Chapter5

Hydrology and Water Assessment

5.0 General

The Bedti - Varada link project (Link-1) envisages diversion of302MCMof water from west flowing Bedti river from the surplus available at Pattanadahalla across Pattanadahalla river and Shalamalahallaacross Shalamalahalla river,both tributaries of Bedti river to the Varada river, a sub tributary of east flowing Krishna basin for irrigation under LBC of Tungabhadra project.The Bedti - Dharma link project (Link-2) envisages diversion of 222MCMof water from proposedSuremane barrage acrossBedti river to Dharma project for irrigation under the LBC of Tungabhadra project.This chapter deals with the assessment of water balance atShalamalahalla,PattanadahallaandSuremanediversion sites in Bedti basin.

5.1 General climate and hydrology

The catchment up to the diversion sites experiences the tropical climate. The climate has four distinct seasons viz., dry period, hot period, south-west monsoon and north-east monsoon.

The Bedtibasinis surplus at 75 % dependability at the proposed Pattanadahalla and Shalamalahallaweirs on the tributaries Pattanadahalla and Shalamalahalla respectively. As such, after meeting upstream requirements (by 2050 AD) of above catchments, surplus of about 302 MCM has been proposed for diversion. Similarly,the water availability study at the proposed Suremane barrageon main Bedti river indicates

surplus and it is proposed to divert 222 MCM at 75% dependability. The schematic diagram of the link project is given at **Fig5.1** below.

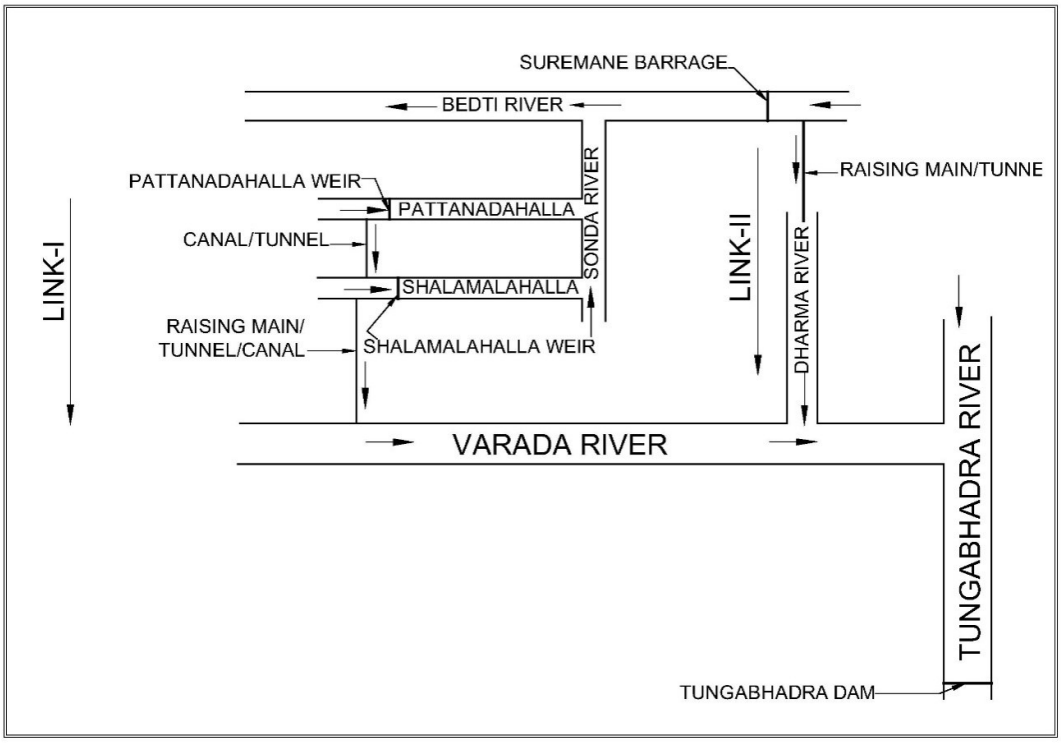

Fig. 5.1:The schematic diagram of the link project (LinkI & LinkII)

5.2 General information about region

The Bedti basin is on western side of Western Ghats.The river Bedti flows westwards and joins Arabian sea. The Tungabhadra sub basin is on eastern side of Western Ghats.The river Tungabhadra flows eastwards to join Krishna river which joins the Bay of Bengal.The description of both the donor and recipient basins is given in the following paras.

(a) Bedti basin

Climate of the basin is pleasant throughout the year.The Honavar IMD station is located nearer to the Bedti basin. The annual normal rainfall (1951-2000)at Honavaris3728.3mm. The basin receives about 95% of the annual rainfall during monsoon period i.e., from June to November. The normal daily maximum and minimum temperature at Honavar (1981-2010)are found to be 33.4^{o}Cand 20.2^{o}Cin the months of Decemberand February respectively.

Normal relative humidity varies from 94% in the month of August to 55% in the month of December. The normal maximum and minimum wind speed is found to be 6 kmph during June and 3.9 kmph during October.The normal maximum cloud cover is 7 oktas during July and minimum cloud cover is0.9 oktas in February.

(b) Tungabhadra sub-basin

There are five IMD stations viz Bellary, Shimoga,Raichur and Gadag in Karnataka and Kurnool in Andhra Pradesh in and around Tungabhadra sub basin. Raichur IMD station is nearer to the Tungabhadra left bank canal command. Climate of the basin is characterized by moderate summer and mild winter. The normal annual rainfall is around757mm(IMD 1951-2000).The basin receives about 79% of the annual rainfall during monsoon period i.e., from June to October. The normal daily maximum temperature varies between 40.5^{0}C (May, Kurnool) and 27.8^{0}C (August, Shimoga) and daily minimum temperatures varies between 27.5^{0}C (May, Kurnool) to be15.3^{o}C (January, Shimoga).The normal relative humidity varies from 87% (August, Shimoga) and 22% (March, Gadag).

5.3 Specific information

5.3.1 Drainage basin

(a) Bedti basin

The Bedti river (Gangavali in lower reaches) is one of the principal west flowing rivers in the Karnataka State. The Bedti basin lies between longitude of 74^0 17' E and 75^0 12' Eand latitudes of 14^0 32'N and 15^0 27' N. The catchment area of the basin is 3902 Sq.km. The basin lies in Dharwad, Haveri and Uttara Kannada districts of Karnataka state.

The streamsShalamalahalla and Bedtihalla join near Kalghatgi town to form Bedti river.Bedtihalla and Shalamalahalla streams rise from the range of hills in the west and south of Dharwaddistrict of Karnataka respectively at an elevation of 700 m above MSL.The total length of river from source to its outfall into sea near Gokarna is about 152 km.Sonda is one of the main tributaries of the Bedti river and after its confluence with Bedti, the Bedtiis popularly known as 'Gangavali' river.Pattanadahalla and Shalamalahalla are tributaries of Sonda.Index map of Bedti basin showing diversion sites is depicted in **Fig5.2.**

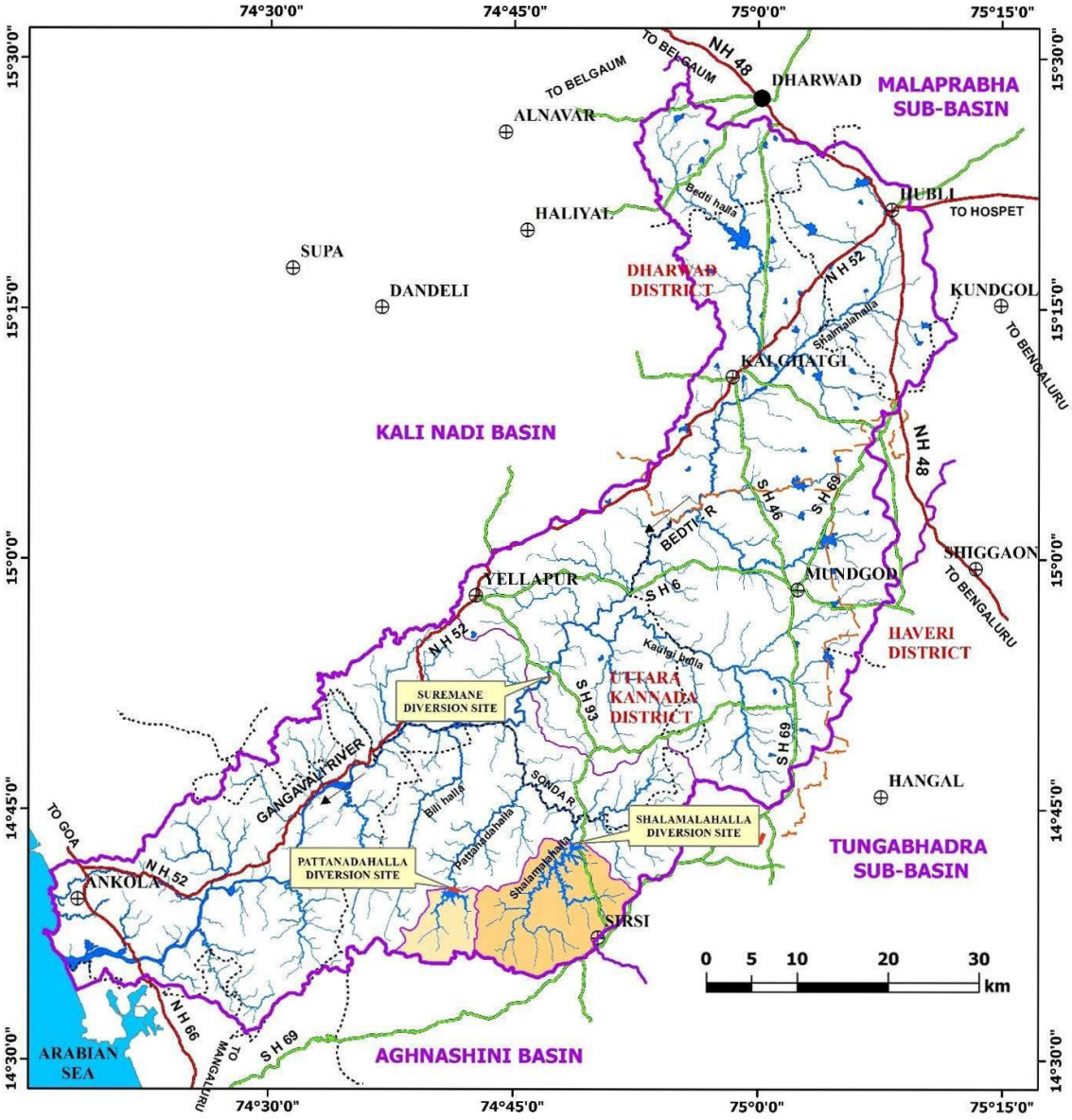

Fig.-5.2: The Index map of BedtiBasin

(b) Tungabhadra sub-basin

The river Tungabhadra is formed by the confluence of the Tunga and Bhadra rivers. The rivers Tunga and Bhadra rise together in the Western Ghats on the VarahaParvata hills at Gangamula at an elevation of about 1198 m. The Tungabhadra sub-basin lies between longitudes of $74^0$50'E and $78^0$20'E and latitudes of $13^0$08'N and $16^0$17'N.The catchment area of

Tungabhadra sub-basinspreads over Bagalkot,Bellary, Raichur, Chikmagalur, Shimoga, Uttara Kannada, Koppal, Gadag, Haveri, Davangere, Dakshina Kannada, Chitradurga, and Udupi districts of Karnataka, Kurnool district in Andhra Pradesh and Mahbubnagar district in Telangana. The catchment area of the sub-basin is 47827 Sq.km. The total length of river is 531 km. The sub-basin is bounded in the north by Lower Krishna, Middle Krishna and Malaprabha sub-basins, in the east by Pennar basin and Vedavati sub-basin, in the south by Cauvery basin and in the west by Bedti andAghanashini basins. Index map of Tungabhadra sub basin showing command area under various projects is shown in **Fig5.3.**

