

## **Chapter 2**

### **Physical features**

#### **2.1 Geographical Disposition**

The Mahanadi (Barmul)- Godavari(Dowlaiswaram) link canal takes off from the proposed Barmul reservoir from its right bank and runs to south direction through out its length of 844.595 km in the states of Odisha and Andhra Pradesh, before its out-fall into the Godavari river upstream of the existing Dowlaiswaram barrage. The canal passes through the districts, Nayagarh, Khurda, Ganjam and Gajapati of Odisha state and Srikakulam, Vizianagaram, Visakhapatnam and East Godavari of Andhra Pradesh State.

The alignment and the proposed en route command area of the Mahanadi(Barmul)- Godavari(Dowlaiswaram) link fall in between latitudes 17° 05' N and 20° 30' N and longitudes 81° 45' E and 84° 52' E. The Dowlaiswaram barrage which will be fed with the Mahanadi waters through the link is situated in East Godavari district at latitude 16° 55' N and longitude 81° 45'E.

#### **2.2 Topography of the basins and command area**

The link project including its command area falls in the basins of the Mahanadi, the streams between Mahanadi and Rushikulya, Rushikulya, the streams between Rushikulya and Vamsadhara, Vamsadhara, Nagavali and the streams between Nagavali and Godavari and Godavari. The topography of these basins is described briefly in the following sections.

##### **2.2.1 Mahanadi basin**

The Mahanadi basin lies north-east of the Deccan plateau between latitudes 19° 20' N and 23° 35' N and longitudes 80° 30' E and 84° 50' E. The Mahanadi basin is bounded on the north by the Central India hills, on the south and east by the Eastern Ghats and on the west by the Maikala range. The upper basin is a saucer shaped depression known as "Chhattisgarh". The basin is circular in shape with a diameter of about 400 km and an exit passage of about 160 km long and 60 km wide. There are four well defined physical regions in the basin viz., i) The Northern plateau, ii) The Eastern Ghats, iii) The Coastal plains and iv) The Erosional plains of the Central table land. The Northern plateau and Eastern Ghats are well forested hilly regions. The coastal plains stretching over the districts of Cuttack and Puri cover the large delta formed by the Mahanadi and is a fertile area well suited for intensive cultivation. The erosional plains of the Central Table Land are traversed by the Mahanadi and its tributaries.

##### **2.2.2 Basin covering the streams between Mahanadi and Rushikulya**

There are several streams between the river Mahanadi and Rushikulya flowing east and draining into Chilka lake. This area lies between latitudes  $19^{\circ} 23' 31''\text{N}$  and  $19^{\circ} 58' 55''\text{N}$  and longitudes  $84^{\circ} 57' 05''\text{E}$  and  $85^{\circ} 34' 09''\text{E}$ . The basin is roughly fan shaped and is undulating and sloping without crops of hillocks and eroded mounds. The entire area can be grouped under flat plains with isolated hills and long ridges.

### **2.2.3 Rushikulya basin**

The Rushikulya basin lies between latitudes  $19^{\circ} 07'\text{N}$  and  $20^{\circ} 20'\text{N}$  and longitudes  $84^{\circ} 01'\text{E}$  and  $85^{\circ} 20'\text{E}$ . There are distinct ridges and valleys with sloping medium land in between the entire basin, which can be grouped under long ridges, flat plains and the valleys with isolated hills. The coastal plains of the basin contain more fertile and irrigated lands but towards the center it is hilly with beautiful valleys. The basin is continuously sloping towards main valley. Physiographically the basin can mainly be divided into 6 units viz., i) Uplands, ii) medium lands, iii) low lands, iv) Hill tops and slopes, v) Coastal plains and vi) River bank. The basin is broadly divided into coastal plains in the east and hill and table land in the west. The table land of the west is the continuation of the great range of the Eastern Ghats which is chiefly formed by two plateaus featuring some of the highest mountains.

