

Chapter-1

Introduction

1.1 General

Water is the most essential natural resource next to air, required for sustaining life on the earth. It is required for drinking and industrial uses, for irrigation to meet the growing food and fiber needs, for power generation, navigation and recreation. The development, use and conservation of water, therefore, play a vital role in the country's development planning. The water resources in the country are, however, limited considering the future demands. The rainfall in the country is mostly confined to monsoon season and is unevenly distributed with respect to both space and time. As a result, some parts of the country are affected by frequent droughts whereas floods affect other parts. Nearly, one third of the country is drought prone. In the very near future, water will become a scarce resource due to increasing thrust of population and increasing demands for various uses. Therefore, it need not be emphasised that water should be harnessed in the most scientific and efficient manner.

The monsoon flood waters should be conserved to the maximum extent possible to meet the demands for irrigation, power generation, domestic and other uses. The water availability and requirements in the various river basins need to be assessed realistically. The reasonable basin requirements should be provided for and the surplus water, if any, should be transferred to the needy areas. The National Water Policy adopted by the Government of India in September, 1987 and subsequently revised and updated in 2002 & 2012 emphasizes that water should be made available to water short areas by transfer from other areas including transfers from one river basin to another, based on a national perspective.

1.1.1 National perspective for water resources development

Realizing the need for achieving a uniform development of water resources reducing regional imbalances, the erstwhile Union Ministry of Irrigation and the Central Water Commission (CWC) formulated, in the

year 1980, a National Perspective Plan (NPP) for water resources development which comprises two components viz. the Himalayan rivers development and the Peninsular rivers development. The distinctive feature of the National Perspective Plan is that the transfer of water from surplus basin to deficit basin would essentially be by gravity and only in some small reaches it would be by lifts not exceeding 120 metres.

(a) Himalayan rivers development

Himalayan rivers development envisages construction of storage reservoirs on the main Ganga and Brahmaputra and their principal tributaries in India and Nepal, along with inter-linking canal systems to transfer surplus flows of the eastern tributaries of the Ganga to the west, apart from linking of the main Brahmaputra with the Ganga. This component would provide additional irrigation of about 22 million ha and generation of hydropower of about 30 million KW, besides providing substantial flood control in the Ganga and Brahmaputra basins. It would also provide the necessary flow required to flush the Kolkata port and for the inland navigation facilities across the country.

(b) Peninsular rivers development

This scheme envisages, as its first part, the diversion of surplus flows of the Mahanadi to the Godavari system and further transfer along with the surplus water from the Godavari system to the water short Krishna, Pennar, Cauvery, Vaigai and Gundar basins. This would benefit areas of Andhra Pradesh, Karnataka, Maharashtra, Orissa, Tamil Nadu and Puducherry. The second part is to construct storages and to inter-link the small west-flowing rivers along the west-coast, north of Mumbai and south of the Tapi, for transfer of surplus waters to the needy areas of Saurashtra and Kutch regions. Another scheme under this part envisages water supply to the metropolitan area of Mumbai. The third part envisages inter-linking of the southern tributaries of the Yamuna by constructing a dam on the Yamuna at Panchnad besides construction of small storages in the system to benefit the Ujjain and Indore areas of Madhya Pradesh and the Bundelkhand region of Uttar Pradesh. The fourth part of the proposal is to divert a part of the surplus waters of the west-flowing rivers of Karnataka and Kerala to the east

for benefiting the drought areas on the eastern side of the Western ghats apart from bringing new areas on the western side under irrigation.

The Peninsular rivers development component is expected to provide additional irrigation benefits to more than 13 million ha in the States of Andhra Pradesh, Orissa, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu, Puducherry and Uttar Pradesh besides generation of about 4 million KW of power.

(c) Overall benefits

The National Perspective Plan proposal would thus, give additional irrigation benefits of 35 million ha i.e. 25 million ha from surface waters and 10 million ha by increased use of ground waters, over and above the ultimate irrigation potential of 140 million ha from Major, Medium and Minor projects and generation of about 34 million KW of power, apart from the benefits of flood control, navigation, water supply, fisheries, salinity, pollution control, etc.

Besides economic development, large scale additional employment potential would be created in the rural areas where agriculture is the main occupation which continues to be the dominant factor of the Indian economy, contributing to 60% of the value of the total gross national product.

The National Water Development Agency (NWDA) was set up in July, 1982 to give concrete shape to the Peninsular Rivers Development Component of the National Perspective Plan for water resources development. The Himalayan Rivers Development Component of the National Perspective Plan was also later entrusted to NWDA in 1990. Further, in 2006, preparation of Detailed Project Reports (DPRs) of link projects under NPP and pre-feasibility/feasibility reports of Intra-State links as proposed by States were also included in the functions of NWDA. The functions of NWDA were further modified in 2011 to undertake the work of preparation of DPRs of Intra-State links also.

1.2 Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai-Gundarlink scheme

The National Water Development Agency took up and completed hydrological analysis of various river basins to assess the water balance position in the basins at the ultimate stage of water resources development (by the year 2050). As per the water balance studies of NWDA, there are considerable surplus waters in Mahanadi and Godavari river basins. On the other hand, Krishna, Pennar, Cauvery, Vaigai and Gundar basins were found to be water deficit. It has been estimated that there will be a net surplus of 22058 Mm³ at the proposed Manibhadra dam site on Mahanadi and a surplus of 15020 Mm³ at the proposed Polavaram dam site on Godavari at 75% dependability after meeting the existing and projected future water requirements within these basins.

The scheme of linking the surplus river basins of Mahanadi and Godavari to the deficit basins of Krishna, Pennar, Cauvery and Vaigai is the most important part of the various proposals for inter-basin transfer of water under the Peninsular Rivers Development Component of the National Perspective Plan explained in section 1.1.1 above. After examining several alternatives, NWDA has formulated a scheme by which the transfer of water from surplus basins to the deficit basins would be carried out through nine link canals. The Southern water Grid is shown in **Plate 1.1**. These nine link canals are briefly described below:

Mahanadi-Godavari Link Canal Project

- (i) Mahanadi (Manibhadra) – Godavari (Dowlaiswaram) Link Canal Project:

A quantity of 12165 Mm³ from Mahanadi basin will be diverted through this link canal. After meeting enroute requirements of Odisha and Andhra Pradesh, a quantity of 6500 Mm³ will be delivered upstream of Dowlaiswaram barrage on Godavari.

Godavari-Krishna Links

- (ii) Godavari (Polavaram) – Krishna (Vijayawada) Link Canal Project:
5325 Mm³ of water will be diverted through this link canal for irrigating lands enroute as well as for stabilizing the existing ayacut of Vijayawada barrage in Krishna delta. This includes 2265 Mm³ (80 TMC) originally planned to be transferred from Godavari under Godavari Water Dispute Tribunal Award.
- (iii) Godavari (Inchampalli)–Krishna (Nagarjunasagar) Link Canal Project:
16426 Mm³ of water comprising of surplus waters of both Mahanadi and Godavari will be transferred through this link canal. Out of this 14200 Mm³ will be delivered into Nagarjunasagar reservoir after meeting enroute requirements. This link necessitates lifting of water from Inchampalli reservoir through 107 m in four stages.
- (iv) Godavari (Inchampalli) – Krishna (Pulichintala) Link Canal Project:
4370 Mm³ of water is proposed to be diverted through this link canal. The entire quantity will be utilized for irrigation in the commands under Inchampalli RBC, Nagarjunasagar Left and Right Bank Canals.

Krishna – Pennar Links

- (v) Krishna (Almatti) – Pennar Link Canal Project:
A quantity of 1980 Mm³ of water will be diverted through this link canal. The entire quantity will be utilized for enroute irrigation in Krishna and Pennar basins.
- (vi) Krishna (Srisailam) – Pennar Link Canal Project:
2310 Mm³ of water is proposed to be diverted through this link canal. No enroute irrigation is planned under this link canal.

Except transmission losses of 215 Mm³, the entire balance quantity will be let into Pennar river.

(vii) **Krishna (Nagarjunasagar) – Pennar (Somasila) Link Canal Project:**

A quantum of 9790 Mm³ of water will be diverted through this link canal. After meeting the enroute irrigation and domestic supply requirements, 8426 Mm³ of water will be delivered into Somasila reservoir on Pennar.