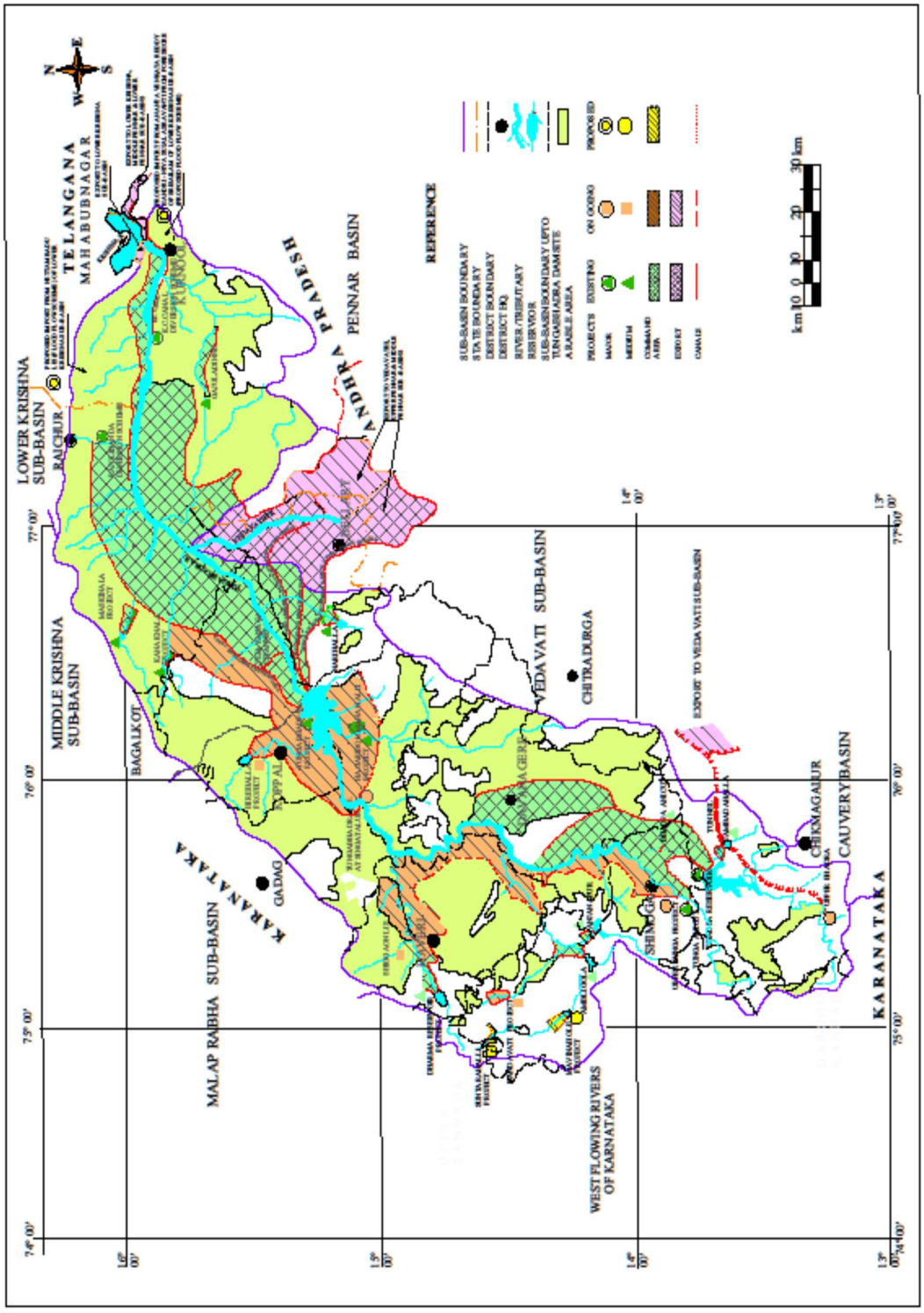

Fig. -5.3: Tungabhadra sub basin map

5.3.2 Command area

Link-Ienvisages diversion of 302 MCM of surplus waters of Bedti river fromPattanadahalla andShalamalahalladiversion sites for augmenting irrigation under left bank canal command of Tungabhadra dam.Link-IIenvisages diversion of 222MCM from Suremane diversion site on main Bedti river for stabilizing the same command. Thetarget command area lies in Raichur district of Karnataka state.

The average annual evaporation losses of Tungabhadra project are computed as 292 MCM. The soils in the target command area are characterized by slow to very slow permeability.

TheGround waterdepths in Raichur district (CGWB, July2013), varies from 0.41 mbgl to 8.32 mbgl during the pre-monsoon period, and from 0.05 mbgl to 8.87 mbgl duringthe post-monsoon period. The decadal fluctuation (May, 2001 to May, 2010) between pre-monsoonand post-monsoon levels shows rise in 30 stations from 0.005 to 0.578 mand fall in 6 stations from 0.009 m to 0.221 m.

5.3.3 Floods and drainage

(a) Bedtibasin

The gauge and discharge data are being observed by the Karnataka Power Corporation Limited, Govt. of Karnataka at Pattanadahalla site on Pattanadahalla river and at Sonda G&D site on Shalamalahalla river. Both the discharge sites are located downstream of the proposed weirs.Dischargesare alsoobservedat Suremane G&D site on main Bedti riverdownstream of the proposed diversion site. The monthly inflow data is available for a period of 18 years i.e., from 1961-62 to 1978-79 for

Pattanadahalla andSonda G&D sites and for 25 years i.e., from 1970-71 to 1994-95 for Suremane G&D site. The maximum observed discharge at Pattanadahalla G & D site was 117cumec in July1961,222 cumec in July1961 at Sonda G&D site and 935.6 cumec at Suremane G&D site during July1978. The map of Bedti basin showing hydrological stations and isohyets is furnished as **Fig.5.4**.

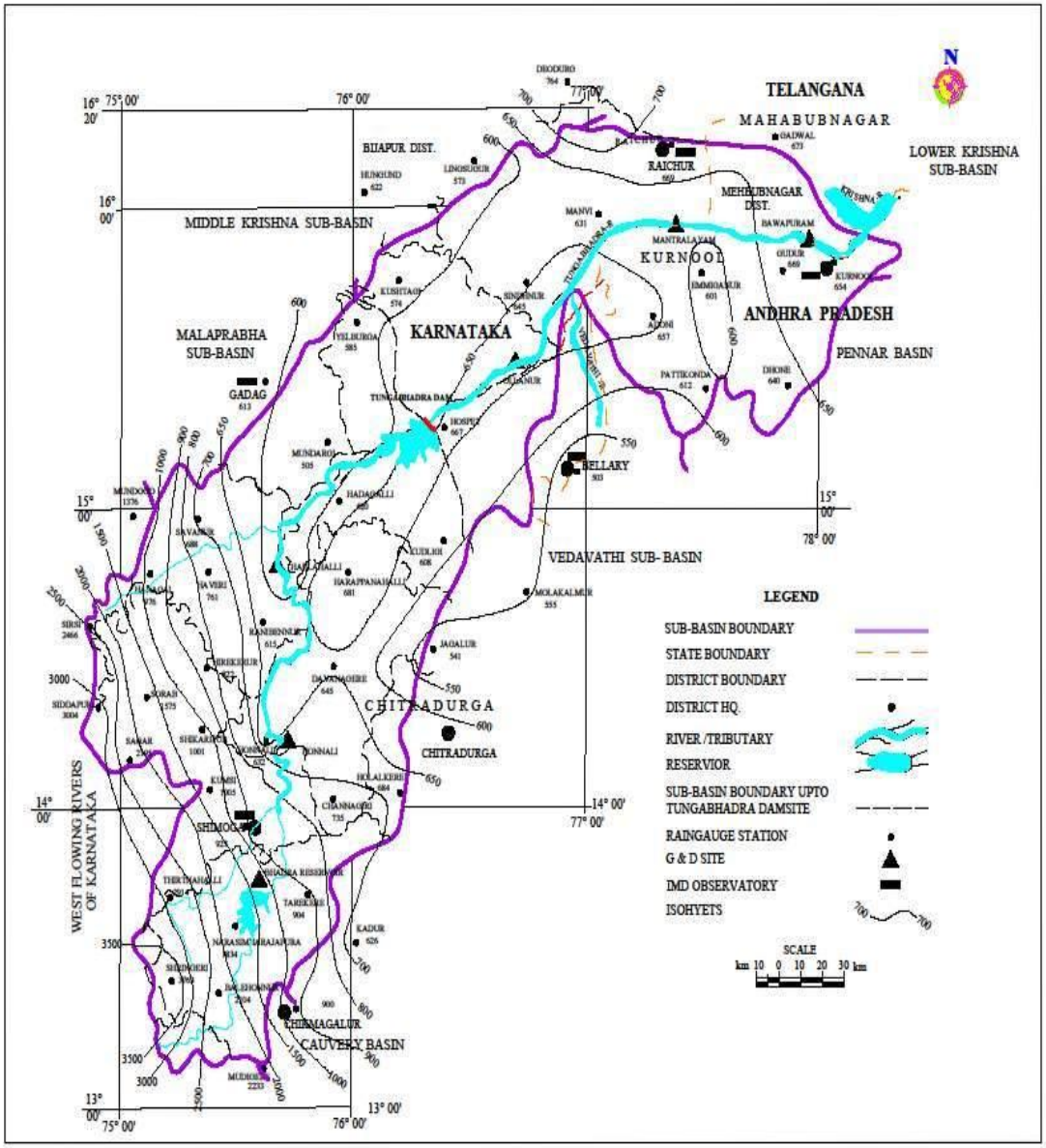

Fig.-5.4: Hydrological stations and isohyets in Bedti basin

(b) Tungabhadrabasin

The gauge and discharge data were recorded by Central Water Commission (CWC) at Marol G&D site on Varada river, a tributary of Tungabhadra river and is available for the period from 1967to 1974 after which the site was closed.

The hydro-meteorological, hydrological stations and isohyets in Tungabhadra river systems are shown in **Fig.5.5.**