### **2.2.4 Basin covering the streams between Rushikulya and Vamsadhara**

The important streams flowing east and draining into the Bay of Bengal lying between the river Rushikulya and Vamsadhara are i) Bahuda, ii) Poichendia, iii) Kontiajore, iv) Bogi and v) Mahendra Tanaya. This area lies between latitudes  $18^{\circ} 25'\text{N}$  and  $19^{\circ} 28'\text{N}$  and between longitudes  $84^{\circ} 04'\text{E}$  and  $85^{\circ} 01'\text{E}$ . The topography of the area has characteristic erosional surface with gentle slopes, residual surface such as sloping ridges and folds with very few isolated rocky hills. The area is continuously sloping towards the main valley. Physiographically the land of the area can be mainly divided into six units viz., i) hill top, foot and slope, ii) uplands, iii) medium land, iv) low lands v) non-bounded medium and uplands and vi) river bank.

### **2.2.5 Vamsadhara basin**

The Vamsadhara basin lies between latitudes  $18^{\circ} 17'\text{N}$  and  $19^{\circ} 57'\text{N}$  and longitudes  $83^{\circ} 20'\text{E}$  and  $84^{\circ} 20'\text{E}$ , and lies in Odisha and Andhra Pradesh states. It is bounded on the north by the Mahanadi basin, on the north east by the Rushikulya basin, on the west by the Nagavali basin and on the east by the Bay of Bengal. The catchment area is mostly hilly. Since the surface is mostly covered with kankar and murum, the run-off is moderate in the basin.

### **2.2.6 Nagavali basin**

The Nagavali basin lies approximately between latitudes  $18^{\circ} 10' N$  and  $19^{\circ} 10' N$  and longitudes  $82^{\circ} 53' E$  and  $84^{\circ} 05' E$  and lies in Odisha and Andhra Pradesh states. It is bounded on the north by the Mahanadi and Vamsadhara basins, on the east by the Bay of Bengal on the west by the Godavari basin and on the south by the Champavati and Peddagedda basins. The basin area in Odisha forms undulating hills and valleys whereas the lower portions form gentle to undulating plains.

### **2.2.7 Basin covering the streams between Nagavali and Godavari**

This basin lies between latitudes  $16^{\circ} 51' N$  and  $18^{\circ} 28' N$  and longitudes  $81^{\circ} 45' E$  and  $83^{\circ} 52' E$ . This basin covers about 10 major streams viz., Kandivalasa gedda, Champavati, Gosthani, Borammagedda, Naravagedda, Sarada, Varaha, Tandava, Pampa and Gorrekhandi (Eleru) draining into Bay of Bengal. The basin consists of hill ranges known as agency tract and coastal plains which are well terrestrial and slope gently towards Bay of Bengal.

### **2.2.8 Godavari basin**

The Godavari basin lies between latitudes  $16^{\circ} 16' N$  and  $22^{\circ} 43' N$  and longitudes  $73^{\circ} 26' E$  and  $83^{\circ} 07' E$ . The basin comprises areas in the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Telangana, Andhra Pradesh, Karnataka and Odisha. The Godavari basin is bounded on the north by the Satmala Hills, the Ajanta Range and the Mahadeo Hills, on the south and east by the Eastern Ghats and on the west by the Western Ghats. It is roughly triangular in shape and the main river itself runs practically along the base of the triangle. Except for the hills forming the watershed around the basin, the entire drainage basin of the river Godavari comprises of undulating country, a series of ridges and valleys interspersed with low hill ranges. Large flat areas which are characteristic of the Indo-Gangetic plains are scarce except in the delta. The Sahyadri ranges of Western Ghats form the western edge of the basin. The interior of the basin is a plateau divided into a series of valleys sloping generally towards east. The Eastern Ghats, which form the eastern boundary, are not so well defined as the Sahyadri range on the west. The northern boundary of the basin comprises of tablelands with varying elevations. Large stretches of plains interspersed by hill ranges lie to the south.

