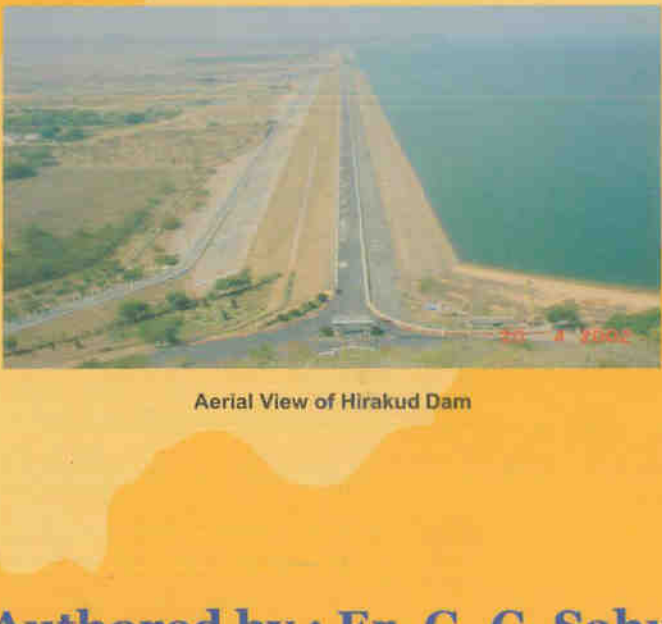
HISTORY OF IRRIGATION DEVELOPMENT IN ORISSA



Aerial View of Hirakud Dam

(Authored by : Er. G. C. Sahu)

(Through WALMI Orissa)

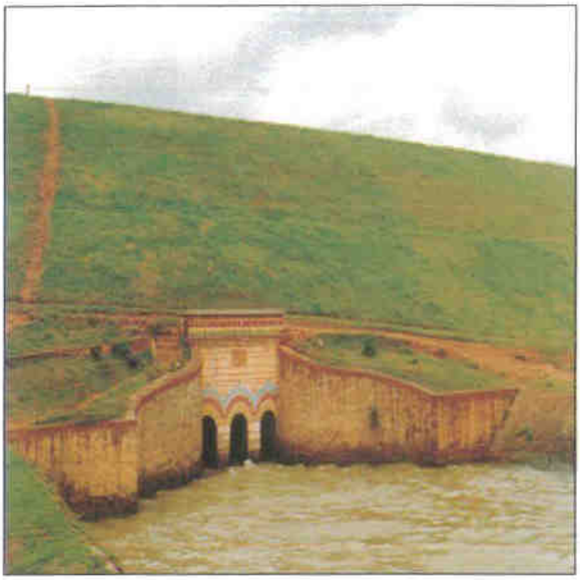
इनसिड - INCID

भारतीय राष्ट्रीय सिंचाई एवं जल निकास समिति

(जल संसाधन मंत्रालय, भारत सरकार द्वारा गठित)

INDIAN NATIONAL COMMITTEE
ON
IRRIGATION & DRAINAGE (INCID)

(CONSTITUTED BY MINISTRY OF WATER RESOURCES, GOVT. OF INDIA)



Bhanjanagar Dam with Head Regulator **Dam and Spillway of Ghodahado Project**

General View of Kanjhari Dam **D/S View of Kukurpeta Dam (MIP)**

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FOREWORD

Irrigation has always been at the root of survival strategy in the history of mankind since its earliest beginning. In India irrigation has a very old history and this history is not merely a transition to posterity. It is a great teacher to those who strive to transform the society for the better.The efforts of past builders and engineers to develop innovative, safe and sound engineering designs for irrigation systems are a fine expression of their irrepressible zeal to favourably maneuver the vagaries of nature for overall development of humanity. A study of these efforts presents a fascinating insight into the innovative techniques of harnessing the precious water resource adopted by our forefathers in their search for survival in a period, technology was still nascent and a scientific approach unheard of. Decisions were based on requirements and site selection by thumb rule and still the structure, stood the test of time providing the much-needed water to the inhabitants during scarcity days.

In pursuance of its objectives and functions, Indian National Committee on Irrigation and Drainage (INCID) has taken up the work of publishing the historical appreciation of development of irrigation and drainage in the country, which will disseminate relevant information related to the subject. INCID has already published two such documents i.e. "History of Irrigation Development in Tamil Nadu" & "History of Irrigation Development Andhra Pradesh", under the centrally sponsored research programme of river valley and flood control schemes. The present document, "History of Irrigation Development in Orissa", the third in the series brings out the irrigation practices and management adopted during different periods in the state of Orissa.

The onerous task of preparing this report was entrusted to Er. G. C. Sahu, Former Engineer-in-Chief, Water Resources Department. Based on the data collected from various sources, the report prepared by Er. G. C. Sahu was sent to Government of Orissa and various organizations like, Central Water Commission, Central Soil Salinity Research Institute (CSSRI), Karnal etc. for their comments. INCID finalized the report taking into account the comments received from various organizations and the report was finally approved by the undersigned.

The present publication contains 12 chapters covering the development of irrigated agriculture in Orissa right from the Dynastic period, through the British period and the period after Independence. The report also covers the issues of Flood, Drainage & Drought in the State of Orissa, Inter-State issues, Water Policy, Future Scenario of Irrigation and Agriculture Development in the State of Orissa alongwith the Problems and Prospects.

INCID acknowledges the contribution of Er. G. C. Sahu, officers from WALMI Cuttack and others associated in documenting available information in this report. The efforts put in by Shri C.D.Khoche, Consultant INCID, and officers of CWC, Shri Ravinder Singh, Chief Engineer, CWC, Shri Y.K.Sharma, Director, Shri Yogesh Paithankar, Director CWC & Member-Secretary INCID and Shri Piyush Ranjan, Deputy Director, CWC as well as other officers of Central Water Commission who contributed in preparation of this report are very much appreciated. Thanks are also due to the Ministry of Water Resources, for providing guidance and requisite grants.

It is hoped that this report will be useful as a reference book to all concerned in the Water Resources Sector, particularly to those working in various State Irrigation Departments/Agencies.

(A. K. BAJAJ)
Chairman INCID &
Central Water Commission &
Ex Officio Secretary to Govt. of India

About the author

Sri Govinda Chandra Sahu graduated in Civil Engineering in the year 1963 and joined in the erstwhile Irrigation & Power Department of the State of Orissa as Assistant Engineer in the same year. He did his Master of Engineering (WRD) from University of Roorkee (Now I.I.T) in 1976. He has varied experience starting from Construction to Planning, Design, Investigation, Monitoring, Estimation, Quality Control, Research and O&M of major and medium river valley projects of the State, viz. Upper Indravati Hydro Electric Project, Rengali Dam, Samal Barrage, Mahanadi Barrage, Naraj Barrage, Mahanadi Chitrotpala Island Irrigation Project, Lift Irrigation and Paradeep Port spanning over 36 years. He superannuated from Government Service as Engineer in Chief (WR) in May 2000.

After superannuation, Sri Sahu worked as Senior Advisor in WAPCOS from October 2000 to February 2005. He was a Member of Task Force on 'Interlinking of Rivers' constituted by Government of India. He was also (i) Member of Expert Panel for rehabilitation of Earthquake devastated Dams in Gujarat (ii) Consultant to Baird Associates (Canada) for 'Storm Surge Embankment' in Orissa, (iii) Chairman 'Safety Review of Large Dams, Orissa (iv) Member of S.D.S.I, team, Andhra Pradesh (v) Member of Expert Panel to advise Tamilnadu on 'Mulla Periyar' Dam and (vi) Govt. of Gujrat on Ukai Dam. At present, he is a member of High Level Technical Group for PI&M of Sadar Sarovar Canal System of Gujarat.

He has received 10 nos. of gold medals from Institution of Engineers (India) - Orissa chapter for technical papers between 1993 to 2009 and another gold medal from Orissa Engineering Congress in 2005. He has 23 published Technical papers to his credit.

Sri Sahu is recipient of Orissa Bigyan Academy Popular Science Award in 1996 for his book 'Gruha Nirman' and Orissa Sahitya Academy Award (2001) for translating 'Hajare Chaurasir Maa'. He was felicitated by Orissa Sahitya Academy for his contribution to Oriya literature in 2004. He has authored so far 10 (ten) books in Oriya out of which four have run into serveral editions. One of his book 'Bhaja Govindam' has also been translated into Hindi, Bengali and Sanskrit language.

Sri Sahu is a Fellow of Institution of Engineers (India), Life Member IWRS (Roorkee), Life Member, Orissa Bigyan Academy and Life Member, Orissa Sahitya Academy.

Preface

Water is the prime life sustaining finite natural resource, which cannot be created like other commodities. It is nature's gift to all living beings particularly to the mankind on the earth. Gradually the water sufficient world is changing to a water deficit one. In our country, the increasing stress on the availability of water is due to population explosion and improved standard of living. The scarcity is compounded further because of massive agricultural and industrial development, improper and indiscriminate exploitation of vital natural resources. The need of the hour is its sustainable development using appropriate scientific methodologies by way of conservation, protection and management. Spatial and temporal variation of rainfall causes considerable skewness in the availability of water from region to region in our country. When one part reels under drought, there is heavy flood in the other part damaging the life and properties. Both drought and heavy rainfall are act of God. Therefore water is contaminator and purifier, bringer of life and death.

Irrigation is vital input for crop growth. It is being practised in our country since pre-historic period. Attempt has been made in this book to present the development of irrigation in the State of Orissa from pre-historic age to the dynastic period and from British days to the post-independence period. The book has been divided into twelve chapters. Those are:

I. Introduction
II. The State of Orissa
III. River System and River Basins of the State
IV. Irrigation Scenario during Dynastic Period
V. Irrigation Development in British Era
VI. Irrigation Development after Independence
VII. Flood, Drainage and Drought
VIII. Interstate Issues
IX. Water Policy
X. Participatory Irrigation Management
XI. Future Scenario
XII. Problems and Prospects

Such type of documentation is an extremely difficult task as old records are not properly preserved and whatever is available is not easily accessible. I along with Er. P.C. Das have visited State Archives, State Museum library, Library of the Board of Revenue, Jubuli Library at Baripada etc. and collected valuable information from number of people and officers both in service and retired. I express my gratitude to the Authors of the books and documents from where I have collected the data, information, and quoted in this compilation.

Hearty thanks to my colleague Er. P.C. Das, former Chief Engineer of Department of Water Resources who unhesitatingly agreed to assist me as Research Fellow for this Project. My esteemed friend Er. G.N.Das was kind enough to go through few chapters and gave his valuable suggestions. My sincere thanks to Er. B.C. Naik, Er. R.K.Sabat, Er. C.V. Prasad, Er. G.P. Panda, Er. K. R. Acharya, Er. Sagar Mohanty, Er. S.C, Charchi, Er. Sudhir Das, Sri N.K. Majhi and other officers of DOWR, for rendering assistance in getting various information and drawings as and when required. I am thankful to Sri Santosh Kumar, Member Board of Revenue who without any reservation authorized to refer the old records and library of the Board. Lastly, I am thankful to Dr. Joygopal Jena, who has worked whole-heartedly and selflessly in bringing out this volume to such a nice shape. Without his help and assistance, it would not have been possible on my part to complete this Herculean task in time. I pray Almighty for his wellbeing and prosperity.

All my labour will be fruitful, if the volume serves as a reference book for the Water Resources Engineers of the State in particular and the country in general. I invite the constructive criticism and suggestions from my engineer friends and academicians so that omissions, if any, could be incorporated in the next edition.

I express my gratitude to INCID (under MOWR, Govt of India) for entrusting me this project and WALMI, Orissa, particularly to Late Er. S. Tarai (Ex-Director) and his staff for their co-operation at every stage of the work.

(Er. G.C. Sahu)

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Contents

Chapter I

INTRODUCTION

1.0 General

History is a Greek word which means systematic account of natural phenomena and methodical record of public events; past events, course of human affairs etc. History is a repository of human values and aspirations, accumulation of efforts, experience, hopes and achievements that have gradually civilized humanity. Past, present and future are linked together in the endless chain of history. Primary aim of the history is to promote understanding of the present by a knowledge of the past. E. H Carr states that 'it is unending dialogue between past and present'. Thinkers have gone to the extent of saying that all our hopes of the future depend on a sound knowledge of the past.

The developments made by the landlords, chieftains, kings, rulers and philanthropists in the field of general administration, law and order, construction of roads, temples, schools, trade and commerce and their patronage on art, culture, literature, their adventures are generally recorded by historians but less or no systematic information is available on the development of irrigation and irrigated agriculture. Well and tank irrigation have been mentioned at places in Vedas and other ancient scriptures. The well irrigation was mostly by the effort of well-to do people. Tank irrigation was either by community or by benevolent rulers. But major irrigation works which needed both skill and finance developed during dynastic rule and British period.

Irrigation has always played a strategic role in the continuous process of agricultural development. In most of the ancient civilizations irrigated agriculture had provided and continues to provide the agrarian basis of society. This prompted to record irrigation development in a methodical manner which may be useful for the academicians, irrigation engineers, researchers and planners in future.

Irrigation is the art and science of application of water artificially for raising of crops. It is needed for the lands which are deprived of receiving adequate and timely supplies of water from natural resources for successful growth of crops. From time immemorial, irrigation is being practised in one form or other in the arid and semiarid parts of the world; almost simultaneously with the first attempts of man to grow crops. Application of irrigation water has undergone sea change during last 100 to 150 years due to rapid advances in the field of science and technology. The works of ancient days were limited in their scope and extent. Modern irrigation projects are gigantic, transcend river basins and envisage to train and harness the mighty rivers for an integrated, comprehensive and optimum exploitation of their potential for multi-sectoral uses, i.e., irrigation, hydropower, flood control, navigation and recreation etc.

'Irrigation is now no more looked upon merely as an artificial application of water to crops in an isolated and individual way, but it has come to have a different meaning, especially in the vast arid and semi arid regions of the world, most of which are undeveloped and underdeveloped. In such regions irrigation provides the essential basis for an integrated all round development and is, therefore, more than a practice and technique; it is a way of life, which embraces all the various aspects of development of a community - economic, social, cultural etc.'

India is a tropical country. Its rainfall is capricious in its incidence and variable in its amount. Therefore crops cannot be raised successfully over most parts of the country for any length of time without artificial irrigation. Artificial irrigation not only acts as an insurance against drought and scarcity but also augments crop yields which are much more than the mere interest on the capital outlay of irrigation projects.

1.1 Evidence of Irrigation in Ancient India

'Irrigation in India is contemporary with dawn of civilization when comparatively small groups of men settled down as the village communities where the main source of sustenance was agriculture. The earliest village communities settled along the river banks where annual inundation of lands coupled with rainfall provided enough moisture for raising crops. Gradually irrigation came to practice not only along the river banks, but further inland by means of wells, tanks and canals on fairly large scale.

About 70% of India's vast population depends upon agriculture directly for their living and therefore agriculture has always been and would remain the main industry of the country in the foreseeable future.

Agriculture is the backbone of our national economy. It is one of the important factors that have moulded the evolution of various civilisations. Pre-historic evidences of agriculture in the river valleys of Tigris, Euphrates and parts of Baluchistan have shown beyond doubt that for food production, agricultural techniques were developed around 7000 B.C.

In our country nothing has shaped us more deeply than rivers. Our culture, our civilisation, heritage, ecology and social customs are deeply related to the river basins. All ancient civilisations have grown up on riverbanks and great epics written.

Importance of irrigation as an efficient and dependable means for enhancing food production was realised by our ancestors during 6500 BC. In course of time, the process has undergone several changes, i.e., modified, remodelled, upgraded and indigenised. Evolution of irrigation system is an ongoing process. Different races, different communities have settled down close to riverbanks and they have developed their own techniques of farming & irrigation.

From the ruins of Indus valley civilisation (i.e., Harappa and Mohenjodaro), Lothal in Gujarat, Inamgaon in Maharashtra and such other places of India, it is seen that there is ample evidence of providing irrigation in the form of bund (embankment) and canals.

In Vedic age (i.e., between 1500 B.C to 1000 BC), historical and other evidences support the existence of irrigation structures. Canal irrigation was also in vogue. In the Rig Veda, the most ancient scripture of the Indians, mention has been made of wells, canals and reservoirs. Similar references to canal, wells and dams are to be found latter in the Yajur and Atharva Vedas. The Verse (VIII. 3. 10) of Rig Veda says "

येना समुद्रमसृजो महीरयस्तादेन्द्र वृष्णि ते शवः ।

सद्यः सो अस्य महिमा न सन्नशे यं क्षोणीरनुचक्रदे ॥ RV. VIII, 3. 10 ॥

"i.e., construction of artificial canals to irrigate desert areas also is possible only by efforts of skilled persons/ engineers."

'Yajur Veda' also contains references directing the man to use rain and river water by means of wells, ponds, and dams and distribute it to various places having need of water for agriculture and other purposes.

In 'Atharvaved' we have references of drought management through efficient use of available water resources and water conservation. It clearly says that the water of river, well etc, if used efficiently will reduce the intensity of drought. Verse (VI. 100. 2) states that:

यद् वो देवा उपजीका आसिंज्वन धन्वन्युदकम् ।

तेन देव प्रसूतेनदं दूंषयता विषम् ॥ **VI, 100.2** ॥

"i.e., the learned men bring water to desert areas by means of well, pond, canal etc. It also emphasises that men should think about the drought, flood and like natural calamities in advance and take appropriate preventive measures accordingly".

We find numerous examples in Purans and 'Manu Smriti'. A study of ancient literature, epigraphical records and ruins of old irrigation works clearly indicates the interest taken by the ancient Hindu rulers of India for providing irrigation facilities for the benefit of their subjects. Once Rishi Narada came to the court of Yudhistira and enquired about the welfare of his state. One of his questions was "Are the farmers sturdy and prosperous? Are their dams full of water and big enough and distributed in different parts of the Kingdom and does agriculture not depend on rains only?"

Brihaspati, a law giver, states that the construction and maintenance of dams is a pious work and its burden should fall on the shoulders of rich men of the land. 'Bisnu Puran' also enjoins merit to a person who effects the repairs to wells, gardens and dams.

'Amarakosha' a work written in the fourth century distinguishes between provinces watered by rain (deva matrika) and those irrigated by rivers (nadi matrika). This indicates that irrigation by artificial means was practised then.

'Dalhana' in his commentary on the medical work 'Shusruta' (during 12th century AD) has differentiated between various types of water reservoirs and water channels. According to him Ganges etc. are called 'nadi' where as Sindhu and Sone as 'nada'. A natural tank is known as 'sara' and that constructed by man is called "tadaga". It is, therefore, evident that artificial irrigation was given supreme importance also during those days.

In ancient India, science of water management was given considerable importance. During Kautilya's period, agricultural planning was practised to manage rainfall excess or deficit. In 'Arthasastra', the author says, "according to the rainfall (i.e., more or less), the superintendent of agriculture shall sow the seeds, which require either more or less water. Kautilya further says that " the King should construct dams, reservoir etc. filled with water either perennial or drawn from some other source or he may provide with sites, roads, timber and other necessary materials those who construct reservoir of their own accord". All these would indicate that engineering skill behind the irrigation activities were not unknown to our people even in ancient days. The Epigraphia Indica, vol.14 of 1917-18 refers to an inscription of 1369 AD which gives an account of factors contributing to construction of a good tank obviously for multipurpose use. The said inscription also emphasizes that the following six faults should be avoided while constructing a good tank. i) Water oozing from the dam, ii) saline soil, iii) side at the boundary of two kingdoms, iv) scanty water supply and extensive stretch of land to be irrigated, v) too little land to be irrigated and vi) excess or over supply of water.

Fault no (iii) for not having any tank in the boundary of two kingdoms was to avoid likely disputes that may crop up in execution, operation and maintenance of the work in question.

Manu, the earliest law giver, says in 'Manu Smriti' that "A king who wishes to conquer his enemy should first of all destroy dams in his territory". Kautilya, the Prime Minister of Chandragupta Maurya in 3rd century B.C. wrote in 'Arthasastra' that "when on war, the tracts of land of the enemy should be flooded with water by breaking the Lakes, Dams and Embankments". He further states that one of the good features of a state is that cultivation in it does not depend on rain alone.

Magasthenes, the Greek ambassador, who came to the court of Chandragupta recorded that the district officers "measure the land and inspect the sluices by which water is distributed into the branches / water courses so that every one may enjoy his fair share of benefit". He further mentions that "the inhabitants of India almost always gather in two harvests annually and even if one of the sowings proves, more or less, abortive they are always sure of the other crop. The fact is that almost all the plains of the country have moisture, which is like genial whether it is derived from the rivers or from the rain of the summer season".

There are numerous examples that the ancient rulers had constructed water harvesting structures such as Sudarsan lake in Girnar (300 BC) which was repaired and widened during the Gupta empire (4-5th century AD); the Western Yamuna canal (14th century AD) which was renovated in the 16th century AD by the Mughals and repaired in the 19th century by British rulers. The Burhia Tal at Etmadpur near Agra was built by Lodhi dynasty during 1451-1562 AD. The Tanka (first underground reservoir) in Rajasthan was constructed in 1607 AD by Raja Sivsinghji. In 1765 AD, Maharaja of Bharatpur had constructed the Keola Deo Jheel (named Ajan dam). The list is endless. No detailed records are available as to how the decisions were taken for implementing these works.

A. L. Basham in his book 'The wonder that was India' (1954) at page 102, states that "in the flat planes, the land was cut by canals running from the great rivers and dotted with artificial reservoirs, which were made by damming smaller streams or enlarging lakes by stopping their outlets. From these water supplies, whether natural or artificial, water was raised by counter poised 'sweeps' and fed into smaller channels, which watered fields"

In southern India, irrigated agriculture was in vogue in Cauvery delta, during Sangam age, which is much earlier than Christian era and concluded during the middle of 3rd century AD. The important work constructed in the 2nd century AD was Grand Anicut across the Cauvery. Many such anicuts or diversion works were built across the streams for gravity irrigation by the rulers of South India.

The middle of 19th century saw construction of large canal system such as Upper Bari Doab canal, Sirhind canal etc. Towards 1890 AD, two canals, one from Chenab (now Lower Chenab) and other from Jhelum (now Lower Jhelum) were constructed. In the earlier part of 20th century, Ranbir and Partap canals were excavated off taking from the Chenab River. However, these small storages were constructed for diverting water into canals for irrigation based on site conditions.

Above descriptions clearly indicate that irrigation was prevalent in India even in Vedic and latter ages. Irrigation has evolved as an art and science in ancient times and developed over centuries to meet the necessities of droughts and floods. In the areas of deficient and erratic rainfall, irrigation by artificial means to supplement rainfall was necessary for raising good harvest. The sub-soil reservoir has therefore been extensively tapped by means of wells, where other sources could not be easily exploited. Consequently, irrigation wells have been practised in India since very early times and this practice is as old as the agriculture itself. The development of Irrigation from pre-historic period up to British rule is furnished in Table 1.1.

1.2 Evidence of Irrigation in Orissa

Orissa known as 'Kalinga' in ancient days has a glorious past. The kings and rulers were very powerful and had extended its boundary from 'Ganga to Godavari. Art and culture flourished in this land under patronage of these rulers up to 15th century. Some of them were benevolent and concerned for the welfare of their subjects. As agriculture is the mainstay and about 70% of people are dependant on agriculture for their livelihood, the kings had constructed tanks, 'sagar's, 'kata's and small reservoirs for providing irrigation. Different types of tanks irrigate a large acerage of land. The upland tanks which provide gravity irrigation are locally known as 'kata'. The dug out tanks are known as 'puskarini', or 'pohkari'. These again require different types of lifts while 'munda' are simply impounded streams which do not require any lift.

The Hatigumpha inscription (2nd half of 1st century B.C.) records that King Kharabela of Cheta dynasty in the fifth year of his reign renovated a canal originally opened by King Nanda 300years earlier to his capital from Tanasuli road. From this inscription, it can be presumed that cultivators of Orissa had some knowledge about canal irrigation. During 18th century A.D. king Padma Narayana Dev and Prataprudra Narayana Dev had constructed Ram Sagar, Laxman Sagar and Bharat Sagar etc. in their state (now in Gajapati district).

The Inscriptions of Bhaumakaras mentions that in Dhenkanal Grant of Tribhuvana Mahadevi in the year 896 AD, the queen Sri- Sindagauri prayed for permanence of the grant as long as the Ganges, the heavenly river, continues to flow; the tremulous shore of the sea encircling the earth and the stars adoring the sky like jewel would exist. The record states that the grant was made with the libation of water for bringing down the rain.

As seen from the 'Report on the administration of Mayurbhanja (then a princely state)', the important works completed during the 1909-10 A.D were:

i. Construction of an irrigation bund at Basilapir in Bamanghatty sub-division to irrigate 1300 acres of land.
ii. Construction of an irrigation bund at Padampur in Joshipur pragana as a protective measure for providing relief to the labourers during the last famine.
iii. There were two ongoing big irrigation projects i.e. Haladia & Baldiha in the head quarter subdivision. Haldia Project was almost complete and Baldiha in the advance stage of construction. Even today Haldia is providing irrigation to 2100 ha and Baldiha to 3800 ha.

Floods and droughts are the twin specters haunting the farmers of Orissa from time immemorial. Due to vagaries of nature, the people of Orissa have been suffering from untold miseries. The economy has crippled and backbone of people broken. The rulers of Orissa in the past had realised this and some localised works were undertaken but not in a systematic and comprehensive way.

Orissa came under the British rule in 1803. The history of Orissa under their rule upto formation of a separate province in 1936 is mainly a history of three districts, i.e. Balasore, Cuttack and Puri. The Commissioners Administrative Report of June 1847 states that "the province of Cuttack is subject to seasons of extreme uncertainty liable to most remarkable vicissitudes of drought and inundation".

The great Orissa famine (Known as 'Na-Anka' durvikshya) occurred in 1865-66. Rainfall in 1865 AD was meager and ceased pre-maturely. Food production was completely damaged. It was followed by flood in 1866. Whatever was spared by drought was swallowed by flood. This forced one of the major calamities on the people of Orissa. Nearly ten lakhs of people comprising about a quarter of Orissa's population died of starvation. The colonial rulers were overwhelmed at the ghastly sight of such human sufferings and launched flood control and irrigation schemes in a large scale. Govt. had to spend Rs. 48 lakhs for relief operation. Subsequently two important irrigation systems were developed by them from 1860 to 1910 AD. These are 'Orissa canal' and 'Rushikulya system'. The former is spread over the deltaic plain where as the latter is confined to Rushikulya basin. Orissa canal system is much bigger in dimension and interlinks three major rivers of Orissa, i.e., the Mahanadi, the Brahmani and the Baitarani. It was primarily meant to serve three major objectives, i.e., irrigation, navigation and flood control. For the development of modern irrigation facilities, the state is indebted to British Rule.

Eminent administrator Sir Charles Trevelyan had recognized the importance of irrigation works. He said "irrigation is every thing in India; water is more valuable than land because when water is applied to land it increases its productiveness at least six fold, and generally a great deal more, and it renders great extent of land productive which otherwise would produce nothing or next to nothing." (Source: The economic history of India Vol.II, Publication Div. 1976, page 262, by Romesh Dutta)

In June 1859, Capt. Beadle, Superintendent of embankments wrote to the Chief Engineer "Indeed the great evil of the province as written large in numerical figures is drought-want of water and not inundation, although for last six years, inundation has been the destructive agent, but remissions on account of inundation are trifling, compared with those made for want of water." Colonel Young, Chief Engineer suggested to the Govt. "If the objects were to obtain irrigation in the dry weather, anicuts should be built across the rivers so that water may be stored for irrigation". In 1862, the East India canal and Irrigation Company began the construction of canal for irrigation and inland navigation. This is, how the modern irrigation system started in Orissa, which will be discussed in subsequent chapters.

Table 1.1 Historical Developments of Irrigation in India

Ancient Period	
Year	**Events**
1- Pre-Historic Period (7,000 B.C to 6,500B.C)	Evidence of use of bundhs and canals by the people of the Indus valley civilization.
2- Vedic Age (1,500 B.C to 1,000 B.C)	Historical and other evidence support the existence of irrigation structures. Channel irrigation was much in practice. (Ref: Translations of the Rig Veda)
3- Budhhist Period; Mauryan Era (600-200 B.C)	Canal irrigation was extensively practised along with lift irrigation: different types of agricultural taxes were fixed for the cultivators depending upon the source of irrigation water, means of carrying etc. Dams were constructed; Embankments were in use. (Ref: Translations of the Arthashashtra of Kautilya)
4- Sanga Dynasty (184-72 B.C): Kanva Dynasty (72-27 B.C): Satvahanas and Kushan Dynasty(1st Century B.C to 2nd Century A.D)	Irrigation used to get high patronage from the Kings: Satvahana Kings were the first to introduce the brick and ring wells: brick ones were mostly for irrigation purpose only.

5- Pandya, Chera and Chola Dynasties of the Southern India (1st Century to 3rd Century A.D)	Lake and well irrigation were in Vogue: Kings were big patrons of agriculture, Large embankment were constructed at suitable points across the Cauvery and Vaigai rivers. Irrigation tanks were extensively constructed. (Ref: Sangam Literatures)
6- Gupta Era (300-500 Century A.D)	Embankments were constructed. Canal irrigation was practised: Kheya and Bundhya channels were dug. (Ref: Fa Hsien's travelogue of 401 to 410 A.D)
7- Pallavas of the Southern India (Early 6th Century on wards)	Great patrons of irrigation works, extensive tapping of groundwater was practised in the form of large scale tank (tataka) construction throughout Tamil Nadu.
8- Chola Era (985-1205 A.D)	(a)Chola kings are revered for introducing quite advanced irrigation system in their kingdom leading to great prosperity in the Deccan region: extensive building of anicuts, tanks took place under their rule.
	(b)Dam construction needs a special mention; upstream ones were used solely for storing water while its overflow was stored the downstream dams. Thus water for irrigation purposes was ensured throughout the year for all types of crops. There was no dependence on the 'Raingods'.
	(c) In total. 1.915 km of functional channel course were dug by the Chola kings of which most are functional in Tamil Nadu even today.
	(d) Chain tanks of Andhra Pradesh & Karnataka need a special mention. These are mostly functional till to date. Thanks to the ingenuity of those ancient builders.
	(e) Village level management committees (Nattyamaikar or such others) were constituted who were made solely responsible for water distribution among the villagers, maintenance, repair, management of the structures concerned, unlike the modern centralized management patterns.
9- State of Irrigation in the Northern India (10th to 12th Century and)	Among other Rajput dynasties, the Paramara Kings were great propagators of irrigation works. The 647 sqkm. Bhopal Lake was dug at their instance; channels were extensively constructed from this lake to make irrigations water available to many far flung regions of their territory.
10- State of Irrigation in the Eastern India; Pal and Sen Dynasties (760 A.D – 1205 A.D)	Pal Kings reigned over Gauda (the present days Bengal) from 760 to 1100 A.D. They constructed many large tanks and lakes throughout their kingdom. Same is known about the Sen rulers [Ref: Medatithi's Abhidhanratnamala; Parashara's Krishi Parashara; Kashyapa's Krishi- Sukti]

Medieval Period	
Year	**Events**
11- Muslim Invasions: Initiation of Muslim Rule; Muhammad Bin Tughlaq's (1325-1351 A.D)	Among the Muslim Rulers, Muhammad Bin Tughlaq was the first one to do something for the peasantry; his policy encouraged farmers to dig wells and reclaiming fallow lands.
12- Feroze Shah Toughlaq's Rule (1351-1388 A.D)	Unlike most of the Muslim rulers, he helped in extending irrigation facilities in vast previously unirrigated dry land tracts of the Northern India. Most remarkable one is the construction of the western Yamuna canal in 1355 A.D [Ref: Shams- E-Shiraz's contemporary writings]
13- Taimur Lang's Tenure (1414-1451 A.D):	His rule led to near destruction of the flourishing agricultural base: large scale famines and droughts followed till the Lodhi Rulers came into power.
14- Lodhi Rulers (1451-1526 A.D)	They were efficient rulers but contributed nothing especially for agriculture / irrigation sectors.
15- Conditions in the southern India: special mention about the Vizianagara kingdom (1336-1546 A.D)	(a) This was the last Hindu Kingdom in the south: Kings were great propagators of public works; wastelands reclamation was highly promoted. Anantarajasagar or Poruma milla tank of the Cuddapah districts (AP) is one of such examples; this one was constructed with a 1.372 mile long earthen embankment on the Maldevi river; its water spread was 41.4 sq.km.
	(b) Interestingly enough, people of this period were so conscious about the possible drawbacks of an irrigation tank; a stone inscription of the King Bukkal (1335-1377 A.D) underlines the following six cautions while construing any irrigation tank: i) Seepage of water: ii) Saline soil or not; iii) No high ground level in the middle of the tank; iv) Over or under estimation of the irrigation capacity; v) Scanty water supply; vi) Excess water supply and distance from the adjacent enemy kingdom.
	(c) King Shri Krishnadevaraya promoted largescale irrigation works which made two time crops possible on previously unirrgated dryland; most remarkable work is the Korrangal dam and the respective distributary cannels (1522 A.D)
Vizianagara Kingdom (Contd.)	(d) Basavanna channel too is worth here, both of which are functional till today. He was the first ruler to engage a foreigner (a protugese engineer expert in irrigation for the benefit of his public).
Vizianagara Kingdom (Contd.)	(e) Large lake was constructed by damming the Sandru hills near Hospet with the help of that Portugeese engineer Mr. Joao de Ponte.
16-Bahamani Kingdom of the Deccan (1388-1422 AD)	During their rule, these Bahamani rulers introduced canal irrigation for the first time in the eastern provides of their territory.
17- Sultan Azin Uddin's Rule in Kashmir (1420-1470 AD)	He was the most acclaimed ruler of Kashmir in the medieval period; during his tenure, a large chunk of karewa (a type of wasteland) lands were turned productive by introducing quite extensive canal irrigation networks eg. Utpalapur, Nadashaila, Bijbihara, Advin etc.
18- Mughal rule; Babar's (1482-1503AD) observation on Indian irrigation scenario.	Babar was astonished on seeing that rivers, through bountiful, were not being tapped for irrigation purpose; instead wells ad tanks, ie. groundwater irrigation was practised. His famous autobiography, the Baburnama describes indigenous lift

	irrigations including that with the help of Charasa and Persian wheels too.
19- Sahajahan's rule (1628-1658 A.D)	No specific mention of contribution of the moghal rulers after Babaur and before Shahajahan's. During Sahajahan's tenure. (i) The defunct Western Yamuna canal was restored, Moreover. (ii) Shahajahan ordered the construction of another canal upto the Red Fort; though beautification of his new capital Shahjahanabad was the aim. Local farmers also benefited (iii) The Bari Doab or Hasli canal was constructed. It was 177 km long and had a 500 cusec discharge capacity. Undivided Punjab was largely benefited from this canal.
20- Rangila Muhammad Sha's Rule (1719-1748 AD)	The Eastern Yamuna canal was constructed at his instance, which started sending irrigation water for a lager section of the previously unirrigated dry tract lying in the northern India.

Source: Irrigation in India–History & Potentials of Social Management by K.S. Bagchi (1995)

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Chapter II

THE STATE OF ORISSA

2.0 History of Orissa

The history of Orissa dates back to antiquity, when its boundaries extended far beyond the present one. Its most famous old names were 'Kalinga', 'Utkal' and 'Odra'. These names are found in the epic 'The Mahabharata'. During the period of Mahavir and Buddha, the Kalinga–Utkal region was recognised on the east coast of India. It was a maritime state. Orissa has passed through similar vicissitudes as other states of the country. Her history is divided into same four periods viz, the Hindu, the Muslim, the British and the post-independence period. Though geographically the state is considered as a part of eastern region, culturally she is as much a part of Northern India as she is of Southern India. The state is thus a confluence of two strands of Indian culture. Historical evidences indicate that its art, architecture, culture and language bear indelible marks of 'Aryabarta' and 'Dakhinatya' civilizations.

Kalinga was ruled by famous kings Asoka, Kharavela & Chodagangadev. In eighth century AD, Orissa's overseas activities were at their peak when the empire was established in present day Malaysia. According to Arab's, the empire even extended to Cambodia and Assam and continued through tenth century AD. Few important events in the ancient history of Orissa is shown in Table 2.1. In twelfth century AD (1078-1191), the Ganga dynasty is credited for ruling over the region extending from Ganga to Godavari. Orissa lost its independence to Muslims in 1568 and came under Moghuls for a little over a century. In 1741 AD, it was invaded by Marathas whose reign continued until the British conquered it in 1803. It was separated from Bihar and came into existence on 1st April 1936. Historic city of Cuttack was the capital before it shifted to Bhubaneswar in 1949-50.

The state in its present form is located in the south-eastern part of the country between latitude $17^0 31'$ to $22^0 27'$ N and longitude $81^0 27'$ to $87^0 30'$ E. It is bounded by West Bengal in the north-east, Jharkhand in the north, Chhatisgarh in the west, Andhra Pradesh in the south and Bay of Bengal in the east. The coastline along the Bay of Bengal is about 480 km long.

Table 2.1 Important Events in the Ancient History of Orissa

Sl. no	Period	Historical Details
I	40-41 BC	Accession of Kharavel. In the fifth year of his reign, he extended the canal from Tansulia road upto Kalinganagari -the canal which has been excavated 300 or 103 years before by king Nanda (a Nanda King) for the purpose of irrigation.
II	261 BC	Ashok's Kalinga war
III	1025-1065 AD	Construction of Lingaraj temple at Bhubaneswar
IV	1038-1435 AD	The Ganga dynasty
V	1198 AD	Construction of temple of Lord Jagannath at Puri.
VI	1282 AD	Construction of Sun temple (Black Pagoda) at Konark
VII	1568 AD	Invasion by 'Kalapahar'
VIII	1592 AD	Rule of Mughals
IX	1751 AD	Marathas conquest
X	1803 AD	British rule on 14th October
XI	1936 AD	Formation of separate province on 1st April
XII	1948 AD	Merger of Princely states with Orissa


Administrative Map of Orissa (13 Districts) Pre - 1992
Jharkhand
West Bengal
Chhattisgarh
ORISSA
Bay of Bengal
Andhra Pradesh
References:
District Boundary
State Boundary


Administrative Map of Orissa (30 Districts) Post - 1992
Jharkhand
West Bengal
Chhattisgarh
Sundergarh
Jharsuguda
Mayurbhanj
Baripada
Deogarh
Keonjhar
Sambalpur
Baleswar
Bargarh
Bhadrak
Sonepur
Nuaparha
Boudh
Angul
Dhenkanal
Jajpur
Balangir
ORISSA
Phulbani
Cuttack
Kendrapara
Kandhamal
Kalahandi
Nayagarh
Khurda
Bhawanipatna
Puri
Ganjam
Bay of Bengal
Nabarangapur
Rayagada
Gajapati
Chhatrapur
Parlakhemundi
Koraput
Malkangiri
Andhra Pradesh
References:
District Boundary
State Boundary

Figure 2.1

During formation of separate province in 1936, it has only six districts. Those were Cuttack, Puri, Balasore, Ganjam, Koraput and Sambalpur. After the merger of princely state in 1948 with Orissa, either they were merged with neighboring district or formed into separate districts like Keonjhar & Mayurbhanj. Thus number of districts rose from six to thirteen. In 1973, the state Government constituted a district reorganization committee. The committee had recommended for creation of four new districts and seven new subdivisions. But this was not acceptable. Subsequently due to public pressure for creation of more districts for better administration, new districts were created from 1990 and within five years the number of districts swelled from 13 to 30. Now, the name of the State has been changed from 'Orissa' to 'Odisha' and its Language from 'Oriya' to Odia'.

District wise areas, total population, % of S.C & S.T, density and literacy rate are furnished in Table 2.2.