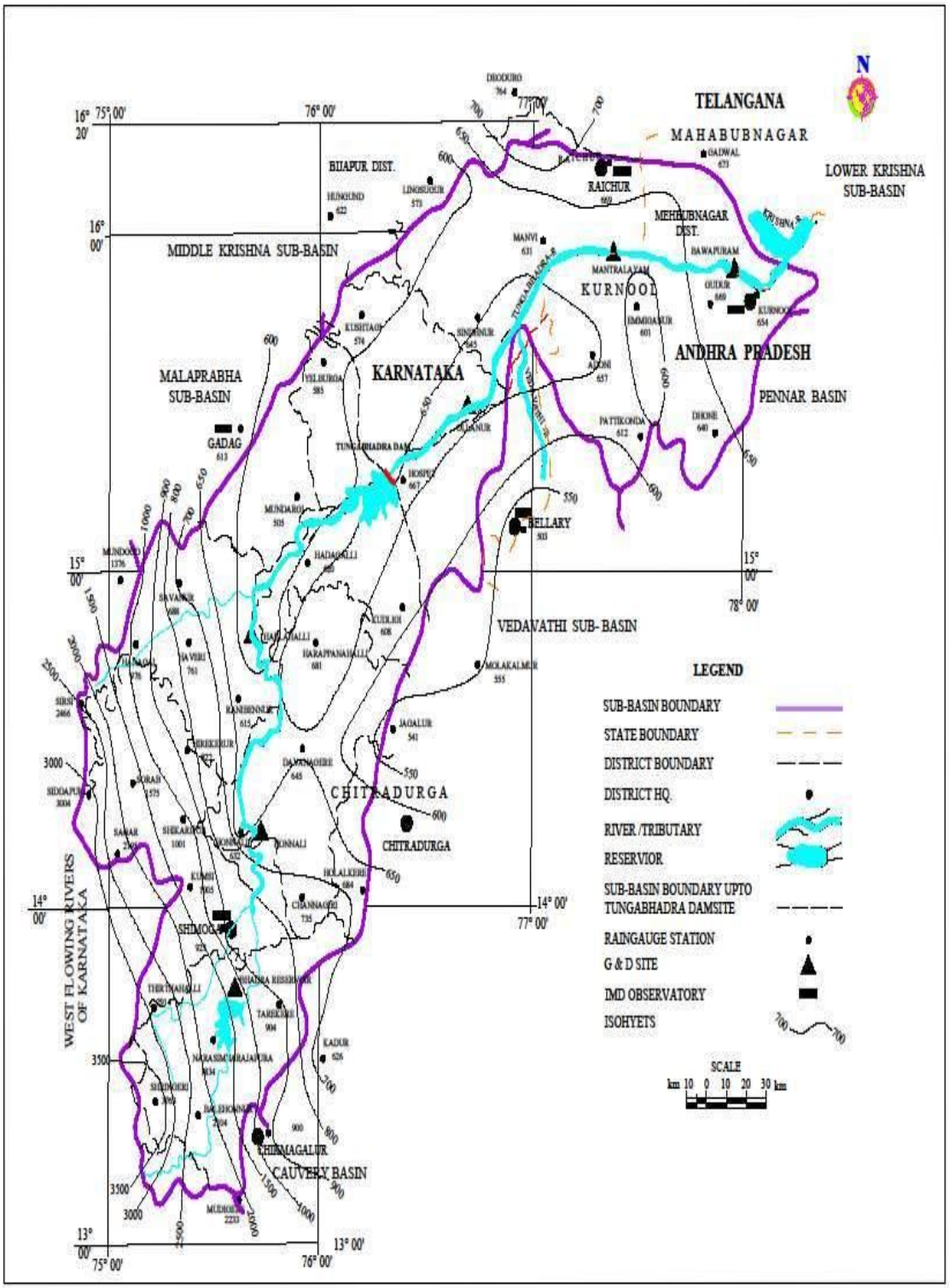

Fig.-5.5: Hydrological stations and isohyetsof Tungabhadra sub-basin

5.3.4 River geometry

Bedti river

The Bedti river originates in the Western Ghats, near Hubli and traverses 30 km before joining Shalmala a tributary from the left at Kalghatgi. After the confluence with Shalmala, the river Bedtiflows in westerly and south-westerly direction for about 69 km. After traversing a total length of 152 km, the river Bedti falls into Arabian sea near Gokarna.

The bed fall of the river is gentle for the first 72 km. beyond which the river falls from a height of about 180m at famous Magod falls.Then it runs in deep gorges with steep fall bedslope. The river has dense evergreen and semi-evergreen forests along its path. The river flows in Dharwad and Uttara Kannada districts of Karnataka. The Bedti basin map showing river course is furnished at **Fig.5.6.**

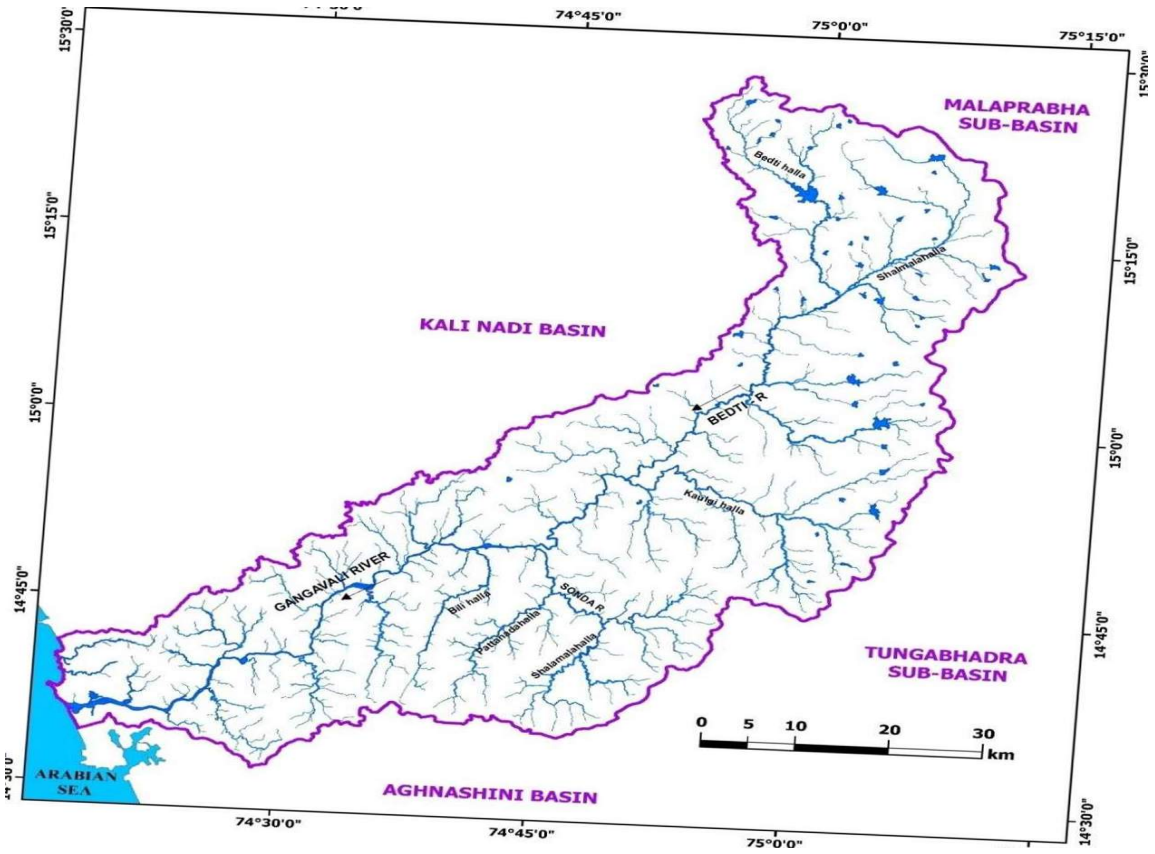

Fig. 5.6:Bedti basin map showing drainage network

5.3.5 Groundwater recharge

The Bedti basin covers areas in Dharwad, Haveri and Uttara Kannada districts of Karnataka. From the ground waterinformation brochures of respective districts, it is seen that the main aquifers in the area are the weathered and fractured zones ofmetavolcanics, meta-sedimentaries, granites, gneissesand laterites. Thealluvial patches are found along the major stream courses.The hilly tracks have thin weathered covers, and the valley portions have thickerweathered zones.Ground water in the aquifer system generally occurs under unconfined,semi-confined and confined conditions. In the shallower zones, it exists underphreatic condition and in the deeper zones it exists under semi-confined toconfined conditions. The ground water is generally being exploited from thedepth range of 3.00 to 31.00mbgl through dug wells and from 30.00 to200.00mbgl through dug-cum-bore wells and bore wells.

The district-wiseground water potential andpresent draft in respect of Dharwad, UttaraKannada and Haveri districts of Karnatakaare furnished in **Table 5.1.**

Table-5.1 Ground water potential and existing draft

Sl. No.	District	Estimated potential(MCM)	Present draft (MCM)
1	Dharwad	261	142
2	Uttara Kannada	918	224
3	Haveri	687	374

Source: National Compilation on Dynamic Ground Water Resource of India, 2020 of CGWB – June2021.

5.3.6 Reservoir area

Two weirs are proposed under Link I, viz., Pattanadahalla weir across Pattanadahalla stream and Shalamalahalla weir across Shalamalahalla stream. The pond level of the Pattanadahalla weir is 499.0 m with a water spread area of 17.88 ha which is mostly confined to river course. The pond level of Shalamalahalla weir is 468.0 m with a corresponding water spread area of 88.53 ha confined to river course.

Similarly, under Link II, one barrage is proposed at Suremane across Bedti river with a pond level of 426.0 m. The corresponding water spread area is 54.38 ha which is confined to river course only.

5.3.7 Catchment area uptodiversion sites

The catchment area up to Pattanadahalla weir on Pattanadahallastream andShalamalahallaweir on Shalamalahallastream,and Suremane on main Bedti river lies in Uttara Kannada district of Karnataka state.The location of the diversion sites and their catchment area are given in **Table 5.2.**

Table 5.2: Location and catchment area of the diversion sites

Sl.No.	Name of the diversion site/stream/river	Location		Catchment area(Sq.km)
		Latitude	Longitude	
1	Pattanadahalla on Pattanadahalla	14°40'15"N	74°41'18"E	52.80
2	Shalamalahalla on Shalamalahalla	14°42'26"N	74°48'31"E	169.42
3	Suremane on Bedti	14°52'53"N	74°47'13"E	2078

All the above diversion sites are approachable from NH-48 (Bengaluru to Haveri) and district road to Sirsi. The nearest town is Sirsi and the nearest railway station is Talaguppa in Shimoga district

a) Evaporation

Since weirs / barrage only are considered as diversion structures, no evaporation is considered.

b) Elevation - Area - Capacity curves

The Survey of India toposheets of 1:50000 scale covering the project area are digitized and from the contours digitized, the DEM of the project area is generated using GIS application. Using the generated DEM, Elevation - Area - Capacity values at the three diversion sites are extracted at 1.0 m interval. The Elevation - Area - Capacity statement of Pattanadahalla weir, Shalamalahalla weir and Suremane barrage are given in**Annexure5.1.1**to**Annexure 5.1.3** respectively.

The corresponding E-A-C curves at the diversion sites are furnished as **Fig. 5.7**to **Fig 5.9** respectively.

