28.91	26.73	35.87
1993-94	1133	25.82	0.026	0.0086	-0.021	6.50	23.67	21.27	30.18
1994-95	1653	37.67	0.001	0.0089	0.014	7.58	34.81	27.44	42.41
1995-96	1662	37.87	0.002	0.0091	0.001	8.15	36.76	27.03	44.92
1996-97	1479	33.70	0.000	0.0093	0.011	7.32	32.00	30.17	39.34
1997-98	1810	41.25	0.000	0.0096	0.011	6.91	37.98	27.20	44.91
1998-99	1027	23.40	0.007	0.0098	-0.047	7.65	21.68	24.86	29.30
1999-00	947	21.58	0.003	0.0101	0.013	6.27	19.63	21.78	25.93
2000-01	768	17.50	0.003	0.0103	-0.036	4.79	13.78	18.94	18.55
2001-02	1000	22.79	0.008	0.0106	-0.005	6.72	21.37	-	28.10
2002-03	1045	23.81	0.005	0.0108	0.024	8.11	23.75	-	31.90
2003-04	915	20.85	0.003	0.0111	-0.006	7.98	20.23	23.40	28.22
2004-05	935	21.31	0.002	0.0114	0.005	5.60	17.74	20.00	23.36
2005-06	2216	50.50	0.003	0.0116	-0.014	7.96	47.83	25.27	55.79
2006-07	1589	36.20	0.001	0.0119	0.021	6.16	33.08	28.13	39.27
2007-08	1019	23.22	0.005	0.0121	-0.021	5.62	19.96	20.80	25.58
2008-09	1166	26.58	0.009	0.0124	-0.015	6.50	22.52	20.57	29.03
2009-10	1062	24.20	0.000	0.0127	-0.024	5.60	19.19	21.64	24.78
2010-11	1633	37.21	0.001	0.0129	0.042	5.51	34.10	28.25	39.67
2011-12	1143	26.05	0.006	0.0132	-0.009	5.36	22.82	21.47	28.19
2012-13	898	20.46	0.005	0.0134	0.006	6.72	19.55	19.92	26.29
2013-14	1670	38.06	0.000	0.0137	0.051	8.03	36.71	20.61	44.80
2014-15	1550	35.32	0.006	0.0140	0.015	8.80	35.65	-	44.49
Avg	1301.60	29.66	0.004	0.01	0.001	7.01	27.70	25.53	34.72

Table - K.2 Water availability at Chetak

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Q-Calib	Q-obs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	702	15.29	0.704	0.051	0.112	0	6.64	-	7.51
1986-87	606	13.20	0.892	0.052	-0.042	0	4.40	-	5.30
1988-89	1046	22.79	0.957	0.054	0.394	0	14.24	-	15.65
1989-90	590	12.85	1.001	0.056	-0.016	0	5.69	-	6.73
1990-91	741	16.14	0.895	0.057	0.116	0	7.92	-	8.99
1991-92	445	9.69	1.094	0.058	-0.088	0	2.38	-	3.45
1992-93	559	12.18	0.813	0.060	-0.077	0	4.57	-	5.36
1993-94	565	12.31	1.166	0.061	-0.062	0	4.88	-	6.04
1994-95	669	14.57	0.961	0.063	0.440	0	6.62	-	8.09
1995-96	931	20.28	0.958	0.065	0.354	0	12.15	-	13.53
1996-97	600	13.07	0.787	0.066	-0.095	0	5.21	-	5.97
1997-98	620	13.51	0.441	0.068	0.171	0	5.62	-	6.30
1998-99	743	16.19	0.814	0.069	0.124	0	7.50	-	8.51
1999-00	468	10.20	1.322	0.071	-0.212	0	4.25	-	5.43
2000-01	466	10.15	1.262	0.073	-0.159	0	3.90	-	5.08
2001-02	481	10.48	1.201	0.074	-0.227	0	2.86	-	3.91
2002-03	442	9.63	1.389	0.075	-0.111	0	3.52	-	4.87
2003-04	657	14.31	0.883	0.076	0.015	0	5.97	-	6.94
2004-05	541	11.78	1.144	0.077	-0.184	0	5.06	-	6.10
2005-06	574	12.51	1.092	0.077	0.044	0	3.31	-	4.53
2006-07	599	13.06	1.010	0.078	-0.151	0	4.51	-	5.45
2007-08	647	14.10	0.667	0.079	-0.269	0	6.29	-	6.77
2008-09	925	20.15	0.463	0.080	-0.009	0	10.47	-	11.00
2009-10	429	9.35	0.755	0.081	-0.399	0	3.60	-	4.04
2010-11	734	15.99	1.120	0.081	0.089	0	5.63	-	6.92
2011-12	903	19.67	1.227	0.082	-0.167	0	8.13	-	9.28
2012-13	723	15.75	0.939	0.083	-0.168	0	5.94	-	6.80
2013-14	623	13.57	0.936	0.084	0.086	0	3.36	-	4.47
2014-15	505	11.00	0.886	0.085	-0.161	0	3.17	-	3.98
Avg	639.10	13.92	0.96	0.07	-0.02	0.00	5.79		6.79
Avg*	624.57	13.61	0.958	0.071	-0.037	0.00	5.484		6.48

*Average excluding high variance year (1988-89);
Water year 1987-88 has been omitted because of exceptionally low rainfall (about 226mm)

Table - K.3 Water availability at Harike

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Snow melt *	Import	Export	Q-calib[#]	Q-obs	Res. Evp.	Water Availability
Year	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10	11	12	13=3+4 +5+6+9 +10+12
1985-86	1312.00	52.96	4.96	0.08	0.06	-1.67	2.30	11.00	4.59	36.12	15.94	0.63	44.77
1986-87	1314.00	53.04	5.30	0.08	-0.01	-0.81	2.30	15.50	5.33	39.53	16.25	0.65	50.07
1987-88	800.00	32.29	7.68	0.08	-0.10	0.90	2.30	16.30	5.08	21.59	10.89	0.37	35.60
1988-89	1761.00	71.08	4.02	0.08	0.24	-2.04	2.30	15.80	3.94	61.07	34.05	0.58	67.89
1989-90	1165.00	47.02	5.70	0.08	-0.11	-0.54	2.30	16.70	4.62	36.33	14.35	0.51	46.59
1990-91	1368.00	55.22	4.73	0.09	0.11	0.10	2.30	17.00	5.02	42.78	21.68	0.58	53.41
1991-92	1104.00	44.56	5.98	0.09	-0.05	0.06	2.30	20.60	4.99	34.24	15.23	0.41	45.72
1992-93	1140.00	46.01	6.50	0.09	-0.12	1.94	2.30	15.10	5.32	32.76	18.87	0.54	47.03
1993-94	1145.00	46.22	6.36	0.09	-0.07	0.33	2.30	12.70	4.09	27.65	15.56	0.38	38.83
1994-95	1324.00	53.44	5.91	0.09	0.02	-0.04	2.30	14.00	4.79	37.93	25.50	0.47	49.17
1995-96	1441.00	58.16	5.94	0.09	0.06	0.53	2.30	13.50	4.62	40.25	24.45	0.45	51.94
1996-97	1204.00	48.60	6.15	0.10	0.02	0.27	2.30	12.90	4.93	31.75	18.49	0.64	43.86
1997-98	1353.00	54.61	3.40	0.10	0.08	-2.04	2.30	12.10	4.58	41.34	20.89	0.63	48.09
1998-99	1182.00	47.71	5.03	0.10	-0.02	0.98	2.30	16.00	4.61	33.37	23.18	0.50	44.57
1999-00	1056.00	42.62	5.47	0.10	-0.08	0.71	2.30	16.10	5.37	30.14	18.12	0.43	42.14
2000-01	854.00	34.47	6.27	0.10	-0.13	0.52	2.30	11.00	4.39	17.79	11.52	0.43	29.37
2001-02	1032.00	41.65	7.46	0.10	-0.06	-0.81	2.30	9.40	4.53	22.13	13.60	0.39	33.74
2002-03	762.00	30.76	6.04	0.10	-0.12	-0.20	2.30	8.00	4.58	12.68	11.36	0.34	23.42
2003-04	850.00	34.31	5.05	0.10	-0.09	1.45	2.30	8.00	1.98	15.21	13.27	0.40	24.10
2004-05	906.00	36.58	7.67	0.11	-0.03	-1.86	2.30	9.00	1.56	21.61	11.35	0.36	29.42
2005-06	1090.00	44.03	6.92	0.11	-0.10	-1.23	2.30	9.00	5.29	23.34	15.91	0.56	34.89
2006-07	1040.00	42.01	7.54	0.11	-0.02	-0.17	2.30	11.00	4.64	22.53	15.06	0.48	35.11
007-08	987.00	39.83	7.45	0.11	-0.10	2.44	2.30	11.00	4.98	16.00	12.90	0.38	31.26
2008-09	1226.00	49.52	7.09	0.11	0.01	-0.13	2.30	11.10	5.01	25.50	17.25	0.42	38.01
2009-10	859.00	34.67	9.35	0.11	-0.10	0.17	2.30	9.00	4.26	11.70	9.37	0.33	25.82
2010-11	1207.00	48.72	6.60	0.11	0.03	-3.79	2.30	10.70	4.92	29.47	16.70	0.47	37.81
2011-12	1158.00	46.74	5.80	0.11	-0.04	2.62	2.30	10.00	5.31	20.35	18.77	0.64	34.79
2012-13	977.00	39.43	6.88	0.11	-0.09	-0.64	2.30	10.00	4.76	21.23	14.29	0.38	32.63
2013-14	1318.00	53.20	5.99	0.11	0.11	-0.54	2.30	10.00	5.09	31.72	18.69	0.63	43.11
2014-15	1062.00	42.87	5.51	0.12	-0.06	-1.22	2.30	10.00	4.95	27.17	12.64	0.39	36.86
Avg	1133.23	45.74	6.16	0.10	-0.03	-0.16	2.30	12.42	4.60	28.84	16.87	0.48	40.00
Avg.*	1111.59	44.87	6.23	0.10	-0.03	-0.09	2.30	12.30	4.63	27.73	16.28	0.48	39.05

* Average values excluding high variance year (1988-89)

Q-calib includes snowmelt and import

Table - K.4 Water availability at Nimoo

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Q-calib	Q-obs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2a()	2(b)	3	4	5	6	7	8	9=3+4+5+6+7
1985-86	1203	27.29	0	0.0006	0.0002	0.00	25.62	-	25.62
1986-87	1048	23.77	0	0.0006	0.0000	0.00	21.27	-	21.27
1987-88	939	21.30	0	0.0006	-0.0036	0.00	19.69	-	19.69
1988-89	1354	30.71	0	0.0006	0.0029	0.00	29.02	-	29.02
1989-90	1114	25.27	0	0.0006	-0.0002	0.00	23.55	-	23.55
1990-91	989	22.43	0	0.0007	0.0043	0.00	19.86	-	19.87
1991-92	737	16.72	0	0.0007	0.0090	0.00	12.79	-	12.80
1992-93	937	21.25	0	0.0007	-0.0063	0.00	18.30	-	18.29
1993-94	922	20.91	0	0.0007	-0.0234	0.00	18.56	-	18.54
1994-95	1115	25.29	0	0.0007	0.0122	0.00	20.72	-	20.73
1995-96	1627	36.91	0	0.0007	0.0006	0.00	35.75	-	35.75
1996-97	1166	26.45	0	0.0008	0.0012	0.00	22.89	-	22.89
1997-98	1095	24.84	0	0.0008	0.0021	0.00	22.18	-	22.18
1998-99	392	8.89	0	0.0008	-0.0369	0.00	4.34	-	4.30
1999-00	383	8.69	0	0.0008	0.0271	0.00	5.20	-	5.23
2000-01	317	7.19	0	0.0008	-0.0359	0.00	3.16	-	3.12
2001-02	667	15.13	0	0.0009	0.0093	0.00	12.27	-	12.28
2002-03	314	7.12	0	0.0009	0.0049	0.00	3.34	-	3.35
2003-04	250	5.67	0	0.0009	-0.0073	0.00	1.84	-	1.83
2004-05	920	20.87	0	0.0009	0.0099	0.00	18.93	-	18.94
2005-06	1269	28.79	0	0.0009	-0.0051	0.00	23.72	-	23.72
2006-07	1346	30.53	0	0.0010	0.0112	0.00	29.69	-	29.70
2007-08	494	11.21	0	0.0010	-0.0144	0.00	6.54	-	6.53
2008-09	651	14.77	0	0.0010	-0.0078	0.00	9.24	-	9.23
2009-10	713	16.17	0	0.0010	-0.0140	0.00	10.91	-	10.90
2010-11	1006	22.82	0	0.0010	0.0257	0.00	18.19	-	18.22
2011-12	884	20.05	0	0.0011	-0.0092	0.00	14.61	-	14.60
2012-13	664	15.06	0	0.0011	0.0065	0.00	10.15	-	10.16
2013-14	783	17.76	0	0.0011	0.0218	0.00	12.41	-	12.43
2014-15	587	13.31	0	0.0011	0.0118	0.00	10.27	-	10.28
Avg	862.87	19.57	0	0.0008	-0.0001	0.00	16.17	-	16.17

Table - K.5 Water availability for Rest of Indus (ROI)

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Q-calib	Q-obs	Water availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9=3+4+5+6+7
1985-86	1068	178.47	1.44	0.141	0.004	0.00	157.83	-	159.42
1986-87	1107	184.99	1.75	0.144	-0.005	0.00	158.52	-	160.41
1987-88	859	143.54	2.00	0.147	-0.025	0.00	123.99	-	126.11
1988-89	1156	193.18	1.98	0.151	0.059	0.00	168.31	-	170.50
1989-90	1007	168.28	2.02	0.154	-0.015	0.00	146.43	-	148.59
1990-91	1106	184.82	1.89	0.158	0.044	0.00	165.43	-	167.52
1991-92	785	131.18	2.33	0.161	-0.012	0.00	106.90	-	109.38
1992-93	1000	167.11	1.67	0.166	-0.005	0.00	142.42	-	144.25
1993-94	879	146.89	2.59	0.170	-0.013	0.00	121.58	-	124.33
1994-95	1218	203.54	1.91	0.175	0.016	0.00	182.35	-	184.45
1995-96	1246	208.22	1.88	0.179	0.045	0.00	167.78	-	169.88
1996-97	958	160.09	1.52	0.184	-0.019	0.00	136.98	-	138.67
1997-98	1002	167.44	0.73	0.188	0.053	0.00	145.74	-	146.71
1998-99	541	90.40	2.40	0.193	-0.006	0.00	64.77	-	67.36
1999-00	502	83.89	2.69	0.197	-0.039	-0.05	60.91	-	63.71
2000-01	428	71.52	2.56	0.202	-0.036	-0.938	48.96	-	50.75
2001-02	669	111.79	2.61	0.206	-0.045	0.09	85.13	-	87.99
2002-03	688	114.97	2.98	0.212	-0.015	-0.66	94.42	-	96.94
2003-04	644	107.62	1.86	0.217	-0.005	0.16	79.85	-	82.08
2004-05	502	83.83	2.39	0.222	-0.034	-0.498	58.12	-	60.20
2005-06	986	164.79	2.20	0.227	-0.019	-0.360	145.65	-	147.70
2006-07	1097	183.38	1.44	0.233	0.016	-0.178	159.13	-	160.64
2007-08	657	109.82	2.41	0.238	-0.046	0.711	75.99	-	79.30
2008-09	724	120.91	2.08	0.243	0.007	0.256	84.25	-	86.84
2009-10	700	116.97	2.16	0.248	-0.087	0.066	86.21	-	88.60
2010-11	844	141.04	2.38	0.254	0.026	-0.527	115.42	-	117.55
2011-12	934	156.08	2.76	0.259	-0.032	0.562	128.27	-	131.82
2012-13	726	121.32	2.37	0.264	-0.030	-0.420	89.92	-	92.10
2013-14	766	128.00	1.78	0.269	0.047	-0.659	102.13	-	103.57
2014-15	773	129.17	1.99	0.275	-0.018	-0.089	113.46	-	115.62
Avg	852.40	142.44	2.09	0.203	-0.006	-0.08	117.23	-	119.43

ANNEXURE-L(a)

UPPER GANGA SUB_BASIN

Table - L.1 Water availability at Rishikesh

Year	Rainfall		Qobs	Fluxes		ECII	Water availability
				DIL	Reservoir flux		
	mm	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7 = 3+4+5+6
1985-86	1705	37.13	23.55	0.01	0.00	0.05	23.61
1986-87	1326	28.88	22.62	0.01	0.00	0.07	22.70
1987-88	969	21.10	17.00	0.01	0.00	0.09	17.10
1988-89	1373	29.90	24.01	0.01	0.00	0.15	24.17
1989-90	969	21.10	20.52	0.01	0.00	0.18	20.71
1990-91	1446	31.49	25.33	0.01	0.00	0.10	25.44
1991-92	1069	23.28	29.93	0.01	0.00	0.09	30.03
1992-93	1357	29.55	23.73	0.02	0.00	0.18	23.92
1993-94	1180	25.70	21.72	0.02	0.00	0.07	21.81
1994-95	1195	26.02	28.16	0.01	0.00	0.20	28.37
1995-96	1402	30.53	28.37	0.02	0.00	0.18	28.57
1996-97	1249	27.19	25.78	0.02	0.00	0.13	25.93
1997-98	903	19.66	19.85	0.02	0.00	0.15	20.02
1998-99	948	20.64	25.71	0.01	0.00	0.09	25.81
1999-00	1152	25.08	21.87	0.02	0.00	0.21	22.10
2000-01	1220	26.58	25.02	0.02	0.00	0.19	25.23
2001-02	1243	27.07	23.50	0.02	0.00	0.25	23.77
2002-03	1135	24.71	23.43	0.02	0.00	0.07	23.52
2003-04	1076	23.42	27.87	0.02	0.00	0.22	28.10
2004-05	1205	26.24	25.63	0.02	0.00	0.02	25.68
2005-06	1003	21.83	21.25	0.02	0.00	0.11	21.38
2006-07	1238	26.97	21.40	0.02	0.00	0.10	21.52
2007-08	1343	29.25	25.96	0.02	-0.22	0.15	25.91
2009-10	895	19.49	16.93	0.02	0.00	0.43	17.38
2008-09	801	17.43	24.86	0.02	-0.01	0.44	25.32
2009-10	916	19.94	16.93	0.02	0.00	0.43	17.38
2010-11	1800	39.20	32.93	0.02	0.02	0.34	33.31
2011-12	1134	24.70	26.23	0.02	-0.01	0.32	26.56
2012-13	1358	29.57	17.61	0.02	0.03	0.59	18.26
Avg.	1193	25.99	23.714	0.018	-0.007	0.193	23.92

Note: $Q_{calibrated}$ is taken as $Q_{observed}$ since the WRA tool does not account snow-melt.

Table - L.2 Water availability at Dabri

Year	Rainfall		ECII	Import	Fluxes		Q-calib	Q-obs	Water availability
				IS*	DIL	GW_Flux			
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3-4+5+6+7
1985-86	1448	34.98	2.62	0.95	0.11	1.12	16.73	11.32	19.63
1986-87	1043	25.21	3.28	1.32	0.11	-0.79	11.86	5.43	13.14
1987-88	636	15.36	8.32	2.64	0.11	-2.71	0.00	1.65	3.03
1988-89	1323	31.95	4.51	1.48	0.11	2.31	12.70	9.96	18.15
1989-90	1134	27.39	4.30	1.54	0.12	-0.54	10.20	3.99	12.54
1990-91	1221	29.49	4.29	1.56	0.13	-0.07	13.98	10.43	16.77
1991-92	871	21.05	6.45	2.10	0.13	-0.62	4.36	3.24	8.22
1992-93	1092	26.39	3.85	1.38	0.13	-0.78	10.43	2.52	12.25
1993-94	986	23.82	3.95	1.48	0.14	-0.63	10.40	6.23	12.38
1994-95	959	23.17	5.87	1.93	0.14	-0.65	8.27	3.95	11.7
1995-96	1147	27.71	5.36	1.95	0.15	1.36	9.34	7.67	14.26
1996-97	1064	25.71	4.09	1.50	0.15	-0.40	9.05	6.04	11.39
1997-98	587	14.17	7.32	2.37	0.16	0.16	0.00	4.38	4.54
1998-99	1056	25.50	5.26	1.81	0.15	2.42	7.10	0.50	13.12
1999-00	1000	24.16	5.13	1.83	0.16	0.04	6.46	16.54	9.96
2000-01	1123	27.13	5.58	1.72	0.17	0.28	10.30	26.82	14.61
2001-02	792	19.12	7.35	2.22	0.17	-0.65	2.44	6.45	7.09
2002-03	918	22.18	6.68	2.24	0.18	-0.80	6.28	4.30	10.1
2003-04	1263	30.51	5.29	1.67	0.18	0.78	12.14	11.34	16.72
2004-05	948	22.90	4.57	1.86	0.19	-1.05	6.71	7.36	8.56
2005-06	966	23.34	4.66	1.71	0.19	0.59	7.38	9.61	11.11
2006-07	752	18.17	5.69	1.73	0.20	-1.01	3.03	3.23	6.18
2007-08	807	19.50	5.56	1.57	0.20	-1.36	5.38	6.02	8.21
2008-09	979	23.65	8.70	1.73	0.20	2.40	0.00	11.00	9.54
2009-10	806	19.48	8.66	2.22	0.20	-1.90	0.72	6.14	5.46
2010-11	1565	37.80	4.54	1.18	0.21	2.92	19.11	15.16	25.6
2011-12	1343	32.44	6.93	1.45	0.21	-2.11	15.63	17.05	19.21
2012-13	907	21.92	7.48	1.48	0.22	-0.95	3.70	3.79	8.97
Avg	1026	24.79	5.58	1.74	0.16	-0.09	7.96	7.93	11.87

** Irrigation support to Dabri from Ghaghra*

Table - L.3 Water availability at Chhatnag

Years	Rainfall		ECII	Import	Fluxes			Export		Discharge coming from upstream G&D sites			Qcalib	Qobs	Ptotal$	Water availability$$
				ECII*	DIL	GW Flux	Reservoir Evaporation	IS**	IS***	Qobs#	Qcalib##	Qcalib###				
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5(a)	5(b)	5(c)	6(a)	6(b)	7(a)	7(b)	7(c)	8	9	10	11
1985-86	1154	57.23	9.46	2.43	0.30	3.96	0.27	0.43	10.75	23.55	76.12	16.73	121.58	120.04	458.74	74.53
1986-87	830	41.16	8.05	2.98	0.31	-2.75	0.27	0.71	11.43	22.62	64.42	11.86	102.83	101.27	345.48	59.11
1987-88	842	41.74	25.07	6.03	0.32	-5.85	0.33	1.71	21.33	17.00	23.50	-0.05	5.82	55.82	296.36	31.06
1988-89	1161	57.60	13.34	3.42	0.32	2.54	0.22	0.82	11.28	24.01	53.91	12.70	95.82	90.95	396.04	77.53
1989-90	803	39.83	15.49	3.82	0.33	-1.33	0.24	0.80	14.01	20.52	9.71	10.20	29.07	44.18	308.35	52.97
1990-91	902	44.73	13.63	3.71	0.35	0.85	0.23	0.88	14.21	25.33	85.33	13.98	118.61	115.29	415.07	67.90
1991-92	721	35.78	17.50	4.66	0.36	-1.61	0.33	1.32	14.27	29.93	53.94	4.36	74.86	79.85	321.52	59.16
1992-93	864	42.85	12.47	3.50	0.37	-0.57	0.23	1.05	12.64	23.73	61.85	10.43	88.03	84.45	376.86	55.77
1993-94	787	39.05	9.63	3.65	0.38	-2.77	0.25	0.90	15.03	21.72	62.04	10.40	91.02	68.15	365.01	55.95
1994-95	791	39.25	16.65	4.53	0.39	-1.10	0.21	1.02	14.01	28.16	92.48	8.27	118.19	110.13	404.60	62.45
1995-96	889	44.08	17.13	4.44	0.41	1.55	0.22	0.95	14.65	28.37	53.33	9.34	79.31	82.01	390.82	67.94
1996-97	943	46.77	11.77	3.16	0.42	0.81	0.24	0.77	11.55	25.78	81.16	9.05	112.35	133.93	430.07	60.73

1	2(a)	2(b)	3	4	5(a)	5(b)	5(c)	6(a)	6(b)	7(a)	7(b)	7(c)	8	9	10	11
1997-98	460	22.83	20.04	5.31	0.43	-0.23	0.22	1.09	16.91	19.85	65.21	-0.73	55.10	77.03	331.46	36.16
1998-99	810	40.20	17.58	5.10	0.44	4.38	0.31	0.92	12.70	25.71	47.43	7.10	64.49	110.16	339.86	61.32
1999-00	828	41.08	15.74	4.65	0.46	0.84	0.25	0.80	13.07	21.87	89.57	6.46	103.60	137.21	382.21	50.74
2000-01	808	40.06	16.60	4.54	0.47	-0.80	0.22	0.56	14.87	25.02	22.83	10.30	47.35	85.33	307.43	62.70
2001-02	763	37.85	21.87	5.31	0.49	-1.85	0.25	0.84	13.68	23.50	48.03	2.44	58.16	75.00	342.54	52.55
2002-03	667	33.06	20.46	5.45	0.50	-2.09	0.30	0.83	14.93	23.43	25.42	6.28	37.82	44.60	251.46	53.49
2003-04	1153	57.20	15.37	3.82	0.51	3.26	0.25	1.81	12.46	27.87	62.85	12.14	101.74	93.57	401.27	79.05
2004-05	648	32.13	15.95	3.76	0.52	-4.09	0.33	1.12	14.18	25.63	20.93	6.71	38.97	50.50	331.65	49.79
2005-06	772	38.27	9.77	3.49	0.53	-1.38	0.23	0.70	13.49	21.25	41.46	7.38	68.53	71.56	333.82	55.99
2006-07	661	32.77	13.15	3.98	0.54	-2.15	0.21	1.01	12.24	21.40	50.88	3.03	65.20	53.37	322.39	44.30
2007-08	574	28.46	15.96	2.90	0.55	-3.94	0.18	0.81	13.97	25.96	14.55	5.38	33.01	32.46	271.45	50.36
2008-09	853	42.33	23.86	4.20	0.56	3.19	0.24	0.73	19.42	16.93	61.06	-0.03	53.04	79.72	366.39	51.74
2009-10	650	32.25	27.38	3.76	0.57	-3.67	0.20	1.31	14.18	24.86	6.16	0.72	4.95	25.07	282.84	46.17
2010-11	1006	49.91	19.00	4.16	0.58	3.60	0.17	0.89	15.04	16.93	22.20	19.11	48.27	59.57	368.20	73.49
2011-12	937	46.48	20.78	3.58	0.59	-1.11	0.29	0.65	12.75	32.93	82.10	15.63	121.19	115.08	438.98	78.46
2012-13	847	42.01	20.45	3.73	0.60	-0.04	0.24	1.18	14.61	26.23	54.59	3.70	66.58	57.34	359.04	56.13
Avg	826	40.96	16.58	4.07	0.45	-0.44	0.25	0.95	14.06	23.93	51.18	7.96	71.62	80.49	355.00	58.13

** Irrigation support from Ghagra; ** Irrigation Support to Galeta sub-basin (YBO) from Chatnag; *** Irrigation Support to Pratappur sub-basin (YBO) from Chatnag; #Observed discharge at Rishikesh G&D site; ## calibrated discharge at Pratappur G&D site (YBO); ###calibrated discharge at Dabri G&D site; $total rainfall combining that of whole Yamuna, Rishikesh, Dabri & Chatnag;*

$$ Water availability = Q_{calib} *(8) + Sum of DIL of Rishikesh, Dabri and Chhatnag + Sum of Reservoir flux of Rishikesh, Dabri and Chhatnag + Sum of GW flux of Rishikesh, Dabri and Chhatnag + Sum of Reservoir evaporation of Rishikesh, Dabri and Chhatnag + ECII of Dabri and Rishikesh + ECII of Chhatnag (3) + Export {6(a) + 6(b)} -* Q_{calib} *at Pratappur {7(b)}*

Table - L.4 Water availability at Varanasi

Years	Rainfall		R_{tool*}	ECII	Import	Fluxes		Upstream discharges	Qcalib	Qobs	P_{total}#	Water availability$
					ECII from LGBO	DIL	GW Flux	Qcalib Chatnag				
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6(a)	6(b)	7	8	9	10	11
1985-86	1053	23.15	12.44	3.65	2.76	0.06	0.42	106.12	114.43	123.72	481.88	86.97
1986-87	884	19.44	10.45	2.28	4.13	0.07	-0.71	81.44	90.25	107.12	364.92	69.56
1987-88	946	20.80	12.54	2.22	2.72	0.07	0.20	5.65	15.70	63.36	317.17	43.59
1988-89	917	20.15	10.94	5.52	2.72	0.07	-0.42	81.49	87.26	89.66	416.19	88.47
1989-90	710	15.62	7.93	4.55	2.80	0.07	0.04	27.75	31.02	43.22	323.97	60.90
1990-91	1088	23.93	13.89	4.56	3.38	0.08	1.15	110.52	118.63	110.10	439.00	81.79
1991-92	891	19.59	11.79	2.39	2.83	0.08	-0.65	55.80	65.77	72.17	341.11	70.95
1992-93	900	19.79	10.31	4.18	3.85	0.08	-0.24	76.99	83.29	81.65	396.66	66.08
1993-94	837	18.41	10.25	2.95	2.73	0.08	-0.50	80.13	87.85	66.22	383.42	66.20
1994-95	1010	22.20	14.68	4.34	4.82	0.08	1.67	111.90	120.49	110.86	426.80	77.13
1995-96	925	20.33	10.52	4.92	4.70	0.09	-0.43	71.34	77.28	88.39	411.16	78.46
1996-97	835	18.35	9.22	4.49	2.82	0.09	-1.02	107.02	112.68	134.45	448.42	69.95
1997-98	859	18.89	11.16	2.61	3.28	0.09	2.04	52.61	59.02	84.38	350.36	47.32
1998-99	762	16.75	8.95	3.02	2.84	0.09	0.43	50.92	56.33	109.04	356.61	70.27
1999-00	1224	26.90	15.91	3.65	2.72	0.10	-0.59	87.64	100.38	130.29	409.11	66.65
2000-01	834	18.35	10.36	4.99	4.23	0.10	-1.11	45.67	52.05	90.96	325.77	73.06
2001-02	1181	25.97	15.64	4.88	3.43	0.10	1.00	50.84	60.49	80.15	368.50	68.19
2002-03	876	19.26	10.71	2.44	4.21	0.11	1.14	32.82	39.83	42.67	270.71	64.20
2003-04	1271	27.94	17.49	5.12	3.80	0.11	1.41	82.65	93.51	113.03	429.21	96.54
2004-05	751	16.51	7.82	2.63	4.21	0.11	-2.51	38.94	46.51	55.33	348.16	57.61
2005-06	860	18.91	10.74	2.57	3.55	0.11	-0.08	63.57	71.70	98.45	352.73	66.73
2006-07	775	17.04	8.53	3.47	3.37	0.12	0.04	61.57	66.46	62.93	339.43	52.83
2007-08	581	12.78	5.34	3.83	3.79	0.12	-0.59	29.33	31.30	35.25	284.23	55.69
2008-09	1032	22.69	13.43	8.30	3.82	0.12	-0.06	34.49	39.55	79.28	389.08	65.17
2009-10	611	13.44	5.15	8.44	2.80	0.12	-1.08	5.15	2.82	25.05	296.28	51.32
2010-11	666	14.63	5.97	8.17	2.80	0.13	-0.35	48.39	46.42	61.02	382.83	79.45
2011-12	1215	26.70	15.98	7.09	3.82	0.13	1.35	122.77	130.19	108.68	465.68	94.44
2012-13	1147	25.22	14.30	6.86	4.45	0.13	1.56	66.91	72.66	64.00	384.26	70.43
Avg	915.80	20.13	11.16	4.43	3.48	0.10	0.08	63.94	70.50	83.27	375.13	69.28

*R_{tool} is the runoff obtained from WRA tool

P_{total} = Total rainfall combining that of Chatnag and Varanasi

$ Water availability = R_{tool} + Water availability at Chhatnag

Table - L.5 Water availability at Maighat

Years	Rainfall		Import	Fluxes		Qobs	Qcalib	Water availability
			IS from Ghaghra	DIL	GW flux			
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8 = 4+5+7
1985-86	1272	38.21	6.49	0.17	3.01	19.32	16.49	19.67
1986-87	892	26.80	6.19	0.18	-3.20	8.07	16.93	13.91
1987-88	633	19.02	10.86	0.18	-1.12	4.81	7.71	6.77
1988-89	1028	30.88	8.85	0.18	-0.17	10.91	14.94	14.95
1989-90	811	24.38	9.86	0.19	0.66	5.59	9.26	10.11
1990-91	892	26.81	9.31	0.20	0.18	8.70	14.65	15.03
1991-92	851	25.57	9.75	0.20	-0.56	7.71	15.49	15.14
1992-93	820	24.64	8.36	0.21	-0.68	4.87	8.03	7.56
1993-94	630	18.93	7.91	0.22	-2.05	3.38	10.78	8.94
1994-95	783	23.53	10.78	0.22	0.38	5.42	9.7	10.30
1995-96	893	26.83	11.41	0.23	0.09	5.08	10.89	11.22
1996-97	970	29.14	7.62	0.24	0.63	6.38	10.93	11.80
1997-98	511	15.37	11.12	0.24	1.01	6.32	5.92	7.17
1998-99	698	20.98	11.18	0.25	0.03	11.16	10.17	10.45
1999-00	886	26.63	9.24	0.26	2.34	10.23	8.61	11.21
2000-01	793	23.83	11.30	0.27	-0.99	6.91	13.41	12.69
2001-02	862	25.91	12.90	0.28	0.55	6.92	11.62	12.45
2002-03	629	18.90	11.50	0.29	-2.62	4.66	11.22	8.88
2003-04	1075	32.30	9.71	0.29	2.80	10.29	14.32	17.41
2004-05	752	22.61	8.88	0.30	-1.96	8.02	12.56	10.90
2005-06	733	22.03	7.17	0.30	-1.32	4.61	11.84	10.82
2006-07	688	20.67	8.55	0.31	-0.59	5.06	10.74	10.46
2007-08	644	19.36	8.92	0.31	-3.02	3.42	11.97	9.26
2008-09	1113	33.46	15.11	0.32	1.34	9.62	18.50	20.15
2009-10	814	24.45	21.43	0.32	-1.01	5.41	8.26	7.57
2010-11	816	24.52	19.43	0.33	-0.51	4.92	9.32	9.14
2011-12	973	29.25	13.80	0.34	0.19	6.20	12.82	13.34
2012-13	968	29.09	11.81	0.34	1.12	4.82	10.66	12.12
Avg	836.82	25.15	10.69	0.26	-0.20	7.10	11.70	11.76

Table - L.6 Water availability at Turtipar

Years	Rainfall		ECII	Export				Fluxes			Discharge coming from upstream G&D sites		Qcalib	Qobs	$P_{total}^{\$}$	Water availability$^{\$\$}$
				IS^{*}	IS^{**}	IS^{***}	IS^{****}	DIL	GW Flux	Res. Evaporation	Qobs Paliakalan	Qobs Elginbridge				
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4(a)	4b)	4(c)	4(d)	5(a)	5(b)	5(d)	6(a)	6(b)	7	8	9	10
1985-86	1498	70.12	11.73	0.95	2.43	6.49	5.95	0.18	1.58	0.56	23.39	70.02	88.45	107.64	202.86	122.29
1986-87	1102	51.59	19.86	1.32	2.98	6.19	6.42	0.19	-2.21	0.56	23.37	66.80	55.43	65.995	152.21	93.50
1987-88	1146	53.62	19.47	2.64	6.03	10.86	9.06	0.19	0.09	0.45	10.98	40.30	12.96	55.151	114.18	66.83
1988-89	1110	51.94	19.62	1.48	3.42	8.85	6.65	0.20	-0.16	0.49	21.58	61.89	58.23	63.49	156.51	105.13
1989-90	1531	71.67	16.89	1.54	3.82	9.86	5.71	0.21	1.78	0.62	14.91	49.38	48.87	71.24	172.59	93.35
1990-91	1214	56.81	20.64	1.56	3.71	9.31	6.66	0.21	-0.35	0.53	25.05	65.49	57.29	83.798	137.53	104.35
1991-92	1033	48.34	24.57	2.10	4.66	9.75	6.55	0.22	-2.74	0.47	16.68	52.23	30.55	66.214	117.13	80.69
1992-93	1062	49.72	17.13	1.38	3.5	8.36	5.16	0.23	0.74	0.59	10.79	40.46	22.01	53.029	136.25	63.24
1993-94	1168	54.69	22.17	1.48	3.65	7.91	6.28	0.23	0.16	0.56	16.55	52.90	41.89	66.982	145.52	88.68
1994-95	1013	47.41	20.79	1.93	4.53	10.78	6.58	0.24	-2.45	0.44	13.44	47.29	26.77	58.29	153.65	74.40
1995-96	1202	56.26	19.43	1.95	4.44	11.41	6.95	0.25	2.06	0.54	17.44	58.34	39.35	70.087	143.82	91.99
1996-97	1165	54.52	17.69	1.50	3.16	7.62	5.96	0.26	0.06	0.53	15.10	64.53	57.11	62.626	146.16	98.66
1997-98	718	33.60	24.52	2.37	5.31	11.12	11.15	0.26	0.91	0.42	14.86	59.47	26.19	55.444	93.84	87.75

1	2(a)	2(b)	4	5(a)	5(b)	5(c)	5(d)	7(a)	7(b)	7(d)	8(a)	8(b)	9	10	11	12
1998-99	938	43.89	27.85	1.81	5.1	11.18	9.67	0.27	0.57	0.43	16.51	76.96	50.38	108.54	121.33	113.66
1999-00	992	46.43	19.74	1.83	4.65	9.24	7.71	0.28	0.52	0.58	16.14	67.12	44.73	47.89	146.91	93.70
2000-01	1341	62.79	19.80	1.72	4.54	11.30	6.32	0.29	-0.77	0.53	20.25	72.20	62.88	80.73	174.36	111.64
2001-02	1292	60.46	20.20	2.22	5.31	12.90	5.95	0.30	0.46	0.54	16.70	55.09	37.35	64.909	177.74	91.27
2002-03	734	34.37	26.20	2.24	5.45	11.50	8.58	0.31	-2.54	0.45	16.32	45.25	9.49	59.95	121.63	65.97
2003-04	1137	53.23	21.19	1.67	3.82	9.71	6.96	0.31	0.65	0.58	23.71	70.10	51.68	76.691	187.63	103.09
2004-05	890	41.67	25.91	1.86	3.76	8.88	8.60	0.32	-1.08	0.56	16.77	40.80	9.80	61.505	146.24	63.59
2005-06	1100	51.47	21.65	1.71	3.49	7.17	6.96	0.32	0.88	0.49	16.20	56.97	33.46	64.502	137.99	81.42
2006-07	861	40.30	24.47	1.73	3.98	8.55	7.76	0.33	-0.51	0.52	14.56	50.14	19.68	54.768	120.45	72.22
2007-08	1096	51.31	20.59	1.57	2.9	8.92	9.00	0.34	0.61	0.48	15.70	88.52	72.17	88.012	146.98	121.82
2008-09	1340	62.70	22.71	1.73	4.2	15.11	9.08	0.34	0.39	0.53	18.49	85.92	67.68	108.05	161.01	127.15
2009-10	908	42.51	27.04	2.22	3.76	21.43	11.10	0.35	-0.82	0.56	23.58	66.42	23.32	93.36	134.52	93.26
2010-11	1023	47.90	19.94	1.18	4.16	19.43	9.80	0.36	0.51	0.48	23.74	77.87	43.68	81.666	146.99	104.57
2011-12	967	45.27	21.46	1.45	3.58	13.80	7.88	0.36	-0.87	0.34	14.49	83.85	55.80	50.783	99.51	108.37
2012-13	1082	50.66	18.88	1.48	3.73	11.81	8.30	0.37	0.49	0.42	5.48	113.00	90.50	71.197	132.88	140.86
Avg	1095	51.26	21.15	1.74	4.07	10.69	7.60	0.28	-0.07	0.51	17.24	63.55	44.20	71.16	143.87	95.12