Table 2.2 District Wise Details

Sl.No	Name of District	Area (sqkm)	Population (million)			% of S.C & S.T Population		Population density (per sqkm)	Literacy Rate (%)
			Male	Female	Total	S.C	S.T		
1	Angul	6347.0	0.59	0.55	1.14	17.20	11.67	179	68.79
2	Balasore	3705.8	1.04	0.98	2.02	18.84	11.28	532	70.56
3	Bargarh	5831.6	0.68	0.67	1.35	19.37	19.36	231	63.99
4	Bhadrak	2787.9	0.67	0.66	1.33	21.50	1.88	532	73.86
5	Bolangir	6551.5	0.67	0.66	1.33	16.92	20.63	203	55.70
6	Boudh	3444.8	0.19	0.18	0.37	21.88	12.47	121	55.73
7	Cuttack	3915.7	1.21	1.13	2.34	19.08	3.57	595	76.66
8	Deogarh	2781.7	0.14	0.13	0.27	15.37	33.60	93	60.36
9	Dhenkanal	4597.1	0.54	0.53	1.07	18.49	12.79	240	69.42
10	Gajapati	3016.8	0.26	0.26	0.52	7.50	50.78	120	41.26
11	Ganjam	8070.6	1.58	1.58	3.16	18.57	2.18	385	60.77
12	Jagatsingpur	1739.4	0.54	0.52	1.06	21.05	0.82	634	79.08
13	Jajpur	2884.9	0.82	0.80	1.62	22.99	7.76	560	71.44
14	Jharsuguda	2203.2	0.26	0.25	0.51	17.07	31.34	245	70.65
15	Kalahandi	8197.4	0.67	0.67	1.34	17.67	28.65	169	45.94
16	Kandhamala	5464.9	0.32	0.33	0.65	16.89	51.96	81	52.68
17	Kendrapara	2565.6	0.65	0.65	1.30	20.52	0.52	492	76.81
18	Keonjhar	8303.0	0.79	0.77	1.56	11.62	44.5	188	59.24
19	Khurda	2887.5	0.99	0.89	1.88	13.54	5.18	667	79.59
20	Koraput	8379.3	0.59	0.59	1.18	13.03	49.62	134	35.72
21	Malkangiri	6115.3	0.25	0.25	0.50	21.35	57.43	87	30.53
22	Mayurbhanj	10418.0	1.10	1.10	2.20	7.68	56.60	213	51.91
23	Nawapara	4307.5	0.26	0.27	0.53	13.62	34.71	138	42.00
24	Nawarangpur	5290.0	0.51	0.51	1.02	14.10	55.03	194	33.93
25	Nayagarh	3954.2	0.45	0.41	0.86	14.04	5.88	222	70.52
26	Puri	3054.8	0.76	0.74	1.50	18.23	0.30	432	77.96
27	Rayagada	7584.7	0.41	0.42	0.83	13.92	55.76	118	36.15
28	Sambalpur	6704.0	0.48	0.46	0.94	17.04	34.50	141	67.25
29	Sonepur	2284.4	0.27	0.27	0.54	23.62	9.78	232	62.84
30	Sundergarh	9712.0	0.94	0.89	1.83	8.62	50.19	188	84.86
	Total	155707	18.66	18.14	36.80	16.33	22.13	236	63.08

Source (i) Census of India 2001, (ii) Economic survey 2005-06, Govt. of Orissa and (iii) Orissa – A district wise analysis by B.Mohanty (1997)

2.1 Demographic Profile of the State

Table 2.3 Demographic Profile of the State

I	Population		36.805 million (3.57% population of India)
II	Male		18.660 million
III	Female		18.140 million
IV	Rural population		31.287 million
V	Urban population		5.517 million
VI	S.C Population		6.082 million
VII	S.T population		8.145 million
VIII	Density of population		236 per sq.km.
IX	Birth rate (2003)		23.0 per thousand
X	Death rate (2003)		9.7 per thousand
XI	People below poverty line (1999-00)		47.2 %
XII	Total no. of main workers (2001)		9.59 million
XIII	Literacy	Male	75.35 %
		Female	50.51 %
XIV	Growth of Population	a) 1901 AD	10.30 million
		b) 1951 AD	14.65 million
		c) 1971 AD	21.94 million
		d) 1991 AD	31.51 million
		e) 2001 AD	36.80 million

2.2 Natural Resources

Mineral Reserve of the state and that of the country is indicated in Table 2.4 to substantiate the richness of the state

Table 2.4 Natural Resources of the State

Name of the Mineral /Ore	Reserve in Orissa (million MT)	Reserve in India (million MT)	Percentage to all India Reserve
Chromite	111	114	97.37
Nickel Ore	174.5	183.5	95.10
Bauxite	1530	3076	49.74
Iron Ore	4177	12317	33.91
Pyrophylite	4.8	22.6	21.24
Manganese	116	406.2	28.56
Coal	60983	221006	27.59

Source: - Mineral Reserves in Orissa & India (2004-2005) Economic Survey, Govt. of Orissa (2005-06) Page-10/1

2.3 Socio- Economic Condition

Endowed with rich mineral deposits, plenty of water resources and long coastline, socio-economic condition of the people of the state ranks much below when compared with other states of the country. A comparative statement has been presented in Table 2.5.

Table 2.5 Comparative Socio-Economic Condition of the States

State	% of literacy 2001 census	Length of road per 1000 sqkm of area in km (1998-99)	Rail route per 1000 sqkm of area in km (2001-02)	Villages' electrified upto Mar.2003 (%)	% of population below poverty line (1999-00)	Yield rate of rice (qntl/ha) (2003-04)	% of net area irrigated to net area sown (2000-01)
Orissa	63	1447	14.90	79	47.2	15.11	33.16
A.P	61	653	18.94	100	15.8	30.09	40.74
West Bengal	69	893	41.48	82	27.0	25.04	43.45
M.P	64	663	15.76	97	37.4	10.03	28.20
Gujrat	70	476	27.09	100	14.1	18.91	31.55
Haryana	69	653	35.01	100	8.7	27.49	83.89
Punjab	70	1282	41.74	100	6.2	36.94	84.72

Source: - Economic survey (2005-06), Government of Orissa.

2.4 Physiography

Physiographically, the state can be broadly divided into three regions, (i) the coastal plains, (ii) the middle mountainous country and (iii) the plateaus and rolling uplands.

2.4.1 Coastal plains

The coastal plains of Orissa cover undivided districts of Cuttack, Puri, Balasore and Ganjam, stretching from Subarnrekha in northeast to Rushikulya in the southwest. Six major rivers i.e. the Mahanadi, Brahmani, Baitarani, Rushikulya, Burhabalanga and Subarnrekha have enriched the plain. Coastal alluvial plains are highly fertile and valuable for agriculture. However, the degree of fertility decreases proportionately to the distance from the river.

There are two major features in the coastal region. One is coastal wetland ecosystem and the other is coastal mangroves, swamps and marshes. Chilika Lake, the second largest brackish water lagoon in Asia is the dominant wetland system. The gregarious and luxuriant mangroves of Orissa are confined to Bhitar-Kanika and partly in Paradip- Hukitola terrain while some remnants are found in the estuaries of Burhabalanga, Devi and Jambu River.

2.4.2 Middle mountainous country

About three-fourth of the entire state comes under this category covering (a) Similipal and Meghasani mountain (b) Mankarnacha- Malayagiri and Gandhamardan mountain of Baitarani & Brahamani interfluve (c) Watershed between Brahmani and Mahanadi (d) Common interfluve of Mahanadi, Rushikulya and Vansadhara (e) Potangi and Chandragiri mountain ranges.

2.4.3 Plateaus and rolling uplands

Plateaus are morphologically divided into following divisions: -

(i) Panposh - Keonjhar–Palalahara plateau of Upper Baitarani basin
(ii) Nawarangapur – Jeypore plateau of Upper Sabri basin.

The rolling uplands are grouped as follows: -

(a) Rairangpur–Panposh uplands of Koel and Sankh river (b) Jharsuguda uplands of Ib basin (c) Bargarh uplands of Jira & Jhaun basin (d) Bolangir – Titilagarh – Patnagarh uplands of northern Tel basin (e) Bhawanipatna uplands of southern Tel basin (f) Malkangiri uplands of Sabri basin.

Source: Geography of Orissa by B.N.Sinha, N.B.T – 3rd edition (1999)

2.5 Broad Classification of Soil Types

Information on land resource by soil type is furnished for an area of 15.48 million ha, out of this net sown area is 5.79million ha (2003-04)

Table 2.6 Classification of Soil Zones of the State

Sl.No	Types of soil	Approx. area (million ha)	% distribution
1	Red loam & red sandy soil	7.05	45.54
2	Mixed red & yellow soil	5.44	35.14
3	Black soil	0.96	6.20
4	Laterite & Lateritic soil	0.70	4.52
5	Deltaic alluvial soil	0.67	4.33
6	Coastal Saline & sandy soil	0.39	2.52
7	Brown forest soil	0.17	1.10
8	Mixed red & Black soil	0.10	0.65
	Total Area	15.48	100.00

Source: - Orissa Development Report by Planning Commission, Govt. of India (2002).

Sl. 1 & 2 constitute more than 80%. Thus there is a predominance of light textured red soil in the state. Fertile alluvial soil zone accounts for a little more than 4% of the area.

2.5.1 Status of land degradation

Due to increase in population, the average size of land has decreased from 1.89 ha in 1970-71 to 1.34 ha in 1990-91. Major cause of land degradation is highest due to soil erosion, followed by shifting cultivation (Poduchas) and degraded forest. Other minor reasons are water salinity, water logging and ravine. The details are presented in Table 2.7.

Table 2.7 Land Degradation Status of the State

Sl.No	Type of degradation	Assessment in 1985 (Lakh ha)	% of geographical area	Assessment in 1994 (Lakh ha)	% of geographical area
1	Soil erosion (water)	27.71	17.8	25.70	16.5
2	Ravines	1.13	0.7	0.18	0.1
3	Saline	4.03	2.6	1.35	0.9
4	Water logged	0.60	0.4	1.42	0.9
5	Mine & Quarry waste	--	--	0.97	0.6
7	Shifting cultivation	26.48	17.0	1.84	1.2
8	Degraded forest	18.07	11.6	26.56	17.1
9	Total for Orissa	78.3	50.1	58.02	37.3
10	Total for country	1721.75	52.8	1074.3	32.7

Source: Orissa Development report Planning commission, Govt. of India (2002). Total water logged area in the state (as per NRSA, Hyderabad, 2000) is 2, 17,845 ha and saline area (as per National Bureau of Land use Planning – ICAR, 2001) 149472 ha.

2.6 Land Utilization Pattern in the State

Table 2.8 Land use Pattern of the State in Thousand ha

Sl. No	Year	Geogr. area	Forest area	Misc Tree	Perm. Pasture	Cultivable Waste	Land put to non-agri.	Barren & un-cult. land	Current fallow	Other Fallow	Net area Sown
1	92-93	15571	5478	857	663	538	781	532	215	203	6304
2	93-94	15571	5534	867	635	487	781	541	180	243	6304
3	94-95	15571	5722	715	514	435	858	553	197	298	6279
4	95-96	15571	5722	715	514	435	858	553	241	323	6210
5	96-97	15571	5606	764	534	445	858	570	483	343	5968
6	97-98	15571	5606	774	534	445	866	590	298	336	6122
7	98-99	15571	5606	774	534	445	866	590	372	336	6048
8	99-00	15571	5606	774	534	445	838	618	345	336	6075
9	00-01	15571	5813	482	443	392	999	843	430	340	5829
10	01-02	15571	5813	482	443	392	999	843	320	434	5845
11	02-03	15571	5813	482	443	392	999	843	485	434	5680
12	03-04	15571	5813	482	443	392	999	843	369	434	5796

Source: - Orissa Economic Survey (2005-06), Government of Orissa. Annexure.4.1

2.7 Climatology

Orissa situated on the eastern seaboard of India enjoys a tropical monsoon type of climate associated with high humidity particularly in coastal belt. The state is surrounded by landmass in the north and west and by Bay of Bengal in the southeast. There are four meteorological seasons namely:

i) Winter (January- February) ii) Hot Weather (March–May)
iii) South West monsoon (June- September) iv) Post monsoon (October–December)

But the year is locally divided into six seasons

a) Grishma (summer) - Baisakha and Jyestha (i.e., from mid April to mid June)
b) Barsha (Rainy season) – Ashadha and Sravana (i.e., from mid June to mid August)
c) Sarad (Autumn) – Bhadrab and Aswina (i.e., from mid August to mid October)
d) Hemanta (Winter)–Kartika & Margasira (i.e., from mid October to mid December)
e) Sisira (Winter) – Pausa and Magha (i.e., from mid December to mid February)
f) Basanta (Spring) – Falguna & Chaitra (i.e., from mid February to mid April).

Above six local seasons are clubbed into three main seasons, i.e., Summer season – Basanta and Grishma. Rainy season – Barsha & Sharad and Winter season – Hemanta and Sisira.

Precipitation, Temperature, Wind, Cloud and Humidity are elements of climate; but amongst all these precipitation is dominant. Monsoon rainfall is of highest importance as it directly controls the crop conditions in the state. Monsoon rainfall is considered high when it exceeds 1400 mm and low when it is less than 1200 mm as this is just sufficient for a good paddy harvest. The mean annual rainfall is 1482 mm with variations in both space and time. Between mid June to mid September, rainfall is about 85%. The mean annual rainfall is very erratic over years. As a result, there is flood is some years and drought in other years. These two phenomena have also occurred in the same years in different areas of the state. Even there are years when the state has experienced three natural calamities, i.e., Flood, Drought and Cyclone (Table 2.9).

Table 2.9 Average Rainfall in the State

Year	Normal Rainfall (mm)	Actual Rainfall (mm)	Deviation from normal		Natural Calamities
			(mm)	(%)	
1961	1502.5	1262.8	-239.7	-15.95	Flood
1962	1502.5	1169.9	-332.6	-22.14	-------
1963	1502.5	1467.0	-35.5	-2.36	-------
1964	1502.5	1414.1	-88.4	-5.88	-------
1965	1502.5	997.1	-505.4	-33.64	Severe Drought
1966	1502.5	1134.9	-367.6	-24.47	Drought
1967	1502.5	1326.7	-175.8	-11.70	Cyclone & Flood
1968	1502.5	1296.1	-206.4	-13.74	Cyclone & Flood
1969	1502.5	1602.1	299.6	19.94	Flood
1970	1502.5	1660.2	157.7	10.50	Flood
1971	1502.5	1791.5	289.0	19.23	Severe Cyclone, Flood
1972	1502.5	1177.1	-325.4	-21.66	Flood, Drought
1973	1502.5	1360.1	-142.4	-9.48	Flood
1974	1502.5	951.2	-551.3	-36.69	Severe Drought, Flood
1975	1502.5	1325.6	-176.9	-11.77	Flood
1976	1502.5	1012.5	-490.0	-32.61	Severe Drought
1977	1502.5	1326.9	-175.6	-11.69	Flood
1978	1502.5	1261.3	-241.2	-16.05	Hailstorm, Whirlwind, Tornado
1979	1502.5	950.7	-551.8	-36.73	Severe Drought
1980	1502.5	1321.7	-180.8	-12.03	Flood, Drought
1981	1502.5	1187.4	-315.1	-20.97	Whirlwind, Tornado, Flood, Drought
1982	1502.5	1179.9	-322.6	-21.47	Severe Flood, Drought, Cyclone
1983	1502.5	1374.1	-128.4	-8.55	--------
1984	1502.5	1302.8	-199.7	-13.29	Drought, Flood
1985	1502.5	1606.8	104.3	6.94	Flood
1986	1502.5	1566.1	63.6	4.23	Drought, cyclone
1987	1502.5	1040.8	-461.7	-30.73	Severe Drought, cyclone
1988	1502.5	1270.5	-232.0	-15.44	Drought
1989	1502.5	1283.9	-218.6	-14.55	Drought
1990	1502.5	1865.8	363.3	24.18	Flood
1991	1502.5	1465.7	-36.8	-2.45	Flood
1992	1502.5	1344.1	-158.4	-10.54	Flood & Drought
1993	1502.5	1421.6	-80.9	-5.38	-------
1994	1502.5	1700.2	197.7	13.16	Flood
1995	1502.5	1588.0	85.5	5.69	Flood
1996	1502.5	990.1	-512.4	-34.10	Severe Drought
1997	1502.5	1493.0	-9.5	-0.63	Flood, Drought
1998	1502.5	1277.5	-225.0	-14.98	Severe Drought
1999	1502.5	1435.7	-56.8	-4.45	Super Cyclone
2000	1502.5	1035.1	-467.4	-31.11	Drought & Flood
2001	1451.2	1616.2	165.0	11.37	Flood
2002	1451.2	1007.8	-443.4	-30.55	Drought

Source: Agricultural Statistics of Orissa at a glance (5^{th} edition, 2004), Page-63 and Human Development Report, 2004, Govt. of Orissa. Table 7.1, Pg. 163.

Table 2.9 shows the actual quantity of rainfall that occurred from 1961 to 2002 against normal annual rainfall. Due to wide variation of rainfall supplemental irrigation is necessary even during Khariff season, mostly in the month of September and October for good growth of crop. One of the troubles in Orissa is that after the monsoon, the whole country dries up when artificial irrigation becomes necessary.

In the administrative report of 1886-87, collector Balasore pointed out that "copious rain in July, August and September (the more, the better) means a full crop-even if no more copious rain comes. If in addition to this, they get more rains than usual in October, the full crop becomes more than full. A perfect year for the crop is an average rainfall in June, a copious rainfall in July, August and September (especially in August and September) and a more than average rainfall in the first half of October."

"The great famine of 1866 was caused by drought in 1865. In the month of May 1865, there was an abnormal and useless rainfall of 13 inches, which hindered ploughing. Only 15 inches of rain fell in July, August and September."

A statement showing rainfall in the months of September and October in Cuttack, Puri and Balasore Districts from 1860 to 1898 is appended vide Table 2.10. It can be seen from the table that "during this 39 years, the rainfall of October has been less than 4 inches, (10 cm) 15 times in Cuttack, 12 times in Balasore and 6 times in Puri; such failure is however more serious in this last district which depends to a great extent on the late rain. On the whole we may say that once in every four years the rainfall is less than the maximum compatible with ripening of the crop, and causes the loss of a fourth to half of the rice in the un-irrigated land." (Source: Orissa final report by S.L. Maddox, 1890-1900, Pg.79)

Table 2.10 Statement Showing the Rainfall in Inches / (mm.)

Year	Cuttack			Balasore			Puri		
	Sept.	Oct.	Total Yearly	Sept.	Oct.	Total Yearly	Sept.	Oct.	Total Yearly
1	2	3	4	5	6	7	8	9	10
1860	12.50 (317.5)	0.70 (17.8)	46.80 (1188.7)	15.20 (386.1)	1.30 (33.0)	50.60 (1285.2)	20.00 (508.0)	4.50 (114.3)	74.10 (1882.1)
1861	15.68 (398.3)	4.56 (115.8)	76.28 (1937.5)	7.40 (188.0)	4.70 (119.4)	76.50 (1943.1)	14.10 (358.1)	6.10 (154.9)	73.00 (1854.2)
1862	11.98 (304.3)	18.88 (479.6)	62.98 (1599.7)	35.40 (899.2)	29.30 (744.2)	111.90 (2842.3)	16.60 (421.6)	42.20 (1071.9)	136.10 (3456.9)
1863	7.10 (180.3)	2.00 (50.8)	69.77 (1772.2)	14.95 (379.7)	7.70 (195.6)	86.80 (2204.7)	15.30 (388.6)	7.80 (198.1)	60.90 (1546.9)
1864	8.90 (226.1)	2.60 (66.0)	48.70 (1237.0)	7.90 (200.7)	6.10 (154.9)	64.80 (1645.9)	8.60 (218.4)	6.20 (157.5)	42.20 (1071.9)
1865	7.44 (189.0)	-- --	51.40 (1305.6)	9.30 (236.2)	0.30 (7.6)	52.60 (1336.0)	5.20 (132.1)	-- --	36.30 (922.0)
1866	2.60 (66.0)	11.85 (301.0)	60.95 (1548.1)	10.50 (266.7)	8.55 (217.2)	68.25 (1733.6)	12.10 (307.3)	11.10 (281.9)	77.20 (1960.9)
1867	10.11 (256.8)	5.40 (137.2)	50.75 (1289.1)	15.22 (386.8)	9.00 (228.6)	67.62 (1717.5)	10.60 (269.2)	14.30 (363.2)	70.00 (1778.0)
1868	9.80 (248.9)	1.96 (49.8)	52.81 (1341.4)	9.60 (243.8)	0.40 (10.2)	77.00 (1955.8)	5.05 (128.3)	0.80 (20.3)	50.97 (1294.6)
1869	9.23 (234.4)	5.35 (135.9)	48.14 (1222.8)	13.19 (335.0)	6.74 (171.2)	49.77 (1264.2)	12.48 (317.0)	6.69 (169.9)	44.87 (1139.7)
1870	8.80 (223.5)	8.61 (218.7)	49.92 (1268.0)	11.46 (291.1)	7.69 (195.3)	54.77 (1391.2)	6.58 (167.1)	10.95 (278.1)	43.44 (1103.4)

1871	9.67 (245.6)	0.91 (23.1)	50.39 (1279.9)	14.82 (376.4)	5.13 (130.3)	63.41 (1610.6)	12.39 (314.7)	1.40 (35.6)	56.32 (1430.5)
1872	8.76 (222.5)	16.16 (410.5)	71.16 (1807.5)	13.97 (354.8)	11.97 (304.0)	71.29 (1810.8)	7.04 (178.8)	16.19 (411.2)	75.14 (1908.6)
1873	6.27 (159.3)	2.54 (64.5)	38.61 (980.7)	7.61 (193.3)	4.69 (119.1)	48.35 (1228.1)	9.21 (233.9)	12.53 (318.3)	52.72 (1339.1)
1874	12.13 (308.1)	10.71 (272.0)	86.74 (2203.2)	7.60 (193.0)	12.03 (305.6)	55.19 (1401.8)	4.87 (123.7)	9.62 (244.3)	61.78 (1569.2)
1875	10.26 (260.6)	10.25 (260.4)	91.92 (2334.8)	12.00 (304.8)	2.87 (72.9)	59.45 (1510.0)	11.37 (288.9)	15.01 (381.3)	64.16 (1629.7)
1876	9.83 (249.7)	4.89 (124.2)	41.28 (1048.5)	15.95 (405.1)	10.32 (262.1)	82.72 (2101.1)	9.61 (244.1)	6.64 (168.7)	34.93 (887.2)
1877	6.25 (158.7)	3.05 (77.5)	41.13 (1044.7)	5.51 (140.0)	3.32 (84.3)	67.40 (1712.0)	6.70 (170.2)	4.51 (114.6)	35.15 (892.8)
1878	6.40 (162.6)	4.92 (125.0)	54.57 (1386.1)	7.90 (200.7)	8.59 (218.2)	61.89 (1572.0)	13.56 (344.4)	14.08 (357.6)	54.66 (1388.4)
1879	9.44 (239.8)	4.98 (126.5)	60.62 (1539.7)	17.09 (434.1)	6.10 (154.9)	49.62 (1260.3)	12.11 (307.6)	4.56 (115.8)	53.57 (1360.7)
1880	10.29 (261.4)	5.17 (131.3)	67.06 (1703.3)	11.63 (295.4)	5.28 (134.1)	74.33 (1888.0)	15.14 (384.5)	10.63 (270.0)	87.58 (2224.5)
1881	11.27 (286.3)	2.38 (60.5)	59.33 (1507.0)	14.72 (373.9)	8.35 (212.1)	79.71 (2024.6)	6.30 (160.0)	4.37 (111.0)	49.83 (1265.7)
1882	11.86 (301.2)	7.64 (194.1)	75.96 (1924.4)	21.69 (550.9)	10.10 (256.5)	79.02 (2007.1)	7.54 (191.5)	7.95 (201.9)	43.93 (1115.8)
1883	12.93 (328.4)	0.55 (14.0)	67.24 (1707.9)	3.76 (95.5)	1.70 (43.2)	63.31 (1608.1)	13.61 (345.7)	4.95 (125.7)	61.18 (1554.0)
1884	8.68 (220.5)	2.40 (61.0)	59.42 (1509.3)	13.57 (344.7)	4.48 (113.8)	76.24 (1936.5)	15.10 (383.5)	17.13 (435.1)	65.01 (1651.2)
1885	8.33 (211.6)	2.60 (66.0)	47.74 (1212.6)	11.07 (281.2)	1.84 (46.7)	59.83 (1519.7)	6.05 (153.7)	5.73 (145.5)	38.16 (969.3)
1886	13.99 (355.3)	11.77 (299.0)	79.70 (2024.4)	17.82 (452.6)	5.65 (143.5)	73.96 (1878.6)	14.78 (375.4)	6.14 (156.0)	56.55 (1436.4)
1887	7.03 (178.6)	2.26 (57.4)	54.03 (1372.4)	4.99 (126.7)	3.09 (78.5)	53.43 (1357.1)	6.31 (160.3)	5.68 (144.3)	38.20 (970.3)
1888	8.81 (223.8)	1.84 (46.7)	56.08 (1424.4)	12.82 (325.6)	1.64 (41.6)	59.84 (1519.9)	7.80 (198.1)	1.66 (42.2)	44.22 (1123.2)
1889	5.26 (133.6)	8.24 (209.3)	69.88 (1775.0)	6.15 (156.2)	8.52 (216.4)	57.26 (1454.4)	6.44 (163.6)	12.43 (315.7)	79.01 (2006.9)
1890	17.53 (445.3)	7.89 (200.4)	65.31 (1658.9)	18.68 (474.5)	10.16 (258.1)	66.57 (1690.9)	14.77 (375.2)	10.61 (269.5)	72.02 (1829.3)
1891	23.72 (602.5)	1.68 (42.7)	73.76 (1873.5)	16.81 (427.0)	0.76 (19.3)	69.52 (1765.8)	16.09 (408.7)	2.83 (71.9)	59.93 (1522.2)
1892	10.35 (262.9)	7.39 (187.7)	50.34 (1278.6)	11.40 (289.5)	7.93 (201.4)	55.24 (1403.1)	8.34 (211.8)	5.87 (149.1)	46.57 (1182.9)
1893	15.44 (392.2)	5.03 (127.8)	81.52 (2070.6)	19.04 (483.6)	5.65 (143.5)	92.39 (2346.7)	17.30 (439.4)	7.96 (202.2)	71.23 (1809.2)
1894	6.45 (163.8)	7.76 (197.1)	60.82 (1544.8)	6.86 (174.2)	4.70 (119.4)	61.69 (1566.9)	7.54 (191.5)	7.50 (190.5)	52.38 (1330.4)
1895	8.60 (218.4)	5.89 (149.6)	67.71 (1719.8)	6.52 (165.6)	3.73 (94.7)	58.67 (1490.2)	12.77 (324.4)	7.31 (185.7)	67.87 (1723.9)
1896	9.49 (241.0)	0.03 (0.8)	58.52 (1486.4)	10.59 (269.0)	-- --	62.17 (1579.1)	6.83 (173.5)	0.31 (7.9)	53.13 (1349.5)
1897	7.89 (200.4)	8.92 (226.6)	68.82 (1748.0)	5.90 (149.9)	14.13 (358.9)	65.05 (1652.3)	7.45 (189.2)	10.12 (257.0)	55.12 (1400.0)

1898	8.56 (217.4)	9.01 (228.9)	59.85 (1520.2)	11.33 (287.8)	10.31 (261.9)	59.62 (1514.3)	6.57 (166.8)	9.75 (247.6)	50.55 (1284.0)
Average	10.22 (259.6)	5.44 (138.2)	60.87 (1546.1)	12.26 (311.4)	6.56 (166.6)	66.34 (1685.0)	10.52 (267.2)	8.55 (217.2)	58.85 (1494.8)

Source: Final Report by S.L. Maddrox Pg. 80

Average of Orissa- Fall in September …… 11.00
Fall in October 6.85
Total fall of the year 62.02

Artificial irrigation is not only an insurance against famine and scarcity, but it augments the crop yield in a proportion much more than the interest upon the capital outlay on irrigation works. Table 2.11 shows Normal rainfall in different periods of the year in various districts of Orissa.

Table 2.11 Normal Rainfall in Orissa in mm.

Undivided District	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total mm.	Average Rainy days per year
Balasore	17.1	30.6	34.3	53.1	105.1	218.2	332.6	313.6	243.1	171.0	42.3	7.2	1568.2	73.2
Bolangir	13.9	18.2	13.9	18.7	29.1	253.7	391.1	407.1	232.0	65.6	15.9	3.7	1443.5	67.0
Cuttack	13.7	27.5	20.8	34.2	56.5	222.3	351.8	315.8	229.2	147.4	46.7	5.04	1501.3	71.7
Dhenkanal	15.5	30.8	18.7	28.8	59.5	208.9	382.0	333.0	220.6	39.6	25.2	4.5	1421.1	72.8
Ganjam	10.8	22.2	21.3	42.3	76.8	169.2	221.6	242.4	229.6	179.8	68.6	11.0	1295.6	65.4
Kalahandi	11.5	15.4	13.6	23.7	33.7	228.3	343.5	384.6	220.9	81.9	17.9	3.2	1378.2	65.4
Keonjhar	22.2	38.0	23.0	43.3	88.9	209.6	391.8	333.3	233.0	112.7	31.7	5.1	1534.5	78.8
Koraput	6.7	11.3	16.2	53.4	75.0	205.8	351.1	380.3	262.1	116.5	35.8	7.6	1521.8	81.7
Mayurbhanj	21.9	35.5	29.8	47.3	96.7	235.2	426.4	375.5	232.3	113.6	27.4	6.6	1648.2	82.9
Phulbani	13.0	27.6	25.1	35.5	66.0	239.1	390.8	373.8	260.3	127.3	31.8	6.9	1597.1	77.4
Puri	14.2	26.2	19.7	26.8	67.2	207.0	310.8	300.3	244.7	167.0	59.9	7.3	1449.1	69.7
Sambalpur	14.3	24.4	16.4	17.6	30.9	218.7	469.6	430.9	224.3	61.6	14.7	3.6	1527.0	70.3
Sundergarh	19.9	36.7	19.3	20.1	41.1	250.9	840.2	458.2	223.9	75.9	16.1	5.3	1647.6	78.2
State Total	14.0	25.9	21.4	35.3	70.8	213.2	351.6	335.6	236.5	131.6	39.9	6.4	1482.2	72.8

Source: Irrigation in Orissa by A.K.Dalua & A.C. Nayak (WALMI, 1991, Page-9)
Note: Rainfall figures are average of last 40 years

2.7.1 Two Worst Natural Calamities (1866 Famine and 1999 Super Cyclone)

2.7.1.1 Na-anka famine

This worst famine which occurred in the year 1866 is so termed as it was during the 9th year of the reign of the then Maharaja Gajapati Divya Singh Dev. Extract of the Report of the Famine Commission of 1878 quoted in Buklands, "Bengal under Lieutenant Governors" (Pg.329) is as follows which explains the gravity of the situation.

"The rainfall of 1865 in Orissa was scanty and ceased prematurely, so that the out turn of the great crop of winter rice on which the country mainly depends, was reckoned at less than a third of average crop. Food stocks were low, both because export had been unusually brisk of late & because the people had not been taught by precarious seasons to protect themselves by retaining sufficient stores at home. When the harvest failed, so totally new to them was the situation that no one realised its meaning and its probable results. The local Government and officials not taking alarm and misconceiving the gravity of the occasion abstained from making special enquiries; prices along remained so moderate that they forced no temptation to importers, and forced no reduction in consumption on the inhabitants, till suddenly the province was found to be almost bare of food. It was only in May 1866 that it was discovered that the markets were so empty that the jail-prisoners and the government establishment could not be supplied. But the southern monsoon had now begun and importation by sea or land became impossible. Orissa was at that time almost isolated from the rest of India; the only road leading to Calcutta across a country intersected by large rivers and liable to inundation, was unmetalled and unbridged and there was very little communication by sea, for what trade there was hard hitherto been a purely export trade, carried on in the months of fine weather. No relief could be obtained from the south where lay the district of Ganjam, itself severely distressed. By great exertions and at enormous cost, the Government threw in about ten thousand tons of food-grain by the end of November, and this was given away gratuitously, or sold at low rates, or distributed in wages to the starving population saving, no doubt, many thousands of lives. But meanwhile, the mortality among those whom this relief did not reach, or reached too late, had been very great and it was estimated that about a third of the population or nearly 10, 00, 000 persons had died."

Historian Pyari Mohan Acharya has given an eye witness account of the horrible picture of the famine in the following words. "One fills stunned when he remembers the shocking events that took place at that time. It is quite impossible to give a faithful picture of the horrors of the famine that came accompanied by the death itself. The towns were filled with the sorrowful shrieks of thousands of men, women and children who had been reduced to mere skeletons. The crematory grounds near the towns and villages were full of innumerable dead bodies and upon them the vultures and jackals feasted to their hearts content. Men and women forsook their natural instincts owing to the unbearable pangs of hunger. Parents cast way their starving children before wild animals to be devoured by them. Some even ate the dead bodies of their own children like demons. Social evils such as murders, suicides etc., became a very common thing at the time. Some people tried to live upon wide shrubs and inedible materials." (Source: The natural calamities of Orissa in 19th Century-1997, by B.B. Bhatta Pp. 106-107.

"The mortality in and about Balasore town, and the famine sights to be seen there were more terrible than at any other place in Bengal and Orissa. The mass of paupers assembled was larger than it was else where. The town lay in the way of many who exhausted and disabled by hunger and diseases from going further, remain to swell the number who were fed by the Relief Committee. Subjects of the neibouring Tributary Rajas also flocked into share in the relief. These, as well as the travelers generally, arrived in such a condition that they were beyond recovery. In the early months Cholera, and subsequently other bowels-complaints caused by bad and insufficient food, carried of hundreds; the least change of weather to cold or damp was immediately fatal. Many who were caught by the bad weather at a distance from the places of the distribution had not strength to crawl back their meal and so died, where they lay, in out-houses or by the way-side. Even in fine weather many were found dead in the morning where they had lain down to sleep at night; others, when they went to drink fell into the water through sheer debility and were drowned." Source: District Gazetteer, Balasore by L.S.S. O' Malley 1907. Pg. 101-102.

Table 2.12 shows the population of Orissa before & after famine of 1866.

Table 2.12 Population of Orissa Before & After Famine

Population of Orissa (lakhs)	Cuttack	Puri	Balasore	Total population (lakhs)
Before Famine	15.04	7.80	7.32	30.16
Death due to Famine	3.78	2.19	2.17	8.14
Migration due to Famine	0.53	0.32	0.30	1.15
Population after famine	10.72	5.29	4.85	20.86
Total animal loss	4.31	2.51	2.47	9.29

Source: - The Natural calamities in Orissa in the 19th century by B.B Bhatta (1997) Pg-134.

Above table shows that about one-third population died during famine of 1866. Total loss of life, cattle, property and crops were incalculable. George Campbell's remark on the famine is as follows: "We were shocked by the human remains we saw all around. From an Indian point of view the area of very intense famine was rather small, being confined to as few millions of people, and the period of intensity was short, being no more than a single half-year. But within these limits, it was I think, by far the most acute famine experienced in any part of India in the present (19th) century."

The 'Report of the Commissioners appointed to enquire into the famine in Bengal and Orissa 1966' mentions that "....we can only say that the mortality has been without doubt enormous. Perhaps some of those who have witnessed most horrible scenes may incline to make a more gloomy view of the destruction than will be borne out when the survivors have settled down again .... The mortality have undoubtedly so great among the old and the young of so many families which have escaped total destruction in so many parts of the great mass of proper labouring population (as distinguished from farming Ryots) seem to have been really so much swept from the face of the earth ...."

The report quotes an eye witness, Mr Kirkwood, Assistant Collector of Cuttack who gave a graphic picture of acute distress. "Many died daily from starvation and 'mehters' (sweeper) are entertained for the purpose of removing their bodies. All ties of kindred or natural affection are at one end and many a mother, I saw, tearing the food out of the hands of her starving child."

The Na-Anka famine had very adverse impact, which ruined the state and shattered its economy. It exposed the failure of the administrative machineries in Orissa to look after the people. A hot debate took place on 2nd August 1867 in the House of Commons in England. Sir Strafford Northcote, the Secretary of State for India, pacified the members by saying as such:

"The catastrophe must always remain a monument of our failure, a humiliation to the people of this country, to the Government of this country and to those of our Indian official of whom we had been perhaps a little too proud. At the same time, we must hope that we might derive from it lessons which might be of real value to ourselves, and that out of this deplorable evil good of no significant kind might ultimately arise".

But the famine of 1866 was a turning point in the history of modern Orissa. It expanded the mental horizon of its inhabitants through new method of education, construction of roads & railways for better connectivity with outer world thereby breaking the economic and geographical isolation. Much has been done by the British after the famine of 1866 to prevent the recurrence of such calamity. The canals, harbours and regular system of communication were improved with Calcutta to break the isolation of Orissa, which was the main cause of the great famine (Source: Statistical Accounts of Bengal, Vol. XVIII Pg.148 –W.W. Hunter). On the other hand the ghastly scene and the traumatic shock could not be erased from the memory of its people for generations.

2.7.1.2 Super Cyclone, the Worst in the Century

The state is intermittently ravaged by floods, famines, and cyclones. The super cyclone that devastated the coastal Orissa occurred on 29-30th October 1999. It crippled state's economy, destroyed the ecosystem and pushed back the economy by over two decades.

Initially Rushikulya basin was affected by cyclone and flood on 17-18th October followed by super cyclone after 12 days. In total 14 coastal districts were affected which are agriculturally rich and thickly populated.

The other major cyclonic floods occurred in the years 1830, 1831, 1834, 1848, 1851, 1855, 1856, 1857, 1862, 1866, 1868, 1872, 1874, 1877, 1879, 1880, 1881, 1885, 1892, 1894, 1895 & 1896. (Vide: Reference Orissa, 2nd edition-2000) Thus between 1830 to 1900 AD, i.e., in a span of 70 years, coastal Orissa experienced 22 worst calamities averaging one in every 3.2 years. The 1865-66 AD disastrous flood, drought and cyclone, which resulted 'Na-Anka famine', still rankles the psyche of people. The incidence of Natural calamities and its frequencies in Orissa from 1803 to 1900 are given in Table 2.14 and Table 2.15.

In 1955-56 there was a major flood in which 'Dalai Ghai' embankment (near Jagatsingpur) breached causing extensive damage in large areas in Mahanadi Delta. Again in 1971 October 30th, the cyclone hit Orissa killing 9265 people and affecting 50-lakh population. Gopalpur coast cyclone of October 17-18th, 1999 killed 205 people where as severe Paradeep cyclone killed 9885 people as per official records (But, unofficial estimate is about 24000, Samaj 07.01.2000), 315886 cows and bullocks, 316372 nos. of goat, sheep and pigs, 1883468 poultry. It damaged 1650086 habitats and 13 lakhs ha of Khariff paddy crop. Total agricultural loss was to the extent of Rs.1733 crores. The U.N. Disaster Management Team who visited Mahanadi Delta during 1st week of November 99 reported that "It will be a long time before cyclone affected people of Orissa can cease to be dependant on outside support for food. Massive tracts of agricultural land are under water, all the standing crops have been destroyed, the bullocks used for ploughing are dead, and seed stocks have been washed away". They also said that the destruction was enormous. Besides physical destruction and loss of human lives, huge areas of cultivable land are now flooded with seawater. In fact the incursion of saline water will render agricultural activity a non-starter for several seasons in these areas. They further stated that it would not be possible for the farmers to grow anything for a longtime. (Source: Times of India 11.11.99).

