Chapter 2
Physical Features

2.0 General

The Bedti - Varada link project (Link-1) envisages diversion of302MCMof water from west flowing Bedti river from the surplus available at Pattanadahallaacross 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 barrageacross Bedti river to Dharma project for irrigation under the LBC of Tungabhadra project.

The present chapter deals with the physical features such as geographical disposition, topography and physiography, geology of the basin areas, river system and basin characteristics in respect of both theproposed link projects.

2.1 Geographical disposition

The Bedti - Varada link canal takes off from the proposed Shalamalahalla weir, located across the Shalamalahalla river nearHulgolvillage in Sirsi taluk of Uttara Kannada district of Karnatakastate. Shalamalahalla receives the surplus waters from adjacent Pattanadahalla reservoir also, which is located nearSiralabail village in Sirsitaluk ofUttara Kannada district. Pattanadahalla and Shalamalahalla are proposed to be interconnected by 6.9 km long conveyance which includes

6.5km of tunnel, 0.10 km of approach channel up to tunnel entry & 0.30 km open canal leading to natural stream after tunnel exit which will further lead to Shalamalahalla. The combined watersof Pattanadahalla and Shalamalahallaare further diverted toVarada river, a tributary of Tungabhadra river. The water from Shalamalahalla is proposed to be lifted to a height of about 107.5~~102.15~~ m (static) through raising main of length 10.15 km and is further taken through a 6.7 km long tunnel and 1.73 km long canal to reach a stream leading to Varada river. The total length of conveyance system of Link-I is 25.48km which traverses through Sirsi taluk of Uttara Kannada district.

The Bedti-Dharma link takes off from the proposed Suremane barrage across Bedti river near Suremane villagein Yellapurtaluk of Uttara Kannada districtand is let into a stream joining Dharma reservoir located on Dharma river which is a tributary of Varadariver near village Malgi in Mundgod taluk of Uttara Kannada district. The water from Suremane weir is proposed to be lifted to a height of about 185.5~~220.76~~ m (static). The total length of the conveyance of Link-II is 26.88 ~~24.01~~km which is a combination of tunnel and~~entirely through~~raising mains.

2.2 Topography of the basins, barrage/weirs and benefittedarea\

The Pattanadahalla weir is located near Siralabail village in Sirsi taluk of Uttara Kannada district of Karnataka at $14^0$40’15’’Nlatitude and $74^0$41’18’’E longitude whereas Shalamalahallaweir will be located near Hulgol villageinSirsi taluk of Uttara Kannada district at $14^0$42’26’’N latitude and $74^0$48’31’’E longitude. Suremane barrage is proposed near Suremane village in Yellapur taluk of Uttara Kannada district at

$14^0$52’53’’N latitude and $74^0$47’13’’E longitude. Theproposed pondlevel of the weirs of Pattanadahalla and Shalamalahalla are499.00 m,468.00mrespectively and the pond level of Suremane barrage is 426.00m.

The Dharma reservoir is an existing medium irrigation project on river Dharma. The dam lies at 14^0 45’ N latitude and 75^0 0’ E longitude.The project is located nearMalgi village in Mundgod taluk of Uttara Kannada district. Itis proposed to act as a balancing reservoir for regulatingwater diverted from Suremane diversion site.

The topography of the sub basins/basins and also in the catchments upto the above diversion sites is described briefly in the following paras:

2.2.1 Topography and physiography

a) Bedti basin

The Bedti river is one of the principal west flowing rivers of Karnataka originating at an elevation of +700m from the ranges of hills near Dharwad which flows into Arabian Sea near Gokarna.The catchment area of Bedti basin spreads in Dharwad, Haveri and Uttara Kannada districts of Karnataka. The total catchment area of Bedti basin is 3902 Sq.km.

The Bedti basin is bounded in the north by Malaprabha sub-basin, in the west by Kalinadi basin, in the south by Aghanashini basin and in the east by Tungabhadra sub-basin.

The basin can be divided into two prominent physiographic zones, viz., (i) Hilly region and (ii) Coastal zone. The basin consists of mostly hilly and thickly dense?wooded forests.Coastal lands are densely populated.

b) Basin area uptoPattanadahalla,Shalamalahallaand Suremane diversionsites

The Pattanadahalla stream originates at an elevation of +620m from hill ranges near village Kirgar in Sirsi taluk of UttaraKannada district and joins Sonda river near Gaddemanevillage in the same taluk which further joins Bedti river. The weir across Pattanadahalla stream is proposed near Siralabailvillage. The river bed level at the proposed diversion site is 491 m. The catchment area of the river up to the weir site is 52.8 Sq.km.