Pennar – Cauvery Link

(viii) **Pennar (Somasila) – Cauvery (Grand Anicut) Link Canal Project:**

A quantity of 8565 Mm³ of water will be diverted through this link canal apart from a quantity of 890 Mm³ provided to Telugu Ganga Project. After meeting enroute requirements, a quantity of 3855 Mm³ will be delivered at Grand Anicut on Cauvery.

Cauvery – Vaigai – Gundar Link

(ix) **Cauvery (Kattalai) – Vaigai – Gundar Link Canal Project:**

2252 Mm³ of water will be let into this canal for providing irrigation in the small basins south of Cauvery. After crossing Vaigai, the canal will terminate in Gundar, a small stream draining into the Gulf of Mannar.

A schematic diagram showing the nine link canals described above is given at **Plate 1.2**. It should be noted that the link canal proposals presume that the new projects of Manibhadra (in Orissa) and Inchampalli (in Telangana), Polavaram and Pulichintala (in Andhra Pradesh) will be in position by the time the link canals are taken up.

1.3 Godavari (Inchampalli) – Krishna (Nagarjunasagar) link canal project

The nine link system has been planned based on the proposed storages at Manibhadra on Mahanadi & Inchampalli on Godavari. These two dams

have not been taken up so far by the State Govts. in view of submergence and inter state issues.

The planning of Mahanadi - Godavari link is under revision in consultation with Govt. of Odisha. Once the issue of surplus water in Mahanadi basin is finalized with the concurrence of Govt. of Odisha, the amount of water that can be transferred to Godavari basin can be quantified. Further, the supplementation from Himalayan component to Mahanadi basin is also proposed which is yet to be finalized.

This link canal proposes to irrigate the command areas proposed under Kakatiya canal stage-II of Sri Ram Sagar Project and Srisailem left bank canal. A portion of the quantity diverted will be discharged into Nagarjunasagar reservoir for further diversion to water short Pennar and Cauvery basins after meeting the enroute requirements in Krishna basin and other intermediate basins as possible.

The Godavari (Inchampalli) – Krishna (Nagarjunasagar) link canal project comprises of the following components.

- i) Head works at proposed Inchampalli barrage across river Godavari in Mahadevpurmandal of JayashankarBhupalapally district with full pond level (FPL) of 87m so as not to affect Kaleswaram project upstream and restrict the submergence to river portion.
- ii) Link canal of length about 1211 km from the proposed Inchampalli barrage to Grand Anicut via existing Musi, Nagarjunasagar, Somasila reservoirs, comprising open canal, lifting arrangements and tunnels.
- iii) Lifting arrangements through 4 stages of 57m (RD 0.0 km), 38m (RD 18.0 km), 23.2m (RD 26.50 km) and 11.0m (RD 60.50 km) totaling to 129.20m of static lift on main canal; a lift of 52.63m for Kakatiya Stage II feeder branch (at RD 97.50 km on main canal), lifting through 3 stages of 64.50 m (RD 0.00 km), 58.0 m (RD 75.00 km) and 74 m (RD 95.00 km) for

the 116 km long Gottimukkala feeder branch canal (taking off at RD 199.15km on main canal) totaling to 196.50m; a lift of 67.14m for Srisailam LBC feeder branch (Alimineti Madhava Reddy LIS) from Nagarjunasagar reservoir.

- iv) One tunnel each at RD 86.35 km of 9.15 km length in the reach from Inchampalli to Nagarjunasagar; 1.3 km long tunnel from RD 302.786 to RD 304.101 km; 4 km long tunnel at the offtake of link canal near headworks of Somasila; one km tunnel from RD 700.976 km to RD 701.976 km; and 3.1 km long tunnel from RD 826.776 to RD 829.876 km.
- v) Two powerhouse complexes one on canal at Musi reservoir with a head of about 9.70m and another powerhouse at canal head at Nagarjunasagar reservoir with a head of about 20m.
- vi) Existing Nagarjunasagar on river Krishna, Somasila on river Pennar as balancing reservoirs enroute.
- vii) In all, 30 branch canals and 7 direct sluices / feeders to facilitate irrigation enroute and in the existing irrigation systems through piped distribution.
- viii) Command area of 887022 ha is proposed to be brought under irrigation in Telangana, Andhra Pradesh and TamilNadu. This will fetch about 944572 ha of irrigation annually as detailed below.
 - a) New areas of 453017 ha as detailed below :
 - i) New area of 80000ha under the proposed Gottimukkala branch canal to irrigate fluoride affected mandals of Munnugodu and Chandur in Nalgonda district as requested by Govt of Telangana.
 - ii) New area of 168017 ha of area between Krishna and Pennar rivers in Prakasam and Nellore districts
 - iii) New area of 205000 ha of area between Pennar and Cauvery in Nellore, Chittoor districts of Andhra

Pradesh and Tiruvallur, Vellore, Kancheepuram, Tiruvannamalai, Villupuram Cuddalore districts of TamilNadu

- b) Stabilisation of existing commands to an extent of 434005ha (491555 ha of annual irrigation) as detailed below:
- i) Stabilisation of command under SRSP to an extent of 178055ha in the drought prone Warangal Plateau, Nalgonda and Khammam districts in Telangana, partly by gravity and partly by lift.
 - ii) Stabilisation of 109250 ha of endemically drought prone upland areas under the Srisailem left bank canal (SLBC) in Nalgonda district in Telangana by lifting from offshore of Nagarjunasagar reservoir through AMRLIS.
 - iii) Stabilisation of 90000 ha under Nagarjunasagar right bank canal (NSRBC) to irrigate 126000 ha annually in Guntur district of AP
 - iv) Stabilisation of Cauvery delta to an extent of 56700 ha to irrigate 78250ha annually in Thanjavur district of TamilNadu
- ix) Number of cross drainage/ cross masonry and regulating works across the link canal.
- x) Canal top solar power generation arrangement at appropriate reaches along the link canal alignment.
- xi) The existing Grand Anicut as outfall structure on river Cauvery with Full Pond Level 59.22 m.

Detailed studies of the alignment of the proposed Godavari (Inchampalli) – Krishna (Nagarjunasagar) link canal project have been carried out on toposheets of scale 1:50,000 and field surveys like topographical and other special surveys have been completed. Based on these studies, the feasibility of the proposal has been assessed. **Plate 1.3** shows the link alignment studied for water transfer between Godavari

and Cauvery under phase-I, The salient features of the link canal project are presented in **Annexure 1.1**.

1.4 Aim of the link project and description of works

The nine link system has been planned based on the proposed storages at Manibhadra on Mahanadi & Inchampalli on Godavari. These two dams have not been taken up so far by the State Govts in view of submergence and interstate issues.

The planning of Mahanadi - Godavari link is under revision in consultation with Govt of Odisha. Once the issue of surplus water in Mahanadi basin is finalized with the concurrence of Govt of Odisha, the amount of water that can be transferred to Godavari basin can be quantified. Further, the supplementation from Himalayan component to Mahanadi basin is also proposed which is yet to be finalized.

Views of concerned states

National Water Development Agency (NWDA) prepared a technical feasibility note and Memorandum of Agreement (MoA) for preparation of DPR and sent to Govt of Chhattisgarh, Telangana, Andhra Pradesh, Tamil Nadu, Puducherry, Karnataka, Odisha for their concurrence. In response to the above, Governments of Chhattisgarh, Puducherry and Telangana submitted their views/ comments which are given below.

Government of Chhattisgarh

The proposed utilization from Indravati waters of Chhattisgarh, in the link project should be reviewed as the state of Chhattisgarh is already in deficit in view of its estimated demand of 10884 Mm³ against water allocation of 8360 Mm³ by GWDT. The consent of Govt. of Odisha is imperative for Mahanadi – Godavari link project. Fulfillment of water demand of Chhattisgarh in summer months shall be ensured while implementing the proposed Godavari – Cauvery link project.

Government of Tamil Nadu

The Godavari – Cauvery link project has to be taken as National Project. The DPR has to be prepared without waiting for the concurrence of co-basin states. Tamil Nadu state does not have any objection for taking up this project.

Government of Telangana

The Government of Telangana is of the view that it is premature to sign MoA before establishing the availability of surplus water after duly considering all the requirements of basin states. The hydrological studies should be conducted by Government of India.