Table 2.13 shows the area submerged due to tidal & flood action in the coastal plains after Super Cyclone on 02.11.99 (Satellite imageries)

Table 2.13 Affected Area During Super Cyclone 1999

Name of District	No. of blocks affected	Submerged Area (ha)	% of area Submerged to the total area of district
Worst affected			
Kendrapara	9	18466	48.3
Bhadrak	7	92502	41.9
Jagatsingpur	8	44437	26.8
Jajpur	10	63239	25.8
Cuttack	8	24934	-----
Partially affected			
Balasore	6	22123	----
Puri	5	21621	----
Keonjhar	5	18466	----
Dhenkanal	2	6878	----
Khurda	--	4876	----
Mayurbhanj	--	2683	----
Total	60	320225	

Source: Reference Orissa (2nd edition, 2000) Pg.623.

Table 2.14 Incidence of Natural Calamities in Orissa (From 1803 to 1900)

Nature of Calamities	Years
Only Flood	1804, 1808, 1812 to 1814, 1817 & 1818,1820, 1834, 1837, &1838, 1844 to 1848, 1852, 1854 to 1858, 1862, 1868, 1871, 1875, 1879, to 1881, 1883, 1886, 1892 & 1894.
Only famine or Scarcity	1803, 1816, 1819, 1828, 1830, 1836, 1839, 1865 & 1897.
Only Cyclone	1831, 1851, 1864, 1885 & 1887.
Flood and Famine without Cyclone	1806 & 1807, 1809, 1826, 1835, 1841, 1853, 1863, 1870, 1877, 1889, 1896 & 1900
Flood & Cyclone without Famine	1823, 1848, 1850, 1872, 1891 & 1893
Famine & Cyclone without Flood	1832 & 1833.
Flood, famine & Cyclone	1840, 1842, 1866, 1877, 1888 & 1890.
No Calamities year	1805, 1810 & 1811, 1815, 1821 & 1822, 1824 & 1825, 1827, 1829, 1843, 1849, 1859 to 1861, 1867, 1869, 1873, 1876, 1878, 1882, 1884, 1898 & 1899.

Table 2.15 Frequency of Natural Calamities in Orissa (1803 to 1900)

Nature of Calamity	Single year	Continuity			
		Double Yr	Triple yrs	More than 3 yrs	Total Yrs
Only Flood	13	2	2	2	33
Only Famine & Scarcity	9	--		--	9
Only Cyclone	5	--	--	--	5
Flood & Famine without cyclone	11	1	--	--	13
Famine & Cyclone without flood	--	1	--	--	2
Flood & cyclone without famine	6	--	--	--	6
Flood, Famine & cyclone	6	--	--	--	6
No calamities year	13	4	1	--	24

Source: The Natural calamities in Orissa in the 19th century by B.B. Bhatta (1997) Pg. 224-24.

2.8 Agro-Climatic Zone

The state has been divided into ten agro-climatic zones basing on soil, water and other relevant characteristics. Characteristic of different zones are presented here.

Table 2.16 Agro-Climatic Zone of the State

Sl. No	Agro-climatic Zone	Agricultural Districts	Climate	NORMAL Mean Annual Rainfall (mm)	Mean maximum summer temp (°C)	Mean minimum winter temp (°C)	Broad soil groups
1	Northern western plateau	Sundargarh parts of Deogarh, Sambalpur & jharsuguda	Hot & moist sub-humid	1600	38.0	15.0	Red, Brown forest, Red & Yellow, Mixed Red & Black
2	Northern central plateau	Mayurbhanj, major parts of Keonjhar, (expect Anandapur & Ghasipur block)	Hot & moist sub-humid	1534	36.6	11.1	Laternic, Red & Yellow, Mixed Red & Black
3	North Eastern coastal plain	Balasore, Bhadrak parts of Jajpur & hatedihi block of Keonjhar	Moist sub-humid	1568	36.0	14.8	Red, Lateritic, Deltaic alluvial, Coastal alluvial & Saline
4	East & South Eastern coastal plan	Kendrapara, Khurda, Jagatsingpur parts of Cuttack, Puri, Nayagarh & parts of ganjam	Hot & humid	1577	39.0	11.5	Saline, Lateritic, Alluvial, Red & Mixed Red & Black
5	North eastern ghat	Phulbani, Rayagada, Gajapati parts of Ganjam & small patches of Koraput	Hot & moist, sub-humid	1597	37.0	10.4	Brown forest, Lateritic Alluvial, Red, Mixed Red & Black
6	Eastern ghat high land	Major parts of Koraput, Nawarangpur	Warm & humid	1522	34.1	7.5	Red, Mixed Red & Black, Mixed Red & Yellow
7	South eastern ghat	Malkangiri & parts of Koraput	Warm & humid	1710	34.1	13.2	Red, Lateritic, Black
8	Western undulating zone	Kalahandi & Nuapada	Hot & moist, sub-humid	1352	37.8	11.9	Red, Mixed Red & Black, Black
9	Western central table land	Bargarh, Bolangari, Boudha, Sonepur, Sambalpur& Jharsuda	Hot & moist, sub-humid	1614	40.0	12.4	Red & Yellow, red & Black, Black, Brown forest, Lateritic
10	Mid central table land	Angul, Dhenkanal parts of Cuttack & Jajpur	Hot & moist, sub-humid	1421	38.7	14.0	Alluvial, Red, Lateritic, Mixed Red & Black

Source: Agricultural statistic of Orissa at a glace (5th edition, 2004) P.76 Directorate of Agri. & Food Production

2.9 Agricultural Scenario

Agricultural is the mainstay of state's economy. It is a way of life for majority of its people. Agriculture and animal husbandry contributed 25.75 % of Net Domestic Product of state in 2004-05 (at 1993-94 price level). As per 2001 census, agriculture provided employment to about 65% of the total work force. Per capita availability of land in 2004-2005 is 0.15 ha.

The state has formulated an Agricultural Policy in 1996 which aims at doubling the production of food grains and oil seeds i.e. from the present level of a subsistence one to a profitable & commercial venture, generating adequate employment opportunities and eradicating rural poverty.

Production of food grain in the state from 2000-01 to 2004-05 is shown in Table 2.17.

Table 2.17 Present Food Production Status of the State

Sl. No	Food crop (Lakh MT)	2000-01	2001-02	2002-03	2003-04	2004-05 (Provisional)
1	Rice	46.13	71.49	32.44	67.34	65.37
2	Total cereals	47.67	72.81	33.50	68.86	67.04
3	Total Pulses	2.08	2.59	2.05	2.66	2.61
	Total food grain	49.75	75.40	35.55	71.52	69.65

Source: - Economic Survey (2005-06), Govt. of Orissa Pg. 4/3.

Over the last two to three decades there has been stagnation in agriculture in the state. The area, yield rate and production of food grains are shown from 1950-51 to 2002-03 in Table 2.22.

2.9.1 Cropping Pattern of Principal Crops in the State

Cropping Pattern of Principal Crops of Orissa is presented in Table 2.18. It is seen that during last five years, paddy coverage is between 76 to 78% of total cropped area. Cash crops like sugarcane, potato, chilly and ginger etc. constitute only meager of 2% of total gross cropped area. Cropping intensity of the state from 2000-01 to 2004-05 and net irrigation potential created in the State through various sources are presented in Tables 2.19 and Table 2.20, respectively.

Table 2. 18 Cropping Pattern of Principal Crops in the State

Principal Crop (Cropped area in %)	2000-01	2001-02	2002-03	2003-04	2004-05 (Provisional)
Paddy	77.5	76.2	77.7	76.4	76.9
All cereals	81.1	79.5	80.8	79.3	79.8
Total Pulses	9.7	11.4	10.9	12.2	11.2
Total food grain	90.8	90.9	91.7	91.5	91.0
Oil seeds	5.9	5.5	4.9	5.2	5.6
Fibers	1.4	1.8	1.3	1.3	1.4
Other crop like sugar cane, Patato, tabaco, chilly & ginger	1.9	1.8	2.1	2.0	2.0
All crops	100	100	100	100	100
Total Area (in 1000 ha)	5720	5907	5499	5891	5840

Source: - Economic Survey (2005-06), Govt. of Orissa Pg. 4/6.

Table 2.19 Cropping Intensity from 2000-01 to 2004-05

Sl.No	Year	Net area sown (1000 ha)	Gross cropped area (1000 ha)	Cropping intensity (%)
1	2000-01	5829	7878	135
2	2001-02	5845	8798	151
3	2002-03	5680	7853	138
4	2003-04	5796	8637	149
5	2004-05 (Provisional)	5739	8701	152

Source: - Economic Survey (2005-06), Govt. of Orissa, Page. 4/7.

Table 2.20 Net Irrigation Potential Through Various Sources

Sl.No.	Sources	Irrigation Potential Created (in 1000 ha) upto end of				
		2000-01	2001-02	2002-03	2003-04	2004-05 (Provisional)
1	Major & Medium	1177.89	1190.54	1220.71	1234.86	1236.55
2	Minor (flow)	450.37	455.63	471.16	497.53	503.97
3	Minor (lift)	336.05	338.72	347.39	385.09	376.33
4	Others (*)	557.92	557.92	570.47	572.58	579.15
5	Total	2522.33	2542.81	2609.73	2663.06	2696.00

(*)Through water harvesting structures, Dug wells under Million Wells scheme and schemes of Panchayat Raj other Department etc.

Source: - Economic Survey (2005-06), Govt. of Orissa Pg. 5/1.

Irrigation Potential created from various sources during Kharif and Rabi is furnished in the Table 2.21.

Table 2.21 District wise Irrigation Potential (Th. ha)

SL No	District	Major and Medium		Minor (Flow)		Minor (lift)		Other Sources		Total	
		Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
1	Balasore	25.88	7.18	7.66	3.05	36.17	21.70	45.41	35.19	115.12	67.12
2	Bhadrak	90.31	12.00	1.27	0.06	19.07	11.44	21.69	18.68	132.34	42.18
3	Bolangir	7.69	0.86	19.66	3.02	10.30	6.19	24.61	15.08	62.26	25.15
4	Sonepur	58.59	25.76	7.02	0.48	8.86	5.32	8.42	6.85	82.89	38.41
5	Cuttack	89.07	54.71	19.16	3.43	21.79	13.07	31.89	31.16	161.91	102.37
6	Jagatsingpur	34.77	17.17	0.00	0.00	8.50	5.10	13.88	8.35	57.15	30.62
7	Jajpur	61.53	32.92	6.15	1.37	29.47	17.68	21.59	15.23	118.74	67.20
8	Kendrapara	65.97	40.59	0.42	0.00	32.47	19.48	27.87	15.18	126.73	75.25
9	Dhenkanal	25.05	7.81	20.87	4.68	9.75	5.85	18.03	17.81	73.70	36.15
10	Angul	16.40	3.24	20.55	3.11	10.22	6.12	23.77	20.60	70.94	33.07
11	Ganjam	128.08	13.68	102.30	6.80	23.86	14.32	30.09	22.66	284.33	57.46
12	Gajapati	0.00	0.00	21.16	2.35	5.05	3.03	6.58	4.19	32.79	9.57
13	Kalahandi	86.20	53.01	23.75	4.50	13.37	8.02	17.47	19.35	140.79	84.88
14	Nawapara	16.89	4.42	10.15	1.56	4.87	2.92	14.87	6.21	46.78	15.11
15	Keonjhar	28.40	6.09	28.52	5.18	15.43	9.26	17.61	20.06	89.96	40.59
16	Koraput	44.50	29.01	6.41	1.52	10.11	6.06	33.00	21.94	94.02	58.53
17	Malkangiri	70.03	34.65	1.34	0.29	1.61	0.96	2.60	2.05	75.58	37.95
18	Nawarangpur	4.25	2.25	6.55	0.60	8.52	5.12	8.13	7.99	27.45	15.96
19	Rayagada	9.80	3.00	21.96	5.34	13.47	8.08	10.51	7.25	55.74	23.67
20	Mayurbhanj	38.41	15.53	39.53	3.47	16.09	9.66	27.15	24.84	121.18	53.50
21	Pulbani	2.39	1.20	8.82	3.43	3.03	1.82	15.33	3.64	29.57	10.09
22	Boudh	24.72	2.02	10.39	0.96	5.45	3.27	4.68	6.23	45.24	12.48
23	Puri	110.18	74.06	0.18	0.02	12.74	7.65	22.39	13.55	145.49	95.28
24	Khurda	43.83	25.81	18.23	1.89	7.45	4.47	14.07	6.64	83.56	38.81
25	Nayagarh	10.93	3.02	20.05	4.33	7.30	4.38	18.23	10.38	56.51	22.11
26	Sambalpur	31.51	23.00	17.75	2.01	6.40	3.84	13.14	10.68	68.80	39.53
27	Baragada	91.22	57.06	22.78	2.87	9.06	5.44	27.30	13.18	150.38	78.55
28	Deogarh	8.10	5.70	4.43	0.13	1.53	0.92	5.26	4.40	19.32	11.15
29	Jharsuguda	0.00	0.00	4.68	1.12	2.90	1.74	7.82	5.30	15.40	8.16
30	Sundergarh	13.46	7.48	25.76	3.78	9.47	5.68	31.58	18.38	80.27	35.32
		1238.16	563.23	497.50	71.35	364.31	218.59	564.97	413.05	2664.94	1266.22

Table 2.22 Food Grain Production Status of the State

Year	Area (ha)	Yield (kg/ha)	Production '000 MT
1951-52	4382.00	546	2393.00
1952-53	4480.00	569	2549.00
1953-54	4547.00	580	2637.00
1954-55	4514.00	563	2541.00
1955-56	4454.00	545	2427.00
1956-57	4422.00	580	2565.00
1957-58	4542.00	442	2008.00
1958-59	4508.00	553	2493.00
1959-60	4944.00	816	4034.00
1960-61	**4447.00**	**906**	**4029.00**
1961-62	4528.00	891	1034.00
1962-63	5678.00	761	4321.00
1963-64	5301.00	906	4803.00
1964-65	5306.00	928	4924.00
1965-66	5371.00	686	3685.00
1966-67	5332.00	793	4228.00
1967-68	5405.00	765	4135.00
1968-69	5576.00	846	4717.00
1969-70	5747.19	823	4728.20
1970-71	**5740.86**	**847**	**4863.19**
1971-72	5949.73	732	4353.17
1972-73	5915.56	822	4862.40
1973-74	6217.58	848	5274.51
1974-75	5991.64	663	3970.62
1975-76	6488.60	853	5570.12
1976-77	6037.81	675	4076.43
1977-78	6519.08	853	5561.38
1978-79	6679.66	863	5765.15
1979-80	6454.90	600	3871.90
1980-81	**6908.82**	**865**	**5976.79**
1981-82	6738.41	822	5537.98
1982-83	6416.72	731	4687.82
1983-84	7323.27	956	7001.32
1984-85	6652.09	843	5607.24
1985-86	7042.60	989	6967.97
1986-87	7010.48	910	6377.92
1987-88	6727.79	750	5048.58
1988-89	6856.64	1021	7001.93
1989-90	6971.64	1144	7973.57
1990-91	**7088.71**	**992**	**7031.26**
1991-92	7252.00	1141	8273.15
1992-93	6946.05	993	6897.81
1993-94	7207.40	1140	8216.25
1994-95	7119.58	1122	7985.80
1995-96	7194.04	1101	7922.92
1996-97	6360.36	841	5346.54
1997-98	6616.36	1105	7311.25
1998-99	6452.17	989	6378.28
1999-00	6687.23	937	6265.73
2000-01	**6262.59**	**884**	**5534.96**
2001-02	6682.86	1232	8232.97
2002-03	5991.84	675	4044.92

Source: Agricultural Statistics of Orissa at a Glance Pg. 26 (5^{th} edition 2004)

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Chapter III

RIVER SYSTEM & RIVER BASINS OF ORISSA

3.0 Introduction

"A river is an apt metaphor for life. It is born, wends its way through the landscape of consciousness, and dies to mingle in the sea of eternity. Constant change is the rule of life and a river is constantly changing; the water it carries is never the same, the face it presents is always different. Unlike hills and mountains it is not inert and immobile; there is life and dynamism in its flow. Some time it is placid, some times enraged. And, life it self, its death is the beginning in the most sublime sense , a recurrent and cyclic regeneration of generations, a looking forward to a future which leaves behind yet embraces the past.

No wonder rivers formed a vital component of the animists awe and worship, being saved by the human imagination into living, breathing presences. Even the theistic fancy was prompted by residual animism, and invested the maternal archetype to rivers." (Vide 'The Brahmaputra' by A.K. Dutta, 2001, N.B.T.,New Delhi)

The rivers of Orissa are mainly peninsular rivers and have their origin from Chota Nagpur Plateau (Jharakhand), the Amarkantak plateau (Chhattisgarh) and Eastern Ghats within the state. No rivers in the state are snow fed. The state comprises of eleven nos. of major river basins covering a geographical area of 1,50,460 sq. km. Except two rivers, i.e., the Rushikulya and the Budhabalanga, all other major rivers either originate or drain into other states. The rest nine rivers basins are Interstate river basins. The catchment area of all eleven numbers of river basins and 75% dependable yield of each basin are shown in Table 3.1 and Table 3.2, respectively. Figure 3.1 shows all the eleven river basins of the State.

Table 3.1 Catchment Area of the River Basins of Orissa (sqkm)

Sl. No	Name of river Basin	Total Catchment area (sqkm)	Catchment area lying within the state	% of C.A. to the Geographical area of the state
1	Subarnarekha	19227	2983	1.92
2	Budhabalanga	4838	4838	3.11
3	Baitarani	14218	13482	8.66
4	Brahmani	39116	22516	14.46
5	Mahanadi	141134	65628	42.15
6	Rushikulya	8963	8963	5.76
7	Bahuda	1118	890	0.57
8	Vansadhara	11377	8960	5.75
9	Nagavali	9275	4500	2.89
10	Kolab	20427	10300	6.61
11	Indravati	41700	7400	4.75
	Total		150460	96.63

From Table No 3.2 it is seen that the amount of water available per year per person is 3000 cum which is sufficient enough to meet the water requirement by international standard. But unfortunately the runoff is not distributed uniformly in space and time. About 90% of annual rainfall occurs in a span of 100 days during monsoon months. Even during this period, the dry spell sometimes exceeds 20-30days. Thus the state is ravaged by Flood, Drought and Cyclone, all occurring in the same time year.

Table 3.2 Basin Wise Water Availability (75% Dependable Yield)

Sl.No	Name of the basin	Average availability water (M cum)	
		Surface	Ground water
1	Subarnarekha	277	597
2	Budhabalanga	3030	819
3	Baitarani	5149	2389
4	Brahmani	8689	2601
5	Mahanadi	43682	10623
6	Rushikulya	3300	1148
7	Bahuda	177	105
8	Vansadhara	3942	701
9	Nagavali	2368	419
10	Kolab	6509	NA
11	Indravati	5403	692

We find numerous references of few rivers of the State in 'Puranas' and other ancient literatures. According to Sarala Das, the author of Mahabharata, the Sun temple at Konarak was situated at the mouth of Chndrabhaga. During his time Mohanadi was known as Chitrotpala. Probably the main flow of Mahanadi passed through present Chitrotpala. The Prachi was an important river in his time. The Baitarani, a sacred river used to flow by the side of the 'Dashswamedha ghat' at Jajpur In the second half of 19th century, the Baitarani was not a deep river. In 1871, the SDO of Jajpur wrote that "Baitarani above the point of its junction with Genguti retains no water except during freshet."

Balasore thrived as a port. "The bar at the mouth of the river had opened and the river it self improved." (Source: Early Annals of the English in Bengal, Vol I)

The rivers deteriorated in the 18th century. Sterling, in 1825, described the rivers of Cuttack district as follows: "the Province of Cuttack is watered by innumerable streams which swell into rivers of magnitude during rains but few of them have any current throughout the year. A great portion of the Mahanadi bed is dry for five or Six months of the year and it is fordable from January to June even at the town of Cuttack."

"The principal channel of 'Cajoree' (Kathjori) terminates in the Alanka (Alaka) which is deep and narrow and pursues a singularly laborious course until it is lost amidst a variety of ramifications. About half way between Cuttack and the sea, the Cajoree sends off a large branch, which after doubling itself, and again branching out in innumerable intricacies enter the sea at last in broad channel about 40 mile North of Black Pagoda, under the name of Deb nadi."

Kittoe visited Orissa in 1837. He wrote that near Tarva in Dhenkanal district the bed of the Brahmani is half a mile wide. "But water during summer occupied one eighth of that space. Being very shallow, it is navigable for small canoes only." All the eleven river basins of the State have been briefly discussed in the following paragraphs. Figure 3.2 to Figure 3.12 shows the Basins maps of all eleven basins of the State.

3.1 Subarnrekha

The river Subarnrekha (the stream of gold) originates near Nagri village of Ranchi plateau in Chhotanagpur high land in Jharkhand state at an elevation of about 740 m. Its very name suggests in Chhotanagpur plateau that it is flowing through gold bearing structures of minutely small content. The gold thus eroded forms part of the placer deposits and the local people are used to collecting gold particles from bed. Now-a-days, the deposits have become rare. Total length of the river from its origin to the Bay of Bengal is 446 km out of which only 79 km is within Orissa. Total catchment area of the basin is 19227sqkm. The state wise coverage of catchment area is shown in Table 3.3

Table 3.3 State wise Catchment areas in Subarnarekha Basin

Sl.No	State	Area in sq. km	% of total basin
1	Jharakhand	12980	67.5
2	West Bengal	3264	17.0
3	Orissa	2983	15.5
Total		19227	100.0

A major portion of Mayurbhanja district and some portion Balasore districts lie in the basin. Total 6 nos. of major tributaries join from left and 8 nos. from right.

The river brings disastrous flood in its lower reaches, i.e., Jaleswar, Bhogorai and Baliapal areas of Balasore district. On 7.8.1978, three co-basin states, i.e., Bihar (now Jharakhand), West Bengal and Orissa have reached an agreement to harness the river for irrigation, hydropower generation and flood control. The project when completed may go a long way in solving the age-old problem of floods and providing irrigation to more than one lakh ha in Orissa.

3.2 Budhabalanga

The river Budhabalanga rises from Similipal hill range at an elevation of about 1050 m in Mayurbhanj district. It travels a length of nearly 200 km before meeting Bay of Bengal. Entire basin area of 4838 sq/km covering districts of Mayurbhanj and Balasore lies in the state of Orissa. Budhabalanga has 7 main tributaries. Those are (i) Palpala (ii) Sunei (iii) Kalo (iv) Sanjo (v) Deo (vi) Gangahari and (vii) Katra.

About 57% of the population of Mayurbhanj district is tribal. The districts also suffer form erratic rainfall. Therefore Maharaja of Mayurbhanj constructed 'Balidiha' irrigation Project (a diversion weir) in 1912 AD, which provide irrigation to 3830 ha. Another reservoir 'Haldia' was also constructed by the King, which has been improved during sixties.

3.3 Baitarani

The Baitarani is the only major river that originates from Keonjhar Plateau. Its source is from the Guptaganga hill of Janghira–Dhenkikote region. The basin area lies mostly in Orissa excluding 736 sqkm in Jharkhand state. It has number of small tributaries, which originate at different elevation from a region surrounded by Janghira in N-W, Dhenkikote in N-E, Ghatagaon in the S-E and Nandona in the S-W. The river flows in a northeasterly direction in its upper reaches. It also runs as the boundary between

Orissa & Jharkhand. Another peculiarity of Baitarani is that in lower reaches it drains into the distributaries of the Brahmani south of Chandbali and has a common mouth to Bay of Bengal at Dhamara. The major tributaries are Deo and Salandi on left bank Kanjhari, Musal and Kusei on the right bank.

The river enters the plains at Anandapur & creates delta below Akhuapada. It bifurcates into two loops, i.e., Kochila and Baitarani, which merge after 8 km at Jajpur. The Burha takes off from Baitarani just below Jokodia anicut. After flowing for about 25 km, it falls into the Kharsuan. The river Salandi which originate from Similipal R.F has a course of about 80 km in the hills in its upper reaches and as much in the plains. It has formed no. of loops and traversed about 144 km before meeting Baitarani near Tinterghat. Salandi also receives enroute the combined waters of the Reba & Kapali. A dam has been constructed across Salandi at Hadgarh for irrigation.

There is a fall known as 'Bhimkund' in Baitarani river near village Balijori where a dam was contemplated much earlier for power generation, Flood control and Irrigation. But unfortunately that could not see the light of the day. The river has an average slope of 26m/km. Thus its erosive capacity is quite high due to such steep slope and high intensity of rainfall in Keonjhar plateau.

3.4 Brahmani

River Brahmani is the 2nd largest river in the state. River Sankh originating in Chhatisgarh, and river Koel originating in Jharakhand meet at Vedavyas near Rourkela, Orissa. The Sankh is the right tributary and Koel is on the left. It is an inter-state river. Total drainage area of the river Brahmani is 39116 sqkm. Brahmani basin lies within the Longitude of 83^0 52' to 87^0-30' E and Lat. 20^0-28' to 23^0 35'N. The river flows through the heart of Orissa in between the Baitarani basin on left and Mahanadi basin on the right and finally outfalls into Bay of Bengal at Dhamara mouth after traveling a length of 701 Km.

The river takes a northern course form Rourkela to Talcher and has formed a minor gorge at Rengali where the river has been harnessed for Irrigation, Power generation & Flood control. This aspect has been discussed at length in Chapter VI. State wise coverage of the drainage area of the river is stated in Table 3.4

Table 3.4 State Wise Drainage Areas in Brahmani Basin

Sl.No	State	Area in sqkm	% of total basin
1	Chhatisgarh	900	2.30
2	Jharakhanda	15700	40.14
3	Orissa	22516	57.56
	Total	39116	100.00

There are as many as 45 tributaries of the river. Few important tributaries on left are Kuradhi, Mankara, Samakoi, Ramiala and Pondara etc. Major right bank tributaries are Rukura, Gohira, Tikira, Singrajore, Nandira and Nigra etc. The Brahmani enters its 'delta' at Jenapur. It then flows a very winding easterly course and meets Bay of Bengal by two mouths i.e. the Dhamara estuary and Maipura River. At the southern end of Sukinda, the Brahmani gives off Patia branch on its left, which is named as Kharsuan further down.

River Kharsuan rejoins Brahmani below 'Aul'. The other principal right back branch is 'Kimiria' which merges with Genguti (a branch of Birupa), Kelua and Birupa (an off shoot of Mahanadi), and falls again into the main stream at Indupur as Birupa. As Brahmani approaches the sea it receives Kharsuan on left. At a short distance below this, its waters unite with Baitarani, below Chandbali forming Dhamara before it outfalls into Bay of Bengal.

The entire drainage basin of Brahmani is complex. Three spill channels with escapes have been provided in the right bank of Kharsuan at Tantighai, Palasahi and Routra. Further below a spill channel Kani off takes off Kharsuan right and joins the same branch downstream.

3.5 Mahanadi

Mahanadi, the 6th largest river of India, is a major east flowing river of the peninsular system and originates from Pharasiya village of Raipur district. It drains large area of Chhatisgarh and Orissa but relatively small area of Jharakanda and Maharashtra. It enters Orissa near Padigan in the district of Jharsuguda. Thus the river basin is an Inter-state one. State wise drainage area is shown in Table 3.5.

Table 3.5 State Wise Drainage Area in Mahanadi Basin

Sl.No.	State	Area (sqkm)	% of total basin	Remark
1	Chhatisgarh	75136	53.24	Out of 141134sq.km., the CA up to head of the delta is 132100 sqkm & rest 9034 sqkm lies in deltaic plain
2	Orissa	65628	46.50	
3	Maharashtra	238	0.17	
4	Jharkhanda	132	0.09	
	Total	141134	100.00	

The river traverses a total distance of 851 km and falls into Bay of Bengal in Orissa forming delta out of which a length of 375 km is in Chhatisgarh and rest 494 km in Orissa. The river basin is bounded by central India hills in the North, Easternghat in the south, Maikala hill range in the west and Bay of Bengal in the east. There are 14 major tributaries of Mahanadi. Out of these, the Ong, Tel and Ib are in Orissa. Rest 11 tributaries are in Chhistagarh. Besides three major tributaries, i.e., Ib, Ong & Tel, the other important tributaries which join the river in the state are Jira, Bagh, Salki, Kuanria, Hariharjore, Sagada, Ret, Hati, Indra, Suktel, Utei, Raul, Udanti, Lanth, Sapua and Kantia etc. The major branches and sub branches of Mahanadi are the Kathjori, Birupa, Kuakhai, Daya, Bhargavi, Kushbhadra, Surua, Biluakhai, Devi, Kandala, Chitrotpala, Luna, Karandia, Paika and Badagenguti. Excepting Daya & Bhargavi, which fall into Chilika Lake, others join Bay of Bengal with Mahanadi. Development of water resources in the basin, i.e., existing, ongoing and contemplated projects will be discussed latter.

The details of Drainage system in Mahanadi Delta is shown in Table 3.6. District wise area distribution of Mahanadi Basin is also furnished in Table No 3.7. Mahanadi river flow (Tree) diagram below head of delta, i.e., Naraj is shown in Figure 3.13.

Table 3.6 Details of Drainage System in Mahanadi Delta

Sl.No.	Name of the Drainage System	Total drainage Area (ha)
	(a) Doab-I Mahanadi-Kathjori, Devi	
1	Hansua-Barnala-Brudha-Tigiria	65918
2	Alaka	857
3	Madhusudanpur Pat-Gobari	9290
4	Singarpur-Nagpur Alaka-Boruan	21699
5	Others	23178
	(b) Doab **-II (Mahanadi-Chitrotpala-Luna-Birupa-Brahmani)**	
1	Gobari Drainage system	39800
2	Others Drainage System	------
	(c) Doab **-III (Luna- Chitrotpala)**	
1	Baghuni	15000
	(d) Doab -IV (Area to East of HLC Range-I)	
1	Chota Genguti	45000
2	Sagadia	9730
3	Matagunja	11580
4	Kumaria	17900
	(e) Doab -V (Kathjori-Kushabhadra)	
1	Prachi	42553
2	Kadua	27116
3	Devi-Kandal Island	7700
4	Devi-Taunla Island	4727
5	Others	15837
	(f) Doab -VI (Kushabhadra-Bhargavi)	
1	Dhanua system	47173
2	Nuagaon	6916
3	Others	8664
	(g) Doab -VII (Daya- Bhargavi)	
1	Bhargavi-Ratnachira	14540
2	Luna-Ratnachira	44500
3	Others	23935
	(h) Doab-VIII (West of Daya)	
1	Gangua system	65400

Source: 3rd spiral study of Mahanadi Basin Plan Pg.32, Dept. of Water resources, Govt. of Orissa.

Table 3.7 District Wise Area Distribution of Mahanadi Basin

Sl No	Name of the Districts	Total geogr. Area (sqkm)	Basin area in District (sqkm)	% of Basin Area in the District
1	Angul	6232	1305.96	20.96
2	Bargarh	5834	5834	100.0
3	Bolangir	6569	6569	100.0
4	Boudh	3444	3444	100.0
5	Cuttack	3733	3713.58	99.48
6	Deogarh	2784	131.16	4.71
7	Dhenkanal	4595	428.83	9.33
8	Ganjam	8706	29.97	0.34
9	Jagatsingpur	1973	1973	100.0
10	Jajpur	2888	128.38	4.45
11	Jharsuguda	2200	2200	100.0
12	Kalahandi	8364	8088.43	96.7
13	Kandhamala	7650	3436.39	44.92
14	Kendrapara	2548	1061.13	41.65
15	Khurda	2889	2109.42	73.02
16	Nawapara	3408	3408	100.0
17	Nawarangpur	4242	4079.3	96.16
18	Nayagarh	5294	889.78	16.81
19	Puri	3051	2780.56	91.14
20	Rayagada	7580	85.67	1.13
21	Sambalpur	6698	6111.78	91.25
22	Sonepur	2344	2344	100.0
23	Sundergarh	9712	5475.66	56.38
	Total	112738	65628	

Source: 3rd spiral study of Mahanadi Basin- W.R. Dept. Govt. of Orissa-Annexure 2.1

3.6 Rushikulya

The river Rushikulya has its origin in the high hills surrounding the plateau of Daringbadi near village Digi in Kandhamal district. It traverses a length of 165 km before meeting Bay of Bengal near Ganjam town. The major tributaries are Badanadi, Baghua and Dhanei on left bank and Padma and Ghodahada on its right bank.

Total catchment area of the basin is 8963 sqkm, which lies entirely within the state and is 4.75% of the geographical area of the state. The basin is almost pear shaped with a well-developed dendritic tributary system, but has failed to develop a delta in its lower reaches due to strong offshore current at its mouth.

During British rule, the district of Ganjam was under Madras Presidency. Ganjam was chronically drought affected. The district witnessed an unprecedented famine during 1865-66 and another in 1871-72.

A civil engineer Major Buckley studied the feasibility to harness the water of river Rushikulya and its tributaries for irrigation. Accordingly integrated systems with two reservoirs and four anicuts have been constructed. The details have been elaborated under Sec 5.3.5.6 .

3.7 Bahuda

The Bahuda is a small hill stream originating from Singhraj hills of Gajapati districts at an elevation of about 1500 m. The river traverses a total length of 96 km up to Bay of Bengal out of which only 18 km is in A.P. The basin lies in the southern part of Orissa covering broadly two districts i.e. Ganjam and Gajapati. The river has four tributaries. Those are Poichandia and Boginadi on right and Batrada & Kantajura nallah on left.

The basin area of Gajapati district is covered with hills and thick forest growth. It is unsuitable for irrigation development. Three diversion weirs namely Kalingdola (medium), Poichandia & Bogi (minor) have been completed and Baghalati reservoir scheme is under construction. More than one hundred minor irrigation projects (CCA varying from 24ha to 2000 ha) are existing.

3.8 Vansadhara

The river Vansadhara originates at an elevation of about 1300m near village Tentulipadar in Lanjigarh of Kalahandi district at Lat. 19^0 51' N and Long.83^0 29' E. It flows in southeast direction inside Orissa till it approaches Orissa–Andhra border near village Battadi downstream of Gunupur town. It forms boundary between Orissa & A.P for nearly 29 km. It finally meets the Bay of Bengal in Andhra Pradesh. Major portion of Vansadhara basin lies in Gajapati and Rayagada districts. Out of basin area of 8960sqkm (Orissa portion) about 4523sqkm (i.e., 50.48%) is covered by forest of different category.

There are 13 nos. of tributaries of the river. Major tributaries are Bhangi and Peddagoda on right and Badnalla, Chauldhua, Pondka nalla, Badajhar, Harabhangi, Sananadi and Mahendra Tanaya on left.

At present, there are only two medium reservoir projects in the basin i.e. Badanalla and Harbhangi. From Harbhangi, the water is exported to adjacent Rushikulya basin for irrigation.

3.9 Nagavali

The Nagavali is an interstate river, which originates in the hill ranges of eastern ghat near village Lakhabahal in Kalahandi district at an elevation of about 1000m. Out of total catchment area of 9275 sqkm, 4500 sqkm lies in Orissa and the rest in A.P. In Orissa, the basin covers the districts of Rayagada, Koraput and Kalahandi. Total length of the river is 217 km of which 125 km is in Orissa and the remaining in A.P.

The river may not be of great importance to the state as far as agriculture is concerned but the basin is rich in mineral for which industrial and mining activities are increasing. At present, there are no major & medium Projects in the basin.

An agreement has been signed between Orissa & A.P on 15-12-1978 for utilising waters of Nagavali, Jhanjavati (a tributary of Nagavali) and Bahuda River.

3.10 Kolab

Kolab basin is located in the southern parts of Orissa covering mainly two districts, i.e., Koraput & Malkangiri. The river originates from the hill ranges in Koraput at an elevation of about 1200m and joins river Godavari in A.P. near Kunavaram. Total drainage area of the basin is 20427sqkm out of which 10300 sqkm, lies inside Orissa and the rest in MP and AP.

There are 11 nos. of tributaries of Kolab. The major tributaries on the left are (i) Guradi nallah (ii) Garia (iii) Dharamgeda (iv) Jam Nadi (v) Potteru vagu nallah (vi) Machhakund (also known as Sileru in lower reach) and (viii) Sileru. Right bank tributaries are (a) Karandi (b) Kanger (c) Malenger and (d) Mulervagu nallah.

The river is a potential one for hydropower generation. There exist three hydroelectric Projects. Those are Balimela, Machhakund and Kolab. In addition to hydropower generation, Kolab & Balimela Projects irrigate vast areas in predominantly tribal inhabited districts. These Projects could be implemented after entering into agreements with Andhra Pradesh on 18-07-61 and 04-09-62 & with M.P on 11-07-99. Award of Godavari Water Disputes Tribunal was received in July 1980.

Kolab is also known as Sabari. The Sileru and Sabari meet at Motu, the extreme southwest point of Orissa and thereafter known as Sabari. Incidentally Sileru forms the southeastern border and Sabari the South–western border of Orissa in Malkangiri district.

3.11 Indravati

The river Indravati originates at an altitude of about 915m from Thuamul Rampur of Kalahandi district and flows in westerly direction. It enters Jagadalpur district of Chhatisgarh. It further flows in west direction upto border of Chhatisgarh and Maharashtra. Then it traverses in a south direction till it joins the Godavari at the border of Maharashtra, Chhatisgarh and A.P.

The river Indravati is a left tributary of Godavari, which is the 2^{nd} largest river basin of the country. Out of total catchment of 41700 sqkm only 7400 sqkm (i.e., 17.75%) lies in Orissa spreading in the districts of Kalahandi, Koraput, Rayagada & Nowarangpur. It encompass between Lat. 18^0 45' to 19^0 44' N and Long. 82^0 04' to 83^0 09'E.

The left tributaries of Indravati are (i) Kandabindha nallah (ii) Chandragiri (iii) Golagar (iv) Podagada (v) Kapur (vi) Muran (vii) Telingiri (viii) Parlijori (ix) Damayanti (x) Modang and (xi) Jaura nallah. The right tributaries are (a) Kesadhar (b) Bangiri (c) Turi (d) Chourjori (e) Kora (f) Pandrikundjori (g) Bhaskel. The Jaura nallah connects river Indravati to river Kolab. Water flows from one to another depending upon the flow condition in respective river.

At present, there are two completed reservoir projects, i.e. Bhaskel medium irrigation Project and Upper Indravati Multipurpose Projects. Pending final allocation of Godavari water an agreement was signed between Orissa and Madhya Pradesh on 09-12-75. This paved the way for construction of Upper Indravati Hydroelectric Project, which comprises of four dams across river Indarvati, Padagad, Kapur and Muran. Through trans-basin transfer of water from Godavari basin to Mahanadi basin, it generates 600MW of power. The tailrace release is picked up at Hati barrage to provide irrigation in the drought prone areas of Kalahandi. No area of Indravati basin gets the benefit of irrigation from this project.

3.12 Tidal Rivers

Depending on the shape of the mouth, depth of channel and extension of sand bars into river mouths, few rivers and their tributaries in the coastal plain are tidal. The tidal channels vary from 5 to 90 km. Table 3.8 shows a clear picture of tidal channels.

Table 3.8 Tidal Channels of Orissa

Sl.No	Name of the river/tributary	Tidal limit from mouth (km)
1	Brahmani	90
2	Baitarani	50
3	Chitrotpala	45
4	Devi	45
5	Paika	40
6	Mahanadi	35
7	Salandi	30
8	Kadua	25
9	Badanai	25
10	Alaka	20
11	Baghuni	05

Source: - Geography of Orissa (1999) by B.N.Sinha, Pg. 44

3.13 Springs / Falls in Orissa

There are many springs and few hot springs in Orissa. The springs have mostly developed on the eastern and western slopes of Eastern Ghats due to heavy rainfall on one hand and hard Gondwana geneissic rocks as the bed rock on the other. Temples have been constructed near most of the sites. List of springs are furnished in Table 3.9.