## **2.3 Geology of the basins and command area**

### **2.3.1 Mahanadi basin**

The Mahanadi basin predominantly consists of Archaean rocks represented by folded Khondalites, Granite gneisses and Charnockite. They are interbanded and the first two appear to grade into one another. Field relationship of these rocks is complex and it is difficult to assign any age relationship. It is generally agreed

that the rocks were deposited during Archaean era (2000 - 2500 Million years) and were folded and metamorphosed by at least two tectonic activities. The rocks have experienced metamorphic conditions of amphibolite facies to granulite facies. Magmatization appears to have played a major role in resulting present state of rocks. The area has been reported to have experienced block faulting during Gondwana times and area u/s of Barmul appears to be a Graben.

### **2.3.2 Basin covering the Streams between Mahanadi and Rushikulya**

The area of the basin covering the streams between Mahanadi and Rushikulya mostly comprises of consolidated gneiss rock formation and semi-consolidated tertiary sedimentaries. Alluvium is also found in the catchment. Alluvial track extends almost to entire length of coastal area. Groundwater is available in the region of alluvium in the confined and unconfined aquifers below 300 m.

### **2.3.3 Rushikulya basin and the basin covering the Streams between Rushikulya and Vamsadhara**

Geologically, the Rushikulya basin and the basin covering the streams between Rushikulya and Vamsadhara mostly comprise of Khondalite and Charnockite groups of rock formations. The catchment also comprises gneiss rock formation next to the Khondalite and Charnockite rocks. The rock has given rise to different soils through different process of weathering and erosion. Alluvium is also found in the catchment. Groundwater is available in the region of alluvium in confined and semi-confined aquifers below 250 m.

### **2.3.4 Vamsadhara basin**

The main geological formations in this area are Dharwars, peninsular granites, puranas, Gondwanas and Archaeans. The groundwater occurs under unconfined conditions in the joints, fissures and fractures extending to deeper levels beneath the weathered zone.

### **2.3.5 Nagavali basin**

The geological structure of the Nagavali basin is formed by pleistocene deposits along the coastal belt along the course of the river and its major tributaries. The greater part of the basin is underlined by Khondalites and unclassified crystallines. Groundwater is found under confined conditions in joints, fissures and fractures extending to deeper levels beneath the weathered zone.

### **2.3.6 Basin covering the streams between Nagavali and Godavari**

The basin area covering the streams between Nagavali and Godavari displays a wide spectrum of geological formations ranging in age from the most ancient to

recent unconsolidated formations. The major streams between Nagavali and Godavari are Kandivalasa gedda, Champavati, Gosthani, Borammagedda, Naravagedda, Sarada, Varaha, Tandava, Pampa and Gorrekhandi (Eleru). The main geological rock formations in the area are Khondalites and Charnockites. The Charnockites occur in parallel narrow bands in between the much wider band of Khondalites and are usually found on higher elevations of the hills. Pakhals are exposed all along the peripheral areas of Godavari valley. Gondwanas are found as disconnected out crops. Intratrappean beds associated with lime stones are also found in the area. Recent to sub-recent deposits of the basin are alluvium, beach sands and Laterite soils. Beds of clay and sand, gravel and boulders belonging to alluvial, stretch along the coast. The thickness of unconsolidated formations varies from 60 m to 100 m. Hydrogeological studies conducted in the area indicate that the groundwater occurs under confined conditions in joints, fissures and fractures extending to deeper levels beneath the weathered zone. The groundwater occurs in both confined and unconfined conditions in the Gondwana formations.

### **2.3.7 Godavari basin**

Different parts of the Godavari basin bear different distinct geological formations. The upper reaches of the basin and the area forming Pravara and Purna sub-basins mainly comprise Basalts which form part of the Deccan trap. These are extruded from fissures type of volcanoes during the upper cretaceous – lower Eocene age. The Deccan traps, not being porous are incapable of holding or transmitting water in their primary stage. The basaltic lava, however, developed a vesicular character on the top layer due to escaping of steam and gas. Similarly, the cooling lava had produced hexagonal joint systems in hard flows. Such vesicular and jointed lava became important water bearing formations.