Government of Puducherry

Detailed project report (DPR) proposed to be prepared shall also consider the feasibility of linking of Godavari (Inchampalli) - Krishna (Nagarjunasagar) -Pennar (Somasila) - Cauvery (Grand Anicut) with south Ponniyar. South Ponniyar shall be linked with Sankaraparani river to benefit the downstream villages of Puducherry districts. Interests of Puducherry shall be protected by ensuring that the UT gets additional quantum of water, on prorata basis, vis a vis the quantum of water to be shared by the stake holder states while implementing this project. This shall be in addition to 7 TMC of Cauvery water allocated through the final Award of Cauvery Water Disputes Tribunal (CWDT), the quantum of which, has since been upheld by the Hon'ble Supreme Court.

The comments of the State Govts and the replies given by NWDA on the DPR of Godavari-Cauvery link project are presented in **Annexure: A**.

Views of Central Water Commission (CWC)

The Central Water Commission (CWC), carried out the water availability studies of Indravati sub-basin of Godavari basin (Nov, 2016) considering inflows at Pathagudem G&D for the period from 1985 to 2014 according to which, the gross yield at 75% dependability is 23170 MCM. This is against the corresponding yield of 21166 MCM as estimated by

NWDA. Thus, the yield of NWDA is on the conservative side and the same is used for computations.

Further, Central Water Commission submitted their report on the technical feasibility note circulated by NWDA in December 2017 stating that the study carried out by NWDA is in order and advised to carryout consistency checks for homogeneity. Further CWC clarified that after complete utilization of its share by Chhattisgarh, the availability of 247 TMC may only be possible at 50% dependability.

In view of the above, an **alternate plan** to utilise the surplus waters of Godavari basin in water short Krishna, Pennar and Cauvery basins has been devised. Now, it is proposed that the originally contemplated nine link system will be taken up in two phases.

- a) Phase I: Identifying surplus waters in Godavari basin without affecting the interests of the co-basin States and transferring these waters upto Cauvery through Godavari - Krishna - Pennar - Palar – Cauvery link system while meeting the requirements of the areas enroute, to the extent possible.
- b) Phase II: Linking Brahmaputra - Ganga -Subernarekha - Mahanadi - Godavari rivers, thus enriching the Phase I with suitable modifications.

Phase I comprises the following links:

1. Godavari (Inchampalli) - Krishna (Nagarjunasagar) link
2. Krishna (Nagarjunasagar) -Pennar (Somasila) link
3. Pennar (Somasila) - Cauvery (Grand Anicut) link

Phase II comprises the following additional links:

1. Mahanadi (Manibhadra) - Godavari (Dowlaiswaram) link
2. Godavari (Polavaram) - Krishna -Pennar link (being planned by Government of Andhra Pradesh)
3. Godavari (Inchampalli) - Krishna (Pulichintala) link project
4. Krishna (Almatti) - Pennar link
5. Krishna (Srisailam) - Pennar link

6. Cauvery (Grand Anicut) - Vaigai – Gundar link

In **Phase I**, the surplus water available in Godavari basin along with the unutilized waters of Chhattisgarh in Indravati sub-basin shall be diverted to Krishna, Pennar and Cauvery basins. Nagarjunasagar on Krishna river and Somasila on Pennar river will be used as balancing reservoirs to transfer water upto Grand Anicut on Cauvery while meeting the enroute requirements in Telangana, Andhra Pradesh and Tamil Nadu. The state of Karnataka shall derive benefits in Phase - II through the Krishna (Almatti) - Pennar link. The salient features of the link project are presented in **Annexure 1.1**. The salient features of Inchampalli barrage, Nagarjunasagar reservoir, Somasila reservoir and Grand Anicut are given in **Annexures 1.2 to 1.5** respectively.

A meeting was held on 17.05.2018 under the Chairmanship of Hon'ble Minister (WR, RD& GR) with Hon'ble Minister, Water Resources, Government of Chhattisgarh to discuss the various issues involved in Godavari– Cauvery (Grand Anicut) link project. Hon'ble Minister, WR Government of Chhattisgarh suggested that the NWDA should carry out survey & investigations (S&I) and prepare DPR. Thereafter, the issue of implementation of the project can be discussed with all the concerned states for concurrence. The Hon'ble Minister, (WR, RD& GR) felt that S&I and preparation of DPR are part of consensus building process and NWDA should first undertake and complete DPR without approaching the states concerned for concurrence. Accordingly, NWDA has taken up the preparation of DPR of the Godavari– Cauvery (Grand Anicut) link project.

1.5 Location of project area

The Godavari (Inchampalli) – Cauvery (Grand Anicut) link project traverses through Godavari, Krishna, Pennar, Palar and Cauvery basins and lies in the States of Telangana, Andhra Pradesh and Tamil Nadu. The alignment of the link canal passes through the districts of Jayashankar Bhoopalapally, Khammam, Waranagal, , Nalgonda of Telangana, Guntur, Prakasm, Nellore, Chittoor districts of Andhra Pradesh and Tiruvallur, Kancheepuram, Tiruvannamalai, Villupuram and Cuddalore districts of Tamil Nadu.

The water balance studies at Inchampalli on the river Godavari below Sri Ram Sagar Project reveal that there will be surplus water of 5002 Mm³ at 75% dependability after the full development in the basin expected to be attained by 2050 AD. In working out the surplus water, about 2978 Mm³ is estimated as requirement of major and medium irrigation projects of Chhattisgarh in Indravati sub-basin. Further, about 1477 Mm³ of water is earmarked for evaporation losses from the proposed hydropower projects of Chhattisgarh in Indravati sub-basin. These projects in Chhattisgarh are likely to take a few more years for their implementation. Hence, it is proposed to consider diversion of the water allocated for these projects through the link project for now. Thus, the estimated irrigation requirement of the future major and medium projects (2978 Mm³) and the likely evaporation losses from the future hydro power projects (1477 Mm³) of Chhattisgarh State in Indravati sub-basin of Godavari basin are also considered as available waters for diversion after duly deducting the regeneration (266 Mm³) from irrigation projects which was estimated to be available while assessing the water balance. Thus, the total water available in Godavari basin for planning in peninsular component of inter-basin water transfer will be about $(5002+2978+1477-266) = \mathbf{9191\ Mcum(324\ TMC)}$.

However, in the absence of sufficient storage on Godavari, a diversion of about 7000 Mcum(247 TMC) is envisaged from Inchampalli barrage on Godavari to Nagarjunasagar on Krishna during monsoon season. The Godavari (Inchampalli) – Krishna (Nagarjunasagar) link is the first leg/reach-I of the Godavari (Inchampalli) - Cauvery (Grand Anicut) link project which is proposed as phase-I of Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai-Gundar nine link system which envisages to provide irrigation, domestic and industrial water supply benefits to the water deficit areas in Krishna, Pennar, Cauvery and other intermediate basins. Thus, the Inchampalli - Nagarjunasagar link which connects Godavari to Krishna, is a vital “Link” in the overall Peninsular rivers development component of National Perspective Plan.

1.6 Communication facilities

The proposed Inchampalli barrage, the head works of the link canal, are located downstream of the confluence of Indravati river with the Godavari river. The nearest rail head is Pedddapalli. The nearest airport is at Hyderabad about 300km from the headworks.

The link canal takes off from Inchampalli and passes in the vicinity of Warangal, Nalgonda in Telangana and falls into Nagarjunasagar. Taking off from Nagarjunasagar, it traverses in the vicinity of Macharla, Karampudi, Vinukonda, Tripuranthakam, Darshi, Podili, Kanigiri, Duttaluru and Pamuru towns in Andhra Pradesh and outfalls into the Somasila reservoir. Taking off from the Somsila reservoir the link canal traverses through Kotturupalle, Gonupalle, Kakulakonda, Vellamapalle, Mokklapudi, Kanudu and Kavanuru in Andhra Pradesh, Sivvada, Nagavedu, Kilambi, Vippedu, Perunagar, Melama, Nallur, Dadapuran, Mattur, Arkadu, Kiliyuru, Kuvvadu, Asanur, Adanur, Kudikadu, Kodukur, Kilaiyur, Dalamaipuram, Pulambadi, Lalgudi, Mettupatti and Satmangalam in Tamil Nadu and finally outfalls into the Grand Anicut.