Table 3.9 Springs in the State

Name of the spring	Tributary / River	Location
Bada Ghagara	Ghagara / Batarani	Near Keonjhar
Sana Ghagara	Sana Ghagara / Batarani	Near Keonjhar
Kapilas	Brahmani	Near Dhenkanal
Chandikhol	Mahanadi	Jajpur District
Mahabinayak	Mahanadi	Jajpur District
Barunei	Daya	Near Khurda
Narayani	Draining to Chilika Lake	Near Khalokote
Nirmal Jhara	Draining to Chilika Lake	Near Khalokote
Pradhan Pat	Brahmani	Near Deogarh
Phuli jharan	Indravati	Near Bhawanipatna
Khandadhara	Brahmani	Near Banei
Nrusinganath	Tel	Bolangir
Harisankar	Jeera / Tel	Bolangir
Gosinga Jhara	Kuanria / Mahanadi	Near Kantilo
Koilijharana	Mahanadi	Near Jharsuguda
Jharbada	Mankada/ Brahmani	Near Malayagiri

Source: Geography of Orissa (1999) by B.N. Sinha Pg. 44-45

Besides, there are three hot springs which contain high percentage of sulphur. Those are 'Attri'' near Khurda, 'Deulijhara' near Athhamallik, on the flood plains of Mahanadi and 'Taptapani' on the eastern slope of Easternghat in Ganjam district.

3.14 Lakes

The lakes in the State can broadly be classified as natural and artificial. Further those can also be differentiated on the basis of salinity of water; thus may be fresh water lakes or brackish ones. Numbers of artificial lakes have been created in form of reservoirs/ ponds by damming rivers. Before independence, two reservoirs such as Bhanjanagar (Rosselkonda) and Sorada in Ganjam District were there. Subsequently other reservoirs were formed by construction of Anicuts, barrages and dams; those are described in Chapter VI. Among the natural lakes brief note of Chilika and Anshupa lake have been presented.

3.14.1 Chilika Lake

The lake, a brackish water lagoon, sprawls along the East Coast of the State. Its pristine beauty has inspired the poet through ages. But the "Legend and the geology provide interesting contrasts in version of history of the Chilika. Legend has it that the pirate king Raktbahu came to ransack Puri with a huge fleet of ships. He anchored out of sight to avoid detection, but the sea washed up refuse from the ships to shore and warned the town people, who fled with all their possessions. Raktabahu thus found a deserted city when he finally arrived. Furious, he insisted that the sea had betrayed him and ordered his army to attack it. The sea retreated until the entire unsuspecting army had entered the sea bed in pursuit. Then it surged back, drowning the army and forming what is now the Chilika Lake." (Source: Chilika by Rahul N. Ram,-1994, Pg. 4)

Geological studies indicate that the coast line extended along the western shores of Chilika in Pleistocene era and that the entire North eastern region above Chilika was under sea. Since then the coast line has moved considerably eastward. Most part of the lagoons seen today were formed as a result of world wide rise in sea levels over last 6000 to 8000 years. There was a pause in the rise in the sea levels about 7000 years ago when a sandy beach may have formed near the coast at southern sector. The sand beach grew gradually with further rise of the sea. It progressed sea ward and to the northeast, to form what is known as spit of Chilika. The spit of the lake is constantly changing. The sand bar has been widening and the position of the mouth constantly shifting, moving generally towards northeast.

The lake is situated between lat. 19°28' to 19° 54'N and Long. 85° 05' to 85°38' E. It extends from southwest corner of Puri and Khurda districts to the adjoining Ganjam district. The water spread of the lagoon varies between 906sqkm in summer to 1165sqkm in monsoon. It attracts the largest concentration of migratory waterfowl found any where in the Indian sub-continent. It harbours a assemblage of marine, brackish and fresh water biota, a number of which are listed in the endangered, threatened and vulnerable categories. On account of its rich biodiversity, Chilika was one of the two sites to be listed first as internationally important wetlands under the Ramsar Convention in 1981, the other being Keoladeo National Park in Rajasthan. The pear shaped lagoon is about 64.5 km long and its width varies from 5km to 18 km. The lake is connected to the sea by a 29km long irregular channel with several small sandy and unusually ephemeral islands. The mouth connecting the channel to the sea is close to the northeastern end of the lake. High tides near this inlet mouth drive in salt water through the channel during the dry months, from December to June. During the monsoon river falling into the northern zone are in spate, causing fresh water currents which gradually pushed the sea water out. As a result of these dynamics the inlet mouth constantly changes its position.

"The lagoon at present is facing the problems like siltation, shrinkage of area, choking of the inlet as well as the outward channel connecting the sea, decrease in salinity, weed infestation, decrease in fish productivity, increase in aquaculture and overall loss of biodiversity."

Siltation is one of the important factors endangering the ecosystem of the lagoon. Rivers and rivulets numbering 52, drain into Chilika carrying huge quantity of sediment of about 0.365 million tonnes (vide Reference Orissa-2nd edition, 2000, pg. 647). Major contribution is from Daya and Bhargavi, (brances of river Kuakhai) which fall in the northern sector.

Salinity is also a dominant factor determining the lagoons ecology. The salinity dynamics are controlled by the nature of connection to the sea associated with the tidal fluctuations and the volume and timing of fresh water inflows into the lagoon from the rivers falling into the lake.

As a drift of about one million cum is prevailing in this part of the coast, mouth is shifting in the north eastern direction. The recent bathymetry of the "Magar mukha, i.e., the gateway between the lake and outward channel indicates that during summer, the depth is hardly 0.30m which prevents discharge of fresh water and sediment to the sea through outer channel in monsoon. This obstructs migration of fish and other animal into the sea and vice-versa. Further tidal ingress into the lake is also reduced. Siltation is the principal factor for degradation of the ecosystem.

As per the model study report of CWPRS Pune, and on the advice of National Institute of Oceanography, Goa, a lead channel has been dredged near 'Magarmukh' to establish the link between the lake and the sea which is considered as a gateway to the lake. This has significantly improved the situation, Further by judicious operation of new Naraj barrage gates initial flow carrying more sediment can be pushed through Mahanadi arm thereby allowing lesser sediment charge in Kathajodi arm.

3.1.4.2 Ansupa Lake

Ecologically the Ansupa Lake is a wetland of immense importance. It is the largest natural fresh water body in the State, which once was a treasury of beauty and splendor. The people of Orissa have sentimental attachment with this lake due to its rich natural heritage and economic importance.

It is said that in earlier times Ansupa was known as 'Ansa-Patak' (ansa-pata), as it is part of water source (pata) formed out of a part (ansa) of river Mahanadi. Some others say that it was known as Hansa-pata, it is a water source (pata) and has attracted hoards of wild swans (hansa) in the past. In course of time, the lake might be known as 'Ansupa'.

Unfortunately, today, due to lack of adequate maintenance its water spread area has reduced from 370acres to 125acres, and the depth has reduced from 15m to only 5m because of siltation on account of erosion from 15.54sqkm catchment (as per records of WR Dept). However, the Revenue records states that there is a big water reservoir in the State called 'Ainspata' covering an area of 419.15 acre in the mouzas of Kadalibari, Santarapur and Bishnupur. It supplied water for irrigation purposes. It is situated on the left side of river Mahanadi, adjacent to Athagarh sub-division near village Subarnapur under Banki block of Cuttack District.

The lake is bounded by Saranda hills on western side, Bishnupur hill on northeastern side. Villages like Subarnapur, Malbiharpur and Kadalibari are dominated with fisherman. Water flows into the Ansupa lake from river Mahanadi during medium to high flood discharge through existing Huluhula nala that leads to Sankha nala at its confluence. The water from Sankhanala then enters to Kantapahara pata, which is a water body. After reaching to a certain level it flows to Ansupa lake through Khandaka nala. The water from Ansupa lake after attaining its storage level flows back again to river Mahanadi through Kabula nala maintaining flow gradient towards river Mahanadi.

Presently the area of the lake has been reduced due to encroachment from all sides. The channels are also silted up and the lake is full of hyacinth and lotus. Unless adequate measures are taken for renovating the lake before it is too late in converting it from a wet land to waste land.

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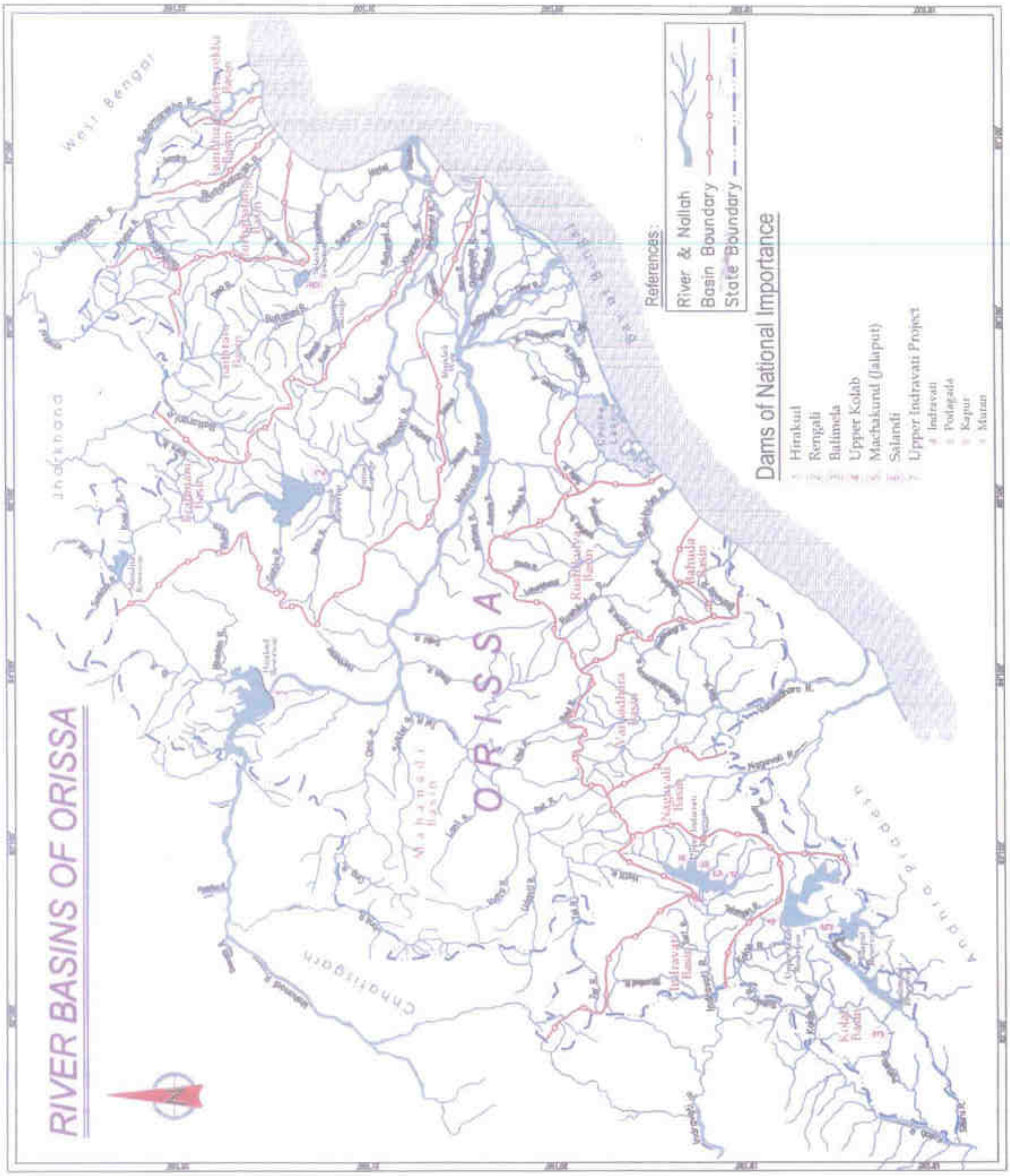

RIVER BASINS OF ORISSA
ORISSA
Mahanadi Basin
West Bengal
Jharkhand
Chhatisgarh
Andhra Pradesh
References:
River & Nallah
Basin Boundary
State Boundary
Dams of National Importance
Hirakud
Rengali
Balimela
Upper Kolab
Machakund (Jalaput)
Salandi
Upper Indravati Project
Indravati
Podagada
Kapur
Muran

Figure 3.1

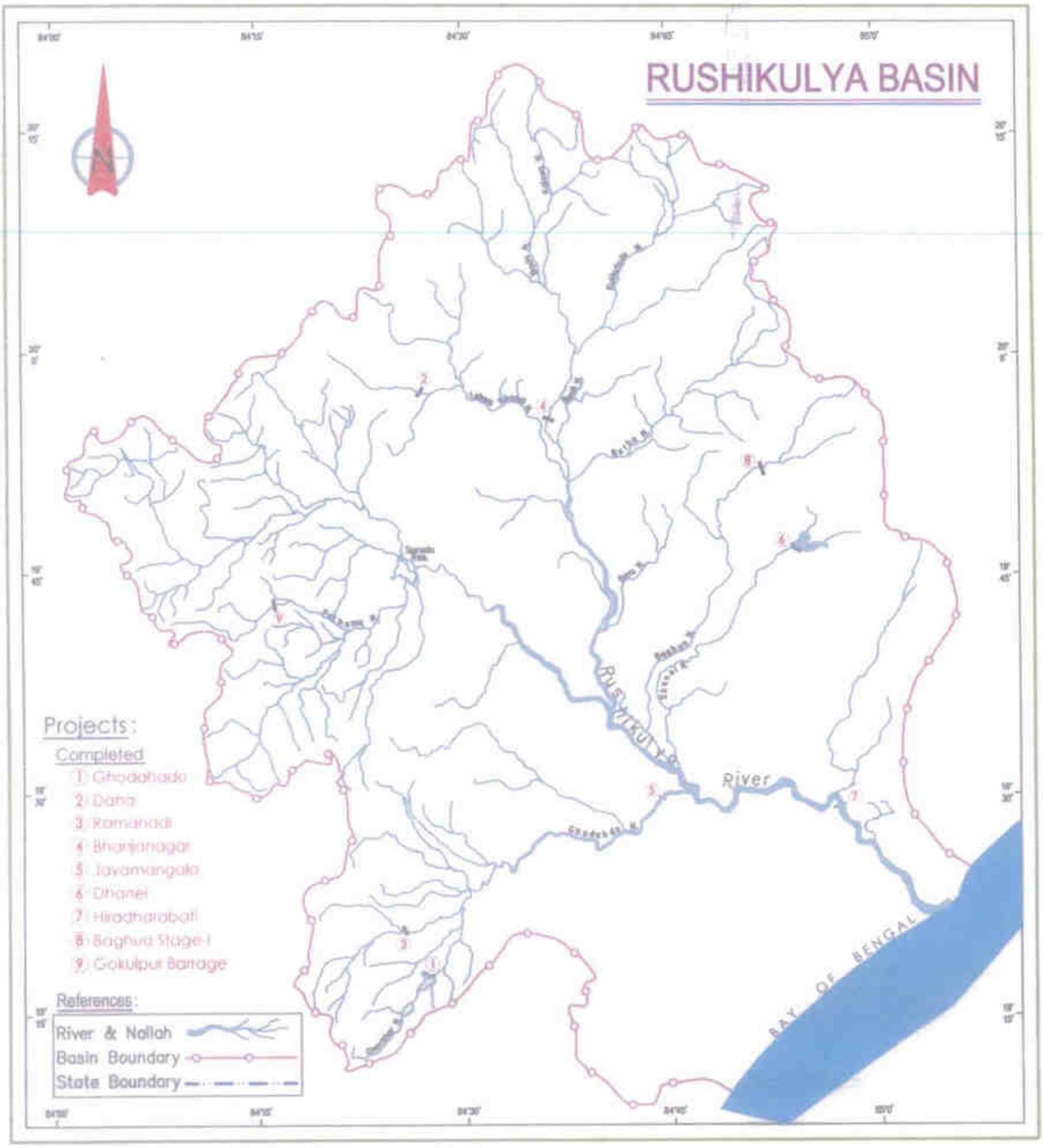
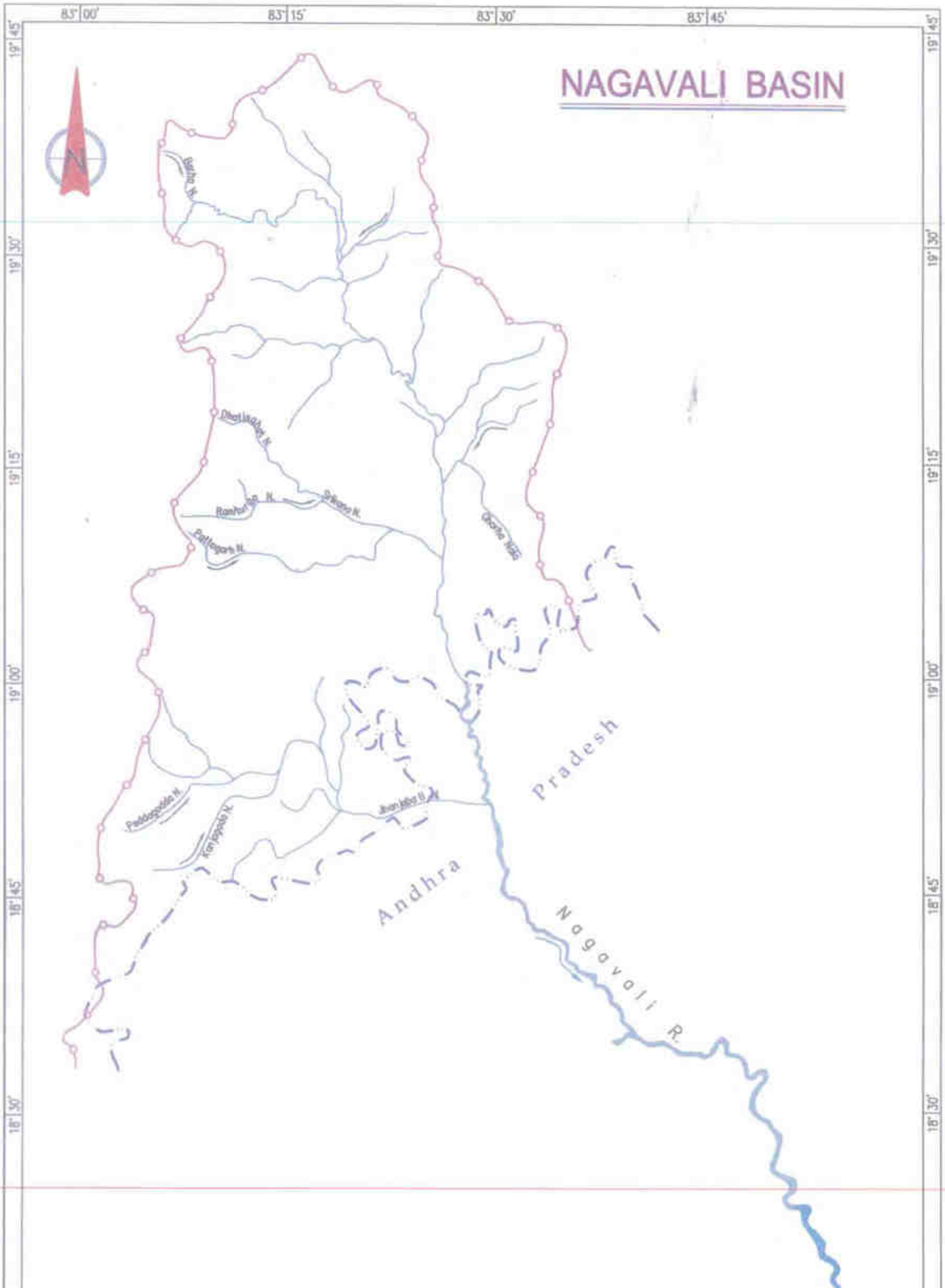

RUSHIKULYA BASIN
N
RUSHIKULYA
River
BAY OF BENGAL
Projects:
Completed
1 Ghodahado
2 Dahi
3 Ramanadi
4 Bhanjanagar
5 Jayamangala
6 Dhanei
7 Hiradharabati
8 Baghua Stage I
9 Gokulpur Barrage
References:
River & Nallah
Basin Boundary
State Boundary

Figure 3.2



NAGAVALI BASIN
N
83° 00'
83° 15'
83° 30'
83° 45'
19° 45'
19° 30'
19° 15'
19° 00'
18° 45'
18° 30'
18° 15'
Andhra Pradesh
Nagavali R.
Bay of Bengal
References :
River & Nallah
Basin Boundary
State Boundary

Figure 3.3

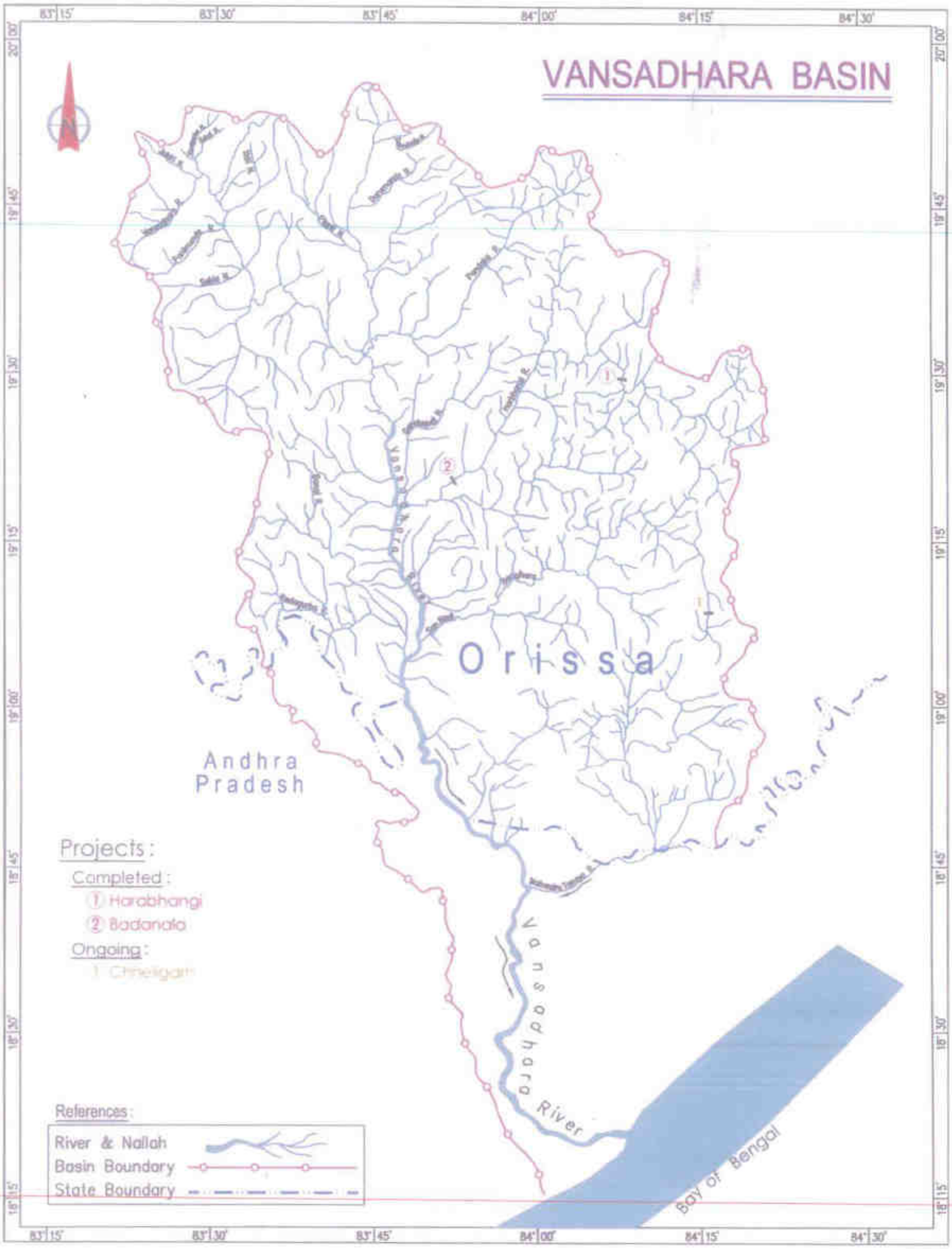
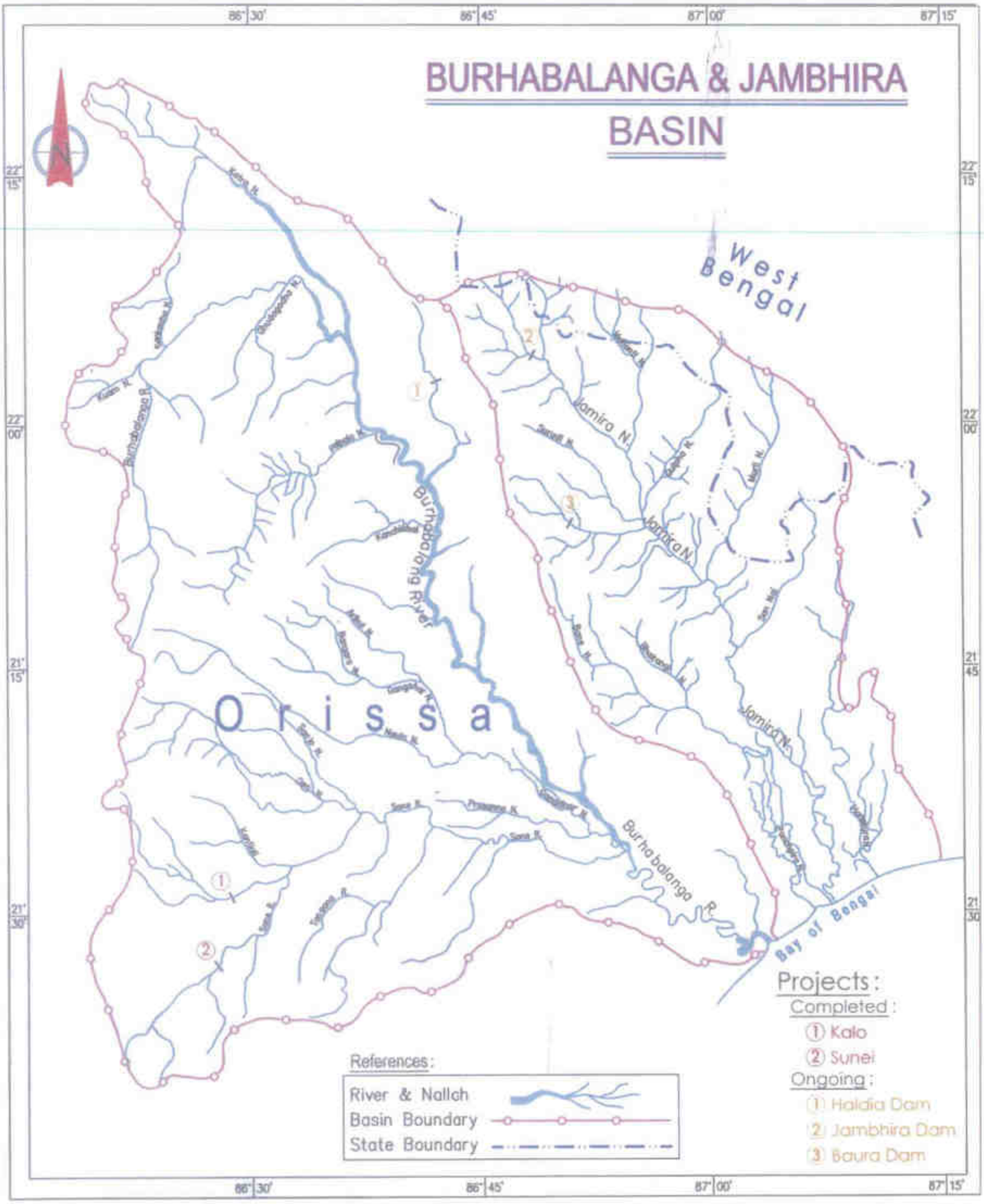

VANSADHARA BASIN
Orissa
Andhra Pradesh
Vansadhara River
Bay of Bengal
Projects:
Completed:
① Harabhangi
② Badanala
Ongoing:
1 Chheligam
References:
River & Nallah
Basin Boundary
State Boundary

Figure 3.4



BURHABALANGA & JAMBHIRA BASIN
West Bengal
Orissa
Burhabalang River
Burhabalanga R.
Jamira N.
Bay of Bengal
Projects:
Completed:
① Kalo
② Sunei
Ongoing:
① Haldia Dam
② Jambhira Dam
③ Baura Dam
References:
River & Nallah
Basin Boundary
State Boundary
86° 30'
86° 45'
87° 00'
87° 15'
22° 15'
22° 00'
21° 45'
21° 30'

Figure 3.5

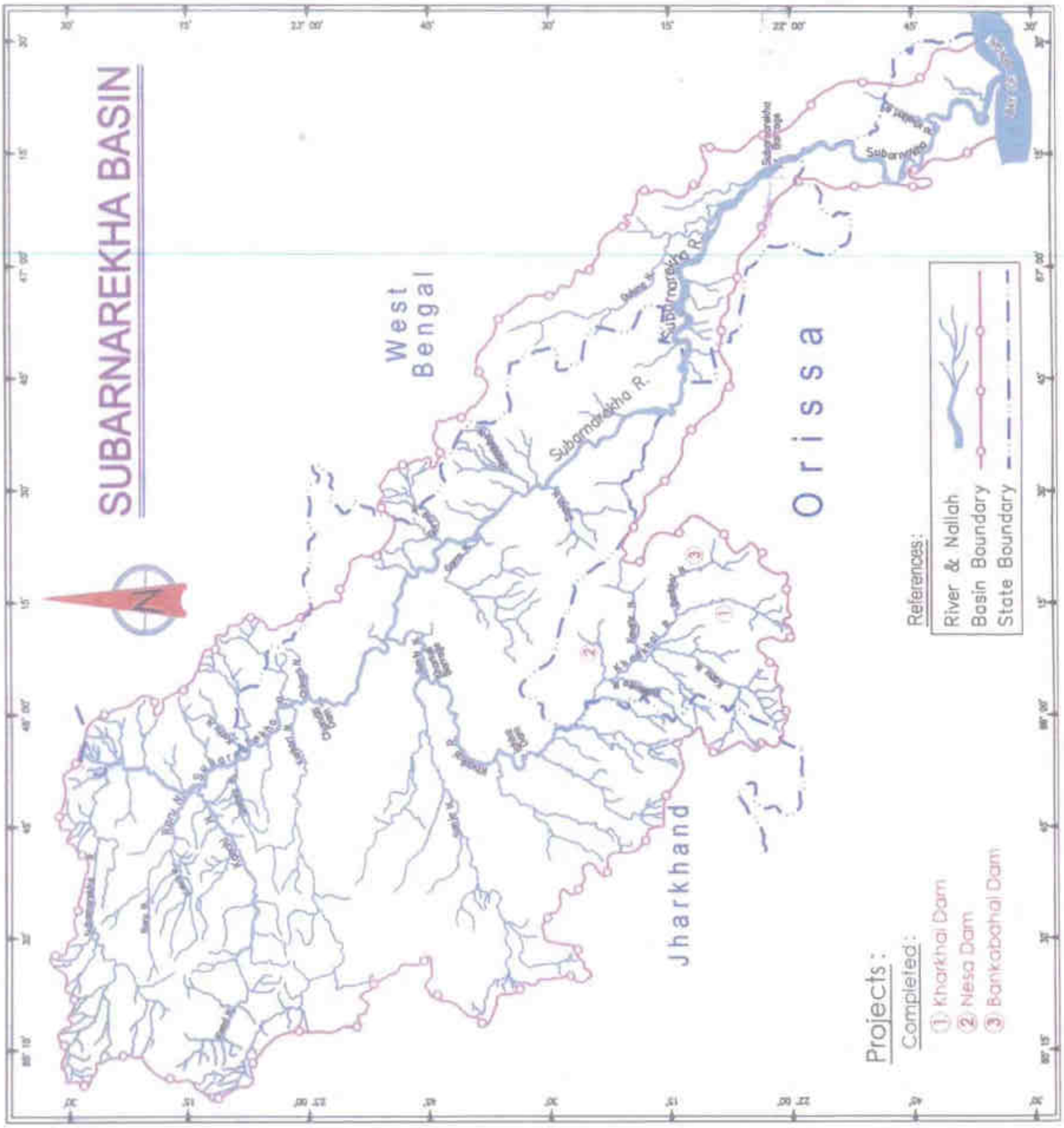

SUBARNAREKHA BASIN
West Bengal
Orissa
Jharkhand
Subarnarekha R.
References:
River & Nallah
Basin Boundary
State Boundary
Projects:
Completed:
1 Kharkhai Dam
2 Nesa Dam
3 Bankabahal Dam

Figure 3.6

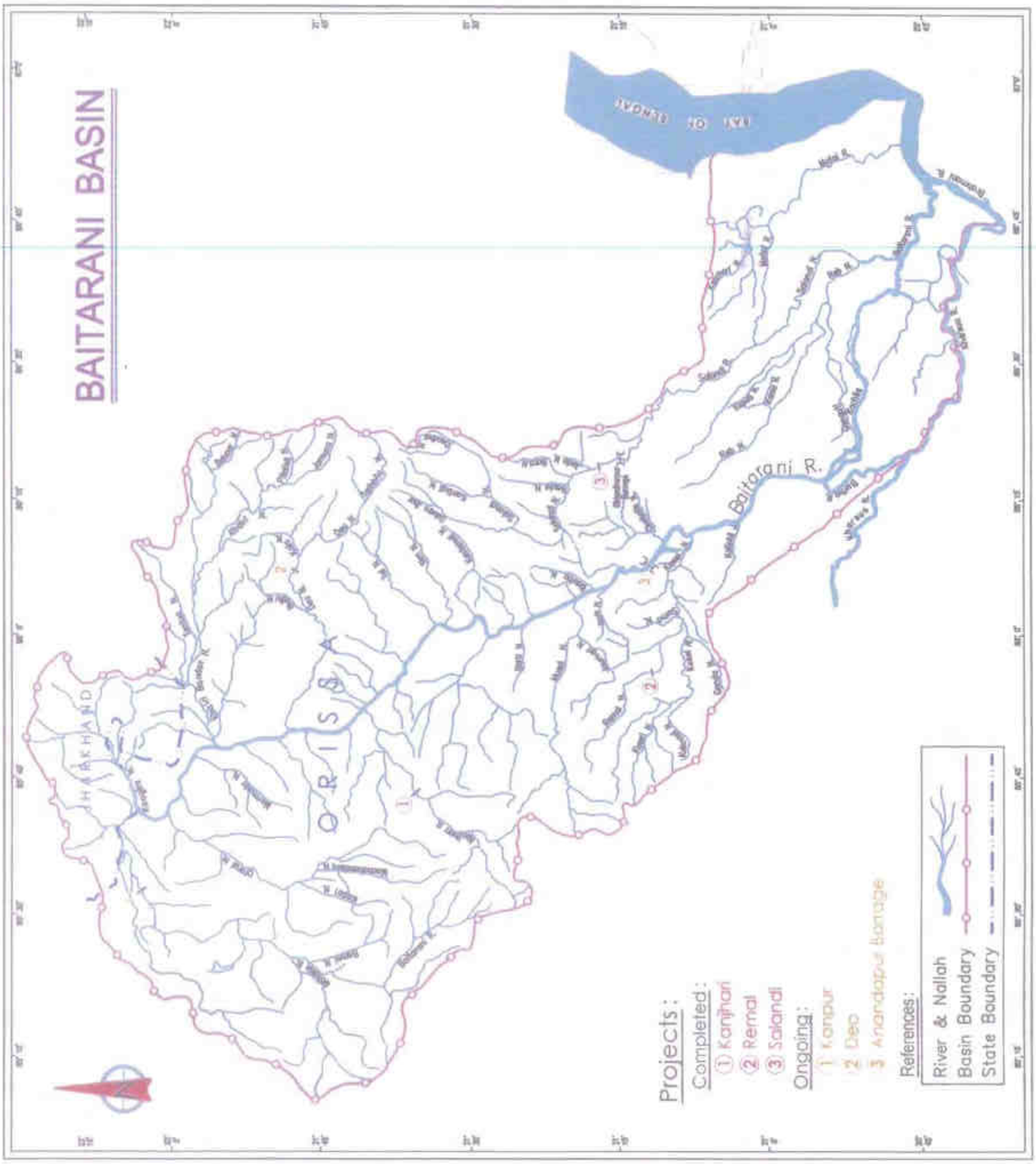

BAITARANI BASIN
BAY OF BENGAL
ORISSA
JHARKHAND
Baitarani R.
Projects :
Completed :
(1) Kanjhari
(2) Remal
(3) Salandi
Ongoing:
1 Kanpur
2 Deo
3 Anandapur Barrage
References:
River & Nallah
Basin Boundary
State Boundary

Figure 3.7

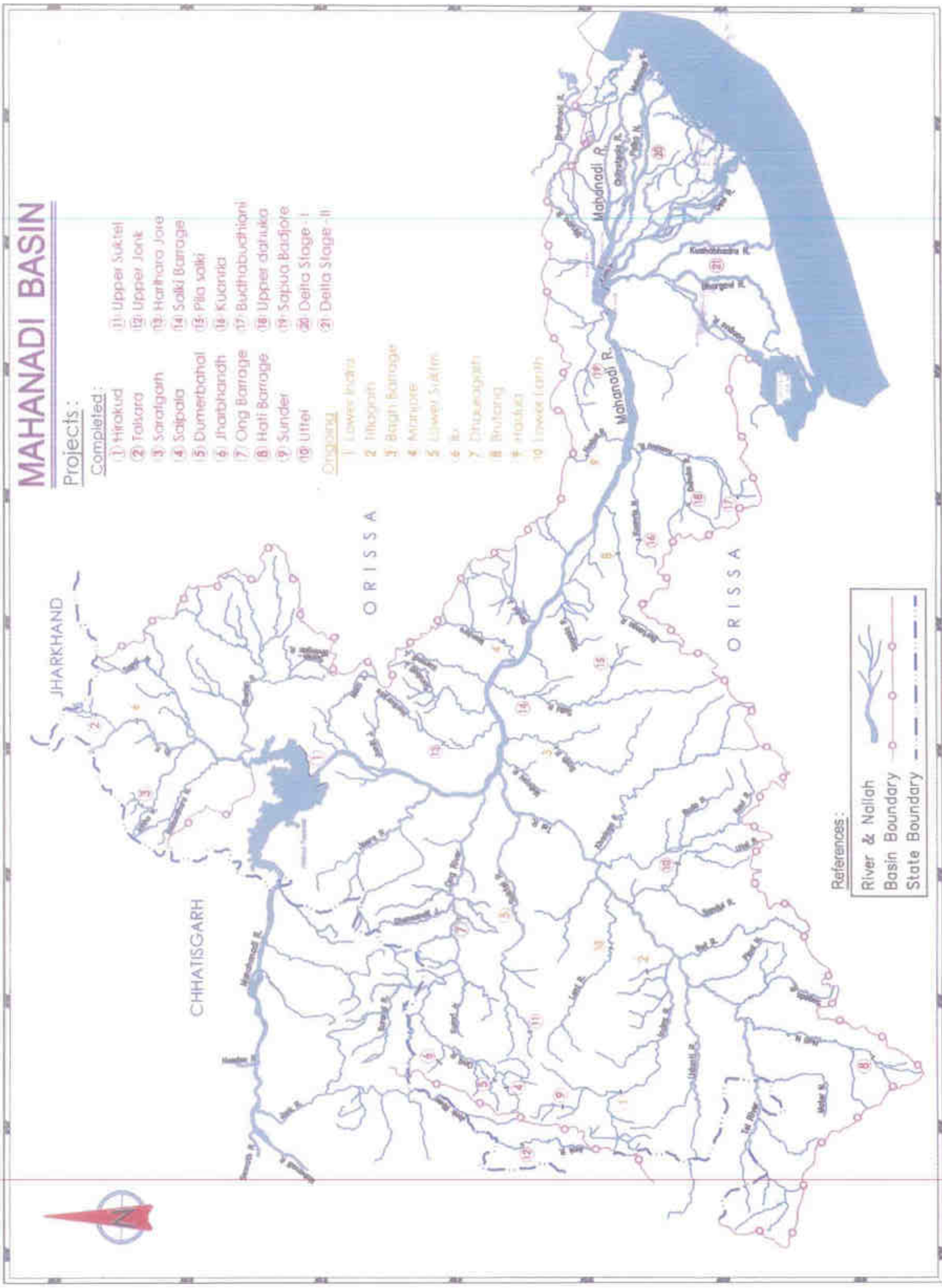

MAHANADI BASIN
Projects :
Completed :
1 Hirakud
2 Talsara
3 Sarafgarh
4 Saipala
5 Dumerbahal
6 Jharbhandh
7 Ong Barrage
8 Hati Barrage
9 Sunder
10 Uttei
11 Upper Suktel
12 Upper Jonk
13 Harihara Jore
14 Salki Barrage
15 Pilla salki
16 Kuanria
17 Budhabudhiani
18 Upper dahuka
19 Sapua Badjore
20 Delta Stage - I
21 Delta Stage - II
Ongoing
JHARKHAND
CHHATISGARH
ORISSA
ORISSA
Mahanadi R.
Mahanadi R.
References :
River & Nallah
Basin Boundary
State Boundary