** Irrigation support to Dabri from Ghaghra; **Irrigation support to Chatnag from Ghagra; ***Irrigation support to Maighat from Ghaghra; Irrigation support to LGBO from Ghagra; $ Total rainfall combining that of Paliakalan, Elginbridge & Turtipar*

$$ Water availability = Qcalib (7) + Sum of DIL of Elginbridge, Palliakalan and Turtipar + Sum of Reservoir flux of Elginbridge, Paliakalan and Turtipar + Sum of GW flux of Elginbridge, Paliakalan and Turtipar + ECII of Elginbridge and Paliakalan + ECII of Turtipar (3 + Export {4(a) + 4(b) + 4(c) + 4(d)}

Note: $Q_{calibrated}$ for Paliankalan and Elgin Bridge has been taken as $Q_{observed}$ for upstream sub-basins since the WRA tool does not account for snow-melt;

DIL, Reservoir flux, ECII and GW flux for Paliankalan and Elgin Bridge have been estimated separately and not given in the present report

Table - L.7 Water resources availability in the Upper Ganga sub-basin

Year	Rainfall	Q-calib	ECII	DIL	Res. Flux	GW Flux	Export	Import	Res. Evap.	Water Availability*
	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2	3	4	5	6	7	8	9	10	11 = 3+4+5+6+7+8-9+10
1985_86	393.55	177.71	36.43	0.88	4.37	11.56	16.70	2.76	0.83	245.72
1986_87	293.69	148.77	44.68	0.90	-3.46	-11.89	17.85	4.13	0.83	193.55
1987_88	232.22	62.31	72.64	0.93	-5.65	-10.96	30.39	2.72	0.78	147.72
1988_89	326.99	145.24	56.89	0.92	2.12	5.53	17.93	2.72	0.71	226.62
1989_90	300.91	110.80	54.90	0.96	-1.29	1.00	19.72	2.80	0.85	184.14
1990_91	293.97	141.21	57.43	1.02	2.00	1.60	20.87	3.38	0.76	221.51
1991_92	242.40	110.96	66.44	1.05	-2.26	-7.35	20.82	2.83	0.80	187.63
1992_93	279.47	89.92	50.03	1.08	-0.81	-1.31	17.80	3.85	0.82	153.69
1993_94	271.43	122.82	51.80	1.12	-3.27	-6.61	21.31	2.73	0.81	185.26
1994_95	287.82	101.12	64.05	1.13	0.57	-2.83	20.59	4.82	0.65	180.46
1995_96	293.32	112.85	63.66	1.19	1.12	4.95	21.60	4.70	0.76	201.42
1996_97	293.33	130.90	49.81	1.22	-0.22	0.78	17.51	2.82	0.77	197.96
1997_98	184.76	66.29	70.90	1.26	1.82	4.20	28.06	3.28	0.64	169.89
1998_99	245.40	111.27	71.03	1.26	4.81	8.14	22.37	2.84	0.74	216.78
1999_00	290.76	110.78	57.67	1.34	0.26	3.56	20.78	2.72	0.83	192.48
2000_01	310.31	139.96	63.41	1.38	-1.90	-3.34	21.19	4.23	0.75	217.20
2001_02	313.65	100.46	73.47	1.42	-0.84	-0.53	19.63	3.43	0.79	190.97
2002_03	239.74	75.96	73.22	1.47	-0.94	-8.55	23.51	4.21	0.75	161.22
2003_04	359.01	140.66	61.70	1.50	4.67	10.55	19.42	3.80	0.83	235.52
2004_05	266.64	86.94	62.99	1.53	-6.60	-10.81	22.78	4.21	0.90	153.52
2005_06	262.37	111.15	51.11	1.56	-1.45	-1.27	20.45	3.55	0.72	178.73
2006_07	236.07	81.32	61.19	1.59	-2.10	-4.34	20.00	3.37	0.72	155.00
2007_08	256.32	140.23	60.03	1.61	-4.74	-8.14	22.97	3.79	0.65	208.82
2008_09	302.64	118.10	83.94	1.64	3.14	7.74	28.50	3.82	0.77	240.01
2009_10	241.57	68.21	97.92	1.64	-4.76	-8.78	25.28	2.80	0.77	177.48
2010_11	293.78	107.78	76.03	1.70	3.25	6.62	24.84	2.80	0.65	218.07
2011_12	273.59	144.06	76.37	1.74	0.25	-4.03	20.63	3.82	0.63	235.82
2012_13	275.83	149.54	70.24	1.77	1.51	2.55	22.91	4.45	0.66	244.73
Avg.	280.77	114.55	63.57	1.31	-0.37	-0.78	21.66	3.48	0.76	197.22

**including water availability for ungauged sub-basin*

ANNEXURE - L (b)

LOWER GANGA SUB_BASIN

Table - L.8 Water availability at Chopan

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Export	Q-calib	Q-obs	Reservoir Evap.	Water availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10	11= 3+4+5+6+7 +8+10
1985-86	1160.79	53.91	5.09	0.05	0.10	1.05	5.35	29.12	16.53	0.40	41.17
1986-87	1005.45	46.69	4.14	0.06	-0.13	-0.69	8.02	21.53	16.29	0.45	33.38
1987-88	1170.17	54.34	4.94	0.06	0.03	1.64	5.28	30.27	20.21	0.35	42.58
1988-89	959.08	44.54	5.18	0.07	-0.64	-0.15	6.57	20.56	15.90	0.39	31.99
1989-90	1068.81	49.63	4.04	0.07	0.16	-0.56	5.49	26.21	14.29	0.47	35.88
1990-91	1229.53	57.10	4.25	0.08	0.55	0.65	7.46	28.53	22.51	0.46	41.98
1991-92	1080.43	50.17	4.91	0.08	-0.55	-0.39	5.29	29.05	24.69	0.38	38.78
1992-93	1011.56	46.98	5.91	0.08	-0.41	-0.01	9.12	18.32	13.77	0.34	33.36
1993-94	1058.04	49.13	5.2	0.09	0.21	0.37	5.47	23.89	17.10	0.44	35.66
1994-95	1577.72	73.27	4.11	0.09	0.24	-0.12	6.36	49.84	43.89	0.45	60.97
1995-96	1056	49.04	6.02	0.10	-0.16	-0.33	5.29	23.8	13.81	0.40	35.12
1996-97	1003.22	46.59	4.72	0.10	-0.62	0.32	8.21	21.9	17.19	0.38	35.02
1997-98	1421.43	66.01	3.11	0.10	1.68	0.64	6.66	37.88	31.10	0.35	50.42
1998-99	1007.05	46.77	5.22	0.11	-0.87	-0.50	8.17	21.43	19.58	0.39	33.94
1999-00	1249.2	58.01	3.71	0.11	0.04	0.44	7.38	31.63	29.46	0.38	43.68
2000-01	1018.22	47.29	4.93	0.12	-0.62	-0.17	8.17	21.89	20.91	0.41	34.74
2001-02	1352.09	62.79	4.35	0.12	-0.04	-0.50	6.89	35.92	27.54	0.46	47.20
2002-03	922.79	42.85	3.82	0.13	-0.49	-0.19	6.53	19.85	9.00	0.32	29.96
2003-04	1436.02	66.69	4.79	0.13	0.73	-0.11	7.36	36.32	28.84	0.46	49.68
2004-05	1003.52	46.60	3.02	0.13	-0.61	-0.03	7.41	23.34	12.77	0.31	33.59
2005-06	1084.91	50.38	9.38	0.14	0.34	-0.09	5.42	22.69	25.29	0.41	38.28
2006-07	1013.7	47.08	8.96	0.14	-0.44	0.32	7.41	18.47	16.93	0.39	35.25
2007-08	773.89	35.94	7.3	0.15	-0.62	0.26	8.62	9.70	6.82	0.29	25.69
2008-09	1014.85	47.13	7.85	0.15	-0.56	0.06	9.07	16.50	10.04	0.33	33.41
2009-10	788.05	36.60	9.86	0.16	0.05	-0.30	9.74	5.92	8.09	0.28	25.71
2010-11	737.51	34.25	10.66	0.16	-0.38	0.22	9.74	3.21	7.20	0.27	23.88
2011-12	1359.25	63.12	9.37	0.16	1.38	3.09	6.44	28.47	22.49	0.41	49.32
2012-13	1304.51	60.58	10.94	0.17	-0.07	-0.73	7.36	25.21	13.77	0.38	43.27
2013-14	1278.26	59.36	10.4	0.17	0.98	2.59	6.50	21.73	13.08	0.44	42.81
2014-15	1002.42	46.55	10.22	0.18	-0.84	-0.26	5.52	17.57	9.43	0.31	32.70
Avg	1104.95	51.31	6.21	0.12	-0.05	0.22	7.08	24.03	18.28	0.38	37.98

Table - L.9 Water availability at Koelwar*

Year	Rainfall		ECII	DIL	GW Flux	Q-calib	Q-obs	Reservoir Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6++8
1985-86	1184.99	24.22	4.56	0.05	0.02	34.66	16.54	0.48	39.77
1986-87	1202.57	24.58	3.47	0.06	-0.01	25.35	16.28	0.48	29.35
1987-88	1316.23	26.90	5.95	0.06	-0.37	36.48	25.33	0.46	42.58
1988-89	868.41	17.75	4.10	0.07	-0.16	20.85	12.01	0.46	25.32
1989-90	978.15	19.99	3.41	0.07	0.38	27.67	11.14	0.46	31.99
1990-91	1072.30	21.92	4.11	0.08	0.10	32.27	21.24	0.45	37.01
1991-92	1116.08	22.81	4.02	0.08	-0.20	32.90	12.01	0.43	37.23
1992-93	698.96	14.29	4.63	0.08	-0.55	17.68	9.87	0.41	22.25
1993-94	1070.17	21.88	4.29	0.09	-0.06	26.84	20.18	0.46	31.62
1994-95	1514.26	30.95	3.24	0.09	0.18	59.55	43.12	0.49	63.55
1995-96	1117.43	22.84	4.64	0.10	0.12	25.61	16.12	0.47	30.94
1996-97	1053.46	21.53	4.01	0.10	-0.03	24.56	17.83	0.43	29.07
1997-98	1490.57	30.47	4.21	0.10	0.24	43.82	28.20	0.54	48.91
1998-99	967.73	19.78	5.01	0.11	0.18	20.93	13.82	0.47	26.7
1999-00	1209.24	24.72	4.33	0.11	-0.29	36.25	21.33	0.49	40.89
2000-01	985.89	20.15	4.27	0.12	-0.18	24.76	11.78	0.46	29.43
2001-02	1049.81	21.46	3.87	0.12	0.59	38.80	20.93	0.52	43.9
2002-03	896.08	18.32	3.67	0.13	-0.10	21.65	10.37	0.44	25.79
2003-04	1164.30	23.80	4.14	0.13	-0.23	40.98	25.68	0.49	45.51
2004-05	871.45	17.81	3.49	0.13	-0.48	24.75	9.00	0.39	28.28
2005-06	872.41	17.83	4.86	0.14	-0.01	22.24	12.53	0.42	27.65
2006-07	1206.76	24.67	3.85	0.14	0.13	23.88	10.11	0.54	28.54
2007-08	1044.11	21.34	5.11	0.15	0.38	11.16	4.50	0.49	17.29
2008-09	991.70	20.27	2.91	0.15	-0.51	21.96	7.22	0.40	24.91
2009-10	716.34	14.64	6.41	0.16	-0.31	3.36	4.00	0.41	10.03
2010-11	743.18	15.19	6.44	0.16	-0.72	0.36	2.76	0.46	6.7
2011-12	1140.91	23.32	5.66	0.16	0.76	31.95	15.02	0.53	39.06
2012-13	1182.54	24.17	5.64	0.17	0.07	26.91	9.38	0.46	33.25
2013-14	1190.75	24.34	4.85	0.17	-0.04	23.30	9.88	0.38	28.66
2014-15	823.76	16.84	7.95	0.18	-0.02	12.72	3.84	0.39	21.22
Avg	1058.02	21.63	4.57	0.12	-0.04	26.47	14.73	0.46	31.58

*Koelwar includes Chopan values

Table - L.10 Water availability at Jamalpur

Year	Rainfall		ECII	DIL	GW Flux	Res. Flux	Q-calib	Q-obs	Res. Evap	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10= 3+4+5+6+7+9
1985-86	1315.78	28.06	3.17	0.18	0.02	0.22	9.94	Not available	0.40	13.93
1986-87	1380.53	29.44	3.08	0.19	-0.01	-0.02	10.77		0.41	14.42
1987-88	1473.65	31.43	4.89	0.20	-0.37	-0.09	12.59		0.52	17.74
1988-89	1060.09	22.61	4.70	0.20	-0.16	-0.10	3.75		0.38	8.77
1989-90	1312.08	27.98	3.71	0.21	0.38	0.19	8.01		0.43	12.93
1990-91	1343.08	28.64	4.06	0.22	0.10	-0.04	11.33		0.38	16.05
1991-92	1245.77	26.57	4.00	0.22	-0.20	-0.04	8.42		0.40	12.8
1992-93	1973.46	42.09	4.85	0.23	-0.55	-0.10	3.88		0.29	8.6
1993-94	1208.42	25.77	4.91	0.23	-0.06	0.16	6.89		0.40	12.53
1994-95	1308.95	27.92	4.04	0.24	0.18	0.01	9.91		0.41	14.79
1995-96	1444.91	30.82	4.65	0.25	0.12	0.05	11.44		0.41	16.92
1996-97	1262.55	26.93	4.46	0.25	-0.03	-0.07	8.92	7.03	0.38	13.91
1997-98	1684.95	35.94	2.81	0.26	0.24	0.10	15.96	10.23	0.68	20.05
1998-99	1393.63	29.72	4.05	0.27	0.18	-0.16	9.07	6.49	0.43	13.84
1999-00	1848.81	39.43	2.33	0.27	-0.29	0.03	19.62	10.88	0.64	22.6
2000-01	1374.96	29.32	4.61	0.28	-0.18	-0.05	7.83	3.91	0.41	12.9
2001-02	1399.66	29.85	3.45	0.28	0.59	0.03	9.62	5.92	0.44	14.41
2002-03	1314.59	28.04	3.60	0.29	-0.10	0.00	9.12	4.09	0.36	13.27
2003-04	1309.65	27.93	3.25	0.30	-0.23	0.25	8.63	5.27	0.44	12.64
2004-05	1262.55	26.93	3.08	0.30	-0.48	-0.13	9.78	6.07	0.35	12.9
2005-06	1083.76	23.11	5.21	0.31	-0.01	-0.17	4.18	2.45	0.31	9.83
2006-07	1444.40	30.81	4.47	0.32	0.13	0.25	9.84	7.06	0.39	15.4
2007-08	1534.32	32.72	4.27	0.32	0.38	-0.16	15.27	7.62	0.50	20.58
2008-09	1398.79	29.83	4.88	0.33	-0.51	-0.08	10.82	10.21	0.39	15.83
2009-10	963.15	20.54	5.76	0.33	-0.31	0.02	3.39	2.99	0.38	9.57
2010-11	912.66	19.46	6.93	0.34	-0.72	-0.02	0.00	1.40	0.38	6.91
2011-12	1012.79	21.60	5.89	0.35	0.76	0.24	3.26	5.35	0.38	10.88
2012-13	1143.70	24.39	6.28	0.35	0.07	0.20	1.58	5.70	0.38	8.86
2013-14	1197.35	25.54	4.34	0.36	-0.04	0.17	5.33	6.03	0.38	10.54
2014-15	1088.87	23.22	9.96	0.37	-0.02	-0.46	0.00	5.68	0.38	10.23
Avg	1323.26	28.22	4.52	0.28	-0.04	0.01	8.31	6.02	0.41	13.49

Table - L.11 Water availability at Mohanpur

Year	Rainfall		ECII	DIL	GW Flux	Res. Flux	Q-calib	Q-obs	Res. Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10= 3+4+5+6+7+9
1985-86	1359.16	7.78	1.31	0.05	0.05	0.18	1.31	-	0.07	2.97
1986-87	1348.36	7.72	1.35	0.05	0.08	0.07	1.27	1.55	0.08	2.9
1987-88	1598.64	9.16	2.24	0.05	-0.14	-0.15	2.67	1.73	0.18	4.85
1988-89	1228.86	7.04	1.83	0.05	-0.25	-0.03	0.66	1.68	0.07	2.33
1989-90	1685.57	9.65	1.33	0.06	0.42	0.12	2.35	2.87	0.08	4.36
1990-91	1707.20	9.78	1.15	0.06	0.05	0.01	3.21	1.54	0.08	4.56
1991-92	1765.03	10.11	1.65	0.06	-0.16	-0.04	2.53	1.79	0.08	4.12
1992-93	1662.33	9.52	1.48	0.06	0.04	-0.07	2.73	1.55	0.09	4.33
1993-94	1589.99	9.11	1.75	0.06	0.19	0.06	2.23	2.79	0.08	4.37
1994-95	1427.17	8.17	1.93	0.06	-0.31	-0.23	2.47	3.47	0.07	3.99
1995-96	1751.29	10.03	1.83	0.06	0.13	0.11	2.81	2.84	0.08	5.02
1996-97	1448.36	8.30	2.01	0.06	0.12	-0.03	1.23	3.08	0.07	3.46
1997-98	1587.88	9.09	1.27	0.07	0.12	0.04	2.49	5.39	0.24	4.23
1998-99	1239.73	7.10	1.72	0.07	-0.51	-0.05	0.80	1.39	0.07	2.1
1999-00	1830.39	10.48	1.01	0.07	0.23	0.00	3.23	2.51	0.21	4.75
2000-01	1244.89	7.13	1.98	0.07	0.02	0.07	0.38	1.92	0.07	2.59
2001-02	1447.25	8.29	1.59	0.07	0.08	-0.09	1.57	3.48	0.08	3.3
2002-03	1632.27	9.35	1.24	0.07	0.02	0.06	3.03	2.52	0.12	4.54
2003-04	1435.82	8.22	1.55	0.07	-0.13	0.00	0.80	1.98	0.08	2.37
2004-05	1541.42	8.83	1.19	0.07	0.07	-0.07	2.18	3.15	0.12	3.56
2005-06	1291.96	7.40	1.79	0.07	-0.04	0.03	0.50	1.85	0.09	2.44
2006-07	1430.70	8.19	1.94	0.08	0.03	-0.05	1.65	2.81	0.07	3.72
2007-08	1743.27	9.98	2.06	0.08	0.03	0.07	3.21	3.89	0.18	5.63
2008-09	1397.66	8.01	1.40	0.08	0.01	-0.05	2.01	3.78	0.10	3.55
2009-10	1383.56	7.92	2.37	0.08	-0.36	0.01	1.16	1.69	0.05	3.31
2010-11	996.96	5.71	2.80	0.08	-0.06	0.04	0.00	0.00	0.03	2.89
2011-12	1413.39	8.10	2.16	0.08	0.14	-0.01	1.77	2.25	0.08	4.22
2012-13	1409.51	8.07	1.94	0.08	-0.05	0.29	0.20	0.21	0.08	2.54
2013-14	1548.15	8.87	0.99	0.08	0.19	-0.06	2.97	2.68	0.08	4.25
2014-15	1102.55	6.32	2.43	0.09	-0.13	0.05	0.00	0.00	0.21	2.65
Avg	1474.98	8.45	1.71	0.07	0.00	0.01	1.78	2.29	0.10	3.67

Table - L.12 Water availability at Gandhighat

Year	Rainfall		ECII	DIL	GW Flux	Q-calib*	Q-obs*	Reservoir Evap.	Water Availability**
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9
1985-86	1179.31	41.90	19.64	0.44	2.41	246.88	242.62	0.85	22.88
1986-87	1408.31	50.03	20.75	0.46	-1.97	187.40	206.39	0.84	20.98
1987-88	1888.12	67.08	27.46	0.48	0.23	134.62	127.74	0.64	24.28
1988-89	1430.55	50.82	20.66	0.49	-0.48	173.84	204.22	0.82	20.21
1989-90	1479.01	52.55	18.83	0.51	1.34	137.71	114.51	0.77	23.05
1990-91	1292.44	45.92	21.80	0.53	0.62	222.59	260.69	0.72	24.22
1991-92	1312.22	46.62	21.79	0.55	-2.46	163.69	255.89	0.71	18.34
1992-93	967.18	34.36	21.54	0.57	-0.62	149.75	229.37	0.80	13.07
1993-94	1315.41	46.73	20.54	0.59	0.49	152.78	288.28	0.79	18.44
1994-95	949.56	33.74	21.33	0.60	0.35	185.24	360.76	0.79	17.60
1995-96	1431.68	50.86	22.72	0.62	0.68	167.37	284.57	0.80	16.07
1996-97	1285.09	45.66	19.75	0.64	-0.52	210.75	285.03	0.87	15.06
1997-98	1503.61	53.42	26.48	0.66	1.44	147.40	150.45	0.69	15.61
1998-99	1612.26	57.28	27.41	0.68	0.53	230.45	327.83	0.75	12.50
1999-00	1780.78	63.27	22.08	0.70	0.12	199.30	307.69	0.66	14.86
2000-01	1359.13	48.29	21.18	0.71	-0.90	180.61	282.63	0.74	15.28
2001-02	1343.61	47.74	17.56	0.73	1.75	158.60	274.05	0.99	19.69
2002-03	1298.20	46.12	23.90	0.75	-1.75	114.87	175.18	1.31	11.63
2003-04	1472.81	52.33	21.70	0.77	0.58	186.46	309.29	0.88	17.08
2004-05	1262.94	44.87	26.26	0.79	-2.88	121.47	147.07	1.05	10.51
2005-06	1056.49	37.54	26.97	0.81	1.75	151.68	154.56	0.73	16.34
2006-07	1264.09	44.91	21.54	0.82	-0.95	118.57	141.26	0.87	11.29
2007-08	1533.36	54.48	25.27	0.84	0.34	141.66	177.80	0.66	21.85
2008-09	1295.72	46.03	25.14	0.86	0.28	206.63	355.39	1.00	19.86
2009-10	1042.03	37.02	34.78	0.88	-3.16	125.01	119.39	0.82	7.39
2010-11	1091.36	38.77	30.85	0.90	0.60	148.28	209.28	0.55	7.60
2011-12	1198.89	42.59	25.81	0.91	0.12	177.92	306.84	0.95	13.00
2012-13	1255.44	44.60	29.48	0.93	1.02	140.48	190.96	0.85	12.79
2013-14	1279.75	45.47	25.81	0.95	1.90	270.92	330.69	0.61	8.55
2014-15	1232.81	43.80	28.34	0.97	-1.21	183.99	143.14	1.20	7.57
Avg	1327.40	47.16	23.91	0.70	-0.01	171.23	232.12	0.82	15.92

** Cumulative discharges i.e. including discharges (from UGBO) at all the upstream G&D sites {Qcalib = Qcalib (Turtipar) + Qcalib (Chattnag) + Model runoff for Gandhighat}; **Water availability = Model runoff + Reservoir evaporation; Model runoff not shown in the table*

Table - L.13 Water availability at Hanskhali

Year	Rainfall		ECII	DIL	GW Flux	Res. Flux	Qcalib	Qobs	Res. Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10= 3+4+5+6+7+9
1985-86	1201.92	20.13	4.76	0.18	0.11	0.04	3.47	1.65	0.20	8.76
1986-87	1428.87	23.93	4.00	0.18	0.24	0.01	6.88	1.99	0.21	11.52
1987-88	1486.28	24.89	7.25	0.19	-0.08	-0.02	7.59	2.98	0.27	15.20
1988-89	1468.16	24.59	3.87	0.20	-0.10	-0.06	7.26	2.20	0.23	11.40
1989-90	1401.75	23.48	5.09	0.20	0.43	0.11	5.83	1.13	0.20	11.86
1990-91	1361.60	22.81	5.40	0.21	-0.03	-0.03	5.83	2.13	0.19	11.57
1991-92	1282.48	21.48	6.19	0.22	-0.36	0.02	3.79	2.05	0.19	10.05
1992-93	1112.94	18.64	6.61	0.22	-0.37	-0.05	1.60	1.35	0.21	8.22
1993-94	1452.55	24.33	5.49	0.23	0.22	0.03	5.92	2.40	0.19	12.08
1994-95	1152.02	19.30	7.26	0.23	-0.37	0.01	1.06	2.39	0.17	8.36
1995-96	1671.99	28.00	4.70	0.24	0.51	0.02	9.18	3.95	0.22	14.87
1996-97	1305.66	21.87	5.43	0.25	-0.34	-0.06	4.84	4.97	0.20	10.32
1997-98	1718.65	28.79	4.62	0.25	0.92	0.22	9.67	5.09	0.33	16.01
1998-99	1595.80	26.73	5.06	0.26	-0.91	-0.17	9.32	4.44	0.21	13.77
1999-00	2146.76	35.96	2.66	0.27	0.51	0.40	17.58	3.65	0.35	21.77
2000-01	2061.28	34.52	6.04	0.27	0.39	0.02	16.44	3.98	0.20	23.36
2001-02	1456.22	24.39	3.86	0.28	-0.38	0.02	7.42	2.38	0.22	11.42
2002-03	1580.22	26.47	5.77	0.28	0.02	0.00	9.36	1.77	0.24	15.67
2003-04	1283.13	21.49	5.00	0.29	-0.29	0.01	4.06	1.89	0.24	9.31
2004-05	1576.38	26.40	5.01	0.30	-0.01	0.04	9.44	1.94	0.21	14.99
2005-06	1230.55	20.61	6.09	0.30	-0.48	0.02	2.62	1.60	0.23	8.78
2006-07	1696.81	28.42	5.98	0.31	0.40	0.05	10.06	1.18	0.24	17.04
2007-08	1582.47	26.50	6.58	0.32	0.00	-0.08	8.92	2.45	0.20	15.94
2008-09	1512.02	25.32	6.63	0.32	0.04	0.00	4.19	2.09	0.28	11.46
2009-10	1109.69	18.59	8.85	0.33	-1.07	0.02	1.54	1.22	0.21	9.88
2010-11	1055.57	17.68	8.52	0.33	0.09	0.01	1.16	0.98	0.15	10.26
2011-12	927.41	15.53	10.29	0.34	0.04	0.02	0.86	1.58	0.16	11.71
2012-13	1046.29	17.52	8.02	0.35	-0.17	0.02	1.79	0.96	0.13	10.14
2013-14	1308.92	21.92	6.62	0.35	0.58	0.02	2.13	1.32	0.16	9.86
2014-15	1161.92	19.46	8.40	0.36	-0.32		1.17	1.20	0.55	10.16
Avg	1412.54	23.66	6.00	0.27	-0.03	0.02	6.03	2.30	0.23	12.52

Table - L.14 Water availability at Chapra

Year	Rainfall		ECII	DIL	GW Flux	Q-calib	Q-obs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8= 3+4+5+6
1985-86	1296.29	3.46	0.81	0.05	0.00	0.02	6.26	0.88
1986-87	1495.23	3.99	0.76	0.05	0.03	0.85	6.00	1.69
1987-88	1631.65	4.35	0.79	0.05	0.02	0.70	9.23	1.56
1988-89	1723.11	4.59	0.61	0.06	0.03	1.11	6.11	1.81
1989-90	1460.75	3.89	0.59	0.06	0.10	0.59	2.07	1.34
1990-91	1427.28	3.81	0.80	0.06	-0.06	0.30	6.25	1.10
1991-92	1335.74	3.56	0.73	0.06	-0.02	0.24	4.62	1.01
1992-93	1257.11	3.35	0.69	0.06	-0.04	0.25	2.25	0.96
1993-94	1458.35	3.89	0.74	0.06	0.04	0.45	3.93	1.29
1994-95	944.18	2.52	1.09	0.07	-0.15	0.00	4.45	1.01
1995-96	1993.38	5.31	0.79	0.07	0.26	1.34	4.93	2.46
1996-97	1338.28	3.57	0.87	0.07	-0.07	0.23	5.46	1.10
1997-98	1746.51	4.66	0.42	0.07	0.12	1.06	5.02	1.67
1998-99	1526.02	4.07	0.76	0.07	-0.20	0.72	7.93	1.35
1999-00	1941.68	5.18	0.66	0.08	0.19	1.26	7.95	2.19
2000-01	1625.20	4.33	0.76	0.08	0.21	1.08	7.07	2.13
2001-02	1378.95	3.68	0.69	0.08	-0.31	0.65	4.89	1.11
2002-03	1354.08	3.61	0.98	0.08	0.02	0.19	3.94	1.27
2003-04	1159.58	3.09	1.01	0.08	-0.04	0.00	5.37	1.05
2004-05	1433.36	3.82	1.08	0.08	-0.03	0.32	3.54	1.45
2005-06	1231.40	3.28	0.61	0.09	-0.08	0.39	3.35	1.01
2006-07	1273.44	3.40	0.85	0.09	-0.13	0.28	2.92	1.09
2007-08	1351.16	3.60	0.92	0.09	0.09	0.10	4.53	1.20
2008-09	1502.46	4.01	1.02	0.09	0.13	0.00	4.10	1.24
2009-10	1316.25	3.51	0.96	0.09	-0.34	0.54	2.12	1.25
2010-11	932.39	2.49	0.99	0.10	0.14	0.00	2.00	1.23
2011-12	938.43	2.50	1.26	0.10	0.13	0.00	3.61	1.49
2012-13	779.68	2.08	0.81	0.10	-0.27	0.00	2.55	0.64
2013-14	1168.86	3.12	0.85	0.10	0.04	0.00	2.60	0.99
2014-15	1222.46	3.26	0.69	0.10	0.17	0.08	1.44	1.04
Avg	1374.78	3.67	0.82	0.08	0.00	0.43	4.55	1.33

Table - L.15 Water availability at Hathidah

Year	Rainfall		ECII	DIL	GW Flux	Q-calib*	Q-obs*	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8
1985-86	1603.50	29.79	4.21	0.16	-0.16	311.80	285.66	20.04
1986-87	1117.31	20.76	5.43	0.18	0.12	269.92	267.06	16.20
1987-88	1568.56	29.14	7.00	0.19	0.06	204.40	257.70	19.17
1988-89	1320.64	24.54	5.49	0.21	-0.64	268.28	286.37	16.18
1989-90	1277.75	23.74	5.96	0.22	0.63	183.34	167.01	12.78
1990-91	1088.91	20.23	7.34	0.24	-0.54	318.70	449.49	9.71
1991-92	850.08	15.79	7.13	0.25	-0.92	290.50	307.62	7.27
1992-93	746.70	13.87	6.86	0.27	0.26	268.85	284.96	6.45
1993-94	1146.56	21.30	6.43	0.28	0.98	334.45	308.25	12.24
1994-95	760.53	14.13	8.11	0.30	-0.95	412.01	374.74	8.01
1995-96	1108.25	20.59	7.09	0.31	0.33	336.45	236.97	9.11
1996-97	1151.30	21.39	5.18	0.33	1.02	343.06	294.13	10.27
1997-98	1311.09	24.36	6.21	0.34	0.31	202.32	216.56	10.08
1998-99	1148.30	21.33	7.49	0.36	-0.56	405.73	362.37	16.11
1999-00	1221.12	22.69	4.57	0.37	0.85	391.79	356.95	12.65
2000-01	1107.35	20.57	5.67	0.39	-0.58	359.76	313.21	12.08
2001-02	1324.48	24.61	3.89	0.40	0.65	355.43	290.17	16.59
2002-03	1163.72	21.62	5.98	0.42	-0.82	254.62	189.14	12.49
2003-04	1239.16	23.02	5.23	0.43	0.96	398.73	345.90	14.02
2004-05	884.68	16.44	6.80	0.45	-1.38	213.93	198.87	12.39
2005-06	838.76	15.58	8.84	0.46	0.91	208.03	242.11	9.34
2006-07	1110.05	20.62	6.64	0.48	0.28	200.51	223.02	7.97
2007-08	1818.35	33.78	6.46	0.49	0.40	287.55	274.28	24.35
2008-09	1370.37	25.46	7.48	0.51	-0.31	411.93	348.52	12.08
2009-10	836.78	15.55	15.43	0.52	-0.60	171.97	218.41	5.08
2010-11	807.36	15.00	13.17	0.54	-0.72	274.01	271.43	4.84
2011-12	1048.33	19.48	10.36	0.55	0.85	364.03	392.72	7.94
2012-13	957.99	17.80	12.51	0.57	0.39	248.86	271.79	5.48
2013-14	816.44	15.17	12.01	0.58	1.02	379.00	429.23	3.87
2014-15	1075.29	19.98	9.88	0.60	0.27	169.90	223.96	6.68
Avg	1127.32	20.94	7.50	0.38	0.07	294.66	289.62	11.38

** Cumulative discharges i.e. including discharges at all the upstream G&D sites { Qcalib = Model runoff for Hathidah - ECII – DIL - GW Flux + Rcalib(Calibrated discharge at Gandhighat G& D site + Observed discgharge at Tribeni G& D site)}; Model runoff not shown in the table*

Table - L.16 Water availability at Farakka

Year	Rainfall		ECII	DIL	GW Flux	Q-calib*	Q-obs*	Reservoir Evap.	Water Availability**
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9
1985-86	1548.76	108.85	16.94	0.57	2.83	403.00	425.29	2.52	57.58
1986-87	1408.31	98.98	21.63	0.61	-0.99	368.47	333.32	2.33	50.49
1987-88	1888.12	132.70	25.33	0.65	0.46	384.77	362.38	2.66	87.60
1988-89	1430.55	100.54	24.86	0.70	-2.21	406.73	365.54	2.37	56.41
1989-90	1479.01	103.94	23.14	0.74	1.65	300.50	300.68	2.30	58.95
1990-91	1292.44	90.83	27.19	0.78	0.20	581.11	399.22	2.17	51.01
1991-92	1312.22	92.22	26.90	0.83	-3.20	416.30	335.52	2.26	48.25
1992-93	967.184	67.97	30.75	0.87	-0.81	350.09	216.86	2.27	27.97
1993-94	1315.41	92.45	27.39	0.91	2.25	421.80	314.15	2.28	51.68
1994-95	949.56	66.73	32.65	0.96	-0.97	464.29	356.63	1.89	27.98
1995-96	1431.68	100.62	27.96	1.00	4.25	341.62	334.24	2.23	54.64
1996-97	1285.09	90.32	26.69	1.04	-2.13	402.95	370.53	2.27	47.24
1997-98	1503.61	105.67	23.76	1.09	1.86	342.07	333.69	2.57	58.89
1998-99	1612.26	113.31	29.00	1.13	-0.85	505.54	433.63	2.30	64.52
1999-00	1780.78	125.15	18.00	1.17	1.18	497.69	387.49	2.88	70.62
2000-01	1359.13	95.52	25.28	1.22	-0.76	415.28	374.55	2.38	52.08
2001-02	1343.61	94.43	20.22	1.26	-0.12	403.27	341.48	2.58	46.06
2002-03	1298.2	91.24	20.94	1.31	0.72	288.58	241.31	2.65	50.50
2003-04	1472.81	103.51	21.91	1.35	-0.46	459.18	387.51	2.76	51.98
2004-05	1262.94	88.76	22.62	1.39	-3.71	293.54	246.92	2.65	51.38
2005-06	1054.49	74.11	35.16	1.44	1.49	296.75	249.42	2.14	36.22
2006-07	1264.09	88.84	26.87	1.48	-0.63	310.23	232.55	2.27	41.14
2007-08	1533.36	107.76	24.45	1.52	0.99	397.09	316.26	2.44	65.96
2008-09	1295.72	91.06	25.86	1.57	-2.89	459.95	330.64	3.22	50.38
2009-10	1042.03	73.23	38.98	1.61	-0.86	316.36	198.44	1.96	32.75
2010-11	1091.36	76.70	34.45	1.65	-0.35	365.65	253.85	2.12	34.33
2011-12	1198.89	84.26	36.71	1.70	1.15	470.28	353.44	3.03	44.02
2012-13	1255.44	88.23	34.68	1.74	0.34	346.02	245.80	2.48	39.07
2013-14	1279.75	89.94	26.75	1.78	2.60	523.20	373.02	1.36	36.09
2014-15	1234.81	86.78	32.07	1.83	-1.43	289.13	221.83	3.23	41.25
Avg	1339.72	94.16	16.94	1.20	-0.01	394.05	321.21	2.42	49.57

** Cumulative discharges i.e. including discharges at all the upstream G&D sites (Qcalib = Model runoff-ECII-DIL-GW flux + Kosi runoff+Calibrated runoff at Hathidah}; Kosi runoff has been calculated separately from the WRA tool;*

***Water availability = Model runoff + Reservoir evaporation; Model runoff not shown in the table*

Table - L.17 Water availability at Delta

Year	Rainfall		ECII	DIL	GW Flux	Q-calib	Reservoir Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8 = 3+4+5+6+7
1985-86	1519.538	76.77	21.73	0.40	0.36	1.50	1.22	25.21
1986-87	1566.119	79.13	19.20	0.44	0.79	13.45	1.28	35.15
1987-88	1155.787	58.40	28.11	0.47	-1.95	12.11	1.87	40.60
1988-89	1308.278	66.10	21.94	0.50	-2.55	10.90	1.26	32.05
1989-90	1450.512	73.29	17.56	0.53	4.73	7.13	1.43	31.37
1990-91	1468.816	74.21	26.22	0.56	-1.23	6.08	1.19	32.83
1991-92	1453.867	73.46	24.99	0.59	-1.01	8.67	1.33	34.57
1992-93	890.3321	44.98	24.85	0.62	-0.64	-0.72	1.72	25.83
1993-94	1534.166	77.51	23.12	0.65	2.03	8.14	1.26	35.20
1994-95	1645.495	83.14	30.14	0.68	-4.84	-7.51	1.22	19.70
1995-96	1470.4	74.29	23.34	0.71	2.75	15.36	1.24	43.41
1996-97	1456.623	73.60	20.75	0.75	0.99	10.92	1.39	34.79
1997-98	1259.987	63.66	22.97	0.78	1.99	14.13	2.05	41.91
1998-99	1074.34	54.28	25.24	0.81	-6.58	13.94	1.30	34.72
1999-00	1481.957	74.88	11.35	0.84	4.41	35.98	2.21	54.80
2000-01	1081.389	54.64	26.22	0.87	-1.55	4.84	1.28	31.66
2001-02	1468.185	74.18	19.92	0.90	0.20	2.64	1.31	24.98
2002-03	1252.711	63.29	20.06	0.93	-0.76	11.88	1.77	33.89
2003-04	1215.368	61.41	19.44	0.96	-1.64	4.57	1.27	24.61
2004-05	1217.233	61.50	19.79	0.99	0.83	9.71	1.75	33.07
2005-06	1418.427	71.67	25.07	1.03	-0.58	5.16	1.67	32.35
2006-07	1189.312	60.09	19.87	1.06	-1.54	11.83	0.46	31.67
2007-08	1462.279	73.88	21.06	1.09	1.79	50.75	0.85	75.54
2008-09	1375.879	69.52	18.98	1.12	0.52	39.97	0.56	61.15
2009-10	981.172	49.57	25.47	1.15	-5.74	25.92	0.28	47.07
2010-11	846.6271	42.78	25.34	1.18	-0.74	12.97	0.49	39.24
2011-12	1348.941	68.16	24.85	1.21	-0.13	23.99	0.50	50.42
2012-13	933.5463	47.17	24.31	1.24	-1.05	5.17	0.47	30.15
2013-14	1310.647	66.22	16.80	1.27	1.24	46.68	0.60	66.59
2014-15	836.5744	42.27	16.66	1.31	0.91	30.11	0.97	49.96
Avg	1289.15	65.13	22.18	0.85	-0.30	14.54	1.21	38.48