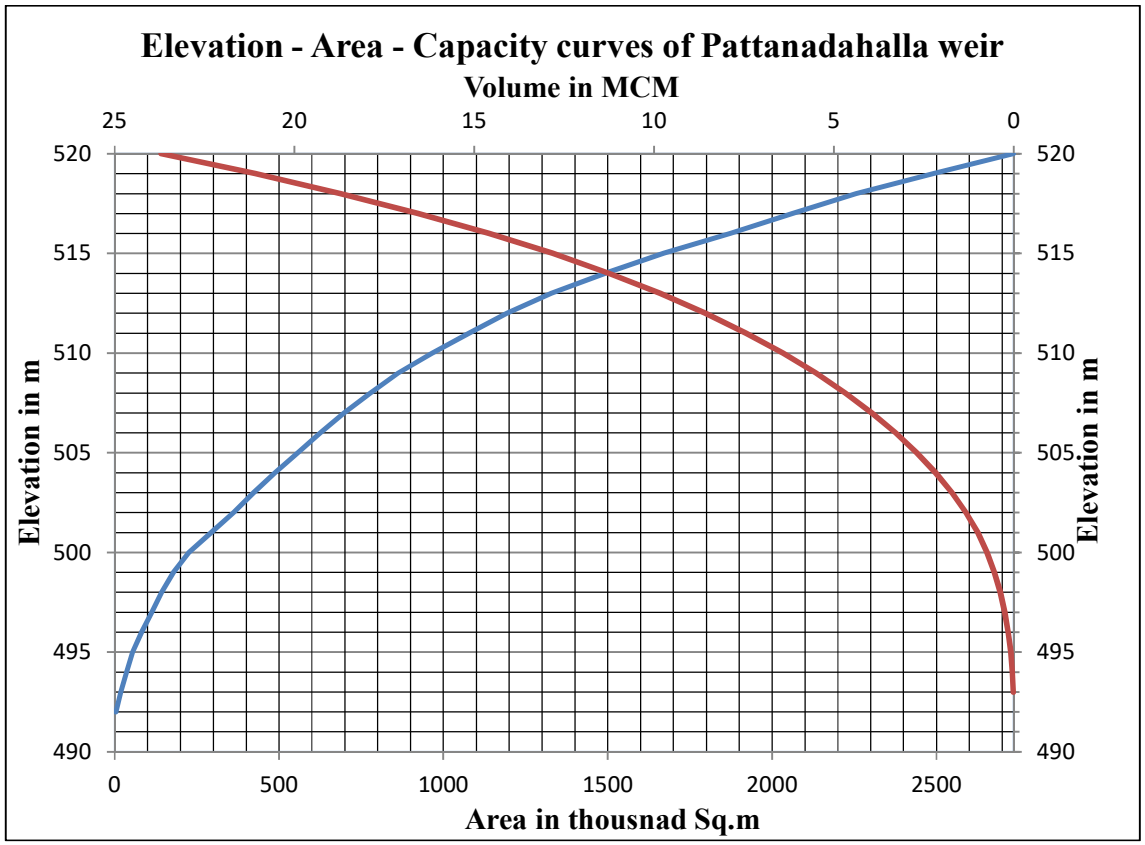

Fig. 5.7:Elevation - Area - Capacity curves of Pattanadahalla weir pond

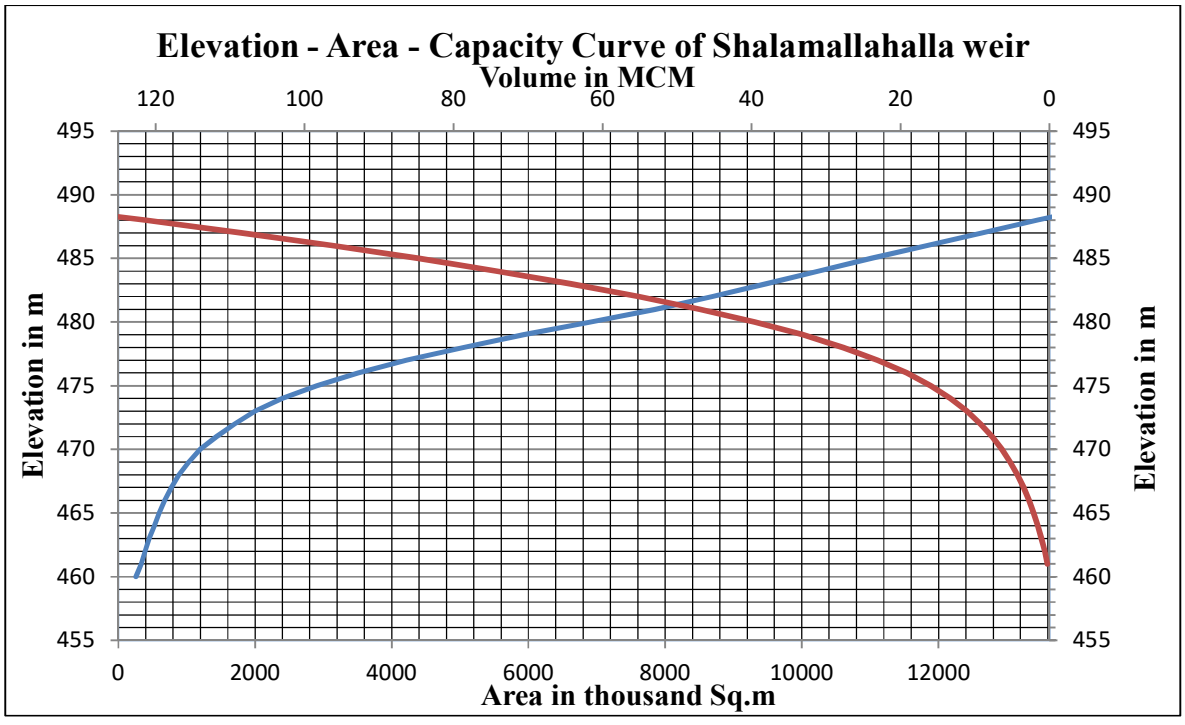

Fig. 5.8: Elevation - Area - Capacity curves of Shalamalahalla weir pond

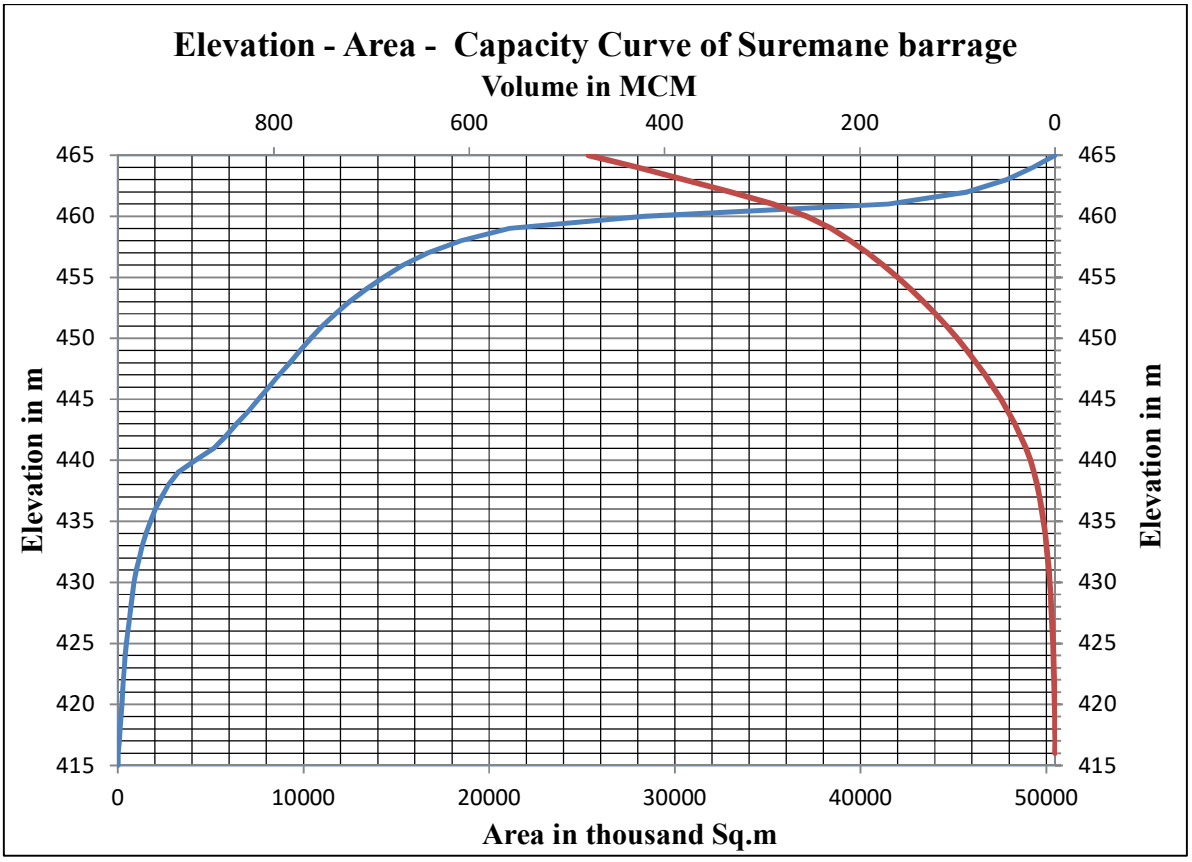

Fig. 5.9:Elevation - Area - Capacity curves of Suremane barrage pond

5.3.8 Other water usage

The water balance at 75% dependability at respective diversion sites is assessed for firming up divertible quantity at diversion sites at 75% dependability.The in-basin water requirement at ultimate stage of development, for annual irrigation up to the 60% of culturable area up to the respective diversion sites, water requirement for domestic, industrial requirement and mandatory lean season releases are considered for assessing the water balance.The entire diverted water (neglecting transmission losses) is proposed for augmenting the irrigation in the command area at the tail end of the TBLBC.

5.3.9 Navigation

The Pattanadahalla, Shalamalahalla, Bedti and Varada rivers are presently not used for any major navigational purpose. There is no provision for navigation in the proposed Bedti-Varada link project.

5.4 Data availability

5.4.1 Rainfall and snowfall

a) **Bedti basin**

There is no snowfall in Pattanadahalla,Shalamalahallaand Suremanecatchments involved in Bedti-Varada link project. The precipitation in the link project area is in the form of rainfall. There are 23 raingauge stations in and around the entire Bedti basin. During consistency check, the data of one station viz., Gunjavati is found to be inconsistent with other stations. As such, the data of Gunjavati station is not considered for working out weighted average monsoon rainfall. From the rainfall data of remaining 22 stations available for varying periods, the monsoon rainfall data from 1970-71 to 2016-17 (47 years) is considered for hydrological analysis in the present study. The list of rain gauge stations along with their locations and corresponding normal annual rainfall is furnished at **Annexure 5.2.** While all the 22 rain gauge stations were considered for working out weighted average monsoon rainfall of entire Bedti basin, the list of stations considered for catchment area upto Pattanadahalla, Shalamalahalla and Suremane diversion sites is furnished in **Table 5.3** below.

Table 5.3

List of raingauge stations considered for the catchment upto the diversion sites

S.No.	Pattanadahalla weir site	Shalamalahalla weir site	Suremane barrage and G & D site
1	Hulikal	Hulikal	Attangi
2	Sorguppa	Sirsi	Devaragudihal
3		Sorguppa	Dharwad
4		Yekkambi	Hubli
5			Kalghatgi
6			Kundagol
7			Malgi
8			Mugod
9			Mundgod
10			Shiggaon
11			Tadas
12			Vajrahalli
13			Yekkambi
14			Yellapur

b) **Tungabhadra sub-basin**

There are 34 rain gauge stations in and around Tungabhadra sub basinupto Tungabhadra dam. There is no snowfall in the basin. The basin receives almost 79% of the annual rainfall during monsoon period from June to October.

5.4.2 Pan evaporation

Since the link project envisages transfer of surplus waters during monsoon period through weirs / barrage with negligible storages, evaporation losses are not considered in the simulation study.

5.4.3 Climatological parameters

The HonavarIMDstation, located in the adjacent Sharavati basin is the nearest station to the Bedtibasin. The normal monthly values (1981-2010) of various climatological parameters at Honavar IMD observatory viz., Mean daily maximum and minimum temperature, Relative humidity, Wind speed and Cloud cover are furnished at **Annexure 5.3.**Also, the normal monthly rainfall (1951-2000) observed at Honavar IMD observatory is given at **Annexure 5.3.**

5.4.4 River gauge and discharge

Gauge and discharge data was being observed at various sites by Karnataka Power Corporation Limited(KPCL) and Water Resources Development Organisation (WRDO), Govt. of Karnataka across Bedti river and its tributaries. Presently, only gauge data is being maintained/furnished. The details of these G&D sites are given in **Table 5.4**.

Table 5.4
Details of Gauge &Discharge Sites in Bedti basin

Sl. No.	Site	Stream / River	Catch-ment Area(Sq .km)	Period of availability	Maintained by
1.	Bilihalla	Bilihalla / Bedti	56.98	1961-62 to 1978-79	KPCL
2.	Kamadhenuweir	Shalamalahalla / Bedti	372.00	1971-72 to 1984-85	WRDO
3.	Pattanadahalla	Pattanadahalla / Sonda /Bedti	168.00	1961-62 to 1978-79	KPCL
4.	Sonda	Sonda/Bedti	342.00	1961-62 to 1978-79	KPCL
5.	Suremane	Bedti	2178.00	1970-71 to 1994-95	KPCL

5.4.5 Sediment (Suspended and bed load) inflow

The catchment areas of the proposed Pattanadahalla and Shalamalahalla weirsand Suremanebarrage are mostly covered by thick forest and by rocks at fringes. As such, the silt load is expected to be small in comparison to other basins which are entirely covered with open catchment. In the absence of any observed silt load at proposed sites, a sediment inflow of 398.61 m^3/Sq.km/year of the catchment can be expectedas assumed by the Karnataka Power Corporation Limited in their studies. However, since the diversion is only through weirs / barrage, without any storages, sedimentation study is not carried out in the present DPR.

5.4.6 Water quality

Presently water quality is not monitored in any of the streams in Bedti basin. The water quality testing would be taken up as part of Comprehensive Environmental Impact Assessment (CEIA) studies to be taken up for the project at a later stage.

5.5 Water availability studies

The proposed Bedti-Varada link (Link-I &Link-II together) envisages diversion of 524MCM of water from Pattanadahalla, Shalamalahalla and Suremane diversion sites of Bedti river to Tungabhadra river to be utilised in Tungabhadra left bank canal command which lies in Raichur district of Karnataka for augmenting the irrigation use. The hydrological studies are carried out for the Bedti basin up to the proposed diversion sites and up to Tungabhadra dam site for Tungabhadra sub-basin.

5.5.1 Methodology

The observed flow data at the relevant G&D site and the rainfall observed at various rain gauge stations in and around the catchment of each of the diversion sites are collected. The upstream utilizations are added to the observed monsoon flows and the regenerated flows are subtracted to get the virgin monsoon yields at the G&D site. Weighted monsoon rainfall for the catchment upto the G&D site and for the whole catchment area of the diversion sites are worked out. Rainfall-runoff relationship is developed by regression analysis, using these virgin monsoon flows and weighted average monsoon rainfall upto the G&D site. Monsoon yields are computed using the best fit equation and weighted average monsoon rainfall for the catchment area of the diversion sites. Non-monsoon yields are added to arrive at the annual gross yields for the catchment area of the diversion sites. The annual gross yields, thus arrived at are arranged in descending order, from which 50% and 75% dependable annual gross yields are obtained.