Figure 3.8

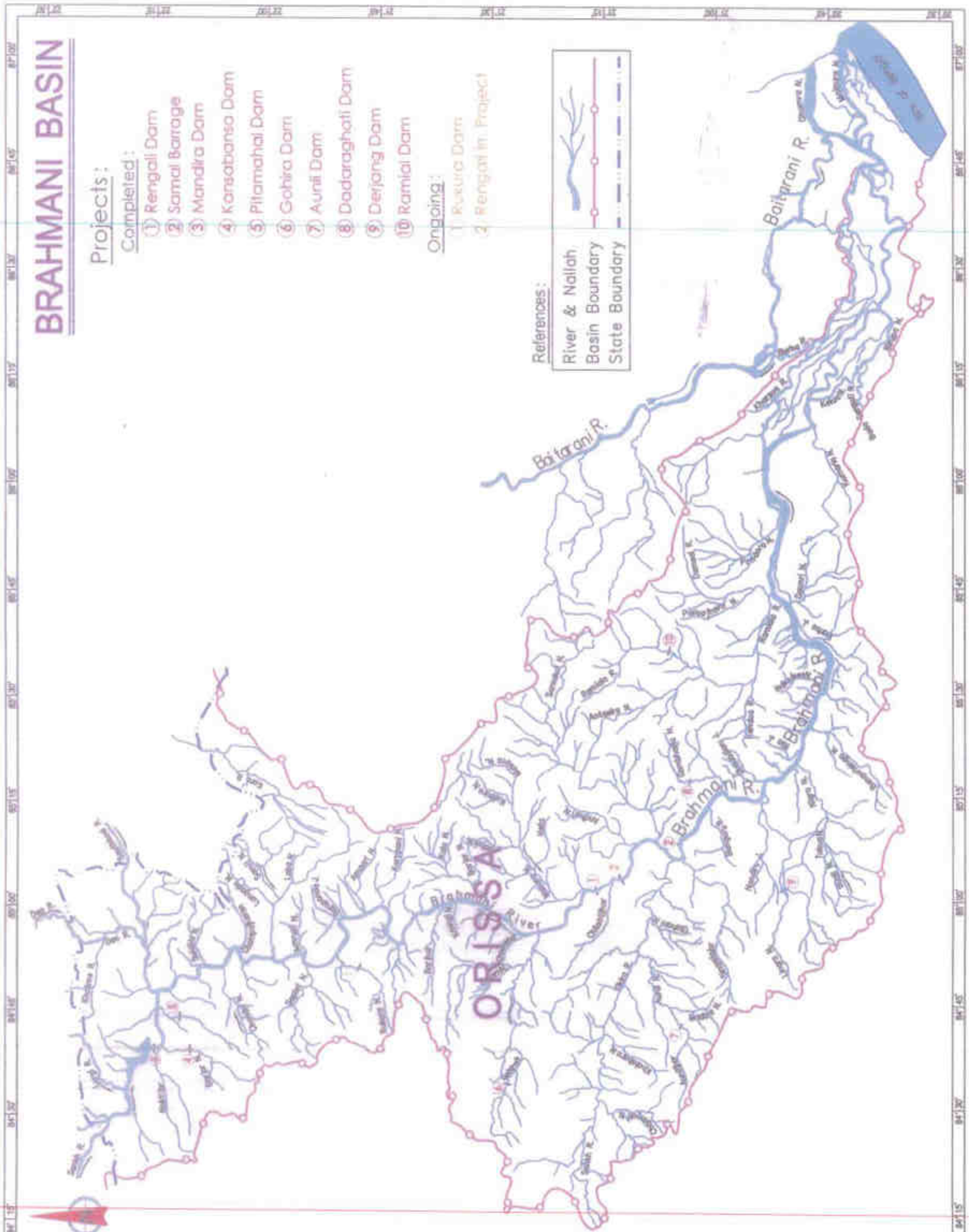

BRAHMANI BASIN
Projects:
Completed:
1 Rengali Dam
2 Samal Barrage
3 Mandira Dam
4 Kansabansa Dam
5 Pitamahal Dam
6 Gohira Dam
7 Aunli Dam
8 Dadaraghati Dam
9 Derjang Dam
10 Ramial Dam
Ongoing:
1 Rukura Dam
2 Rengali Irr. Project
References:
River & Nallah
Basin Boundary
State Boundary
Baitarani R.
Brahmani R.
Brahmani River
ORISSA

Figure 3.9

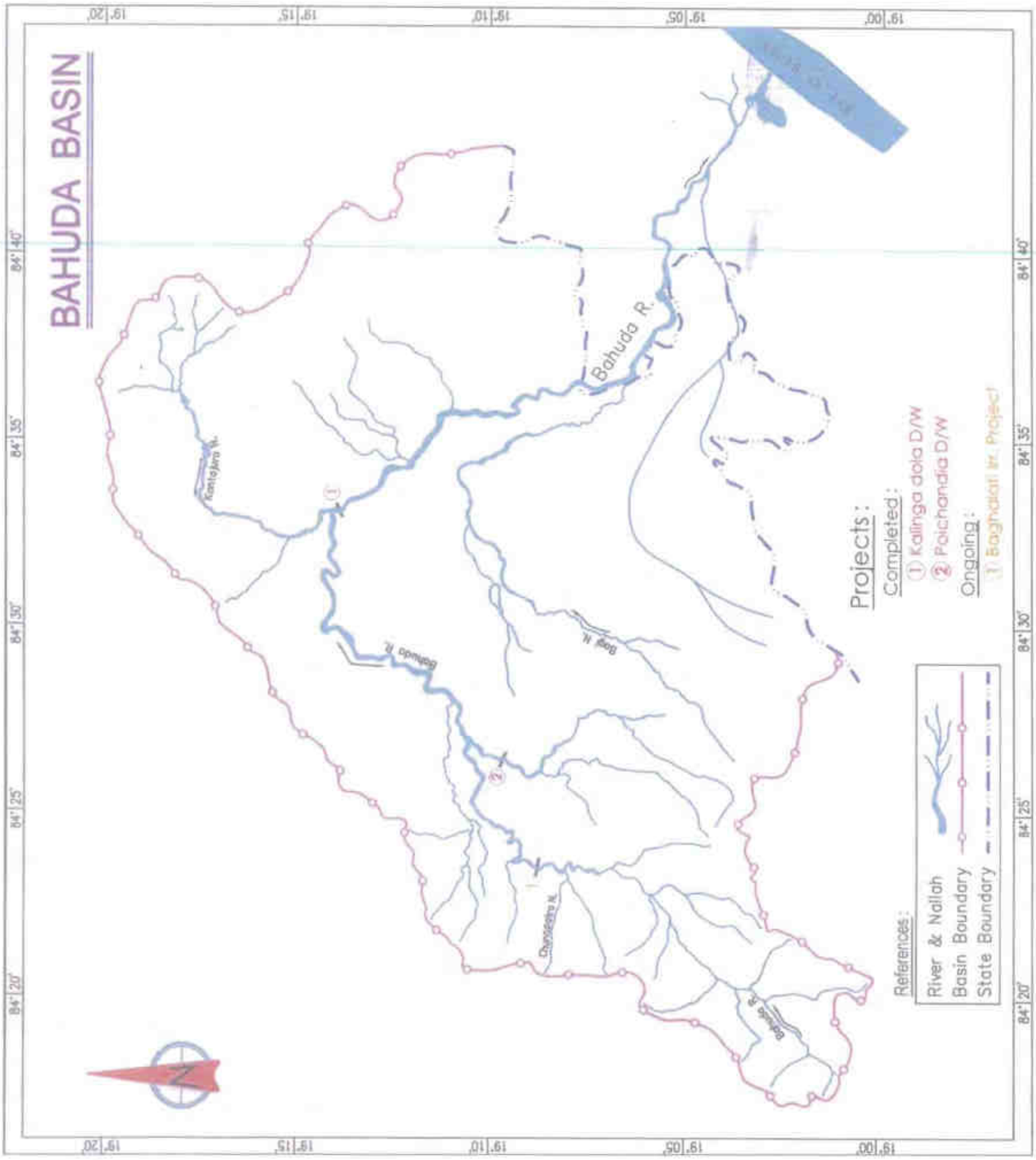

BAHUDA BASIN
Projects :
Completed :
1 Kalinga dola D/W
2 Poichandia D/W
Ongoing :
1 Baghalati Irr. Project
References :
River & Nallah
Basin Boundary
State Boundary
Bahuda R.
84° 20'
84° 25'
84° 30'
84° 35'
84° 40'
19° 00'
19° 05'
19° 10'
19° 15'
19° 20'

Figure 3.10

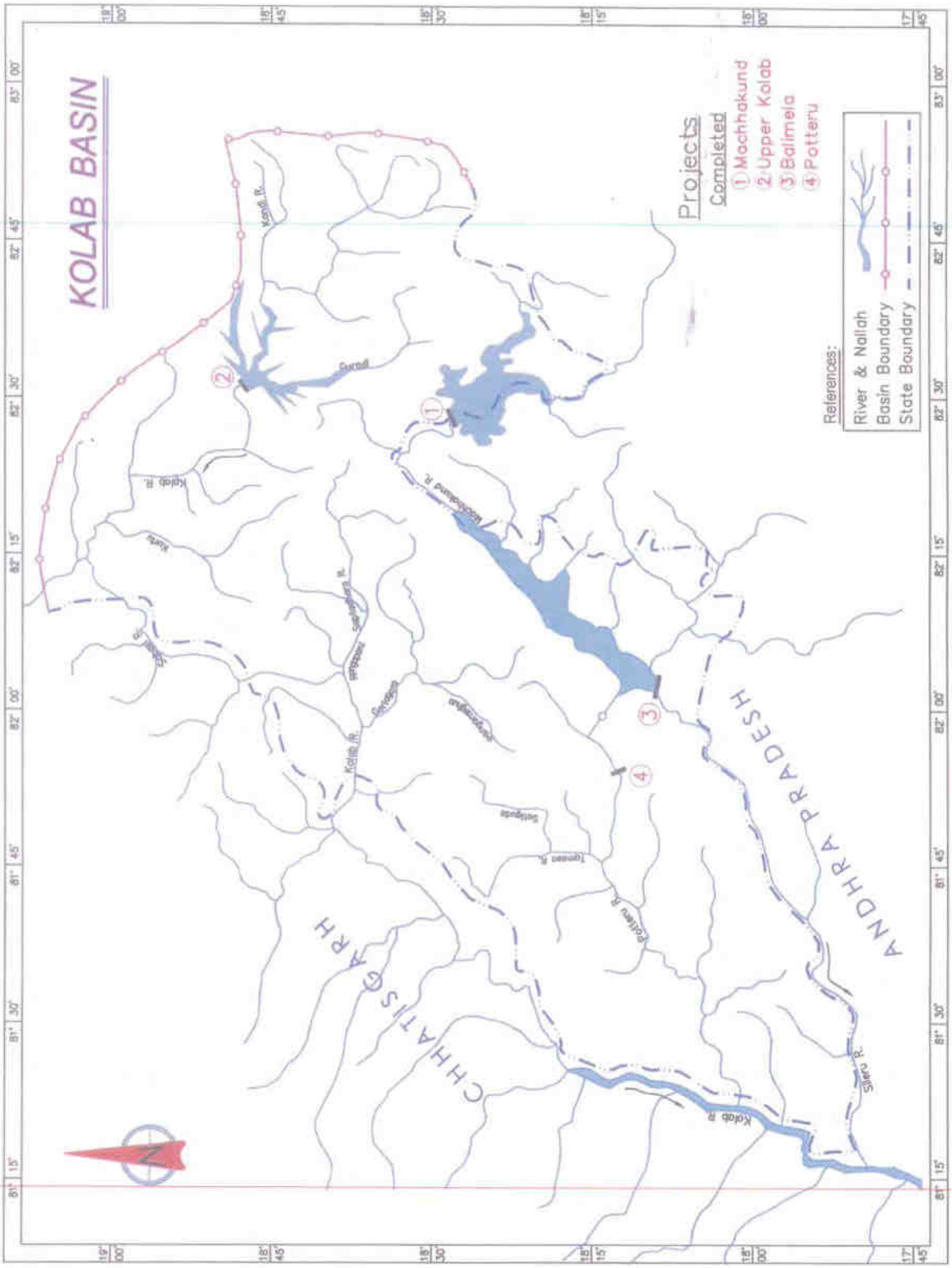

KOLAB BASIN
Projects
Completed
1 Machhakund
2 Upper Kolab
3 Balimela
4 Potteru
References:
River & Nallah
Basin Boundary
State Boundary
ANDHRA PRADESH
CHHATISGARH

Figure 3.11

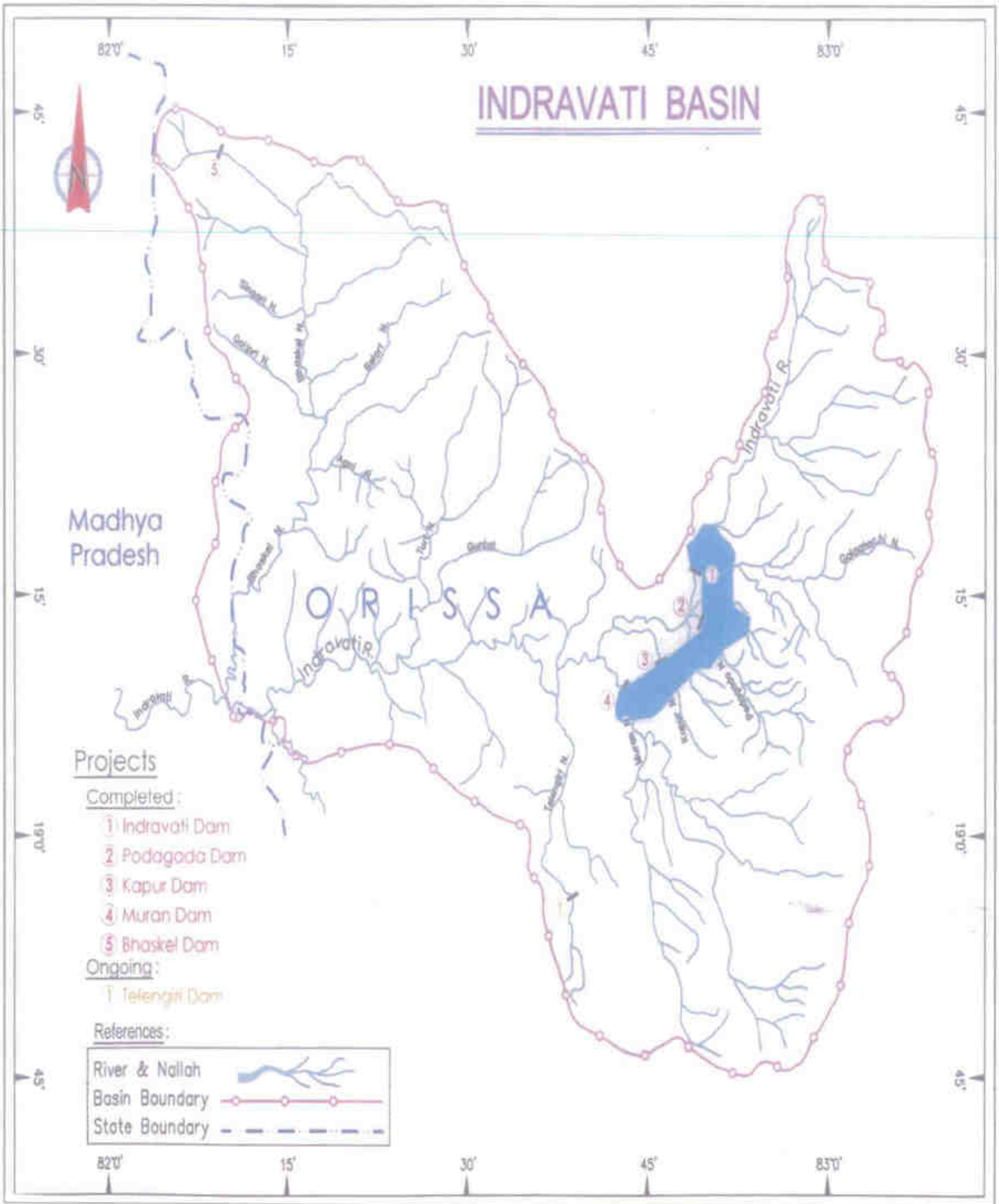

INDRAVATI BASIN
82'0'
15'
30'
45'
83'0'
Madhya
Pradesh
O R I S S A
Indravati R.
Projects
Completed :
1 Indravati Dam
2 Podagada Dam
3 Kapur Dam
4 Muran Dam
5 Bhaskel Dam
Ongoing :
1 Telengiri Dam
References :
River & Nallah
Basin Boundary
State Boundary

Figure 3.12

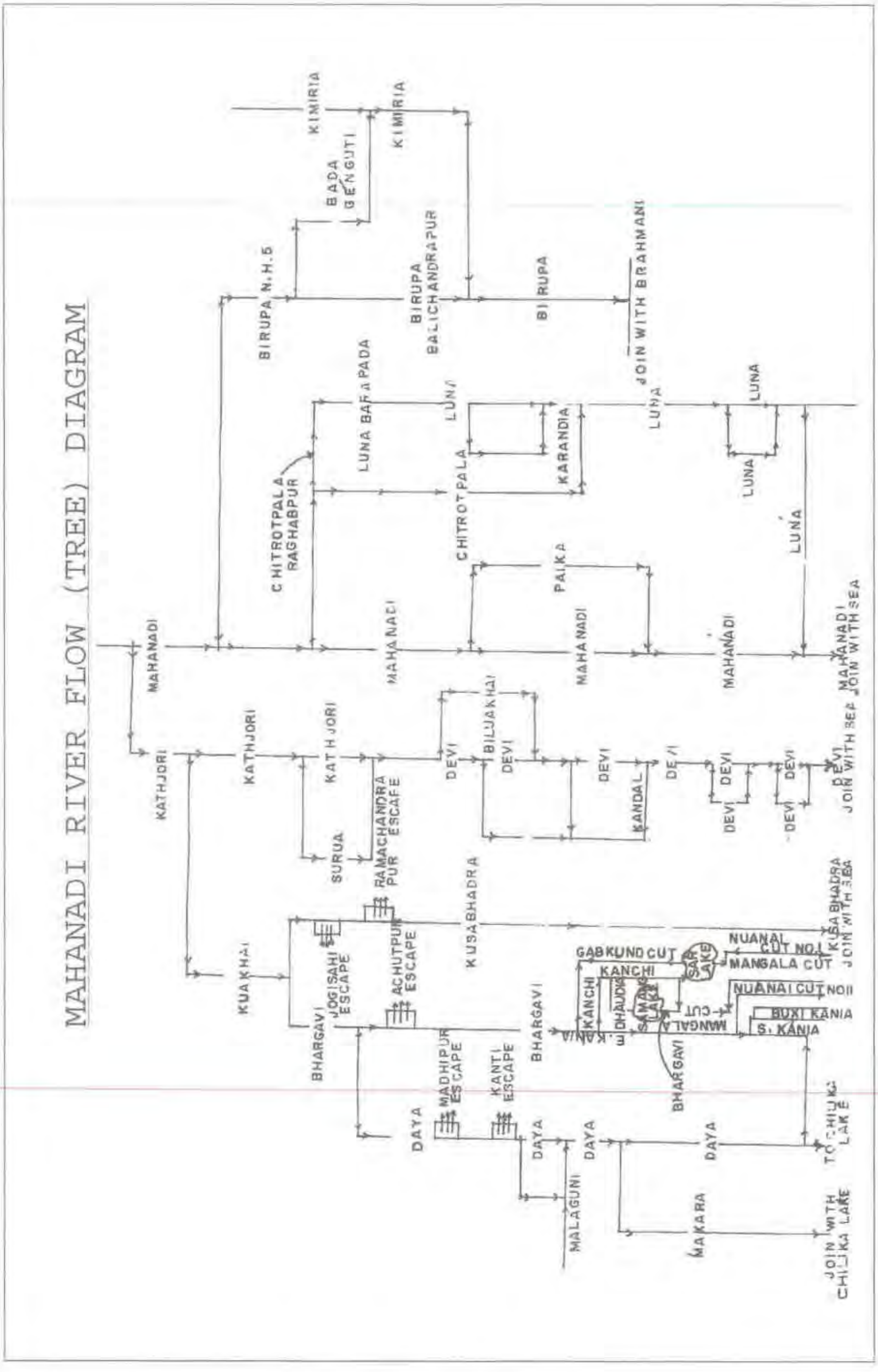

MAHANADI RIVER FLOW (TREE) DIAGRAM
MAHANADI
KATHJORI
BIRUPA
N.H.5
KIMIRIA
BADA GENGUTI
BIRUPA BALICHANDRAPUR
JOIN WITH BRAHMANI
LUNA
LUNA BARAPADA
CHITROTPALA RAGHABPUR
CHITROTPALA
KARANDIA
PAIKA
DEVI
BILUAKHAI
KANDAL
JOIN WITH SEA
SURUA
RAMACHANDRA PUR ESCAPE
KUSABHADRA
KUAKHAI
BHARGAVI
JOGISAHI ESCAPE
ACHUTPUR ESCAPE
GABKUND CUT
NUANAI CUT NO.I
MANGALA CUT
KANCHI
NUANAI CUT NO.II
BUXI KANIA
S. KANIA
DAYA
MADHIPUR ESCAPE
KANTI ESCAPE
MALAGUNI
MAKARA
JOIN WITH CHILIKA LAKE
TO CHILIKA LAKE

Figure 3.13

Chapter IV

IRRIGATION SCENARIO DURING DYNASTIC PERIOD

4.1 Introduction

Irrigation in India has been practised in one form or another from pre-historic days. To day it has the largest irrigated area in the world. Vedas, Purans and ancient scriptures made reference to wells, tanks, canals and dams which were beneficial for the community. Civilisation flourished on the banks of rivers. Water sources were harnessed for sustenance of life. In ancient period, digging of tanks and wells etc. were considered as the greatest amongst meritorious and pious deeds of a man.

During 300 BC Kautilya stated that "During times of famine, the King and his subjects took shelter near dams; aquatic life in rivers, canals and dams were protected and fishing was allowed under a license. If privately managed dams were neglected for five years, their charge was taken over by the State. If they were constructed by public contribution, revenue for five years was remitted."

In 1568, Akbar wrote "In acknowledging God's mercy in establishing this great empire, purer than water, is to supply the wants of poor, and to leave permanent marks of the greatness of my empire by digging canals and founding cities, by which too, the revenues of my empire will be increased. For God has said, from water all things are made. I consequently ordain that this jungle in which subsistence is obtained with thirst, be converted to a place of comfort, free from that evil". (Source: Development of Irrigation, Drainage and Flood control in India by INCID, April 1991 Pg.5).

'Ramayan' the sacred historical work of sage Valmiki records an account of the gigantic feet of King Bhagiratha and his engineers of diverting the course of waters of river Ganga from the altitudes of the Himalayas towards the present Indo- Gangetic plain.

"In Sanskrit literature 'Pranali', 'Kulya', 'Sarasi', 'Nika', 'Nala' and 'nalika' are the words used for different types of canals and channels. There also occurs another word 'tilamaka' which denotes 'a channel which leads the water from hill side over the fields which rise in terraces one over the other'. Similarly the words 'kund' and 'tala' are used for small and big tanks and the words 'tataka' and 'sarasi' for big dams. According to the lexicographer Amar (1st century AD) 'Kulya' is a small artificial stream. This also indicates that canals were dug for the purpose of irrigation". (Source: Irrigation in India through ages, CBIP, 2nd edition 1953).

The rivers were dammed for the purpose of irrigation. "The 'Kunala Jataka' (prior to 4th century B.C) mentions a dispute between two tribes for the use of water of a dam. The Sakiya and the Koliya had the river Hohini which flows between the cities of Kapilvastu and Koli confined by a single dam, and by means of it cultivated their crops. In the month of Jethamula when crops began to flag and droop, the labourers from both the cities assembled together. Then Kolians said; should this water be drawn off on both sides, it will not prove sufficient for both of us. But our crops will thrive with a single watering, give us then water." (Source: Irrigation in India through ages CBIP, 2nd edition 1953 Pg.6).

The entire landscape in Southern and Central India is studded with number of tanks for irrigation purpose which wee excavated many centuries before commencement of Christian era. Grand anicut across river Cauvery was believed to have been constructed during 2nd century AD by King Chola.

The famous King Krishna Devaraya and his descendants made large scale improvements to the Thanjavur delta in South India while creating minor irrigation tanks to bring dry areas under irrigation.

Mahendra – tataka tank situated in the Village Mahendravadi in the north Arcot district was constructed by Mahendara Varman I. The date of construction of the tank is not known. The tank served lands extending seven to eight miles away. Paramesvara–tataka situated in the village Kuram in Chingleput district was constructed by the grand son of Mahendra Varman I where 108 families studying four Vedas were residing. The tank had a feeder channel from Palar river.

An inscription of Rajaraja I (AD 985 – 1013) refers to a big tank at Bahur near Pondicherry. Villages had agreed to contribute to the revenue of the tank. The committee constituted for supervision of tank levied the contribution and agreed to remove the silt annually. If any of the inhabitants of the locality refused to contribute his share, the ruler was authorised to impose penalty.

The Achyutapuram copper plate grant of Indravarman (during 11^{th} century AD) registers the grant of a village to a Brahmana. This village was situated near Raja tataka or the King's Tank. The donee was permitted to utilise its water. This grant was made permitted to utilize its water. This grant was made on the occasion of the consecration of a tank which was considered to be quite an important ceremony.

History of Dharmasastra written by Kane mentions that Bhavadeva Bhatta constructed a reservoir of water in Radha part of ancient Bengal.

Shahjahan revived and extended the irrigation works in Northern India which was initially constructed towards end of 14^{th} century by Firoze shah. Ali Mardan Khan was familiar with the canal system. He suggested tapping the river Ravi where it emerged from the hills to water the country even up to Lahore. (Source: Cambridge History of India, Vol. IV Pg. 201).

It can be concluded from above that some benevolent rulers had taken keen interest for welfare of their subjects to provide irrigation facilities in both southern & northern parts of India. Kings and rulers of Orissa were not left far behind. These are being discussed in subsequent sections of this chapter though the same has been briefly outlined in Chapter I, Sec. 1.2.

As tanks and wells were major sources of irrigation developed then, the area irrigated by wells and tanks from 1936-37 to 1960-61 in the country is furnished in Table 4.1 which show that 46.4% of total irrigated area were by wells and tanks.

Table 4.1 Area Irrigated by Different Sources from 1936-37 to 1960-61 in the Country.

Year	Net area irrigated in Th. ha.					
	Govt. canal	Pvt. canal	Tank	Well	Other sources	Total area irrigated
1936-37	12718	3292	6866	11592	5700	40168
1937-38	13793	3497	7139	12329	5798	42556
1938-39	13858	3314	6689	12735	6639	43235
1939-40	14143	3706	6717	13137	6630	44333
1940-41	14298	4241	7033	13421	6233	45226
1941-42	14664	3589	6651	13840	6320	45064

1942-43	14576	3848	7041	12696	5581	43742
1943-44	15037	4572	8199	13006	6016	46830
1944-45	15155	4527	8239	13102	6095	47118
1945-46	15797	4839	7876	13133	6414	48059
1946-47	15679	4843	8487	13049	6396	48454
1947-48	15312	4448	7991	12525	6368	46644
1948-49	15929	4524	7658	12643	6171	46925
1949-50	16934	2864	8486	13687	7935	49906
1950-51	17938	2817	8288	14695	7601	51339
1951-52	18616	2950	8511	16104	5832	52013
1952-53	18777	3342	7942	16024	5998	52083
1953-54	18679	3248	10346	16408	5158	53839
1954-55	19356	2868	9889	16562	5587	54262
1955-56	19332	3360	10874	16643	5444	55653
1956-57	19561	3353	11100	16227	5441	55682
1957-58	20517	3334	11210	16848	5312	57221
1958-59	20734	3160	11761	16521	5649	57825
1959-60	21626	3225	11486	17503	5457	59297
1960-61	22478	3029	11288	18030	6016	60841
Average	17020	3631	8711	14498	6072	49932
% of average area irrigated	34.1	7.3	17.4	29	12.2	

4.2 Agriculture in Feudatory States of Orissa

Orissa had 26 Feudatory States. Those were Angul, Athagarh, Athmallik, Bamra, Banki, Baramba, Baud, Bonai, Daspalla, Dhenkanal, Gangpur, Hindol, Kalahandi, Keonjhar, Khandapara, Mayurbhanja, Narashingpur, Nayagarh, Nilgiri, Pallahara, Patna, Rairakhol, Ranpur, Sonepur, Talcher and Tigiria. Excepting Mayurbhanj others merged with Orissa in 1948. Mayurbhanj joined the mainstream in 1949.

One of the most important elements in the economic system of Feudatory States of Orissa was agriculture. It was primary occupation of about 75% of total population. According to Richardson, the Settlement Commissioner about one-eighth of the total cultivable area was cultivated in 1841. (Vide Orissa Historical Research Journal, Vol. II No.2, July 1958 Pg. 92-94). In 1842, Macpherson was in agreement with this assessment. For example, Nilgiris total area was 251600 acres (101823 ha) out of which only 47600 acres (19264 ha) were under cultivation. Of course in Mayurbhanj, situation was relatively much better where large area was under cultivation.

Reasons for low cultivable and cultivated areas may not be entirely attributed on rulers as the States contained mostly bare rock of mountain peaks and rocky soil in hill slopes unsuitable for cultivation. By and large in Feudatory states four forms of cultivation were practised as there were four types of land. Some system of cultivations was also prevailing in all part of Orissa State then. Those were 'Toila', 'Bazefasal', 'Harfasal', and the 'Sharad'. (Source: Economic History of Orissa by N.R. Patnaik, 1997, Pg.179). Forest land prepared and reclaimed by cutting jungle was known as 'Toila'. Mostly by burning forest, such lands were prepared. For three successive years, such lands were cultivated for mainly growing cotton, oilseeds and millets and thereafter such land became unfit for the purpose.

With application of cow dung and other manures, these unfit lands become suitable for cultivating crops like mustard, castor oil plants and maize. This was called 'Bazefasal'. Lands situated adjacent to villages and rain-fed were known as 'Harfasal' in which all types of crops were grown. Lastly irrigated lands located along river banks or below low ridges wee called 'Sharad' which were suitable for regular rice cultivation.

Another system of cultivation, i.e., Dahi or Jhum or Poddu (shifting cultivation) was in vogue which was a very primitive system and was found more or less in all the Feudatory States of Orissa adopted mostly by the tribal people. This practice was extensively followed in Athamallik, Bamra, Kalahandi, Keonjhar, Pallahara and Rairakhol where there was vast tracts of lofty and dense forests for growing miscellaneous crops viz. barely, rice, maize, millet, oilseeds and turmeric. After two to three years of cultivation, the area was abandoned for a period until the trees have grown for a second felling. The process is repeated until the land is denuded of soil and nutrients and no more forest growth possible. Then the land was finally abandoned. Both 'Dahi' and "Poddu' have caused immense damage to the forests as well as to the land.

Agriculture in the Feudatory States entirely depended on rainfall. Streams were rarely used for irrigation purposes. However, unlike the plains, canals, embankments and tanks were unknown in the States. This was because kings or rulers did not take much interest in the welfare of their subjects. Moreover, in other areas tanks were usually dug by well-to-do and religious people. But that was not the case in Feudatory States lest the King or Raja may impound the rich who has shown the signs of his wealth by excavating a tank (vide 'Final Report on Survey and settlement of the Province of Orissa, 1890-1900', Vol.II Pg.421). But very few Kings of ancient and medieval times constructed some canals to serve the cause of agriculture. Considering the vastness of the land, these canals were pitifully low.

4.3 Well & Tanks

Kautilya says that tanks and wells should be built in barren and less fertile parts of the country. It may be inferred that such areas were subjected to droughts and scarcities. Moreover, wells, tanks and embankments which needed less outlay, less technical know-how and yielded faster results appear to have been more beneficial for the agriculture. These factors prompted some benevolent kings to construct water storages in their Kingdom.

In the Hatigumpha record, it is found that king Kharavela constructed embankments of deep cool tank ('Sital tadaga padiyo') in the city of Kalinga. The Hatigumpha inscription at Udayagiri near Bhubaneswar throws some light on the irrigation system of Orissa. The cave dwellers of Udayagiri and Khandagiri were utilising water for their daily use from a series of rock-cut stepped wells. In Khandagiri there were two such wells named 'Gupta Ganga' and 'Syamakunda' which were collecting rain water. People dug wells (kupa) both inside and outside their premises. Wells dug outside were mostly for irrigation purposes. The rock and pillar edicts of Ashoka refer to the digging of wells on highway at every half 'Krosa' (one mile) interval. He had also excavated canals for the welfare of the people of Kalinga. It is needless to elaborate regarding benevolent king Ashoka who had undertaken various measures for irrigation and drinking water facilities for his subjects.

Further, Kautilya opines that irrigation work having a perennial supply of water is better than that fed by water drawn from other sources. In the great epic 'Mahabharat' it is told that a tank is hundred times more important than a well. In spite of this, percolation wells have been used for watering the fields from Vedic days. 'Mahabharat' written by Sarala Das in Oriya language mentions about construction of tanks, wells and canals by kings for drinking and irrigation purposes during 15th century AD. Wells & tanks have always been important means of irrigation in Orissa's economy.

The Meghesvara and Sobhanesvara inscription reveal that King Anangabhimdeva had set up good roads and bridges for communication besides temples and tanks etc. Regarding river embankments and tanks, the king had spent huge amount of 108 lakh 'madhas' (denotes coin of any metal viz. gold or copper of specific weight prevalent then) and completed the construction of twenty tanks. (Source: Cultural advancement of Orissa under the Gangas of Kalinga by D.R. Rao, 1994, Pg. 109). During reign of Bhanudev, a tank at Padmatolaghati was much popular.

The opening ceremony of tanks were observed with much pomp and grandeur. The Almanda plates of Anantavarman during 802 AD were issued on such occasion on the day of a solar eclipse. The names of the person who constructed the tanks for the welfare of farmers do not appear in the inscriptions. But this can be concluded that there were some reservoirs of water or streams created by natural process or artificially dug by human beings which assisted in increasing crop yield.

Often inscriptions refer to water reservoirs like tanks and wells ('tataka', 'vapi'), 'puskarani', 'bandha' and 'joda'. The epigraphic refer to several tanks and wells, that were excavated for irrigation and other uses also. The Achyutapuram plates of early Ganga king Indravarman (7th century A.D) record the grant of one 'hala' of land in the village Sidharthaka near Rajatatak (i.e. the kings tanks), the water of which the donee was permitted to utilise for irrigation. The grant was made on occasion of consecration of a 'tataka' (tank) in honour of king's mother. The record further states that no one should obstruct the donee when he opens the sluices. The Uriam plates of Hastivaraman refer to the Ghosana tank situated on the eastern boundary of a cultivable tract in the village of Hondivaka. The Orissa Museum plates of Anangabhimdev III (AD 1211-1238) refer to tanks named Alapa and Narayana Sadhu which formed boundaries of donated land. The Kendupatana plates of Narasimha II of 1924 AD mention regarding tank (puskarani) on a donated land. These epigraphic evidences are enough to establish that the water of the tanks was used by the cultivators for irrigating the adjoining lands.

At the same time, it is noticed that due to irrigational facilities, the progressive cultivators had developed double cropping in some areas. From the inscription of early Ganga king Madhavavarman (8th century AD), it is seen that the grant of certain lands which were growing two crops in a year (i.e. one in autumn and the other in summer) was given. The same inscription also refers to some other plots of land which were unsuitable for double cropping and were yielding only one crop in autumn. Historians believe that irrigation for the rice crop was widely in practice in coastal Orissa and Andhra Pradesh. It was from these regions that it spread to bordering states of Taminadu around 300 B.C. (vide Irrigation in India, History & Potentials of social Management, 1995 by K.S. Bagchi Pg. 8).

4.4 Irrigation Development by Ex-Rulers Prior to Independence

The fertile soil and favorable climate of Orissa made the cultivation of various kinds of crops possible during the medieval period. The cultivated lands were generally located near the water source where irrigation for agriculture was convenient. Some rulers of ancient and medieval time had constructed few water sources to serve the causes of agriculture but those were not enough. Virtually agriculture was left at the mercy of rain God. At places, people had made attempts to solve their problems in various ways, i.e., by constructing wells, tanks and bandhas. Even on hill slopes cultivators learnt how to preserve water in terraces. Such methods by people did not prove adequate enough to meet the need particularly during drought when peasants felt helpless. There is always lighting in dark clouds. During such distressed period, some benevolent Rajas / rulers came forward and did their best for improving the economic conditions of farming community by creating water resources. This aspect has been discussed in subsequent paragraphs.

4.4.1 Irrigation in Mayurbhanj

The average rainfall in the district is about 1648 mm (65 inches) which is adequate for crop growth. But the uneven distribution both in space and time causes uncertainty in cultivations for which artificial irrigation is needed. The district getting irrigation facilities from various types of irrigation is about 12% of total cultivable area.

The ex-State Govt. had undertaken two notable irrigation projects, one at Balidiha and the other at Haldia. Details of these two projects are briefly narrated as under.

4.4.1.1 Balidiha Irrigation Project

This is an ungated diversion weir scheme constructed across a hill stream 'Palpala' in the village Balidiha at Long. 860 36' E and Lat.210 54' N. The weir intercepts a catchment area of 205 sq.km. The Palpala nallah emerges from Similipal hill range and near Balildiha cuts through two hillocks where the passages has been bunded. Maximum flood discharge is 4323 cumec. The length of weir and its crest width are respectively 173 m and 1.22 m. Two canals off take from the reservoir; the left canal has a length of 6.60 km and the right one of length 13.5 km to irrigate an ayacut of 3832 ha during Kharif and 50 ha. during Rabi.

During the period of King Sri Ram Chandra Bhanja Deo, this laterite masonry structure was completed in 1912 AD for providing irrigation which has been renovated during 2005 by encasing the structure with R.C.C. Due to silting of the bed of the reservoir, the storage capacity reduced which necessitated to raise the height of the structure. Maximum height of this broad crested weir above deepest foundation is 6.96 m. The original estimated cost of the project was Rs.4, 56 lakhs (vide Orissa Districts Gazetteers, Mayurbhanj, 1967 Pg. 199).

4.4.1.2 Haldiha Irrigation Project

Haldiha reservoir scheme was completed in all respect during 1921. It comprises of an earthern dam of 2580 ft (756.4m) long across river 'Chipot' and spillway having 52 vents fitted with one meter height automatic falling shutters. It was constructed by Raja of Mayurbhanj during 1st decade of twentieth century in Budhabalanga basin to provide irrigation to CCA of 2429 ha in Kuliana Block. The earth dam has been constructed of local materials with the state of art prevailing then.