In the area forming Manjra sub-basin, the main geological rock formations are the peninsular granites, the Puranas and the Gondwanas. The presence of zeolites in the cavities of rock and moorum indicate abundant water circulation. The groundwater occurs under both the confined and unconfined conditions.

The main geological rock formations found in the middle reaches of the Godavari basin and the area forming the Maner sub-basin are the peninsular granites, Puranas, Dharwars and Gondwanas. The hydrogeological studies in the area indicate that the groundwater occurs under confined conditions in joints, fissures, fractures and crevices extending to deeper levels beneath the weathered zone. In the peninsular gneiss and Gondwanas, the groundwater occurs in unconfined conditions, where the yields are higher.

The area comprising Penganga, Wardha and Pranhita sub-basins forms part of the peninsular shield area composed of the Archaean formation. Lying over the Archaean mass are Deccan trap lavas and Gondwanas which can mainly be

assigned to the precambrian and partly to the cambrian age. The hydrogeological studies indicate that the groundwater occurs in the Vindhyan groups, Gondwanas, Deccan traps, laterites and alluvium, in the soil cover, weathered mantle and in the highly jointed and fractured zones of the hard rock.

The lower reaches of the Godavari basin, and the areas comprising Indravati and Sabari sub-basins, geologically form part of the great Archaean Peninsular shield. The important rock formations found are Pakhals, Sullavais, Peninsular granites, Dharwars, Khondalites and Charnockites ranging in age from the lower precambrian to upper cretaceous. Ground water occurs in the weathered, fractured, sheared zones and also along the schistose planes of gneiss, schists and granites of the area. Groundwater also occurs in confined conditions, in the areas occupied by calcareous formation and the argillaceous and arenaceous members of the Lower Gondwana age. Alluvium of the area by virtue of its high porosity and permeability acts as potential aquifer.

### **2.3.8 Command area**

The command area proposed en route the link falls in the basins of Lower Mahanadi, the streams between Mahanadi and Rushikulya, Rushikulya, the streams between Rushikulya and Vamsadhara, Vamsadhara, Nagavali and the streams between Nagavali and Godavari. The geological features of these basin areas are described in the preceding paras.

## **2.4 River system and catchment area**

The river systems and the respective catchment areas of the Mahanadi and the Godavari rivers along with the other intervening rivers are briefly described below.

### **2.4.1 Mahanadi basin**

The Mahanadi is one of the major peninsular rivers of India draining into Bay of Bengal. It rises in a pool, 6 km from Pharsiya village near Nagri town in Raipur district of Chhattisgarh state at an elevation of 457 m. The Mahanadi splits into several streams just before falling into the Bay of Bengal. The total length of the river is about 851 km out of which 357 km is in Chhattisgarh and 494 km is in Odisha. The important tributaries of river Mahanadi are i) Sheonath, ii) Jonk, iii) Hasdeo, iv) Mand, v) Ib, vi) Tel, and vii) Ong. The drainage area of the Mahanadi is 141589 km<sup>2</sup> extending in Madhya Pradesh (107 km<sup>2</sup>), Chhattisgarh (75229 km<sup>2</sup>), Odisha (65889 km<sup>2</sup>), Maharashtra (238 km<sup>2</sup>) and Jharkhand (126 km<sup>2</sup>) states. The state- wise / district-wise and sub-basin-wise distribution of the drainage area of Mahanadi basin is given at **Annexure 2.1**. The index map of Mahanadi basin is appended as **Plate 4**.

Barmul is a proposed project on river Mahanadi proposed by the Odisha state, from which the proposed M-R-G link takes off. The proposed Barmul dam site is located about 17 km upstream of Manibhadra dam site. NWDA has prepared water balance study report of Mahanadi at Manibhadra. Hence the details in this report have been made use in this FR keeping in view of proximity. The catchment area of the Mahanadi up to Barmul dam site is 122454 km<sup>2</sup>. The State- wise / district-wise and sub-basin-wise distribution of the drainage area of Mahanadi basin upto Barmul dam site is given at **Annexure 2.2**.