The overall surface water available in each catchment is arrived at by summing up the yield at the respective dependabilitiesandimport and the export, if any.

Water requirement

The requirements of water at the ultimate stage of development (by 2050 AD) for various uses viz. irrigation, domestic, industrial and environmental release are worked out as follows.

Irrigation needs

The irrigation water requirements are worked out for all the existing, ongoing and proposed major, medium and minor projects in the sub basin. The designed annual utilizations are considered for the existing and ongoing projects. In case of future projects, the irrigation water requirement is estimated as per the NWDA guidelines laid down by its Technical Advisory committee (TAC) and Special Committee on ILR. In a surplus sub basin, the annual irrigation at the ultimate stage is increased to 60% of the maximum culturable area. The increased annual irrigation is considered at 50% each under future medium and minor schemes.

Domestic needs

The domestic water requirement for the projected (2050 AD) human population and livestock is estimated using the latest available census. The daily water requirement per capita are considered at 70 litres and 135 litres for the rural and urban human population respectively as per the recommendations of the Ministry of Works and Housing in their manual "Water Supply and Treatment". For livestock a daily requirement of 50 litres per capita is considered. The requirement of 50% of rural population and the entire urban population is considered to be met from the surface water while the requirement of remaining 50% of the rural human population and of the entire livestock is considered to be met from ground water.

Industrial needs

In the absence of reliable data on total industrial water requirement at the ultimate stage of development, the industrial water requirement is considered to be equal to the total domestic water requirement for human

population and livestock. The entire industrial requirement is considered to be met from surface water.

Hydro power needs

As there are no existing, ongoing or proposed hydropower stations in the catchment, the water for consumptive use of hydro power generation is not considered.

Regeneration

The regeneration is considered (a) 20% from all the existing, ongoing and future identified major and medium projects and (b) 80% of the domestic and industrial use to be met from the surface water.

Water balance

The total water requirement of each of the catchments worked out on the methodology outlined above, is subtracted from the overall availability of water in the catchment to determine the water balances (surplus/deficit) at 75% and 50% dependabilities.

5.5.2 Hydrological and water balance studies of the Bedti basin

1) **UptoPattanadahalla and Shalamalahallaweirs**
2) **UptoSuremanebarrage**

To determine the annual divertible quantity at 75% dependability, at the three proposed diversion sites, the water balance study has been carried out at these sites based on the methodology discussed in para 5.5.1 above.

5.5.2.1 Hydrological data requirement

For development of rainfall-runoff relationship, monthly rainfall and concurrent stream flow data is required. The inflows at the G&D sitesare affected by water utilization in the upstream. Hence, the utilization data of the upstream projects as required to compute the gross flow at G&D site, is considered.

5.5.2.2 Time unit for simulation studies

The project envisages diversion of surplus water through weirs / barrage and let in to a stream flowing to Varada river. Daily simulation is carried out to firm up the divertible quantity at 75% dependability at the proposed weirs/barrages.In absence of daily flow data, the estimated net monsoon yields have been proportioned into daily flows based on the daily rainfall data of the major influencing raingaugestation of the respective weir / barrage sites and is used in the daily simulation.

5.6 Compilation and processing of basic hydrological data

5.6.1 Hydrological Investigation

The observed discharge data at Pattanadahalla and Sonda (for Shalamalahalla) sites is available for the period from 1961-62 to 1978-79 (18 years). However upstream utilization data (source wise irrigation data) is available for the period from 1970-71to 1978-79 (8 years) only. In view of the limited data available for computing the virgin yields and to develop rainfall - run off relationship at both these sites, the equation developed at Suremane G& D site on main Bedti river is adopted for generating yield series at Pattanadahalla and Shalamalahalla.

5.6.2 Data from other sources

Most of the data used in this study was collected from other Central and State Govt. agencies.Rainfall data was collected from IMD and Department of Economics and Statistics, Govt. of Karnataka.The inflows at G&D sites werecollected from Karnataka Power Corporation Ltd. and upstream project utilizations were collected from Water Resources Department, Govt. of Karnataka.

5.6.3 Processing of data

The following hydrological variables were processed in this study: (i) Observed rainfall data, (ii) Observed discharge dataand (iii) upstream utilisation data.

5.6.4 Quality of data

There are some missing records in daily rainfall data. The missing data have been estimated using standard statistical methods.

5.6.5 Filling of short data gaps

The rainfall data for the year 1970-71 to 2016-17 is considered for the catchment up to all the three diversion sites. The missing records in rainfall data have been estimated using standard statistical methods. These gaps are filled by the normal ratio formula as given below:

$$P_x = N_x/m\ [\ P_1/N_1 + P_2/N_2 + \ldots\ldots\ P_m/N_m]$$

where,

P_x = estimated rainfall of a station

N_x = normal rainfall of a station

$P_1, P_2 \ldots\ldots\ldots P_m$ = observed rainfall values of neighboring stations

$N_1, N_2 \ldots\ldots N_m$ = normal rainfall values of neighboring stations

5.6.6 Adjustment of records

The observed monsoon discharge is converted to gross monsoon yields by adding net upstream utilisations of the concurrent period to develop rainfall - runoff relationship between weighted average monsoon rainfall and gross monsoon (virgin monsoon yields) at the G & D site.

5.6.7 Consistency of data

Internal consistency

Consistency check of rainfall data

In any analysis, the consistency of the considered data is vital for obtaining reliable and realistic outcome. Therefore, in the above analysis, before using the rainfall data for hydrological analysis, the rainfall records of each of the rain-gauge stations pertaining to the Bedti basin have been checked for continuity and consistency. Double - Mass Curve (DMC) technique is employed to check the consistency of rainfall records. This analysis is based on the principle that when each recorded data comes from the same parent population, they are consistent.

A group of base stations in neighborhood of the index station (for which the consistency test is required) is selected. The data of the monsoon rainfall of the index station X and the average monsoon rainfall of the group of base stations covering a long period is arranged in the reverse chronological order i.e., the latest record as the first entry and the oldest record as the last entry in the list. The accumulated monsoon precipitation of the index station X (i.e., Px) and the accumulated average monsoon

precipitation values of the group of base stations (i.e., Pav) are calculated starting from the latest record. Individual cumulative rainfall values of the index station are plotted against cumulative mean values of group of base stations for consecutive time periods. The plot should be an ascending straight line to indicate good consistency of the rainfall data of the index station with that of the base stations.

In this way, the double-mass curve technique was employed for checking the consistency of all the rain gauge stations considered for hydrological studies in Bedti basin. It was observed that all the rainfall records of the stations are almost consistent, except Gunjavati, which is hence not considered in the study. Hulikal,Soraguppa and Attangi are more influencing raingauge stations to Pattanadahalla,Shalamlahalla and Suremane diversion sites respectively. Double mass curve of these three raingauge stations are given in **Fig. 5.10, Fig 5.11** and**Fig 5.12**respectively.