It is providing irrigation for about nine decades. The original cost of the project was Rs.6.52 lakhs. After merger of Mayurbhanj with Orissa in January 1949, the maintenance of the project wasfirst transferred to Works Dept., subsequently came to Irrigation Department. Now Haldia project forms a part of Subarnakha Irrigation Project (SIP) as one of the three command area reservoirs (CAR).


D/S View of Fall board Shutters of Haldia Spillway

The SIP under execution will provide irrigation to 1,09,627ha on completion in Mayurbhanj and Balasore districts when the existing Haldia Dam will be upgraded by raising its height, storage capacity and command area. In the proposed upgradation scheme, Haldia reservoir will be directly fed by Subarnrekha Main canal through a link channel upstream of H.R of Betonati branch canal.

4.4.1.3 Few Other Minor Irrigation Projects in Mayrubhanj:

The report on Administration of Mayurbhanj (1931-32 Pg. 61-61) states that in the Sadar subdivision of the State, a sum of Rs.1780 – 10 – 6 was given as grant and people's contribution was Rs.557 -8 – 0 for repair and renovation of following bundhs and tanks. Those bundhs are i) Khanna, ii) Khejuria, iii) Jamsole, iv) Baiganbaria, v) Pokharia, vi) Bathuria, vii) Badavasole, viii) Damodar, ix) Kumbhar Mundakata, x) Murunia and xi) Ahari tank.

In the Bamanghati subdivision, the repair works viz. a) Bankatia Maharia, b) Mayadhar bundha and c) Patharkata bundha were completed during the year with an expenditure of Rs.417-12-0. Further repair and improvement of Jatapani bundha was taken up by P.W.D and completed.

In the Panchapira subdivision, two bundhs and five tanks were re-sectioned and one new tank excavated. A sluice was provided to Khejuri Sagar tank at Karanjia which was expected to irrigate about 400 'mans' (acre) of land.

The Administration Report of Mayurbhanj (1907-08 at Pg.8) records regarding grant of Rs.20000/- for construction of small irrigation works in the Sadar subdivision. In the report of 1914-15 Pg.20, there is mention of various irrigation works in the State including the survey and investigation of proposed large Burhabalanga project.

The Administration report of 1940-41 at Pg.27 states that "The P.W.D was constituted in 1884 and an ambitious programme of public building and irrigation projects was undertaken. During the years that followed good roads were opened out, old large number of new ones was excavated. According to the census of 1931, the State has got 1324 state irrigation bundha and 1745 private bundhs. Besides there are three major projects, long since brought to completion at a cost of six lakh rupees which alone provide irrigation facilities to an area covering 13000 acres".

List of other irrigation schemes taken up during ex-Durbar period are presented in Table 4.2.

Table 4.2 Irrigation Projects Constructed in ex-Durbar's Period

Sl. No	Name of Irrigation Projects	Name of G.P/ block	Location	Length of Dam/weir (m)	Length of spillway (m)	Ayacut (ha)		Year of completion
						Khariff	Rabi	
1	Rajabandha	Pokhoir / Saraskana	Lat. 22^0 14' 39" N Long. 86^0 35' 58" E	473.0	38.2	207.0	--	1925
2	Maranda	Bada Dundu / Jamda	Lat. 22^0 21' 17" N Long. 86^0 02' 02" E	323.0	12.1	62.0	16.0	1935
3	Mandasila	Badajharan / Bijatola	Lat. 22^0 16' 07" N Long. 86^0 14' 32" E	442.0	30.5	100.0	64.0	1930
4	Kochagobara	Pandupani / Tiring	Lat. 22^0 31' 0" N Long. 86^0 45' 0" E	655.0	30.5	64.0	32.0	1930
5	Sundarsanpur	Sudarsanpur / Raiangpur	Lat. 22^0 6' 0" N Long. 86^0 21' 0" E	335.0	19.8	40.0	20.0	1930
6	Aharbandha	Hat-Badra / Kusumi	Lat. 22^0 7' 30" N Long. 86^0 8' 0" E	150.0	30.5	279.0	40.0	1920
7	Dhalpur	Hensda / Jamada	Lat. 21^0 12' 45" N Long. 86^0 6' 0" E	853.0	35.0	97.0	40.0	1920
8	Nuagaon	Narayanpur / Tiring	Lat. 22^0 30' 5" N Long. 86^0 04' 30" E	747.0	18.3	62.0	10.0	1935
9	Patepani	Rairangapur / Rairangapur	Lat. 22^0 17' 45" N Long. 86^0 9' 15" E	460.0	--	136.0	--	1915
10	Sunamara	Hensda / Jamda	Lat. 22^0 12' 0" N Long. 86^0 4' 0" E	695.0	21.6	107.0	--	1935
11	Udayapur	Sudarsapur / Rairangapur	Lat. 22^0 21' 15" N Long. 86^0 13' 0" E	450.0	11.3	63.0	--	1930
12	Jhipabandha	Jhipabandha / Kusumi	Lat. 22^0 3' 40" N Long. 86^0 2' 50" E	613.0	30.5	280.0	40.0	1930
13	Narayanpur	Narayanpur / Tiring	Lat. 22^0 28' 30" N Long. 86^0 5' 30" E	762.0	31.7	80.0	10.0	1935
14	Dalki-Jorda	Kusumi / Jorda	Lat. 22^0 6' 50" N Long. 86^0 5' 35" E	520.0	43.2	320.0	40.0	1930
15	Gadigaon	Gadigaon / Morada	Lat. 21^0 15' 40" N Long. 86^0 55' 30" E	823.0	38.1	127.0	--	N.A
16	Sirsapal	Chitrada / Morada	Lat. 21^0 51' 50" N Long. 86^0 56' 50" E	518.0	90.0	250.0	26.0	N.A
17	Morada	Morada / Morada	Lat. 21^0 50' 55" N Long. 86^0 59' 30" E	800.0	9.1	123.0	--	N.A
18	Kuchiasole	Badampur / Rasgovindpur	Lat. 21^0 45' 20" N Long. 87^0 0' 0" E	625.0	12.2	42.0	--	N.A
19	Amarada	Amarda / Rasgovindpur	Lat. 21^0 47' 30" N Long. 87^0 8' 0" E	1219.0	12.0	63.0	20.0	N.A
20	Saria	Dahikothi / Betnoti	Lat. 21^0 46' 50" N Long. 86^0 53' 15" E	1128.0	38.0	108.0	--	N.A
21	Chekamara	Jadunathpur / Barsahi	Lat. 21^0 51' 20" N Long. 86^0 38' 30" E	260.0	16.0	167.0	5.0	N.A
22	Ambojoda	Betnoti / Betnoti	Lat. 21^0 43' 0" N Long. 86^0 50' 20" E	457.0	15.0	81.0	--	1928

(Source: Chief Engineer, Minor Irrigation, Orissa, Bhubaneswar.)

4.4.2 Irrigation in Bolangir

Ex- Patna Durbar in Bolangir encouraged tenants to dig more tanks and develop other water sources to utilise water free of rent. Such water sources were declared as public 'Jalchar' land during the settlement. Water from these sources were distributed to the field by village Panch and villagers were required to keep them in good repair. An Irrigation Khaitan (record) was being maintained indicating the plots irrigated and the sources from which they were receiving water. The plots irrigated from wells were not recorded in the Khaitan. Settlement Report of ex-State of Patna (1937) indicates the right of ryots to dig, maintain and repair those water sources. Some of those are in derelict condition due to silting up of their beds.

Towards 1919, there were 83211 acres (33675.5 ha) of irrigated land in ex-State of Patna. This increased to 131744 acres (53317 ha) by 1937. Towards 1938, ex-State of Sonepur had 1, 26, 117 acres (51040 ha) of land with provision of water. The various categories of land having facilities of water supply or irrigation are given below in Table 4.3 (a), Table 4.3 (b).

Table 4.3 (a) Irrigation Facility in ex-Patna State

Sl. No	Category of land having irrigation facility	Year 1919 (acre)	Year 1937 (acre)
1	Paddy	74406	117902
2	Barcha	6081	7890
3	Bari	2724	5952
	Total	83, 211	1, 31, 744

Table 4.3 (b) Irrigation Facility in ex-Sonepur State

Sl. No	Classification of land	Irrigated area. By 1938 (acre)	Un irrigated area. By 1938 (acre)
1	Barcha	3993.3	----
2	Bari	2370.13	----
3	Bahal	73789.25	14521.64
4	Berna	35521.00	39038.29
5	Mal	10410.97	56917.75
6	At	32.35	112445.86
	Total	126117.0	222923.54

(Source: Orissa Districts Gazetteer, Bolangir, 1968, Pg.137)

Details of few minor irrigation Projects constructed by the Kings / Zamindars are furnished in Table 4.4.

Table 4.4 Irrigation Projects Constructed by Rajas / Zamindars

Sl. No	Name of the M.I.P	Village / Block	Ayacut (ha)		Year of construction	Present status
			Designed	verified		
1	Barkat (Res.)	Deolgaon / Patnagarh	59.0	40.0	1914	Partly derelict
2	Jharbandha kata (Tank)	Suleikela / Belpada	71.0	10.0	1939	Left canal system needs renovation and modernisation
3	Loisingha sagar (Res.)	Loisingha / Loisingha	100.0	90.0	1916	Partly derelict
4	Chakra sagar (Res.) & Jadamunda	Loisingha / Loisingha	85.0	40.5	1916	Both MIPs are interlinked. Leading channel to be constructed
5	Raja kata (Res.)	Uchhabahal / Agalpur	100.0	20.0	1912	Derelict

(Source: Chief Engineer, Minor Irrigation, Orissa).

4.4.3 Irrigation in Ganjam

'There are tanks in almost all villages and towns of the district. These tanks are used for bathing as well as drinking purposes. Many of these tanks are also utilized for pisciculture and irrigation.

Many big tanks are found in and around Paralakhemundi (now in Gajapati district) amongst which mention may be made of the Ram Sagar and Sita Sagar near Kimedi, Brundaban Sagar near Upalada, Krushna Sagar near Gopili and Chaitanya Sagar to the northwest of Paralakhemundi. Another notable tank is Radha Sagar of this region. All these tanks serve as source of irrigation (vide Orissa District Gazetteers, Ganjam, 1995-Edited by N.C. Beuria).

The Administrative Report of Paralakhemundi Zamindary states that "Zamindary abounds in numerous tanks and natural water courses which constitute chief sources of irrigation. There are altogether 1281 tanks and 66 natural streams". (About 60% of those have been transferred to A.P). "The maintenance and control of these tanks rests in the hands of the zamindar. To look after their management, there is an establishment maintained at a cost of Rs.7000.00. Large sums of money varying from Rs.20000.0 to Rs.25000.0 are spent annually for upkeep and improvement of these water resources to the great advantage of the tenants of the land. What the zamindars get in return is a few hundred rupees derived from separate cess levied on the water used for the purpose of irrigation from these tanks and streams".

View of Sita Sagar

View of Ram Sagar

Salient features of five MIPs are given in Table 4.5.

Table 4.5 Salient Features of MIPs

Project details	Radha Sagar	Krushna Sagar	Sita Sagar	Ram Sagar	Mahendra Tanaya D.W
Location	Labanyagada Gosani Block	Badakoturu G.P of Gajapati	Paralakhemundi	Paralakhemundi	Batisiripur Gosani Block
Latitude	18^0 30' 0"N	18^0 51' 0"N	18^0 47' 0"N	18^0 52' 30"N	18^0 52' 0"N
Longitude	84^0 20' 15"E	84^0 15' 0"E	84^0 5' 15"E	84^0 15' 15"E	84^0 10' 30"E
Catchment area (sq.km)	12.30	79.25	10.5	21.5	559.4
Dam Type	Earth fill	Earth fill	Earth fill	Earth fill	Broad crested with fall board shutters
Dam Length (m)	732	2332	1180	792	54.8
MWL (m)	31.40	90.80	54.50	28.00	Top of shutter 28.25
FRL (m)	30.80	89.00	54.09	27.00	Crest 27.35
DSL (m)	27.10	85.95	51.60	24.00	---
Surplus Type	Broad crested	Broad crested	Broad crested	Flush	Flush
Surplus length(m)	24.6	90.0 (2nos)	47.0 (2 nos)	12.0	---
Ayacut Khariff (ha)	108	2284	217	309	1784
Rabi (ha)	--	---	40.5	202	1012
No. of villages benefited	4	25	2	2 nos. & Paralakhemundi	18
Feeding tanks (nos) / pickup weirs	--	Pickup weirs 7 on left & 6 on right	---	---	5
Year of construction	--	More than 300 years ago	More than 300 years ago	---	1870 AD

(Source: Chief Engineer, Minor Irrigation, Orissa)

4.4.4 Irrigation Practices in Sambalpur during Pre-Independence Period

Water is a far more important factor than soil, and an ample and well- distributed rainfall is a matter of vital importance to cultivators. In most years the amount of rainfall is sufficient, the average being about 58" per annum, but it is often unevenly distributed, and deficiency in the critical months is fatal to crops. So, artificial irrigation is absolutely necessary. Before the completion of the Hirakud Dam Project, the main source of irrigation was the tank. The tanks were of three kinds– Kata, Munda and Bandh.

(i) Kata

'An ordinary irrigation tank, which is known as a Kata, is constructed by throwing a strong earthen embankment, slightly curved at either end, across a drainage line, so as to hold up an irregularly shaped sheet of water. The undulations of the country usually determine its shape as that of a long isosceles triangle of which the dam is the base. It commands a valley, the bottom of which is the Bahal land and the sides of which are the Mal terrace. As a rule, there is a cutting high up the slope near one end of the embankment. From this the water is led either by a small channel or Tal, or from field to field along the terraces, down which it finds its way to the lower land. In ordinary years, irrigation may be entirely unnecessary and in that case the superfluous water is passed along until it falls into the nallah in which the small valley ends. In years of short rainfall the centre of the tank is sometimes cut through, when the bottom lands need irrigation, but in ordinary years such an expedient would be dangerous, for the water is deepest at the centre and no sluices are used. Such tanks supply water to at least 5 acres (2.025 hectares) and usually to an area of 30 to 300 acres (12 to 121 ha).'

(ii) Munda

'The Munda is an embankment of smaller size across a drainage channel. Embankments of this sort are very common, as they can easily be constructed by the Raiyats themselves for the benefit of their own holdings. These men have perhaps a few fields commanded by the main village tank, but have built Mundas to protect their outlying fields, more recently acquired from others or reclaimed from the waste. For its purpose the Munda is useful, for if a failure of rain is not very serous, it may provide water enough in the later months of growth to save the crop. But it is necessarily shallow and cannot give more than a certain supply'.

(iii) Bandh

'The Bandh is four-sided tank excavated below the Kata, from which it derives its water by percolation. They are almost invariably use for drinking purposes only, are properly regarded as suitable monuments of piety or charity, and are invariably consecrate or married to a God. Apart from their obvious sanitary advantages, they add to the irrigated area by spreading percolation and by rendering it possible in years of drought to empty the irrigation tank completely'.

(iv) Wells

'Apart from tanks, the district has special irrigational advantages in the wells. Its sandy soil holds in most places a plentiful store of sub-soil water at no great depth (15 to 29 feet) from the surface. Such wells hold water through the hot water and are largely used for the irrigation of sugarcane plots. Temporary wells are also sometimes used for the irrigation of rice in the tracts near the Mahanadi where water is found close to the surface'.

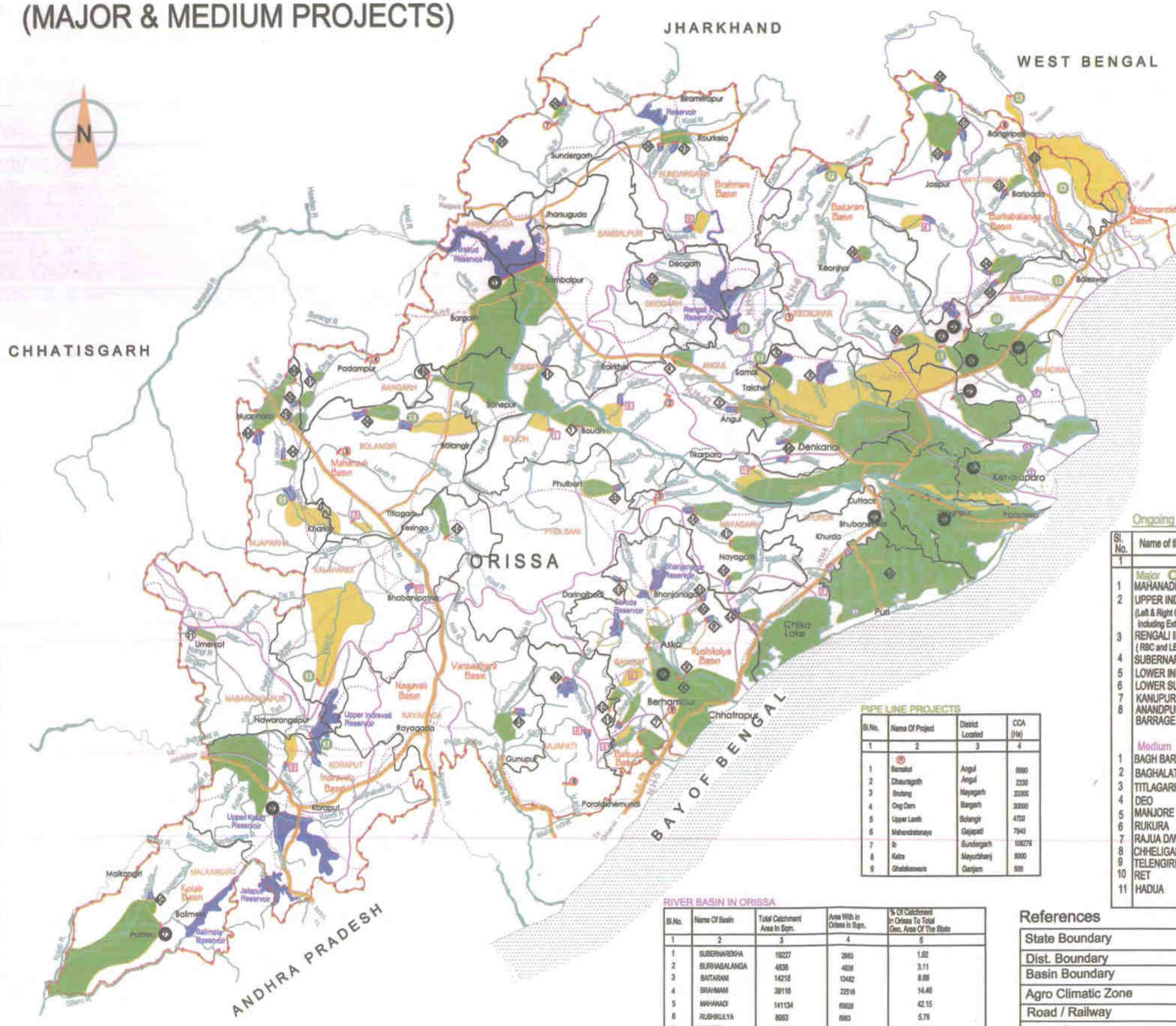
(v) Other means of Irrigation

'Other means of irrigation are of little importance. At places, irrigation by nallahs is taken recourses to, by means of which the water is diverted and carried into the fields. For raising, water from a lower to a higher level the common lever lift called 'tenda' is used. This consists of a long pole poised between two uprights and weighted at its lower end, and is used invariably whether water is required form a well or from a tank. If there is only a small difference of level, baskets (Sena) worked by two men are often used'.

(vi) Methods of cultivation adopted by different communities

In the past, irrigation in the district was done mostly by tanks. This was due to suitability of the district for tank-making. The Imperial Gazetteer (1908) mentions it in these words: "In 1903-04 the irrigated area was only 31 square miles, but in the previous year it had been over 196, being the maximum recorded. With the exception of 12 square miles under surface and garden produce, the only crop irrigated is rice. It is not too much to say the very existence of villages over a large portion of the area is dependent on the tanks which have been constructed near them. There are 9, 500 irrigation tanks, or between three and four to every village in the district on an average. The ordinary Sambalpur tank is constructed by throwing a strong embankment across a drainage line, so

ORISSA IRRIGATION MAP
(MAJOR & MEDIUM PROJECTS)



STATUS OF IRRIGATION PROJECTS
(As on 2006)

Irrigation

Completed Projects

Sl. No	Name of the Project	District Located	CCA (Ha)
1	2	3	4
	Major ◎		
1	Hirakud System	Sambalpur	155660
2	Baitarani System	Balasore,Bhadrak	32770
3	Salandi System	Keonjhar	45730
4	Anandapur Barrage	Keonjhar	40178
5	Mahanadi Delta Stage I & II	Cuttack, Puri Jagatsinghpur	303000
6	Upper Kolab	Koraput	44500
7	Potteru (Central)	Malkangiri	61030
8	Rushikulya System	Ganjam	61790
	Medium ◇		
1	Salki	Boudh	19890
2	Derjang I & II	Angul	7392
3	Dadaraghati	Dhenkanal	4510
4	Aunli	Angul	1746
5	Ramiala	Dhenkanal	7325
6	Jayamangal	Ganjam	7350
7	Bahuda	Ganjam	8085
8	Dhanei	Ganjam	4587
9	Hiradharabati	Ganjam	6307
10	Baghua Stage I&II	Ganjam	6240
11	Ghodahado	Ganjam	7763
12	Ramanadi	Ganjam	1600
13	Daha	Ganjam	4760
14	Salia	Khurda	9480
15	Budhabudhiani	Nayagarh	4290
16	Kuanria	Nayagarh	3770
17	Dahuka	Nayagarh	2740
18	Uttei	Kalahandi	9630
19	Saipal	Nuapara/Baragarh	3090
20	Dumerbahal	Nawapara	3600
21	Bhaskel	Nawapara	4250
22	Haladia	Nabarangpur	2270
23	Baladia	Mayurbhanj	3830
24	Kalo	Mayurbhanj	4900
25	Khadkai	Mayurbhanj	7990
26	Nesa	Mayurbhanj	1200
27	Pitamahal	Sundergarh	2650
28	Sarafgarh	Sundergarh	2750
29	Talasara	Sundergarh	3580
30	Remala	Keonjhar	4710
31	Jharbandha	Bargarh	2130
32	Pilasalki	Phulbani	2388
33	Gohira	Deogarh	8170
34	Sunder	Nawapara	5080
35	Sunei	Mayurbhanj	9190
36	Kansabahal	Sundergarh	4200
37	Bankabahal	Mayurbhanj	7400
38	Kanjhari	Keonjhar	10600
39	Upper Suktel	Balangir	1350
40	Satiguda	Malkangir	9060
41	Hariharjore	Sonepur	9450
42	Ong D/W (Pt.)	Bargarh	9830
43	Badanalla	Rayagada	8650
44	Upper Jonk	Nuapara	9430
45	Harabhangi	Gajapati/Ganjam	9150
46	Sapua Badajore	Dhenkanal	2520
47	Birupa-GengutiIIP	Cuttack	3869
48	Gobardhanpur Barrage	Puri	1800
49	Kharkhara Nalla	Nuapara	1950
50	Baghua DhaneiDoab	Ganjam	1950
51	Creek Irr.Project (10 nos.)	Bhadrak, Puri, Bolangir,Jajpur.	3750

Ongoing Projects

Sl. No.	Name of the Project	District Located	CCA (Ha)
1	2	3	4
	Major ○		
1	MAHANADI-CHTR'PALA	KENDRAPARA	15340
2	UPPER INDRAVATI (Left & Right Canal including Extension)	KALAHANDI	120454
3	RENGALI IRRIGATION (RBC and LBC)	ANGUL	235500
4	SUBERNAREKHA	MAYURBHANJ	109630
5	LOWER INDRA	NAWAPARA	29900
6	LOWER SUKTEL	BOLANGIR	31830
7	KANUPUR	KEONJHAR	29580
8	ANANDPUR BARRAGE PROJECT	BALASORE, BHADRAK, KEONJHAR.	60000
	Medium □		
1	BAGH BARRAGE	BOUDH	9860
2	BAGHALATI	GANJAM	5050
3	TITLAGARH	BOLANGIR	2600
4	DEO	MAYURBHANJ	9900
5	MANJORE	ANGUL	6780
6	RUKURA	SUNDARGARH	5750
7	RAJUA D/W	KHURDA	2690
8	CHHELIGADA	GANJAM	3000
9	TELENGIRI	KORAPUT	9950
10	RET	KALAHANDI	8500
11	HADUA	CUTTACK	3950

PIPE LINE PROJECTS

Sl.No.	Name Of Project	District Located	CCA (Ha)
1	2	3	4
1	Samakoi	Angul	9990
2	Dhauragoth	Angul	2230
3	Brutang	Nayagarh	22300
4	Ong Dam	Bargarh	30000
5	Upper Lanth	Bolangir	4700
6	Mahendratanaya	Gajapati	7940
7	Ib	Sundergarh	108279
8	Kalra	Mayurbhanj	8000
9	Ghatakeswara	Ganjam	500

RIVER BASIN IN ORISSA

Sl.No.	Name Of Basin	Total Catchment Area In Sqm.	Area With In Orissa In Sqm.	% Of Catchment In Orissa To Total Geo. Area Of The State
1	2	3	4	5
1	SUBERNAREKHA	19227	2983	1.92
2	BURHABALANGA	4838	4838	3.11
3	BAITARANI	14218	13482	8.66
4	BRAHMANI	39116	22516	14.46
5	MAHANADI	141134	65628	42.15
6	RUSHIKULYA	8963	8963	5.76
7	BAHUDA	1118	890	0.57
8	VANSADHARA	11377	8960	5.75
9	NAGAVALI	9275	4500	2.89
10	KOLAB	20427	10300	6.61
11	INDRAVATI	41700	7400	4.75
	SUB-TOTAL		150480	96.63

References

State Boundary	
Dist. Boundary	
Basin Boundary	
Agro Climatic Zone	
Road / Railway	
River	
Dam/ Reservoir	
Ayacut : Completed	
: Ongoing	

as to hold up an irregularly shaped sheet of water. Below the embankment a four-sided tank is excavated, which constitutes the drinking supply of the village. Irrigation is generally effected by leading cannels from the ends of the embankment, but in the years of short rainfall the centre of the tank is sometime cut through. Embankments of small size are frequently thrown across drainage channels by tenants for the benefit of their individual holdings. The Jambor and Sarsuitia Nallaha near Machida are perennial streams, and the water is diverted from them by temporary dams and carried into the fields. In certain tracts near the Mahanadi where water is very close to the surface, temporary wells are also sometimes constructed for the irrigation of rice. Irrigation from permanent well is insignificant".

"By 1931, the position further improved. An area of about 221, 347 acres (89, 646 hectares) was brought under irrigation from tanks and well. The number of tanks swelled to 12,282. The increase in the irrigated land was most remarkable in Baragarh ex-Zamindari areas where 47, 784 acres (19, 353 hectares) of rice land could get irrigation compared with 28, 205 acres (11, 423 hectares) twenty years back."

The following is an interesting account from the Sambalpur District Gazetteer (1932) which highlights the difference in the methods of irrigation adopted by the Agharia and Kulta cultivators.

"There is a great difference between the methods of irrigation practised by the Agharia immigrants from Chhatisgarh, who have settled in the flatter riparian tracts to the north, and by the Oriya Kultas, who prefer a comparatively undulating county. The Agharia works only on rich soil, and this he finds in the level tracts which the Kulta avoids. The latter depends almost entirely on his water supply, and likes rolling country with surface drainage and shallow sub-soil water. The Agharia is a poor tank builder and constructed only the shallow square tank commonly used in Raipur and Bilaspur which gathers no surface drainage, depends altogether on direct rainfall, and fails in a year of short rainfall. One glance at a stretch of rice fields suffices to distinguish Kulta from Agharia cultivation. The former builds only low and narrow banks between his fields, seldom more than two feet high, because he has frequently to cut them in order to pass his irrigation water from plot to plot. The Agharia builds high field boundaries, making a tank of each field, because each must catch and keep its rainfall. The two systems suit the tracts to which they are applied. In any ordinarily favourable year the Agharia reaps the heavier crop, but in a bad year he loses more the Kulta does".

(vii) Administration of tanks

'The construction of tanks is of such vital importance in this district that special concessions have been made to encourage it. Land made irrigable by tank construction is secured against assessment at irrigated rates at the ensuing settlement; and in addition to this, it has been ruled for raiyatwari villages that a gaontia or raiyat who makes a tank on his land is entitled to remission of the revenue on the area submerged from the date on which the tank is completed. The distribution of water from the public tanks has hitherto been left in the hands of the panchayat or village committee, and though this gives rise to much contention in a year of drought, no more impartial and expert agency is available. Such an arrangement is necessary; for it is impossible to state definitely for every year what blocks of fields should first be irrigated from the public tanks. This is a question of each year's rainfall, on the state of each tank and on the state of the crops'.

As regards the maintenance of tanks, Mr. Dewar, in his Settlement Report, writes as follows: "At last settlement all the old tanks not constructed on the proprietary land of gaontias were regarded as public property and were recorded as the property of Govt. This step, intended to prevent selfish or short sighted misuse and encroachment, has probably been of real service. But encroachment on the beds of public tanks has been the rule rather than the exception. Many cases have come to light in which parts of the beds of the old tanks, temporarily cropped at last settlement, were then entered in private holdings. It has been found to be impossible to legally dispossess the encroachers, and as they can now claim damages if their crops are submerged, many gaontias who wish to restore old tanks to their former level are deterred from doing so. The abuse is a result of the imperfect system of repair adopted by the villagers. As they have pressing need for irrigation only once or twice in 8 to 10 years, they do not annually repair embankments, but allow them to lose a few inches every year by the wash of rain, until the water level has fallen two or three feet, when a subscription is called for and the earthwork made up. But in the intervening years, the falling water exposes round the upper edge of the tank a strip of rich land into which the nearest cultivators are tempted to turn their ploughs, the gaontia himself being not infrequently a transgressor".

"It may be added that the famine of 1900 taught two lessons, viz, the need of extending irrigation tanks and of adopting a system of closer cultivation. There was scarcely a single gaontia in the famine stricken tracts who did not double his desire for an irrigation tank and do his best to obtain it: - indeed, the gaontia who handled the money valued earth work more than silver. The shortness of the grain supply, again, made the cultivators adopt a system of closer cultivation. They abandoned, for the time being, light and comparatively useless land which they had been in the habit of scratching, and devoted their attention to the proper embanking of the better fields. They had no seed to waste, and consequently they were willing to abandon the wasteful system of broadcasting and bihura, and transplanted their rice wherever they could".

(Source: Bengal Districts Gazetteer, Sambalpur Published by Bengal secretariat Book Depot, 1909).

4.4.5 Irrigation in Balasore and People's custom:

In the old gazetteer of 1907 (vide L.S.S.O Malley, Bengal District Gazetteer, Balasore, Canal and Embankments Chapter) an interesting events has found place in this regard. It is mentioned, "the people generally were reluctant to resort to artificial irrigation, and as an instance of this feeling, mention may be made of the course of events in 1869 in Pargana Randhiyaorgara, which suffered severely from want of rain in the year. The river Salandi runs through the centre of this tract, and when the drought made itself felt and the people were praying for help, the Collector asked them why they did not use the river water as a means of irrigation. They only replied that it was not the custom; that the proprietors of lands on the river banks would object to channels being cut through their lands for the purpose of carrying water to fields further inland; that it would be very hard work; that it would not pay; and that river water was not so fertilizing as that which came 'from heaven'. At all events, the river water was not used and the crops perished in consequence".

In that gazetteer it has been mentioned that in 1895-96 the irrigated area was only 10, 105 acres (4, 089.36 hectares); it increased to 29, 248 acres (11, 836.28 hectors) in 1898-99; in the 5 years ending in 1904-05 the average areas irrigated was 37, 000 acres (15, 256.69 hectares) and in 1905-06 water was supplied to 42, 784 acres (17, 314.12 hectares); of which 42, 000 acres (16, 996.85 hectares)were under rice.

However the situation and scope of irrigation has been changed considerably. Tanks, rivers, Nalas and other water reservoirs are being utilised of irrigation.

(Source: Orissa District Gazetteers, Blasore, 1992).

4.4.6 Irrigation Practices in Puri

'Wells form the least important source of supply; they are but little used, only a few fields of sugarcane or country potatoes being watered from wells dug yearly for the purpose. Properly speaking, there is no perfect system of irrigation in the whole district. A system of irrigation to be of real value should afford means of irrigating the fields whenever water is needed for the crops, i.e. the source of supply should be perennial, or the supply should be drawn from some reservoirs where water can be stored up to meet the emergency of a drought. But, with the present system of irrigation, there is no command over the source of supply'.

"In the hilly tracts which form the Khurda subdivision the natural source of water supply are the rainfall and the perennial springs issuing from the jungle-clad hills. These natural sources are inadequate for the requirements of cultivation and are supplemented by tanks, and by utilizing the water of the numerous nallahs and streams. When the latter method of irrigation is employed, dams are put across natural streams, and the water being thus headed up either flows over the cultivated area or is led to the fields by means of small natural artificial channels, locally known as 'pahanis'. Tanks are of two kinds. Some are tanks of the ordinary kind made by excavation, which are occasionally fed by natural springs. Others are formed by construction embankments across slopping land, so as to intercept the drainage of the land above. Sometimes they are artificially deepened by excavation to increase their capacity, and sometimes they are fed by natural springs; they are known locally as 'gahiras'. Perhaps the most valuable tract in the Khurda estate is the area irrigated from the Salia river in Banpur, but even then, if the rain fails in the basin of the river, the harvest is lost".

(Source: Bihar and Orissa Districts Gazetteers, Puri, 1929 by L.S.S.O' Malley Revised by P.T. Mansfield Pg.166).

4.4.7 Irrigation in Jeypore (Koraput)

The Jeypore estate had two masonry dams built on the Sokata Nala and the Champikota Gedda irrigating about 280 and 1,000 acres respectively. Both these dams continue to be useful.

(Source: Orissa District Gazetteers, Koraput 1966 Pg.156).

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Chapter V

IRRIGATION DEVELOPMENT DURING BRITISH ERA

5.0 Background

In the year 1757, British rule in India began in the eastern province of Bengal after defeating Siraj-ud-Daula in the battle of Plassey. Thereafter British rule gradually extended over to more areas of the country and Orissa came under British rule in 1803. But up to 1815, the Britishers were consolidating their position and establishing a sure and certain means of revenue and land settlement etc. During this period, no attention was paid by them for increasing food production and developing irrigation potential. Even the irrigation assets created in the medieval period deteriorated badly due to long neglect.

Initially the district collectors were in charge of public works and Irrigation. But this did not function satisfactorily. In 1809, engineers with designation as 'Superintendent of Tank repairs' were appointed to assist collectors. By 1825, the post of 'Inspector General of civil estimates' was created to work under Board of Revenue and to supervise the works of the 'Superintendent of tank repairs' in the districts. Subsequently on the recommendation of the Public Works Commission of East India Company, Public works Department was headed by a Chief Engineer. Most of the engineers had Military Engineering background.

First such attempt to propagate agriculture was made during the period of Sir Hasting (1815-1818) who conducted survey of Western Yamuna canal, which was virtually defunct. The canal was desilted and renovated at a cost of Rs.3.0 lakhs for use by the cultivators.

Indian agriculture owes a lot to Maj. P.T. Cautley for boosting irrigation particularly in the drier parts of U.P. During 1837-38 more than 8 lakhs people perished due to severe famine when the then Governor recommended for taking up irrigation projects. Maj. Cautley began ambitious Ganga canal projects in 1842.

When Maj. Cautley was single mindedly harnessing maximum possible utilisation of Ganga canal for irrigation, another military engineer Sir Arthur cotton started similar works in southern India. He engineered the famous Cauvery Delta Scheme (1836-38) followed by Godavari and Krishna Delta schemes (1846-55).

Rule of the East Indian Company came to an end in 1858 and India was put under direct rule of Queen Victoria. After transfer of power to Her Majesty's Government, Earl of Mayo was appointed as Viceroy (1869 to 1872) when large scale modifications were done to the existing irrigation works and new irrigation canal systems were executed.

At the instance of Sir Mayo some rivers of Bihar were harnessed to provide irrigation facilities to dry land areas. Like wise a large irrigation project was also undertaken in Orissa. Among others, names of John Colvin, Arthur cotton and S.L.Jacob would be long remembered for their splendid work in building some of the most important and magnificent canal system in this country. Arthur Cotton was at the summit of his fame in the fifties with successful execution of large irrigation projects in South India, i.e. the Cauvery Delta System, the Godavari Delta System and the Krishna Delta System under his supervision & guidance. Those projects were considered as a boon to the farmers and proved to be financially quite sound, which were looked upon as a potential gold mine.

5.1 Enquiry Commission

The great and the worst Orissa famine of 1866 has been described in a nutshell under Sec.2.7.1.1. The Secretary of State for India constituted an enquiry commission in Dec.1866 consisting of three members. The commission remarked: "The famine in Orissa stands almost alone in this, that there was a almost no importation, and the people, shut up in a narrow province between pathless jungles and an impracticable sea, were in the condition of passengers in a ship without provisions". The famine exposed the failure of the administrative machineries in Orissa to look after the people. It was quoted in the Famine commission's Report that "Orissa was by that time isolated from the rest of India, the only road leading to Calcutta across the country intersected by large rivers and liable to inundation was unmetalled and unbridged and there was little communication by sea". The commission further remarked that "It is a melancholy reflection that while a larger sum of money was spent on this famine than had ever been spent before, it should be associated in history only with the memory of a greater mortality than had ever been recorded".

The immediate results of the famine were, no doubt, sorrowful. But it was a blessing in disguise. It ushered a new epoch in the field of administration by expanding education, facilitating communication with outer world by constructing roads and railways and harnessing river to control flood and provide irrigation and navigation. Thus it gave passport to the people of Orissa to avail modern amenities.

5.1.1 Recommendation of the Commission

The commission after a detailed inquiry submitted its report on 6th April 1867 after visiting Orissa. In the report, they blamed the local officials and the entire system of administration of Bengal. The executive knew a little about the material condition of people of Orissa and administered as judicial officers. The Commission observed "Bengal thus was administered judicially and not by executive power. The executive reigns but does not govern. It has little executive machinery and it may be said that in principle it avoids interference with the affairs of the mass of the people". The commission also highlighted the evils associated with land and salt policies and suggested some remedies for them. However, they recommended irrigation work for drought prone areas and improvement of communication & transport system by land and sea.

5.2 Private participation

Large irrigation and navigation schemes, covering the entire country were in the air. The pressure was thrust on the Government of India to entrust further exploitation of irrigation potential of the country to private enterprise under 'guarantee' system i.e., a guaranted return of five percent on the capital outlay as was the case of railways in the country during that time. The Government was unable to finance larger irrigation projects. Therefore, in 1858, it was reluctantly decided to let private enterprise step in for developing the irrigation sector under guarantee system.

Two irrigation companies were floated in England viz, the East India Irrigation & canal company and Madras Irrigation Company. The former was formed in 1858 to exploit the coastal areas of Orissa but it became operational in 1863.

5.2.1 The East India Irrigation & Canal Company

The irrigation project in the coastal areas, as originally envisaged comprised for closely connected schemes viz,

i) The Mahanadi series of canals

ii) The Brahmani & Baitarani series

iii) The Subarnrekha series

iv) The Cossye (Midnapore) series

Each series is named after the river or rivers, whence it derives its supply and all were to be connected by canal running from river to river with little or no fall to irrigate the highest land and at the same time form a great navigable highway connecting the Chilika Lake, Cuttack, Balasore and Midnapore with Calcutta.

As in the case of Madras Irrigation Company, huge profits were anticipated from its operations. But within three years of its commencement of the construction work, entire capital of the company was spent and mortgages were being raised on the property. Although only a fraction of the works contemplated was taken up, Government of India had to come to the rescue with advances. As the company failed miserably, Govt. took over the works in November 1868 paying the company about a million pounds, canceling a debt of 1.52 lakh pounds representing advance made and granting fifty thousands pound as compensation to the company employees. The failure of private enterprise to execute large scale irrigation projects taught valuable lessons to the administration. Even same situation exists today when no private companies have come forward to take up major irrigation works.