Thus, the entire link canal traverses in the vicinity of many villages and towns. The head works, balancing reservoirs and canal alignment are well approachable by means of highways, major district roads and village roads of bituminous top. All the villages/towns in the vicinity of head works, balancing reservoirs, link canal alignment are fully electrified and connected by telephone lines. Detailed information on the communication network in the project area is presented in Chapter 4: Surveys & investigations.

1.7 General climatic conditions of the states and project area

The climate of the Telangana and Andhra Pradesh is characterized by hot summer and mild winter. The sub-basin is affected by both south west and the north east monsoons. There are three seasons prevailing in the project area, summer from March to May, monsoon from June to November, the winter from December to February. The state of Tamil Nadu gets south-west monsoon from June to September, northeast monsoon from

October to December. The state experiences winter from January to February and summer from March to May.

1.8 General topography, physiography and geology of the project area

(i) *Godavari Basin*

The Catchment area of Godavari upto Inchampalli barrage is 269000 km². 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 range of Western Ghats forms the Western edge of the basin. The interior of the basin is a plateau divided into a series of valleys sloping generally towards the 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 elevation. Large stretches of plains interspersed by hill ranges lie to the South.

(ii) *Krishna Basin*

The catchment area of Krishna basin upto Nagarjunsagar reservoir is 220705 Km². The Krishna basin is bounded on the north by the common ridge separating it from Godavari basin, on the south and east by the Eastern Ghats and on the west by Western Ghats. Except for the hills forming the watershed round the basin, the entire drainage basin of the river comprises of rolling and undulating country and a series of ridges and valleys interspersed with low hill ranges. Large flat areas of the type seen in the Indo-Gangetic plains are scarce except in the deltas. The interior of the basin in its middle reaches is a plateau, the greater part of which is at an elevation of 300 to 600 m. Its general slope is eastwards. Great undulating plains divided from each other by flat topped ranges of hills are the chief characteristics of this plateau. The hill sides are marked by conspicuous, wide terrain except in the southern part of the plateau where the hills are frequently crowned with great 'tors' or rounded hummocks of bare rock as a result of constant weathering.

(iii) Gundlakamma basin

The river Gundlakamma is the largest of the small independent east flowing rivers between the Krishna and the Pennar. The Gundlakamma basin lies in Deccan plateau. The basin is arcshaped. The upper catchment of the basin is mostly hilly with dense forests. The middle portion comprises of small groups of hillocks and the lower portion is plain.

(iv) Basin area of the streams between Gundlakamma and Pennar

The basin area of the streams between Gundlakamma and Pennar comprises of mainly three independent east flowing rivers viz. the Musi, the Palleru and the Manneru. The three rivers in their upper reaches flow in the Velikonda hills and thereafter immediately enter the plains. To a limited extent, the upper reaches are covered with dense forests and the remaining area with moderate to low altitude hill range. The catchment area of the basin is fan shaped and the boundaries are Gundlakamma basin in the north, Pennar basin in the south and west, and the Bay of Bengal in the east. The basin lies in Andhra Pradesh covering an area of 9886 km² in the districts of Prakasam and Nellore.

(v) Pennar basin

The Pennar basin extends over an area of 55213 km² and the drainage area of Pennarbasin upto Somasila Dam is 50492.5 Km². The Pennar basin is a fan shaped basin and is bounded on the north by the Erramala hills, on the east by the Nallamala and Velikonda hills of Eastern Ghats, on the south by the Nandidurg hills and on the west by the narrow ridge separating it from Vedavati valley of the Krishna basin. After Somasila gorge, the basin is moderately flat and then the coastal delta area begins. The interior of the Pennar basin has long ridges with isolated hills and small streams except in the deltas. The delta of the river Pennar is formed by deposits at the mouth of the river over the ages which consists of river borne alluvium.

(vi) Basin area covered by the streams between Pennar and Palar

There are seven river systems in the basin and these are grouped together to form the basin of streams between Pennar and Palar . They are (i) Kandaleru (ii) Swarnamukhi (iii) small streams draining into the

pulicatlake, (iv) AraniAr(v) Kortalaiyar, (vi) Cooum and (vii) Adyar. The catchment area of the basin is roughly rectangular in shape, having average length and breadth of about 173 km and 94 km respectively. The basin is bounded on the north by Pennar delta sub-basin and west by Lower Pennar sub-basin and Palar basin and south by Palar basin and east by Bay of Bengal. There are three major topographical divisions in the basin; the upper reaches the general topography of the basin is hilly and rather rugged with abrupt diverse slopes conducive to appreciable erosion. The coastal uplands have undulation to rolling topography while the delta is flattish and even trough shaped at places.

(vii) *Palar basin*

The total length of the Palar river is 348 km and it drains an area of 17871 km². There are three major topographical divisions in the basin i) the hilly ranges at the upper reaches separating the Pennar and Ponnaiyar basins ii) the table land or the plateau region and iii) the coastal plains. The catchment area of the basin is roughly rhombus in shape with broader width in the middle reach and narrow width at the upper and lower reaches. The basin is bounded by Pennar basin in north “Streams between Pennar and Palar” basin in the north-east and Bay of Bengal in the east and by the “Streams between Palar and Cauvery” basin on the west and south.

(viii) *Basin area covered by the streams between Palar and Cauvery*

This basin area with a total catchment of 27048 km² and comprises of the combined catchments of four rivers viz. Ongur, Varahanadi, Ponnaiyar and Vellar. Ponnaiyar and Vellar rivers with their tributaries are the two major rivers in this basin area. It is bounded on the north by the Palar river basin, on the west and south by the Cauvery river basin and on the east by the Bay of Bengal. The shape of this basin area resembles the letter ‘L’ with maximum width of 250 km in the western portion and 100 km in the eastern side. This basin has a coastal line extending over 125 km.

(ix) *Cauvery basin*

The catchment area of the Cauvery basin is 81155 km² and the area of the basin up to Grand Anicut is 70129 km². The Cauvery basin is bounded on the north by the ridges separating it from Krishna and Pennar basins, by

the Eastern Ghats on the east and south and by Western Ghats on the west. The upper reach of the basin is covered with hill ranges of the Western Ghats and the sub-basin areas are broad and open with gently undulating country. In the north-west and south, there are a number of hill ranges which have steep slopes. The maximum length of Cauvery basin from west to east is 540 km. The maximum width from north to south is 255 km.

The area of the sub-basin comprises of an extensive plateau of an elevation of about 640 m above MSL at the source and about 52 m above MSL near its confluence with the river Krishna with scattered hills. The sub-basin has the shape of an arc with an average length and width of 225 km. and 45 km respectively. The geological rock formations of the sub-basin are the peninsular granites, the Puranas and the Deccan traps. These formations have considerable effect on the runoff in the sub-basin. The types of soils generated from these formations are mostly permeable. Hydrogeological studies have been carried out by the Central Ground Water Board and the State Ground Water Department in the sub-basin. They show that ground water occurs in all the geological formations viz. peninsular granites, puranas, shales, sand-stones etc., in the sub-basin. The occurrence and movement of ground water in these rocks are controlled by the nature and extent of weathering and the presence of joints and fractures.

The project area in Tamil Nadu falls in the range of elevations from 100m to 60m above MSL and reducing to sea level on the coast. The area is an alluvial pan with ground slope of 1 in 2000 to the east and to the south. The geological formations range from pre-camsediments. The archaean crystalline rocks consists of granites and gneisses.

1.9 Population

The population in the districts pertaining to the project area according to 2011 census carried out by Govt. of India is shown in **Table-1.1**.