Table - L.18 Water resources availability in Lower Ganga sub-basin

Year	Rainfall	Q-calib	ECII	DIL	GW Flux	Reservoir Flux	Export	Reservoir Evap.	Water Availability
	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2	3	4	5	6	7	8	9	10 = 3+4+5+6+7+8+9
1985-86	394.87	101.76	74.96	2.14	5.73	1.49	5.35	6.13	197.56
1986-87	385.26	104.34	74.14	2.28	-1.85	-0.64	8.02	6.07	192.35
1987-88	438.39	146.01	104.04	2.41	-2.13	1.38	5.28	6.95	263.94
1988-89	363.12	89.06	81.41	2.54	-7.17	-0.33	6.57	5.99	178.08
1989-90	388.16	101.01	72.62	2.67	10.21	-0.14	5.49	6.14	198.00
1990-91	375.24	102.17	89.04	2.80	-0.24	0.59	7.46	5.64	207.47
1991-92	362.80	93.95	90.10	2.93	-9.07	-0.45	5.29	5.78	188.53
1992-93	296.06	25.84	94.34	3.07	-3.70	-0.23	9.12	6.13	134.56
1993-94	372.10	82.26	87.41	3.20	6.29	0.62	5.47	5.88	191.13
1994-95	359.86	76.29	97.62	3.33	-6.64	-0.33	6.36	5.50	182.13
1995-96	392.41	97.93	90.76	3.46	9.01	-0.16	5.29	5.85	212.14
1996-97	359.74	83.61	81.66	3.59	-1.61	0.16	8.21	5.99	181.60
1997-98	422.06	126.41	85.02	3.72	8.91	1.00	6.66	7.45	239.18
1998-99	380.37	91.08	96.86	3.86	-9.61	-0.88	8.17	5.93	195.41
1999-00	459.76	176.50	62.95	3.99	6.94	0.87	7.38	7.82	266.45
2000-01	361.77	91.88	88.92	4.12	-4.14	-0.12	8.17	5.94	194.77
2001-02	391.41	99.05	70.87	4.25	3.01	-0.54	6.89	6.61	190.14
2002-03	350.91	85.87	78.95	4.38	-3.25	-0.13	6.53	7.21	179.56
2003-04	391.49	93.32	78.64	4.51	-0.73	0.14	7.36	6.62	189.86
2004-05	341.96	88.07	80.84	4.65	-8.67	-0.19	7.41	6.83	178.94
2005-06	321.52	33.12	107.32	4.78	3.28	-0.21	5.42	6.00	159.71
2006-07	357.02	79.86	86.42	4.91	-2.73	0.57	7.41	5.23	181.67
2007-08	400.00	144.58	92.34	5.04	3.77	0.08	8.62	5.62	260.05
2008-09	366.64	114.31	89.49	5.17	-3.81	-0.07	9.07	6.27	220.44
2009-10	277.18	12.95	128.56	5.31	-12.71	-0.24	9.74	4.38	148.00
2010-11	268.03	5.19	106.37	5.44	-2.85	0.26	9.74	4.43	128.57
2011-12	348.66	58.11	115.07	5.57	5.22	3.34	6.44	6.03	199.77
2012-13	334.62	25.33	116.72	5.70	0.29	-0.22	7.36	5.23	160.41
2013-14	359.94	72.89	96.26	5.83	8.47	2.72	6.50	4.00	196.67
2014-15	308.47	31.66	113.69	5.96	-2.62	-0.65	5.52	7.23	160.80
Avg	364.33	84.48	91.11	4.05	-0.41	0.26	7.08	6.03	192.60

YAMUNA SUB_BASIN

Table - L.19 Water availability at Baghpat

Year	Rainfall		ECII	DIL	GW Flux	Export	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+7
1985-86	1478.00	24.83	1.63	0.099	0.43	0.95	11.02	3.71	14.12
1986-87	1132.00	19.02	1.74	0.101	-0.21	1.27	5.81	3.99	8.72
1987-88	740.00	12.43	3.67	0.103	-1.28	2.40	0.17	0.63	5.06
1988-89	1535.00	25.79	1.61	0.105	1.05	1.15	11.58	12.34	15.49
1989-90	1156.00	19.42	2.16	0.107	-0.15	1.56	5.84	6.93	9.51
1990-91	1134.00	19.05	1.65	0.109	0.37	1.11	8.59	5.67	11.83
1991-92	800.00	13.44	2.44	0.112	-0.81	1.17	1.98	1.24	4.89
1992-93	1117.00	18.76	2.25	0.114	0.17	1.37	5.98	4.98	9.89
1993-94	1058.00	17.77	2.27	0.116	-0.60	1.63	4.46	3.74	7.88
1994-95	1262.00	21.20	1.92	0.118	0.30	1.40	8.54	8.78	12.28
1995-96	1338.00	22.48	1.77	0.121	0.63	1.14	8.62	7.95	12.28
1996-97	1228.00	20.63	1.33	0.123	0.10	1.08	7.51	6.34	10.14
1997-98	1160.00	19.49	1.70	0.125	0.54	1.70	5.24	5.26	9.30
1998-99	1169.00	19.64	1.37	0.128	0.05	0.99	6.47	11.23	9.01
1999-00	1009.00	16.95	2.29	0.130	-0.41	1.38	4.15	3.41	7.54
2000-01	978.00	16.43	1.99	0.133	-0.51	1.31	4.26	4.73	7.19
2001-02	1064.00	17.87	2.43	0.135	0.28	1.62	5.00	3.32	9.46
2002-03	808.00	13.57	2.68	0.138	-0.57	1.69	1.77	2.21	5.71
2003-04	928.00	15.59	2.08	0.140	0.03	0.07	4.03	2.61	6.35
2004-05	900.00	15.12	2.36	0.142	-0.32	1.54	2.55	0.93	6.27
2005-06	982.00	16.50	2.08	0.145	-0.19	1.23	3.80	3.74	7.07
2006-07	960.00	16.13	2.13	0.147	-0.50	1.39	4.55	2.09	7.72
2007-08	812.00	13.64	2.41	0.150	-0.47	1.58	0.90	1.75	4.57
2008-09	1000.00	16.80	2.23	0.152	-0.21	1.46	4.98	7.20	8.61
2009-10	733.00	12.31	3.51	0.154	-0.86	1.78	0.05	1.16	4.63
2010-11	1427.00	23.97	1.80	0.157	1.39	1.18	9.58	13.30	14.11
2011-12	1106.00	18.58	2.25	0.160	-0.65	1.52	6.35	6.91	9.63
2012-13	1279.00	21.49	2.68	0.162	-0.02	1.56	8.78	2.51	13.15
2013-14	1331.37	22.37	1.78	0.165	0.32	1.14	9.06	8.75	12.47
2014-15	947.14	15.91	2.64	0.169	-1.52	1.73	3.57	3.17	6.59
Avg	1085.72	18.24	2.16	0.13	-0.12	1.37	5.51	5.02	9.05

Table - L.20 Water availability at Galeta

Year	Rainfall		ECII	DIL	GW Flux	Import	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3+4+5-6+7
1985-86	1192.12	5.31	1.38	0.060	0.15	1.38	1.63	1.03	1.84
1986-87	770.25	3.43	1.98	0.061	-0.18	1.98	1.05	0.87	0.93
1987-88	360.12	1.61	4.11	0.062	-0.74	4.11	1.11	0.73	0.44
1988-89	1165.41	5.20	1.97	0.063	0.73	1.97	2.28	1.47	3.07
1989-90	757.58	3.38	2.36	0.065	-0.13	2.36	1.43	0.89	1.36
1990-91	1020.73	4.55	1.99	0.066	0.22	1.99	1.80	0.99	2.08
1991-92	697.39	3.11	2.49	0.067	-0.36	2.49	1.23	0.66	0.95
1992-93	771.65	3.44	2.42	0.068	0.03	2.42	1.47	1.13	1.57
1993-94	669.24	2.98	2.53	0.070	-0.61	2.53	1.62	0.60	1.08
1994-95	1271.31	5.67	2.42	0.071	0.37	2.42	2.27	1.50	2.71
1995-96	991.34	4.42	2.09	0.073	0.24	2.09	1.49	1.45	1.81
1996-97	914.35	4.08	1.85	0.074	0.00	1.85	1.86	1.34	1.93
1997-98	611.07	2.72	2.79	0.075	0.29	2.79	0.46	1.30	0.82
1998-99	1122.58	5.00	1.91	0.077	-0.10	1.91	2.46	1.91	2.44
1999-00	808.35	3.60	2.18	0.078	-0.22	2.18	1.33	1.22	1.19
2000-01	820.00	3.66	1.87	0.080	-0.20	1.87	1.70	1.50	1.58
2001-02	796.18	3.55	2.46	0.081	0.42	2.46	1.44	1.04	1.93
2002-03	887.45	3.96	2.52	0.083	-0.08	2.52	1.91	1.09	1.91
2003-04	1032.92	4.60	1.88	0.084	-0.12	1.88	1.92	1.53	1.88
2004-05	688.47	3.07	2.66	0.086	-0.32	2.66	1.53	0.85	1.30
2005-06	1040.40	4.64	1.93	0.087	0.06	1.93	2.67	1.48	2.81
2006-07	653.21	2.91	2.40	0.089	-0.25	2.40	1.22	0.91	1.06
2007-08	640.24	2.85	2.39	0.090	-0.13	2.39	1.10	1.71	1.06
2008-09	737.95	3.29	2.19	0.091	-0.14	2.19	1.73	1.54	1.68
2009-10	539.44	2.40	3.09	0.093	-0.42	3.09	1.23	0.79	0.90
2010-11	1011.29	4.51	2.07	0.094	0.75	2.07	1.68	2.16	2.53
2011-12	825.56	3.68	2.17	0.096	-0.37	2.17	1.71	1.62	1.43
2012-13	938.03	4.18	2.74	0.098	0.10	2.74	2.13	1.12	2.33
2013-14	1430.22	6.38	1.46	0.099	-0.13	1.46	2.70	1.31	2.67
2014-15	755.50	3.37	2.95	0.101	-0.46	2.95	1.08	0.33	0.72
Avg	864.01	3.85	2.31	0.08	-0.05	2.31	1.64	1.20	1.67

Table - L.21 Water availability at Seondha

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Reservoir Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+8
1985-86	1182.25	19.41	6.01	0.07	1.55	4.26	4.00	0.05	11.94
1986-87	607.46	9.97	3.06	0.07	-1.61	2.66	1.70	0.14	4.31
1987-88	653.55	10.73	3.80	0.07	-0.27	0.00	3.20	0.04	3.63
1988-89	792.91	13.02	2.66	0.07	-0.11	3.73	2.30	0.05	6.40
1989-90	599.83	9.85	3.79	0.07	-0.68	0.29	0.77	0.03	3.51
1990-91	947.22	15.55	2.77	0.07	0.61	5.23	5.12	0.04	8.72
1991-92	715.95	11.75	3.09	0.07	-0.35	3.88	3.07	0.14	6.84
1992-93	844.35	13.86	2.54	0.08	0.08	3.91	2.54	0.05	6.66
1993-94	863.33	14.17	2.90	0.08	-0.54	5.21	2.09	0.03	7.69
1994-95	800.65	13.14	3.96	0.08	-0.37	3.41	3.67	0.05	7.13
1995-96	888.56	14.59	3.14	0.08	0.43	4.46	2.77	0.04	8.15
1996-97	964.28	15.83	3.22	0.08	0.34	4.90	5.10	0.06	8.59
1997-98	967.62	15.89	1.75	0.08	0.55	5.99	2.44	0.04	8.43
1998-99	741.83	12.18	2.78	0.08	-0.58	3.80	1.29	0.04	6.11
1999-00	853.74	14.02	2.53	0.09	-0.08	4.88	2.89	0.04	7.46
2000-01	698.31	11.46	4.02	0.09	-1.31	2.40	1.84	0.03	5.22
2001-02	857.06	14.07	2.87	0.09	0.18	4.92	2.29	0.18	8.24
2002-03	451.13	7.41	3.91	0.09	-1.48	0.63	0.25	0.03	3.17
2003-04	801.49	13.16	2.94	0.09	1.26	2.34	1.29	0.04	6.67
2004-05	694.74	11.41	6.41	0.09	-1.48	0.52	0.87	0.12	5.66
2005-06	647.47	10.63	3.15	0.10	0.16	0.87	1.22	0.04	4.31
2006-07	725.80	11.92	2.63	0.10	-0.96	3.74	0.63	0.04	5.54
2007-08	506.54	8.32	3.26	0.10	-1.67	0.57	0.08	0.03	2.29
2008-09	1012.32	16.62	2.87	0.10	1.71	5.02	2.08	0.05	9.76
2009-10	680.67	11.18	2.83	0.10	-0.62	1.81	0.23	0.04	4.16
2010-11	837.37	13.75	2.80	0.10	0.83	2.05	0.49	0.05	5.83
2011-12	982.86	16.14	3.30	0.11	0.90	4.29	2.71	0.07	8.66
2012-13	669.53	10.99	3.45	0.11	-0.33	1.72	1.75	0.05	5.00
2013-14	1201.05	19.72	3.22	0.11	2.18	6.67	5.61	0.06	12.24
2014-15	734.23	12.05	3.74	0.11	-0.89	1.50	0.73	0.03	4.50
Avg	797.47	13.09	3.31	0.09	-0.08	3.19	2.17	0.06	6.57

Table - L.22 Water availability at Shahjina

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Reservoir Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+7+8
1985-86	1312.08	57.23	11.07	0.168	1.85	20.97	21.17	0.51	34.57
1986-87	845.13	36.87	9.49	0.171	-1.59	14.15	11.64	0.43	22.65
1987-88	1019.14	44.46	10.26	0.174	-0.39	13.80	10.89	0.48	24.32
1988-89	883.03	38.52	10.85	0.178	-0.14	10.42	9.72	0.45	21.76
1989-90	662.16	28.88	12.92	0.181	-0.30	0.58	4.83	0.33	13.72
1990-91	1099.85	47.98	10.65	0.185	1.23	20.98	21.19	0.44	33.48
1991-92	877.64	38.28	9.96	0.188	-1.32	17.71	12.13	0.41	26.94
1992-93	880.84	38.42	9.43	0.192	0.55	12.36	11.41	0.41	22.95
1993-94	1072.65	46.79	9.20	0.196	-0.10	18.35	10.18	0.44	28.09
1994-95	1101.98	48.07	11.55	0.199	-0.48	23.27	24.68	0.42	34.96
1995-96	893.24	38.96	10.68	0.203	-0.21	11.19	11.07	0.43	22.29
1996-97	1079.00	47.07	10.01	0.207	0.90	19.94	13.12	0.45	31.49
1997-98	1005.91	43.88	8.74	0.211	1.32	15.54	13.37	0.40	26.22
1998-99	874.94	38.17	8.13	0.215	-0.93	15.26	10.78	0.31	22.98
1999-00	1340.02	58.45	8.07	0.219	0.28	32.33	19.67	0.46	41.36
2000-01	855.94	37.34	13.47	0.224	-1.75	10.65	8.04	0.39	22.98
2001-02	896.51	39.11	9.98	0.228	-0.36	16.43	7.54	0.50	26.78
2002-03	686.88	29.96	8.74	0.232	-1.08	8.74	2.31	0.22	16.85
2003-04	1071.79	46.75	9.66	0.236	1.93	17.52	10.19	0.47	29.82
2004-05	838.06	36.56	11.05	0.240	-1.06	7.64	3.26	0.44	18.30
2005-06	885.12	38.61	8.65	0.244	0.43	13.92	12.15	0.32	23.57
2006-07	771.41	33.65	6.34	0.248	-2.11	14.37	15.44	0.29	19.13
2007-08	576.21	25.14	7.36	0.252	-2.84	5.23	1.04	0.25	10.26
2008-09	1077.62	47.01	11.45	0.256	2.54	16.27	10.24	0.52	31.04
2009-10	887.69	38.72	16.05	0.260	-0.77	2.64	0.87	0.50	18.67
2010-11	738.29	32.21	10.00	0.265	0.41	3.79	4.20	0.42	14.89
2011-12	1082.43	47.22	10.81	0.269	1.97	18.53	22.29	0.56	32.13
2012-13	824.88	35.98	12.95	0.273	-0.07	8.20	7.63	0.39	21.74
2013-14	1463.16	63.83	10.15	0.279	2.93	34.28	34.45	0.59	48.22
2014-15	781.79	34.10	11.67	0.285	-1.49	4.18	21.56	0.24	14.88
Avg	946.18	41.27	10.31	0.22	-0.02	14.31	12.23	0.42	25.24

Table - L.23 Water availability at Banda

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Reservoir Evap.	Water availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+7+8
1985-86	1272.00	32.26	4.83	0.065	0.80	7.28	8.26	0.06	13.04
1986-87	844.00	21.40	7.00	0.066	-0.98	2.91	3.89	0.08	9.08
1987-88	1102.00	27.94	10.46	0.067	0.36	8.42	8.10	0.05	19.37
1988-89	898.00	22.77	4.58	0.069	-0.46	8.97	6.51	0.05	13.21
1989-90	842.00	21.35	7.50	0.070	-0.12	1.57	3.06	0.05	9.08
1990-91	1440.00	36.52	2.13	0.071	0.69	21.01	17.16	0.05	23.96
1991-92	1023.00	25.94	9.61	0.073	-0.77	6.31	10.10	0.07	15.28
1992-93	1234.00	31.29	9.08	0.074	0.39	15.32	12.70	0.05	24.91
1993-94	1117.00	28.32	2.23	0.076	0.07	11.86	7.61	0.05	14.29
1994-95	1335.00	33.85	4.36	0.077	-0.13	17.63	16.13	0.06	22.00
1995-96	840.00	21.30	7.98	0.079	-0.15	2.69	5.79	0.05	10.64
1996-97	988.00	25.05	7.48	0.080	0.07	6.28	7.84	0.06	13.96
1997-98	1236.00	31.34	4.93	0.082	0.98	11.68	10.26	0.06	17.73
1998-99	843.00	21.38	7.50	0.083	-0.88	3.60	5.76	0.04	10.34
1999-00	1453.00	36.85	4.59	0.085	0.50	22.95	19.55	0.05	28.18
2000-01	851.00	21.58	7.54	0.087	-0.64	3.39	4.29	0.05	10.43
2001-02	1056.00	26.78	8.82	0.088	-0.17	6.20	8.68	0.08	15.02
2002-03	876.00	22.21	7.93	0.090	0.10	8.83	5.13	0.04	16.99
2003-04	1418.00	35.96	4.14	0.091	0.07	18.68	13.14	0.05	23.04
2004-05	976.00	24.75	7.47	0.093	-0.35	3.47	5.44	0.09	10.77
2005-06	1304.00	33.07	6.81	0.094	0.09	16.42	15.22	0.04	23.46
2006-07	652.00	16.53	7.24	0.096	-0.85	2.08	4.15	0.04	8.61
2007-08	517.00	13.11	7.97	0.097	-1.02	0.58	1.22	0.36	7.98
2008-09	1106.00	28.04	5.00	0.099	1.01	9.95	7.68	0.06	16.12
2009-10	907.00	23.00	9.62	0.101	-0.10	0.44	3.59	0.06	10.12
2010-11	833.00	21.12	8.96	0.102	-0.82	2.89	3.78	0.05	11.19
2011-12	1236.00	31.34	3.58	0.104	0.87	14.50	8.18	0.08	19.13
2012-13	962.00	24.39	7.75	0.106	-0.16	6.22	5.38	0.06	13.98
2013-14	1606.73	40.74	4.95	0.108	1.84	18.14	13.62	0.08	25.12
2014-15	785.80	19.93	7.20	0.110	-1.37	4.02	2.70	0.06	10.01
Avg	1051.78	26.67	6.64	0.09	-0.04	8.81	8.16	0.07	15.57

Table - L.24 Water availability at Pali

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Qobs	Reservoir Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10= 3+4+5+6+7+9
1985-86	945	72.47	11.90	0.295	1.34	-1.05	19.04	18.70	0.47	31.99
1986-87	1005	77.07	15.22	0.300	-1.39	1.41	35.29	29.63	0.57	51.40
1987-88	776	59.51	15.92	0.306	-0.92	-1.48	6.47	12.48	0.43	20.73
1988-89	808	61.96	12.33	0.312	0.39	-0.20	11.71	9.65	0.63	25.17
1989-90	664	50.92	18.61	0.318	-1.30	-0.81	0.00	5.24	0.35	17.16
1990-91	997	76.46	13.54	0.324	1.83	3.61	17.79	16.71	0.50	37.59
1991-92	795	60.97	14.87	0.331	-1.42	-0.44	21.41	17.65	0.55	35.30
1992-93	731	56.06	14.35	0.337	-0.27	-2.70	9.59	9.74	0.55	21.86
1993-94	929	71.24	11.72	0.344	-0.04	-0.16	20.72	12.79	0.66	33.24
1994-95	1097	84.13	12.15	0.350	1.03	3.31	28.10	23.20	0.66	45.59
1995-96	849	65.11	14.06	0.357	-1.09	-0.83	16.38	14.10	0.52	29.41
1996-97	1113	85.35	15.86	0.364	1.04	0.90	28.12	34.81	0.60	46.89
1997-98	931	71.40	8.77	0.371	1.61	0.05	24.59	10.02	0.66	36.05
1998-99	756	57.98	14.87	0.378	-2.09	-1.98	9.73	7.21	0.45	21.36
1999-00	890	68.25	10.73	0.385	-0.29	-0.48	20.69	14.28	0.56	31.60
2000-01	612	46.93	20.19	0.393	-3.05	-0.84	0.79	8.01	0.34	17.81
2001-02	845	64.80	13.91	0.401	0.77	0.09	21.41	14.43	0.67	37.26
2002-03	486	37.27	19.89	0.407	-2.40	0.05	0.00	1.93	0.37	18.32
2003-04	770	59.05	13.74	0.414	3.26	-0.11	7.69	5.73	0.55	25.54
2004-05	884	67.79	17.76	0.421	-0.20	1.23	19.52	11.46	0.57	39.30
2005-06	719	55.14	17.18	0.427	0.45	-1.13	3.10	5.51	0.43	20.46
2006-07	1094	83.90	12.53	0.434	2.01	3.59	30.44	25.89	0.62	49.63
2007-08	765	58.67	15.14	0.442	-1.63	-1.62	10.23	6.46	0.50	23.06
2008-09	771	59.13	12.97	0.449	-0.51	-1.63	8.64	6.42	0.63	20.56
2009-10	708	54.30	20.92	0.456	-1.24	-0.02	0.00	3.16	0.44	20.55
2010-11	678	52.00	19.14	0.464	0.74	-0.20	0.00	2.55	0.48	20.62
2011-12	1165	89.34	12.85	0.471	2.74	1.95	33.18	25.49	0.75	51.94
2012-13	865	66.34	13.08	0.481	-0.75	1.44	19.79	11.67	0.54	34.59
2013-14	1292	99.07	12.83	0.492	3.11	-1.61	48.49	36.94	0.68	63.99
2014-15	871	66.78	16.42	0.503	-1.29	-	9.83	6.81	0.21	25.68
Avg	860.36	65.98	14.78	0.39	0.02	0.01	16.09	13.62	0.53	31.82

Table - L.25 Water availability at Udi

	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Qobs	Reservoir Evap.	Water Availability
Year	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)*	3*	4*	5*	6*	7*	8*	9*	10= 3+4+5+6+7
1985-86	945	110.21	28.99	0.564	0.72	-1.05	17.08	22.05	0.83	47.13
1986-87	1005	110.74	32.83	0.575	-4.02	1.41	33.97	38.19	1.10	65.86
1987-88	776	83.25	42.58	0.586	-4.62	-1.48	0.00	14.40	0.68	37.74
1988-89	808	99.77	33.06	0.597	1.27	-0.20	2.71	17.81	1.33	38.76
1989-90	664	87.69	37.40	0.609	-2.79	-0.81	0.00	8.43	0.66	35.07
1990-91	997	119.95	28.59	0.620	2.67	3.61	20.13	25.12	0.86	56.48
1991-92	795	97.01	32.48	0.633	-0.61	-0.44	17.07	26.99	1.09	50.22
1992-93	731	103.55	32.99	0.645	2.09	-2.70	10.79	17.02	1.33	45.16
1993-94	929	107.09	34.08	0.657	-4.94	-0.16	15.55	20.71	1.29	46.47
1994-95	1097	133.37	33.49	0.670	4.00	3.31	29.26	32.63	1.81	72.54
1995-96	849	111.65	37.37	0.683	-0.28	-0.83	17.26	21.51	1.24	55.45
1996-97	1113	138.73	37.06	0.696	4.56	0.90	29.68	49.62	1.85	74.75
1997-98	931	113.36	25.76	0.710	0.66	0.05	26.28	16.65	1.39	54.86
1998-99	756	95.42	36.75	0.724	-4.59	-1.98	5.72	15.18	0.93	37.56
1999-00	890	101.24	34.67	0.738	-4.63	-0.48	13.69	22.09	1.15	45.14
2000-01	612	74.89	43.08	0.752	-7.44	-0.84	0.00	16.79	0.82	36.38
2001-02	845	101.16	43.88	0.767	1.91	0.09	6.83	18.58	1.10	54.57
2002-03	486	55.09	42.67	0.779	-9.36	0.05	0.00	2.85	0.72	34.86
2003-04	770	96.57	35.18	0.792	4.59	-0.11	0.00	9.48	1.28	41.73
2004-05	884	108.28	49.59	0.805	1.19	1.23	5.21	12.90	1.06	59.09
2005-06	719	92.86	38.60	0.818	-1.54	-1.13	0.00	7.61	0.91	37.66
2006-07	1094	120.14	35.12	0.831	0.99	3.59	23.47	26.57	1.46	65.47
2007-08	765	91.71	32.90	0.845	-4.42	-1.62	6.17	7.52	0.85	34.73
2008-09	771	99.91	34.16	0.859	-2.68	-1.63	7.06	7.79	1.45	39.22
2009-10	708	80.76	44.51	0.873	-7.02	-0.02	0.00	2.83	0.69	39.03
2010-11	678	99.15	39.77	0.887	4.69	-0.20	0.00	4.50	1.50	46.65
2011-12	1165	139.45	34.73	0.902	5.14	1.95	29.89	24.51	2.13	74.73
2012-13	865	114.47	37.00	0.921	-1.42	1.44	23.25	8.64	1.83	63.02
2013-14	1292	151.32	34.83	0.941	5.72	-1.61	49.12	36.53	2.44	91.45
2014-15	871	110.33	41.79	0.962	-0.72	-	0.15	16.74	1.69	43.87
Avg	860.36	104.97	36.53	0.75	-0.70	0.01	13.01	18.41	1.25	50.85

** including the values for Pali Sub-basin*

Table - L.26 Water availability at Pratappur

Year	Rainfall		ECII	DIL	GW Flux	Import	Qcalib	Qcalib*	Q-obs	Res. Evap	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10	11= 3+4+5-6+7+10
1985-86	944.65	330.09	25.77	0.782	3.60	10.75	13.88	76.12	78.87	0.06	33.34
1986-87	613.33	250.64	23.90	0.798	-3.45	11.43	3.86	64.42	68.14	0.04	13.73
1987-88	462.28	218.21	37.94	0.813	-6.98	21.33	0.00	23.50	47.78	0.04	10.49
1988-89	870.77	277.88	22.35	0.829	1.93	11.28	14.20	53.91	78.99	0.05	28.09
1989-90	578.82	220.53	27.41	0.845	-2.60	14.01	0.00	9.71	33.95	0.34	11.99
1990-91	778.18	309.91	29.04	0.861	1.40	14.21	7.59	85.33	105.17	0.06	24.75
1991-92	614.67	241.76	27.92	0.878	-1.24	14.27	5.76	53.94	71.40	0.29	19.33
1992-93	788.96	278.51	24.48	0.895	-0.55	12.64	12.00	61.85	74.38	0.06	24.24
1993-94	654.18	277.39	26.51	0.912	-3.27	15.03	4.99	62.04	48.37	0.05	14.17
1994-95	689.09	316.95	24.60	0.930	-0.44	14.01	8.10	92.48	75.86	0.00	19.19
1995-96	774.34	290.00	29.62	0.948	0.58	14.65	7.61	53.33	52.30	0.05	24.17
1996-97	808.27	331.35	22.80	0.967	3.80	11.55	11.01	81.16	64.35	0.06	27.08
1997-98	472.41	275.76	29.27	0.985	-0.08	16.91	0.01	65.21	46.91	0.04	13.32
1998-99	665.22	254.24	25.16	1.004	2.08	12.70	10.12	47.43	45.45	0.05	25.72
1999-00	773.29	292.03	24.82	1.024	0.43	13.07	10.24	89.57	83.38	0.06	23.51
2000-01	562.83	214.07	28.68	1.044	-4.20	14.87	0.44	22.83	41.25	0.05	11.15
2001-02	661.17	259.00	25.26	1.064	-0.54	13.68	7.22	48.03	52.31	0.34	19.66
2002-03	488.90	171.76	27.28	1.085	-6.28	14.93	3.53	25.42	28.63	0.03	10.72
2003-04	890.97	290.62	24.09	1.102	4.01	12.46	18.37	62.85	76.13	0.06	35.18
2004-05	557.89	251.10	30.22	1.120	-3.88	14.18	0.00	20.93	36.58	0.30	13.58
2005-06	544.23	251.09	26.75	1.139	-0.77	13.49	3.78	41.46	41.78	0.04	17.46
2006-07	484.04	245.09	23.45	1.157	-6.71	12.24	1.45	50.88	34.48	0.04	7.14
2007-08	389.22	194.88	25.50	1.176	-8.17	13.97	0.00	14.55	16.58	0.03	4.57
2008-09	734.78	281.61	25.80	1.196	6.89	19.42	16.04	61.06	43.34	0.06	30.57
2009-10	504.60	214.29	37.80	1.215	-4.99	14.18	0.00	6.16	12.26	0.05	19.89
2010-11	667.91	261.63	28.66	1.235	3.51	15.04	2.20	22.20	27.55	0.04	20.60
2011-12	704.80	321.21	24.60	1.255	1.39	12.75	6.84	82.10	79.76	0.07	21.41
2012-13	616.96	270.80	28.27	1.276	0.54	14.61	4.29	54.59	52.63	0.05	19.82
2013-14	963.32	385.21	21.76	1.465	5.76	11.58	18.53	138.51	64.33	0.06	36.00
2014-15	509.05	243.07	34.04	1.498	-4.08	19.77	0.00	14.50	30.63	0.04	11.72
Avg	658.97	267.36	27.13	1.05	-0.74	14.17	6.40	52.87	53.78	0.08	19.75

** including the values for Baghpat, Galeta, Seondha, Shahjina, Banda, Udi & Pratappur*

Table – L.27 Water resources availability in Yamuna sub-basin

Year	Rainfall	Qcalib*	ECII	DIL	GW Flux	Reservoir Flux	Import	Reservoir Evap.	Water Availability
	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2	3	4	5	6	7	8	9	10 = 3+4+5+6+7-8+9
1985-86	331.67	76.12	88.13	2.02	9.83	-1.05	11.18	1.51	165.37
1986-87	252.20	64.42	94.15	2.05	-15.13	1.41	12.14	1.79	136.56
1987-88	219.70	23.50	113.65	2.09	-19.16	-1.48	23.04	1.29	96.86
1988-89	279.37	53.91	82.83	2.14	5.67	-0.20	12.10	1.93	134.17
1989-90	221.97	9.71	106.52	2.18	-8.77	-0.81	14.81	1.42	95.44
1990-91	311.57	85.33	91.80	2.22	7.44	3.61	15.09	1.45	176.76
1991-92	243.32	53.94	101.74	2.26	-6.43	-0.44	15.60	1.99	137.48
1992-93	279.94	61.85	100.97	2.31	3.98	-2.70	13.70	1.89	154.60
1993-94	278.81	62.04	82.86	2.35	-10.53	-0.16	15.92	1.86	122.50
1994-95	318.52	92.48	98.79	2.40	3.36	3.31	15.03	2.33	187.64
1995-96	291.50	53.33	108.19	2.44	4.96	-0.83	15.59	1.80	154.30
1996-97	332.87	81.16	99.05	2.49	12.34	0.90	12.32	2.47	186.09
1997-98	277.19	65.21	88.60	2.54	3.56	0.05	18.00	1.94	143.89
1998-99	255.87	47.43	91.18	2.59	-4.33	-1.98	13.62	1.37	122.64
1999-00	293.74	89.57	85.00	2.64	-7.08	-0.48	13.87	1.77	157.56
2000-01	215.65	22.83	106.11	2.69	-19.21	-0.84	15.43	1.35	97.51
2001-02	260.63	48.03	98.99	2.74	0.04	0.09	14.52	2.21	137.58
2002-03	173.25	25.42	98.91	2.79	-21.44	0.05	15.76	1.04	91.01
2003-04	292.22	62.85	87.83	2.84	12.37	-0.11	14.27	1.90	153.41
2004-05	252.59	20.93	112.48	2.88	-7.67	1.23	15.30	2.01	116.57
2005-06	252.62	41.46	97.45	2.93	-1.34	-1.13	14.18	1.35	126.55
2006-07	246.55	50.88	88.67	2.98	-13.66	3.59	13.24	1.87	121.09
2007-08	196.34	14.55	88.17	3.03	-20.55	-1.62	14.78	1.53	70.33
2008-09	283.23	61.06	93.64	3.08	8.38	-1.63	20.15	2.13	146.51
2009-10	215.68	6.16	119.19	3.13	-17.95	-0.02	15.49	1.33	96.35
2010-11	263.00	22.20	102.59	3.18	13.94	-0.20	15.93	2.05	127.83
2011-12	322.91	82.10	87.91	3.23	6.27	1.95	13.40	2.89	170.94
2012-13	272.52	54.59	106.06	3.29	-1.33	1.44	15.79	2.38	150.62
2013-14	387.03	138.51	88.85	3.52	19.45	-1.61	13.04	3.24	238.93
2014-15	244.57	14.50	106.61	3.60	-14.84	-	20.99	2.06	90.94
Average	268.90	52.87	97.23	2.69	-2.59	0.01	15.14	1.87	136.94

** Qcalib at the Pratappur G&D site*

ANNEXURE - L(d)

BRAHMAPUTRA BASIN

Table - L.28 Water availability at Bhalukpong

Year	Rainfall		ECII	DIL	GW Flux	Res. Flux	Q-Model	Q-obs	Water availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 7
1986-87	3177.73	27.58	0.00	0.001	0.00	0.00	18.55	_	18.55
1987-88	2972.76	25.8	0.00	0.001	0.00	0.00	18.66	_	18.66
1988-89	4811.15	41.76	0.00	0.001	0.00	0.00	32.74	_	32.74
1989-90	4743.38	41.17	0.00	0.001	0.00	0.00	32.39	_	32.39
1990-91	4379.93	38.02	0.00	0.002	0.00	0.00	29.41	25.65	29.41
1991-92	3465.77	30.08	0.00	0.002	0.00	0.00	22.35	29.21	22.35
1992-93	3832.56	33.27	0.00	0.002	0.00	0.00	24.96	34.02	24.96
1993-94	4797.67	41.64	0.00	0.002	0.00	0.00	32.88	38.22	32.88
1994-95	3944.56	34.24	0.00	0.002	0.00	0.00	25.84	21.61	25.84
1995-96	4170.48	36.2	0.00	0.002	0.00	0.00	27.89	26.1	27.89
1996-97	4167.01	36.17	0.00	0.002	0.00	0.00	27.66	24.78	27.66
1997-98	3984.55	34.59	0.00	0.002	0.00	0.00	26.25	20.89	26.25
1998-99	3858.05	33.49	0.00	0.002	0.00	0.00	25.03	36.29	25.03
1999-00	3391.47	29.44	0.00	0.002	0.00	0.00	21.45	22.15	21.45
2000-01	3332.41	28.93	0.00	0.002	0.00	0.00	20.98	23.65	20.98
2001-02	4123.95	35.8	0.00	0.002	0.00	0.00	27.01	20.74	27.01
2002-03	4158.9	36.1	0.00	0.002	0.00	0.00	27.48	19.08	27.48
2003-04	3612.4	31.36	0.00	0.002	0.00	0.00	23.31	26.46	23.31
2004-05	3687.32	32.01	0.00	0.002	0.00	0.00	24.13	33.88	24.13
2005-06	2154.57	18.7	0.00	0.002	0.00	0.00	11.45	28.32	11.45
2006-07	2667.57	23.15	0.00	0.002	0.00	0.00	15.5	21.19	15.5
2007-08	4248.03	36.87	0.00	0.002	0.00	0.00	27.98	29.86	27.98
2008-09	4413.85	38.31	0.00	0.003	0.00	0.00	29.15	27.6	29.15
2009-10	5184.07	45	0.00	0.003	0.00	0.00	35.18	21.41	35.18
2010-11	3959.97	34.37	0.00	0.003	0.00	0.00	25.83	19.52	25.83
2011-12	3436.42	29.83	0.00	0.003	0.00	0.00	21.66	19.47	21.66
2012-13	4632.87	40.21	0.00	0.003	0.00	0.00	31.02	28.18	31.02
2013-14	4112.80	35.7	0.00	0.003	0.00	0.00	26.96	10.5	26.96
Average	3907.94	33.92	0.00	0.002	0.00	0.00	25.49	25.37	25.49

Table - L.29 Water availability at Chenimari

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Q-Model	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9=7
1986-87	2002.17	8.30	0.08	0.011	0.11	0.00	4.18	_	4.18
1987-88	2179.31	9.03	0.16	0.011	0.01	0.00	5.16	_	5.16
1988-89	2771.58	11.49	0.06	0.011	0.07	0.00	6.93	_	6.93
1989-90	3424.38	14.19	0.06	0.012	0.16	0.00	9.16	_	9.16
1990-91	2999.18	12.43	0.07	0.012	-0.21	0.00	7.60	_	7.60
1991-92	2356.78	9.77	0.16	0.012	0.07	0.00	5.74	_	5.74
1992-93	2103.01	8.72	0.04	0.012	0.00	0.00	4.80	_	4.80
1993-94	3252.20	13.48	0.06	0.013	0.28	0.00	8.59	_	8.59
1994-95	2455.01	10.18	0.20	0.013	-0.39	0.00	5.78	6.70	5.78
1995-96	2836.78	11.76	0.07	0.013	0.42	0.00	7.07	9.40	7.07
1996-97	2626.49	10.89	0.12	0.013	-0.38	0.00	6.49	6.06	6.49
1997-98	2268.00	9.40	0.18	0.014	0.08	0.00	5.27	5.05	5.27
1998-99	3142.70	13.03	0.07	0.014	-0.18	0.00	8.31	9.33	8.31
1999-00	2224.67	9.22	0.04	0.014	0.54	0.00	5.02	7.37	5.02
2000-01	2245.32	9.31	0.28	0.014	-0.51	0.00	5.39	5.61	5.39
2001-02	2712.79	11.24	0.25	0.015	0.20	0.00	6.72	4.04	6.72
2002-03	2038.13	8.45	0.07	0.015	-0.02	0.00	4.67	4.28	4.67
2003-04	2335.86	9.68	0.20	0.015	0.38	0.00	5.51	6.08	5.51
2004-05	2426.59	10.06	0.20	0.015	-0.25	0.00	6.18	7.35	6.18
2005-06	1310.38	5.43	0.38	0.015	-0.22	0.00	2.29	4.82	2.29
2006-07	1496.53	6.20	0.38	0.016	0.04	0.00	3.00	3.81	3.00
2007-08	2772.98	11.49	0.03	0.016	0.00	0.00	6.91	5.85	6.91
2008-09	2724.37	11.29	0.12	0.016	0.00	0.00	6.79	5.25	6.79
2009-10	2687.76	11.14	0.05	0.016	0.00	0.00	6.29	7.01	6.29
2010-11	2474.66	10.26	0.05	0.017	0.00	0.00	5.95	8.14	5.95
2011-12	1657.41	6.87	0.21	0.017	0.00	0.00	3.43	4.84	3.43
2012-13	2866.74	11.88	0.18	0.017	0.00	0.00	7.11	8.23	7.11
2013-14	1870.49	7.75	0.24	0.017	0.00	0.00	4.19	5.12	4.19
Average	2437.94	10.11	0.14	0.014	0.008	0.00	5.88	6.22	5.88