The Orissa projects became the property of Government on 1st January 1869. The secretary of state in his letter dated August 10, 1876 observed. "The lesson taught by the past history of Orissa works will no doubt be borne in mind whenever undertakings on a large scale of similar magnitude will be contemplated".

The causes of the failure of the Orissa canal projects have been summed up thus: "Works on immense scale were entered into with no proper estimates of what they might cost and with the vaguest knowledge of what the earnings might be". Now also that holds good for River valley projects. This is one of the reasons for price escalation.

5.2.2 Change in policy

The failure of private sectors forced Government to take some radical measures in 1866 which changed the policies and principles governing the execution and financing of irrigation schemes. Those decisions are as follows: -

a) Irrigation Projects, in future, would be constructed by the state only through its own agency.

b) The projects would be financed from public loans raised specifically for the purpose.

c) Political boundaries would not be allowed to come in the way when best possible utilization of water of a river for irrigation was being considered, i.e. "the best that can be devised irrespective of the territorial boundaries of British and foreign states (here Princely states) in the benefits of which the native states should be allowed to participate on like terms with our own subjects".

Unfortunately optimal utilization of river water in the best interest of the county is not being done today due to political considerations, as the water is in the state list.

5.2.2.1 Irrigation Commission

In 1901, the Govt. of India appointed 1st Indian Irrigation Commission to report on irrigation as protection against famine in India. The Commission submitted their report in 1903 in which they recommended definite policy regarding the selection, financing and maintenance to irrigation woks. Further the report dealt in detail practically every scheme under consideration at the time. As a result of the commission's recommendation, a large number of new works were undertaken.

In this regard, the extract of the Government Resolution is as follows:

"In considering proposals for new irrigation works, the commission will understand that greater importance may often be attached to the extent and reliability of the protection that will be afforded than to the merits of the schemes regarded as financial investment. The irrigation works hitherto constructed by the state in India have on the whole proved directly remunerative; but it is recognized that the programme of works of this kind may be approaching completion, and that the great storage works required for an considerable extension of irrigation in the tracts which are most exposed to famine must necessarily be more costly per acre protected and therefore less remunerative, than the completed works which draw unfailing and perennial supplies from the great rivers in northern and southern India. As regards new works, therefore, the main question is not whether they will be likely to prove directly remunerative, but whether the net financial burden which they may impose on the state in the form of charges for interest and maintenance will be too high a price to pay for protection against famine which they may be relied on to afford. It is from this point of view that the commission should consider proposals for the extension of irrigation in districts in which cultivation is very insecure and precarious". This was a very important policy decision. Although in pursuance of this principle the commission recommended a number of protective projects, some of which were undertaken, never the less, due to 1st World War and consequent paucity of funds, the emphasis remained on the remunerative-ness or productiveness of irrigation projects, rather than security they could insecure afford to insecure and precarious areas.

The Montagu-Chemsford Reforms in 1921 brought significant change in the policy governing the administration and financing irrigation projects. The provincial Governments were authorised to raise loans for financing irrigation projects themselves. This change coupled with end of 1st World War in 1918 led to an increase in the tempo of construction of new irrigation projects.

In 1935, the British Parliament passed the Government of India Act, according to which the irrigation was transferred from the control of centre to that of respective provincial Government. The Government of India was, there after, no more concerned with the development of irrigation except where dispute arose between neighboring provinces.

5.3 Commencement of Canal Work

5.3.1 Background of Construction

Ironically agriculture was exposed to the vagaries of monsoon. The agricultural production was adversely affected due to erratic rainfall leading to natural calamites like floods, droughts and famines. From 1803 to 1900, floods and inundation occurred 57 times, droughts & famine 32 times and cyclone 19 times with either of the two occurring 21 times and all three ravaged the province six times (Ref: Economic History of Orissa-1997, Edited by N.R.Pattnaiak, Page 292).

The need for irrigation was long felt in Orissa towards middle of the nineteenth - century. In 1836 and 1837, severe droughts occurred in the province when the remissions in revenue amounted for about eleven lakhs. Again in 1840, there was drought. This caused loss of revenue of nearly six lakhs. Scarcity condition prevailed in1841. In 1845, there was drought in the northern parts of Balasore. Each of the calamites exerted heavy blow on the backbone of farmers. Their economic condition became miserable and they were unable to pay taxes. As a result, the Government was compelled to sanction remission of land rent as a measure of relief. Again for flood in the Mahanadi and Kathjori in 1834, there was remission in land rent. Between 1830 & 1840, total remission of land rent amounted to Rs.2,55, 476.00 for floods in central Cuttack alone. The Inundation Committee estimated the loss of paddy due to flood in 1866 as 7811247 maunds valued at Rs.2,17, 35, 644.00 (Refer: Economic History of Orissa-1997, Page293). From 1832 up to 1867, the remissions on the ground of inundation and drought were almost equal: the total remission on the former ground being Rs.6, 25, 844.00 and on the latter Rs.6, 18, 660.00 i.e., totalling to Rs.12.5 lakhs (Refer: The Natural Calamities in Orissa in the 19th century, by B.B. Bhatta, 1997, Page 104). Thus protection of agriculture from floods, drought and famines was the primary concern of people and the Government. It necessitated protective embankments to arrest the free flow of uncontrolled flood water over agricultural land and network of drainage system for channelising the flood water into the sea. Besides construction of canals to irrigate cultivated lands was felt because irrigation would act as insurance against droughts and famines and will increase the productivity. In addition, the Government was also concerned regarding loss of revenue due to remission of land rent. This is the background how construction of canals for irrigation and navigation began in the state.

5.3.2 Circumstances Leading to Construction of Naraj Anicut

Commissioners administrative Report of 1st June 1847 states "The province is subject to seasons of extreme uncertainty liable to most remarkable, vicissitudes of drought and inundations". In 1854 flood committed great havoc in Puri district. On 13th October 1854, E.V. Samuells, commissioner wrote to the Board of Revenue, Calcutta suggesting construction of a weir across Kathjori. In February 1855, captain short, Executive Engineer recommended that a stone weir be constructed at Naraj at the head of Kathjori for reducing the volume of flood water entering the Kathjori. Captain Beadle, Supt. of Embankment agreed with the proposal and recommended to the Chief engineer on 24.9.1855.

In 1854, it was observed that a great change is taking place at the head of the Mahanadi, as a result much larger share of floodwater entering the head of Kathjori, which the lower portion of the river was not capable of carrying off. The Mahanadi bed rose due to the decrease in the scouring action. The yearly erosion of the Kathjori bank led to the widening of the channel thus endangering Cuttack town due to more volume of water flowing in the enlarged section of Kathjori. The very high flood of 1855 drew the attention of Government to the critical state of revetment of Kathjori as well as the inundation in the districts of Cuttack and Puri.

On the basis of the recommendation of the Supt. of Embankment, Govt. of Bengal placed Lieutenant Harris on special duty to survey Mahanadi. In June 1856 Lieutenant Harris submitted his first report for flood control by way of construction of stone spurs or groin at Naraj to protect Cuttack town from flood havoc of the Mahanadi and Kathjori. The stone spur would cause the Mahanadi main channel to deepen thus enabling it to take relatively large volume of flood. On 29th Sept.1857, Captain Young, Chief Engineer, opined that "if anicuts or weirs are to be constructed, I would propose that they be constructed exactly upon the Madras model in a direct line across both streams at their divergence, from bank to bank". After two years of correspondence, in April 1858 Bengal Government sanctioned construction of a stone spur at Naraj to regulate volume of water entering the Kathjori. In 1859, the Chief Engineer recommended further extension of spur, which was sanctioned by Government. Harris in his report of 1st February 1860 stated that the spur caused proportionately more water to pass down Mahanadi in the flood season of 1859. The spur was subsequently developed into Naraj anciut.

5.3.3 Proposal of Arthur Cotton

But positive proposal for irrigation and flood control came from Colonel Arthur Cotton who visited the state in 1858 at the request of Government of India. His primary concern was regulation of flood water "that will wipe off the terrible disgrace of the district on degree worse than it was under the former distracted native rule, in a system of works that will completely regulate the waters of the province". He further advocated that "there is not a single acre of land in Bengal, in all India, or in the world that would not be more productive if it were irrigated at one time and drained at another". Col. Cotton submitted a memorandum to the Govt. of India embodying following view on the subject. "But though this now great evil can thus be easily remedied, it would only restore things to their former state, which was still such that the whole delta was continually subject to awful droughts and floods. This question of control of the Mahanadi is not a question of the preservation of the town of Cuttack, containing 35000 inhabitants; it is a question of preservation of the Provinces of Cuttack and Puri, containing about 1.25 million".

Col. Cotton maintained that "the only way of effecting this was to carry out a system of works that would completely regulate the waters of the Province, similar to those in the Godavari and Krishna deltas. He proposed a scheme for irrigation and navigation of the Orissa deltas and through communication to Calcutta and urged that the Government should at once take the project in hand as being eminently practicable, as one most thoroughly proved by the success of Madras works, and as the only one that met the demand of the case. Finally he suggested that if the Government was unwilling to execute these works itself, that an English company should be permitted to carry them out". He recommended construction of canal for irrigation, navigation and flood control following the principle then being carried for the deltas of the Krishna and the Godavari. Arthur Cotton's suggestions were (i) Weirs across the Mahanadi, Brahmani and Baitarani, (ii) Irrigation and navigation channels throughout the deltaic region (iii) Drainage channels in between all irrigating channels to minimise drainage congestion (iv) Flood embankment to rivers for protecting agricultural lands and properties and (v) High level canals for navigation from Cuttack to Calcutta.

5.3.4 Performance of Private Company in the State

Cotton approved the construction of an anicut across river Kathjori with necessary head works. He estimated the cost of works at 13.0 lakh pounds for providing irrigation to 22.5 lakh acres. As anicut across Birupa was also recommended by him with off taking canals along left bank of Mahanadi –Nuna and along the right bank of Nuna. On the advice of Cotton, Madras irrigation and Canal Company was tempted to take up the work with a view of gaining profit. The company proposed to raise two million pound on the condition that Government should guarantee a return of five percent on capital. But Government was not prepared to entertain any guarantee on interest. This did not discourage the promoters of the company due to the financial success of irrigation works in the deltas of Godavari, Krishna and Cauvery. On 2nd June 1860, the secretary of state approved the formation of an unguaranted company for the construction of canals for irrigation and navigation with certain conditions.

The Madras Irrigation and canal company now issued the prospectus for a new company named 'East India Irrigation and Canal Company'. Sir Frederick Halliday, Lt. Governor of Bengal warned the company against any sanguine expectation. He stated, "Counsellors of vast works of irrigation improvement are often led by sanguine temperament and impatience of careful calculation; habitually to exaggerate prospective profits and to underestimate the necessary expenses ....The same good results of irrigation can not be reasonably expected in the province of Cuttack, that are seen in Tanjor, Guntoor and Rajamahendry, which are not under the influence of south-west monsoon. In Madras, the only limit of cultivation is water; in Cuttack, the only limit is land".

The plans for various components of the scheme were submitted by the company and were approved. The works known as 'Orissa Undertaking' had four distinct objectives i.e., (i) Flood protection (ii) Inland navigation (iii) Irrigation and (iv) Drainage by embanked escape channels. Services of Col. Rundall were lent by the Government as Chief Engineer.

Construction works commenced in 1863. The company had miserable performance even during the famine of 1865-66. On 20th April 1866 the first irrigation lease was signed for 3.5 acres. By end of Feb. 1867, the area irrigated was 6674.75 acres. (Source: Papers relating to Orissa canal, 1869-77 & 1881-83, pp 85). The Famine commission (1866) blamed the local and provincial administration including commissioner of Orissa, Member Board of Revenue and Lt. Governor of Bengal for misleading the Government of India. The Commission recommended the Government to pursue vigorously the extension of irrigation network with specific emphasis for completing Kendrapara canal system. The anicuts at Naraj (across Kathjori) and Jobra (across Mahanadi) commenced in autumn 1863 but were not completed in every respect even towards end of 1868 when Government took over the work. The returns thus not coming in, the shares of the company fell in the market, and in the words of the Director, it became necessary "to await the realization of profits from their initiatory sections before raising capital for undertaking the balance of the larger scheme".

Such was the position of affairs when in November 1867, Government made following offer to the company of taking over the works: "The secretary of state is convinced that the promotion of irrigation is of highest consequence to the welfare of India. He believes that the works projected by the East India Irrigation and canal company are well calculated to confer great benefit upon the agriculture of the district in which it is proposed to execute them. Every year shows more clearly how desirable it is that works of this kind should be carried on with the utmost vigour ...... That expectation however has not been realised".

Looking at the present position of Orissa works and at the system of advances by which they are now being carried on, Sir Stafford Northcote considers that "it would for the advantage of the Government and of the company, and still more for the advantage of the public, that the Government should purchase these works, together with the company's interest in Bihar and complete them by means of their own agency. The present system of advances which was adopted to meet an immediate emergency will come to an end at the close of the present year...... If therefore the works remain in the hands of the company, it can scarcely be expected that as much progress as is desirable will be made with them".

On 30th November 1868, Government finally bought out the East India Irrigation Company.

5.3.5 Government Takeover

After taking over, the administration brought some modification in the original plan. A statement showing the expenditure on the woks comprising the 'Orissa Undertaking' from the commencement up to 31st Dec.1868 is furnished in Table 5.1; vide col. Rundall, Chief Engineer's letter to Government (Source: Papers relating to Orissa canal, 1869-77 & 1881-83, Page-29).

Table 5.1 Statement of Expenditure of 'Orissa Under Taking'

Sl. No	Name of Works	Govt. sanction order No & date	Estimated cost (Rs.)	Expenditure upto 31.12.1868 (Rs)
1	Mahanadi anicut and head works, head sluice at Jobra, city protective works & junction canal	4971/24.10.1865	1243800	971910
2	Naraj weir and dividing embankment	2537/24.4.1863	452093	414323
3	1st section of High level canal i.e. to the Brahmani including Brahmani river embankment	345/19.1.1865	1160353	461605
4	Birupa anicut & Head works including head sluices to Kendrapara & High level canals	345/19.1.1865	312474	252326
5	Distributaries from 1st section of High level canal	55/27.7.1867	291242	71448
6	Birupa left bank river embankment	345/19.01.1865	19736	---
7	Birupa right bank river embankment	345/19.01.1865	41000	
8	2nd section of High level canal i.e. Baitarani including embankment on its right bank	3135 I/17.05.1867	462563	---
9	Anicut across Brahmani	3135 I/17.05.1867	494691	4562
10	Distributaries from 2nd section for 50000 acres	3135 I/17.05.1867	115389	---
11	Distributaries between Brahamani and Patia for 50000 acres	3135 I/17.05.1867	126591	---
12	3rd section of High level canal i.e. Salandi including embankments on left bank of Baitarani & right bank of Salandi	3135 I/17.05.1867	760093	---
13	Anicut across Baitarani	3135 I/17.05.1867	224064	4247
14	Distributaries from 3rd section for 50000 acres	3135 I/17.05.1867	100000	
15	Kendrapara canal	82 /03.01.1866	645820	585640
16	Distributaries there from to 1,50,000 acres	180/18.01.1866	300000	107824
17	Main or Pattamundai branch from Kendrapara canal, 46 miles.	82/03.01.1865	368000	---
18	Distributaries there from for 1, 13, 000 acres	82/03.01.1865	226000	---
19	Taladanda canal	3304/02.07.1865	585000	116280
20	Distributaries there from for 80000 acres	188/18.01.1866	160000	---
21	Machhagaon canal	3063/06.06.1867	304000	13402
22	Distributaries there from for 80, 000 acres	3063/06.06.1867	160000	---
23	Mahanadi, Nuna and Chitrotpala river embankments (left bank) with groynes	----	17561	16968
24	Midnapur canal	81/03.11.1865	1931528	1228897
25	Distributaries there from for 1, 60, 000 acres	5919/11.12.1865	320000	59885

Above table indicates the financial progress ending 31.12.1868. It is seen that progress of works on High level canals and their distributaries (i.e., Sl.No.3, 5, 8,10,11,12 and 14) are poor. Similarly much importance has not been attributed towards distributaries of Kendarpara canal (Sl.No.16), and other systems (i.e., sl.17, 18 to 22). More stress has been given for construction of anicuts viz. Naraj weir, Mahanadi (Jobra) anicut and Birupa anicut. Description of few works and their physical progress at the time of takeover by the Government has been presented as under.

5.3.5.1 Naraj Anicut

5.3.5.1.1 Naraj Spur

Below the bifurcation of the Mahanadi and Kathjori and across the head of the latter the most important anicut has been constructed which is a continuation and addition to the spur formerly constructed by Major Harris. Prior to 1856, the head of Kathjori was enlarging greatly after each years flood, admitting a larger volume of water than its branches could carry, thus causing extensive breaching of embankments in the lower reaches and consequent damage to crops. At the same time, Mahanadi bed was silting up.

With a view of regulating to some extent the relative discharges, of the two rivers in accordance with the carrying capacity of their channels, the spur was contemplated by Major Harris. The spur work commenced in 1856 and was completed in 1860. It started from the west bank opposite the village of Naraj and stretched across Kathjori branch. Its length in November 1860 was 5650ft (1722m). Quantity of stone used was 20183 ton. Cost of works exclusive of superintendence was Rs.59814.00

The spur was of rubble stone roughly packed. The crest was not uniform. The slopes did not exceed 1.5 to 1.0. It was consequently liable to be breached at every flood. Its east end merely died out in the high sand ridge dividing the water of the Mahanadi from that of Kathjori. It did not, to the full extent required, regulate the waters of the two rivers during high floods. In the year 1863, the work was handed over to the company who decided to build the present anicut with a view of permanent regulation of two rivers.

For achieving this objective, it was decided to construct a high abutment wall at the east end of spur and to restrict the width of the river so as to regulate the volume of water flowing in the Kathjori and Mahanadi in the proportion of 3 to 5. (Refer: Papers relating to Orissa Canals, 1869-77 &1881-83, pp 2)

To attain this proportionate discharge, the abutment wall was constructed with crest 77.5 ft above mean sea-level (i.e., 15.5 ft. above river bed).

5.3.5.1.2 Brief description of Naraj Anicut

The description of the works constructed by the East India Irrigation company has been narrated by A.G. Crommelin (in his note dated 13th Aug. 1869), which are as follows: The anicut has a total length of 3600 ft (1097 m) from west end to the east abutment (subsequently made 1168m). From the west end to the sluices, a distance of 180 ft (55m), the anicut is composed of merely a breast wall founded on rock, and backed by a rough stone apron of loose ruble 30 ft (9.15m) in breadth. The sluices had 15 vents of 6ft (1.83m) clear span and built at an angle of skew of 70^0. From the sluices to the east abutment, the breast wall is 3265 ft (995.3m). The foundation was taken to low water of Kathjori i.e. 62 ft above M.S.L. In the east end of the anicut, the breast wall is founded on double row of wells each 5 ft 6 inch (1.67m) outer dia. and sunk to a depth of 7 to 9 ft below the bed of the river. In rear of the breast wall and at a distance of 30 ft (9.14m), is a second wall, built throughout the whole length of the anicut and taken to the same level and in the similar manner i.e. on wells, the breadth of the second wall is 3 ft and height 8 ft. At the north end of the anicut, the breast wall is connected with this second wall by 14 cross walls each 103 ft (31.4m) centre to centre. Forty feet in rear of the second wall and parallel to it, there is a third wall, which extends for a distance of 1000 ft (304.9m) from the east end of the anicut. A fourth wall 40 ft (12.2m) in the rear of third wall extends for a length of 650 ft (198.2m) from the north abutment. The object of these parallel walls is to retain the apron stones. The third and fourth walls are founded throughout nearly their whole length on wells sunk 6 ft (1.83m) below low water.

"The apron has a slope from the crest of the breast wall to the rear of 1 in 9 (nine) but at the north end, in order to obtain breadth, the slope varies from 1 in 9 to 1 in 15. The average width of the apron, comprising of large rubble stones, is 90 ft (27.4m). But at the north end, it is about 150 ft (45.8m). The upper layer is packed with stones, being not less than 3 ft in depth. The upper side of the breast wall is protected by ruble stone, the upper surface of which is packed with a slope of 2 to 1."

"The abutment wall at the end of the anicut, which protects and connects with the dividing embankment, is 480 ft (146.3m) long, 80 ft (24.4m) being built in rear of the breast wall to protect the flank of the apron. It is built to a height of 96.5 ft (29.4m) above M.S.L. It is founded on 295 wells and is constructed of rubble masonry with dressed free stone quoins and parapets. To assimilate the batter of the wall to the slope of the dividing embankment, the wall for 200 ft (61m) next the embankment is stepped down and its height supplemented by a revetment of blocks of laterite. The revetment has a slope of 1.5 to 1, and an average thickness of 5 ft (1.5m). The thickness of the abutment is 5 to 6.25 ft at top and from 19' (5.80m) to 25 ft (7.6m) above the footing." Crest level of anicut is RL 74 ft (22.55m) and that of sluice is 68.50 ft (20.88m).

The principal building materials used in these head works have been free stone and laterite. The quantities of main items are as follows: -

i) Rubble masonry 497144 cft (14075 cum)
ii) Rubble packing 851143 cft (24098 cum)
iii) ----do-----(2^{nd} rate) 12, 77, 433 cft (36167 cum)
iv) Laterite revetment 22056 cft (625 cum)
v) Rubble stone work 49600cft (1404 cum)
vi) Earth & sand work 2, 80, 72, 302 cft (794800 cum)

Source: - Papers relating to Orissa canals (1869-77 & 1881-83)- Published in 1884 by Bengal Secretariat Press, Calcutta (Pg.2-3)

The section of the abutment of old anicut has been shown in the Figure 5.1. Figure 5.2 shows the cross section of old anicut and the new barrage. The anicut after serving for more than a century exhibitted signs of distress. Replacement of anicut was, therefore imminent since its sudden collapse would render irrigation in stage-I delta (undivided Cuttack district) impossible. The anicut has been replaced with a new barrage under OWRCP funded by World Bank during 1996-2003.

5.3.5.2 Brief Description of Mahanadi Anicut

The Anicut at Jobra across river Mahanadi was constructed with an objective to raise the water level during the dry weather to such a height as to give a depth of 8 ft (2.44m) in the canals drawing their supply from it. This was to be accomplished by raising a breast wall of anicut to a certain height across the river with its accompanying aprons etc. and partly by shutters to be fixed on the breast wall when required.

The brief note given by A.G. Crommelin, Superintending Engineer dated 13th August 1869, reveals that the total length of the anicut between the abutments is 6400 ft (1951.0m) having design discharge of 8.62 lakh cusec (24408cumec) in high flood. Its crest is 64.50 ft (19.66m) above M.S.L. or 13 ft (3.96m) above the average summer water level and pond level 69.50 ft (21.18m).

The anicut is provided with two scouring sluices, one in the centre (which was subsequently closed) and the other at its southern extremity. Central sluice is provided with 10 ft (3.04m) high French shutters. The floor level of the sluice is at 58.50 ft (17.83m). There are divide walls at both ends of the sluice due to high velocity in the central portion. The downstream apron was getting damaged year after year for which crib walls filled with rubble in bullah crates were provided but was not effective. In the year 1942, again serious scour of 7.62m deep occurred at the downstream toe of the talus. Basing on the model study, some corrective measures were undertaken. Subsequently it was decided to close the central sluice with raising of sill from RL 58.5 ft (17.83m) to RL 63.5 ft (19.35m) and to replace the old French shutters with crest shutters of 5'0" (1.52m) height. This remodelling was completed in 1948. The portion of the work to the north of central sluice is 2950 ft (899.2m) and is founded on wells of 7 to 9 ft in depth excepting 826 ft (251.77m) which rests on clay. At a distance of 30 ft (9.1m) from the breast wall there is a second wall parallel to it which is 5 ft (1.52m) wide at bottom and 4 ft (1.22m) at crest. Rear slope is 10:1 and is founded in the similar manner as of breast wall. The space between the two walls is solidly packed with picked up stones. The lower wall is protected by rough stone apron in continuation of the slope of 10:1. Minimum apron width is 55 ft (16.76m).

The southern portion of the anicut is 2600 ft (792.5m) long. It is constructed in the similar manner as that of northern portion but with an additional wall spaced at a distance of 34 ft (10.36m) from the second wall protected by rough stone apron. The first and second walls are founded partly on stiff clay but the third wall is founded on rubble stone. The face of the anicut for entire length is protected by rubble stone packing from 5 to 10 ft at top with a base of 20 to 40 ft (6.1 m to 12.2m).

The southern end of the anicut is connected with the head sluices (regulator) of the Taladanda canal and the northern end by an abutment wall carried well above the flood level.

The materials used were bricks for the wells, sandstone and laterite set in first rate mortar for the walls of the anicut; laterite and cuts sand stones for the sluice piers, flank walls and flooring; rubble sandstone and laterite for the aprons; and cut laterite for the coping stones of the breast wall. Both Mahanadi and Birupa anicuts have been replaced with new barrages during 1980 – 90 under World Bank assistance. Sections of the old anicut and new barrage are shown in Figure 5.3, Figure 5.4 and Figure 5.5. An Index Map showing Munduli, Naraj, Mahanadi and Birupa Barrage is furnished in Figure 5.6.

5.3.5.3 Brief description of Birupa Anicut

The Birupa anicut, constructed with an objective of supplying water to Kendrapara and High level canals is placed one mile below the off take of Birupa from Mahanadi. Its total length including under sluice at both ends is 1980 ft (603.5m). The body of the anicut consists of breast wall and rear wall of laterite masonry with crest at RL 68.50 ft (20.88m). Rear wall is spaced at a distance of 40 ft (12.2m) from the breast wall. The space between them is closely packed with laterite blocks. The average width of the apron is 90 ft (27.4m) having a slope of 1:12. The breast and rear walls are founded for some length on rock and the rest on 591 nos. of wells sunk 6 ft (1.83m) below river bed.

The under sluice at south end has 20 vents each 5 ft (1.5m) in width. Entire piers, flooring and abutments are constructed with dressed laterite block set in good hydraulic mortar. The sluice floor is 4 ft (1.22m) thick and 61 ft (18.6m) long. The laterite blocks have been laid on edge and supported by masonry curtain wall founded on wells and further protected by dry packed laterite apron of 90 ft (27.4m) long. Additional curtain wall of 3 ft (0.91m) both in height and thickness founded on wells has been provided beyond which rough stone apron of 40 ft (12.2 m) long exists.

At the north end, the under sluice has 20 number of vents of 1.52m width built of same material. It is founded on rock for which no flooring or apron is necessary. The abutment of these sluices next to the body of the anicut is extended to 400 ft (122m) upstream to guide the flow towards under sluices. These scouring sluices are intended to keep the entrances to the Kendrapara and High level canals free from silt.

5.3.5.4 Canal irrigation

"While embankments have existed from earliest times, canals are of recent construction and owe their origin to the East India Irrigation company. The company started with a most ambitious scheme for a system of canals for navigation and irrigation extending from Calcutta to Puri. The works began in early sixties and were partly completed in 1867-68 when Government took over from them at a valuation and completed with great modifications."

The works sanctioned included the Taladanda and Machhagaon canals for irrigating the lands between the Mahanadi and the Kathjori rivers; the Kendrapara and Pattamundai canals for irrigating the area between the Chitrotpala and the Birupa and three ranges of High level canals for irrigating the strip lying at the foot of the hills from Cuttack to Bhadrak.

By 1874, the greater part of this modified scheme was completed but the collection proved disappointing. In 1884 a revised scheme was approved for the extension of the Taladanda and Machhagaon canals and construction of new distributaries, bringing the total estimated cost to Rs.3, 23,15, 845.00

5.3.5.4.1 Taladanda canal

The canal takes off from the right head regulator of Mahanadi anicut at Jobra and runs in a south easterly direction to Biribati where it gives off Machhgaon canal. It is about 52 miles (83km) long from Jobra to Paradeep near which it falls into river Mahanadi. For major length excepting 38km the canal and river have one common embankment. From Choumuhani (RD 82km) one branch canal has been excavated during 1962 for supplying fresh water to Paradeep Port. A lock also existed at Choumuhani which has become defunct long since. The bed width of the canal at the head is 38m and reduced to 20m after off take of Machhagaon system. The carrying capacity of Taladanda canal after this point is 48 cumecs. The canal was navigable throughout.

5.3.5.4.2 Machhagaon Canal

The canal takes off from Taladanda canal and runs along the left bank of river Kathjori and its branch Alka for a distance of about 32 km terminating 10km away from Machhagaon. It has a discharge capacity of 44 cumec (1554 cusec) and irrigates 34800 ha.

5.3.5.4.3 Kendrapara canal

The oldest and the most important of 'Orissa Canals' is the Kendrapara canal which had initially taken off from the right side of Birupa anicut. It came into operation in 1869 AD. Consequent upon construction of Mahanadi Barrage (1990-91), now it off takes from the left of Mahanadi Barrage. It skirts the left bank of Mahanadi and its tributary Nuna for about 39 miles (62.4km) and irrigates the fertile and highly assessed area between Mahanadi and Gobri drainage channel with its right bank forming protective embankment. Design discharge of the canal is 104.8 cumec (3700cusec) and irrigates 82438ha. It is provided with number of locks (now defunct) and was navigable up to Marshaghai. After running a distance of 87 km it falls into Jambu River.

5.3.5.4.4 Pattamundai canal

It branches off from Kendrapara canal only after 800 m below its head and runs along right bank of Birupa River down to Indupur and Pattamundai. Finally it connects to Gobri Extension canal at Alka after a circuitous course 47 miles (75km). Its left bank forms a protective embankment against the floods of Birupa and Brahmani. The design discharges is 41cumec (1448cusec) and it provides irrigation to 31590ha. The canal is not navigable. In its lower reach, some of the lands are too low to require artificial irrigation.

5.3.4.5.4.5 Gobri canal

This canal branches off from Kendrapara canal at 32nd mile (51km) It runs for about 15 miles (24.8km) in an easterly direction to join Gandakia river. It forms a part of navigation route between Cuttack and Chandabali. Its design discharge is 8.5cumecs.

5.3.5.4.6 Gobri extension canal

This is the shortest canal system having length of 6 miles (9.6km). It serves as a connecting link between the terminus of the Gobri canal on Gandakia River and river Brahmani at Alka as a navigation channel. It receives water partly from Pattamundai canal and partly from rivers and irrigates mostly in Utikan area.

5.3.5.4.7 High level canal

This canal was initially contemplated to serve the twin purpose of navigable route for trade between Cuttack and Calcutta and to provide irrigation to the country through which it passed. Originally this scheme was to run for 230 miles (368km) across Midnapore to meet river Hooghly below Calcutta to establish a link between Cuttack & Calcutta. The scheme was abandoned because the H.L.C was not remunerative as navigation channel. Even in 1897-98 before the railway communication, the gross receipts were about Rs.50, 000.00 of which Rs.41, 000.00 were from irrigation (vide 'Irrigation, Inland Navigation & Flood Problems in North Orissa during British Rule' by P.Mukherji Pg.10). The railways further affected the tollage from H.L.C. The canal revenue did not even meet the working expenses.

There are three ranges of H.L.C. The Range I have its H.R. on the left side of Birupa anicut (which has been replaced with a new barrage now) at Jagatpur and meets Brahmani at Jenapur. The length of Range I is 33 miles (52.8km). Range II covers a distance of 12.5 miles (20km) from Brahamani to Rudhia across Baitarani. The Range III runs for a length of 39 miles (62.4km) from Baitarani to Salandi.

"It is one of the most picturesque of all the canals of Orissa then, skirting the very base of wooded hills of Darpan and Balarampur. The traveller, by launches that ply on it, looks east wards over almost boundless rice plains whose level surface is broken only by a few hills that here and there rise steeply from the surrounding country, while to the west his eyes see nothing but range upon range of rugged hill and valley in endless confusion. As an irrigation canal it is not a success, and the newly constructed railway will detract much from its value as a navigation route", (Refer 'Orissa Final Report' by S.L.Maddox Settlement Report 1890 to 1900 Pg.24). H.L.C Range I and III respectively provide irrigation to 13800ha), and 19600ha. HLC Range II is defunct at present.

5.3.5.4.8 Jajpur canal

The Jajpur canal is the youngest member of Orissa Canal system. It originated from the fork of Baitarani and Budha rivers and runs for 6.5 miles (10.4km) in an easterly direction to Jajpur town upto which it is navigable. It actually supplied water to 37000 acres (14980 ha) in 1896-97 (vide S.L. Maddox Report). The present ayacut is 13100ha. The canal secures from drought the valuable land between Baitarani and Kharsuan rivers and has been a great boon to the low lying villages, growing spring rice, which were earlier irrigated with brackish water from creeks.

5.3.5.4.9 Dudhei canal

Dudhiya or Dudhei canal from Jenapur had a short life. In 1900, Government sanctioned an expenditure of Rs.85000.00 for the canalization of the natural channel known as Dudhei nallah (vide Bengal Administration Report, 1900). The canal carried water from Brahmani for irrigating Dalua paddy in the vicinity of Aul. It has been abandoned now (Refer 'Irrigation, Inland Navigation and flood control in North Orissa during British Rule by P.Mukherjee).

5.3.5.4.10 Ricketts canal

Churaman or Ricketts canal was nine miles (14.4km) long intended to transport salt to Churamani port on Matei River. Governor- General sanctioned in 1823 an amount of Rs.59000.00 for a canal from the river Matei (near Basudevpur) to river Gamai (order No.365 of 1823). Though it is known as Rickett's canal, it was completed before 1826 AD, when Henry Ricketts came to Balasore district as magistrate (as per Mr. Toynbee's History of Orissa). The canal was not completed entirely and soon fell into disrepair.

Salient feature of the canal system described from Sec. 5.3.5.4.1 to 5.3.5.4.8 is shown in Table 5.2.

Table 5.2 Salient Features of Some Selected Old Canals

Sl. No	Name of the canal	Total length (km)	Navigable length (km)	F.S.D (m)	Maxm. Bed width (m)	Maxm. Discharge (cumec)	Designed ayacut (ha)
1	Taladanda	83	83	2.30	20	90.6	62300
2	Machhagaon	52.3	-	-	-	44.0	34800
3	Kendrapara	87	83	3.75	30	104.8	82438
4	Pattamundai	80.5	-	1.85	15.4	41.0	31590
5	Gobari	24.8	24.8	2.00	12.3	8.5	Included in sl-3
6	Gobari extension	9.7	9.7	2.10	18.3	4.3	Included in sl-4
7	HLC Range-I	53	53	2.40	22.1	22.6	13800
8	HLC Range II	20	20	----	---	-----	defunct
9	HLC Range III	27	27	----	----	32.6	19600
10	Jajpur	10.1	10.1	2.50	12.3	19.8	14300
11	Coast canal (Orissa Portion)	123.0	---	NA	NA	----	nil

Source: S.E. Eastern Circle, WR Dept. Cuttack

5.3.5.5 Coast canal

Orissa Coast canal bears a separate identity, even though it is integrated with Orissa Canal system. In 1862, the Lieutenant Governor of Bengal suggested construction of a canal linking Cuttack and Balasore with Uluberia on the Hooghly. In 1874, Sir Richard Temple favoured the scheme for construction of a canal from Bhadrak to Midnapure. In July 1875, Executive Engineer Mr. Vertannes proposed construction of a canal connecting river Budhabalanga with Hijli which meets Rupnarayan River for communication. His suggestion had favourable response which encouraged him to develop the scheme in 1877. The collector of Balasore Mr. T. Norman also supported the proposal. Col. Haig, Chief Engineer pointed out that the proposed canal route would be better than the sea route for facilitating transport in times of scarcity. The much debated Coast Canal was constructed as a substitute for railways. Against bitter criticism, the Secretary to the Government of Bengal Mr. Mackenzie defended its construction and wrote to Government of India in 1879 that "the heavy bridging necessary for making railway line into Orissa would make the cost of such a work enormous, whilst the coast canal would secure the province against famine." Regarding inland navigation, Arthur cotton stated before the Parliamentary committee in the following words: - "What India wants is water carriage; that the railways have completely failed; they can not carry at the price required; they can not carry the quantities, and they cost the country three millions a year and increasing to support them. That steam boat canals would not have cost more than one eighth that of the railways; would carry any quantities at nominal price and at any speed; would require no support from the Treasury; and would be combined with irrigation". Initially Government of India was reluctant to sanction the project. But Bengal Government agreed to provide funds. It was sanctioned in November 1880.

On 25th September 1881, the Executive Engineer intimated that cost of construction of Coast Canal was Rs.44.75 lakhs while average annual cost of work expenses came to about Rs.59, 000.00 (vide Irrigation, Inland Navigation and F.C problems in North Orissa during British Rule by P.Mukherjee, Page 21).

The canal runs along the sea shore at a distance varying between 3 to 16 km from the coast. The canal is continuation of tidal canal in Midnapore district. First two ranges of the canal are within West Bengal. The first range startes from Geonkhali which is located at the junction of Roopnaryan and Hooghly. It terminates at Rasulpur River. The 2nd range connects the rivers Haldia and Rasulpur.

The Orissa portion of Coast Canal (Range III) begins from Rasulpur river near Contai and enters Orissa at Nasirabad. It meets Subarnrekha River at Bhograi. It leaves Subarnrekha at Jamkunda and ends at Panchapara lock at Panchapara River. There after it continues to Nalkula on river Budhabalanga. Three km. downstream of Nalkula, the canal again starts and runs to Charbatia on river Matei which subsequently flows to Dhamra estuary.

Part of coast canal lying in Orissa is 113.67 km long (Range III, IVA, IV B and Range V). The canal being fed by tidal water is of no use for irrigation. The canal was partially opened on 15th July 1885 and entirely in September 1887.

With the completion of the railways in March 1900, the importance of the Coast Canal declined. Its utility for navigation almost ceased and the tollage collected at various locks hardly paid for the establishment employed to collect it. Thus the Coast Canal became useless within two decades of its construction. Long before it was abandoned, the Coast Canal was neglected.

Flood Advisory committee of 1928 recommended to abandon the Orissa portion of the canal as it affected the drainage in Balasore district. The portion extending from Hooghly to Subarnrekha is in existence at present, and is still relevant for navigation.

5.3.5.5 Irrigation by 'Orissa Canals'

The areas irrigated by Orissa Canals from 1870 to 1899 are presented in Table 5.3.

Table 5.3 Irrigation Coverage of Orissa canals during 1870-99 (Acres)

Year	Taladenda canal & its branches	Kendrapara canal & its branches	High level canal Range I	High level canal Range II	High level canal Range III	Jajpur canal	Total (Acres)
1	2	3	4	5	6	7	8
1869-70	--	1564	165	--	--	--	1729
1870-71	999	8967	12162	--	--	--	22128
1871-72	292	3860	7501	--	--	--	11653
1872-73	198	4318	237	--	--	--	4753
1873-74	1733	7825	3013	--	--	--	12571
1874-75	4095	11105	7259	--	--	--	22459
1875-76	1271	11577	5561	--	--	--	18409
1876-77	5157	17206	8019	--	--	--	30382
1877-78	32604	53769	12122	--	--	--	98495
1878-79	36097	61083	14070	--	--	--	111250
1879-80	37279	57641	13715	189	214	--	109038
1880-81	39400	61871	14023	182	51745	--	117221
1881-82	43941	70627	15588	283	1839	--	132278
1882-83	44131	72468	13955	289	1585	--	133028
1883-84	10300	23685	11937	323	2515	--	48760
1884-85	10546	33022	12270	--	3104	--	58942
1885-86	15489	36375	13404	265	6806	--	72339
1886-87	18685	39714	12412	407	6491	--	77709
1887-88	31277	54404	15312	994	7569	--	109506
1888-89	40391	72796	18092	2385	25628	--	159292
1889-90	40246	77874	26599	2563	39345	--	186627
1890-91	41806	74970	21984	2503	39036	--	180299
1891-92	41906	74180	22423	2513	36211	452	177685
1892-93	36591	67728	21225	2329	32201	878	160952
1993-94	12054	61259	10491	2052	15802	1868	103526
1894-95	24606	65482	13771	2581	14432	1689	122561
1895-96+	25672	63936	3859	892	10105	4996	119460
1896-97+	52048	81300	23042	3330	31215	16080	207015
1897-98+	50304	75811	22052	3243	29193	14999	185602
1898-99+	51175	74371	22232	2937	28685	10466	189866

N.B: - Total in col. 8 does not tally in all cases.