Table-1.1**Population in the Districts pertaining to the project area**

Sl.no.	Name of the State/ district	Male	Female	Total
	Telangana			
1	Khammam*	1298543	1308523	2607066
2	Nalgonda [#]	1759772	1729037	3488809
	Andhra Pradesh			
3	Krishna	2267375	2250023	4517398
4	Guntur	2440521	2447292	4887813
5	Prakasam	1714764	1682684	3397448
6	Nellore	1492974	1470583	2963557
7	Chittoor	2090204	2083860	4174064
	Tamil Nadu			
8	Tiruvallur	1876062	1852042	3728104
9	Vellore	1961688	1974643	3936331
10	Kancheepuram	2012958	1985294	3998252
11	Tiruvannamalai	1235889	1228986	2464875
12	Villupuram	3458873	1740819	1718054
13	Cuddalore	1311697	1294217	2605914
14	Perambalur	282157	283006	565223
15	Tiruchirappalli	1352284	1370006	2722290

*-includes BhadrakotiKothagudem district; [#]-includes Suryapet district

Source: District Census Handbooks, 2011

1.10 Occupation

The social fabric of villages in the project area is predominantly agrarian and main occupation of people is farming, which may get boost if adequate irrigation facilities are made available.

1.11 Natural Resources

1.11.1 Water Resources

The water resources potential of various river basins / sub-basins from Godavari to Cauvery in the region is characterized by some intra-regional disparities. **Table-1.2** furnishes the information on water resources scenario in various basins/ sub-basins in and around the region.

Table-1.2
Water resources scenario in various basins / sub-basins

Sl.No	River basin	Sub-basin/ diversion point	Status of water resources
1	Godavari	Indravati	Surplus
		Sabari	Surplus
		Lower Godavari	Deficit
		Inchampalli	Surplus
2	Krishna	Nagarjunasagar	Deficit
3	Pennar	Somasila	Deficit
4	Palar	Intermittent basin	Deficit
5	Cauvery	Grand Anicut	Deficit

Source: Water balance studies of NWDA

1.11.2 Land resources

In the project area, the culturable area constitutes about 56 percent of the geographical area. The net area sown accounts for 66 percent of the total culturable area (the range being 53 to 82 percent). The district wise land use statistics of the region as available for different states are placed in **Annexure 1.6** while the district-wise gist of land use is furnished in **Table-1.3**.

Table-1.3
Gist of district-wise land use details in the project area

Unit: thousand ha

District	Geographical area	Culturable area	Net area sown	Gross cropped area	% of net sown area to culturable area
Telangana (2011-12)					
Khammam	1580	582	446	471	76
Nalgonda	1422	1060	560	658	53
Andhra Pradesh (2015-16)					
Krishna	873	596	486	724	82
Guntur	1133	754	615	863	82
Prakasam	1714	905	547	596	60
Nellore	1316	559	313	336	56

Chittoor	1498	705	419	471	59
Tamil Nadu (2016-17)					
Tiruvallur	342	201	119	153	59
Vellore	592	318	214	264	67
Kancheepuram	443	247	151	187	61
Tiruvannamalai	631	359	241	323	67
Villupuram	722	469	343	381	73
Cuddalore	368	303	225	291	74

Source: Bureau of economics and Statistics of Telangana, Andhra Pradesh and Tamil Nadu

1.11.3 Agriculture

The main food crops of the region are rice, sorghum (jowar), bajra, barley, maize, pulses, sugarcane, vegetables, condiments & spices. The main cash crops of the region are cotton, oranges, groundnut, chillies and soya bean. The source-wise irrigation particulars for the districts in the project area as available are furnished in **Table-1.4**.

Table-1.4

Source-wise irrigation in the districts pertaining to Project area Unit:ha

District/Year	Total net area irrigated			% of net area irrigated to net area sown	Area irrigated more than once	Total gross area of crops irrigated	% of area irrigated to the cropped area
	Surface	Well	Total				
Telangana (2013-14)							
Khammam	124260	92164	216424	45.3	57563	273987	49.3
Nalgonda	109145	194751	303896	44.0	161973	465869	52.9
Andhra Pradesh (2014-15)							
Krishna	229621	64276	293897	60.5	88938	382835	52.9
Guntur	357185	79488	436673	70.0	93404	530077	65.0

Prakasam	107640	116496	224136	38.2	7982	232118	38.2
Nellore	152469	81954	234423	69.9	63670	298093	74.2
Chittoor	14692	115624	130316	38.7	39135	169451	44.7
Tamil Nadu (2015-16)							
Tiruvallur	19380	78957	98337	90.7	-	143594	94.7
Vellore	1999	81021	83020	49.1	-	107699	53.2
Kancheepuram	55952	42885	98837	96.4	-	122333	93.1
Tiruvannamalai	140792	13168	153960	85.4	-	221969	77.1
Villupuram	40897	200482	241379	71.6	-	356239	73.8
Cuddalore	42078	102245	144323	92.1	-	198672	59.8

Source: Bureau of Economics & Statistics, Government of Telangana, AP and Tamil Nadu

As can be seen, there is a wide gap between cropped area and level of irrigation in the project area, particularly in the districts of Khammam, Nalgonda, Prakasam, Chittoor and Vellore districts. Hence, there is much scope for extending irrigation facilities through non-conventional means like inter basin water transfer apart from conventional projects.

1.11.4 Mineral wealth

The district Khammam in Telangana are located in the mineral belt. The Singereni Collieries is in the vicinity of the link project.

1.11.5 Industry

There are many large, medium and small scale industries in the sub-basin. Most of the large scale industries are located in the Hyderabad and Rangareddy districts. Some of the important industries are the Bharat Heavy Electricals Limited, the Hindustan Machine Tools Limited, the Voltas Limited, the Hyderabad Usha works, the Electrical Transformer and Equipment Company, the Krishi Engineers, the Aluminium Industries Limited, the Hyderabad Chemicals and Fertilizers Limited etc. The Andhra Pradesh Mining Corporation has set up a crushing and calcination plant in Mahabubnagar district. There are so many private viz. Infosys, Wipro,

Microsoft, Infotech enterprises in the information technology sector and are operating from the newly formed city of Cyberabad in Hyderabad. Hyderabad has recently become one of the leading hub in IT sector in the world. The private sector have dominant role in pharmaceutical industry with most players viz. Dr. Reddy's laboratories, Matrix laboratories etc. are producing world class drug solutions. The small scale and cottage industries in the sub-basin cover handloom weaving, hosiery, tanning, leather goods, handmade paper matches, ivory and horn, cane works, dyeing and printing and potteries.

There is a cement factory at Dalmiapuram and number of small scale industries engaged in manufacture of food products, safety matches, coir products and rice mills are existing in the sub-basin.

1.11.6 Tourism

A number of tourist spots are located in the project area. Kinnerasani, Nagarjunasagar, Srisailam, Kaundinya wild life sanctuaries and Vedanthangal bird sanctuary are located in the vicinity of the link project. The MedaramSammakka-Sarakka mela, Warangal fort and thousand pillar temple, Nandikonda at Nagarjunasagar, Kotappakonda, Guttikonda, Tripuranthakam, Nallamala forest, Kancheepuram, Thirucchirapalli, Thanjavur and several other places are significant from tourism point of view.

1.11 .7 Scriptural importance

There is a mention of Telangana region in various scriptures. Ramayana has reference to Bhadrachalam and Parnashala located near the off take of the link project. Bhadrachalam existed in "Dandakaranya" of Ramayana period where Lord Rama with his consort Sita and brother Laxmana were said to have spent their time during Vanavasa and Parnashala (the place from where Sita was abducted by Ravana) is also in the vicinity of this temple site. The historical Warangal fort and the famous 1000 pillar temple, Ramappa temple of Kakateeyaperiod too are in the vicinity.

In Andhra Pradesh, Dharanikota (Amaravati) - the capital of Shatavahana kings, Nagarjunakonda – the ancient Buddhist centre during

Ikshvaku regime, Palnadu, Srisailem (one of the Jyotirlingas) are located in the vicinity of link canal.

The unique cultural heritage of Tamil Nadu is seen all along the link canal. There is a mention of several places in Sangam literature and their remnant features are strikingly visible even in present times. Tiruvallur, Vellore, Kancheepuram, Tirunelveli, Thanjavur, Tiruchirapalli are some of the places of religious and historical importance got place in scriptures.