Table - L.30 Water availability at Passighat

Year	Rainfall		ECII	DIL	GW Flux	Reser voir Flux	Q-Model	Qobs (including Tuting)	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9=7
1986-87	3025.14	42.56	0.00	0.002	0.00	0.00	28.21	_	28.21
1987-88	2850.32	40.10	0.00	0.003	0.00	0.00	28.64	_	28.64
1988-89	4334.90	60.99	0.00	0.003	0.00	0.00	46.46	_	46.46
1989-90	4242.00	59.68	0.00	0.003	0.00	0.00	45.42	_	45.42
1990-91	3872.22	54.48	0.00	0.003	0.00	0.00	40.71	_	40.71
1991-92	3510.44	49.39	0.00	0.003	-0.07	0.00	36.56	_	36.56
1992-93	3416.96	48.08	0.00	0.003	0.01	0.00	35.09	_	35.09
1993-94	4473.90	62.95	0.00	0.003	0.03	0.00	48.49	_	48.49
1994-95	2990.80	42.08	0.00	0.003	0.12	0.00	29.75	_	29.75
1995-96	3731.37	52.50	0.00	0.003	-0.01	0.00	39.23	_	39.23
1996-97	3765.18	52.98	0.00	0.003	-0.07	0.00	39.30	_	39.30
1997-98	3425.68	48.20	0.00	0.003	0.02	0.00	35.08	_	35.08
1998-99	3823.49	53.80	0.00	0.003	0.00	0.00	39.86	_	39.86
1999-00	3248.51	45.71	0.00	0.003	0.00	0.00	32.69	_	32.69
2000-01	3588.57	50.49	0.00	0.003	-0.10	0.00	37.00	_	37.00
2001-02	4305.21	60.57	0.00	0.003	0.06	0.00	45.47	_	45.47
2002-03	3714.24	52.26	0.00	0.003	0.00	0.00	38.44	_	38.44
2003-04	3669.44	51.63	0.00	0.003	0.06	0.00	38.27	_	38.27
2004-05	3563.83	50.14	0.00	0.003	-0.01	0.00	37.15	_	37.15
2005-06	2151.56	30.27	0.00	0.003	-0.18	0.00	19.31	_	19.31
2006-07	2719.19	38.26	0.00	0.003	0.11	0.00	26.20	_	26.20
2007-08	4361.25	61.36	0.00	0.003	0.00	0.00	46.24	_	46.24
2008-09	4314.53	60.71	0.00	0.003	0.00	0.00	45.52	_	45.52
2009-10	4770.71	67.12	0.00	0.003	0.00	0.00	51.17	_	51.17
2010-11	3802.01	53.49	0.00	0.003	0.00	0.00	39.61	157.88	39.61
2011-12	3206.86	45.12	0.00	0.003	0.00	0.00	32.37	132.37	32.37
2012-13	4873.37	68.57	0.00	0.003	0.02	0.00	52.71	159.817	52.71
2013-14	4211.24	59.25	0.00	0.003	0.00	0.00	44.60	120.16	44.60
Average	3712.96	52.24	0.00	0.003	-0.001	0.00	38.55	142.55	38.55

Table - L.31 Water availability at NT Road Crossing

Year	Rainfall		ECII	DIL	GW Flux	Res. Flux	Q-Model	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9=7
1986-87	2511.51	5.73	0.00	0.002	0.00	0.00	3.55	–	3.55
1987-88	2131.74	4.86	0.00	0.002	0.00	0.00	2.81	–	2.81
1988-89	3606.56	8.23	0.00	0.002	0.00	0.00	5.71	–	5.71
1989-90	3813.71	8.70	0.00	0.003	0.00	0.00	6.14	–	6.14
1990-91	3326.48	7.59	0.00	0.003	0.00	0.00	5.11	4.18	5.11
1991-92	2660.88	6.07	0.00	0.003	0.01	0.00	3.77	4.46	3.77
1992-93	2923.65	6.67	0.00	0.002	0.02	0.00	4.34	5.35	4.34
1993-94	3821.23	8.72	0.00	0.002	0.02	0.00	6.19	4.89	6.19
1994-95	2989.18	6.82	0.00	0.002	-0.01	0.00	4.42	4.60	4.42
1995-96	3324.28	7.59	0.00	0.002	0.02	0.00	5.11	4.41	5.11
1996-97	3064.04	6.99	0.00	0.002	-0.13	0.00	4.66	4.97	4.66
1997-98	2811.01	6.41	0.00	0.002	0.06	0.00	4.12	4.52	4.12
1998-99	2695.74	6.15	0.00	0.002	0.01	0.00	3.97	4.99	3.97
1999-00	2153.83	4.92	0.00	0.002	0.02	0.00	2.76	4.29	2.76
2000-01	2491.50	5.69	0.00	0.002	-0.02	0.00	3.41	3.54	3.41
2001-02	3160.56	7.21	0.00	0.002	0.00	0.00	4.70	3.42	4.70
2002-03	2861.31	6.53	0.00	0.002	0.02	0.00	4.09	3.29	4.09
2003-04	2783.68	6.35	0.00	0.002	0.10	0.00	3.95	2.28	3.95
2004-05	3277.70	7.48	0.00	0.002	-0.05	0.00	5.03	1.43	5.03
2005-06	1397.42	3.19	0.00	0.002	-0.04	0.00	1.28	1.11	1.28
2006-07	1806.65	4.12	0.00	0.002	0.07	0.00	2.07	1.24	2.07
2007-08	3362.65	7.67	0.00	0.002	0.00	0.00	5.08	1.47	5.08
2008-09	3600.04	8.22	0.00	0.002	0.00	0.00	5.56	0.88	5.56
2009-10	4286.30	9.78	0.00	0.002	0.00	0.00	6.97	1.01	6.97
2010-11	3027.44	6.91	0.00	0.003	0.00	0.00	4.48	1.26	4.48
2011-12	2695.67	6.15	0.00	0.003	0.00	0.00	3.74	1.55	3.74
2012-13	3921.79	8.95	0.00	0.003	0.00	0.00	6.32	1.97	6.32
2013-14	3041.61	6.94	0.00	0.003	0.00	0.00	4.56	0.72	4.56
Average	2983.86	6.81	0.00	0.002	0.004	0.00	4.43	2.99	4.43

Table - L.32 Water availability at Chouldhowaghat

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Q-Model	Qobs (including Lemeking)	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	(BCM)
1	2(a)	2(b)	3	4	5	6	7	8	9=7
1985-86	2490.56	39.92	0.00	0.003	0.00	0.00	20.10	72.98	20.10
1986-87	3321.20	53.23	0.00	0.003	0.00	0.00	31.20	63.15	31.20
1987-88	4057.29	65.03	0.00	0.003	0.00	0.00	42.93	81.00	42.93
1988-89	3409.15	54.64	0.00	0.003	0.00	0.00	32.83	65.06	32.83
1989-90	3332.77	53.41	0.00	0.003	0.00	0.00	32.55	74.39	32.55
1990-91	3566.76	57.16	0.00	0.003	0.00	0.00	36.63	74.96	36.63
1991-92	3214.54	51.52	0.00	0.003	0.00	0.00	30.70	85.69	30.70
1992-93	2681.07	42.97	0.00	0.003	0.00	0.00	22.75	71.57	22.75
1993-94	3594.01	57.60	0.00	0.003	0.00	0.00	36.37	95.67	36.37
1994-95	2482.23	39.78	0.00	0.003	0.00	0.00	18.55	70.91	18.55
1995-96	3258.42	52.22	0.00	0.004	0.00	0.00	31.02	83.71	31.02
1996-97	2224.92	35.66	0.00	0.004	0.00	0.00	15.93	76.48	15.93
1997-98	2495.51	40.00	0.00	0.004	0.00	0.00	20.15	62.87	20.15
1998-99	2961.62	47.47	0.00	0.004	0.00	0.00	26.14	89.44	26.14
1999-00	3381.86	54.20	0.00	0.004	0.00	0.00	31.58	92.70	31.58
2000-01	2695.98	43.21	0.00	0.004	0.00	0.00	29.08	82.24	29.08
2001-02	1962.98	31.46	0.00	0.004	0.00	0.00	18.99	67.53	18.99
2002-03	2758.19	44.21	0.00	0.004	0.00	0.00	29.81	64.48	29.81
2003-04	4090.40	65.56	0.00	0.004	0.00	0.00	48.07	84.40	48.07
2004-05	3505.13	56.18	0.00	0.004	0.00	0.00	35.95	82.66	35.95
2005-06	3195.93	51.22	0.00	0.004	0.00	0.00	34.93	68.43	34.93
2006-07	3543.27	56.79	0.00	0.004	0.00	0.00	33.99	69.92	33.99
2007-08	3930.45	62.99	0.00	0.004	0.00	0.00	38.98	69.32	38.98
2008-09	3264.19	52.32	0.00	0.005	0.00	0.00	29.51	82.48	29.51
2009-10	3498.81	56.08	0.00	0.005	0.00	0.00	32.72	100.46	32.72
2010-11	2985.17	47.84	0.00	0.005	0.00	0.00	25.97	128.46	25.97
2011-12	3881.02	62.20	0.00	0.005	0.00	0.00	40.51	108.52	40.51
2012-13	3028.79	48.54	0.00	0.005	0.00	0.00	30.95	99.15	30.95
2013-14	2293.23	36.75	0.00	0.005	0.00	0.00	19.65	81.95	19.65
2014-15	2650.20	42.47	0.00	0.005	0.00	0.00	26.66	67.54	26.66
Average	3164.82	50.72	0.00	0.004	0.000	0.00	30.17	81.34	30.17

Table - L.33 Water availability at Sivasagar

Year	Rainfall		ECII	DIL	GW Flux	Res. Flux	Q-Model	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9=7
1985-86	1570.70	10.83	0.10	0.017	-0.06	0.00	4.53	3.78	4.53
1986-87	1892.29	13.04	0.02	0.017	-0.01	0.00	5.20	3.29	5.20
1987-88	2342.21	16.14	0.07	0.018	0.20	0.00	7.86	3.74	7.86
1988-89	2659.68	18.33	0.02	0.018	-0.07	0.00	9.43	3.85	9.43
1989-90	2908.11	20.04	0.00	0.019	0.13	0.00	11.11	5.88	11.11
1990-91	2771.27	19.10	0.06	0.020	-0.17	0.00	10.60	4.15	10.60
1991-92	2704.21	18.64	0.01	0.020	0.05	0.00	9.73	4.26	9.73
1992-93	2326.18	16.03	0.01	0.021	0.04	0.00	7.87	6.57	7.87
1993-94	2212.69	15.25	0.05	0.022	0.04	0.00	7.11	5.20	7.11
1994-95	2093.54	14.43	0.07	0.022	-0.02	0.00	6.51	4.48	6.51
1995-96	2660.35	18.34	0.03	0.023	-0.04	0.00	9.18	4.29	9.18
1996-97	2028.32	13.98	0.05	0.024	-0.10	0.00	6.57	4.28	6.57
1997-98	2085.82	14.38	0.10	0.024	0.12	0.00	6.53	4.96	6.53
1998-99	2625.68	18.10	0.13	0.025	-0.16	0.00	9.64	5.69	9.64
1999-00	2585.25	17.82	0.03	0.026	0.28	0.00	9.58	5.89	9.58
2000-01	2065.09	14.23	0.11	0.027	-0.25	0.00	8.50	3.65	8.50
2001-02	2156.39	14.86	0.11	0.027	0.15	0.00	9.08	4.05	9.08
2002-03	2116.30	14.59	0.03	0.027	-0.03	0.00	8.89	3.55	8.89
2003-04	2749.97	18.95	0.03	0.027	0.22	0.00	11.10	4.33	11.10
2004-05	2676.80	18.45	0.01	0.027	0.10	0.00	11.04	3.96	11.04
2005-06	2034.75	14.02	0.14	0.027	-0.21	0.00	7.50	3.62	7.50
2006-07	1963.72	13.53	0.17	0.027	-0.27	0.00	5.96	3.79	5.96
2007-08	2453.67	16.91	0.02	0.027	0.00	0.00	8.46	5.08	8.46
2008-09	1997.65	13.77	0.14	0.027	0.00	0.00	5.72	4.48	5.72
2009-10	2905.95	20.03	0.04	0.027	0.00	0.00	11.24	5.42	11.24
2010-11	2710.13	18.68	0.02	0.027	0.00	0.00	10.03	5.79	10.03
2011-12	2252.83	15.53	0.13	0.027	0.00	0.00	7.80	3.48	7.80
2012-13	1870.49	12.89	0.37	0.027	0.00	0.00	7.00	6.40	7.00
2013-14	1813.84	12.50	0.09	0.027	0.00	0.00	6.81	4.36	6.81
2014-15	1781.78	12.28	0.18	0.027	0.00	0.00	6.11	4.06	6.11
Average	2345.11	16.16	0.08	0.024	-0.001	0.00	8.22	4.59	8.22

Table - L.34 Water availability at Udaipur

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Q-Model	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9=7
1985-86	2317.94	2.03	0.00	0.000	-0.01	0.00	1.03	_	1.03
1986-87	1948.93	1.71	0.00	0.000	0.00	0.00	0.66	_	0.66
1987-88	2638.92	2.31	0.00	0.000	0.00	0.00	1.24	_	1.24
1988-89	3035.28	2.66	0.00	0.000	0.01	0.00	1.52	_	1.52
1989-90	2736.91	2.39	0.00	0.000	0.01	0.00	1.29	_	1.29
1990-91	2963.04	2.59	0.00	0.000	-0.03	0.00	1.49	_	1.49
1991-92	3167.24	2.77	0.00	0.001	0.01	0.00	1.64	_	1.64
1992-93	2512.07	2.20	0.00	0.001	-0.02	0.00	1.11	_	1.11
1993-94	2727.62	2.39	0.00	0.001	0.06	0.00	1.29	_	1.29
1994-95	2684.82	2.35	0.00	0.001	-0.05	0.00	1.18	1.22	1.18
1995-96	3547.91	3.10	0.00	0.001	0.03	0.00	1.90	2.67	1.90
1996-97	2375.97	2.08	0.00	0.001	-0.03	0.00	0.97	1.61	0.97
1997-98	2433.94	2.13	0.00	0.001	0.01	0.00	1.02	1.51	1.02
1998-99	3401.27	2.98	0.00	0.001	-0.03	0.00	1.77	2.71	1.77
1999-00	2832.74	2.48	0.00	0.001	0.06	0.00	1.36	2.70	1.36
2000-01	2237.00	1.96	0.00	0.001	-0.05	0.00	1.28	2.47	1.28
2001-02	2267.90	1.98	0.00	0.001	0.03	0.00	1.39	1.70	1.39
2002-03	2329.02	2.04	0.00	0.001	0.01	0.00	1.39	1.72	1.39
2003-04	2740.02	2.40	0.00	0.001	0.02	0.00	1.61	2.28	1.61
2004-05	3241.54	2.84	0.00	0.001	-0.04	0.00	2.02	2.32	2.02
2005-06	2172.08	1.90	0.00	0.001	-0.02	0.00	1.10	1.69	1.10
2006-07	2030.03	1.78	0.00	0.001	0.01	0.00	0.75	1.60	0.75
2007-08	2415.38	2.11	0.00	0.001	0.00	0.00	1.00	2.16	1.00
2008-09	2054.39	1.80	0.00	0.001	0.00	0.00	0.70	1.83	0.70
2009-10	3046.44	2.67	0.00	0.001	0.00	0.00	1.53	1.82	1.53
2010-11	2482.98	2.17	0.00	0.001	0.00	0.00	1.05	2.36	1.05
2011-12	2186.64	1.91	0.00	0.001	0.00	0.00	0.84	1.67	0.84
2012-13	1771.17	1.55	0.00	0.001	0.00	0.00	0.72	1.99	0.72
2013-14	1671.54	1.46	0.00	0.001	0.00	0.00	0.62	1.43	0.62
2014-15	1790.54	1.57	0.00	0.001	0.00	0.00	0.76	1.60	0.76
Average	2559.03	2.24	0.00	0.001	0.000	0.00	1.21	1.97	1.21

Table - L.35 Water availability at Golaghat

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Q-Model	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9=7
1985-86	1727.84	14.23	0.24	0.019	0.07	0.00	5.81	8.25	5.81
1986-87	1533.50	12.63	0.16	0.020	0.01	0.00	4.60	4.33	4.60
1987-88	1821.22	15.00	0.22	0.020	-0.21	0.00	6.25	6.22	6.25
1988-89	1435.43	11.82	0.08	0.021	0.13	0.00	2.93	4.71	2.93
1989-90	2120.42	17.46	0.04	0.021	0.10	0.00	8.26	6.39	8.26
1990-91	2205.32	18.16	0.05	0.022	-0.12	0.00	9.10	7.93	9.10
1991-92	2021.01	16.64	0.06	0.022	-0.18	0.00	7.41	6.49	7.41
1992-93	2349.94	19.35	0.01	0.023	0.18	0.00	9.60	6.43	9.60
1993-94	2079.14	17.12	0.12	0.024	-0.03	0.00	8.29	6.49	8.29
1994-95	1679.60	13.83	0.24	0.024	0.06	0.00	5.78	6.16	5.78
1995-96	1323.04	10.89	0.19	0.025	0.07	0.00	2.87	6.66	2.87
1996-97	1574.58	12.97	0.12	0.025	-0.20	0.00	5.03	4.55	5.03
1997-98	1993.50	16.41	0.13	0.026	0.33	0.00	7.89	5.51	7.89
1998-99	1690.88	13.92	0.15	0.027	-0.37	0.00	5.24	5.45	5.24
1999-00	1824.14	15.02	0.19	0.027	0.36	0.00	6.54	7.59	6.54
2000-01	1754.25	14.44	0.13	0.028	-0.16	0.00	6.04	6.62	6.04
2001-02	1850.06	15.23	0.11	0.028	0.09	0.00	6.51	6.03	6.51
2002-03	1602.64	13.20	0.18	0.029	-0.09	0.00	4.98	6.48	4.98
2003-04	2099.70	17.29	0.07	0.029	0.04	0.00	7.64	8.15	7.64
2004-05	1954.66	16.09	0.04	0.029	0.08	0.00	7.01	7.89	7.01
2005-06	1480.83	12.19	0.17	0.030	-0.26	0.00	4.22	6.65	4.22
2006-07	1327.61	10.93	0.42	0.030	-0.03	0.00	3.34	5.37	3.34
2007-08	1811.15	14.91	0.15	0.031	0.00	0.00	5.84	8.35	5.84
2008-09	1763.85	14.52	0.27	0.031	0.00	0.00	6.23	6.98	6.23
2009-10	1764.85	14.53	0.23	0.031	0.00	0.00	5.71	5.04	5.71
2010-11	1791.65	14.75	0.20	0.032	0.00	0.00	6.01	9.15	6.01
2011-12	1660.46	13.67	0.21	0.032	0.00	0.00	6.13	7.31	6.13
2012-13	1413.60	11.64	0.51	0.032	0.00	0.00	5.35	6.39	5.35
2013-14	1301.30	10.71	0.28	0.033	0.00	0.00	4.05	6.70	4.05
2014-15	1463.22	12.05	0.25	0.033	0.00	0.00	4.24	4.83	4.24
Average	1758.15	14.48	0.17	0.027	-0.003	0.00	5.96	6.50	5.96

Table - L.36 Water availability at Bhomoraguri

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Q-Model	Qobs*	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9=7
1985-86	2624.95	149.59	0.79	0.102	-0.84	0.00	94.07	_	94.07
1986-87	2409.83	137.33	0.34	0.103	-0.27	0.00	85.05	_	85.05
1987-88	3280.72	186.96	0.63	0.105	0.00	0.00	135.25	_	135.25
1988-89	2586.48	147.40	0.23	0.107	0.63	0.00	91.80	_	91.80
1989-90	2401.91	136.88	0.12	0.109	0.77	0.00	81.35	_	81.35
1990-91	2896.34	165.05	0.39	0.112	-1.48	0.00	113.04	_	113.04
1991-92	2751.26	156.79	0.27	0.114	-0.04	0.00	101.82	_	101.82
1992-93	2184.40	124.48	0.20	0.116	0.48	0.00	72.94	_	72.94
1993-94	2591.97	147.71	0.72	0.118	0.37	0.00	79.75	_	79.75
1994-95	1959.95	111.69	1.11	0.121	-1.31	0.00	45.93	_	45.93
1995-96	2784.93	158.70	0.50	0.123	2.82	0.00	81.70	_	81.70
1996-97	1987.40	113.26	0.80	0.125	-3.76	0.00	50.02	_	50.02
1997-98	2199.67	125.35	1.03	0.128	1.98	0.00	46.89	_	46.89
1998-99	2537.28	144.59	1.29	0.130	-1.98	0.00	66.77	_	66.77
1999-00	1844.71	105.12	0.50	0.132	3.00	0.00	55.57	_	55.57
2000-01	1798.67	102.50	1.35	0.135	-2.57	0.00	56.87	_	56.87
2001-02	1942.15	110.68	0.95	0.137	1.31	0.00	50.86	_	50.86
2002-03	1953.68	111.33	0.42	0.139	-0.47	0.00	74.28	_	74.28
2003-04	2584.47	147.28	0.29	0.140	3.49	0.00	110.21	391.90	110.21
2004-05	2792.56	159.14	0.05	0.142	-1.66	0.00	116.71	475.75	116.71
2005-06	1727.27	98.43	1.38	0.144	-1.61	0.00	72.17	415.67	72.17
2006-07	1791.43	102.09	1.67	0.146	-1.24	0.00	34.23	359.71	34.23
2007-08	2183.64	124.44	0.37	0.148	0.00	0.00	45.42	423.47	45.42
2008-09	1390.81	79.26	1.37	0.150	0.00	0.00	38.28	420.15	38.28
2009-10	2473.98	140.98	0.81	0.152	0.00	0.00	83.80	448.06	83.80
2010-11	2026.71	115.50	0.79	0.154	0.00	0.00	63.52	648.29	63.52
2011-12	1849.87	105.42	2.00	0.156	0.00	0.00	35.02	518.63	35.02
2012-13	1379.01	78.59	3.77	0.158	0.02	0.00	44.15	434.76	44.15
2013-14	1869.95	106.56	1.68	0.160	0.00	0.00	53.48	326.67	53.48
2014-15	2192.74	124.96	1.25	0.163	0.00	0.00	76.28	341.63	76.28
Average	2220.75	127.27	0.90	0.132	-0.079	0.00	71.91	442.09	71.91

**including upstream catchment discharges*

Table - L.37 Water availability at Pancharatna

Year	Rainfall		ECII	DIL	GW Flux	Res. Flux	Q-Model	Qobs*	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9=7
1985-86	2008.86	94.55	1.58	0.175	0.48	0.00	46.57	536.10	46.57
1986-87	2108.92	99.26	0.35	0.179	0.30	0.00	51.88	466.52	51.88
1987-88	2625.67	123.50	0.87	0.184	-0.53	0.00	76.90	560.81	76.90
1988-89	2161.01	101.71	0.69	0.189	-0.40	0.00	58.47	548.91	58.47
1989-90	2357.48	110.96	0.69	0.193	3.54	0.00	65.34	489.03	65.34
1990-91	2188.18	102.99	0.72	0.198	-1.77	0.00	63.73	474.52	63.73
1991-92	2119.81	99.77	0.75	0.204	-1.10	0.00	53.98	424.34	53.98
1992-93	2207.31	103.89	0.66	0.210	1.45	0.00	61.25	347.72	61.25
1993-94	2424.40	114.11	0.54	0.215	-0.50	0.00	71.77	462.08	71.77
1994-95	1795.15	84.49	1.71	0.221	-1.19	0.00	38.91	356.87	38.91
1995-96	2322.28	109.30	0.94	0.227	0.94	0.00	67.78	458.03	67.78
1996-97	1696.91	79.87	1.19	0.232	-0.35	0.00	39.19	407.21	39.19
1997-98	1961.76	92.33	2.04	0.238	0.49	0.00	51.16	386.53	51.16
1998-99	2065.15	97.20	1.35	0.244	-2.97	0.00	56.52	580.48	56.52
1999-00	2466.51	116.09	0.73	0.249	1.89	0.00	70.16	494.00	70.16
2000-01	2162.65	101.79	1.44	0.255	1.19	0.00	60.97	458.68	60.97
2001-02	1991.41	93.73	1.74	0.260	2.11	0.00	49.37	424.38	49.37
2002-03	2268.07	106.75	0.68	0.266	-0.77	0.00	63.52	389.69	63.52
2003-04	2244.62	105.65	0.41	0.271	1.98	0.00	62.53	565.30	62.53
2004-05	2179.32	102.57	0.32	0.277	-1.33	0.00	59.84	621.05	59.84
2005-06	1852.41	87.19	1.10	0.282	-1.70	0.00	43.82	454.32	43.82
2006-07	1524.47	71.75	3.03	0.288	1.30	0.00	31.88	398.59	31.88
2007-08	1909.50	89.87	0.38	0.293	0.00	0.00	46.13	479.91	46.13
2008-09	1755.82	82.64	2.37	0.299	0.00	0.00	40.63	460.24	40.63
2009-10	1964.76	92.48	1.44	0.304	0.00	0.00	46.35	487.04	46.35
2010-11	1766.96	83.17	1.72	0.310	0.00	0.00	39.89	547.67	39.89
2011-12	1383.05	65.10	2.72	0.316	0.00	0.00	27.53	446.30	27.53
2012-13	1713.35	80.64	2.86	0.322	0.00	0.00	46.30	521.95	46.30
2013-14	1581.64	74.44	1.88	0.328	0.00	0.00	32.17	414.18	32.17
2014-15	1880.65	88.52	1.77	0.335	0.00	0.00	49.57	435.64	49.57
Average	2022.94	95.21	1.29	0.252	0.102	0.00	52.47	469.94	52.47

**including upstream catchment discharges*

Table - L.38 Water availability at Domohani

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+ 7
1985-86	2985	27.07	0.00	0.065	0.13	0.00	23.98	26.42	24.18
1986-87	2828	25.65	0.00	0.066	-0.02	0.00	22.76	24.16	22.81
1987-88	2888	26.19	0.00	0.068	-0.05	0.00	22.07	36.26	22.08
1988-89	2779	25.21	0.00	0.070	-0.01	0.00	21.13	29.25	21.19
1989-90	2974	26.97	0.00	0.071	0.11	0.00	21.69	34.79	21.87
1990-91	3102	28.14	0.00	0.073	-0.12	0.00	24.39	33.49	24.35
1991-92	2832	25.69	0.00	0.075	-0.03	0.00	22.61	41.07	22.65
1992-93	2074	18.81	0.00	0.076	0.04	0.00	15.62	34.74	15.74
1993-94	2157	19.56	0.00	0.078	0.01	0.00	16.28	22.85	16.37
1994-95	2373	21.52	0.00	0.080	-0.14	0.00	19.01	22.47	18.95
1995-96	3433	31.14	0.00	0.082	0.19	0.00	27.69	31.53	27.96
1996-97	2444	22.17	0.00	0.084	-0.13	0.00	19.20	20.50	19.16
1997-98	2788	25.29	0.00	0.086	0.15	0.00	22.28	16.66	22.51
1998-99	3212	29.13	0.00	0.088	-0.04	0.00	24.61	20.14	24.66
1999-00	2383	21.61	0.00	0.090	0.04	0.00	17.82	24.32	17.95
2000-01	2126	19.28	0.00	0.095	-0.12	0.00	15.31	23.74	15.28
2001-02	2680	24.31	0.00	0.097	0.18	0.00	20.02	21.96	20.30
2002-03	2649	24.03	0.00	0.099	-0.01	0.00	19.80	18.87	19.89
2003-04	2997	27.18	0.00	0.100	0.02	0.00	22.40	25.87	22.52
2004-05	2397	21.74	0.00	0.101	-0.15	0.00	16.08	19.76	16.03
2005-06	2408	21.84	0.00	0.102	-0.04	0.00	18.45	18.90	18.51
2006-07	2459	22.30	0.00	0.104	0.07	0.00	18.20	21.50	18.37
2007-08	2663	24.15	0.00	0.105	-0.05	0.00	19.60	21.05	19.65
2008-09	2872	26.05	0.00	0.106	0.11	0.00	21.38	24.28	21.59
2009-10	2954	26.79	0.00	0.108	-0.15	0.00	22.82	21.83	22.77
2010-11	2771	25.13	0.00	0.109	0.06	0.00	21.12	18.28	21.29
2011-12	2377	21.56	0.00	0.110	-0.01	0.00	17.36	19.33	17.46
2012-13	2893	26.24	0.00	0.112	-0.06	0.00	22.17	21.94	22.22
2013-14	2631	23.86	0.00	0.113	-0.02	0.00	21.01	22.87	21.10
2014-15	2824	25.61	0.00	0.115	0.12	0.00	22.95	21.98	23.19
Average	2698	24.47	0.00	0.091	0.002	0.00	20.66	24.69	20.75

Table - L.39 Water availability at Mekhliganj

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Q obs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+7
1985-86	3244	2.55	0.00	0.00	0.00	0.00	2.07	_	2.07
1986-87	2766	2.17	0.00	0.00	0.00	0.00	1.69	_	1.69
1987-88	3573	2.80	0.00	0.00	0.00	0.00	2.28	_	2.28
1988-89	4260	3.34	0.00	0.00	0.00	0.00	2.64	_	2.64
1989-90	4831	3.79	0.00	0.00	0.00	0.00	3.03	_	3.03
1990-91	3995	3.14	0.00	0.00	0.00	0.00	2.74	_	2.74
1991-92	3006	2.36	0.00	0.00	0.00	0.00	2.03	_	2.03
1992-93	2333	1.83	0.00	0.00	0.00	0.00	1.58	_	1.58
1993-94	2681	2.10	0.00	0.00	0.00	0.00	1.79	_	1.79
1994-95	1992	1.56	0.00	0.00	0.00	0.00	1.2	_	1.20
1995-96	3069	2.41	0.00	0.00	0.00	0.00	2.34	_	2.34
1996-97	2376	1.87	0.00	0.00	0.00	0.00	1.64	_	1.64
1997-98	2524	1.98	0.00	0.00	0.00	0.00	1.59	_	1.59
1998-99	3818	3.00	0.00	0.00	0.00	0.00	2.66	_	2.66
1999-00	2743	2.15	0.00	0.00	0.00	0.00	1.83	_	1.83
2000-01	2934	2.30	0.00	0.00	0.00	0.00	1.97	_	1.97
2001-02	3186	2.50	0.00	0.00	0.00	0.00	2.09	_	2.09
2002-03	2776	2.18	0.00	0.00	0.00	0.00	1.91	_	1.91
2003-04	3904	3.06	0.00	0.00	0.00	0.00	2.52	_	2.52
2004-05	4176	3.28	0.00	0.00	0.00	0.00	2.67	_	2.67
2005-06	3531	2.77	0.00	0.00	0.00	0.00	2.34	_	2.34
2006-07	3367	2.64	0.00	0.00	0.00	0.00	2.2	_	2.20
2007-08	3666	2.88	0.00	0.00	0.00	0.00	2.38	_	2.38
2008-09	3789	2.97	0.00	0.00	0.00	0.00	2.48	_	2.48
2009-10	3667	2.88	0.00	0.00	0.00	0.00	2.25	_	2.25
2010-11	4496	3.53	0.00	0.00	0.00	0.00	3.07	_	3.07
2011-12	3071	2.41	0.00	0.00	0.00	0.00	1.97	_	1.97
2012-13	3593	2.82	0.00	0.00	0.00	0.00	2.32	_	2.32
2013-14	3118	2.45	0.00	0.00	0.00	0.00	2.05	_	2.05
2014-15	3015	2.37	0.00	0.00	0.00	0.00	1.97	_	1.97
Average	3317	2.6	0.00	0.00	0.00	0.00	2.18	–	2.18

Table - L.40 Water availability of remaining portion

Year	Rainfall		ECII	DIL Flux	GW Flux	Reservoir Flux	Q-Model	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8=7
1985-86	3041.64	55.17	0.34	0.065	0.30	0.00	39.76	39.76
1986-87	2987.05	54.18	0.00	0.066	-0.22	0.00	38.15	38.15
1987-88	4294.74	77.90	0.00	0.067	-0.13	0.00	59.15	59.15
1988-89	4049.27	73.45	0.00	0.069	-0.47	0.00	56.66	56.66
1989-90	3663.50	66.45	0.00	0.070	1.13	0.00	49.62	49.62
1990-91	3722.21	67.51	0.00	0.071	-0.50	0.00	51.96	51.96
1991-92	3058.75	55.48	0.68	0.081	-2.37	0.00	41.84	41.84
1992-93	2592.51	47.02	0.30	0.091	1.14	0.00	31.44	31.44
1993-94	3601.83	65.33	0.00	0.102	-0.29	0.00	47.25	47.25
1994-95	2207.62	40.04	0.00	0.112	-0.82	0.00	23.28	23.28
1995-96	3916.96	71.05	0.00	0.122	1.19	0.00	54.34	54.34
1996-97	2690.94	48.81	0.35	0.133	-0.10	0.00	34.12	34.12
1997-98	2677.58	48.57	0.86	0.143	0.92	0.00	33.39	33.39
1998-99	3763.34	68.26	0.58	0.153	-0.09	0.00	53.47	53.47
1999-00	3104.29	56.31	0.27	0.164	-0.43	0.00	40.73	40.73
2000-01	3091.44	56.07	1.14	0.174	-0.06	0.00	40.99	40.99
2001-02	2755.33	49.98	0.00	0.177	1.64	0.00	33.61	33.61
2002-03	3272.31	59.35	0.13	0.180	-0.32	0.00	42.09	42.09
2003-04	3479.05	63.10	0.00	0.183	0.29	0.00	46.83	46.83
2004-05	3822.74	69.34	0.00	0.186	-0.50	0.00	52.69	52.69
2005-06	3284.47	59.57	0.31	0.189	-0.33	0.00	42.36	42.36
2006-07	2955.58	53.61	0.00	0.192	0.10	0.00	36.18	36.18
2007-08	3316.86	60.16	0.14	0.195	-0.06	0.00	43.34	43.34
2008-09	3351.91	60.80	0.39	0.198	0.14	0.00	45.10	45.10
2009-10	3239.08	58.75	0.00	0.201	-0.20	0.00	42.58	42.58
2010-11	3228.26	58.55	0.72	0.204	0.10	0.00	44.43	44.43
2011-12	2541.47	46.10	1.43	0.208	-0.03	0.00	32.24	32.24
2012-13	3646.35	66.14	0.00	0.211	-0.10	0.00	50.19	50.19
2013-14	2739.05	49.68	0.72	0.214	-0.22	0.00	34.58	34.58
2014-15	3177.82	57.64	0.74	0.218	0.72	0.00	42.12	42.12
Average	3251.95	58.81	0.30	0.148	0.014	0.00	42.82	42.82

Table - L.41 Water resources availability in Brahmaputra basin

Year	Rainfall	Q-Model	ECII	DIL	GW Flux	Reservoir Flux	Reservoir Evap.	Water Availability
	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2	3	4	5	6	7	8	9
1986-87	483.37	295.73	0.95	0.47	-0.09	0.00	0.00	295.73
1987-88	595.72	409.24	1.95	0.48	-0.70	0.00	0.00	409.24
1988-89	561.02	369.34	1.07	0.49	-0.11	0.00	0.00	369.34
1989-90	562.12	367.55	0.90	0.51	5.94	0.00	0.00	367.55
1990-91	576.37	396.48	1.29	0.52	-4.41	0.00	0.00	396.48
1991-92	524.97	340.23	1.93	0.54	-3.65	0.00	0.00	340.23
1992-93	473.32	293.48	1.22	0.56	3.34	0.00	0.00	293.48
1993-94	567.97	366.16	1.49	0.58	0.01	0.00	0.00	366.16
1994-95	423.02	226.10	3.34	0.60	-3.74	0.00	0.00	226.10
1995-96	565.20	358.41	1.73	0.63	5.64	0.00	0.00	358.41
1996-97	437.67	250.77	2.62	0.65	-5.25	0.00	0.00	250.77
1997-98	465.04	261.86	4.34	0.67	4.17	0.00	0.00	261.86
1998-99	531.10	324.06	3.57	0.69	-5.80	0.00	0.00	324.06
1999-00	480.09	297.23	1.75	0.71	5.77	0.00	0.00	297.23
2000-01	450.20	287.77	4.46	0.74	-2.65	0.00	0.00	287.77
2001-02	459.56	276.12	3.16	0.75	5.78	0.00	0.00	276.12
2002-03	481.01	321.46	1.51	0.77	-1.68	0.00	0.00	321.46
2003-04	549.49	384.09	0.99	0.78	6.61	0.00	0.00	384.09
2004-05	549.31	376.47	0.62	0.79	-3.80	0.00	0.00	376.47
2005-06	406.74	261.30	3.48	0.80	-4.62	0.00	0.00	261.30
2006-07	407.16	213.70	5.67	0.82	0.15	0.00	0.00	213.70
2007-08	515.84	297.41	1.08	0.83	-0.11	0.00	0.00	297.41
2008-09	452.65	277.26	4.66	0.84	0.24	0.00	0.00	277.26
2009-10	548.23	348.60	2.57	0.85	-0.36	0.00	0.00	348.60
2010-11	474.36	291.17	3.48	0.87	0.16	0.00	0.00	291.17
2011-12	421.86	230.71	6.69	0.88	-0.04	0.00	0.00	230.71
2012-13	458.66	306.38	7.68	0.89	-0.12	0.00	0.00	306.38
2013-14	428.08	254.84	4.90	0.91	-0.24	0.00	0.00	254.84
Average	495.00	310.14	2.82	0.70	0.02	0.00	0.00	310.14
Water Availability of Brahmaputra basin = Q_{model} + Mean discharge of 8 years at Kibutu, Lemeking and Tuting sites=310.14+ 36.08 +5.78+89.68								441.68

ANNEXURE - L(e)

BARAK & OTHERS BASIN

Table - L.42 Water availability at Fulertal

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8 = 3+4+5+6
1986-87	1908.01	26.57	0.02	0.01	0.06	14.06	0.00	14.15
1987-88	2202.08	30.66	0.03	0.01	-0.13	17.61	0.00	17.52
1988-89	1843.41	25.67	0.03	0.02	0.00	12.68	0.00	12.73
1989-90	2275.90	31.69	0.01	0.02	0.13	19.37	0.00	19.53
1990-91	2584.95	35.99	0.01	0.02	0.00	23.21	24.81	23.24
1991-92	2197.94	30.60	0.00	0.02	0.01	17.67	18.68	17.70
1992-93	2346.96	32.68	0.01	0.02	0.02	20.00	17.91	20.05
1993-94	1919.27	26.72	0.05	0.02	-0.02	15.15	18.05	15.20
1994-95	1340.83	18.67	0.13	0.02	-0.13	5.79	13.07	5.81
1995-96	1898.35	26.43	0.03	0.02	0.15	13.17	16.38	13.37
1996-97	1734.77	24.15	0.04	0.02	-0.17	11.86	12.28	11.75
1997-98	1879.36	26.17	0.10	0.02	0.17	13.58	15.63	13.87
1998-99	1627.95	22.67	0.08	0.02	-0.26	10.52	17.16	10.36
1999-00	2085.01	29.03	0.02	0.02	0.38	13.01	26.20	13.43
2000-01	1794.22	24.98	0.02	0.02	-0.15	12.33	23.08	12.22
2001-02	1952.73	27.19	0.04	0.02	0.03	14.12	24.31	14.21
2002-03	1643.27	22.88	0.04	0.02	0.02	10.38	14.93	10.46
2003-04	2210.22	30.77	0.04	0.02	0.00	17.79	22.57	17.85
2004-05	2325.44	32.38	0.01	0.02	-0.04	20.38	26.63	20.37
2005-06	1727.92	24.06	0.02	0.02	-0.03	11.49	15.45	11.50
2006-07	1950.35	27.15	0.13	0.02	0.10	14.21	15.38	14.46
2007-08	2161.53	30.10	0.01	0.02	0.00	15.65	22.69	15.68
2008-09	2411.99	33.58	0.01	0.02	0.00	20.97	20.66	21.00
2009-10	1921.67	26.76	0.06	0.02	0.00	12.67	15.96	12.75
2010-11	2155.79	30.02	0.02	0.03	0.00	16.38	21.94	16.43
2011-12	2129.80	29.65	0.10	0.03	0.00	17.48	14.77	17.61
2012-13	1948.25	27.13	0.08	0.03	0.00	16.72	12.99	16.83
2013-14	1481.23	20.62	0.09	0.03	0.00	8.27	9.97	8.39
2014-15	1502.56	20.92	0.09	0.03	0.00	9.11	9.63	9.23
Avg.	1973.18	27.47	0.05	0.02	0.00	14.74	15.04	14.81