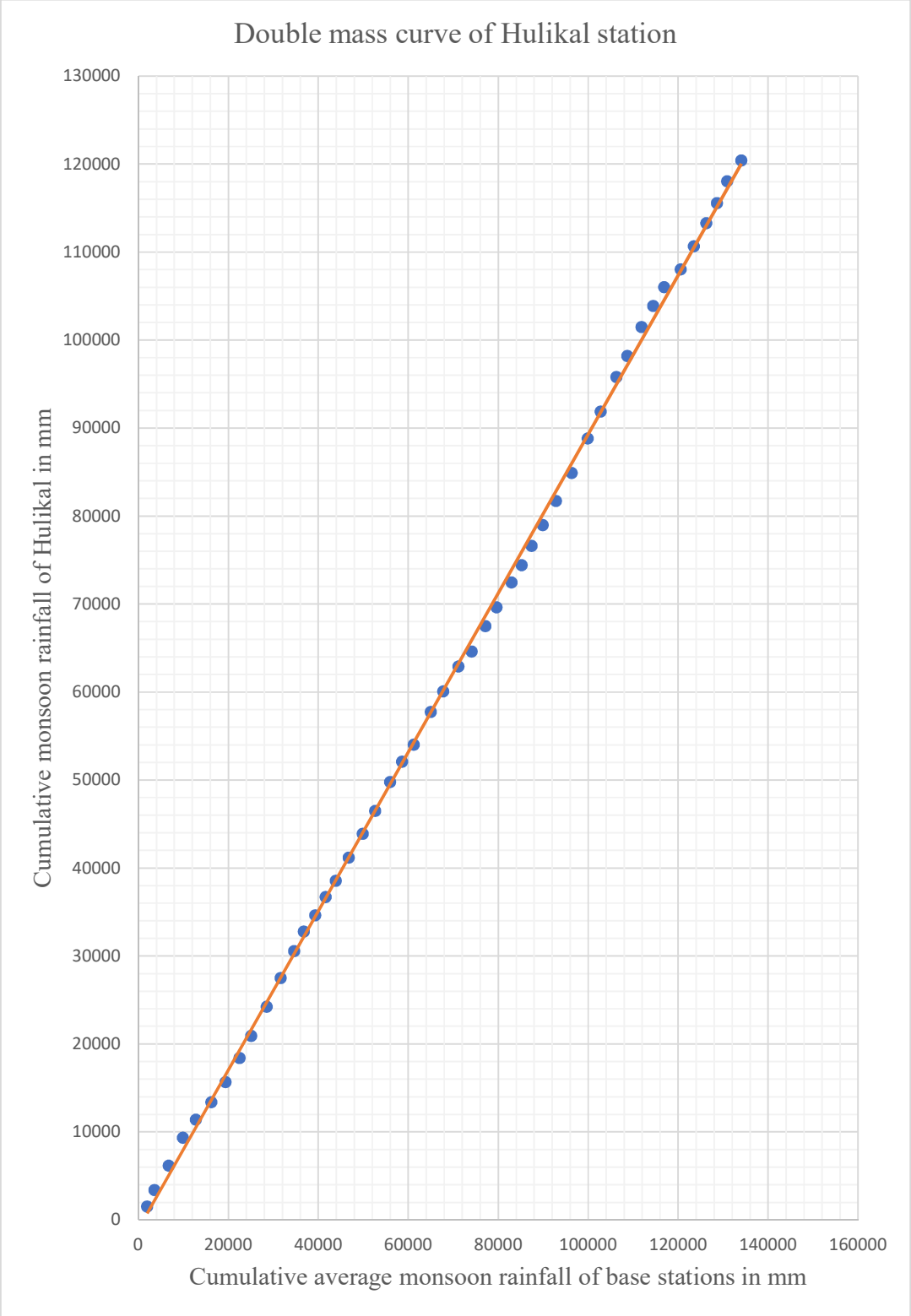

Fig. - 5.10: Double mass curve of Hulikalraingauge station

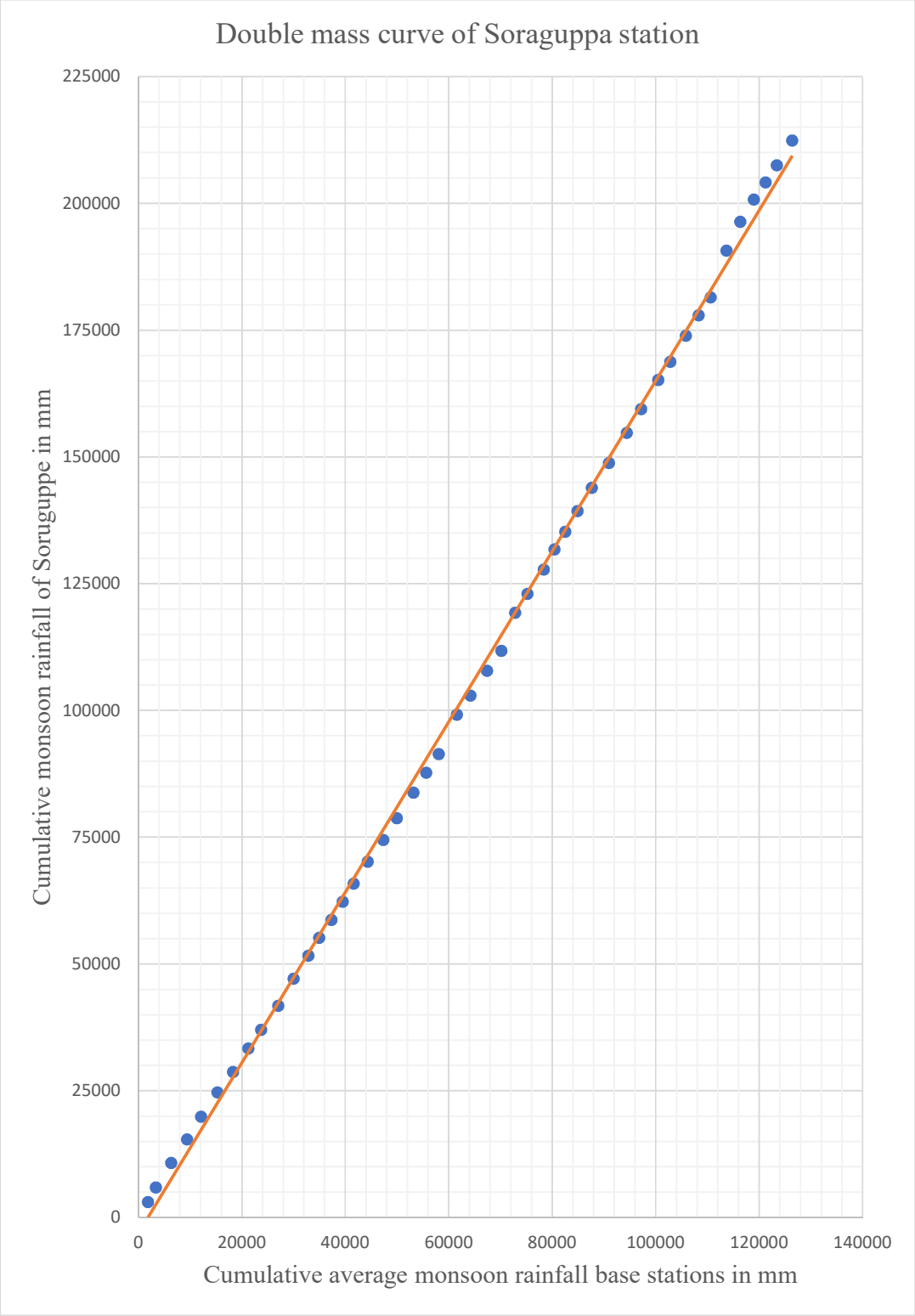

Fig.-5.11: Double mass curve of Soraguppa rain gauge station

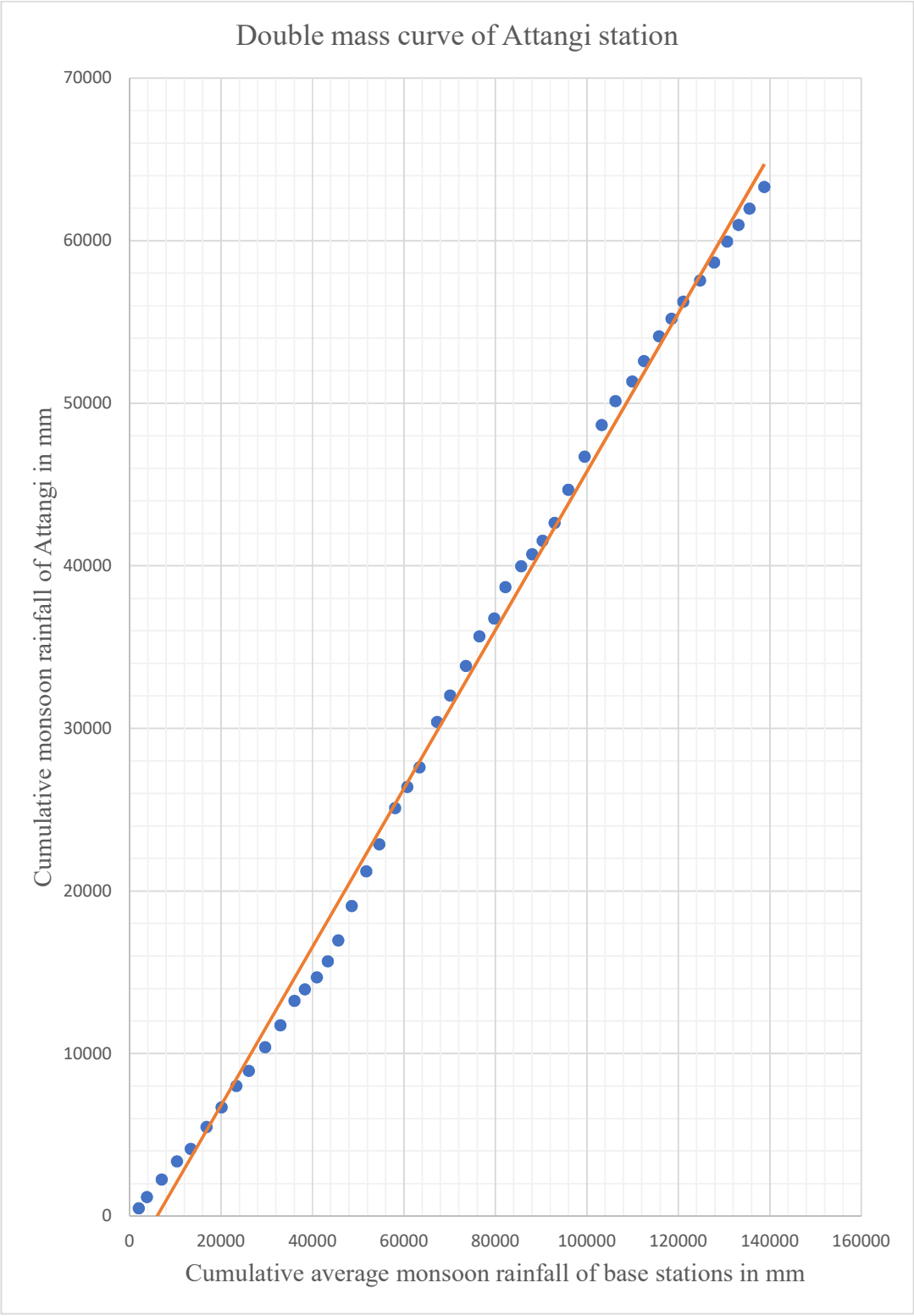

Fig. - 5.12: Double mass curve of Attangi rain gauge station

5.6.8 Availability of rainfall data

Weighted average monsoon rainfall (June to November) for the catchment upto the SuremaneG&D site is computed by Thiessen's polygon method for the period from 1970-71 to 1994-95, considering 14 rain gauge stations located in and around the catchment area. The detailed computations are furnished at **Annexure 5.4.1.**Similarly, the weighted average monsoon rainfall of catchment areas up to the proposed diversion sites viz., Pattanadahalla, Shalamalahalla and Suremane are computed for generating long term yield series at the diversion sites. The weighted average monsoon rainfall for the period from 1970-71 to 2016-17 for Pattanadahalla, Shalamalahalla and Suremane diversion sites is given at **Annexure 5.4.2 to Annexure 5.4.4.** Similarly, the weighted average monsoon rainfall for entire Bedtibasin considering all the 22 stations located in and around the basin is computed and details are furnished at **Annexure 5.4.5.**

5.6.9 Availability of G&D data

The observed discharge data is available for the period from 1970-71 to 1994-95 (with some gaps) at Suremane G & D site across Bedti river.Observed monthly discharge at the Suremane G&D site is furnished in **Annexure-5.5**. The same has been used for developing rainfall-runoff relationship by regression analysis and is used for hydrological studies of Pattanadahalla, Shalamalahalla and Suremanediversion sites.

5.6.10 Upstream utilisation

There are no existing major and medium projects in the catchment up to the proposed SuremaneG & D site. Therefore, the actual upstream

utilisation from minor irrigation through tanks & other sources are considered.There is an import of drinking water from adjacent Malaprabha sub basin to the Hubli - Dharwad twin cities located in the catchment of SuremaneG & D site. The regeneration from this import is duly considered while computing the upstream utilisations.The upstream utilizations are added to the observed monsoon yields (June to November) and the corresponding regenerated flows are subtracted to get the virgin monsoon yields at the G&D site. The computation of gross monsoon yields (virgin monsoon yields) are given in **Annexure 5.6.**

5.6.11 External consistency

The external consistency is checked between gross monsoon runoff at Suremane G & D site **(Annexure 5.6)** and the weighted average monsoon rainfall upto that point **(Annexure 5.4.1).Fig. 5.13** shows the external consistency of the gross monsoon yields.

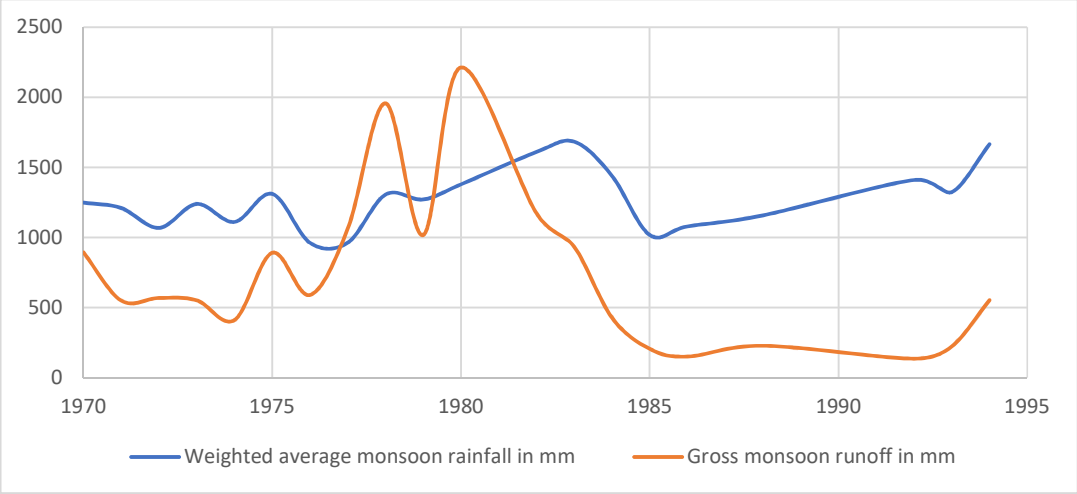

Fig. 5.13: External consistency between Gross monsoon yield and WAMRF atSuremane G & D site

From the above graph, it can be seen that in the years 1977, 1978 and 1980, the gross monsoon run-off is more than the corresponding weighted average monsoon rainfall which is inconsistent. In the absence of

any tangible justification, the data sets for theseyearsare not considered for development of rainfall -runoff relationship.

5.7 Computation of yieldsatPattanadahalla, Shalamalahallaand Suremane diversion sites.

5.7.1 Development of rainfall-runoff equation at Suremane G & D site

Rainfall-runoff relationship is developed by regression analysis, using the gross monsoon yields and corresponding weighted average monsoon rainfall atSuremane G&D site for the period from 1970 to 1994. The results of the regression analysis are furnished in **Table 5.5** below.

Table 5.5

Results of regression analysis at Suremane G & D site

S.No.	Equation	Regression coefficient (r)	Standard error of estimate
1	Linear equation, $X_1 = 1.21514\ X_2 - 887.5742$	0.80	201.05
2	Non-linear equation $X_1 = 1.19965*10^{-6}*X_2^{2.79987}$	0.76	231.48

Based on the least standard error of estimate, the linear equation is found to be the best fit and the same is adopted to generate monsoon yield series for all the three diversion sites as well as for the entire Bedti basin. The regression analysis for linear and non-linear equations is furnished at**Annexure 5.7.1** to**Annexure 5.7.2** respectively.

The graph representing the regression analysis is furnished as **Fig.-5.14**.