1.11.8 Culture & people

Telangana, Andhra Pradesh and Tamil Nadu have their rich cultural and historical background distinct from rest of the country. Telangana is the place centrally located and the meeting point of southern and northern cultures. Hindu festivals like Holi, Diwali and Vijayadasami/ Dussehra, Pongal are celebrated throughout these States along with several Islamic festivals around the capital city of Hyderabad. Being ruled by Qutub Shahis and Nizams for several centuries, the cultural fabrication of Telangana well absorbed the Islamic culture. The Salarjung museum in Hyderabad is one of the best personal collections in the world with exhibits of world class. The Golkonda Fort, Charminar and other structures are the living cultural spots portraying Telangana heritage. The Andhra culture is predominantly seen between Krishna and Pennar rivers with the heritage of Shatavahana, Ikshavkus, Tulu kings, Palnadu kings and other royal families. The State of Tamil Nadu preserved its Dravidian culture though ruled by Pandyas, Cholas, Pallavas and other rulers of north for brief periods.

1.12 Land use and socio-economic aspects

1.12.1 Cropping Pattern

Three dominant cropping patterns can be discerned in the project area. Paddy, Jowar, Bajra, Maize, Groundnut, Fodder, Pulses, Chillies in Kharif; Groundnut, Pulses, Jowar, Paddy in Rabi; and Sugarcane as perennial crop are grown.

1.12.2 Socio-economic aspects

The proposed command area of 9.37 lakh ha under the link project is spread in the States of Telangana, Andhra Pradesh and Tamil Nadu. Based on the available district-wise statistics in these States, certain socio-economic aspects are furnished below in **Table-1.5**.

Table-1.5

Socio-economic aspects in the States pertaining to the link project

Sl No.	Aspect	Telangana	Andhra Pradesh	Tamil Nadu
1.	Area ('000 km ²)	112.08	162.97	130.06
2.	Population (lakh)	350.03	495.77	721.47
3.	Rural (lakh)	213.95	349.67	372.30
4.	Urban (lakh)	136.09	146.10	349.17
5.	% of Urban	38.88	29.47	48.40
6.	Population density/Km ²	312	304	555
7.	Literacy rate (%)	66.54	67.35	80.09
8.	Scheduled Caste (%)	15.45	17.08	20.01
9.	Scheduled Tribe (%)	9.08	5.53	1.10
10.	Total workers (lakh)	163.42	230.81	328.85
11.	Cultivators (lakh)	31.51	143.93	42.48
12.	Agricultural labourers (lakh)	59.15		96.07
13.	Workers in House hold industry (lakh)	7.77	86.88	13.65
14.	Other workers (lakh)	64.99		17.66

Source: Census statistics, 2011, Statistical Year book -2016 of Telangana; Statistical Abstract -2015 of Andhra Pradesh.

1.12.3 Drought prone areas

Telangana and Andhra Pradesh are influenced by south west monsoon and the State of Tamil Nadu is influenced by the retreating north east monsoon. Shortage of rainfall coupled with its erratic distribution during rainy season causes severe water deficit conditions resulting in various intensities of drought. The absence of rain, results in deficiency of soil moisture in the crop root zone, to support crop growth and productivity and lowering of water levels in tanks, lakes, reservoirs resulting in various types

of drought. Non-availability of irrigation facilities, erratic distribution of rainfall, limitations on the front of ground water exploration, makes the areas drought prone. The changes in the monsoon pattern also add to the cause for proneness to droughts. As per Drought Manual of Telangana State (Draft-2016), out of total net sown area, around 38 percent is irrigated and the remaining area depends on rainfall. Mahabubnagar and Nalgonda are the potential drought prone districts in the State. The districts of Srikakulam, Prakasam, Nellore, Chittoor, Kadapa, Anantapur and Kurnool in Andhra Pradesh are drought prone. Likewise, about eight districts including Tiruchirapalli are considered drought prone in Tamil Nadu State. Some of these drought prone districts in the three States will get relief from the assured water supplies through the proposed link canal.

1.12.4 Ground water

The ground water profile of various States was developed by the Central Ground Water Board (CGWB). Accordingly, the annual replenishable ground water resource of various districts falling in the command area is 20.04 BCM out of which the ground water draft is 10.35BCM which indicates about 52% of average ground water development in the region. However, it is seen that groundwater is over exploited in Vellore, Tiruvannamalai and Villupuram districts of Tamil Nadu. The district wise ground water potential & draft is furnished in **Table-1.6**.

Table-1.6
Ground water resources and utilization in districts
falling in the project command area

Sl. No	District	Annual Replenishable GWR	Net Annual GW	Annual GW draft for irrigation	Projected demand for M&I uses upto 2025	GW available for future irr.n use	Stage of GW development (%)
1.	Khammam	174047	159305	60615	9144	95623	38
2.	Nalgonda	185499	168251	108955	12590	56794	65
3	Krishna	150798	136296	54809	9539	82026	40
4.	Guntur	163499	147544	47447	14685	100727	32

5.	Prakasam	172190	155996	52747	9677	100062	34
6.	Nellore	282406	256729	80274	9535	172725	31
7.	Chittoor	182555	164882	117696	18817	47341	71
8.	Tiruvallur	78291	70462	48147	19141	21773	68
9.	Vellore	65523	58971	60806	7354	-2641	103
10.	Kancheepuram	117164	105448	68469	7056	34985	65
11.	Tiruvannamalai	124097	111687	102962	3726	8277	92
12.	Villupuram	165301	148771	146413	5689	1680	98
13	Cuddalore	142772	128495	85927	34551	42178	67
Total (BCM)		20.04		10.35			

Source: Dynamic Groundwater Resources of India, June, 2017, CGWB (data as on 31st March, 2013)

1.12.5 Water quality

Ground water is an essential and vital component of our life support system. The ground water resources are being utilized for drinking, irrigation and industrial purposes. There is growing concern on deterioration of ground water quality due to geogenic and anthropogenic activities. Increase in overall salinity of the ground water and/or presence of high concentrations of fluoride, nitrate, iron, arsenic, total hardness and few toxic metal ions have been noticed in large areas in several States of India. In the project area, high concentrations of contaminants such as salinity, fluoride are found in Nalgonda, Prakasam and Nellore districts.

1.13 Choice of the project

The Godavari (Inchampalli) - Cauvery (Grand Anicut) link project is proposed as an alternate option for the time being as Phase-I of Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai-Gundar nine link system until finalisation of Mahanadi-Godavari link project by NWDA in consultation with Govt. of Odisha. This project envisages diversion of 7000 Mm³ annually from Godavari at Inchampalli and comprises the following three link projects:

1. Godavari (Inchampalli) - Krishna (Nagarjunasagar) link
2. Krishna (Nagarjunasagar) - Pennar (Somasila) link
3. Pennar (Somasila) - Palar - Cauvery (Grand Anicut) link

Govt of Telangana suggested to take up the conveyance from the Inchampalli with reduced dam height and to follow the alignment as considered in the feasibility report of Godavari (Inchampalli) - Krishna (Nagarjunasagar) link project. Further, it was suggested to consider irrigation and water supply to the fluoride affected mandals of Munugodu and Chandur in Nalgonda district vide Lr. No ENC (I)/ DCE-I/OT-1/AEE-4/NWDA Akinepalli-Cauvery / 2019 dated 16.01.2019.

Godavari (Inchampalli) - Cauvery (Grand Anicut) link project comprises the following components.

- i) A barrage on river Godavari at Inchampalli with F.P.L. 87.0 m, gross (and live) storage capacity of 450 Mm³.
- ii) A link canal of length 299.26 km (including a tunnel of 9.15 km length for crossing the ridge between Godavari and Krishna basins) off-taking from the Inchampalli barrage (through an approach channel of 10 km) and outfalling into the existing Nagarjunasagar reservoir via Musi reservoir. The link will cross the main ridge between the Godavari and the Krishna basins through a tunnel of 9.15 km length. The proposal envisages the construction of a barrage at Inchampalli on river Godavari and the two other intermediate reservoirs viz. Peddavagu&Tummalagutta. The link canal runs in moderate lifts and by gravity in its initial stages upto RD 60.500 km. The total lift involved is about 129 m in four stages. The lifts involved in four stages at RDs 0.00, 18.00, 26.50 and 60.50 km are 57, 38, 23 and 11 m respectively. The canal passes through Mahadevpur, MatharamMandals of Karimnagar district and Bhupalpalli, Venkatapuram, Regonda, Shayampet, Duggondi, Narasmpet, Chennaraopet, Nekkonda, Kesamudram, Nellikudur, DhantalapalliMandals of Warangal district and Nutankal, Jajireddigudam, Suryapet, Ketipalli,

Nakrekal, Tiparthy, Nidmanoor, Anumula and Peddavoora Mandals of Nalgonda district.