Table - L.43 Water availability at BP Ghat

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8=3+4+5+6
1985-86	2311.04	56.58	0.41	0.05	0.17	35.67	32.86	36.29
1986-87	2149.29	52.62	0.09	0.05	0.08	30.63	35.22	30.84
1987-88	2547.80	62.38	0.17	0.05	-0.13	39.53	33.46	39.62
1988-89	2170.73	53.14	0.07	0.05	0.03	30.21	38.59	30.36
1989-90	2682.05	65.66	0.06	0.05	0.41	44.19	43.14	44.70
1990-91	2935.84	71.88	0.02	0.05	-0.09	49.76	49.83	49.74
1991-92	2395.51	58.65	0.05	0.05	0.03	36.03	37.41	36.16
1992-93	2590.75	63.43	0.06	0.05	-0.02	41.61	30.69	41.71
1993-94	2205.76	54.00	0.36	0.05	0.08	33.32	42.66	33.81
1994-95	1505.33	36.85	0.31	0.05	-0.58	14.53	24.60	14.31
1995-96	2208.33	54.06	0.29	0.05	0.57	30.26	29.88	31.18
1996-97	1953.38	47.82	0.21	0.06	-0.66	26.72	24.55	26.32
1997-98	2145.21	52.52	0.35	0.06	0.66	30.13	29.22	31.19
1998-99	1907.30	46.69	0.57	0.06	-1.06	25.42	31.72	24.98
1999-00	2537.25	62.12	0.02	0.06	1.55	33.02	37.37	34.65
2000-01	2183.09	53.45	0.06	0.06	-0.50	31.59	36.30	31.21
2001-02	2384.00	58.37	0.10	0.06	0.05	35.57	33.05	35.78
2002-03	1885.64	46.16	0.15	0.06	0.24	23.67	24.86	24.13
2003-04	2539.83	62.18	0.14	0.07	-0.02	39.27	34.76	39.46
2004-05	2579.52	63.15	0.04	0.07	-0.13	42.57	42.63	42.55
2005-06	1925.79	47.15	0.13	0.07	-0.20	25.37	24.00	25.37
2006-07	2160.25	52.89	0.35	0.07	0.44	29.38	29.85	30.23
2007-08	2271.53	55.61	0.05	0.07	0.00	30.97	41.32	31.09
2008-09	2597.71	63.60	0.08	0.07	0.00	41.06	32.86	41.21
2009-10	2325.49	56.93	0.21	0.07	0.00	32.38	35.22	32.66
2010-11	2366.96	57.95	0.09	0.08	0.00	34.28	52.04	34.44
2011-12	2273.48	55.66	0.47	0.08	0.00	33.81	34.25	34.37
2012-13	2113.15	51.73	0.12	0.08	0.00	32.84	21.96	33.04
2013-14	1547.99	37.90	0.12	0.08	0.00	15.94	34.25	16.15
2014-15	1715.32	41.99	0.30	0.08	0.00	21.01	21.96	21.39
Avg.	2237.18	54.77	0.18	0.06	0.03	32.36	34.02	32.63

Table - L.44 Water availability at Tulargram

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8=3+4+5+6
1985-86	2755.90	6.23	0.05	0.01	0.01	4.25	3.50	4.31
1986-87	2496.60	5.65	0.01	0.01	0.00	3.58	2.97	3.60
1987-88	3057.00	6.91	0.02	0.01	-0.01	4.75	3.03	4.77
1988-89	2627.80	5.94	0.01	0.01	0.00	3.8	3.19	3.82
1989-90	3170.10	7.17	0.01	0.01	0.06	5.17	4.75	5.24
1990-91	3662.70	8.28	0.00	0.01	0.00	6.16	4.13	6.17
1991-92	2747.80	6.21	0.01	0.01	0.00	4.06	3.34	4.08
1992-93	3149.00	7.12	0.00	0.01	0.01	5.08	3.31	5.09
1993-94	2736.00	6.19	0.02	0.01	-0.01	4.22	4.78	4.23
1994-95	1415.20	3.20	0.04	0.01	-0.06	1.16	3.62	1.14
1995-96	2578.60	5.83	0.02	0.01	0.07	3.56	4.06	3.66
1996-97	2384.30	5.39	0.02	0.01	-0.07	3.42	2.89	3.37
1997-98	2610.60	5.90	0.04	0.01	0.08	3.78	3.97	3.9
1998-99	2446.80	5.53	0.06	0.01	-0.12	3.41	2.93	3.36
1999-00	3284.30	7.43	0.00	0.01	0.17	4.53	4.10	4.71
2000-01	2894.80	6.55	0.00	0.01	-0.07	4.51	4.58	4.45
2001-02	3037.60	6.87	0.01	0.01	0.01	4.73	4.48	4.76
2002-03	2287.90	5.17	0.01	0.01	0.01	3.01	3.17	3.04
2003-04	3087.20	6.98	0.01	0.01	0.00	4.77	4.35	4.79
2004-05	3018.00	6.82	0.00	0.01	-0.02	4.96	4.48	4.95
2005-06	2222.90	5.03	0.01	0.01	-0.01	2.97	2.86	2.98
2006-07	2568.80	5.81	0.04	0.01	0.04	3.53	3.23	3.62
2007-08	2453.00	5.55	0.01	0.01	0.00	3.29	4.12	3.31
2008-09	3028.00	6.85	0.01	0.01	0.00	4.67	3.57	4.68
2009-10	2982.50	6.74	0.03	0.01	0.00	4.45	2.84	4.50
2010-11	2803.70	6.34	0.01	0.01	0.00	4.13	4.70	4.15
2011-12	2669.70	6.04	0.05	0.01	0.00	3.91	3.32	3.97
2012-13	2301.80	5.21	0.01	0.01	0.00	3.31	4.36	3.33
2013-14	1575.30	3.56	0.01	0.01	0.00	1.38	3.52	1.40
2014-15	1880.50	4.25	0.03	0.01	0.00	2.27	-	2.31
Avg.	2664.48	6.03	0.02	0.01	0.00	3.89	3.73	3.92

Table - L.45 Water availability at AP Ghat

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8= 3+4+5+6
1985-86	2210.93	40.43	0.24	0.03	-0.01	24.90	26.81	25.16
1986-87	2045.52	37.40	0.05	0.03	0.07	20.89	19.69	21.04
1987-88	2400.66	43.90	0.09	0.03	-0.13	26.70	27.66	26.69
1988-89	2029.94	37.12	0.05	0.03	0.00	20.02	29.03	20.10
1989-90	2489.28	45.52	0.03	0.03	0.24	29.32	32.83	29.62
1990-91	2781.57	50.86	0.01	0.03	0.00	34.08	38.44	34.12
1991-92	2304.79	42.14	0.03	0.03	0.02	25.10	31.79	25.18
1992-93	2485.33	45.45	0.04	0.03	0.02	28.87	29.06	28.96
1993-94	2035.82	37.23	0.22	0.03	-0.02	21.93	39.97	22.16
1994-95	1395.87	25.52	0.23	0.03	-0.26	8.72	23.00	8.72
1995-96	2058.78	37.65	0.17	0.03	0.30	19.99	22.15	20.49
1996-97	1869.24	34.18	0.13	0.04	-0.34	18.11	17.49	17.94
1997-98	2034.84	37.21	0.21	0.04	0.35	20.48	17.96	21.08
1998-99	1785.94	32.66	0.34	0.04	-0.52	16.57	21.03	16.43
1999-00	2342.51	42.83	0.02	0.04	0.75	21.31	25.02	22.12
2000-01	2038.39	37.27	0.04	0.04	-0.29	20.73	22.07	20.52
2001-02	2181.72	39.89	0.08	0.04	0.05	22.67	22.57	22.84
2002-03	1777.81	32.51	0.08	0.04	0.08	15.79	17.90	15.99
2003-04	2410.25	44.07	0.09	0.04	0.00	26.83	26.79	26.96
2004-05	2471.84	45.20	0.02	0.04	-0.07	29.43	30.75	29.42
2005-06	1838.34	33.61	0.08	0.04	-0.07	17.08	20.93	17.13
2006-07	2069.42	37.84	0.24	0.04	0.19	20.51	18.29	20.98
2007-08	2230.28	40.78	0.03	0.05	0.00	22.03	27.61	22.11
2008-09	2524.33	46.16	0.05	0.05	0.00	29.33	22.09	29.43
2009-10	2163.56	39.56	0.14	0.05	0.00	21.03	26.34	21.22
2010-11	2297.73	42.01	0.05	0.05	0.00	24.12	45.35	24.22
2011-12	2235.46	40.88	0.26	0.05	0.00	24.58	19.28	24.89
2012-13	2058.74	37.64	0.10	0.05	0.00	23.51	11.01	23.66
2013-14	1534.69	28.06	0.10	0.05	0.00	11.55	15.39	11.70
2014-15	1628.53	29.78	0.19	0.05	0.00	14.18	32.50	14.42
Avg.	2124.4	38.85	0.11	0.04	0.01	22.01	25.36	22.17

Table - L.46 Water availability at Matijuri

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8=3+4+5+6
1985-86	2502.50	11.13	0.05	0.01	0.07	7.24	4.25	7.36
1986-87	2456.60	10.92	0.01	0.01	0.01	6.82	5.13	6.85
1987-88	2951.50	13.12	0.01	0.01	0.00	8.87	6.82	8.89
1988-89	2497.30	11.10	0.01	0.01	0.03	6.71	4.51	6.75
1989-90	3208.70	14.27	0.01	0.01	0.06	10.36	4.73	10.44
1990-91	3531.00	15.70	0.00	0.01	-0.03	11.58	6.35	11.56
1991-92	2637.00	11.73	0.00	0.01	0.01	7.51	4.38	7.53
1992-93	2986.20	13.28	0.00	0.01	-0.02	9.33	4.76	9.31
1993-94	3003.40	13.36	0.00	0.01	0.04	9.28	6.89	9.34
1994-95	1766.50	7.86	0.04	0.01	-0.15	3.69	4.25	3.58
1995-96	2629.60	11.69	0.01	0.01	0.11	7.19	5.13	7.32
1996-97	2216.60	9.86	0.01	0.01	-0.12	6.04	6.82	5.94
1997-98	2479.20	11.02	0.06	0.01	0.10	6.94	4.51	7.10
1998-99	2264.80	10.07	0.06	0.01	-0.20	5.99	4.73	5.86
1999-00	3110.50	13.83	0.00	0.01	0.30	8.38	4.76	8.69
2000-01	2577.50	11.46	0.00	0.01	-0.06	7.40	6.89	7.35
2001-02	3075.00	13.67	0.01	0.01	0.00	9.54	4.25	9.55
2002-03	2255.40	10.03	0.01	0.01	0.06	5.85	5.13	5.93
2003-04	2867.20	12.75	0.01	0.01	-0.01	8.53	6.82	8.54
2004-05	2918.00	12.98	0.00	0.01	-0.02	9.45	4.51	9.45
2005-06	2164.20	9.62	0.01	0.01	-0.06	5.76	4.73	5.73
2006-07	2508.80	11.16	0.05	0.01	0.10	6.63	4.76	6.79
2007-08	2348.00	10.44	0.01	0.01	0.00	6.07	6.89	6.08
2008-09	2898.40	12.89	0.01	0.01	0.00	8.64	4.25	8.66
2009-10	2700.70	12.01	0.04	0.01	0.00	7.56	5.13	7.61
2010-11	2523.00	11.22	0.01	0.01	0.00	6.92	6.82	6.94
2011-12	2430.30	10.81	0.05	0.01	0.00	6.77	4.51	6.84
2012-13	2247.80	10.00	0.01	0.01	0.00	6.15	4.73	6.17
2013-14	1484.40	6.60	0.02	0.01	0.00	2.63	4.51	2.66
2014-15	1869.60	8.31	0.02	0.01	0.00	4.24	4.73	4.27
Avg.	2570.32	11.43	0.02	0.01	0.01	7.27	5.22	7.31

Table - L.47 Water availability at Kailashar

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8=3+4+5+6
1985-86	2184	4.84	0.06	0.01	0.04	2.96	2.63	3.06
1986-87	2448.4	5.43	0.02	0.01	0.00	3.35	1.77	3.37
1987-88	2808.6	6.23	0.00	0.01	-0.01	4.13	1.89	4.13
1988-89	2413.1	5.35	0.01	0.01	0.04	3.23	2.95	3.29
1989-90	3123.6	6.93	0.01	0.01	0.01	5.04	2.62	5.07
1990-91	3292.8	7.30	0.01	0.01	0.00	5.23	4.04	5.26
1991-92	2277	5.05	0.02	0.01	0.02	2.92	2.78	2.97
1992-93	2727	6.05	0.00	0.01	-0.04	4.14	2.26	4.11
1993-94	3268.7	7.25	0.01	0.01	0.05	5.16	2.91	5.23
1994-95	1789.5	3.97	0.03	0.01	-0.16	2.07	1.66	1.94
1995-96	2758.2	6.12	0.00	0.01	0.10	3.81	2.40	3.92
1996-97	1896.9	4.21	0.03	0.01	0.01	2.30	2.15	2.35
1997-98	2176.6	4.83	0.05	0.01	-0.06	2.95	2.58	2.95
1998-99	1896.7	4.21	0.05	0.01	-0.05	2.21	1.94	2.23
1999-00	2624.5	5.82	0.00	0.01	0.09	3.36	2.90	3.47
2000-01	2060.7	4.57	0.01	0.01	0.01	2.54	3.48	2.57
2001-02	2714.3	6.02	0.00	0.01	-0.01	3.94	3.76	3.95
2002-03	2307.4	5.12	0.01	0.01	0.01	3.06	3.3	3.09
2003-04	2607.9	5.78	0.02	0.01	-0.01	3.69	3.54	3.71
2004-05	3026.8	6.71	0.02	0.01	-0.01	4.83	3.54	4.85
2005-06	2240.9	4.97	0.00	0.01	-0.07	3.08	1.98	3.03
2006-07	2187	4.85	0.05	0.01	0.11	2.68	2.41	2.85
2007-08	2133.7	4.73	0.00	0.01	0.00	2.62	2.96	2.63
2008-09	2460.1	5.46	0.01	0.01	0.00	3.38	1.30	3.39
2009-10	2506.6	5.56	0.01	0.01	0.00	3.41	2.25	3.44
2010-11	2240.4	4.97	0.00	0.01	0.00	2.85	3.05	2.87
2011-12	2142.2	4.75	0.08	0.01	0.00	2.80	1.80	2.89
2012-13	2180.9	4.84	0.03	0.01	0.00	2.90	2.16	2.94
2013-14	1612.5	3.58	0.06	0.01	0.00	1.53	1.69	1.60
2014-15	2080	4.61	0.03	0.01	0.00	2.57	1.99	2.61
Avg.	2406.23	5.34	0.02	0.01	0.00	3.29	2.56	3.32

Table - L.48 Water availability at Ranikor

Year	Rainfall		ECII	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7=3+4+5
1985-86	3338.4	8.32	0.07	0.01	5.97	6.5	6.05
1986-87	3364.1	8.39	0.01	0.05	6.07	4.8	6.13
1987-88	6282.6	15.66	0.00	-0.03	13.07	8.29	13.04
1988-89	6175.9	15.39	0.00	-0.03	12.86	15.92	12.84
1989-90	5387	13.43	0.00	0.05	11.04	11.48	11.09
1990-91	4248.5	10.59	0.01	-0.03	8.35	Not Available	8.33
1991-92	5087.6	12.68	0.00	0.02	10.25		10.27
1992-93	3821	9.52	0.01	0.02	7.00		7.04
1993-94	5086.8	12.68	0.01	0.01	10.25		10.26
1994-95	3425	8.54	0.05	0.00	6.08		6.13
1995-96	4833.4	12.05	0.04	0.02	9.53		9.6
1996-97	3485.5	8.69	0.03	0.01	6.38		6.43
1997-98	5963.2	14.86	0.08	0.00	12.44		12.54
1998-99	8171.6	20.37	0.00	-0.04	17.84		17.8
1999-00	2669.8	6.65	0.01	0.03	3.31		3.34
2000-01	2541.3	6.33	0.02	0.00	3.76		3.79
2001-02	6742.5	16.81	0.00	0.04	14.21		14.25
2002-03	6236.9	15.55	0.01	-0.02	13.01		13
2003-04	6594.9	16.44	0.00	0.00	13.9		13.9
2004-05	2659	6.63	0.02	0.01	4.41		4.44
2005-06	5454.3	13.6	0.00	-0.01	10.96		10.95
2006-07	1399.9	3.49	0.18	0.03	0.97		1.18
2007-08	1939.1	4.83	0.03	0.00	2.14		2.18
2008-09	2386	5.95	0.07	0.00	3.34		3.42
2009-10	5401.1	13.46	0.00	0.00	10.8		10.81
2010-11	4487.8	11.19	0.00	0.00	8.49		8.5
2011-12	1503	3.75	0.15	0.00	1.44		1.59
2012-13	2655.8	6.62	0.03	0.00	4.25		4.28
2013-14	4627.4	11.53	0.01	0.00	8.93		8.95
2014-15	6533.6	16.29	0.02	0.00	14.25		14.27
Avg.	4416.76	11.01	0.03	0.00	8.51	9.40	8.54

Table - L.49 Water availability at Bhagmara

Year	Rainfall		ECII	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7=3+4+5
1985-86	2088.2	4.81	0.03	0.00	2.57	4.29	2.61
1986-87	2373.9	5.47	0.00	0.04	3.02	4.64	3.06
1987-88	4696.6	10.82	0.00	-0.02	8.25	6.88	8.24
1988-89	4176.5	9.62	0.01	-0.05	7.05	9.14	7.01
1989-90	4162.9	9.59	0.00	0.07	7.08	6.92	7.15
1990-91	3334.9	7.69	0.00	-0.03	5.37		5.35
1991-92	2112.2	4.87	0.00	0.01	2.52		2.53
1992-93	2512.8	5.79	0.02	0.03	3.28		3.34
1993-94	3367.1	7.76	0.01	-0.03	5.35		5.33
1994-95	2158.5	4.97	0.03	0.01	2.45		2.49
1995-96	3539.7	8.16	0.02	0.02	5.75		5.8
1996-97	2197.7	5.06	0.01	0.00	2.72		2.73
1997-98	4373.5	10.08	0.03	0.01	7.69		7.74
1998-99	5824.1	13.42	0.00	-0.03	10.81		10.78
1999-00	2398.5	5.53	0.03	0.03	2.54		2.61
2000-01	2139.3	4.93	0.02	-0.01	2.63		2.64
2001-02	4247.1	9.79	0.01	0.05	7.23	Not available	7.28
2002-03	4563.5	10.52	0.01	-0.02	8.06		8.06
2003-04	4454.3	10.27	0.00	-0.02	7.71		7.7
2004-05	3162.9	7.29	0.00	0.03	4.88		4.91
2005-06	4414.2	10.17	0.00	-0.02	7.66		7.64
2006-07	2124.1	4.9	0.01	0.02	2.24		2.28
2007-08	2522.3	5.81	0.00	0.00	3.2		3.21
2008-09	2586.5	5.96	0.00	0.00	3.45		3.45
2009-10	3539.5	8.16	0.02	0.00	5.49		5.51
2010-11	3370.1	7.77	0.01	0.00	5.19		5.2
2011-12	1685.8	3.89	0.03	0.00	1.58		1.62
2012-13	2629.9	6.06	0.03	0.00	3.82		3.85
2013-14	3067.1	7.07	0.01	0.00	4.5		4.52
2014-15	4539.4	10.46	0.01	0.00	8.19		8.21
Avg.	3278.77	7.56	0.01	0.00	5.08	6.37	5.10

Table - L.50 Water resources availability in Barak & others basin

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Reservoir Evap.	Water availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7+8
1985-86	2727.29	136.46	1.18	0.11	0.27	0.00	93.23	0.78	95.57
1986-87	2891.21	144.74	0.47	0.11	0.19	0.00	101.39	0.79	102.95
1987-88	3518.03	176.36	0.42	0.12	-0.24	0.00	126.72	0.73	127.74
1988-89	3043.71	152.41	0.36	0.12	-0.18	0.75	102.14	0.93	104.12
1989-90	3370.65	168.93	0.31	0.12	0.88	0.18	120.96	0.85	123.29
1990-91	3305.94	165.66	0.26	0.12	-0.30	0.31	116.35	0.71	117.46
1991-92	2933.67	146.87	0.38	0.13	0.12	0.11	98.45	0.71	99.89
1992-93	2898.22	145.08	0.27	0.13	-0.11	0.16	97.32	0.85	98.61
1993-94	3032.52	151.85	0.65	0.13	0.24	0.12	104.84	0.82	106.80
1994-95	1975.41	98.51	0.85	0.13	-1.15	0.01	51.27	0.91	52.02
1995-96	3008.20	150.63	0.62	0.13	1.29	0.07	99.79	0.89	102.80
1996-97	2287.10	114.23	0.60	0.14	-0.90	0.01	69.31	0.68	69.84
1997-98	2816.59	140.96	1.06	0.14	0.73	0.15	92.61	0.88	95.56
1998-99	2849.45	142.60	1.06	0.14	-1.66	0.04	92.94	0.80	93.32
1999-00	2530.97	126.55	0.34	0.14	2.14	0.13	65.63	0.91	69.30
2000-01	2234.50	111.59	0.47	0.15	-0.60	0.05	64.06	0.85	64.97
2001-02	3051.05	152.79	0.32	0.15	0.25	0.04	101.73	0.86	103.35
2002-03	2658.24	132.96	0.51	0.16	0.30	0.07	83.28	0.86	85.18
2003-04	3072.89	153.89	0.53	0.16	-0.01	0.09	101.78	0.84	103.38
2004-05	2674.93	133.82	0.41	0.16	-0.13	0.13	86.55	0.76	87.89
2005-06	2507.39	125.35	0.39	0.17	-0.55	0.02	76.45	0.81	77.29
2006-07	2245.24	102.03	1.26	0.17	0.90	0.01	51.20	0.91	54.45
2007-08	2201.38	109.91	0.38	0.17	0.00	0.12	57.22	0.91	58.80
2008-09	2463.75	123.15	0.50	0.17	0.00	0.01	72.74	0.85	74.27
2009-10	2802.42	140.24	0.69	0.18	0.00	0.01	87.12	0.96	88.96
2010-11	2650.07	132.55	0.42	0.18	0.00	0.02	80.94	0.88	82.43
2011-12	2028.32	101.17	1.69	0.19	0.00	0.00	54.10	0.63	56.61
2012-13	2235.25	111.62	0.61	0.19	0.00	0.09	66.36	0.62	67.87
2013-14	2016.73	100.59	0.63	0.19	0.00	0.02	52.45	0.88	54.17
2014-15	2528.79	126.43	0.75	0.20	0.00	0.00	79.73	0.48	81.16
Avg	2685.33	134.00	0.61	0.15	0.05	0.09	84.96	0.81	86.67

MAHI BASIN

Table - M.1 Water availability at Mataji

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Qobs	Water availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	**2(a)**	**2(b)**	**3**	**4**	**5**	**6**	**7**	**8**	**9 = 3+4+5+6+7**
1985-86	619	2.31	0.71	0.01	0.09	0.00	0.56	0.17	1.38
1986-87	1005	3.75	1.03	0.01	0.16	0.00	1.39	1.23	2.60
1987-88	706	2.64	0.96	0.01	0.00	0.00	0.41	0.49	1.39
1988-89	1205	4.50	0.44	0.01	0.02	0.00	1.67	1.92	2.14
1989-90	816	3.05	1.16	0.02	-0.05	0.00	0.34	0.71	1.46
1990-91	1398	5.22	1.08	0.02	0.02	0.00	2.48	2.32	3.59
1991-92	763	2.85	0.90	0.02	-0.09	0.00	1.01	1.34	1.84
1992-93	741	2.77	0.33	0.02	0.01	0.00	0.51	0.39	0.86
1993-94	1010	3.77	0.80	0.02	0.02	0.00	0.84	1.11	1.67
1994-95	1587	5.93	0.98	0.02	0.04	0.00	3.17	2.57	4.20
1995-96	1022	3.82	0.52	0.02	0.05	0.00	1.55	0.89	2.14
1996-97	1183	4.41	0.40	0.02	0.04	0.00	2.40	1.83	2.86
1997-98	1028	3.84	0.50	0.02	0.07	0.00	1.77	1.39	2.36
1998-99	1095	4.09	0.51	0.02	-0.02	0.00	1.12	1.55	1.63
1999-00	718	2.68	0.67	0.02	-0.15	0.00	0.52	0.26	1.07
2000-01	401	1.50	0.21	0.02	-0.09	0.00	0.24	0.14	0.38
2001-02	667	2.49	1.09	0.02	-0.02	0.00	0.13	0.16	1.22
2002-03	638	2.38	0.55	0.02	0.00	0.00	0.15	0.22	0.72
2003-04	1173	4.38	0.41	0.03	0.03	0.00	2.10	1.56	2.56
2004-05	1041	3.89	0.91	0.03	-0.05	0.00	1.19	1.06	2.38
2005-06	846	3.16	0.44	0.03	0.09	0.00	0.95	1.02	1.50
2006-07	1611	6.01	0.82	0.03	0.11	0.00	3.47	4.06	4.43
2007-08	1217	4.54	1.01	0.03	-0.05	0.00	1.78	2.16	2.77
2008-09	735	2.74	0.25	0.03	0.10	0.00	0.65	0.28	1.02
2009-10	783	2.92	0.40	0.03	-0.07	0.00	0.78	1.07	1.14
2010-11	690	2.58	0.60	0.03	-0.09	0.00	0.58	0.62	1.12
2011-12	1082	4.04	0.75	0.03	-0.03	0.00	1.78	3.00	2.53
2012-13	1204	4.49	1.43	0.03	-0.03	0.00	1.78	2.23	3.21
2013-14	1415	5.28	0.70	0.03	-0.18	0.00	2.66	3.49	3.22
2014-15	730	2.73	0.64	0.03	-0.02	0.00	0.33	0.70	0.97
Avg.	971	3.62	0.71	0.02	0.003	0.00	1.29	1.36	2.02
Avg. excluding 2006-07	949	3.54	0.70	0.02	-0.01	0.00	1.21	1.27	1.93

Table - M.2 Water availability at Paderdibadi

Year	Rain fall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	630	10.30	2.04	0.05	-0.25	0.96	1.91	0.85	4.71
1986-87	716	11.70	3.33	0.05	0.08	0.27	3.24	1.74	6.97
1987-88	564	9.22	2.63	0.05	-0.18	0.03	1.95	0.69	4.48
1988-89	787	12.86	4.45	0.06	0.24	-0.28	0.47	0.89	4.94
1989-90	779	12.74	4.85	0.06	0.22	-0.39	1.23	0.97	5.97
1990-91	1064	17.39	3.04	0.06	0.17	0.13	6.90	3.91	10.30
1991-92	721	11.79	3.09	0.06	0.26	0.14	3.90	2.23	7.45
1992-93	752	12.29	1.45	0.06	0.07	0.00	2.61	0.74	4.19
1993-94	776	12.70	3.68	0.06	0.13	-0.02	1.75	1.32	5.60
1994-95	1207	19.73	3.23	0.07	0.30	0.02	8.94	6.43	12.56
1995-96	629	10.29	2.63	0.07	0.32	0.08	1.71	0.37	4.81
1996-97	778	12.72	2.57	0.07	0.23	0.07	3.40	2.97	6.34
1997-98	650	10.63	3.05	0.07	0.07	-0.02	1.89	1.36	5.06
1998-99	598	9.77	3.00	0.07	-0.16	0.15	0.18	1.10	3.24
1999-00	485	7.94	2.57	0.08	-0.36	-0.35	1.03	0.32	2.97
2000-01	388	6.34	1.03	0.08	0.60	0.00	0.46	0.10	2.17
2001-02	651	10.64	3.48	0.08	0.28	-0.01	1.63	0.30	5.46
2002-03	472	7.71	1.30	0.08	0.22	0.01	0.22	0.37	1.83
2003-04	747	12.21	2.32	0.09	0.26	0.50	2.11	0.66	5.28
2004-05	844	13.80	4.89	0.09	0.40	-0.05	2.46	1.84	7.79
2005-06	744	12.17	2.07	0.09	0.17	0.04	2.62	0.93	4.99
2006-07	1291	21.10	3.42	0.09	0.48	-0.24	11.12	10.95	14.87
2007-08	776	12.69	3.58	0.10	0.21	0.11	2.72	1.60	6.72
2008-09	652	10.66	1.05	0.10	0.36	0.33	1.78	0.31	3.62
2009-10	651	10.64	1.88	0.10	0.19	0.05	1.32	0.55	3.54
2010-11	729	11.91	2.07	0.11	0.31	-0.04	1.87	0.41	4.32
2011-12	955	15.62	2.58	0.11	0.33	0.59	5.47	3.78	9.08
2012-13	995	16.27	4.95	0.11	0.10	0.03	5.01	2.95	10.20
2013-14	1091	17.83	2.87	0.12	0.12	0.08	5.39	3.00	8.58
2014-15	751	12.28	1.91	0.12	0.36	-0.21	1.39	1.36	3.57
Avg	762.43	12.46	2.83	0.08	0.18	0.06	2.89	1.83	6.04
Avg. excluding 2006-07	744.21	12.17	2.81	0.08	0.17	0.08	2.61	1.52	5.75

Table - M.3 Water availability at Khanpur

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Q calib	Qobs	Water availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	529	17.45	6.80	0.14	-1.14	0.76	0.77	0.76	7.33
1986-87	677	22.32	9.64	0.15	0.07	-0.07	1.85	2.07	11.64
1987-88	588	19.38	8.32	0.15	-0.34	-0.04	0.89	1.11	8.99
1988-89	856	28.24	10.18	0.15	-1.25	0.57	2.10	2.76	11.76
1989-90	798	26.32	10.80	0.16	0.21	-0.60	1.97	2.30	12.54
1990-91	1125	37.12	8.12	0.16	0.65	0.04	13.20	11.55	22.17
1991-92	697	22.99	11.12	0.17	-0.97	0.01	3.82	4.63	14.15
1992-93	712	23.48	6.04	0.17	0.00	0.13	0.67	0.87	7.02
1993-94	802	26.45	9.71	0.18	-0.16	-0.01	2.31	3.47	12.03
1994-95	1315	43.36	8.35	0.19	-1.03	0.06	19.95	19.68	27.52
1995-96	631	20.82	9.13	0.19	-0.99	-0.25	1.20	0.79	9.27
1996-97	946	31.21	4.97	0.50	0.82	0.54	10.32	8.80	16.84
1997-98	851	28.09	6.75	0.50	0.38	-0.30	8.20	8.12	15.22
1998-99	763	25.16	7.14	0.21	-0.46	0.27	1.57	3.58	8.73
1999-00	547	18.03	6.77	0.22	1.02	-1.28	0.26	0.55	6.98
2000-01	402	13.28	3.56	0.22	-1.98	-0.16	1.97	0.43	3.61
2001-02	618	20.38	9.09	0.23	0.33	0.00	0.26	0.48	9.91
2002-03	519	17.12	3.51	0.23	-0.50	0.17	0.50	0.77	3.91
2003-04	839	27.69	10.04	0.24	-1.58	1.43	1.74	3.55	11.87
2004-05	947	31.24	11.09	0.24	-0.62	-0.09	2.56	6.89	13.18
2005-06	812	26.79	4.98	0.25	-0.05	0.27	5.77	2.78	11.21
2006-07	1470	48.47	8.23	0.25	1.05	0.04	24.08	21.88	33.64
2007-08	993	32.76	10.76	0.26	0.28	-0.11	7.16	6.74	18.35
2008-09	623	20.56	5.89	0.26	-1.12	0.32	1.04	0.87	6.38
2009-10	641	21.15	5.74	0.27	0.69	-0.50	0.24	0.55	6.73
2010-11	703	23.19	5.73	0.27	0.89	-0.05	1.24	1.08	8.07
2011-12	966	31.86	8.30	0.28	0.43	1.19	7.91	5.01	18.11
2012-13	1043	34.40	13.65	0.28	-0.09	0.30	6.55	7.04	20.70
2013-14	1101	36.33	8.94	0.29	0.51	0.06	7.90	8.79	17.69
2014-15	724	23.90	6.81	0.30	-0.75	-0.48	1.69	2.20	7.56
Avg.	808	26.65	8.00	0.22	-0.19	0.08	4.66	4.67	12.77
Avg. excluding 2006-07	785	25.90	8.00	0.22	-0.23	0.08	3.99	4.08	12.06

Table - M.4 Water availability at Pingalwada

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1989-90	912	2.32	0.57	0.02	-0.01	0.00	0.39	0.35	0.98
1990-91	1292	3.29	1.11	0.02	0.03	0.00	1.04	0.96	2.20
1991-92	658	1.67	0.62	0.03	-0.03	0.00	0.32	0.30	0.93
1992-93	694	1.77	0.19	0.03	-0.02	0.00	0.17	0.14	0.37
1993-94	839	2.13	0.80	0.03	-0.01	0.00	0.45	0.43	1.27
1994-95	1200	3.05	0.58	0.03	0.03	0.00	1.32	0.64	1.97
1995-96	561	1.43	0.43	0.03	-0.03	0.00	0.34	0.35	0.77
1996-97	1119	2.85	0.59	0.03	0.03	0.00	0.82	0.57	1.48
1997-98	1146	2.92	0.86	0.03	-0.01	0.00	0.89	0.72	1.77
1998-99	1060	2.70	0.63	0.04	0.00	0.00	0.65	0.45	1.31
1999-00	578	1.47	0.19	0.04	-0.01	0.00	0.05	0.05	0.26
2000-01	468	1.19	0.30	0.04	-0.05	0.00	0.11	0.16	0.40
2001-02	748	1.90	0.56	0.04	0.00	0.00	0.40	0.42	1.00
2002-03	628	1.60	0.32	0.04	-0.01	0.00	0.13	0.27	0.49
2003-04	950	2.42	0.66	0.04	0.06	0.00	0.61	0.49	1.37
2004-05	1108	2.82	0.96	0.04	0.00	0.00	0.78	0.56	1.78
2005-06	1140	2.90	0.57	0.04	0.01	0.00	1.05	1.01	1.67
2006-07	1655	4.21	0.84	0.04	0.02	0.00	2.18	1.24	3.09
2007-08	1229	3.13	1.14	0.04	-0.01	0.00	0.51	0.65	1.68
2008-09	879	2.24	0.77	0.04	-0.02	0.00	0.28	0.53	1.07
2009-10	519	1.32	0.53	0.04	-0.02	0.00	0.09	0.12	0.64
2010-11	878	2.23	0.48	0.05	0.03	0.00	0.48	0.70	1.03
2011-12	1032	2.63	0.98	0.05	0.00	0.00	0.38	0.34	1.41
2012-13	896	2.28	0.91	0.05	-0.01	0.00	0.21	0.29	1.17
2013-14	1292	3.29	0.93	0.05	0.03	0.00	0.88	0.63	1.88
2014-15	983	2.50	1.06	0.05	-0.05	0.00	0.44	0.80	1.50
Avg.	941	2.39	0.68	0.04	0.00	0.00	0.58	0.50	1.30
Avg. excluding 2006-07	912	2.32	0.67	0.04	0.00	0.00	0.51	0.47	1.22

Table - M.5 Water resources availability in Mahi basin*

Year	Rainfall	ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Qobs	Reservoir Evp.	Water Availability*
	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2	3	4	5	6	7	8	9	10 = 3+4+5+6+7+9
1985-86	22.22	6.96	0.15	-1.17	0.77	0.79	0.77	0.42	7.93
1986-87	26.86	9.87	0.15	0.07	-0.07	1.90	2.12	0.35	12.28
1987-88	24.34	8.53	0.15	-0.35	-0.04	0.92	1.14	0.31	9.53
1988-89	38.13	10.43	0.16	-1.28	0.59	2.15	2.83	1.01	13.08
1989-90	34.90	11.06	0.16	0.22	-0.62	2.02	2.36	1.10	13.97
1990-91	49.01	8.32	0.17	0.66	0.04	13.52	11.83	0.99	23.73
1991-92	29.36	11.39	0.17	-0.99	0.01	3.91	4.74	0.63	15.14
1992-93	29.85	6.19	0.18	0.00	0.14	0.69	0.89	0.70	7.91
1993-94	34.99	9.94	0.18	-0.16	-0.01	2.37	3.56	1.11	13.47
1994-95	55.74	8.56	0.19	-1.06	0.06	20.45	20.17	1.37	29.60
1995-96	26.95	9.36	0.50	-1.02	-0.26	1.23	0.81	0.54	10.06
1996-97	41.48	5.09	0.50	0.84	0.55	10.57	9.02	0.59	17.86
1997-98	39.70	6.91	0.21	0.39	-0.31	8.40	8.32	0.65	16.26
1998-99	36.04	7.31	0.21	-0.47	0.28	1.61	3.67	1.23	10.21
1999-00	23.78	6.93	0.22	1.05	-1.31	0.27	0.57	0.53	7.70
2000-01	17.57	3.65	0.23	-2.03	-0.17	2.02	0.44	0.31	4.01
2001-02	26.26	9.31	0.23	0.34	0.00	0.27	0.49	0.45	10.61
2002-03	22.90	3.60	0.24	-0.52	0.17	0.52	0.79	0.41	4.43
2003-04	36.34	10.28	0.24	-1.62	1.47	1.78	3.64	1.21	13.40
2004-05	41.18	11.36	0.25	-0.64	-0.09	2.62	7.06	0.70	14.22
2005-06	36.66	5.10	0.25	-0.06	0.27	5.91	2.85	0.75	12.26
2006-07	64.15	8.43	0.26	1.07	0.04	24.67	22.42	0.86	35.35
2007-08	44.17	11.02	0.26	0.29	-0.11	7.34	6.90	0.65	19.47
2008-09	27.73	6.03	0.27	-1.15	0.32	1.06	0.89	0.65	7.20
2009-10	25.07	5.88	0.28	0.70	-0.21	0.24	0.57	0.39	7.29
2010-11	30.14	5.87	0.28	0.91	-0.05	1.27	1.10	0.56	8.84
2011-12	42.12	8.51	0.29	0.44	1.22	8.10	5.14	0.60	19.17
2012-13	43.76	13.99	0.29	-0.09	0.31	6.71	7.21	1.23	22.47
2013-14	46.96	9.16	0.30	0.52	0.06	8.10	9.00	1.43	19.59
2014-15	31.62	6.98	0.30	-0.77	-0.49	1.73	2.26	0.90	8.66
Avg.	35.00	8.20	0.24	-0.20	0.09	4.77	4.79	0.75	13.85
Avg. excluding 2006-07	33.99	8.19	0.24	-0.24	0.09	4.09	4.18	0.75	13.12