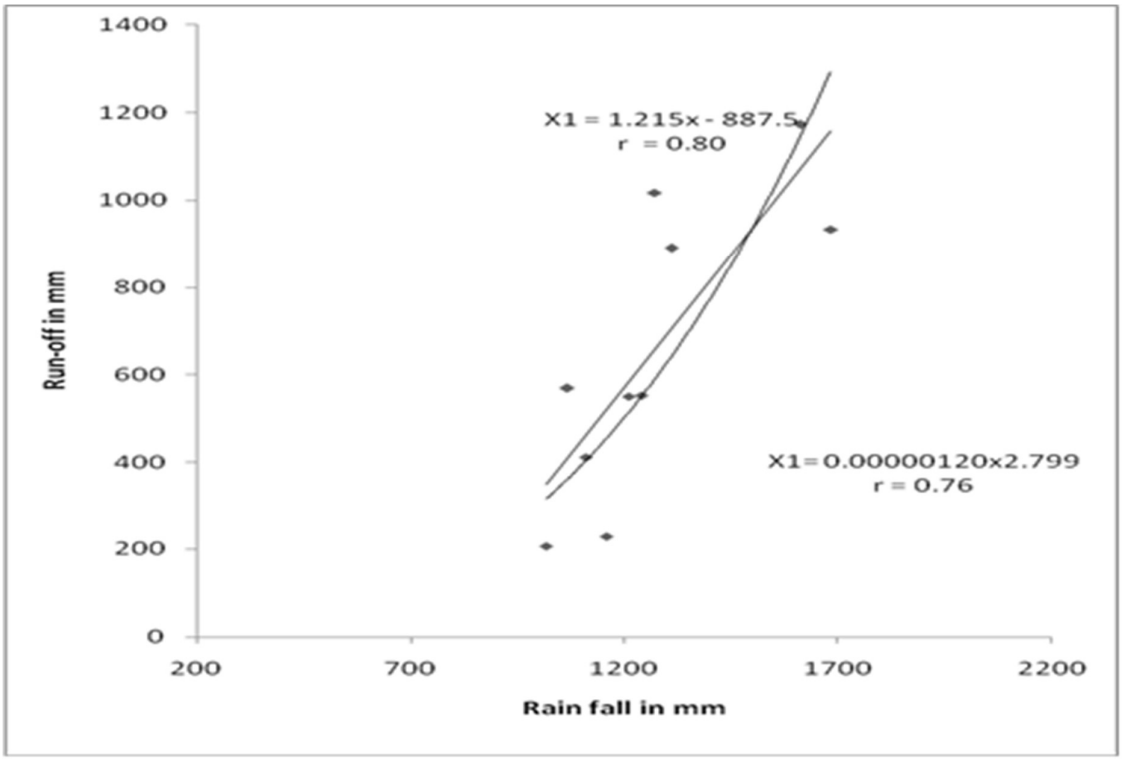

Fig.-5.14: Regression graph at Suremane G&D site

5.7.2 Non-monsoon yields

The non - monsoon yields are considered as percentage of average gross monsoon yields computed from the observed discharge data at respective G & D sites. The non-monsoon yields as percentage of gross monsoon yields at Pattanadahalla, Sonda and Suremane G & D sites are found to be 0.83%, 1.23% and 8.52% respectively and the details are furnished at **Annexure 5.8.1**to **Annexure 5.8.3** respectively. The non-monsoon yields computed as percentage of monsoon yields are added to get gross annual yields at the diversion sites.

5.7.3 Generation of yield series at Pattanadahalla, Shalamalahalla, Suremane diversion sites and for entire Bedti basin.

The best fit linear R-R equation developed at Suremane G & D site (X_1= 1.21514 X_2 - 887.5742) is used to generate long term (1970-71 to

2016-17 = 47 years) yield series at all the three proposed diversion sites in the Bedti basin viz., Pattanadahalla weir, Shalamalahalla weir and Suremane barrage site as well as for the entire Bedti basin. The weighted average monsoon rainfall computed at the three sites (and for the Bedti basin) is substituted in the best fit linear equation to get the estimated gross monsoon yields. The non-monsoon yields computed as average percentage of gross monsoon yields are added to the estimated monsoon yields to get the gross annual yields. The estimated gross annual yield series is arranged in descending order to get the 75% and 50% dependable gross annual yields. However, in case of Suremane site, since the difference in catchment area of Suremane G&D site (2178 Sq.km) and that at Suremane barrage site (2078 Sq.km) is very less, the gross monsoon yields (virgin yields) computed at Suremane G & D site (for the period considered in regression analysis) are used to compute the gross monsoon yields at Suremane barrage site on proportionate area basis. For the remaining period, the same is computed using the best fit equation. The computations of yield series at Pattanadahalla, Shalamalahalla and Suremane diversion sites as well as for entire Bedti basin are furnished as **Annexure5.9.1**to **Annexure 5.9.4** respectively. The 75 % and 50% gross annual yields at the diversion sites and for entire Bedti basin are furnished in the **Table 5.6** below.

Table 5.6

75% and 50% dependable gross annual yields

Sl. No.	Diversion site	Catchment area (Sq.km)	Gross Annual yields (MCM) at	
			75% dependability	50% dependability
1	Pattanadahalla	52.8	184	226
2	Shalamalahalla	169.42	286	365
3	Suremane	2078	583	1247
4	Bedti basin	3902	5877	7614

5.8 Surface water requirement

5.8.1 Domestic water requirement

The human population of the Bedti basin and for the catchment area up to the diversion sites for the year 2011 was estimated on proportionate area basis from the district-wise census records of 2011. The population is projected to 2050 AD adopting the annual compound medium variant growth rates as per the UNO publication "World Population Prospects: The 2019 Revision" using the following formula.

$$P_{(at\ 2050)} = P_{(at\ 2011)} \frac{(1+r)^n}{100}$$

Where,

r = annual compound rate of growth

n = number of years

The computation of population and its projection to 2050AD in respect of Pattanadahalla, Shalamalahalla and Suremanediversion sites and that for entire Bedti basin are furnished in **Annexure 5.10.1**to **Annexure 5.10.4** respectively.

The livestock population has also been projected to 2050 AD using the livestock census of 2019 and considering an annual compound growth rate of 1%.Relevant computations in respect of Pattanadahalla, Shalamalahalla and Suremanediversion sites and that for entire Bedti basin are furnished in **Annexure 5.11.1**to**Annexure 5.11.4** respectively.

The per capita daily water requirement of rural and urban population isconsidered as 70 litres and 135 litres respectively as per the norms prescribed by the Ministry of Works and Housing, Govt. of India in the manual "Water Supply and Treatment". The per capita daily water requirement for livestock has been considered as 50 litres, in the absence of any standard norms.The requirement for 50% of rural population and the

entire urban population is considered to be met from the surface water while the requirement for the remaining 50% of the rural human population and of the entire livestock is considered to be met from ground water.

Thus, the domestic water needs of the catchment up to Pattanadahalla,ShalamalahallaandSuremanediversion sites as well as for entire Bedti basin have been assessed to be0.32MCM,1.01 MCM,26MCM and 37MCMrespectively as shown below in **Table 5.7.**

Table 5.7
Computation of domestic water requirement

Sl No	Site / Category	Population by 2050 AD	Per capita daily needs (liters)	Water needs (MCM)
A	Pattanadahalla			
	Rural	4630	70	0.12
	Urban	5187	135	0.26
	Livestock	3021	50	0.06
	Total			0.44
	Domestic use to be met fromsurface water			0.32
B	Shalamalahalla			
	Rural	14583	70	0.38
	Urban	16643	135	0.82
	Livestock	9694	50	0.18
	Total			1.38
	Domestic use to be met fromsurface water			1.01
C	Suremane			
	Rural	377300	70	10
	Urban	422760	135	21
	Livestock	212910	50	4
	Total			35
	Domestic use to be met fromsurface water			26

D	Bedti basin as a whole			
	Rural	535574	70	14
	Urban	600103	135	30
	Livestock	317278	50	6
	Total			50
	Domestic use to be met from surface water			37

Eighty percent of the domestic water requirement to be met from surface water is considered to be available as regeneration, which works out to 0.10MCM, 0.81MCM,21MCMand 30MCM respectively for catchment up to Pattanadahalla,Shalamalahallaand Suremane diversion sites and Bedti basin respectively.

5.8.2 Irrigation needs

a) Pattanadahalla and Shalamalahalla diversion sites

There are no existing, ongoing major or medium projects in the catchments of Pattanadahalla and Shalamalahalla diversion sites. Annual irrigation from the existing minor projects, tanks and other sources is reported to be 110haand 352harespectively in these catchments. There are no future identified major, medium or minor projects in the catchments upto the two diversion sites. Thus, the total annual irrigation from all the existing, ongoing and identified future major, medium and minor projectsuptoPattanadahalla and Shalamalahalla sites, works out to 110 ha and 352 ha only which is 12.28% and 12.23% of the maximum culturable area of 896ha and 2877 ha respectively.

In basins/sub-basins, where annual irrigation from all the existing, ongoing and proposed projects is less than 60% of culturable area of the basin, additional area is to be considered for providing irrigation for single

dry crop (100% intensity of irrigation), so as to extend the annual irrigation in the basin upto 60% of the culturable area. 50% of such additional area is to be considered under major and medium projects and the remaining 50% from minor projects.

Accordingly, additional area of 428 hauptoPattanadahalla and 1374 hauptoShalamalahallaare considered. However, this additional area is considered under minor projects only as the same is too small to be qualified as medium project (CCA>2000 ha). The details of irrigation through existing and proposed projects in the catchment area uptoPattanadahallasite are furnished in **Annexure 5.12.1.1** and **Annexure5.12.1.2** respectively and those in respect of catchment area uptoShalamalahallaare furnished in **Annexure 5.12.2.1** to**Annexure5.12.2.2** respectively.

b) Suremane diversion site

There are no existing and ongoing major or medium projects in the catchment uptoSuremane site in the Bedti basin. The annual irrigation from existing minor projects (including Attiveri tank and Bachanki tank) is assessed to be 3305 haand that from ongoing minor projects is assessed to be 258 ha. The details are furnished in **Annexure 5.12.3.1** and**Annexure 5.12.3.2**. There is no proposed major project in the catchment. There are two proposed medium projects viz.,Veerapur and Mundgod lift irrigation project in the catchment with an annual irrigation of 7693 ha.The annual irrigation proposed through minor projects is estimated to be 2379 ha. The details are furnished in **Annexure 5.12.3.3**. Thus, the total annual irrigation from existing, ongoing and proposed major, medium and minor projects in the catchment area uptoSuremane diversion site is estimated to be 13635 ha which works out to about 13.60% of the culturable area of 100260 ha of the catchment uptoSuremane site. An additional area of 46521 ha is proposed to

be provided with irrigation to make the annual irrigation in the catchment area upto 60% of the culturable area. Accordingly,23261 hais proposed through future major and medium projects and 23260 ha is proposed through future minor projects.

c) Bedti basin as whole

The annual irrigation from existing projects in Bedti basin is assessed to be 8570 ha and that from ongoing projects is assessed to be 258 ha. The annual irrigation from proposed projects including additional area is estimated to be 66507 ha. The details are furnished in **Annexure 5.12.4.1**to **Annexure 5.12.4.3**respectively.

Crop water requirement

Honavar IMD observatory is located in the close vicinity of the Bedti basin. The monthly potential evapotranspiration and monthly normal rainfall at Honavar IMD station are furnished at **Annexure 5.13.1** and the same are considered for working out the monthly crop water requirement (NIR) of various crops as per the proposed cropping pattern in the Bedtibasin. The computations of monthly crop water requirement are furnished in **Annexure 5.13.2**.Average delta for the proposed medium and minor projects is estimated to be 0.93 m and 0.77 m respectively, the details of which are furnished at **Annexures 5.13.2.1**to **Annexure5.13.2.2** respectively. Similarly, the average delta for additional area (for single dry crop) from medium and minor projects is worked out to be 0.50 m and 0.41 m respectively. The details are furnished in **Annexure 5.13.2.3**. The annual utilization from proposed projects (including additional area) is worked out using the average delta computed as discussed above.