The link canal takes-off from the Musi reservoir with FSL of 187.300 m. The head available at Musi reservoir is about 9.70 m which is adequate for generation of power in the form of mini hydel scheme (canal power house). Hence, a canal power-house has been proposed at the canal offtake from Musi reservoir for generation of power by utilising the head of about 9.70m, available between the reservoir FRL and the canal FSL. The water to be drawn from the Musi reservoir for onward transmission to the link canal will be guided through this power-house to generate power. It is proposed to install 15 units of 5 MW bulb turbines with one standby unit. The effective installed capacity of the powerhouse will be 70 MW. An approach channel of 3 km long from the reservoir to the powerhouse is proposed to suit the topography at the Musi head works. The water after power generation will be released to the main canal through a tailrace channel. The water received at the end of the link canal will be stored in the existing Nagarjunasagar reservoir on the Krishna river. The gross and live storage capacities of the reservoir at F.R.L. 179.83 m are 11560 Mm³ and 5733 Mm³ respectively. The dead storage level is 149.05 m.

Part of the water so diverted to Nagarjunasagar reservoir will be used in meeting the requirement of Nagarjunasagar Project (NSRBC). Balance water is further diverted to Pennar and Cauvery river basins. The link canal is proposed to be lined throughout its length.

This link will provide irrigation to the command areas under Kakatiya canal stage-II of Sri Ram Sagar Project and Srisailem left bank canal (Alimineti Madhava Reddy canal under Nagarjunasagar project) in the districts of Khammam, Warangal and Nalgonda. A lead canal is proposed to transfer water from Inchampalli - Nagarjunasagar link canal to Kakatiya canal stage-II. The lead canal takes-off from the link canal at RD 97.50 km and after traversing a distance of 21.85 km, it outfalls into the Kakatiya canal (stage-I) at RD 260.70 km.

- iii) Existing Nagarjunasagar on river Krishna, Somasila on river Pennar as balancing reservoirs enroute.
- iv) Cross drainage/ cross masonry and regulating works across the link canal.
- v) Canal top solar power generation arrangement at appropriate reaches along the link canal alignment.
- vi) The existing Grand Anicut as outfall structure on river Cauvery with FPL 59.22 m.
- vii) Total CCA of 887022 ha with annual irrigation of 944572 ha in Telangana, Andhra Pradesh and Tamilnadu states.

The Index map of the link system is furnished in **Plate 1.3** and the reach wise Index maps are presented at **Plate 1.3.1, 1.3.2** and **1.3.3**.

1.13.1 Project planning and optimisation of benefits

The link project envisages diversion of 7000 Mm³ from the proposed Inchampalli barrage during monsoon months of June to October for irrigation, domestic and industrial needs of Telangana, Andhra Pradesh and Tamil Nadu States in various enroute river basins.

The link canal will provide irrigation to a total command area of about 887022ha out of which 453017 ha is new area. The water allocated for irrigation is about 5049 Mm³ including 2259 Mm³ allocated for new areas. The link canal will provide 1456 Mm³ of water for municipal and industrial water supply to the enroute villages/towns lying in the command area in the vicinity of the link project in the three States. About 495Mm³ of water is estimated to be lost in transmission.

Since, there will be a diversion of 7000 Mm³ of water through the proposed link canal during the monsoon months, which constitute the prime flood season, it is likely that the intensity of flood in Godavari will be moderated to a little extent in downstream reaches. Thus, the proposed Godavari (Inchampalli) - Cauvery (Grand Anicut) link project is expected to provide incidental benefit of flood moderation in Godavari river.

The Inchampalli barrage may be operated with 83 m crest level instead of 76 m and with a higher pond level to avoid the afflux of water retained at the Tupakulagudem barrage located in the near proximity. The location of the Inchampalli barrage could as well be moved upstream. The required water could as well be lifted from the storage created by Tupakulagudem barrage.

1.14 Stages / phases of development of the link project

The Godavari (Inchampalli) - Cauvery (Grand Anicut) link project is a mega water resources development project with several integrated components as discussed above.

The development of the project can be planned in the following stages in sequence or simultaneously.

1. First stage may include irrigation to the existing commands for their stabilisation
2. Second stage may include the new areas after duly developing command area and distributary network.
3. Third stage may include integration of existing infrastructure for domestic and industrial water supply

Integration of existing reservoirs is the prominent feature of this project. In each stage of development, the existing enroute reservoirs play vital role in supplying regulated flow as per the monthly demands in the command area. The benefits of the project can be partially accrued right from the completion of first stage of development.

1.15 Fitment of the scheme in overall development of the region

There are vast tracks of culturable area in Telangana, Andhra Pradesh and Tamil Nadu which need to be brought under irrigation. Further, the commands under existing projects are also deprived of reliable water supply due to monsoon vagaries. There are abundant flows in Godavari while the flows are diminished year by year in Krishna, Pennar and Cauvery basins. Farmers are mostly dependent on open wells, tanks and other sources which usually fail during dry years. The usual practice among the farming community is to irrigate the fields through pumping of water which often

leads to groundwater depletion. All these factors suggest that a water resources development project like Godavari (Inchampalli) - Cauvery (Grand Anicut) link project is essential so as to provide the necessary impetus to the irrigation development in the three southern States. The link project will fit well in contributing to the overall development of the region, like a spoke in the wheel.

1.16 Intimation to other development authorities regarding the scheme

The technical feasibility note of the link project was prepared and circulated to Governments of Chhattisgarh, Telangana, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Puducherry in the month of December 2018. Observations are received from the Govt of Telangana, Chhattisgarh, Tamil Nadu, Puducherry and Karnataka.

1.17 Public announcements and public hearings

The benefits to be accrued from the proposed project have been brought to the notice of the general public during the field survey and other investigations of the scheme by the NWDA officials from time to time bringing out the importance of the inter basin water transfer scheme to meet the water shortage of the region. Thus, the people in the vicinity are well conversant of the link project. The State Government authorities are made aware of the scheme while preparing detailed project report (DPR). The public hearings will be taken up at appropriate time, in connection with environmental impact assessment of the link project.

1.18 Interlinking of the scheme with neighboring schemes

The integration of existing reservoirs Nagarjunasagar, Somasila and Grand Anicut is the crucial component of the link project. The command areas under these reservoirs are often facing shortage of water due to reduced inflows. The link project will be able to stabilize the existing command areas under these reservoirs/Anicut. Further, the pressure of obligation on upstream States to release waters from their reservoirs will be reduced due to this augmentation from the link project. Appropriate planning in the upstream catchments of these reservoirs can be taken up by

the respective States/project authorities in exchange wherever feasible, due to supplementation of water through the link project.

1.19 Inter-state / International aspects

There are no international boundaries concerning the project area and hence no such issues are involved. Godavari, Krishna, Pennar and Cauvery are inter-State rivers involving two or more States in each of the basins, Hence, the prevailing Awards by Godavari Water Disputes Tribunal (GWDT), Krishna Water Disputes Tribunal (KWDT) and Cauvery Water Disputes Tribunal (CWDT) are duly considered while planning for diversion from Godavari to Krishna and further south. The link project will not affect the provisions regarding inter-State adjudication on sharing the waters of Godavari basin. The inter-State issues are dealt in detail in **Chapter 3: Inter-State aspects**

1.20 Cost and benefits of the scheme

1.20.1 Cost of the project

The total cost of the Godavari (Inchampalli) - Cauvery (Grand Anicut) link considering the three reaches are presented in **Table-1.7**.

Table-1.7
Abstract of cost of the
Godavari(Inchampalli)- Cauvery (Grand Anicut) link project

Sl.No	Unit	Cost component	Amount (Rs lakh) Inchampalli-GrandAnicut
1	I	Head works	392052
2	II	Conveyance system	6989726
3	III	Hydro power	91621
4	IV	Lifting arrangements	1105926
Estimated cost of the project			8579325
5	V	Onfarm development	16911
Total project cost			8596236

1.20.2 Benefits from the project

The benefits from the link system include revenue from agriculture produce, irrigation service fee, domestic and industrial water supply, power generation, pisciculture, plantations on canal banks and animal husbandry. The details are furnished below in **Table-1.8**.