** excluding water availability for Dhadhar sub-basin and uncalibrated area*

ANNEXURE – N

SABARMATI BASIN

Table - N.1 Water availability at Derol Bridge

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2 (a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+7
1985-86	523.485	3.26	0.41	0.029	-0.36	0.00	2.227	-	2.301
1986-87	387.899	2.41	0.47	0.030	-0.40	0.00	0.486	-	0.581
1987-88	229.772	1.43	0.26	0.030	-0.58	0.00	0.459	-	0.168
1988-89	814.897	5.07	0.50	0.031	0.39	0.00	2.633	-	3.551
1989-90	653.093	4.06	0.84	0.031	0.00	0.00	2.054	-	2.918
1990-91	987.36	6.14	0.70	0.032	0.37	0.00	1.002	-	2.101
1991-92	633.45	3.94	0.90	0.030	-0.29	0.00	2.495	-	3.132
1992-93	872.35	5.43	0.87	0.030	0.17	0.00	3.975	0.854	5.042
1993-94	745.67	4.64	1.10	0.031	-0.24	0.00	3.149	0.839	4.039
1994-95	1247.32	7.76	0.53	0.031	0.55	0.00	5.196	2.022	6.311
1995-96	543.9	3.38	0.55	0.032	-0.56	0.00	2.466	0.286	2.488
1996-97	659.41	4.10	0.67	0.032	-0.09	0.00	0.741	0.165	1.352
1997-98	790.65	4.92	0.69	0.033	0.07	0.00	0.502	0.694	1.300
1998-99	762.92	4.75	0.71	0.033	-0.02	0.00	1.851	0.164	2.570
1999-00	364	2.26	0.47	0.034	-0.76	0.00	1.524	0.023	1.263
2000-01	460.32	2.86	0.50	0.036	-0.45	0.00	1.828	0.000	1.919
2001-02	604.08	3.76	1.33	0.036	-0.16	0.00	0.581	0.015	1.779
2002-03	341.71	2.13	0.24	0.037	-0.47	0.00	0.729	0.002	0.538
2003-04	813.77	5.06	0.34	0.037	0.34	0.00	2.691	0.013	3.414
2004-05	560.33	3.49	1.05	0.038	-0.14	0.00	1.193	0.009	2.140
2005-06	862.54	5.37	0.11	0.039	0.36	0.00	2.360	0.157	2.870
2006-07	1316.85	8.19	1.26	0.039	0.68	0.00	3.664	2.864	5.645
2007-08	926.06	5.76	1.43	0.040	-0.17	0.00	1.186	0.693	2.494
2008-09	498.03	3.10	0.95	0.041	-0.44	0.00	1.182	0.026	1.729
2009-10	515.98	3.21	0.41	0.042	-0.45	0.00	1.422	0.014	1.420
2010-11	827.68	5.15	0.67	0.043	0.25	0.00	1.856	0.032	2.817
2011-12	811.28	5.05	1.19	0.043	0.22	0.00	2.878	0.326	4.336
2012-13	738.318	4.59	0.51	0.044	-0.26	0.00	1.950	0.05	2.248
2013-14	822.458	5.12	0.24	0.045	0.06	0.00	1.584	0.061	1.928
2014-15	712.44	4.43	0.59	0.046	-0.05	0.00	1.219	0.038	1.800
Avg	700.93	4.36	0.68	0.04	-0.08	0.00	1.90	0.41	2.54

Table - N.2 Water availability at Kheda

	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Qobs	Water Availability
Year	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2 (a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+7
1985-86	488.13	2.81	0.83	0.07	-0.43	0.00	0.31		0.78
1986-87	423.07	2.44	1.25	0.07	-1.33	0.00	0.92		0.91
1987-88	336.32	1.94	0.77	0.07	0.09	0.00	0.00		0.93
1988-89	951.20	5.48	1.30	0.07	0.78	0.00	1.04		3.20
1989-90	748.95	4.31	2.09	0.07	-0.14	0.00	0.00	0.15	2.02
1990-91	1106.22	6.37	1.68	0.07	0.49	0.00	1.83	0.74	4.07
1991-92	661.70	3.81	2.49	0.06	-0.32	0.00	0.07	0.19	2.31
1992-93	641.40	3.69	1.87	0.07	-0.19	0.00	0.00	0.03	1.75
1993-94	671.02	3.86	2.71	0.07	-0.37	0.00	0.12	0.28	2.53
1994-95	1317.01	7.58	1.47	0.07	0.84	0.00	2.76	1.29	5.14
1995-96	543.09	3.13	1.35	0.07	-0.67	0.00	0.42	0.02	1.17
1996-97	815.62	4.70	1.57	0.07	-0.11	0.00	0.45	0.11	1.98
1997-98	1291.09	7.44	1.89	0.07	0.15	0.00	2.00	1.90	4.11
1998-99	983.82	5.67	1.43	0.07	0.24	0.00	1.12	0.50	2.86
1999-00	597.21	3.44	1.12	0.07	-1.05	0.00	0.85	0.04	0.99
2000-01	556.79	3.21	1.29	0.08	-0.77	0.00	0.54	0.02	1.14
2001-02	565.47	3.26	2.48	0.08	-0.62	0.00	0.00	0.00	1.94
2002-03	412.80	2.38	0.80	0.08	-0.52	0.00	0.14	0.00	0.50
2003-04	960.65	5.53	1.12	0.08	0.76	0.00	0.74	0.35	2.70
2004-05	878.99	5.06	2.12	0.08	-0.20	0.00	0.99	0.33	2.99
2005-06	1022.05	5.89	0.34	0.08	0.84	0.00	1.77	0.87	3.03
2006-07	1488.30	8.57	2.08	0.09	0.83	0.00	3.08	2.60	6.08
2007-08	1215.66	7.00	2.44	0.09	0.08	0.00	1.77	0.92	4.38
2008-09	642.02	3.70	2.24	0.09	-0.79	0.00	0.00	0.09	1.54
2009-10	553.22	3.19	1.40	0.09	-0.24	0.00	0.34	0.06	1.59
2010-11	893.81	5.15	1.43	0.09	0.22	0.00	0.62	0.15	2.36
2011-12	964.84	5.56	2.38	0.09	0.15	0.00	0.55	0.36	3.17
2012-13	819.58	4.72	1.35	0.09	-0.34	0.00	1.12	0.23	2.23
2013-14	1183.24	6.81	0.70	0.10	0.31	0.00	2.30	0.35	3.41
2014-15	903.18	5.20	1.46	0.10	-0.19	0.00	1.20	0.13	2.57
Avg	821.22	4.73	1.58	0.08	-0.08	0.00	0.90	0.45	2.48

Table - N.3 Water availability at Voutha

Year	Rainfall		ECII	DIL Flux	GW Flux	Reservoir Flux	Qcalib	Qobs	Water Availability
	Mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2 (a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+7+9
1985-86	504.81	9.18	2.693	0.165	-1.57	0.00	2.80	-	4.09
1986-87	397.01	7.22	3.952	0.168	-4.15	0.00	2.36	-	2.33
1987-88	286.10	5.20	1.310	0.171	-1.12	0.00	0.71	-	1.07
1988-89	893.63	16.25	4.157	0.174	3.93	0.00	1.74	-	10.00
1989-90	722.94	13.14	5.640	0.177	-0.42	0.00	1.88	-	7.28
1990-91	1068.25	19.42	4.915	0.160	1.48	0.00	4.17	-	10.73
1991-92	645.24	11.73	6.674	0.154	-1.40	0.00	2.48	-	7.90
1992-93	721.73	13.12	5.464	0.157	-0.68	0.00	3.41	-	8.35
1993-94	705.35	12.82	7.397	0.159	-1.12	0.00	2.71	-	9.14
1994-95	1289.55	23.44	3.781	0.162	3.09	0.00	9.97	-	17.01
1995-96	532.09	9.67	4.543	0.165	-2.39	0.00	2.55	-	4.87
1996-97	765.57	13.92	4.105	0.168	-0.11	0.00	1.20	-	5.36
1997-98	1067.79	19.41	5.034	0.171	1.30	0.00	3.76	-	10.26
1998-99	890.07	16.18	4.123	0.174	0.62	0.00	3.02	-	7.94
1999-00	510.60	9.28	3.980	0.177	-4.23	0.00	3.74	-	3.67
2000-01	519.76	9.45	4.484	0.183	-3.37	0.00	3.49	-	4.79
2001-02	596.90	10.85	6.954	0.185	-2.57	0.00	0.61	0.187	5.18
2002-03	392.49	7.14	3.140	0.188	-1.66	0.00	0.06	0.239	1.73
2003-04	918.76	16.70	3.379	0.191	2.80	0.00	3.62	3.871	9.99
2004-05	758.36	13.79	5.959	0.195	-0.50	0.00	2.60	2.490	8.25
2005-06	971.74	17.67	1.376	0.198	3.84	0.00	4.42	4.144	9.84
2006-07	1399.57	25.44	6.352	0.202	2.60	0.00	8.16	6.539	17.32
2007-08	1108.59	20.15	7.199	0.205	0.88	0.00	2.85	5.599	11.14
2008-09	606.55	11.03	6.011	0.209	-2.65	0.00	1.11	1.291	4.67
2009-10	518.72	9.43	5.490	0.213	-1.81	0.00	0.23	0.914	4.12
2010-11	878.52	15.97	4.837	0.215	1.02	0.00	1.72	1.267	7.79
2011-12	905.72	16.47	6.604	0.217	-0.35	0.00	4.39	3.078	10.86
2012-13	775.33	14.10	4.643	0.221	-0.78	0.00	2.34	1.894	6.42
2013-14	1041.86	18.94	1.788	0.225	1.92	0.00	4.38	3.851	8.32
2014-15	817.23	14.86	4.806	0.229	-0.80	0.00	2.45	1.831	6.69
Avg	773.70	14.07	4.690	0.190	-0.27	0.00	2.96	2.660	7.57

Table - N.4 Water resources availability in Sabarmati basin

Year	Rainfall	ECII	DIL flux	GW Flux	Reservoir Flux	Qcalib	Qobs	Reservoir Evp	Water Availability
	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2	3	4	5	6	7	8	9	10=3+4+5+6+7+9
1985-86	16.55	4.51	0.29	-1.84	0.00	3.092	-	0.17	6.22
1986-87	12.31	6.74	0.30	-7.12	0.00	3.501	-	0.14	3.56
1987-88	8.74	5.90	0.30	-1.89	0.00	0.00	-	0.10	4.41
1988-89	28.15	7.71	0.31	5.19	0.00	2.571	-	0.21	15.99
1989-90	22.37	11.52	0.32	-1.00	0.00	0.00	-	0.92	11.76
1990-91	33.29	9.72	0.28	1.21	0.00	7.419	-	0.92	19.55
1991-92	18.43	7.47	0.27	-2.42	0.00	5.363	-	0.14	10.82
1992-93	24.29	10.97	0.28	-0.64	0.00	1.019	-	0.20	11.83
1993-94	22.98	14.64	0.28	-1.53	0.00	0.080	-	0.77	14.24
1994-95	39.40	7.71	0.29	4.19	0.00	12.855	-	0.46	25.51
1995-96	16.56	7.43	0.29	-3.81	0.00	3.216	-	0.17	7.30
1996-97	22.57	9.30	0.30	-0.59	0.00	0.00	-	0.99	10.00
1997-98	32.74	9.44	0.30	1.69	0.00	6.044	-	1.07	18.54
1998-99	26.79	7.94	0.31	0.34	0.00	2.988	-	0.22	11.80
1999-00	17.23	6.67	0.32	-6.78	0.00	6.040	-	0.18	6.43
2000-01	17.96	7.63	0.33	-4.50	0.00	5.664	-	0.15	9.27
2001-02	20.85	12.65	0.33	-3.76	0.00	0.244	0.33	0.87	10.33
2002-03	12.72	5.69	0.34	-3.26	0.00	0.914	0.42	0.13	3.81
2003-04	28.50	6.45	0.34	3.03	0.00	5.878	6.79	0.21	15.91
2004-05	24.75	10.01	0.35	0.15	0.00	3.687	4.37	0.17	14.37
2005-06	32.95	2.54	0.35	5.64	0.00	9.794	7.27	1.31	19.63
2006-07	43.95	10.67	0.36	3.84	0.00	12.109	11.47	0.23	27.21
2007-08	37.31	11.88	0.37	2.75	0.00	5.970	9.82	0.45	21.42
2008-09	21.67	11.50	0.37	-3.51	0.00	1.040	2.27	1.02	10.42
2009-10	16.53	10.05	0.38	-4.20	0.00	0.240	1.60	0.15	6.62
2010-11	31.15	8.48	0.38	2.28	0.00	3.296	2.22	0.24	14.68
2011-12	36.04	10.97	0.39	-1.11	0.00	12.378	5.40	0.17	22.80
2012-13	23.11	8.88	0.39	-0.80	0.00	0.439	3.32	0.14	9.05
2013-14	33.62	5.59	0.40	3.04	0.00	4.678	6.76	0.25	13.96
2014-15	26.39	8.64	0.41	-1.40	0.00	3.553	3.21	0.27	11.47
Avg	25.00	8.64	0.33	-0.56	0.00	4.140	4.66	0.41	12.96

ANNEXURE – O

NARMADA BASIN

Table - O.1 Water availability at Manot

Year	Rainfall		ECII	DIL	GW flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	**2(a)**	**2(b)**	**3**	**4**	**5**	**6**	**7**	**8=3+4+5+6**
1985-86	941.17	4.56	0.45	0.01	-0.01	2.86	3.64	3.31
1986-87	962.58	4.66	0.41	0.01	0.03	2.27	3.60	2.72
1987-88	814.35	3.94	0.20	0.01	-0.01	2.54	3.92	2.74
1988-89	1094.73	5.30	0.37	0.01	0.01	2.71	3.25	3.09
1989-90	945.42	4.58	0.23	0.01	0.11	1.13	1.42	1.48
1990-91	1313.95	6.36	0.27	0.01	-0.13	3.72	4.33	3.87
1991-92	833.34	4.03	0.82	0.01	-0.05	2.74	3.27	3.51
1992-93	862.97	4.18	0.50	0.01	-0.06	1.75	2.56	2.20
1993-94	1126.30	5.45	0.32	0.01	0.08	2.67	2.85	3.07
1994-95	1505.33	7.29	0.36	0.01	0.00	6.14	5.55	6.50
1995-96	886.75	4.29	0.50	0.01	0.00	2.31	3.48	2.82
1996-97	1013.82	4.91	0.47	0.01	-0.05	2.57	2.21	2.99
1997-98	1249.23	6.05	0.21	0.01	0.09	4.11	3.86	4.41
1998-99	1077.71	5.22	0.21	0.01	-0.08	1.73	2.29	1.87
1999-00	1269.91	6.15	0.23	0.01	0.06	2.88	4.12	3.17
2000-01	693.06	3.36	0.61	0.01	-0.06	1.32	2.04	1.87
2001-02	949.28	4.60	0.69	0.01	-0.08	2.67	3.73	3.29
2002-03	909.30	4.40	0.43	0.01	-0.04	1.51	2.00	1.91
2003-04	1216.73	5.89	0.28	0.01	0.01	3.25	4.44	3.55
2004-05	1009.71	4.89	0.51	0.01	0.02	2.78	3.47	3.32
2005-06	1121.31	5.43	0.24	0.01	0.03	4.05	4.89	4.33
2006-07	1078.60	5.22	0.41	0.01	-0.03	2.01	2.90	2.40
2007-08	864.56	4.19	0.72	0.01	-0.04	0.00	1.43	0.66
2008-09	849.88	4.11	0.56	0.01	0.03	1.76	2.23	2.36
2009-10	973.45	4.71	0.57	0.01	-0.03	0.86	1.22	1.40
2010-11	935.25	4.53	0.30	0.01	0.00	1.43	2.02	1.74
2011-12	1121.96	5.43	0.46	0.01	0.11	3.48	3.88	4.06
2012-13	1166.83	5.65	0.40	0.01	-0.09	1.93	2.18	2.24
2013-14	1587.92	7.69	0.42	0.01	0.06	3.00	2.88	3.49
2014-15	1007.33	4.88	0.13	0.01	0.01	2.00	2.16	2.14
Avg	1046.09	5.06	0.41	0.01	0.00	2.47	3.06	2.89

Table - O.2 Water availability at Barmanghat

Year	Rainfall		ECII	DIL	GW flux	Res. flux	Qcalib	QObs	Res. Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10=3+4+5+6+7+9
1985-86	941.17	24.49	2.18	0.05	0.07	0.00	14.88	11.66	0.00	17.18
1986-87	962.58	25.05	2.54	0.05	-0.34	0.00	9.97	8.77	0.00	12.22
1987-88	814.35	21.19	2.11	0.05	-0.34	0.00	11.59	7.56	0.00	13.40
1988-89	1094.73	28.49	2.69	0.05	-0.20	0.00	15.16	12.87	0.00	17.69
1989-90	945.42	24.60	2.67	0.05	-0.13	0.23	7.82	4.83	0.20	10.83
1990-91	1313.95	34.19	1.91	0.05	0.18	0.66	22.20	18.20	0.23	25.23
1991-92	833.34	21.69	3.72	0.05	-0.40	-0.74	15.45	13.87	0.15	18.23
1992-93	862.97	22.46	3.24	0.05	0.01	0.26	11.64	9.79	0.19	15.39
1993-94	1126.30	29.31	2.71	0.05	0.04	0.00	14.31	11.03	0.22	17.33
1994-95	1505.33	39.17	2.77	0.05	0.61	0.39	29.00	28.47	0.24	33.07
1995-96	886.75	23.08	2.97	0.05	-0.23	-0.53	14.56	13.28	0.21	17.03
1996-97	1013.82	26.38	3.08	0.06	-0.34	-0.01	10.73	6.45	0.22	13.74
1997-98	1249.23	32.51	2.29	0.06	1.03	0.53	20.10	13.38	0.25	24.26
1998-99	1077.71	28.05	2.41	0.06	-0.55	-0.38	13.98	9.39	0.22	15.73
1999-00	1269.91	33.05	2.41	0.06	0.27	-0.15	24.87	23.11	0.19	27.64
2000-01	693.06	18.04	3.45	0.06	-0.90	0.10	9.25	7.14	0.18	12.14
2001-02	949.28	24.70	3.37	0.06	0.20	-0.10	14.77	12.48	0.21	18.51
2002-03	909.30	23.66	3.47	0.06	-0.30	0.03	9.73	9.00	0.18	13.17
2003-04	1216.73	31.66	2.30	0.06	0.00	-0.11	21.44	17.98	0.22	23.93
2004-05	1009.71	26.28	2.66	0.06	-0.43	0.05	13.90	11.17	0.29	16.54
2005-06	1121.31	29.18	2.41	0.06	0.78	0.09	23.08	21.04	0.23	26.65
2006-07	1078.60	28.07	3.61	0.07	-0.71	0.01	7.27	9.27	0.15	10.40
2007-08	864.56	22.50	4.13	0.07	-0.45	0.07	1.60	6.15	0.09	5.50
2008-09	849.88	22.12	2.41	0.07	-0.21	0.03	11.62	8.57	0.22	14.14
2009-10	973.45	25.33	3.76	0.07	0.40	0.11	6.37	5.72	0.21	10.91
2010-11	935.25	24.34	2.86	0.07	-0.12	0.16	11.25	7.79	0.20	14.41
2011-12	1121.96	29.20	2.11	0.07	0.61	-0.19	18.99	17.85	0.23	21.83
2012-13	1166.83	30.36	2.35	0.07	-0.39	0.34	13.89	10.31	0.24	16.51
2013-14	1587.92	41.32	2.03	0.08	0.81	-0.09	23.50	22.33	0.27	26.60
2014-15	1007.33	26.21	1.67	0.08	-0.13	0.02	8.27	8.88	0.12	10.02
Avg	1046.09	27.22	2.74	0.06	-0.04	0.03	14.37	12.28	0.18	17.34

Table - O.3 Water availability at Hoshangabad

Year	Rainfall		ECII	DIL	GW flux	Res. flux	Qcalib	Qobs	Res. Evap	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10=3+4+5+6+7+9
1985-86	941.17	42.01	1.84	0.02	0.31	0.74	26.31	19.48	0.13	29.35
1986-87	962.58	42.97	3.59	0.02	-0.55	-0.53	23.31	24.11	0.14	25.99
1987-88	814.35	36.35	2.94	0.02	-0.48	0.09	16.09	12.35	0.13	18.79
1988-89	1094.73	48.87	3.36	0.02	0.12	-0.03	23.35	20.56	0.13	26.95
1989-90	945.42	42.20	3.76	0.02	0.29	-0.30	15.43	12.62	0.13	19.34
1990-91	1313.95	58.65	2.89	0.03	0.31	0.30	38.32	32.53	0.14	41.99
1991-92	833.34	37.20	4.43	0.03	-0.77	-0.56	23.83	21.31	0.09	27.04
1992-93	862.97	38.52	3.78	0.03	-0.01	0.18	18.75	17.08	0.11	22.84
1993-94	1126.30	50.28	3.07	0.03	0.42	0.31	28.39	21.37	0.13	32.36
1994-95	1505.33	67.20	3.40	0.03	0.30	0.04	51.32	52.63	0.15	55.23
1995-96	886.75	39.58	3.73	0.03	0.11	-0.19	19.38	19.48	0.12	23.18
1996-97	1013.82	45.26	3.69	0.03	-0.42	0.01	18.28	11.10	0.10	21.70
1997-98	1249.23	55.76	2.44	0.03	1.09	0.58	34.01	22.98	0.14	38.29
1998-99	1077.71	48.11	2.44	0.03	-0.30	-0.25	25.02	17.08	0.13	27.07
1999-00	1269.91	56.69	2.86	0.03	0.27	-0.43	49.27	43.78	0.14	52.14
2000-01	693.06	30.94	4.54	0.03	-1.43	-0.17	16.34	10.99	0.10	19.41
2001-02	949.28	42.37	3.79	0.04	-0.08	0.26	21.97	17.11	0.12	26.09
2002-03	909.30	40.59	3.83	0.04	-0.04	0.13	18.55	17.53	0.15	22.64
2003-04	1216.73	54.31	3.12	0.04	0.40	-0.05	33.82	29.91	0.16	37.49
2004-05	1009.71	45.07	3.80	0.04	-0.69	-0.37	22.13	15.60	0.16	25.06
2005-06	1121.31	50.05	3.29	0.04	0.80	0.20	33.38	29.70	0.17	37.88
2006-07	1078.60	48.15	3.46	0.04	-0.63	0.09	17.25	20.52	0.14	20.35
2007-08	864.56	38.59	3.50	0.04	-0.70	-0.27	8.25	12.69	0.16	10.98
2008-09	849.88	37.94	3.02	0.04	-0.06	-0.09	15.32	12.34	0.17	18.41
2009-10	973.45	43.45	3.33	0.05	0.07	0.87	18.18	13.83	0.19	22.69
2010-11	935.25	41.75	3.51	0.05	-0.25	-0.61	17.14	12.87	0.15	19.99
2011-12	1121.96	50.08	3.04	0.05	0.56	-0.05	29.15	25.28	0.17	32.92
2012-13	1166.83	52.09	3.31	0.05	0.24	-0.09	27.52	21.08	0.15	31.18
2013-14	1587.92	70.88	2.85	0.05	0.15	-0.06	47.10	38.71	0.18	50.28
2014-15	1007.33	44.97	2.70	0.05	-0.30	0.33	14.20	12.49	0.10	17.08
Avg	1046.09	46.70	3.31	0.04	-0.04	0.00	25.05	21.30	0.14	28.50

Table - O.4 Water availability at Handia

Year	Rainfall		ECII	DIL	GW flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8= 3+4+5+6+7
1985-86	941.17	48.47	1.32	0.01	0.01	29.45	22.85	30.78
1986-87	962.58	49.57	1.50	0.01	-0.16	28.78	30.67	30.13
1987-88	814.35	41.94	1.72	0.01	-0.13	17.42	12.30	19.02
1988-89	1094.73	56.38	1.48	0.01	0.22	25.68	20.64	27.39
1989-90	945.42	48.69	1.73	0.01	0.08	17.47	14.61	19.28
1990-91	1313.95	67.67	1.39	0.01	0.14	43.59	34.84	45.14
1991-92	833.34	42.92	1.93	0.01	-0.24	26.07	22.33	27.77
1992-93	862.97	44.44	1.98	0.01	-0.15	20.13	19.00	21.98
1993-94	1126.30	58.00	1.41	0.01	0.37	33.62	26.03	35.41
1994-95	1505.33	77.52	1.48	0.01	-0.02	58.83	58.51	60.29
1995-96	886.75	45.67	1.40	0.01	0.06	21.09	21.02	22.56
1996-97	1013.82	52.21	1.85	0.01	-0.09	21.66	13.84	23.44
1997-98	1249.23	64.34	1.38	0.01	0.31	37.22	26.68	38.91
1998-99	1077.71	55.50	1.15	0.01	-0.22	27.99	21.14	28.93
1999-00	1269.91	65.40	1.36	0.01	-0.06	55.97	48.51	57.28
2000-01	693.06	35.69	2.14	0.01	0.01	16.35	11.93	18.51
2001-02	949.28	48.89	1.63	0.01	-0.10	24.09	18.11	25.64
2002-03	909.30	46.83	1.76	0.02	0.12	21.14	20.97	23.03
2003-04	1216.73	62.66	1.51	0.02	0.37	38.32	36.18	40.21
2004-05	1009.71	52.00	1.80	0.02	-0.39	25.86	18.55	27.29
2005-06	1121.31	57.75	1.49	0.02	0.15	36.06	31.74	37.72
2006-07	1078.60	55.55	1.62	0.02	0.14	22.80	25.64	24.58
2007-08	864.56	44.53	1.55	0.02	-0.35	10.64	16.74	11.85
2008-09	849.88	43.77	1.49	0.02	-0.19	16.77	14.91	18.09
2009-10	973.45	50.13	1.12	0.02	-0.02	21.97	18.69	23.08
2010-11	935.25	48.17	1.84	0.02	0.12	18.50	16.99	20.47
2011-12	1121.96	57.78	1.62	0.02	0.45	32.36	28.39	34.45
2012-13	1166.83	60.09	1.38	0.02	-0.26	34.39	26.49	35.54
2013-14	1587.92	81.78	1.12	0.02	0.04	53.93	44.00	55.11
2014-15	1007.33	51.88	1.81	0.02	-0.11	15.80	14.83	17.51
Avg	1046.09	53.87	1.56	0.01	0.00	28.46	24.57	30.03

Table - O.5 Water availability at Mandleshwar

Year	Rainfall		ECII	DIL	GW flux	Res. flux	Qcalib	Qobs	Res. Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10= 3+4+5+6+7+9
1985-86	941.17	67.70	1.16	0.03	-0.65	0.00	33.67	23.70	0.00	34.21
1986-87	962.58	69.24	1.52	0.03	0.58	0.00	36.78	37.69	0.00	38.91
1987-88	814.35	58.58	1.49	0.03	-0.57	0.00	19.55	15.63	0.00	20.51
1988-89	1094.73	78.74	0.38	0.03	0.66	0.00	36.11	31.64	0.00	37.18
1989-90	945.42	68.00	1.39	0.03	-0.07	0.00	23.39	19.68	0.00	24.74
1990-91	1313.95	94.51	0.71	0.03	0.27	0.00	56.98	48.60	0.00	57.99
1991-92	833.34	59.94	2.21	0.03	-0.72	0.00	29.22	25.63	0.00	30.74
1992-93	862.97	62.07	1.25	0.03	-0.12	0.00	22.35	19.27	0.00	23.51
1993-94	1126.30	81.01	0.72	0.04	0.45	0.00	43.20	35.87	0.00	44.40
1994-95	1505.33	108.28	0.94	0.04	0.00	0.00	74.03	70.23	0.00	75.00
1995-96	886.75	63.78	1.45	0.04	-0.16	0.00	23.48	24.64	0.00	24.82
1996-97	1013.82	72.92	1.56	0.04	0.15	0.00	33.59	23.87	0.00	35.35
1997-98	1249.23	89.86	1.02	0.04	0.35	0.00	45.88	33.38	0.00	47.29
1998-99	1077.71	77.52	1.33	0.04	-0.16	0.00	36.22	27.98	0.00	37.44
1999-00	1269.91	91.34	0.89	0.04	-0.23	0.00	66.30	55.95	0.00	67.00
2000-01	693.06	49.85	2.52	0.05	-1.48	0.00	18.39	12.66	0.00	19.47
2001-02	949.28	68.28	1.35	0.05	-0.32	0.00	29.21	22.93	0.00	30.28
2002-03	909.30	65.41	1.74	0.05	0.52	0.00	25.65	22.44	0.00	27.96
2003-04	1216.73	87.52	1.44	0.05	0.99	0.00	46.94	34.56	0.00	49.42
2004-05	1009.71	72.63	1.60	0.05	-0.75	0.00	34.07	19.49	0.22	35.19
2005-06	1121.31	80.65	1.96	0.06	-0.41	0.67	39.15	33.88	0.32	41.74
2006-07	1078.60	77.58	1.27	0.06	0.88	0.02	31.92	33.30	0.36	34.52
2007-08	864.56	62.19	0.39	0.06	-0.36	-0.21	18.42	24.54	0.39	18.68
2008-09	849.88	61.13	2.33	0.06	-0.53	0.29	19.38	16.21	0.43	21.95
2009-10	973.45	70.02	2.01	0.06	0.60	0.02	28.65	28.07	0.48	31.82
2010-11	935.25	67.27	2.69	0.07	0.04	0.69	24.04	28.46	0.39	27.91
2011-12	1121.96	80.70	2.13	0.07	-0.15	-0.08	44.41	44.89	0.46	46.84
2012-13	1166.83	83.93	1.89	0.07	0.03	0.07	50.08	46.01	0.41	52.55
2013-14	1587.92	114.22	1.00	0.08	0.51	0.07	71.06	65.04	0.55	73.28
2014-15	1007.33	72.46	2.69	0.08	-0.27	0.29	22.65	25.13	0.12	25.57
Avg	1046.09	75.24	1.50	0.05	-0.03	0.06	36.16	31.71	0.14	37.88

Table - O.6 Water availability at Garudeshwar

Year	Rainfall		ECII	DIL	GW flux	Res. flux	Export	Qcalib	Qobs	Res. Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10	11=3+4+5+6+7+8+10
1985-86	941.17	81.61	3.14	0.03	-0.62	0.00	0.00	33.58	23.59	0.00	36.13
1986-87	962.58	83.47	6.49	0.03	0.43	0.00	0.00	33.69	34.93	0.00	40.64
1987-88	814.35	70.62	4.71	0.03	-0.17	0.00	0.00	18.47	15.06	0.00	23.03
1988-89	1094.73	94.93	1.29	0.03	0.36	0.00	0.00	41.42	33.26	0.00	43.11
1989-90	945.42	81.98	3.03	0.03	0.07	0.00	0.00	27.52	23.45	0.00	30.65
1990-91	1313.95	113.94	1.53	0.03	-0.01	0.00	0.00	64.63	51.21	0.00	66.18
1991-92	833.34	72.26	4.39	0.03	-0.52	0.00	0.00	29.24	26.14	0.00	33.14
1992-93	862.97	74.83	3.47	0.04	0.25	0.00	0.00	21.44	20.89	0.00	25.19
1993-94	1126.30	97.67	2.36	0.04	-0.09	0.00	0.00	47.32	35.99	0.00	49.61
1994-95	1505.33	130.54	1.42	0.04	0.23	0.00	0.00	83.41	74.06	0.00	85.10
1995-96	886.75	76.90	3.40	0.04	-0.35	0.00	0.00	24.03	23.39	0.00	27.12
1996-97	1013.82	87.91	1.89	0.04	0.14	0.00	0.00	41.78	27.25	0.00	43.85
1997-98	1249.23	108.33	2.67	0.04	0.20	0.00	0.00	51.52	33.80	0.00	54.42
1998-99	1077.71	93.45	1.62	0.04	0.02	0.00	0.00	40.87	23.11	0.00	42.54
1999-00	1269.91	110.12	2.47	0.04	-0.55	0.00	0.00	68.13	49.03	0.00	70.10
2000-01	693.06	60.10	4.23	0.04	-0.35	0.00	0.00	17.15	11.49	0.00	21.07
2001-02	949.28	82.32	3.25	0.04	-0.17	0.00	0.00	31.05	23.28	0.00	34.17
2002-03	909.30	78.85	2.86	0.05	-0.42	0.00	0.00	28.18	21.02	0.00	30.66
2003-04	1216.73	105.51	1.39	0.05	0.41	0.00	0.00	53.31	30.31	0.00	55.16
2004-05	1009.71	87.56	2.49	0.05	-0.43	0.00	0.00	39.78	17.51	0.00	41.88
2005-06	1121.31	97.24	2.37	0.05	-0.08	0.07	0.00	40.86	25.68	0.07	43.34
2006-07	1078.60	93.53	1.09	0.05	0.90	0.53	2.50	39.72	32.52	0.07	44.86
2007-08	864.56	74.97	1.79	0.05	-0.10	-0.01	2.77	22.61	18.43	0.07	27.18
2008-09	849.88	73.70	2.28	0.05	-0.62	-0.09	4.99	16.63	4.49	0.06	23.31
2009-10	973.45	84.41	2.91	0.05	0.63	0.25	5.63	25.13	6.74	0.06	34.66
2010-11	935.25	81.10	2.12	0.06	-0.11	-0.13	4.73	23.61	8.30	0.07	30.35
2011-12	1121.96	97.29	2.37	0.06	-0.26	-0.08	7.64	41.29	21.74	0.06	51.07
2012-13	1166.83	101.18	2.16	0.06	-0.14	0.12	9.43	45.68	21.90	0.06	57.37
2013-14	1587.92	137.70	0.89	0.06	0.35	-0.13	9.67	72.55	49.13	0.09	83.48
2014-15	1007.33	87.35	2.37	0.06	0.24	0.53	8.39	17.20	9.07	0.00	28.78
Avg	1046.09	90.71	2.62	0.04	-0.03	0.03	1.86	38.06	26.56	0.02	42.60

Table - O.7 Water availability at Outlet to Sea

Year	Rainfall		ECII	DIL	GW flux	Res. flux	Qcalib	Res. Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+7+8
1985-86	941.17	90.97	2.48	0.03	-0.47	0.00	34.20	0.00	36.24
1986-87	962.58	93.04	3.29	0.03	-0.19	0.00	32.57	0.00	35.70
1987-88	814.35	78.71	3.87	0.03	-0.19	0.00	15.93	0.00	19.63
1988-89	1094.73	105.82	1.37	0.03	0.77	0.00	45.10	0.00	47.26
1989-90	945.42	91.38	2.58	0.03	-0.01	0.00	29.64	0.00	32.24
1990-91	1313.95	127.01	1.74	0.03	0.21	0.00	70.83	0.00	72.82
1991-92	833.34	80.55	2.89	0.03	-0.51	0.00	29.94	0.00	32.35
1992-93	862.97	83.41	1.83	0.03	0.12	0.00	22.90	0.00	24.87
1993-94	1126.30	108.87	2.15	0.03	0.13	0.00	50.36	0.00	52.67
1994-95	1505.33	145.50	1.63	0.03	0.25	0.00	91.36	0.00	93.28
1995-96	886.75	85.71	3.07	0.03	-0.32	0.00	24.89	0.00	27.67
1996-97	1013.82	98.00	1.37	0.03	-0.67	0.00	47.59	0.00	48.33
1997-98	1249.23	120.75	1.83	0.04	0.80	0.00	57.61	0.00	60.28
1998-99	1077.71	104.17	1.19	0.04	-0.45	0.00	46.69	0.00	47.47
1999-00	1269.91	122.75	2.14	0.04	-0.46	0.00	68.36	0.00	70.08
2000-01	693.06	66.99	3.03	0.04	-0.59	0.00	16.32	0.00	18.80
2001-02	949.28	91.76	2.43	0.04	0.30	0.00	33.07	0.00	35.85
2002-03	909.30	87.89	2.43	0.04	-0.29	-0.01	30.37	0.00	32.55
2003-04	1216.73	117.61	1.63	0.04	0.53	0.11	58.38	0.00	60.69
2004-05	1009.71	97.60	2.71	0.04	-0.08	-0.10	44.92	0.22	47.71
2005-06	1121.31	108.39	1.78	0.04	0.43	0.28	46.50	0.32	49.35
2006-07	1078.60	104.26	1.22	0.04	0.18	-0.08	49.14	0.36	50.87
2007-08	864.56	83.57	1.50	0.05	0.13	-0.18	30.18	0.39	32.05
2008-09	849.88	82.15	2.13	0.05	-0.04	-0.01	18.67	0.43	21.24
2009-10	973.45	94.09	3.06	0.05	-0.70	-0.01	25.63	0.48	28.50
2010-11	935.25	90.40	1.76	0.06	0.21	0.04	26.36	0.39	28.81
2011-12	1121.96	108.45	1.58	0.06	-0.16	-0.05	45.32	0.46	47.22
2012-13	1166.83	112.79	2.04	0.06	-0.17	0.02	48.44	0.41	50.80
2013-14	1587.92	153.49	1.20	0.06	0.63	0.04	80.71	0.55	83.19
2014-15	1007.33	97.37	2.25	0.06	-0.50	-0.07	19.69	0.12	21.56
Avg	1046.09	101.11	2.14	0.04	-0.04	0.00	41.39	0.14	43.67

Table - O.8 Water resources availability in Narmada basin

Year	Rainfall	Q_{Calib}	ECII	DIL	GW Flux	Res. Flux	Export from Basin	Res. Evap.	Water Availability
	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2	3	4	5	6	7	8	9	10=3+4+5+6+7+8+9
1985-86	97.13	34.20	12.57	0.17	-1.36	0.74	0.00	0.13	46.45
1986-87	100.18	32.57	19.34	0.17	-0.19	-0.53	0.00	0.14	51.50
1987-88	84.24	15.93	17.04	0.17	-1.90	0.09	0.00	0.13	31.46
1988-89	112.45	45.10	10.95	0.18	1.93	-0.03	0.00	0.13	58.26
1989-90	97.18	29.64	15.39	0.18	0.33	-0.07	0.00	0.33	45.80
1990-91	134.77	70.83	10.46	0.19	0.98	0.96	0.00	0.36	83.77
1991-92	86.17	29.94	20.39	0.19	-3.21	-1.30	0.00	0.24	46.25
1992-93	88.47	22.90	16.04	0.20	0.04	0.43	0.00	0.30	39.91
1993-94	117.20	50.36	12.74	0.20	1.39	0.31	0.00	0.35	65.35
1994-95	157.00	91.36	12.00	0.21	1.37	0.43	0.00	0.39	105.75
1995-96	90.31	24.89	16.52	0.21	-0.89	-0.72	0.00	0.33	40.35
1996-97	104.51	47.59	13.91	0.22	-1.28	0.01	0.00	0.32	60.77
1997-98	129.41	57.61	11.84	0.23	3.87	1.10	0.00	0.39	75.03
1998-99	110.98	46.69	10.33	0.23	-1.74	-0.63	0.00	0.35	55.23
1999-00	132.01	68.36	12.35	0.24	-0.69	-0.58	0.00	0.33	80.00
2000-01	71.30	16.32	20.51	0.24	-4.80	-0.07	0.00	0.28	32.48
2001-02	96.88	33.07	16.50	0.25	-0.25	0.16	0.00	0.33	50.07
2002-03	94.11	30.37	16.51	0.26	-0.45	0.15	0.00	0.34	47.18
2003-04	125.08	58.38	11.68	0.26	2.71	-0.05	0.00	0.40	73.38
2004-05	104.21	44.92	15.56	0.27	-2.76	-0.42	0.00	0.69	58.26
2005-06	117.04	46.50	13.55	0.28	1.71	1.30	0.00	0.82	64.15
2006-07	112.12	49.14	12.68	0.29	0.73	0.58	2.50	0.74	66.66
2007-08	87.68	30.18	13.56	0.29	-1.88	-0.60	2.77	0.73	45.06
2008-09	87.36	18.67	14.21	0.30	-1.61	0.14	4.99	0.90	37.59
2009-10	100.23	25.63	16.76	0.31	0.95	1.22	5.63	0.95	51.45
2010-11	96.27	26.36	15.07	0.32	-0.12	0.15	4.73	0.83	47.34
2011-12	116.66	45.32	13.30	0.33	1.16	-0.45	7.64	0.94	68.25
2012-13	122.10	48.44	13.52	0.34	-0.78	0.46	9.43	0.89	72.31
2013-14	163.69	80.71	9.52	0.35	2.56	-0.16	9.67	1.12	103.76
2014-15	103.26	19.69	13.61	0.36	-1.07	1.10	8.39	0.34	42.42
Avg.	108.00	41.39	14.28	0.25	-0.18	0.12	1.86	0.49	58.21