The Shalamlahalla stream originates at an elevation of +560m from hill ranges near village Sadashivalli in Sirsi taluk of UttaraKannada district and joins Sonda river near village Sonda, which joins Bedti river. The weir across Shalamalahalla stream is proposed near Hulgol village inSirsi taluk. The river bed level near the weir site is 458m.The catchment area of the river up to the weir site is 169.42 Sq.km.

The Suremane barrage site is proposed on Bedti river near village Suremane in Yellapur taluk of Uttara Kannada district for diverting the surplus water to Tungabhadra sub-basin.The river bed level at the barrage site is 415m. The catchment area of the river up to the barrage site is 2078 Sq.km.

The catchment area upto all the three diversion sites can be divided into two prominent physiographic zones,viz., (i) Hilly region and (ii) The intermediate or transitory sub-mountain region with undulating uplands. The catchment consists of mostly hilly, undulating uplands and thickly wooded forests.

c) Tungabhadra sub-basin

The Tungabhadra sub-basin has a fern leaf type of catchment with an average width and length of 100 km and 531 km respectively. The south-western part of the sub-basin which lies on the eastern slopes of the Western Ghats is hilly and highly undulating and covered with dense and evergreen forests. The central portion of the sub-basin consists of undulating plains and broad flat terrains interspersed with isolated ridges and small hills. The south eastern boundary is the common ridge with the Cauvery basin in the lower part, the Vedavathi sub-basin in the middle part and the Pennar basin in the upper reaches. The northern boundary forms the common ridge with Malaprabha, Middle Krishna and Lower Krishna sub-basins and in the West by Bedti, Aghanashini basins and Malaprabha sub-basin.

The Tungabhadra sub-basin has a catchment area of 47827 Sq.km which is spread in the states of Karnataka, Telangana and Andhra Pradesh. The catchment area of Tungabhadra sub-basin upto Tungabhadra dam site spreads in Bellary, Chikmagalur, Shimoga, Uttara Kannada, Koppal, Gadag, Haveri, Davangere, Dakshina Kannada, Chitradurga and Udupi districts of Karnataka. The catchment area of the sub-basin upto Tungabhadra dam site is 28179 Sq.km.

d) Dharma river/Varada river and sub-basin area upto Dharma reservoir

Dharma is a major tributary ofVarada river in Tungabhadra Sub-basin. Dharma originates from the hill ranges near Islur at an elevation of +620m in Mundgod taluk of Uttara Kannada district. Dharma river joins Varada river near village Haravi in Haveri taluk of Haveri district. Varada

river further joins Tungabhadra river near village Galaganathain Haveri taluk of Haveri district.

The Dharma Reservoir project is an existing medium irrigation project on river Dharma. The project is located at Malgi village in Mundgod taluk of Uttara Kannada district. The river catchment up to the damsite is 97.77 Sq.km.

2.2.2 Topography of the command/ benefited area

The Bedti- Varada and Bedti-Dharmalink canals areproposed to divert water for irrigating the command area under Tungabhadra left bank canal in Raichur districtwhich is a drought prone district of Karnataka identified by DPAP of Government of India.

The undulating black cotton soil strips, cut by numerous nalas, characterize the region of Dharwad schists in the district, which is practically denuded of trees and presents a monotonous landscape. Whereas the gneissic region is generally more or less broken and covered with a thin mantle of red loamy soil. Gneissic hills, sedimentary formations which cover a small belt of the region adjoining the confluence of Krishna and Tungabhadra rivers, occupy more or less flat plateaus.

2.3 Geology of the basin/sub-basin and command area.

Bedti is a west flowing river draining in Uttara Kannada, Haveri and Dharwad districts from which the diversion is proposed,and Varada is a tributary of Tungabhadra riverin Krishna basin and Dharma is a tributary of Varada river. The head works proposed are weirs/barrageand the diverted

water will be utilized in identified drought prone area of Raichur district, whichis left out under Tungabhadra LBC due to shortage of water. The geology of the basin/sub-basin involved in the link project is described briefly in the following sections:

2.3.1 Geology of Bedti basin

The basin consists of rock formations of oldest rocks of earth crust. Rocks of the Archaeozoic also occur in this basin. The Archaean formations are divisible into an older group of sediments, which are highly metamorphosed and classified as Dharwad systems and younger group of plutonic intrusive termed as gneisses. Other rock formations are quartzite, magnetic quartzite, limonite quartzite, sericite-quartz-schist, phyllite, fine grained grey lime stone, dolomite, epidiorite and other igneous rocks. The geology of Uttara Kannada district in which the diversion sites are located is described in the following section.