Table-1.8

Annual Benefits of the Godavari (Inchampalli) – Cauvery (Grand Anicut) link project considering the three reaches between Godavari and Krishna

Sl No	Component	Annual benefits (Rs lakh)
		Inchampalli barrage -Grand Anicut AI: 944572 ha
1	Irrigation	641493
2	M&I	607041
3	Power	14640
4	Irrigation cess	14169
5	Pisciculture	53385
6	Animal husbandry	10637
7	Plantations	18425
	Total	1359790

The benefit - cost ratio (BCR) and internal rate of return (IRR) of the Godavari (Inchampalli) - Cauvery (Grand Anicut) link system are worked out considering the annual cost and the annual likely benefits at 2020-21 price level for 100 years life of the project. The economic parameters BCR & IRR of the link system are 1.24& 11.9 respectively.

1.21 Public cooperation and participation

The project will provide impetus to all-round development of the region and reduce the socio-economic imbalance by enhancing agricultural production and employment opportunities. Hence, good co-operation and whole hearted participation is anticipated from the beneficiary areas.

The link project has an added advantage of not having any R&R problems as the existing reservoir space is planned to be used enroute the link canal for regulating the flows. Moreover, it has been perceived while carrying out topographical surveys that the farmers are in favour of such large water resources project in the region keeping in view the chronic and continuous spell of droughts and ever growing irrigation, domestic and industrial water needs.

1.22 Provision for domestic and industrial water supply

The link canal will provide 1456 Mm³ of water for domestic (512Mm³) and industrial water supply (944Mm³) to the enroute villages/towns lying in the command area in Warangal, Khammam, and Nalgonda districts of Telangana; Krishna, Guntur, Prakasam, Nellore and Chittoor districts of Andhra Pradesh; and Tiruvallur, Vellore, Kancheepuram, Thiruvannamalai, Villupuram, Cuddalore districts of Tamil Nadu.

1.23 Methodology

The pre-feasibility report of Godavari (Inchampalli) - Cauvery (Grand Anicut) link project along with feasibility reports of (i) Godavari (Inchampalli)-Krishna (Nagarjunasagar tail pond), (ii) Krishna (Nagarjunasagar) – Pennar (Somasila) & (iii) Pennar (Somasila) - Palar - Cauvery (Grand Anicut link projects prepared by NWDA formed the basis for the preparation of detailed project report (DPR).

1.23.1 Survey & investigations

The topographical surveys were carried out for preparation of the feasibility reports of the link project. The same data has been used for preparation of DPR. Topographical surveys were carried out as per the “Guidelines for Preparation of Detailed Project Reports of Irrigation and Multipurpose Projects” of Ministry of Water Resources (Now Ministry of Jal Shakti), Govt of India, 2010, to the extent applicable. Other investigations and special studies as required were got done through expert agencies/organizations.

1.23.2 Special studies by other Agencies

Various other surveys and investigations required for preparation of DPR were got done through expert organizations/ outside agencies as enumerated below in **Table-1.9**.

Table-1.9
Investigations carried out by other organisations /agencies

Sl No.	Survey/ Investigation	Organisation/Agency
1	Topographical surveys	NWDA, NRSC, Hyderabad
2	Geological mapping and investigations	Geological Survey of India
3	Geophysical surveys	NGRI, Hyderabad & Mysore University
4	Geotechnical investigations	Osmania University; NWDA/APERL, Hyderabad
5	Construction Material Investigations	JNTU, Hyderabad, APERL, Hyderabad; CSMRS, New Delhi
6	Borrow area surveys	Andhra University, Visakhapatnam, APERL, Hyderabad, CSMRS, New Delhi

NRSC-National Remote Sensing Centre, NGRI-National Geographical Research Institute, JNTU-Jawaharlal Nehru Technological University, APERL-Andhra Pradesh Engineering Research Laboratory, CSMRS-Central Soil and Materials Research Station

1.23.3 Technical studies

Hydrological Studies

The hydrological studies are carried out for the Godavari basin at Inchampalli barrage site. The transferable quantity is estimated at 7000 Mm³ during monsoon months of June to October.

Irrigation planning and command Area

The link is proposed to provide annual irrigation to an area of 944572ha in Warangal, Khammam, and Nalgonda districts of Telangana; Krishna, Guntur, Prakasam, Nellore and Chittoor districts of Andhra Pradesh; and Tiruvallur, Vellore, Kancheepuram, Tiruvannamalai, Villupuram and Cuddalore districts of Tamil Nadu. Since the proposed diversion from Inchampalli barrage is only during monsoon period from June to October, the existing Nagarjunasagar reservoir on Krishna and Somasila reservoir on Pennar are planned to be utilised as balancing reservoirs so that the command area can be supplied with water during rabi season also. In all 36 branch canals / direct sluices are proposed from the link canal to provide irrigation. The crop water requirements in the command areas are worked out by climatological approach considering the approved cropping pattern by the State agriculture departments.

Design of important project components

The Inchampalli barrage is proposed across river Godavari as headworks from where the 1211 km long link canal takes off with FPL of 87 m. The link canal is provided with four stages of lifting and several CD/CM works enroute. The project involves design of i) Barrage, ii) Canal head regulator, iii) Link canal section, iv) Lifting arrangements v) Tunnels and various CD/CM works etc. All the above designs have been carried out following the guidelines laid down in the respective BIS codes.

Construction program, man-power and plant planning

The details of construction programme, man-power deployment and plant planning are evolved keeping in view the construction period as five

years and furnished in Chapter 10: Construction programme, manpower deployment and plant planning.

EIA, EMP and Socio-economic survey

The Environmental Appraisal Committee (EAC) of Ministry of Environment, Forests and Climate Change (MoEF&CC) has been approached by NWDA for obtaining the approval for the proposed Terms of Reference (ToR) to take up the comprehensive EIA studies including socio-economic survey of the link project. These studies will be carried out through the expert agencies on consultancy basis. The details of the study will be incorporated later in the DPR.

The link project has no major proposed reservoir and there is no submergence of land or villages under Head works. While fixing the canal alignment also, due care has been exercised to avoid traversing through the habitations to the extent feasible. However, few villages needs relocation in the reach between Nagarjunasagar and Somasila as the canal is planned parallel to NSRBC upto 200Km and acquisition of villages on the canal banks couldn't be avoided. These aspects are discussed in detail in Chapter 11: Environmental, ecological and socio-economic aspects.

Cost estimate

The cost estimate has been prepared considering the quantities worked out based on the field surveys & investigations and the designs of various structures involved in the project. The estimates for the project are prepared based on the 'Guidelines for Preparation of Detailed Project Report of Irrigation and Multipurpose Projects' (2010) of the then Ministry of Water Resources (Now Ministry of Jal Shakti), Govt. of India. The cost estimates have been framed on the basis of latest available Schedule of Rates of WRD/ PWD of various States and are brought to year 2020-21 price level with appropriate escalation.

1.23.4 Clearances required

The Godavari (Inchampalli) - Cauvery (Grand Anicut) link project will require the clearances from the Govt. Departments/ Agencies as indicated below in **Table-1.12**.

Table-1.12
Clearances required for the project

Sl. No.	Clearance	Agency
(i)	Techno-economic	Central Water Commission, TAC of Ministry of Jal Shakti.
(ii)	Forest Clearance	Ministry of Environment, Forest and Climate Change (MoEF& CC)
(iii)	Environmental clearance	Ministry of Environment, Forest and Climate Change (MoEF& CC)
(iv)	R & R Plan of Tribal population	Ministry of Tribal Affairs (MoTA)

The above clearances shall be obtained by NWDA, as the project proponent, before taking up the implementation of the project.

1.23.5 Organisation of chapters

The detailed project report comprises the following chapters along with annexures and drawings.

1. Introduction
2. Physical features
3. Inter-State aspects
4. Surveys and investigations
5. Hydrology and water Assessment
6. Design aspects
7. Reservoirs and enroute storages
8. Irrigation planning and command area development
9. Power
10. Construction programme, manpower deployment and plant planning
11. Environmental impact assessment and environmental management plan
12. Socio - economic studies, resettlement & rehabilitation
13. Cost estimates
14. Revenues, benefit-cost ratio and IRR
15. Other aspects of the project