#### **2.4.2 Basin covering the streams between Mahanadi and Rushikulya**

There are several streams flowing between Mahanadi and Rushikulya river systems and draining into the Chilika lake. The important streams are i) Todinala, ii) Dultal dhara nadi, iii) Kharia or Khaljhor nadi, iv) Kusumi nadi, v) Salia nadi and vi) Khalhor nadi. The catchment area of the basin is 1320 km<sup>2</sup> and roughly fan shaped. The entire catchment area lies in Odisha state in three districts viz., Khorda (675 km<sup>2</sup>), Nayagarh (276 km<sup>2</sup>) and Ganjam (369 km<sup>2</sup>).

#### **2.4.3 Rushikulya basin**

The river Rushikulya is one of the important rivers of Odisha flowing east and joining the Bay of the Bengal. It originates from Digi village on eastern slope of Eastern Ghats in the undivided Phulbani district at an elevation of about 1000 m. The length of the river is about 160 km. The important tributaries are Padma, Badanadi, Baghua and Goraharah. The catchment area of the Rushikulya basin is 8024 km<sup>2</sup> which lies in Kandhamal (882 km<sup>2</sup>), Nayagarh (271 km<sup>2</sup>), Khorda (21 km<sup>2</sup>), Gajapati (668 km<sup>2</sup>) and Ganjam (6182 km<sup>2</sup>) districts of Odisha.

#### **2.4.4 Basin covering the streams between Rushikulya and Vamsadhara**

As mentioned earlier, the important streams flowing east and draining into the Bay of Bengal between the river Rushikulya and Vamsadhara are i) Bahuda, ii) Poichendia, iii) Kontiajore, iv) Bogi and v) Mahendra Tanaya. The catchment area of these streams is 3790 km<sup>2</sup> and is roughly fan shaped. The catchment area lies in Ganjam (1724 km<sup>2</sup>), Gajapati (186 km<sup>2</sup>) districts of Odisha and Srikakulam district of Andhra Pradesh (1880 km<sup>2</sup>).

#### **2.4.5 Vamsadhara basin**

The Vamsadhara is an important east flowing river between Mahanadi and Godavari. The river rises just south of the Belagad village in the undivided Phulbani district of Odisha at an elevation of about 600 m. The total length of the river is about 221 km of which 125 km is in Odisha, 23 km is as boundary between Odisha and Andhra Pradesh and 73 km is in Andhra Pradesh. The important tributaries of Vamsadhara are Chuvaldhua, Poladi, Gangudu, Sannanai

and Mahendratana, Bhangipedda, Peddagedda and Bellagedda. The catchment area of the Vamsadhara river is 10830 km<sup>2</sup> of which 8926 km<sup>2</sup> lies in Odisha state (1178 km<sup>2</sup> in Khandamal, 191 km<sup>2</sup> in Kalahandi, 4056 km<sup>2</sup> in Rayagadda and 3501 km<sup>2</sup> in Gajapati districts) and 1904 km<sup>2</sup> lies in Andhra Pradesh state (221 km<sup>2</sup> in Vizianagaram and 1683 km<sup>2</sup> in Srikakulam districts).

#### **2.4.6 Nagavali basin**

The Nagavali river rises in the eastern slopes of the Eastern Ghats in the Kalahandi district of Odisha at an elevation of about 915 m. The total length of the river is about 256 km of which about 161 km lies in Odisha, 2 km form the boundary between Odisha and Andhra Pradesh and about 93 km lies in Andhra Pradesh. The main tributaries of the river Nagavali are Barha, Baldiya, Satnala, Sitagurha, Srikona, Janjavati, Gumudgedda, Vottigedda, Suvarnamukhi, Vonigedda, Relligedda and Vagavati. The catchment area of the basin is 9410 km<sup>2</sup> of which 4462 km<sup>2</sup> lies in Odisha state (434 km<sup>2</sup> in Kalahandi, 2384 km<sup>2</sup> in Rayagada, and 1664 km<sup>2</sup> in Koraput districts) and 4948 km<sup>2</sup> lies in Andhra Pradesh State (1789 km<sup>2</sup> in Srikakulam, 3096 km<sup>2</sup> in Vizianagaram and 63 km<sup>2</sup> in Visakhapatnam districts).