ANNEXURE – P

TAPI BASIN

Table - P.1 Water availability at Burhanpur

Year	Rainfall	Rainfall	Qcalib	ECII	DIL	GW Flux	Qobs	Water availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8 = 3+4+5+6
1985-86	776.90	6.97	1.18	1.04	0.06	0.00	1.55	2.27
1986-87	1095.60	9.83	5.09	0.70	0.01	-0.10	3.77	5.69
1987-88	684.00	6.14	1.50	0.90	0.01	-0.50	1.21	1.91
1988-89	1293.20	11.60	5.16	0.67	0.01	0.60	6.55	6.44
1989-90	1011.70	9.08	4.40	0.51	0.01	-0.20	3.96	4.72
1990-91	1665.00	14.94	9.14	0.80	0.01	0.00	10.58	9.95
1991-92	814.20	7.30	2.79	1.34	0.01	-0.50	2.64	3.65
1992-93	906.40	8.13	3.32	0.92	0.01	-0.40	2.89	3.85
1993-94	1333.40	11.96	5.14	0.89	0.01	0.70	6.58	6.74
1994-95	1551.90	13.92	8.69	0.66	0.01	0.00	10.30	9.36
1995-96	991.60	8.89	2.73	1.26	0.01	-0.30	3.63	3.70
1996-97	1106.50	9.93	5.43	0.39	0.01	0.10	4.90	5.93
1997-98	1150.50	10.32	4.10	0.93	0.02	0.40	5.83	5.45
1998-99	1129.50	10.13	3.91	1.05	0.02	-0.10	7.33	4.87
1999-00	1235.80	11.09	5.16	0.64	0.02	-0.10	6.69	5.72
2000-01	647.70	5.81	2.01	1.23	0.02	-1.30	1.28	1.97
2001-02	908.70	8.15	2.39	1.22	0.02	0.20	3.09	3.83
2002-03	862.90	7.74	3.03	0.40	0.02	-0.10	3.17	3.36
2003-04	975.20	8.75	2.62	1.09	0.03	0.60	3.30	4.34
2004-05	891.00	7.99	3.90	0.62	0.03	-0.70	2.36	3.85
2005-06	1031.90	9.26	3.24	0.88	0.03	0.50	3.34	4.65
2006-07	994.30	8.92	3.76	0.89	0.04	0.20	4.91	4.88
2007-08	1289.60	11.57	5.51	1.07	0.04	0.00	9.80	6.62
2008-09	769.60	6.90	1.57	1.03	0.04	-0.30	2.31	2.35
2009-10	1112.60	9.98	2.74	1.78	0.05	0.10	2.03	4.66
2010-11	979.60	8.79	3.17	0.58	0.05	0.40	3.98	4.20
2011-12	1039.30	9.32	4.51	1.18	0.06	-0.80	5.04	4.94
2012-13	1474.00	13.22	6.51	1.29	0.06	0.80	8.03	8.66
2013-14	1544.20	13.85	7.33	0.96	0.07	0.50	8.93	8.86
2014-15	1199.20	10.76	7.74	1.15	0.08	-0.10	5.19	8.86
Avg	1082.20	9.71	4.26	0.94	0.03	-0.01	4.84	5.22

Table - P.2 Water availability at Yerli

Year	Rainfall	Rainfall	Qcalib	ECII	DIL	GW Flux	Reservoir Flux	Qobs	AWA
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	696.32	11.03	1.26	2.48	0.14	0.1	0.00	1.24	3.98
1986-87	843.47	13.37	4.99	1.64	0.01	0.3	0.02	2.64	6.97
1987-88	676.95	10.73	2.49	2.08	0.01	-0.9	-0.01	0.72	3.67
1988-89	1168.85	18.52	5.17	4.25	0.02	1.7	-0.01	7.25	11.13
1989-90	756.98	12	3.52	2.55	0.02	-0.6	0.03	1.81	5.52
1990-91	1172.04	18.57	8.22	2.93	0.02	0	0.00	4.88	11.16
1991-92	624.29	9.89	1.09	3.5	0.02	-0.9	0.01	0.76	3.72
1992-93	833.36	13.21	1.22	4.86	0.02	-0.2	-0.03	1.73	5.88
1993-94	916.39	14.52	1.4	3.3	0.03	0.6	0.01	1.09	5.33
1994-95	1089.73	17.27	4.08	3.89	0.03	1.1	0.00	3.47	9.1
1995-96	744.58	11.8	1.95	3.11	0.03	-1.1	0.01	1.1	4.01
1996-97	839.24	13.3	2.19	3.55	0.03	-0.7	-0.03	0.95	5.04
1997-98	952.91	15.1	2.3	3.23	0.04	0.4	0.03	1.2	6
1998-99	966.91	15.32	1.3	3.4	0.04	1.2	0.00	3.01	5.94
1999-00	949.09	15.04	3.78	3.51	0.05	-0.2	0.02	2.25	7.15
2000-01	666.55	10.56	3.96	2.73	0.05	-1.7	-0.01	0.75	5.03
2001-02	813.18	12.89	3.04	3.89	0.06	0.4	-0.03	1.09	7.35
2002-03	883.87	14.01	2	4.8	0.06	-0.5	0.01	2.65	6.37
2003-04	815.1	12.92	0.46	4.17	0.07	-0.3	-0.01	0.5	4.39
2004-05	685.71	10.87	0.74	3.18	0.07	-1	-0.01	0.22	2.98
2005-06	912.13	14.45	2.39	4.16	0.08	0.8	0.00	1.05	7.43
2006-07	977.66	15.49	1.75	5.21	0.09	1	0.02	3.52	8.07
2007-08	961.59	15.24	5.56	3.71	0.1	0	-0.01	3.34	9.36
2008-09	567.9	9.00	1.14	2.45	0.11	-0.8	-0.02	0.37	2.88
2009-10	860.63	13.64	1.18	5.17	0.12	-0.3	-0.01	0.64	6.16
2010-11	1022.74	16.21	0.63	5.18	0.13	1.5	0.01	2.43	7.44
2011-12	801.54	12.7	2.1	4.12	0.14	-1.1	0.06	0.86	5.33
2012-13	962.63	15.25	1	5.55	0.16	0.6	-0.05	1.83	7.27
2013-14	1288.65	20.42	4.23	4.27	0.17	1.9	0.01	3.82	10.59
2014-15	954.07	15.12	2.42	4.51	0.19	-0.9	0.05	1.79	6.27
Avg	880.17	13.95	2.59	3.71	0.07	0.01	0.00	1.97	6.38

Table - P.3 Water availability at Sarangkheda

Year	Rainfall	Rainfall	Qcalib	ECII	DIL	GW Flux	Reservoir Flux	Qobs	AWA
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	699.26	38.84	4.74	10.78	0.43	-3.80	0.43	3.19	12.58
1986-87	828.75	46.03	7.85	6.58	0.04	3.80	0.04	6.86	18.31
1987-88	672.35	37.35	4.83	7.97	0.04	0.00	0.04	2.75	12.88
1988-89	1130.16	62.77	14.90	12.80	0.05	2.40	0.05	16.81	30.20
1989-90	850.84	47.26	10.26	10.86	0.05	-0.50	0.05	8.84	20.73
1990-91	1120.92	62.26	19.26	11.53	0.06	0.40	0.06	16.34	31.31
1991-92	660.77	36.70	3.65	13.12	0.06	-1.50	0.06	4.24	15.39
1992-93	832.64	46.25	3.66	12.60	0.07	0.40	0.07	5.65	16.80
1993-94	975.39	54.18	8.76	12.53	0.08	0.20	0.08	7.88	21.64
1994-95	1095.86	60.87	18.88	11.72	0.09	0.60	0.09	14.65	31.38
1995-96	726.57	40.36	2.91	12.36	0.09	-2.20	0.09	4.20	13.26
1996-97	836.50	46.46	9.40	9.99	0.10	0.20	0.10	6.40	19.79
1997-98	982.41	54.57	7.66	12.44	0.11	0.60	0.11	6.52	20.92
1998-99	1040.42	57.79	10.86	12.20	0.13	1.40	0.13	14.43	24.71
1999-00	912.20	50.67	11.02	10.31	0.13	-2.10	0.13	6.62	19.50
2000-01	592.35	32.90	4.88	11.02	0.15	-3.50	0.15	3.15	12.71
2001-02	783.33	43.51	2.44	14.82	0.17	-0.10	0.17	3.21	17.49
2002-03	855.89	47.54	7.80	12.07	0.19	0.50	0.19	8.62	20.74
2003-04	922.95	51.26	6.31	13.56	0.20	1.30	0.20	6.99	21.58
2004-05	773.94	42.99	3.95	12.34	0.22	-1.50	0.22	3.17	15.23
2005-06	868.02	48.21	5.39	12.67	0.24	0.20	0.24	5.04	18.75
2006-07	1046.81	58.15	16.93	14.53	0.26	2.70	0.26	17.49	34.69
2007-08	939.90	52.21	11.79	13.96	0.30	-1.20	0.30	11.41	25.14
2008-09	648.94	36.05	2.27	9.90	0.32	-1.20	0.32	3.44	11.61
2009-10	914.32	50.79	0.55	18.47	0.36	-0.50	0.36	3.07	19.23
2010-11	955.45	53.07	5.07	14.51	0.39	0.90	0.39	7.00	21.26
2011-12	835.10	46.39	3.41	15.82	0.43	-1.50	0.43	6.20	18.60
2012-13	983.58	54.63	7.40	14.41	0.47	-2.00	0.47	8.30	20.75
2013-14	1304.76	72.47	14.05	12.77	0.52	3.90	0.52	12.35	31.77
2014-15	951.70	52.86	5.06	17.46	0.57	-1.10	0.57	3.85	22.55
Avg	891.40	49.51	7.86	12.54	0.21	-0.11	0.21	7.62	20.71

Table - P.4 Water availablity at Ghala

Year	Rainfall	Rainfall	Qcalib	ECII	DIL	GW Flux	Reservoir Flux	Qobs	Rerservoir Evaporation	AWA
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10 = 3+4+5+6+7+9
1985-86	637.11	40.87	1.16	13.95	0.49	-0.80	0.12	3.19	0.64	15.56
1986-87	711.21	45.62	12.00	8.34	0.04	0.00	-0.39	6.86	0.69	20.68
1987-88	577.89	37.07	3.62	9.88	0.05	-0.80	1.21	2.75	0.74	14.70
1988-89	1112.81	71.39	22.86	14.05	0.06	1.30	-1.23	16.81	0.79	37.83
1989-90	881.01	56.52	9.28	14.73	0.06	-0.10	1.30	8.84	0.77	26.04
1990-91	1028.59	65.98	20.01	16.32	0.07	-0.10	-0.09	16.34	0.71	36.92
1991-92	630.69	40.46	2.74	15.79	0.07	-0.90	-0.11	4.24	0.60	18.19
1992-93	904.11	58	5.69	15.72	0.08	0.20	-0.96	5.65	1.06	21.79
1993-94	934.9	59.97	9.49	14.91	0.09	0.10	1.53	7.88	0.77	26.89
1994-95	1162.11	74.55	15.85	23.69	0.10	0.30	-0.09	14.65	0.79	40.64
1995-96	699.76	44.89	3.73	15.73	0.11	-0.60	-0.86	4.20	0.69	18.80
1996-97	894.91	57.41	5.62	11.48	0.11	0.00	-0.47	6.40	0.81	17.55
1997-98	995.57	63.87	9.55	15.39	0.13	0.30	0.67	6.52	0.82	26.86
1998-99	1054.5	67.65	15.56	13.51	0.15	0.40	0.18	14.43	0.90	30.70
1999-00	770.18	49.41	5.02	16.55	0.15	-0.50	0.05	6.62	0.99	22.26
2000-01	543.73	34.88	1.01	14.07	0.17	-1.10	0.07	3.15	0.63	14.85
2001-02	795.48	51.03	7.13	15.27	0.19	0.90	-1.60	3.21	0.72	22.61
2002-03	806.15	51.71	7.68	16.75	0.21	-0.80	0.43	8.62	0.83	25.10
2003-04	1043.19	66.92	11.05	15.54	0.23	1.00	0.92	6.99	0.85	29.59
2004-05	952.19	61.08	5.84	15.87	0.26	-0.30	0.09	3.17	0.75	22.51
2005-06	887.66	56.94	4.98	17.72	0.28	0.20	-0.84	5.04	0.98	23.32
2006-07	1231.36	78.99	24.79	17.16	0.30	0.30	1.06	17.49	0.76	44.37
2007-08	1048.92	67.29	13.37	17.07	0.34	0.10	0.07	11.41	0.79	31.74
2008-09	662.69	42.51	2.10	12.19	0.37	-0.20	-0.16	3.44	0.74	15.04
2009-10	864.62	55.47	1.54	22.26	0.41	-0.80	-0.65	3.07	0.59	23.35
2010-11	948.75	60.86	8.35	16.90	0.45	0.10	-0.55	7.00	0.78	26.03
2011-12	851.55	54.63	3.08	17.60	0.49	0.00	1.36	6.20	0.63	23.16
2012-13	821.34	52.69	7.15	15.96	0.54	-0.50	-0.48	8.30	0.64	23.31
2013-14	1339.47	85.93	17.24	20.65	0.60	0.80	0.01	12.35	1.05	40.35
2014-15	857.85	55.03	22.37	3.20	0.65	-1.00	0.43	3.85	0.86	26.51
Avg	888.34	56.99	9.33	15.28	0.24	-0.08	0.03	7.62	0.78	25.58

Table - P.5 Water resources availability in Tapi Basin (upto Ghala)

Year	Rainfall*	Qcalib	ECII	DIL	GW Flux	Res. Flux	Res. Evapo-ration	Water Avail-Ability*
	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2	3	4	5	6	7	8	9 = 3+4+5+6+7+8
1985-86	44.09	1.16	13.95	0.49	-0.80	0.12	0.64	15.56
1986-87	48.17	12.00	8.34	0.04	0.00	-0.39	0.69	20.68
1987-88	44.19	3.62	9.88	0.05	-0.80	1.21	0.74	14.70
1988-89	77.13	22.86	14.05	0.06	1.30	-1.23	0.79	37.83
1989-90	58.54	9.28	14.73	0.06	-0.10	1.30	0.77	26.04
1990-91	70.67	20.01	16.32	0.07	-0.10	-0.09	0.71	36.92
1991-92	41.90	2.74	15.79	0.07	-0.90	-0.11	0.60	18.19
1992-93	56.49	5.69	15.72	0.08	0.20	-0.96	1.06	21.79
1993-94	63.86	9.49	14.91	0.09	0.10	1.53	0.77	26.89
1994-95	77.78	15.85	23.69	0.10	0.30	-0.09	0.79	40.64
1995-96	48.07	3.73	15.73	0.11	-0.60	-0.86	0.69	18.80
1996-97	58.70	5.62	11.48	0.11	0.00	-0.47	0.81	17.55
1997-98	64.11	9.55	15.39	0.13	0.30	0.67	0.82	26.86
1998-99	72.06	15.56	13.51	0.15	0.40	0.18	0.90	30.70
1999-00	56.42	5.02	16.55	0.15	-0.50	0.05	0.99	22.26
2000-01	39.45	1.01	14.07	0.17	-1.10	0.07	0.63	14.85
2001-02	52.95	7.13	15.27	0.19	0.90	-1.60	0.72	22.61
2002-03	56.23	7.68	16.75	0.21	-0.80	0.43	0.83	25.10
2003-04	65.38	11.05	15.54	0.23	1.00	0.92	0.85	29.59
2004-05	55.97	5.84	15.87	0.26	-0.30	0.09	0.75	22.51
2005-06	57.09	4.98	17.72	0.28	0.20	-0.84	0.98	23.32
2006-07	79.27	24.79	17.16	0.30	0.30	1.06	0.76	44.37
2007-08	66.56	13.37	17.07	0.34	0.10	0.07	0.79	31.74
2008-09	45.66	2.10	12.19	0.37	-0.20	-0.16	0.74	15.04
2009-10	60.74	1.54	22.26	0.41	-0.80	-0.65	0.59	23.35
2010-11	62.70	8.35	16.90	0.45	0.10	-0.55	0.78	26.03
2011-12	52.23	3.08	17.60	0.49	0.00	1.36	0.63	23.16
2012-13	53.02	7.15	15.96	0.54	-0.50	-0.48	0.64	23.31
2013-14	82.08	17.24	20.65	0.60	0.80	0.01	1.05	40.35
2014-15	58.38	22.37	3.20	0.65	-1.00	0.43	0.86	26.51
Average	59.00	9.33	15.28	0.24	-0.08	0.03	0.78	25.58
Total for Tapi basin (Tapi river basin upto Ghala + Delta), = 25.58+0.66								26.24

**Rainfall is for whole Tapi basin (including the area after Ghala also,)*

ANNEXURE - Q

WFR FROM TAPI TO TADRI

Table - Q.1 Water availability at Durvesh

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Qobs	Reservoir Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9	10=3+4+5+6+7 +9
1985-86	2285	4.31	0.01	0.07	0.00	-	3.60	1.52	0.02	3.69
1986-87	1867	3.52	0.08	0.07	0.00	-0.05	2.65	1.68	0.02	2.82
1987-88	1716	3.24	0.06	0.07	0.00	-0.03	2.41	1.42	0.02	2.56
1988-89	2407	4.54	0.03	0.07	0.02	0.08	3.68	3.07	0.02	3.82
1989-90	1941	3.66	0.03	0.07	0.01	0.00	2.60	2.27	0.02	2.73
1990-91	2409	4.55	0.00	0.07	0.00	0.02	3.87	3.50	0.02	3.97
1991-92	2076	3.92	0.07	0.07	-0.15	-0.04	3.33	2.27	0.02	3.34
1992-93	2002	3.78	0.03	0.08	0.29	0.00	3.10	1.91	0.02	3.52
1993-94	2590	4.89	0.01	0.08	0.03	0.02	3.87	2.49	0.02	4.00
1994-95	3161	5.96	0.04	0.08	-0.01	-0.03	5.11	4.00	0.02	5.24
1995-96	1765	3.33	0.03	0.08	-0.02	-0.04	2.28	1.66	0.02	2.39
1996-97	1836	3.46	0.01	0.08	0.02	0.04	2.52	2.23	0.02	2.65
1997-98	2126	4.01	0.05	0.08	0.01	0.00	3.14	2.84	0.02	3.31
1998-99	2288	4.32	0.00	0.09	0.00	0.02	3.58	3.67	0.02	3.69
1999-00	2049	3.87	0.00	0.09	0.04	-0.02	3.68	2.67	0.01	3.82
2000-01	1822	3.44	0.07	0.09	-0.06	-0.04	2.91	2.33	0.02	3.02
2001-02	1898	3.58	0.04	0.09	0.00	0.00	2.95	3.06	0.02	3.10
2002-03	2071	3.91	0.06	0.09	-0.02	0.01	3.43	3.18	0.02	3.58
2003-04	2459	4.64	0.04	0.09	0.03	0.02	3.80	4.19	0.02	3.99
2004-05	2832	5.34	0.03	0.09	-0.03	0.01	4.66	3.99	0.02	4.77
2005-06	3277	6.18	0.03	0.10	0.00	0.01	5.17	5.34	0.02	5.31
2006-07	3147	5.94	0.03	0.10	0.02	0.00	5.21	5.04	0.02	5.38
2007-08	2337	4.41	0.04	0.10	0.11	-0.02	3.72	4.08	0.02	3.99
2008-09	2591	4.89	0.03	0.10	-0.11	-0.01	4.33	4.36	0.02	4.38
2009-10	1883	3.55	0.02	0.10	0.02	-0.01	2.51	2.08	0.02	2.66
2010-11	2658	5.02	0.00	0.10	-0.01	0.07	3.88	3.83	0.03	4.00
2011-12	1891	3.57	0.02	0.11	-0.07	-0.02	3.16	3.70	0.02	3.24
2012-13	1730	3.26	0.00	0.11	0.18	0.00	2.31	2.47	0.03	2.62
2013-14	2920	5.51	0.00	0.11	-0.12	0.01	4.75	3.75	0.03	4.77
2014-15	2566	4.84	0.06	0.11	0.00	-0.06	3.87	2.97	0.03	4.06
Avg	2286.67	4.31	0.03	0.09	0.01	0.00	3.54	3.05	0.02	3.69

Table - Q.2 Water availability at Gadat

	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Reservoir Evap.	Water Availability
Year	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3++4+5+6+8
1985-86	1265	1.86	0.30	0.005	-0.01	1.27	1.07	0.01	1.57
1986-87	1102	1.62	0.33	0.005	-0.01	0.77	0.89	0.01	1.11
1987-88	937	1.38	0.36	0.005	-0.06	0.51	0.37	0.01	0.82
1988-89	2112	3.11	0.25	0.005	0.10	2.32	2.27	0.02	2.69
1989-90	1632	2.40	0.24	0.005	0.02	1.33	1.27	0.01	1.60
1990-91	1392	2.05	0.24	0.005	-0.03	1.35	1.10	0.02	1.57
1991-92	1010	1.49	0.29	0.005	-0.04	0.64	0.94	0.01	0.91
1992-93	1639	2.41	0.20	0.005	0.03	1.53	1.39	0.01	1.78
1993-94	1615	2.38	0.23	0.005	0.01	1.99	1.70	0.02	2.25
1994-95	2591	3.81	0.22	0.006	-0.02	3.49	3.86	0.02	3.72
1995-96	1137	1.67	0.43	0.006	-0.01	0.95	0.94	0.02	1.39
1996-97	1719	2.53	0.20	0.006	0.04	1.73	1.37	0.01	1.99
1997-98	1667	2.45	0.26	0.006	-0.02	1.78	1.21	0.01	2.04
1998-99	1936	2.85	0.19	0.006	0.03	2.29	1.63	0.01	2.54
1999-00	1235	1.82	0.18	0.006	0.02	1.02	1.65	0.01	1.24
2000-01	796	1.17	0.36	0.006	-0.10	0.43	0.69	0.02	0.71
2001-02	1733	2.55	0.27	0.006	0.01	1.89	1.29	0.01	2.19
2002-03	1517	2.23	0.26	0.006	-0.01	1.56	1.06	0.01	1.82
2003-04	2322	3.42	0.23	0.007	0.03	2.63	1.58	0.01	2.92
2004-05	1792	2.64	0.22	0.007	0.02	1.79	1.60	0.01	2.05
2005-06	1504	2.21	0.23	0.007	-0.01	1.55	3.01	0.02	1.80
2006-07	2054	3.02	0.29	0.007	-0.01	2.28	2.13	0.01	2.58
2007-08	1518	2.23	0.30	0.007	0.01	1.42	1.73	0.02	1.77
2008-09	1415	2.08	0.36	0.007	-0.01	1.35	1.79	0.03	1.74
2009-10	1248	1.84	0.42	0.007	-0.03	0.80	0.70	0.02	1.22
2010-11	1484	2.18	0.32	0.007	0.06	1.20	1.20	0.01	1.60
2011-12	1353	1.99	0.28	0.007	-0.03	1.30	1.30	0.01	1.56
2012-13	1120	1.65	0.31	0.008	-0.02	0.91	0.64	0.01	1.22
2013-14	1815	2.67	0.21	0.008	0.02	1.42	2.16	0.02	1.69
2014-15	918	1.35	0.30	0.008	-0.03	0.45	1.16	0.01	0.75
Avg	1562	2.24	0.28	0.01	0.00	1.47	1.46	0.01	1.77

Table - Q.3 Water availability at Mahuwa

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8= 3+4+5+6
1985-86	921	1.57	0.32	0.003	-0.01	0.74	1.00	1.05
1986-87	909	1.55	0.38	0.004	-0.01	0.56	0.50	0.93
1987-88	806	1.37	0.44	0.004	-0.09	0.28	0.36	0.63
1988-89	1843	3.14	0.25	0.004	0.13	1.87	2.08	2.25
1989-90	1404	2.39	0.29	0.004	0.02	1.36	1.22	1.68
1990-91	1234	2.10	0.21	0.004	-0.03	1.28	1.08	1.46
1991-92	769	1.31	0.32	0.004	-0.01	0.47	0.62	0.78
1992-93	1398	2.38	0.22	0.004	0.01	1.31	0.99	1.54
1993-94	1291	2.20	0.21	0.004	0.01	1.27	1.38	1.49
1994-95	1932	3.29	0.20	0.004	-0.02	2.64	2.99	2.83
1995-96	996	1.69	0.47	0.004	-0.01	0.65	0.71	1.10
1996-97	1415	2.41	0.21	0.004	0.03	1.56	1.16	1.80
1997-98	1340	2.28	0.28	0.004	-0.02	1.45	1.03	1.72
1998-99	1567	2.67	0.19	0.004	0.03	1.70	1.53	1.92
1999-00	1028	1.75	0.20	0.005	0.02	0.69	0.78	0.91
2000-01	739	1.26	0.43	0.005	-0.09	0.31	0.38	0.66
2001-02	1277	2.17	0.30	0.005	0.01	1.48	0.87	1.79
2002-03	1291	2.20	0.30	0.005	0.00	1.20	1.12	1.50
2003-04	2021	3.44	0.24	0.005	0.03	2.43	1.69	2.71
2004-05	1489	2.53	0.24	0.005	0.01	1.50	2.00	1.75
2005-06	1225	2.08	0.20	0.005	-0.02	1.30	3.40	1.49
2006-07	1701	2.89	0.28	0.005	0.01	2.00	2.55	2.29
2007-08	1241	2.11	0.30	0.005	0.02	1.21	1.76	1.54
2008-09	1020	1.74	0.38	0.005	-0.02	0.97	2.02	1.33
2009-10	1235	2.10	0.43	0.005	-0.04	0.90	0.57	1.29
2010-11	1375	2.34	0.40	0.005	0.08	1.00	0.93	1.49
2011-12	1035	1.76	0.27	0.005	-0.04	1.07	0.86	1.31
2012-13	868	1.48	0.29	0.006	0.00	0.72	0.53	1.02
2013-14	1840	3.13	0.18	0.006	0.01	2.27	1.55	2.47
2014-15	803	1.37	0.24	0.006	-0.02	0.51	0.51	0.74
Avg	1562	2.16	0.29	0.005	0.000	1.22	1.27	1.52

Table - Q.4 Water availability of remaining area of WFR from Tapi to Tadri basin

Year	Rainfall		ECII	DIL	GW Flux	Reservoir Flux	Qcalib	Reservoir Evap.	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9= 3+4+5+6+7 +8
1985-86	2525	134.59	6.66	0.41	-0.15	0.00	94.13	1.05	102.1
1986-87	2009	107.08	8.70	0.42	0.41	0.00	66.13	0.96	76.62
1987-88	2240	119.39	8.14	0.43	-0.06	0.00	72.5	1.11	82.12
1988-89	3032	161.61	6.40	0.44	0.42	0.00	119.53	1.14	127.93
1989-90	2643	140.87	6.73	0.45	0.16	0.00	94.34	1.23	102.91
1990-91	3151	167.95	5.43	0.45	-1.08	-0.02	129.52	1.35	135.65
1991-92	2727	145.35	8.14	0.46	-0.11	0.10	107.87	0.89	117.35
1992-93	2754	146.79	6.46	0.47	-2.13	-0.11	105.01	1.15	110.85
1993-94	3162	168.54	4.89	0.48	3.49	0.02	120.38	1.51	130.77
1994-95	3503	186.71	5.69	0.49	1.03	-0.01	145.66	1.29	154.15
1995-96	2417	128.83	7.94	0.50	0.35	0.17	82.03	1.22	92.21
1996-97	2607	138.96	5.62	0.51	-0.35	-0.16	95.08	1.17	101.87
1997-98	2891	154.09	7.44	0.52	0.32	0.13	110.62	1.15	120.18
1998-99	2922	155.75	4.19	0.53	0.58	-0.13	106.15	1.38	112.7
1999-00	2724	145.19	5.16	0.54	0.55	0.16	98.95	1.35	106.71
2000-01	2439	130.00	8.15	0.55	-1.32	-0.18	88.91	1.18	97.29
2001-02	2223	118.49	7.80	0.56	-0.32	0.11	77.31	1.05	86.51
2002-03	2303	122.75	8.11	0.57	-0.47	-0.13	78.76	1.04	87.88
2003-04	2719	144.93	7.34	0.57	0.74	0.13	95.81	1.16	105.75
2004-05	2679	142.79	7.47	0.58	-0.36	-0.15	100.11	1.04	108.69
2005-06	3383	180.32	6.69	0.59	1.24	0.33	117.47	1.52	127.84
2006-07	3283	174.99	6.13	0.60	-0.81	-0.18	121.85	1.30	128.89
2007-08	3223	171.79	6.43	0.61	0.29	-0.23	113.71	1.29	122.1
2008-09	2860	152.44	7.54	0.62	-0.63	0.19	104.72	1.38	113.82
2009-10	2604	138.80	7.71	0.63	0.02	-0.12	90.65	1.54	100.43
2010-11	3019	160.92	5.71	0.64	0.23	0.06	110.75	1.62	119.01
2011-12	3215	171.36	6.96	0.65	-0.87	-0.05	128.2	1.46	136.35
2012-13	2621	139.70	6.04	0.66	0.74	-0.02	93.67	1.68	102.77
2013-14	3212	171.20	4.78	0.67	0.08	0.06	126.37	1.65	133.61
2014-15	2603	138.74	5.89	0.68	-0.14	-0.07	89.58	0.89	96.83
Avg	2789.77	148.70	6.68	0.54	0.06	0.00	102.86	1.26	111.40

Table - Q.5 Water resources availability in WFR from Tapi to Tadri basin

Year	Rainfall	Qcalib	ECII	DIL	GW Flux	Reservoir Flux	Reservoir Evap.	Water Availability
	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2	3	4	5	6	7	8	9=4+5+6+7+8
1985-86	145.80	99.75	7.28	0.50	-0.20	0.00	1.08	108.41
1986-87	116.74	70.07	9.50	0.51	0.41	-0.05	0.98	81.42
1987-88	127.05	75.69	9.00	0.52	-0.21	-0.03	1.14	86.11
1988-89	177.27	127.38	6.93	0.53	0.68	0.08	1.17	136.77
1989-90	151.67	99.6	7.28	0.54	0.22	0.00	1.26	108.9
1990-91	181.94	136	5.88	0.55	-1.14	0.01	1.38	142.68
1991-92	156.82	112.32	8.82	0.56	-0.34	0.05	0.92	122.33
1992-93	159.79	110.69	6.92	0.57	-1.57	-0.11	1.18	117.68
1993-94	183.39	127.46	5.33	0.58	3.57	0.04	1.55	138.53
1994-95	207.44	157.1	6.16	0.59	0.95	-0.03	1.33	166.10
1995-96	136.52	85.8	8.87	0.60	0.39	0.13	1.25	97.04
1996-97	149.74	100.96	6.04	0.61	-0.34	-0.13	1.20	108.34
1997-98	168.59	116.91	8.02	0.62	0.37	0.13	1.19	127.24
1998-99	169.86	113.66	4.58	0.64	0.67	-0.11	1.41	120.85
1999-00	155.49	104.32	5.54	0.65	0.64	0.14	1.38	112.67
2000-01	138.85	92.63	9.01	0.66	-1.66	-0.22	1.21	101.63
2001-02	129.62	83.6	8.40	0.67	-0.29	0.10	1.09	93.57
2002-03	132.98	84.95	8.73	0.68	-0.54	-0.12	1.07	94.77
2003-04	157.89	104.6	7.86	0.69	0.89	0.16	1.19	115.39
2004-05	155.91	108.09	7.95	0.70	-0.41	-0.15	1.07	117.25
2005-06	194.33	125.42	7.16	0.72	1.27	0.33	1.55	136.45
2006-07	192.90	131.34	6.72	0.73	-0.80	-0.18	1.34	139.15
2007-08	183.72	120.04	7.07	0.74	0.44	-0.25	1.33	129.37
2008-09	164.50	111.36	8.30	0.75	-0.77	0.18	1.42	121.24
2009-10	150.02	94.82	8.58	0.76	-0.02	-0.12	1.58	105.6
2010-11	172.85	116.83	6.44	0.78	0.35	0.14	1.67	126.21
2011-12	183.41	133.73	7.52	0.79	-1.02	-0.07	1.50	142.45
2012-13	150.21	97.61	6.65	0.80	0.87	-0.02	1.72	107.63
2013-14	185.69	134.56	5.17	0.81	0.04	0.27	1.69	142.54
2014-15	148.99	94.05	6.49	0.82	-0.21	0.23	0.94	102.32
Avg	161.00	109.05	7.27	0.66	0.07	0.012	1.29	118.35

TADRI TO KANYAKUMARI BASIN

Table - R.1 Water availability at Adoor

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8 = 3+4+5+6
1985-86	2610	1.8	0.04	0.01	-0.02	1.4	-	1.43
1986-87	2907	2.01	0.03	0.01	0.02	1.57	-	1.63
1987-88	2336	1.61	0.03	0.01	-0.04	1.22	-	1.22
1988-89	4846	3.34	0.01	0.01	0.05	2.98	-	3.05
1989-90	3863	2.67	0.04	0.01	-0.02	2.98	-	2.32
1990-91	3573	2.47	0.03	0.01	0.01	2.02	-	2.07
1991-92	3579	2.47	0.05	0.01	0.01	2.06	-	2.13
1992-93	5901	4.07	0.02	0.01	0.08	3.59	-	3.70
1993-94	3493	2.41	0.04	0.01	0.00	2.00	-	2.05
1994-95	5345	3.69	0.02	0.01	-0.02	3.19	-	3.20
1995-96	3629	2.50	0.04	0.01	-0.10	2.19	-	2.14
1996-97	3607	2.49	0.04	0.01	0.01	2.06	-	2.12
1997-98	4479	3.09	0.05	0.01	0.16	2.46	-	2.68
1998-99	3364	2.32	0.03	0.01	0.04	1.82	-	1.9
1999-00	3963	2.73	0.04	0.01	-0.06	2.33	-	2.32
2000-01	3386	2.34	0.04	0.01	-0.02	1.92	-	1.95
2001-02	3454	2.38	0.04	0.01	-0.01	1.96	-	2.00
2002-03	2692	1.86	0.03	0.01	-0.01	1.47	-	1.50
2003-04	3226	2.23	0.04	0.01	0.08	1.73	-	1.86
2004-05	2795	1.93	0.04	0.01	-0.06	1.58	-	1.57
2005-06	2807	1.94	0.03	0.01	0.12	1.4	-	1.56
2006-07	4166	2.87	0.03	0.01	-0.13	2.62	-	2.53
2007-08	4334	2.99	0.03	0.01	0.11	2.51	-	2.66
2008-09	2860	1.97	0.04	0.01	-0.06	1.64	2.02	1.63
2009-10	3931	2.71	0.06	0.01	0.03	2.09	2.53	2.19
2010-11	4068	2.81	0.04	0.01	0.06	2.26	2.68	2.37
2011-12	5469	3.77	0.03	0.01	-0.12	3.47	2.72	3.39
2012-13	4479	3.09	0.04	0.01	-0.08	2.75	1.88	2.72
2013-14	5183	3.58	0.04	0.01	0.07	3.07	2.52	3.19
2014-15	4487	3.10	0.03	0.01	0.04	2.61	2.02	2.69
Average	3841	2.64	0.04	0.01	0.00	2.21	2.31	2.26

Table - R.2 Water availability at Bantwal

Year	Rainfall		ECII	DIL	GW Flux	QCalib	QObs	Water Availabilty
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	**2(a)**	**2(b)**	**3**	**4**	**5**	**6**	**7**	**8 = 3+4+5+6**
1985-86	2912	9.32	0.23	0.01	0.08	7.25	9.47	7.57
1986-87	3140	10.05	0.18	0.01	0.03	8.05	9.73	8.27
1987-88	2501	8.01	0.00	0.01	-0.03	5.96	6.69	5.94
1988-89	3120	9.99	0.08	0.01	0.05	8.17	9.17	8.31
1989-90	3386	10.84	0.20	0.01	-0.06	8.91	9.48	9.06
1990-91	3618	11.58	0.15	0.01	0.03	9.27	12.40	9.46
1991-92	3386	10.84	0.20	0.01	0.03	8.67	11.09	8.91
1992-93	3944	12.63	0.13	0.01	0.13	10.25	12.67	10.52
1993-94	3276	10.49	0.13	0.01	-0.01	8.47	9.57	8.60
1994-95	4609	14.76	0.10	0.01	-0.02	12.17	15.07	12.26
1995-96	3374	10.80	0.20	0.01	-0.16	8.86	9.99	8.91
1996-97	3395	10.87	0.17	0.01	0.03	8.62	10.05	8.83
1997-98	3911	12.52	0.25	0.01	0.20	9.91	12.07	10.37
1998-99	3944	12.63	0.14	0.01	0.06	10.29	12.48	10.50
1999-00	3459	11.08	0.19	0.01	-0.08	8.94	10.94	9.06
2000-01	3168	10.14	0.17	0.01	0.00	8.01	9.25	8.19
2001-02	3941	12.62	0.18	0.01	-0.04	10.25	8.60	10.40
2002-03	2442	7.82	0.18	0.01	0.00	5.97	6.40	6.16
2003-04	3078	9.86	0.13	0.01	0.08	7.72	7.63	7.94
2004-05	2830	9.06	0.17	0.01	-0.05	7.05	8.75	7.18
2005-06	2160	6.92	0.13	0.01	0.17	4.61	12.31	4.92
2006-07	3806	12.19	0.17	0.01	-0.16	10.23	13.64	10.25
2007-08	4374	14.01	0.05	0.01	0.13	11.43	14.91	11.62
2008-09	3568	11.42	0.13	0.01	-0.07	9.45	10.98	9.52
2009-10	4111	13.16	0.27	0.01	0.04	10.14	11.91	10.46
2010-11	3346	10.71	0.2	0.01	0.08	7.91	11.97	8.20
2011-12	3009	9.63	0.06	0.01	-0.15	7.55	12.12	7.47
2012-13	2610	8.36	0.16	0.01	-0.13	6.15	9.29	6.19
2013-14	4148	13.28	0.15	0.01	0.08	11.13	13.17	11.37
2014-15	3715	11.90	0.06	0.01	0.06	9.42	10.87	9.55
Average	3423	10.92	0.15	0.01	0.01	8.69	10.76	8.86