2.3.1.1 Geology of Uttara Kannada district

Geologically speaking, the region of Uttara Kannada district consists of rock of the earth's crust. Archaeozoic rocks occur over the whole of the district. A system of ridges and plateau characterises the region with the plateau on the west descending rapidly creating between itself and the Arabian sea, a narrow strip of low land covered by alluvium. The low land is regarded as a creation of later period (of glacial and interglacial age) than the up-ghat regions. The Archaean formation comprises the earlier metamorphosed Dharwad system and later peninsular gneisses overlain by laterite cap. The ridge of hills in the western part of the district, sometimes rising to a height of 700 m, nearly runs parallel to the coastline and consists

of varied assemblage of granites and schists. These separate the Sahyadris consisting of Deccan traps in the north from the Western Ghats consisting of Dharwad schists in the south. The eastern part of the district, being entirely hilly, consists of Dharwad and the peninsular gneisses, the latter being found in low ground areas.

2.3.2 Geology of Tungabhadra sub-basin

The important rock formations in the sub-basin are crystalline schists, granitic gneisses, lateritic granites, laterites, quartzites and quartz schists.Hydro-geological studies in the sub-basin have been carried out by the Ground Water Departments of the respective States and the Central Ground Water Board.The studies indicate that ground water occurs in all the geological formation (Archaean granites, gneisses, phyllites and schists) and that the occurrence and movement of ground water in these rocks is controlled by the nature and extent of weathering and the presence of joints and fractures.

2.3.3 Geology of command area(LBC of Tungabhadra project)

The command area to be benefitted under both the link canals in Tungabhadra sub-basin falls in Raichur district of Karnataka state.The district-wise geology ofRaichur districtis furnished in the following sections:

2.3.3.1 Geology of Raichur district

Granites, gneisses and Dharwad schists are the main rock formations in the district. These formations are grouped under ‘hard rock’,

as they do not have any primary porosity. However, secondary porosity is developed due to faults, fractures, joints, and due to weathering, which improved permeability and water yielding capacity of these rocks. Ground water occurs under water table conditions in the weathered and jointed hard rock, and under confined to semi-confined conditions in the fractured rock.

2.4 River system and catchment area

The schematic diagram illustrating an overview of the river system of the Bedti-Varada and Bedti-Dharma link projects is given in **Chapter5: 'Hydrology and Water Assessment'**. The major river systems of the link are described below.

2.4.1 Bedti river

The Bedti river is one of the principal west flowing rivers of Karnataka. The two streams Shalamala and Bedtihalla originate at an elevation of +700 m from the ranges of hills in the west and south of Dharwad district, join near Kalghatgi town and form Bedti river. Pattanadahalla and Shalamalahalla originating in south-eastern ridge of the Bedti basin join Sonda river nearGaddemane village and Sonda village respectively.Sonda is one of the major tributaries of Bedti river. After its confluence with Sonda river, Bedti is popularly known as Gangavali river. Total length of the Bedti river is 152 km. The catchment area of Bedti basin spreads in Dharwad, Haveri and Uttara Kannada districts of Karnataka. The total catchment area of Bedti basin is 3902 Sq.km. The river joins Arabian Sea near Gokarna. The geographical extent of the basin lies between latitudes $14^0$32' N and $15^0$27' N and longitudes 74^0 17' E and $75^0$12' E.

The main tributaries of Bedti river areVibuthi hole, Hulidevarakodlu, Yenne hole, Shalamala andSonda. The bed fall of the river is gentle for the first 72 km (45 m). On its course towards the Arabian sea, the river falls from a height of 180 m at a point called Magod on the western face of the Sahyadri, popularly known as the Magodfalls. Afterwards, the river runs in deep gorges with steep bed falls. The Sondariver joins the Bedti river after the Magodfalls. The river has dense evergreen and semi-evergreen forests along its path.

2.4.2 Tungabhadra/Varada/Dharmariver

The river Tungabhadra is formed by the confluence of the Tunga and the 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 river Tungabhadra flows for about 531 km in a generally north easterly direction through Karnataka, Andhra Pradesh and Telangana and joins the Krishna beyond Kurnool at an elevation of about 264 m.The Varada and Hagari rivers are two important tributaries of the Tungabhadra. The Varada river drains a large area of the Western Ghats and falls into the Tungabhadra at an elevation of about 509 m about 161 km below the confluence of Tunga and Bhadra. The Hagari river joins the Tungabhadra about 169 km upstream of its confluence with the Krishna.The Tungabhadra sub-basin is taken to include the entire catchment of the Tungabhadra and its tributaries except that of the Vedavati. The sub-basin lies between north latitudes 13^0 08’ and 16^0 17’ and east longitudes 74^0 50’ and 78^0 20’.

2.5 Basin characteristics

The basin characteristics of river basins/sub-basins pertaining to the Bedti-Varada link project are described as per the respective Revised/Updated WBS reports and based on the data of IMD publications 'Climatological Tables of Observatories in India (1961-1990) & (1981-2010) and IMDRainfall Normals (1951-2000).