#### **2.4.7 Basin covering the Streams between Nagavali and Godavari**

There are several small and big streams flowing between rivers Nagavali and Godavari and draining into Bay of Bengal. The important streams are Peddagedda, Kandivalasa, Champavati, Gosthani, Maddigedda, Mahadrigedda, Borrammedda, Naravagedda, Sarada, Varaha, Tandava, Pampa and Eleru. The lengths of these streams varies from 26 km to 125 km. The catchment area of the basin is 15058 km<sup>2</sup> which lies entirely in Andhra Pradesh State (473 km<sup>2</sup> in Srikakulam, 2977 km<sup>2</sup> in Vizianagaram, 7512 km<sup>2</sup> in Visakhapatnam and 4096 km<sup>2</sup> in East Godavari districts).

#### **2.4.8 Godavari basin**

The river Godavari is the second largest in the country and the largest in Southern India covering about 10% of the geographical area of the country. It rises in the Sahyadri hills at an altitude of about 1067 m near Triambakeswar in the Nasik district of Maharashtra state and flows across the Deccan plateau from the Western Ghats to Eastern Ghats. Rising in the Western Ghats about 80 km from the shore of the Arabian sea, it flows for a total length of about 1465 km in a general south - eastern direction through the States of Maharashtra, Karnataka, Telangana and Andhra Pradesh before joining the Bay of Bengal at about 97 km south of Rajahmundry in Andhra Pradesh. The index map of Godavari basin is shown in **Plate 5**.



The major tributaries joining the Godavari are (i) Pravara, (ii) Purna, (iii) Manjra, (iv) Maner, (v) Pranhita, (vi) Penganga, (vii) Wardha, (viii) Wainganga, (ix) Indravati and (x) Sabari. The total drainage area of the Godavari basin is 312813 km<sup>2</sup>, extending over Maharashtra (152199 km<sup>2</sup>), Karnataka (4406 km<sup>2</sup>), Telangana (57829 km<sup>2</sup>), Andhra Pradesh (15372 km<sup>2</sup>), Madhya Pradesh (26168 km<sup>2</sup>), Chhattisgarh (39087 km<sup>2</sup>) and Odisha (17752 km<sup>2</sup>) states.

## **2.5 Basin Characteristics**

### **2.5.1 Mahanadi basin**

#### **2.5.1.1 Rainfall**

The spatial variation in rainfall is moderate in the basin. More than 90% of the total annual rainfall occurs during monsoon season spread over from June to October. The annual rainfall varies from 1032 mm to 1166 mm over the entire basin. The hydrological map of Mahanadi basin showing the locations of IMD observatories and G & D sites is given at **Plate 6**. The map of Mahanadi basin showing Isohyets is presented at **Plate 7**.

#### **2.5.1.2 Temperature**

January is the coldest month with the mean minimum temperature ranging between 13.80<sup>o</sup> C to 30.60<sup>o</sup> C in land. May is the hottest month in this region where the mean maximum temperature ranges from 22.60<sup>o</sup>C over the hills to 35.80<sup>o</sup> C in the plains. As compared to eastern portion and delta area, western portions record the lowest and highest temperatures during winter and summer respectively. The diurnal range of temperatures during July-August is of the order of 5<sup>o</sup> C – 6<sup>o</sup> C and the same during winter is maximum and is of the order of 14<sup>o</sup> C to 16<sup>o</sup> C.

#### **2.5.1.3 Relative Humidity**

The highest relative humidity in the basin varies between 67% and 85% and occurs during July/August. The lowest relative humidity occurs during April/May and varies between 80% and 85%. The average highest relative humidity in the basin is 81% and the average lowest relative humidity is 78%.