The annual irrigation and corresponding annual utilization from existing, ongoing and proposed projects in the catchment upto the three diversion sites as well as for entire Bedti basin are furnished in **Table 5.8** below.

Table 5.8
Annual Irrigation and utilization from existing, ongoing and proposed projects in Bedti basin

S.No.	Site / Status of project	Annual irrigation (ha)	Annual utilization (MCM)
A	**Pattanadahalla**		
	Existing	110	1.00
	Ongoing	0	0
	Proposed	428	1.80
	Total	**538**	**2.80**
B	**Shalamalahalla**		
	Existing	352	3.10
	Ongoing	0	0
	Proposed	1374	5.60
	Total	**1726**	**8.70**
C	**Suremane**		
	Existing	3305	30.18
	Ongoing	258	2.00
	Proposed	56593	301.55
	Total	**60156**	**333.73**
D	**Bedti basin as a whole**		
	Existing	8570	75.99
	Ongoing	258	2.00
	Proposed	66507	346.65
	Total	**75335**	**424.64**

5.8.3 Industrial needs

In the absence of information on existing, ongoing and future needs of industries, it is assumed that the ultimate requirement of water for industrial purpose would be in the same order as that of total domestic requirement by 2050 AD. Accordingly, the industrial water requirement for the catchment up to Pattanadahalla, Shalamalahalla and Suremane diversion sites would be0.44MCM,1.38MCM and 35MCM respectively. Similarly, the industrial water requirement in the Bedti basin as a whole is 50MCM. The entire industrial water requirement is proposed to be met from surface water resources. 80% of this use is considered to be available as regeneration, which works out to 0.35MCM,1.10 MCM,28MCMand 40 MCM respectively for three catchments and whole Bedti basin.

5.8.4 Hydropower needs

There are no existing, ongoing or planned hydro-power projects in the catchments up to all the threediversion sites as well as in Bedti basin. Hence, no provision is made towards hydropower needs.

5.8.5 Environmental needs

The minimum flow requirement in the river for environmental and ecological needs is considered as 10% of average lean season flow.Accordingly, the environmental needs are worked out as 0.36 MCM, 0.72 MCM and 15 MCM forPattanadahalla, Shalamalahalla and Suremane diversion sites respectively.

5.8.6 Regeneration from irrigation

20% of net water utilisation from all the existing, ongoing and future major and medium projects is considered to be available as regeneration to the stream. Since the utilization for irrigation is less,

regeneration from the utilisations up to Pattanadahalla and Shalamalahallasites are 'negligible'.However, regeneration from irrigation uptoSuremane diversion site and from Bedti basin isworked out to 31MCM and35MCM respectively as shown in **Table 5.9.**

Table 5.9
Regeneration from irrigation use

Unit: MCM

S.No.	Projects	Annual utilisation	Net utilisation	Regeneration
A	**UptoSuremane site**			
	Proposed projects	71.55	59.63	11.93
	Additional area	116.31	96.93	19.39
	Total			**31.32 Say 31**
B	**Bedti basin**			
	Proposed projects	71.55	59.63	11.93
	Additional area	141.09	117.58	23.52
	Total			**35.45 Say 35**

5.9 Water balance

5.9.1 Water balance up to Pattanadahalla,Shalamalahalla and Suremane diversion sites and in whole Bedti basin

The annual water balance takingintoaccount the availability, import, export, regeneration and water needs for theBedti basin and its area up to Pattanadahalla,Shalamalahallaand Suremane diversionsitesare given below in **Table 5.10**.

Table 5.10

Annual water balance at Pattanadahalla, Shalamalahalla and Suremane diversion sites and in Bedti basin

Unit: MCM

		Pattana-dahalla	Shalama-lahalla	Sure-mane	Bedti (whole)
5.9.1.1	**Surface water availability**				
	a) Gross annual yield at				
	i) 75% dependability	184	286	583	5877
	ii) 50% dependability	226	365	1247	7614
	b) Import (+) / Export (-)	0	0	+45	+45
	c) Overall availability at				
	i) 75% dependability	184	286	628	5922
	ii) 50% dependability	226	365	1292	7659
5.9.1.2	**Surface water requirement for**				
	i)Irrigation	2.8	8.7	334	425
	ii) Domestic use	0.32	1.01	26	37
	iii) Industrial use	0.44	1.38	35	50
	iv) Environmental needs	0.36	0.72	15	--
	v) Salinity control	--	--	--	588
	Sub-total	**3.92**	**11.81**	**410**	**1100**
5.9.1.3	**Regeneration from**				
	i) Irrigation use	0	0	31	35
	ii) Domestic use	0.10	0.81	21	30
	iii) Industrial use	0.35	1.10	28	40

	Sub-total	**0.45**	**1.91**	**80**	**105**
5.9.1.4	**Surface water balance at**				
	i) 75% dependability	**181**	**276**	**298**	**4927**
	ii) 50% dependability	223	355	962	6664

From the above, it could be seen that at the three proposed diversion sites as well as in the Bedti basin as whole, there is adequate surplus water available at 75% dependability, after meeting all the in-basin water requirements at the ultimate stage of development.As such, the proposal of diversion of water from west flowing Bedti river to water short catchment of Tungabhadra sub-basin upto Tungabhadra dam is justified.

5.9.2 Water balance of Tungabhadra sub-basin at Tungabhadra dam site

The preliminary water balance study of Tungabhadra sub-basin and at Tungabhadra dam site (T.S.No.65) was carried out by NWDA in October, 1988 and the same has been revised / updated during March, 2016. The RWBS of Tungabhadra basin upto Tungabhadra dam reveled that the catchment is deficit by 712 MCMat 75% dependability. The details are furnished in the **Table 5.11** below.

Table 5.11

Water balance of Tungabhadra sub-basin at Tungabhadra dam

	75% dependability	50% dependability
I. Surface water availability		
a) Gross annual yield	10725	12179
b) Import (+)	0	0
c) Export (-)	7022	7022
d) Overall availability	**3703**	**5157**
II. Surface water requirement for		
i) Irrigation	4540	4540
ii) Domestic use	302	302
ii) Industrial use	465	465

Sub-total	**5307**	**5307**
III. Regeneration from		
i) Irrigation use	278	278
ii) Domestic use	242	242
iii) Industrial use	372	372
Sub-total	**892**	**892**
IV. Surface water balance	**(-)712**	**742**

Water deficit under Tungabhadra LBC

The CCA under Tungabhadra LBC is 324213 ha with a corresponding annual irrigation of 244381 ha.The designed water utilization (as allocated by the KWDT award) for TLBC is 2633.45 MCM (2605.13 for left bank low level canal + 28.32 for left bank high level canal). However, the average utilization under Tungabhadra left bank canal (from 2012-13 to 2019-20) is found to be of the order of 1456.87 MCM against the allocation of 2633.45 MCM. The details are furnished at **Annexure 5.14.**Thus, it could be seen that there is a deficit of about 1177 MCM in the designed utilization under Tungabhadra left bank canal.

Keeping in view the above scenario, 524 MCM of water available in the west flowing Bedti river basin is proposed to be diverted through Bedti - Varada link project (LinkI and Link II) to benefit water short areas under Tungabhadra left bank canal command.

5.10 Quantum of diversion

The annual water balance available at the proposed three diversion sites viz., Pattanadahalla, Shalamalahalla and Suremane at 75%

dependability is 181 MCM, 276 MCM and 298MCM respectively. However, since only weirs/barrage, without major storage, are proposed for diversionduring monsoon months, it is necessary to firm up the quantum of dependable diversion through daily simulation at the proposed sites. Accordingly, net monsoon yields available at diversion sites are arrived by subtracting the corresponding monsoon utilisations (90% of irrigation use and 50% of domestic, industrial and environmental use are considered asmonsoon utilization). The net monsoon yields available at the three diversion sites for the period from 1970-71 to 2016-17 are furnished at **Annexure 5.15.1 to Annexure 5.15.3.**

Distribution of net monsoon yields into daily yields

In absence of observed daily inflow data at any of the diversion sites, the net monsoon yields at the three diversion sites are distributed into daily yields based on the daily rainfall (for the concurrent period) of the most influencing rain gauge stations in respective catchments of the three diversion sites viz. Pattanadahalla (Soruguppa RG station), Shalamalahalla (Hulikal RG station), and Suremane (AttangiRG station).

Daily simulation for LinkI

Daily simulation is carried out at Pattanadahalla during monsoon months (June to November) for the period from 1970-71 to 2016-17, with various daily diversion limits to find out optimum quantum of diversion. It is found that with a daily maximumdiversion of 1.75 MCM, it is possible to divert 113.70 MCM annually at 75% dependability. The daily diverted quantity from Pattanadahalla is added to the daily inflows of Shalamalahalla to arrive at the combined daily inflows for daily simulation at

Shalamalahalla. With a daily maximum diversion of 4.75 MCM, it is seen that a quantum of 302 MCM could be diverted annually at 75% dependability through Link I.

Daily simulation for LinkII

Daily simulation is carried out at Suremane barrage site for the monsoon months, June to November, for period from 1970-71 to 2014-15, and it is seen that with a daily maximum diversion of 6 MCM, an annual quantum of 222 MCMcould be diverted at 75% dependability.

Theannual abstract along with monthly abstracts of daily simulation viz., monthly inflows, monthly diversions and monthly spills at the three diversion sites viz., at Pattanadahalla, Shalamalahalla and Suremane are furnished as are furnished at **Annexure 5.16, Annexure 5.16.1 to 5.16.3, Annexure 5.17, Annexure 5.17.1 to 5.17.3**and**Annexure 5.18, Annexure 5.18.1 to 5.18.3** respectively.

The gross annual yields, water balance and the firmed up divertible quantity at 75% dependability at the three diversion sites are furnished in the **Table 5.12** below.

Table 5.12

Annual yields, water balance and divertible quantity at the three diversion sites

Unit: MCM

Diversion site	75% dependable annual gross yields	75 % dependable water balance	75% dependable divertible quantity
Pattanadahalla	184	181	114

Shalamalahalla (Link-I)	286	276	(Combined) 302
Suremane (Link-II)	583	298	222
Total	**1053**	**755**	**524**

5.11 Effect of project on hydrologic regime

5.11.1 Effect on low flows

Since the diversion is contemplated during monsoon months from weirs and barrage without major storage, no adverse impact on low flows is anticipated. Further, environmental flows at 10% of average lean season flows are earmarked for downstream release from these weirs and barrage.

5.11.2 Effect on peak flood

No storage dams, with flood cushion, are proposed as part of the link project. There are no existing structures on the d/s of proposed diversion sites. Weirs and barrage are designed to pass the entire design flood. As such no effect on peak flood is anticipated.

5.11.3 Effect on total run-off

No reservoir is proposed in the link project. Evaporation from pondage of weirs / barrage is negligible. As such, no decrease in total run-off is anticipated at the diversion sites. The diverted water is proposed to be utilized under the command of existing Tungabhadra project left bank canal.

Since, the utilization is contemplated during the monsoon months only, and the diverted quantity is very small compared to the live storage of the Tungabhadra dam, no additional evaporation loss is considered from the diverted water.

5.11.4 Effect on sediment flow

The catchment areas of the proposed Pattanadahalla, Shalamalahalla and Suremane diversion sites are mostly covered by thick forests and by rocks at fringes and the silt load is expected to be minimum. Around 400 m^3/Sq.km/year of sediment is estimated by KPCL.Under sluices are proposed at the Suremane barrage to flush out bed load portion of the sediment at regular intervals. However, no under sluices are proposed at Pattanadahalla and Shalamalahalla weirs. The settled sediment loadis proposed to be removed during non-monsoon period. No other effect on sediment flow or quality is anticipated because of the link proposal, as no project utilization / enroute utilization is proposed from these weirs/barrage, except use in far away Tungabhadra left bank canal command.

5.11.5 Effect on water demand

While firming up the quantum of diversion from the diversion sites, all in basin water demands at the ultimate stage of development by 2050 AD. Further, the proposed diversion of 524 MCM is only about 9% of the 75% dependable annual grossyield (5877 MCM) of the entire Bedti basin. The diversion is proposed during the monsoon months of June to November only. No adverse effect on water demands / schedule of water use is anticipated.