Table - R.3 Water availability at Perumannu

Year	Rainfall		ECII	DIL	GW Flux	QCalib	QObs	Water Availabilty
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8 = 3+4+5+6
1985-86	2478	2.53	0.19	0.01	0	1.47	3.96	1.67
1986-87	2694	2.75	0.18	0.01	0.01	1.72	2.8	1.92
1987-88	1957	1.99	0.13	0.01	0.03	1.04	1.9	1.21
1988-89	2523	2.57	0.12	0.01	0	1.67	3.06	1.8
1989-90	2902	2.96	0.17	0.01	0.03	1.92	3.08	2.13
1990-91	2905	2.96	0.13	0.01	0.02	1.85	3.69	2.01
1991-92	3215	3.28	0.16	0.01	0.02	2.25	3.62	2.44
1992-93	4048	4.12	0.14	0.01	0.06	2.82	4.74	3.03
1993-94	2771	2.82	0.08	0.01	-0.01	2.03	3.35	2.11
1994-95	3990	4.07	0.15	0.01	-0.02	2.78	6.06	2.92
1995-96	2653	2.7	0.17	0.01	-0.05	1.65	3.26	1.78
1996-97	2837	2.89	0.14	0.01	0.03	1.79	3.56	1.97
1997-98	3406	3.47	0.18	0.01	0.03	2.19	4.16	2.41
1998-99	3256	3.32	0.16	0.01	-0.01	2.09	4.31	2.25
1999-00	2577	2.63	0.17	0.01	-0.02	1.59	3.96	1.75
2000-01	2905	2.96	0.12	0.01	0.01	1.78	2.91	1.92
2001-02	2317	2.36	0.15	0.01	-0.01	1.32	3.03	1.47
2002-03	2387	2.43	0.15	0.01	-0.01	1.45	2.97	1.6
2003-04	2541	2.59	0.09	0.01	0.02	1.67	2.6	1.79
2004-05	1872	1.91	0.17	0.01	-0.02	1.12	3.65	1.28
2005-06	2532	2.58	0.11	0.01	0.09	1.62	4.84	1.83
2006-07	3394	3.46	0.22	0.01	-0.07	2.6	4.74	2.76
2007-08	3201	3.26	0.04	0.01	0.07	2.11	5.52	2.23
2008-09	2939	2.99	0.11	0.01	-0.06	2.22	3.09	2.28
2009-10	2970	3.03	0.27	0.01	0.01	1.84	3.6	2.13
2010-11	2396	2.44	0.18	0.01	0.04	1.36	3.25	1.59
2011-12	3260	3.32	0.26	0.01	-0.08	2.5	4.06	2.69
2012-13	2780	2.83	0.15	0.01	-0.01	2.01	2.89	2.16
2013-14	2997	3.05	0.14	0.01	0.02	2	5.37	2.17
2014-15	2800	2.85	0.03	0.01	0.03	1.91	4.65	1.98
Average	2807	2.90	0.15	0.01	0.01	1.88	3.76	2.05

Table - R.4 Water availability at Kuniyil

Year	Rainfall		ECII	DIL	GW Flux	QCalib	QObs	Water Availaility
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8 = 3+4+5+6
1985-86	1938	3.86	0.26	0.03	-0.04	2.65	3.44	2.90
1986-87	2273	4.53	0.22	0.03	-0.02	3.35	3.36	3.58
1987-88	1914	3.81	0.25	0.03	0.05	2.54	2.15	2.87
1988-89	1632	3.25	0.03	0.03	-0.05	2.53	4.06	2.54
1989-90	1775	3.54	0.23	0.03	0.08	2.37	3.4	2.71
1990-91	1824	3.63	0.21	0.03	0.07	2.45	3.26	2.76
1991-92	2380	4.74	0.17	0.03	0.07	3.01	4.31	3.28
1992-93	1959	3.9	0.22	0.03	0.02	2.66	5.53	2.93
1993-94	2367	4.72	0.07	0.03	0.01	3.15	3.94	3.26
1994-95	3027	6.03	0.26	0.03	-0.03	4.20	6.78	4.46
1995-96	2317	4.62	0.15	0.03	0.02	3.56	3.84	3.76
1996-97	2274	4.53	0.21	0.03	0.01	3.41	3.93	3.66
1997-98	3052	6.08	0.28	0.03	0.00	4.20	4.61	4.51
1998-99	3001	5.98	0.19	0.03	0.00	4.20	5.77	4.42
1999-00	2227	4.44	0.21	0.04	-0.01	3.28	4.84	3.52
2000-01	2568	5.12	0.16	0.03	0.03	3.55	3.4	3.77
2001-02	2053	4.09	0.21	0.04	-0.07	2.72	3.62	2.9
2002-03	1747	3.48	0.24	0.04	0.04	2.05	2.1	2.37
2003-04	2088	4.16	0.14	0.03	-0.01	2.78	2.12	2.94
2004-05	2291	4.56	0.13	0.03	0.00	3.03	3.81	3.19
2005-06	1771	3.53	0.12	0.03	0.02	2.32	6.16	2.49
2006-07	2090	4.16	0.21	0.03	-0.01	2.93	5.11	3.16
2007-08	2851	5.68	0.16	0.03	0.06	4.47	6.98	4.72
2008-09	1834	3.65	0.13	0.03	-0.07	2.86	3.18	2.95
2009-10	2470	4.92	0.2	0.04	0.00	3.77	4.48	4.01
2010-11	2505	4.99	0.19	0.03	0.07	3.6	3.87	3.89
2011-12	2465	4.91	0.26	0.04	-0.12	3.5	5.09	3.68
2012-13	1987	3.96	0.17	0.04	-0.01	2.33	2.82	2.53
2013-14	2826	5.63	0.18	0.03	0.02	4.32	5.81	4.55
2014-15	3140	6.25	0.05	0.04	0.03	4.65	4.62	4.77

Table - R.5 Water availability at Kumbidi

Year	Rainfall		ECII	DIL	GW Flux	Res Flux	QCalib	QObs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	1324	7.66	1.02	0.07	-0.06	-0.01	3.66	3.97	4.68
1986-87	1362	7.88	0.59	0.07	-0.09	0.01	4.33	3.56	4.91
1987-88	1532	8.86	0.80	0.07	0.18	-0.02	4.56	2.69	5.59
1988-89	1328	7.68	0.29	0.08	-0.15	0.05	4.00	4.33	4.27
1989-90	1602	9.26	0.82	0.07	0.08	-0.03	4.85	4.12	5.79
1990-91	1422	8.22	1.01	0.07	-0.09	0.01	4.05	3.81	5.05
1991-92	1820	10.53	1.07	0.07	-0.04	0.01	5.95	5.52	7.06
1992-93	1909	11.04	0.88	0.08	0.16	0.01	6.37	6.04	7.50
1993-94	1544	8.93	0.44	0.08	0.05	0.01	5.65	3.68	6.23
1994-95	2119	12.25	1.00	0.08	0.03	0.06	6.53	8.91	7.70
1995-96	1751	10.13	0.82	0.08	-0.12	-0.04	5.53	4.73	6.27
1996-97	1576	9.11	0.92	0.08	0.07	-0.03	4.58	3.84	5.62
1997-98	2159	12.49	1.02	0.08	0.09	0.02	7.36	4.04	8.57
1998-99	2265	13.10	0.8	0.08	-0.04	-0.02	8.26	5.44	9.08
1999-00	1688	9.76	0.91	0.08	0.01	0.05	5.5	3.6	6.55
2000-01	1687	9.76	0.79	0.08	-0.06	-0.04	5.12	2.64	5.89
2001-02	1396	8.07	1.05	0.08	-0.1	-0.01	3.81	4.22	4.83
2002-03	1165	6.74	0.55	0.09	-0.02	0.01	3.43	2.76	4.06
2003-04	1255	7.26	0.67	0.08	-0.14	-0.02	3.77	2.13	4.36
2004-05	1654	9.57	0.38	0.08	0.19	0.02	5.45	3.90	6.12
2005-06	1430	8.27	0.42	0.08	0.14	0.00	4.78	5.57	5.42
2006-07	2081	12.03	0.70	0.08	-0.05	0.09	7.39	6.08	8.21
2007-08	2170	12.55	0.77	0.08	0.16	-0.01	8.00	8.38	9.00
2008-09	1548	8.95	0.82	0.08	-0.19	0.03	4.70	2.83	5.44
2009-10	1992	11.52	1.10	0.08	-0.02	-0.06	6.18	4.91	7.28
2010-11	1996	11.54	0.77	0.08	0.15	0.06	6.13	5.09	7.19
2011-12	2195	12.69	0.90	0.08	-0.10	0.02	8.03	5.73	8.93
2012-13	1606	9.29	0.84	0.09	-0.15	-0.06	5.10	2.24	5.82
2013-14	2169	12.54	1.13	0.08	-0.01	-0.08	7.78	6.01	8.90
2014-15	2352	13.60	0.57	0.09	0.25	0.06	8.59	6.34	9.56
Average	1823	10.04	0.80	0.08	0.00	0.00	5.65	4.57	6.53

Table - R.6 Water availability at Neeleshwaram

Year	Rainfall		ECII	DIL	GW Flux	Res Flux	Qcalib	Qobs	Water Availabilty
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	2562	10.33	0.17	0.02	-0.04	0.05	6.29	6.57	6.49
1986-87	2027	8.17	0.14	0.02	-0.06	-0.18	4.65	5.63	4.57
1987-88	1992	8.03	0.15	0.02	0.20	-0.07	4.21	4.85	4.51
1988-89	2226	8.98	0.17	0.02	-0.11	-0.46	5.34	5.56	4.96
1989-90	2172	8.76	0.17	0.02	0.08	-0.11	4.50	7.63	4.66
1990-91	2234	9.01	0.17	0.02	-0.04	0.65	4.81	6.18	5.61
1991-92	2757	11.12	0.02	0.02	-0.09	-0.38	6.65	9.94	6.22
1992-93	2849	11.49	0.14	0.02	0.11	-0.38	8.23	8.14	8.12
1993-94	2419	9.76	0.13	0.02	0.00	0.50	4.38	6.36	5.03
1994-95	2892	11.66	0.14	0.02	0.05	0.38	7.12	4.72	7.71
1995-96	2153	8.68	0.16	0.02	-0.10	0.06	5.39	6.70	5.53
1996-97	2098	8.46	0.17	0.02	0.06	-0.35	5.73	6.05	5.63
1997-98	2578	10.4	0.23	0.02	0.04	-0.13	7.09	6.60	7.25
1998-99	3297	13.3	0.13	0.02	0.00	0.28	9.18	8.76	9.61
1999-00	2606	10.51	0.10	0.02	0.02	0.14	6.84	5.76	7.12
2000-01	2642	10.66	0.10	0.02	-0.07	0.30	6.89	6.26	7.24
2001-02	1952	7.87	0.16	0.02	-0.04	-0.13	4.96	6.89	4.97
2002-03	1498	6.04	0.17	0.03	-0.01	-0.23	3.29	5.31	3.25
2003-04	1748	7.05	0.11	0.02	-0.10	-0.05	4.45	4.66	4.43
2004-05	2459	9.92	0.10	0.02	0.16	0.32	6.27	6.62	6.87
2005-06	1906	7.69	0.02	0.02	0.05	-0.18	4.94	9.31	4.85
2006-07	2368	9.55	0.14	0.02	-0.03	0.28	6.15	7.02	6.56
2007-08	3307	13.34	0.10	0.02	0.14	-0.08	9.40	10.04	9.58
2008-09	2196	8.86	0.13	0.02	-0.11	0.07	5.98	5.60	6.09
2009-10	2763	11.14	0.04	0.02	-0.05	-0.21	6.44	6.68	6.24
2010-11	2620	10.57	0.20	0.02	0.08	0.04	5.62	7.51	5.96
2011-12	2276	9.18	0.23	0.02	-0.02	0.05	5.09	7.47	5.37
2012-13	1594	6.43	0.16	0.03	-0.11	-0.05	3.41	3.95	3.44
2013-14	2840	11.45	0.10	0.02	0.04	-0.01	7.01	9.39	7.16
2014-15	2903	11.71	0.07	0.03	0.15	0.19	7.32	8.03	7.76
Average	2420	9.67	0.13	0.02	0.01	0.01	5.92	6.81	6.09

Table - R.7 Water availability at Malakkara

Year	Rainfall		ECII	DIL	GW Flux	Res Flux	QCalib	QObs	Water Availabilty
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	1746	2.83	0.10	0.01	-0.02	-	1.4	3.65	1.49
1986-87	1334	2.16	0.08	0.01	-0.05	-	1.1	3.12	1.14
1987-88	1434	2.32	0.08	0.01	0.13	-	1.01	3.15	1.23
1988-89	1497	2.43	0.08	0.01	-0.04	-	1.24	3.64	1.29
1989-90	1800	2.92	0.10	0.01	0.07	-	1.37	4.35	1.55
1990-91	2470	4.00	0.11	0.01	-0.01	-	2.26	3.29	2.37
1991-92	3057	4.95	0.06	0.01	-0.11	-	3.35	4.05	3.31
1992-93	3494	5.66	0.08	0.01	0.08	-	3.78	5.40	3.95
1993-94	3284	5.32	0.08	0.01	-0.02	-	3.28	4.30	3.35
1994-95	3565	5.78	0.08	0.01	0.02	0.04	3.22	2.03	3.37
1995-96	2690	4.36	0.08	0.01	-0.05	-0.38	2.86	4.23	2.52
1996-97	3274	5.30	0.07	0.01	0.04	0.04	3.19	3.78	3.35
1997-98	3387	5.49	0.12	0.01	0.02	0.02	3.39	3.66	3.56
1998-99	4634	7.51	0.05	0.01	0.00	0.06	5.20	5.29	5.32
1999-00	2888	4.68	0.07	0.01	0.01	-0.1	2.97	3.71	2.96
2000-01	2640	4.28	0.08	0.01	-0.04	0.01	2.44	3.45	2.50
2001-02	3223	5.22	0.08	0.01	-0.02	-0.02	3.23	3.59	3.28
2002-03	2533	4.10	0.03	0.01	0.01	0.00	2.11	1.96	2.16
2003-04	3277	5.31	0.04	0.01	0.06	0.00	3.25	2.43	3.36
2004-05	3063	4.96	0.06	0.01	0.09	-0.04	3.20	3.42	3.32
2005-06	2337	3.79	0.08	0.01	0.02	0.10	2.03	5.10	2.24
2006-07	3207	5.20	0.07	0.01	-0.01	-0.09	3.50	4.25	3.48
2007-08	4378	7.09	0.03	0.01	0.08	0.12	4.40	4.52	4.64
2008-09	3057	4.95	0.05	0.01	-0.07	0.07	3.29	2.23	3.35
2009-10	3258	5.28	0.05	0.01	-0.02	-0.11	3.40	3.29	3.33
2010-11	3487	5.65	0.06	0.01	0.02	-0.01	3.87	4.58	3.95
2011-12	2563	4.15	0.10	0.01	0.01	-0.02	2.10	3.58	2.20
2012-13	1686	2.73	0.07	0.01	-0.06	-0.03	1.18	1.72	1.17
2013-14	3916	6.34	0.04	0.01	0.05	-0.02	3.60	4.58	3.68
2014-15	3554	5.76	0.02	0.01	0.05	0.08	3.11	4.04	3.27
Average	3172	4.68	0.07	0.01	0.01	-0.01	2.81	3.68	2.89

Table - R.8 Water availability at Pattazhy

Year	Rainfall		ECII	DIL	GW Flux	Res Flux	QCalib	QObs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	1708.05	1.94	0.1	0.01	-0.01	0.05	0.87	1.3	1.02
1986-87	1137.26	1.29	0.08	0.01	-0.08	0.05	0.52	0.9	0.58
1987-88	1457.33	1.66	0.06	0.01	0.11	0.05	0.65	1.46	0.88
1988-89	1416.32	1.61	0.07	0.01	-0.04	0.12	0.69	1.39	0.85
1989-90	1783.41	2.03	0.12	0.01	0.07	-0.01	0.88	1.89	1.07
1990-91	2136.49	2.43	0.06	0.01	-0.02	0.06	1.34	1.51	1.45
1991-92	2703.62	3.08	0.15	0.01	-0.05	0.02	2.23	1.93	2.36
1992-93	3055.7	3.48	0.06	0.01	0.05	0.02	2.22	2.84	2.36
1993-94	2747.63	3.13	0.01	0.02	0.01	0.02	1.95	1.53	2.01
1994-95	2912.67	3.31	0.02	0.02	0.00	0.01	1.85	2.04	1.9
1995-96	2325.53	2.65	0.09	0.02	-0.05	-0.24	1.57	1.46	1.39
1996-97	2354.54	2.68	0.08	0.02	0.02	-0.05	1.39	1.19	1.46
1997-98	2956.68	3.36	0.13	0.02	0.02	0.01	1.68	1.21	1.86
1998-99	3440.79	3.92	0.05	0.02	0.04	0.04	2.18	2.05	2.33
1999-00	2765.63	3.15	0.07	0.02	-0.03	0.10	1.87	1.71	2.03
2000-01	2447.56	2.79	0.07	0.02	-0.02	-0.07	1.52	1.37	1.52
2001-02	2319.53	2.64	0.08	0.03	-0.01	-0.01	1.43	1.3	1.52
2002-03	2099.48	2.39	0.03	0.03	0.00	0.01	1.28	0.99	1.35
2003-04	2346.54	2.67	0.04	0.02	-0.03	-0.02	1.62	0.77	1.63
2004-05	2296.52	2.61	0.05	0.02	0.07	0.01	1.41	0.98	1.56
2005-06	1643.38	1.87	0.06	0.02	0.01	0.00	0.9	1.13	0.99
2006-07	3085.7	3.51	0.08	0.02	0.00	0.03	2.22	0.94	2.35
2007-08	3103.71	3.53	0.01	0.02	0.06	0.00	2.28	0.99	2.37
2008-09	2301.53	2.62	0.07	0.02	-0.06	0.05	1.26	0.54	1.34
2009-10	2240.51	2.55	0.10	0.02	0.00	-0.04	1.24	1.11	1.32
2010-11	2955.68	3.36	0.04	0.02	0.01	0.01	1.76	2.47	1.84
2011-12	2274.52	2.59	0.11	0.03	0.01	0.00	1.20	1.42	1.35
2012-13	1558.36	1.77	0.10	0.03	-0.08	-0.01	0.90	0.56	0.94
2013-14	2693.62	3.07	0.08	0.03	0.05	-0.06	1.95	1.73	2.05
2014-15	2530.58	2.88	0.02	0.03	0.06	0.02	1.52	1.69	1.65
Average	2503	2.69	0.07	0.02	0.00	0.01	1.48	1.41	1.58

Table - R.9 Water availability in Ungauged catchment

Year	Rainfall		ECII	DIL	GW Flux	Res. Flux	Qcalib	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8=3+4+5+6+7
1985-86	2662	92.49	4.93	0.58	-0.03	-0.03	66.06	71.51
1986-87	2553	88.70	4.17	0.58	-0.02	-0.01	63.94	68.66
1987-88	2408	83.66	4.00	0.58	-0.06	0.02	59.97	64.51
1988-89	2713	94.26	0.24	0.58	-0.01	0.03	71.58	72.42
1989-90	2973	103.29	4.70	0.58	0.05	0.51	76.46	82.30
1990-91	2966	103.05	4.29	0.58	-0.02	-0.48	78.35	82.72
1991-92	3293	114.41	4.44	0.58	-0.02	0.68	93.51	99.19
1992-93	3521	122.33	4.14	0.58	0.09	0.68	94.74	100.23
1993-94	3052	106.04	0.95	0.58	0.01	0.48	85.87	87.89
1994-95	3945	137.06	2.00	0.59	-0.03	-0.50	104.54	106.60
1995-96	2872	99.78	4.52	0.59	-0.03	-0.20	73.35	78.23
1996-97	2864	99.50	4.15	0.59	0.01	-0.47	73.84	78.12
1997-98	3535	122.82	5.48	0.59	0.07	0.02	91.96	98.12
1998-99	3812	132.44	3.80	0.60	0.01	0.13	103.36	107.90
1999-00	3057	106.21	4.29	0.60	-0.01	0.43	78.8	84.11
2000-01	2946	102.35	3.93	0.65	-0.01	-0.53	75.45	79.49
2001-02	2892	100.48	4.10	0.66	-0.03	0.07	72.84	77.64
2002-03	2400	83.38	3.30	0.61	-0.02	-0.27	59.30	62.92
2003-04	2873	99.82	3.40	0.58	-0.01	-0.08	75.49	79.38
2004-05	2645	91.90	3.53	0.59	0.02	0.33	67.17	71.64
2005-06	2384	82.83	2.65	0.59	0.06	0.00	63.07	66.37
2006-07	3367	116.98	3.76	0.59	-0.05	0.66	90.88	95.84
2007-08	3780	131.33	0.54	0.60	0.10	-0.50	103.12	103.86
2008-09	2798	97.21	3.54	0.60	-0.07	0.11	70.00	74.18
2009-10	3252	112.98	4.39	0.60	0.01	-0.18	85.51	90.33
2010-11	3405	118.30	4.04	0.65	0.04	0.16	83.71	88.60
2011-12	3300	114.65	5.95	0.66	-0.05	0.28	79.84	86.68
2012-13	2679	93.08	3.88	0.61	-0.08	-0.15	63.88	68.14
2013-14	3739	129.90	3.96	0.65	0.05	-0.24	97.45	101.87
2014-15	3431	119.20	1.77	0.61	0.04	0.14	90.77	93.33
Average	3128	106.68	3.63	0.60	0.00	0.04	79.83	84.09

Table - R.10 Water resources availability in WFR from Tadri to Kanyakumari basin

Year	Rainfall	ECII	DIL	GW Flux	Res Flux	Qcalib	Res Evap	Water Availability
	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2	3	4	5	6	7	8	9=3+4+5+6+7+8
1985-86	128.00	7.04	0.75	-0.14	0.06	91.05	1.33	100.09
1986-87	122.75	5.67	0.75	-0.26	-0.13	89.23	1.32	96.58
1987-88	115.95	5.50	0.75	0.57	-0.02	81.16	0.42	88.377
1988-89	129.73	1.09	0.76	-0.30	-0.26	98.20	0.50	99.99
1989-90	141.63	6.55	0.75	0.38	0.36	103.55	1.41	113.00
1990-91	146.10	6.16	0.75	-0.05	0.24	106.40	1.43	114.93
1991-92	162.31	6.32	0.75	-0.18	0.33	127.68	1.41	136.31
1992-93	176.79	5.81	0.76	0.78	0.33	134.66	1.47	143.808
1993-94	151.13	1.93	0.77	0.04	1.01	116.78	0.44	120.97
1994-95	193.63	3.77	0.78	-0.02	-0.01	145.60	1.09	151.21
1995-96	142.15	6.23	0.78	-0.64	-0.80	104.96	1.35	111.88
1996-97	143.00	5.95	0.78	0.28	-0.86	104.61	1.43	112.19
1997-98	174.44	7.74	0.78	0.63	-0.06	130.24	1.45	140.78
1998-99	189.50	5.35	0.79	0.10	0.49	146.58	1.65	154.96
1999-00	152.62	6.05	0.80	-0.17	0.62	112.12	1.48	120.9
2000-01	147.99	5.46	0.84	-0.18	-0.33	106.68	1.62	114.09
2001-02	137.37	6.05	0.87	-0.33	-0.10	102.52	1.43	110.44
2002-03	114.23	4.68	0.84	-0.02	-0.48	80.35	1.40	86.77
2003-04	136.28	4.66	0.77	-0.05	-0.17	102.48	1.43	109.12
2004-05	134.33	4.63	0.78	0.40	0.64	96.28	1.53	104.26
2005-06	117.25	3.62	0.78	0.68	-0.08	85.67	1.00	91.67
2006-07	166.28	5.38	0.78	-0.51	0.97	128.52	1.42	136.56
2007-08	190.33	1.73	0.79	0.91	-0.47	147.72	0.49	151.17
2008-09	139.82	5.02	0.79	-0.76	0.33	101.4	1.21	107.99
2009-10	163.23	6.48	0.80	0.00	-0.60	120.61	1.41	128.7
2010-11	166.36	5.72	0.84	0.55	0.26	116.22	1.42	125.01
2011-12	161.92	7.90	0.87	-0.62	0.33	113.28	1.70	123.46
2012-13	129.32	5.57	0.84	-0.71	-0.30	87.71	1.54	94.65
2013-14	183.28	5.82	0.85	0.37	-0.41	138.31	1.12	146.06
2014-15	172.41	2.62	0.84	0.71	0.49	129.90	1.31	135.87
Average	151.00	5.22	0.79	0.05	0.05	111.68	1.27	119.06

<u>**ANNEXURE – S**</u>

WFR OF KUTCH AND SAURASHTRA INCLUDING LUNI BASIN

Table - S.1 Water availability at Gandhav

Year	Rainfall		ECII	DIL Flux	GW Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	9 = 3+4+5+6
1985-86	200.47	12.44	4.61	0.03	-2.36	0.02	0.00	2.30
1986-87	208.74	12.96	0.13	0.03	2.09	0.02	0.00	2.27
1987-88	105.31	6.54	7.13	0.03	-7.00	0.04	0.00	0.20
1988-89	330.27	20.50	1.21	0.03	2.64	0.01	0.00	3.89
1989-90	324.80	20.16	4.20	0.03	-0.07	0.04	0.00	4.20
1990-91	673.11	41.78	10.26	0.03	8.37	2.35	2.01	21.01
1991-92	245.24	15.22	2.26	0.03	0.05	0.02	0.00	2.36
1992-93	535.49	33.24	6.08	0.03	6.23	0.83	0.85	13.18
1993-94	356.73	22.14	9.37	0.03	-2.23	0.01	0.09	7.18
1994-95	550.21	34.15	10.42	0.03	4.30	0.72	0.47	15.47
1995-96	448.48	27.84	13.17	0.03	-2.48	0.97	0.49	11.70
1996-97	391.78	24.32	5.15	0.03	-1.32	1.44	0.02	5.30
1997-98	424.48	26.35	4.20	0.03	2.31	0.37	0.23	6.90
1998-99	342.08	21.23	7.88	0.03	-5.97	0.02	0.01	1.97
1999-00	219.63	13.63	6.17	0.03	-4.06	0.02	0.02	2.17
2000-01	297.61	18.47	7.72	0.12	-1.91	0.07	0.00	6.01
2001-02	375.67	23.32	2.34	0.12	2.71	0.27	0.20	5.44
2002-03	137.20	8.52	8.08	0.13	-7.20	0.09	0.00	1.10
2003-04	457.35	28.39	8.59	0.13	3.35	0.00	0.01	12.07
2004-05	289.60	17.97	7.77	0.13	-4.17	0.01	0.00	3.74
2005-06	317.48	19.70	3.62	0.13	-0.01	0.02	0.00	3.75
2006-07	530.08	32.90	8.66	0.13	5.28	0.73	0.00	14.80
2007-08	365.18	22.67	5.43	0.14	-2.30	0.95	0.23	4.22
2008-09	340.12	21.11	8.95	0.14	-5.07	0.03	0.00	4.06
2009-10	186.05	11.55	7.76	0.14	-6.82	0.07	0.00	1.16
2010-11	577.02	35.81	8.53	0.22	3.46	0.06	0.00	12.26
2011-12	497.71	30.89	10.48	0.22	-1.75	0.03	0.00	8.99
2012-13	419.56	26.04	8.47	0.23	-0.85	0.01	0.00	7.85
2013-14	424.64	26.36	12.84	0.23	-6.17	0.01	0.00	6.91
2014-15	410.70	25.49	2.96	0.02	1.75	0.01	0.00	4.74
Average	366.09	22.72	6.81	0.09	-0.64	0.31	0.15	6.57
Average (Excluding 2006-07, 2011-12)	355.54	22.07	6.62	0.08	-0.81	0.30	0.17	6.19

Table - S.2 Water availability at Kamalpur

Year	Rainfall		ECII	DIL	GW Flux	Reserv-oir Flux	Qcalib	Qobs	Water Avail-ability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9=3+ 4+5+6+7
1985-86	380.13	2.32	1.23	0.02	-0.50	0.00	0.13	0.01	0.88
1986-87	316.13	1.93	0.94	0.02	-0.58	0.00	0.06	0.00	0.44
1987-88	151.82	0.93	1.12	0.02	-1.17	0.00	0.07	0.00	0.04
1988-89	712.26	4.36	1.39	0.02	0.10	-0.01	0.04	0.05	1.54
1989-90	673.67	4.12	1.42	0.02	-0.11	0.01	0.04	0.03	1.37
1990-91	1051.84	6.43	2.23	0.02	0.66	-0.03	2.41	0.65	5.29
1991-92	406.51	2.49	1.68	0.02	-0.96	0.03	0.02	0.00	0.79
1992-93	1083.86	6.63	1.98	0.02	0.98	-0.01	1.55	0.87	4.52
1993-94	711.09	4.35	2.18	0.02	-0.48	0.00	1.15	0.98	2.87
1994-95	1344.11	8.22	1.51	0.02	0.85	0.01	2.84	3.28	5.23
1995-96	579.61	3.54	1.92	0.02	-1.01	0.00	0.06	0.06	0.99
1996-97	516.97	3.16	1.39	0.02	-0.78	0.01	0.01	0.00	0.65
1997-98	792.29	4.85	1.54	0.02	0.31	0.00	0.28	0.23	2.14
1998-99	749.28	4.58	1.51	0.02	-0.55	0.00	0.02	0.01	1.00
1999-00	318.98	1.95	1.91	0.02	-1.77	0.00	0.00	0.00	0.17
2000-01	497.13	3.04	1.00	0.03	0.07	0.00	0.00	0.00	1.10
2001-02	593.38	3.63	1.63	0.03	-0.57	0.00	0.00	0.00	1.10
2002-03	255.24	1.56	1.01	0.03	-0.92	0.00	0.00	0.00	0.13
2003-04	805.77	4.93	2.17	0.03	0.32	-0.01	0.20	0.11	2.72
2004-05	472.81	2.89	1.26	0.03	-0.57	0.00	0.05	0.04	0.78
2005-06	783.59	4.79	1.39	0.03	0.58	-0.01	0.17	0.01	2.17
2006-07	1237.79	7.57	2.20	0.03	0.99	0.00	2.41	0.55	5.63
2007-08	854.25	5.22	2.09	0.04	-0.08	0.00	0.99	0.21	3.04
2008-09	514.91	3.15	1.68	0.04	-0.92	0.00	0.02	0.02	0.81
2009-10	418.44	2.56	1.57	0.04	-0.86	0.00	0.01	0.04	0.75
2010-11	946.13	5.79	2.11	0.07	0.35	0.00	0.79	0.08	3.31
2011-12	886.67	5.42	3.13	0.07	0.21	0.00	0.17	0.10	3.58
2012-13	724.80	4.43	1.72	0.07	-0.21	0.00	0.07	0.12	1.66
2013-14	640.55	3.92	2.60	0.07	-0.89	-0.01	0.39	0.10	2.16
2014-15	672.78	4.11	1.49	0.07	-0.28	0.00	0.09	0.09	1.37
Average	669.76	4.09	1.70	0.03	-0.26	0.00	0.47	0.26	1.94
Average *	635.43	3.88	1.64	0.03	-0.34	0.00	0.38	0.28	1.71

*Exl. 1985-86, 2005-06, 2006-07, 2007-08, 2010-11, 2013-14

Table - S.3 Water availability at Gungan

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Qobs	Water Availabi-lity
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8 = 3+4+5+6
1985-86	291.49	0.67	0.26	0.01	-0.13	0.03	0.04	0.17
1986-87	291.49	0.67	0.20	0.01	-0.11	0.10	0.11	0.19
1987-88	159.98	0.37	0.00	0.01	-0.01	0.01	0.01	0.00
1988-89	973.15	2.24	0.57	0.01	0.20	0.38	0.67	1.15
1989-90	495.04	1.14	0.48	0.01	-0.09	0.13	0.19	0.53
1990-91	411.75	0.95	0.36	0.01	-0.02	0.05	0.05	0.40
1991-92	282.28	0.65	0.33	0.01	-0.14	0.00	0.00	0.20
1992-93	543.84	1.25	0.27	0.01	0.12	0.04	0.05	0.44
1993-94	357.77	0.83	0.26	0.01	-0.10	0.00	0.00	0.17
1994-95	1019.23	2.35	0.47	0.01	0.19	0.67	0.68	1.34
1995-96	384.99	0.89	0.49	0.01	-0.14	0.02	0.02	0.37
1996-97	487.00	1.12	0.35	0.01	-0.02	0.03	0.03	0.37
1997-98	648.68	1.50	0.08	0.01	0.10	0.16	0.25	0.35
1998-99	586.03	1.35	0.16	0.01	-0.05	0.02	0.02	0.13
1999-00	292.49	0.67	0.29	0.01	-0.12	0.00	0.00	0.18
2000-01	400.71	0.92	0.47	0.01	-0.03	0.01	0.01	0.46
2001-02	411.72	0.95	0.33	0.01	0.07	0.01	0.01	0.42
2002-03	332.11	0.77	0.27	0.01	-0.06	0.01	0.01	0.22
2003-04	778.75	1.80	0.67	0.01	0.16	0.02	0.01	0.85
2004-05	635.79	1.47	0.46	0.01	0.03	0.01	0.02	0.51
2005-06	906.46	2.09	0.50	0.01	0.11	0.49	0.43	1.11
2006-07	927.15	2.14	0.75	0.01	0.02	0.40	0.11	1.18
2007-08	1288.63	2.97	0.92	0.01	0.07	0.92	0.61	1.92
2008-09	809.28	1.87	0.79	0.01	-0.09	0.26	0.29	0.97
2009-10	524.09	1.21	0.54	0.01	-0.02	0.01	0.01	0.54
2010-11	1082.85	2.50	0.54	0.02	0.13	0.51	0.57	1.19
2011-12	1703.03	3.93	0.78	0.02	-0.02	3.25	0.63	4.03
2012-13	386.50	0.89	0.36	0.02	-0.04	0.01	0.00	0.34
2013-14	782.73	1.81	0.61	0.02	0.09	0.13	0.12	0.86
2014-15	426.56	0.98	0.33	0.02	-0.08	0.01	0.01	0.28
Avg.	620.72	1.43	0.43	0.01	0.00	0.26	0.17	0.70
Avg. (Excluding 2006-07, 2011-12)	571.12	1.32	0.41	0.01	0.00	0.15	0.15	0.57

Table - S.4 Water resources availability at Ganod

Year	Rainfall		ECII	DLI	GW Flux	Reservoir Flux	Qcalib	Qobs	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7	8	9 = 3+4+5+6+7
1985-86	373.98	2.05	0.45	0.01	-0.37	0.01	0.01	0.01	0.12
1986-87	380.98	2.09	0.54	0.01	-0.03	-0.01	0.06	0.06	0.59
1987-88	122.90	0.67	0.00	0.01	0.04	0.00	-0.05	0.00	0.01
1988-89	947.72	5.20	0.62	0.01	0.40	-0.04	1.83	1.73	2.82
1989-90	602.48	3.31	0.83	0.01	0.12	0.04	0.30	0.30	1.30
1990-91	491.55	2.70	0.64	0.01	-0.05	0.00	0.16	0.17	0.76
1991-92	340.48	1.87	0.86	0.01	-0.24	0.00	0.09	0.08	0.73
1992-93	649.48	3.57	0.82	0.01	0.26	-0.02	0.36	0.37	1.43
1993-94	387.86	2.13	0.55	0.01	-0.25	0.02	0.04	0.04	0.36
1994-95	889.15	4.88	1.63	0.01	0.45	-0.01	1.10	0.84	3.18
1995-96	499.06	2.74	1.34	0.01	-0.34	0.01	0.04	0.04	1.07
1996-97	555.66	3.05	0.88	0.02	0.06	-0.01	0.39	0.42	1.34
1997-98	635.93	3.49	0.81	0.02	0.09	0.00	0.12	0.13	1.03
1998-99	660.14	3.62	0.56	0.02	-0.09	0.01	0.04	0.04	0.53
1999-00	351.41	1.93	0.35	0.02	-0.19	0.00	0.01	0.01	0.19
2000-01	363.06	1.99	0.90	0.03	-0.08	0.00	0.00	0.00	0.85
2001-02	283.29	1.56	0.96	0.03	0.06	0.02	0.08	0.07	1.14
2002-03	398.66	2.19	0.65	0.03	0.03	0.00	0.07	0.08	0.78
2003-04	775.12	4.25	1.77	0.03	0.41	-0.03	0.14	0.14	2.31
2004-05	677.87	3.72	1.33	0.03	-0.09	0.03	0.48	0.08	1.79
2005-06	877.84	4.82	1.35	0.03	0.40	-0.12	0.70	0.25	2.37
2006-07	955.87	5.24	1.56	0.03	-0.07	-0.01	1.48	0.80	2.99
2007-08	1370.90	7.53	1.44	0.03	0.19	-0.01	2.85	2.05	4.50
2008-09	800.26	4.39	0.88	0.03	-0.20	-0.01	0.85	0.80	1.54
2009-10	658.10	3.61	1.97	0.03	-0.16	-0.04	0.18	0.20	1.98
2010-11	1280.22	7.03	2.40	0.04	0.31	-0.04	0.65	0.70	3.36
2011-12	1339.29	7.35	2.35	0.04	-0.15	0.02	3.58	0.63	5.84
2012-13	405.59	2.23	0.59	0.04	-0.15	0.02	0.01	0.00	0.52
2013-14	863.12	4.74	1.31	0.04	0.30	-0.06	1.11	1.09	2.70
2014-15	399.21	2.19	1.00	0.05	-0.31	0.04	0.01	0.00	0.78
Average	644.57	3.54	1.04	0.02	0.01	-0.01	0.56	0.37	1.62
Average*	614.53	3.37	0.99	0.02	0.01	0.00	0.42	0.37	1.44

**Excluding 1987-88, 2004-05, 2005-06, 2006-07 & 2011-12*

Table - S.5 Water availability of Shetrunji Sub-basin

Year	Rainfall		ECII	DIL	GW Flux	Qcalib	Water Availability
	mm	BCM	BCM	BCM	BCM	BCM	BCM
1	2(a)	2(b)	3	4	5	6	7=3+4+5+6
1985-86	376.19	1.94	0.73	0.00	-0.45	0.19	0.47
1986-87	376.19	1.94	0.50	0.00	-0.22	0.34	0.63
1987-88	182.06	0.94	0.28	0.00	-0.18	0.49	0.59
1988-89	931.50	4.81	0.69	0.00	0.48	2.91	4.08
1989-90	622.87	3.22	0.74	0.00	-0.08	1.00	1.66
1990-91	596.23	3.08	1.08	0.00	-0.08	0.72	1.72
1991-92	328.71	1.70	0.24	0.00	-0.53	1.18	0.90
1992-93	707.54	3.66	0.84	0.00	0.19	1.04	2.07
1993-94	574.44	2.97	0.78	0.00	-0.04	0.56	1.30
1994-95	738.88	3.82	0.56	0.00	0.20	1.48	2.24
1995-96	438.29	2.27	0.85	0.00	-0.48	0.31	0.67
1996-97	552.16	2.85	0.91	0.00	0.24	0.49	1.65
1997-98	555.30	2.87	0.80	0.00	-0.19	0.58	1.19
1998-99	605.05	3.13	0.96	0.00	0.10	0.33	1.39
1999-00	414.35	2.14	0.51	0.00	-0.48	0.21	0.24
2000-01	248.48	1.28	0.31	0.00	-0.39	0.19	0.11
2001-02	542.82	2.81	0.95	0.00	0.16	0.57	1.68
2002-03	625.81	3.23	0.78	0.00	0.58	1.09	2.45
2003-04	704.95	3.64	0.66	0.00	0.05	0.60	1.32
2004-05	403.33	2.08	0.73	0.00	-0.04	0.36	1.06
2005-06	597.29	3.09	0.63	0.00	0.73	0.81	2.17
2006-07	1026.42	5.31	0.56	0.00	-0.18	3.26	3.63
2007-08	1241.54	6.42	1.35	0.00	0.47	3.07	4.88
2008-09	711.40	3.68	1.45	0.00	-0.23	0.42	1.64
2009-10	485.81	2.51	0.85	0.00	-0.61	0.56	0.81
2010-11	906.05	4.68	1.17	0.00	0.75	1.24	3.17
2011-12	2361.40	12.21	0.53	0.00	-0.32	9.77	9.98
2012-13	427.88	2.21	0.37	0.00	-0.14	0.41	0.64
2013-14	904.13	4.67	0.31	0.00	0.33	2.06	2.70
2014-15	528.30	2.73	0.56	0.00	0.21	0.47	1.24
Average	661.62	3.42	0.73	0.00	-0.01	1.25	1.97
Average*	514.35	2.66	0.71	0.00	-0.07	0.60	1.24

*excluding 1988-89, 2006-07, 2007-08, 2010-11, 2011-12 & 2013-14