### **2.5.2 Intervening basins between Mahanadi and Godavari**

There are six basins between Mahanadi and Godavari viz., (i) Basin covering the Streams between Mahanadi and Rushikulya, (ii) Rushikulya, (iii) Basin covering the Streams between Rushikulya and Vamsadhara, (iv) Vamsadhara, (v) Nagavali, and (vi) Basin covering the Streams between Nagavali and Godavari. The characteristics such as rainfall, temperature, humidity, wind velocity and cloud cover of these 6 intervening basins are presented below in **Table 2.1**.

**Table 2.1**  
**Basin characteristics of the intervening basins**  
**between Mahanadi and Godavari**

Basin	Mean annual rainfall (mm)	Mean temperature (°c)		Relative humidity (%)		Maximum wind velocity (kmph)	Cloud Cover (Octas)	
		Max.	Min.	Max.	Min.		Max.	Min.
1. Basin covering the streams between Mahanadi and Rushikulya	1166	37.7	13.2	85	67	12.8	6.6	1.8
2. Rushikulya basin	1166	37.7	13.2	85	67	12.8	6.6	1.8
3. Basin covering the streams between Rushikulya and Vamsadhara	1127	38.4	13.5	84	67	15.2	6.6	2.0
4. Vamsadhara basin	1127	38.4	13.5	84	67	15.2	6.6	2.0
5. Nagavali basin	1127	38.4	13.5	84	64	15.2	6.6	2.0
6. Basin covering the streams between Nagavali and Godavari	1032	41.3	13.7	78	62	8.8	6.3	2.1

Source: Climatological data 1981-2010(Published by IMD, Pune)

### 2.5.3 Godavari basin

#### 2.5.3.1 Rainfall

Like most parts of India, the Godavari basin receives the major portion of its rainfall during the south-west monsoon period. The other rainy seasons are not so well defined and well spread as the south-west monsoon season. They contribute only about 16% of the total annual rainfall in the Godavari basin.

January and February are almost entirely dry in the Godavari basin, the rainfall during these two months being less than 15 mm. During the next three months up to end of May, it varies from 11 mm to about 63 mm in most parts of the basin.

#### 2.5.3.2 Temperature

The Godavari basin has a tropical climate. The mean annual surface temperature in the Western Ghats area is about 13.70° C, and it increases gradually towards the east and attains a maximum of 41.30° C on the east coast. During January, which may be taken as a typical winter month, the mean daily minimum temperature going from west to east, increases from 14.50° C, on the Western

Ghats to about 32.00° C on the east coast; the mean daily maximum temperature generally exceeds 32° C in the western part of the Godavari basin and it is only slightly less than 32.90° C in the eastern part.

#### **2.5.3.3 Relative Humidity**

The relative humidity is high in the basin during the south-west monsoon season. With the withdrawal of the monsoon, humidity gradually decreases and in summer the air is generally dry. The climate generally remains dry for about 7 months in the year from November to May. The maximum relative humidity is generally recorded during July/August and the minimum during April/May. The maximum relative humidity in the basin varies between 62% and 78%, the average being 70%.

#### **2.5.3.4 Wind Speed.**

Winds are generally light to moderate with increasing speeds in the later part of summer and during monsoon. In the south-west monsoon season, winds blow mostly from directions between south-west to north-west. In the post-monsoon period and cold seasons, winds are mainly from directions between north and north-east. In the summer season winds mainly blow from directions between west and north. The maximum wind speed in the basin varies between 7.30 kmph and 16.00 kmph, the average maximum wind speed being 10.8 kmph over the basin. The minimum wind speed varies between 5.1 kmph and 8.8 kmph, the average minimum speed being 6.65 kmph.

#### **2.5.3.5 Cloud Cover**

The skies are heavily clouded and overcast during the south-west monsoon season. During the rest of the year clear and lightly clouded skies prevail. The maximum cloud cover in the basin varies between 2.10 octas to 6.30 octas, the average being 4.20 octas. The minimum cloud cover ranges from 0.70 octas to 3.2 octas, the average being 1.95 octas. Clouds in the atmosphere reduce the amount of sunshine that reaches the vegetation and evaporation losses are also reduced.