2.5.1 Bedti basin

The Bedti basin experiences the tropical climate. The basin has four distinct seasons viz., dry period from January to February, hot period from March to May, south-west monsoon from June to September and north-east monsoon from October to December. The various characteristics of the basin are described based on the data of Honavar IMD observatory (presented in **Annexure 5.3**) located in the vicinity of the basin.

2.5.1.1 Rainfall

The Bedti basin experiences both south-west monsoon and north-east monsoon. South-west monsoon sets in June and lasts till September. The north-east monsoon strikes the basin in October and continues till November. 95% of rainfall occurs during the monsoon period. The annual rainfall over the catchment varies from 571 mm to 4606 mm. The normal rainfall at the Honavar observatory is 3728 mm.

2.5.1.2 Temperature

The mean daily maximum temperature in the basin varies from 33.4^{o}C to 28.6^{0}C and the mean daily minimum temperature varies from 25.9^{0}C to 20.2^{0}C.

2.5.1.3 Relative humidity

The mean relative humidity is high during the monsoon period and comparatively low during the post-monsoon period. The relative humidity in the basin ranges from 55% in December to 94% in August.

2.5.1.4 Wind speed

Winds blow mainly from south-west during the south-west monsoon season and between north and north-east during the north-east monsoon season. The maximum mean wind speed of 6.0 kmph occurs in June and the minimum mean wind speed of 3.9 kmph occurs in October.

2.5.1.5 Cloud cover

Sky is generally heavily clouded during the monsoon season. During the post-monsoon season, cloudiness decreases. The cloud cover in the basin varies from 1.1 oktas in February to 7.0 oktas in July.

2.5.1.6 Evaporation

Normal monthly potential evapotranspiration (ETo) data computed by the IMD and obtained from the IMD publications - 'Potential Evapotranspiration (PE) over India (Scientific Report No. 136, February 1971)' for Honavar IMD observatoryis presented in **Annexure5.13.1**. It is seen that the monthly ETo varies from 91.7 mm in July to 145.5 mm in March.

2.5.2 Tungabhadra sub-basin

The climate of the sub-basin is characterized by moderate summer and mild winter. The sub-basin is influenced mainly by the south-west monsoon. There are five IMD observatories viz. Bellary, Gadag, Raichur,

Shimoga and Kurnool located in and the vicinity of the sub-basin. Based on the data of these observatories, the sub-basin characteristics are described.

2.5.2.1 Rainfall

The Tungabhadra sub basin experiences mostly south-west monsoon and to some extent north-east monsoon. South-west monsoon sets in June and lasts till October.The average annual rainfall of the sub-basin is 1022 mm. The annual rainfall over the catchment varies from 392 mm to 3504 mm. Whereas, the normal annual rainfall of the five IMD observatories varies from 518 mm to 919 mm as presented in **Annexure2.1**.

2.5.2.2 Temperature

The monthly average maximum and minimum temperature for the five IMD observatories are given in **Annexure 2.2**. The mean daily maximum temperature in the sub-basin varies from 40.5°C in May to 27.8^{0}C in August and the mean daily minimum temperature varies from 27.5^{0}C in May to 15.3^{0}C in January.

2.5.2.3 Relative humidity

The mean relative humidity is high during the monsoon period and comparatively low during the post-monsoon period. The relative humidity in the sub-basin ranges from 22% in March to 87% in August. Data on monthly mean relative humidity for the five IMD observatories are given in **Annexure2.3**.

2.5.2.4 Wind speed

Winds blow mainly from west and south-west during the monsoon season. In the non-monsoon period, winds from north-east and south-east are common.The maximum mean wind speed of 17.4 kmph occurs in July and the minimum mean wind speed of 1.8 kmph occurs in December. Data on monthly mean wind speed for the five IMD observatories are given in **Annexure2.4**.

2.5.2.5 Cloud cover

Sky is generally heavily clouded during the south-west monsoon season. During the remaining part of the year, the sky is clear or lightly clouded. The cloud cover in the sub-basin varies from 0.8 oktas in March to 7.1 oktas in July/August. Data on monthly normal cloud cover for the five IMD observatories are given in **Annexure2.5**.

2.5.2.6 Evaporation

Normal monthly potential evapotranspiration (ETo) data computed by the IMD and obtained from the IMD publications - 'Potential Evapotranspiration (PE) over India (Scientific Report No. 136, February 1971)' & 'Estimation of Weekly Potential Evapotranspiration and Climatic Soil Water Balance for 144 locations in India-2008' for the five IMD observatories are presented in **Annexure2.6**. It is seen that the monthly ETo varies from 95.4 mm in July to 259 mm in May in the sub-basin.