Source: - Orissa Final Report by S.L.Maddox pp 81.

When the canals were first commissioned, the people hung back being timid and averse from innovation and they were also afraid that irrigation would be an excuse for the enhancement of rent and revenue. To allay their apprehensions a proclamation (Notification of 19th July, 1866) was published by Government declaring the water rate to be wholly distinct from land revenue and promising that at the next revision of the settlement no increased rate of assessment would be imposed on any lands by reason only of their being irrigated. These promises failed to produce much effect and on 10th August 1876, they were withdrawn by the issue of a revised proclamation.

A more effective inducement to take water was the gradual reduction of the rate from Rs.3.00 per acre to Rs.1.50 in 1877. This was described by Lieutenant Governor Sir Campbell as resembling a Dutch auction i.e. the seller coming down lower and lower and the buyer still holding out. (Vide Orissa Final Report by S.L.Maddox pp.81). Income and expenditure on canal from 1872 to 99 is furnished in Table 5.4.

Table 5.4 Financial Return of Orissa Canals for the Period 1872-99

Year	Income (Rs)	Expenditure (Rs)	Deficit (Rs)
1872-73	36623.00	338009.00	201386.00
1881-82	223149.00	1103834.00	880685.00
1882-83	319625.00	354896.00	35271.00
1887-88	179211.00	501932.00	122721.00
1892-93	497375.00	505507.00	8132.00
1893-94	375365.00	535467.00	160162.00
1898-99	465492.00	495213.00	29721.00

Source: - The Natural Calamities in Orissa in 19^{th} century by B.B. Bhatta, 1997 Pg. 186.

5.3.5.5.1 Water rent and yield from irrigated land

"Enquiries into comparative out turn of rice on wet and dry lands have been carried on for many years past. Mr. Boothby and Mr. Shore, of the Irrigation Company, estimated the yield of clean rice from irrigated land at 1200 lb per acre (13.5qntl /ha) or nearly double than from unirrigated. These estimates were based on the result of Godavari delta and were hardly applicable to Orissa. In 1872, Colonel Haig, one of the most eminent engineers who have made a study of the Orissa Canal System, estimated the average yield of the year on well irrigated light soil at 25 to 29maunds of paddy per acre while that of similar unirrigated lands was 12.5 to 13maunds only. He also found the ryots admit that on lower and stiffer soils irrigation, even in a year of heavy rainfall, would have raised the outturn from 27.5 to 32.5maunds, because in the first place the crop would have been planted earlier and have been strong enough to withstand the heavy rain of June; and secondly, because the silty canal water would have enriched the soil". (Vide Orissa Final Report by S.L.Maddox, pp 83).

The cultivators never accepted the official claim for increase in production of irrigated land. On the basis of crop cutting experiments the Government concluded average increase of five maunds during 1877 to 1884 and four maunds during 1886-1896. Price index was fluctuating. Acute scarcity occurred in 1837 and 1841, 'Na-anka' famine in 1865-66, Madras famine in 1876 and drought in Bengal in 1891. These calamities pushed the price of rice very high. Converting the products into money and calculating the cost of production, one found very little or no profit from irrigation. (Same situation even prevails today, when farmers are committing suicide). Gradual decline of the average productivity of the cultivated land was the concern of farmers. The money value of paddy from an acre of land slumped form Rs.43.00 in 1899-1900 to Rs.30.00 in 1910-11 for irrigated land and from Rs.32.00 to Rs.24.00 for unirrigated land during the corresponding years (Vide 'Economic History of Orissa', edited by N.R. Patnaik, 1997 pp 301). Similarly in 1930, the money value of average products was Rs.29.00 and Rs.23.00 for irrigated and unirrigated lands respectively. "More tragic was the effect of economic depression on price during 1930s. However, productive effectiveness of canal irrigation to act as insurance against the drought had the unique result. The cultivators of late, realized the loss of crops by drought was higher than the water rent paid" (Refer 'Economic History of Orissa' edited by N.R. Patnaik, 1997 Page 301).

For popularising irrigation among cultivators, the water rate per acre was as follows (vide Orissa Final Report by S.L.Maddox pg 85).

Long leases (five years) for khariff

Flow irrigation	Rs.1.50
Lift irrigation	Rs.1.00
Waterlogged land (Dhoya)	Rs.0.50

Perennial crops (mainly sugar cane)

Flow irrigation	Rs.6.00
Lift irrigation	Rs.4.00

Rabi

Flow irrigation	Rs.0.50 to Rs.2.00
Lift irrigation	Rs.0.50 to Rs.1.50

Total water rates for 1897-98 were merely Rs.315000-00. The rate of water rent continued till 1902 AD when it increased to Rs.1.75 per acre of long term lease and to Rs.2.00 in 1912 AD. During post-war period, water rent was enhanced to Rs.2.50 in 1921 and Rs.3.50 in 1922. But the rate was reduced to Rs.3.00 in 1931. There was further reduction in 1938 by 25%. Through Orissa canals were included under productive major irrigation works in 1916-17, it was administrated at a great financial loss, as the interest charges on capital investment has reached a staggering amount of Rs.354.79 lakhs by 1911.

The financial status of irrigation works for the triennial period on average has been reflected in Table 5.5.

Table 5.5 Financial Status of Irrigation Works

Year	Receipt (in Rupees)			Working expenses (Rs)	Net Receipts (Rs)
	Water rent	Navigation	Total		
1905	337248	69071	406319	370684	(+) 35635
1908	413936	67342	481278	423702	(+) 57576
1911	456154	61205	517359	471442	(+) 45917
1814	423930	70879	494809	487003	(+) 7806
1917	451524	70475	521999	482320	(+) 39679
1920	454975	67441	522416	481513	(+)40903
1926	462867	64865	527732	473459	(+)54273
1936	551489	60321	611810	483520	(+) 128290
1939	Breakup not available		959418	737789	(+) 221629

Source: - 'Economic History of Orissa' - Edited by N.R. Patnaik, 1997 Pg.305.

However, one can not deny the fact that introduction of large scale canal irrigation was a major contribution of the British Government and the capital invested much earlier bears fruit at present. During post independence period, water resources development was possible in a planned manner by construction the first major multipurpose project across Mahanadi at Hirakud. This facilitated for providing irrigation in stage II delta (i.e. undivided Puri district) by construction a weir at Munduli. Besides this number of major and medium projects have been taken up in Mahanadi basin which have been discussed under Chapter VI.

5.3.5.6 Rushikulya System Development

Rushikulya river system and river basin has been described in chapter III under Sec. 3.5. This river is the life line of the Ganjam district. The district suffered from the terrible famine of 1866. At that time it was under Madras Presidency. The number of deaths reported was 10898 (vide Ganjam district manual, Madras 1918 Pg.157 by T.J. Maltby) but it had not suffered like that of any part of the Orissa province. The district earlier had witnessed a famine in 1792 about which the then Assistant Collector Mr.Warricker had written: "I was an eye witness of the melancholy effects of the famine; about six persons had gathered around a fire and were feeding upon the carcass of a dog killed on suspicion of its being mad". Still worse was the plight of people during famine of

1865-66. This holocaust drew attention of the British Government for harnessing the water of Rushikulya river system as a famine relief measure. The resident engineer Major Buckley was entrusted with task of formulating feasibility report in 1868. He submitted the report in September 1872 for utilising the water resources of river Rushikulya. When the project was under detailed investigation, another famine was apprehended in 1879. Government of India sanctioned the Project as a famine protection work vide their letter No.266-1 Dt 6-6-1883. The projects work commenced in 1884 and took about ten years for completion. The original estimated cost of the project was Rs.28.60 lakhs. The cost was revised thrice and the capital account of the project was closed on 31.3.1901 at a final cost of Rs.49.46 lakhs (with cost over-run of 73%).

The Rushikulya irrigation system is an integrated system with two storage reservoirs and four anicuts for water diversion. Those are: -

i) Bhanjanagar (Russelkonda Reservoir)
ii) Sorada Reservoir at Sorada
iii) Gallery anicut at Sorismuli
iv) Ghumusar anicut at Madhaborida
v) Janivilly anicut at Janivilly
vi) Padma anicut at Sorada

The details of above structures are given in the Table 5.6.

Table 5.6 Details of Water Retaining Structures of Rushikulya System Reservoirs

Sl. No	Name of the reservoir	River	Storage capacity (ha.m)	Length of dam (m)	Length of surplus (m)	Ayacut (ha)
1	Bhanjanagar	Boringa nallah	5113	1310	67.06	1038
2	Sorada	Padma	3274	6035	365.76	--

Anicuts

Sl. No	Name of the anicut	River	Catchment area (sqkm)	Length of weir (m)	Remark
1	Sorismuli (Gallery)	Badanadi	430	62.94	Padma and Sorismulli anicuts have been replaced with barrages under DSARP
2	Madhaborida (Ghumusar)	Mahanadi	2255	182.88	
3	Padma	Padma	498	132.62	
4	Janivilly	Rushikulya	1813	246.88	

Above reservoir and anicuts can be divided into two independent systems namely Bhanjanagar system and Sorada system. These have been shown in Figure 5.4.

5.3.5.6.1 Bhanjanagar system

Bhanjanagar system comprises of Bhanjanagar (Russelkonda) reservoir, Sorismuli (Gallery) anicut and Madhaborida (Ghumusar) anicut along with a link channel from Sorismuli anicut to Russelkonda (Bhanjanagar) reservoir and a feeder canal (known as Mahanadi canal) from Madhabarida (Ghumusar) anicut to Janivilly anicut.

The Russellkonda reservoir has derived its name from town Russellkonda (now known as 'Bhanjanagar') situated to the south of reservoir. The town Russelkonda is a combination of two words i.e., 'Russel' and 'Konda'. Mr. Russel was the then commissioner of Ganjam and 'Konda' is a Telugu word which means hill- range.

The reservoir has been formed by construction an earth dam having a puddle core at the centre across 'Boringa nallah' which joins river Loharkhandi, a tributary to river

Badanadi. The reservoir has an independent catchment of 65 sqkm. It has a capacity of 2160 Mc.ft (61.16 Mcum). The reservoir is augmented by Galley canal of 10.50 km long which off takes from Gallery or Sorismuli anicut constructed across river Badanadi. The gallery canal irrigates 808 ha enroute. The anicut intercepts a catchment of 430 sq.km. The storage of Bhanjanagar (Russelkonda) reservoir is released to supplement the irrigation requirement of Sorada system during the period of scarcity. The water from the reservoir is released directly through the head sluice provided in the dam to irrigate 1348 ha. Further spill from the reservoir is let down though a 300 m long channel to Boringa nallah and from Boringa nallah to Loharkhandi river. This water is picked up at Ghumusar (Madhabarida) anicut. The river Loharkhandi and Boda join the river Badanadi on the upstream of the anicut. Two canals i.e. Girisola and Mahanadi take off respectively from left and right flank of Ghumusar (Madhabarida) anicut. Girisola canal commands an ayacut of 3238 ha and Mahanadi canal 5084 ha. Mahanadi canal outfalls into Rushikulya River upstream of Janivilly anicut.

The century old Bhanjanagar Dam has been strengthened and TBL raised from RL 98.3 m to RL 100.0 m by which the loss of storage capacity due to siltation has been made up. New spillway to accommodate revised design flood of 479 cumec (against original flood of 154 cumec) has been constructed with six nos. of vertical lift gates. Above works were carried through World Bank assisted project (DSARP) and completed in 1999-2000.

5.3.5.6.2 Sorada system

Sorada dam is a homogeneous earth fill dam of 5.50 km length across river Padma and has a free board of 16'-0" (4.88m) above FRL. Catchment area intercepted at dam site is 43 sq.km. The materials used in the dam was mainly black cotton (as per Chief Engineer inspection rcpot No.211/1, dated 1st March 1897). Sufficient quantity of red earth cover was given on the slopes after removing large quantity of soil during 1897-98. The upstream slope varies from 1:2.5 to 1:2. Above MWL, the upstream slope is 1:1.5. The down stream slope is 1:1.5 for top 22 ft (6.7m) with a berm of 27 ft (8.23m) at that elevation and the rest upto foundation level has a slope of 1:2. The reservoir has no independent ayacut of it own. It functions as a storage reservoir. Padma anicut constructed across Padma diverts water to fill the reservoir. The water released from this reservoir through a head sluice to river Joro (a tributary to Rushikulya) is picked up at Janivilly anicut constructed across river Rushikulya. The anicut is located 22 km downstream of Sorada. The Janivilly anicut thus receives flow of river Padma, Joro and releases from Sorada reservoir on right side. On the other side, it receives flow of river Bodanadi, Loharkhandi, Badanadi and releases from Bhanjanagar reservoir through Mahanadi canal along with flow of Rushikulya.

The Rushikulya Main canal (RMC) off takes on the right of Janivilly anicut to provide irrigation to 61283 ha besides drinking water supply to Berhampur, Bhanjanagar, Aska and Chatrapur town. The main canal passes through deep cutting of about 40 ft (12.2m) at Padmapur and crosses river Ghodahado through an aqueduct (which has been replaced with a new one during 1964).

There are ninety numbers of tanks (contour tanks) inside the command area which have been integrated to this system. The tanks are fed from the canal and also have their own catchment. These tanks besides their normal function of community use provide irrigation in patches at the time of need.

The Rushikulya system, a brain child of Mr. Buckly is a magnificent example of basin approach. It is a befitting long term solution to any grave drought situation and project has immensely benefited the people of Ganjam by solving acute problem of water for irrigation and drinking purpose.

After successfully serving for nearly for a century, the Soroda earth dam had no serious distress barring undulated crest, inadequate top width and erosion on the downstream slope but the 'Factor of safety were inadequate as per present day standards. These necessitated strengthening of slopes and bring the reservoir capacity to its original capacity as the reservoir was silted up. Accordingly, the TBL was raised from RL 94.5 m to 95.9 m. Salient Features of Diversion weir and Reservoirs constructed are given respectively in Table 5.7 and 5.8.

Table 5.7 Salient Features of the Diversion Weir Structures Constructed before Independence in Rushikulya

Sl. No	Item	Rushikulya system				Jjayamangal anicut
		Gallery anicut	Ghumusar anicut	Padma anicut	Janivilli anicut	
1	Location	Sorismuli Bhanjaganagar block	Madhabarida Belaguntha block	Bugurha Sorada block	Janivilli Dharakot block	Hinjilicut
2	Name of the river / tributary	Badanadi	Mahanadi	Padma	Rushikulya	Ghodahado
3	Latitude	20^0 04' N	19^0 51' N	19^0 43' N	19^0 40' N	19^0 29' N
4	Longitude	84^0 37' E	84^0 37' E	84^0 26' E	84^0 34' E	84^0 44' E
5	Catchment area	430 sq. km	2255 sq. km	498 sq. km	1813 sq. km	1218 sq. km
Diversion weir						
6	Length of the weir	61.57 m	163.14 m	152.4 m *	215 m	82.30 m
7	Solid crest level	100.19 m	57.97 m	90.22 m	51.36 m	24.46 m
8	Pond level	101.04 m	58.88 m	90.22 m	52.27 m	24.46m
9	Deepest bed level	98.60 m	55.78 m	--	48.92 m	20.09 m
10	Crest width	1.22 m	1.22 m	6.4 m	1.22 m	1.07 m
11	Height size & No. of falling shutters	0.85 m height x 3.05 m each 20 nos.	7 nos. of each 3.05 m x 1.6 m, 12 nos. of each 1.83 m x 0.91 m, 38 nos. each 3.05 m x 0.91 m	No falling shutters	0.91 m x 3.05 m each	No falling shutters
Scouring Sluices						
12	Number and size of vents	3 nos. 1.83 m x 1.37 m	Right 4 nos. each 1.83 m x x1.98 m Left 2 nos. each 3.05 m x 1.98 m	6 nos. 2.59 m x 2.44 m	4 nos. 1.83 m x 1.83 m	8 nos. 2.44 m x 1.52 m
13	Sill level	98.60 m	55.78 m	87.78 m	48.92 m	22.94 m
Head Regulator						
14	Crest level	98.83 m	Right: 56.08 m Left: 57.08 m	89.15 m**	49.22 m	22.48 m
15	Crest width	0.760 m	--	--	--	1.07 m
16	No. & size of vents	8 nos. 1.83m x 1.30 m	Right 9 nos. 1.67 m x 1.67 m Left 2 nos. 2.44 m x 0.99 m & 1.83 m x 0.99 m	4 nos. 3.50 m x 1.37 m**	12 nos. 1.83 m x 1.76 m	10 nos. 1.22 m x 1.83 m
Canal at Head Regulator						
17	FSL	100.13 m	Right: 57.91 m Left: 57.99 m	90.22 m	51.05 m	24.46 m
18	FSD	1.30 m	Right: 1.83 m Left: 0.91 m	1.07 m	1.83 m	1.98 m
19	Bed level	98.83 m	Right: 56.08 m Left: 57.08 m	89.15 m	49.22 m	22.48 m
20	Bed width	21.34 m	Right: 11.58 m Left: 4.42 m	16 m	22.55 m	11.58 m

* Including the length of central scouring sluice of 21.8 m

** Cross regulator

Table 5.8 Salient Features of the Reservoirs Constructed in Rushikulya System Before Independence

Sl.No	Item No.	Rushikulya System	
		Bhanganagar	Sorada
1	Location	Across River Boringanala tributary of Loharkhandi	Across a Small Tributary of River Padma
2	Latitude	19^0 57'N	19^0 45' N
3	Longitude	84^0 35' E	84^0 26' E
4	Catchment Area	65 sq. km	19.42 sq. km
Reservoir			
5	T.B.L	98.30 m	94.49 m
6	F.R.L	95.10 m	90.22 m
7	M.W.L	95.71 m	90.83 m
8	D.S.L	80.77 m	81.07 m
9	Storage capacity	61.17 Mcum	49.69 Mcum
10	Submerged area at F.R.L	777 ha	732 ha
11	Submerged area at M.W.L	894 ha	775 ha
Dam & Spillway			
12	Type	Earth Dam with puddle core and upstream revetment	Earth Dam
13	Length of Dam	1310 m	5500 m
14	Length of surplus	67 m	368.8 m
15	Dam height from Deepest foundation	19.35 m	16.76 m
16	No. type & size of gates	Falling shutters18 nos. each 0.61 m height	Falling shutters 121 nos. each 0.45 m
Head Regulator			
17	No. of vents & size	3 nos. 0.91 m x 1.83 m	4 nos. 0.91 m x 1.83 m

5.3.5.7 Jayamangal Irrigation System

Jayamangal system was taken up during 1884 and was completed in 1901 along with Rushikulya system during British period as a drought relief measure. It is a diversion weir scheme constructed across Ghodahado River. It intercepts a catchment area of 1218 sq. km. It diverts the water of river Ghodahado to Jayamangal nallah. It is located on the downstream of present S.H. bridge near Kukudakhandi. The Jayamangal nallah has been utilized as the main canal having a length of 35.6 km. The same nallah also functions as a drainage channel during high floods. The system comprises of four diversion weirs over Jayamangal nallah, two tanks (Karatali Tampara and Sara of Sarabhimpur), four surplus escapes and four cross regulators. The system commands an area of 7350 ha in khariff and 200ha. in Rabi. Rabi crop is mostly grown under the command area of Karatali Tampara tank.

The head works comprises of an ungated body wall of 82.30 m long having crest width of 0.92 m and stepped apron of dry stone packing with masonry toe wall on the downstream. There is an additional dry rubble escape of 29.0 m long on the left of D.W. On right of D.W, scouring sluice having eight vents is located. Head Regulator exists on the right side to supply 7.5cumec of water into Jayamangal nallah.

Karatali Tampara tank is fed by a feeder canal from Angu D.W constructed at RD 26.53 km of Jayamangal nallah to command an ayacut of 1955 ha. The Sara of Sarabhimapur is located at RD 35.2 km of the nallah to irrigate 1235 ha.

Salient feature of the project is shown Table 5.9 and schematic diagram is shown in Figure 5.5.

Table 5.9 Silent Features Jayamangal Irrigation Projects

I.	**General**	
	State	Orissa
	District	Ganjam
	River	Ghodahada
	Latitude	19^0-29'-34" N
	Longitude	84^0-44'-13" E
II.	**Hydrology**	
	Catchment area	1218 sq. km.
	Designed flood	1206.52 cumec
III.	**Diversion weir**	
	Length	82.296 m
	Crest level / Width	24.46 m / 0.92 m
	Pond level	24.46 m
	HFL (Observed)	28.017 (1923)
	Cistern level	22.936 m
	Deepest bed level	19.888 m
VI.	**Scouring sluice**	
	Location	Right Side
	No. and size of vents	8 x 2.439 m x 1.524 m
	Sill level of sluice	22.936 m
	Cistern level	22.876 m
V.	**Head regulator**	
	Design discharge	7.5 cumec
	No. and size of vents	10 x 1.219 m x 1.828 m
	Crest level / width	22.479 m / 1.067 m
	FSL of canal at HR	24.46 m
	Bed level of canal at HR	22.479 m
VI.	**Irrigation System**	
	Length of main canal	35.6 km
	GCA	10481 ha.
	CCA	7550 ha.
	Khariff	7350 ha.
	Rabi	200 ha.

5.3.5.8 Basin Development

The river Rushikulya drains more than 85% of Ganjam district of the state. The famine that occurred in 1865-66 inflicted untold miseries and claimed several thousand of human lives and cattle wealth. But this catastrophe opened new area of planned development to utilise waters of Rushikulya for the benefit of future generations. This system development ignited the mind to construct Jayamangal Irrigation scheme as a drought relief measure. Due to these two irrigation systems, the adverse effects of successive famines were considerably reduced.

Besides above two systems, during the post independence period number of projects, i.e., Ghodahad Dam, Daha Dam, Dhanei Dam, Ramanadi D.W, Hiradharbati D.W, Baghua Dam, Baghalati Dam, Bahuda D.W and Cheligrah Dam (under construction) etc. have been taken up for utilising the water resources of the basin for economic upliftment. The details of these schemes have been discussed under chapter VI. The development planning which was contemplated by Mr. Buckley is gradually growing day by day and bearing more and more fruit for the people of the locality. The journey is not yet complete. The process of development would continue to spread its branches with time for the betterment of mankind.

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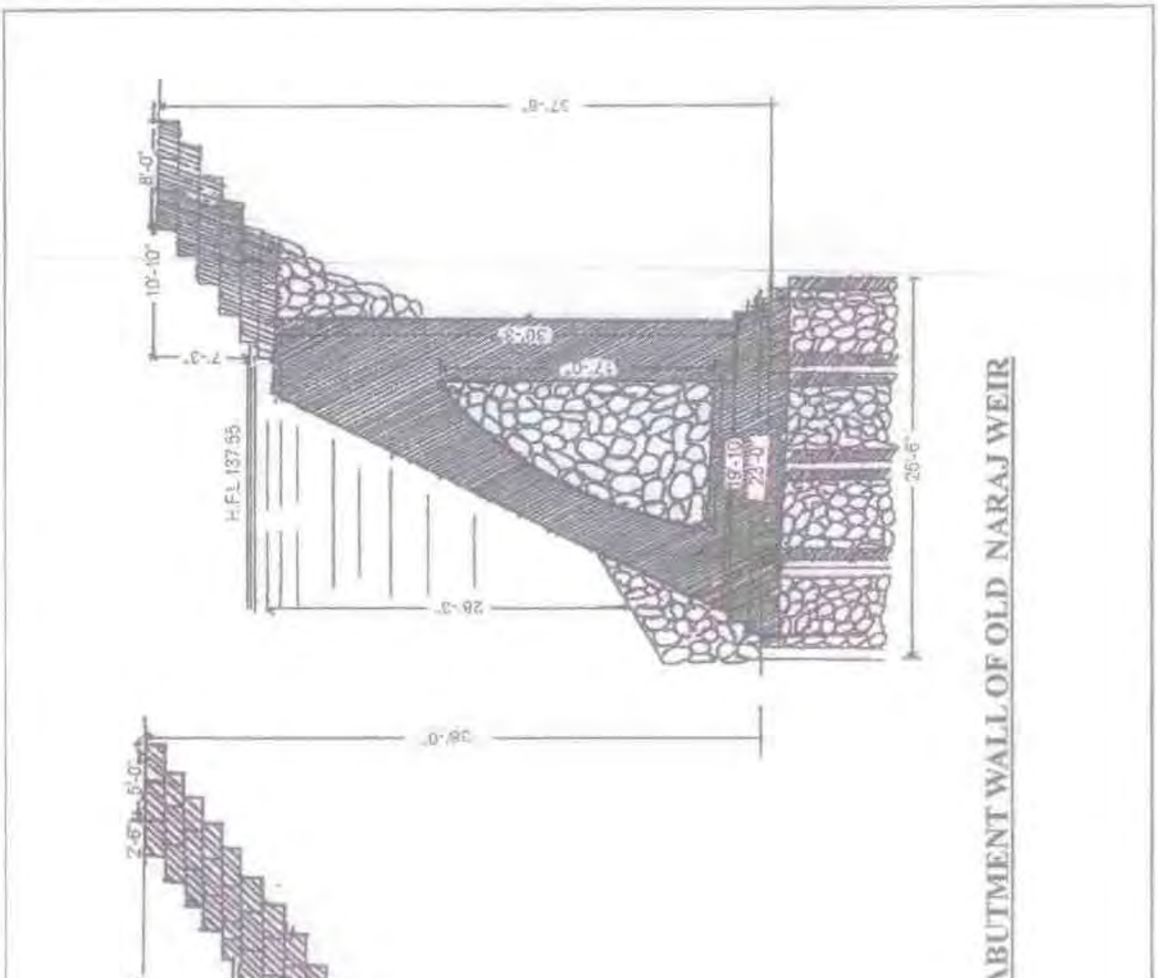

SECTION OF LEFT ABUTMENT WALL OF OLD NARAJ WEIR
H.F.L 137.55
H.F.L 137.55
25'-6"
25'-6"

Figure 5.1

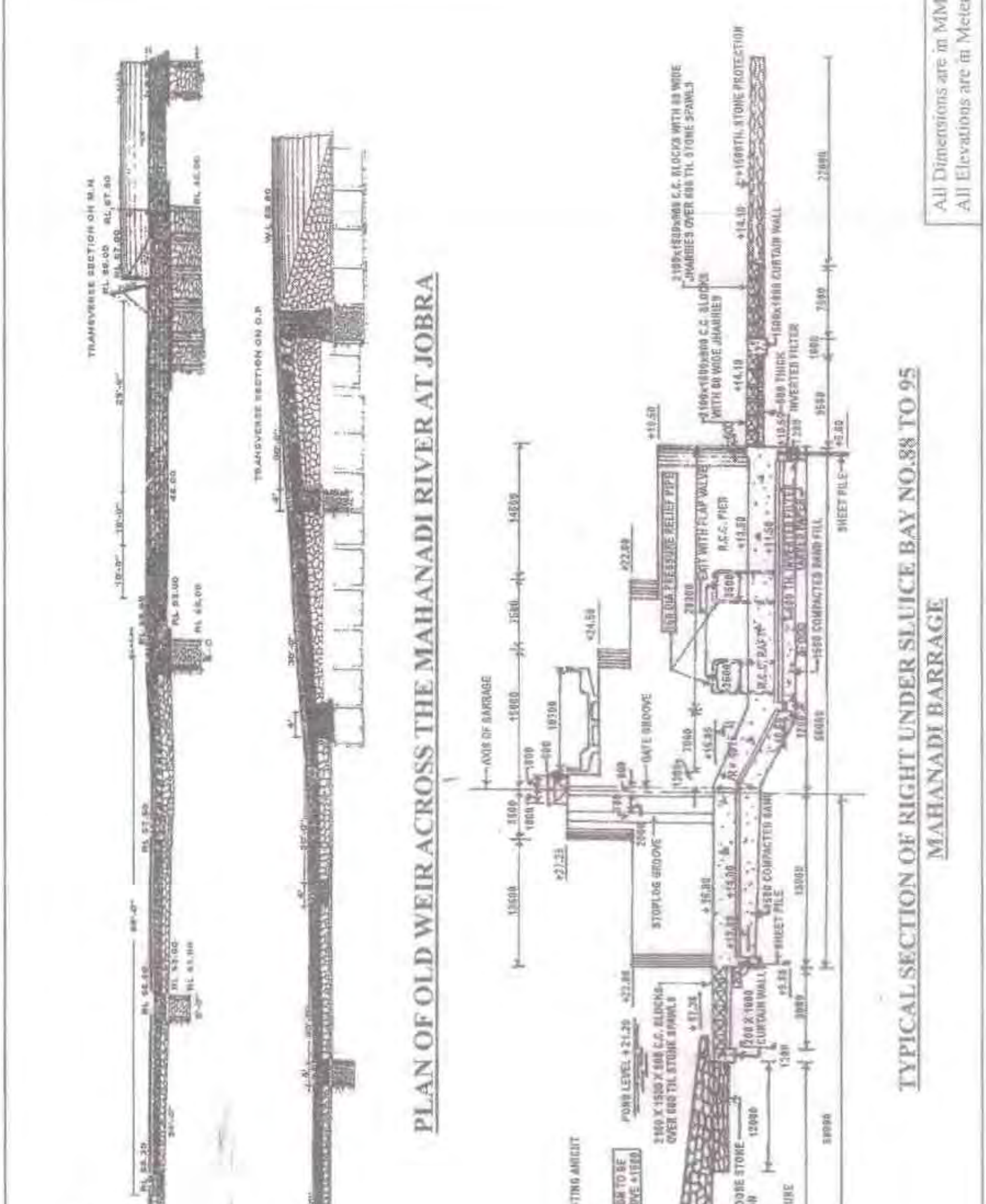

PLAN OF OLD WEIR ACROSS THE MAHANADI RIVER AT JOBRA
TYPICAL SECTION OF RIGHT UNDER SLUICE BAY NO.88 TO 95
MAHANADI BARRAGE
All Dimensions are in MM.
All Elevations are in Meter.

Figure 5.2

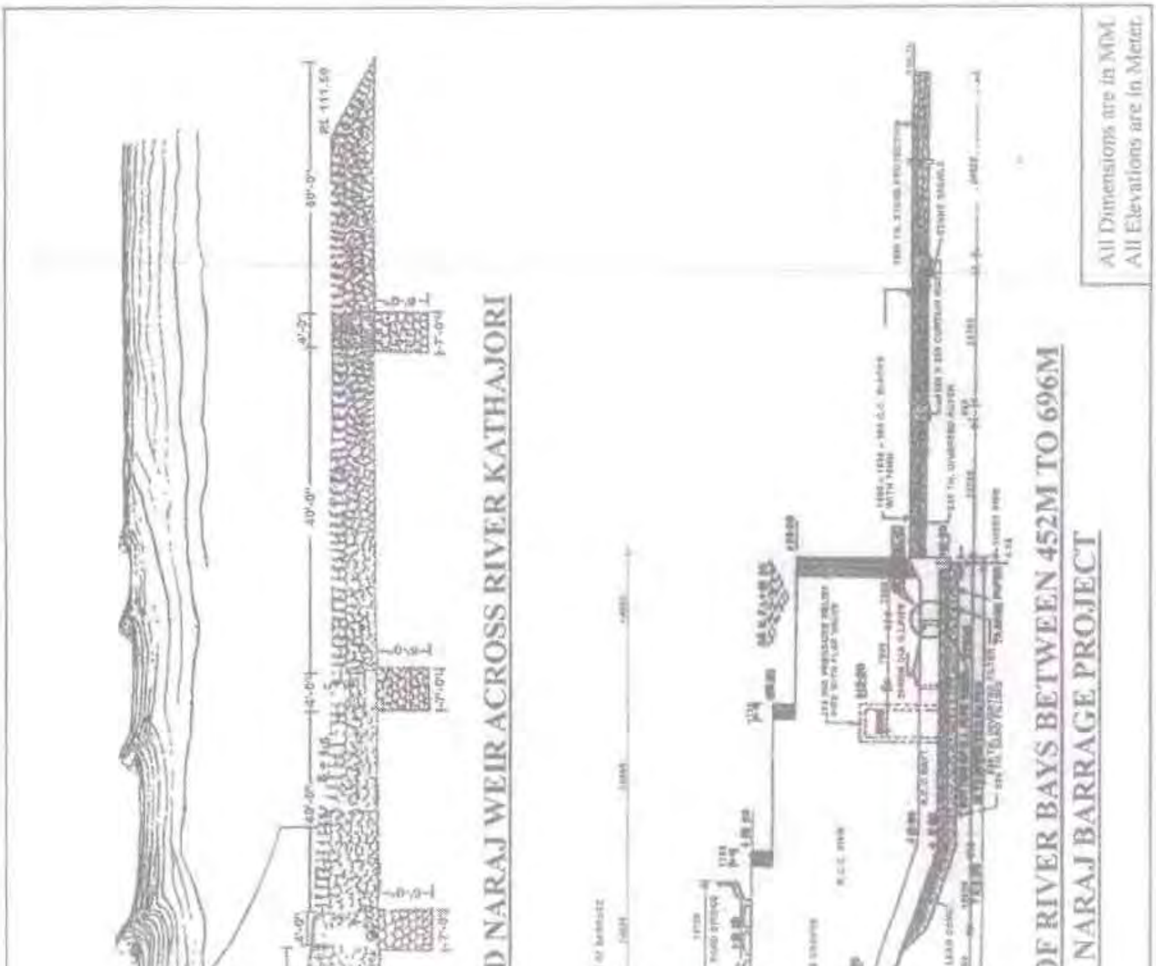

CROSS SECTION OF OLD NARAJ WEIR ACROSS RIVER KATHAJORI
TYPICAL SECTION OF RIVER BAYS BETWEEN 452M TO 696M
OF NEW NARAJ BARRAGE PROJECT
All Dimensions are in MM.
All Elevations are in Meter.

Figure 5.3


GALLERY ANICUT
REFERENCES
RIVER
MAIN CANAL
DISTRIBUTARY
ANICUT
RESERVOIR
AYACUT
RUSSELLKONDA RESERVOIR
BODA NADI
BUDA NADI
GHUMUSAR ANICUT
SORADA RESERVOIR
PADMA ANICUT
PADMA RIVER
JORO RIVER
JANAVILLY ANICUT
GOKULAPUR ANICUT
GOKULAPUR
RUSHIKULYA R.
MAHANADI CANAL
KIRISOLA CANAL
BAGHUA RIVER
DHANEI RIVER
ASKA
NIRADHARABATI ANICUT
RUSHIKULYA RIVER
RUSHIKULYA CANAL
JAVAMANGAL ANICUT
GHODAHADA RIVER
CHILIKA LAKE
BERHAMPUR
GOPALPUR ON SEA
BAY OF BENGAL
CATCHMENT AREA
1. GALLTERY ANICUT .... 430 SQ.KM
2. RUSSELLKONDA RESERVOIR - 65 SQ.KM
3. GUMUSAR ANICUT - 2255 SQ.KM
4. PADMA ANICUT - 498 SQ.KM
5. JANAVILLY ANICUT - 1813 SQ.KM
6. SORODA RESERVOIR - 19 SQ.KM
AYACUT
1. GALLERY ANICUT TO RUSSELLKONDA RESERVOIR - 800.85 HA.
2. RUSSELLKONDA RESERVOIR TO GUMUSAR ANICUT - 1348.47 HA.
3. GUMUSAR ANICUT TO JANAVILLY ANICUT - 3,156.40 HA
4. JANAVILLY ANICUT TO BAY OF BENGAL-50,925.28 HA
TOTAL - 61,231.00 HA

Figure 5.4

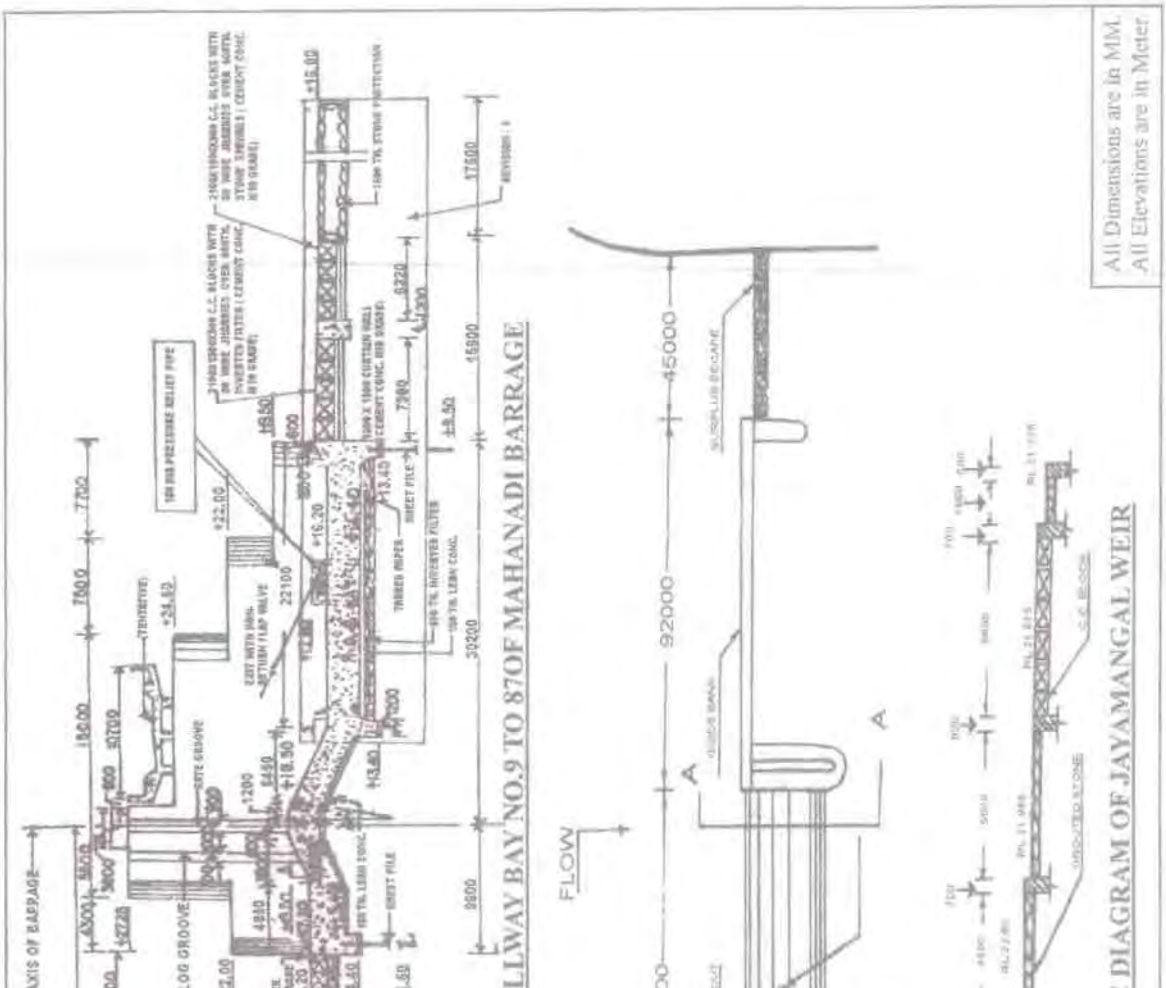

TYPICAL SECTION OF SPILLWAY BAY NO.9 TO 87OF MAHANADI BARRAGE
SCHEMATIC DIAGRAM OF JAYAMANGAL WEIR
FLOW
All Dimensions are in MM.
All Elevations are in Meter

Figure 5.5

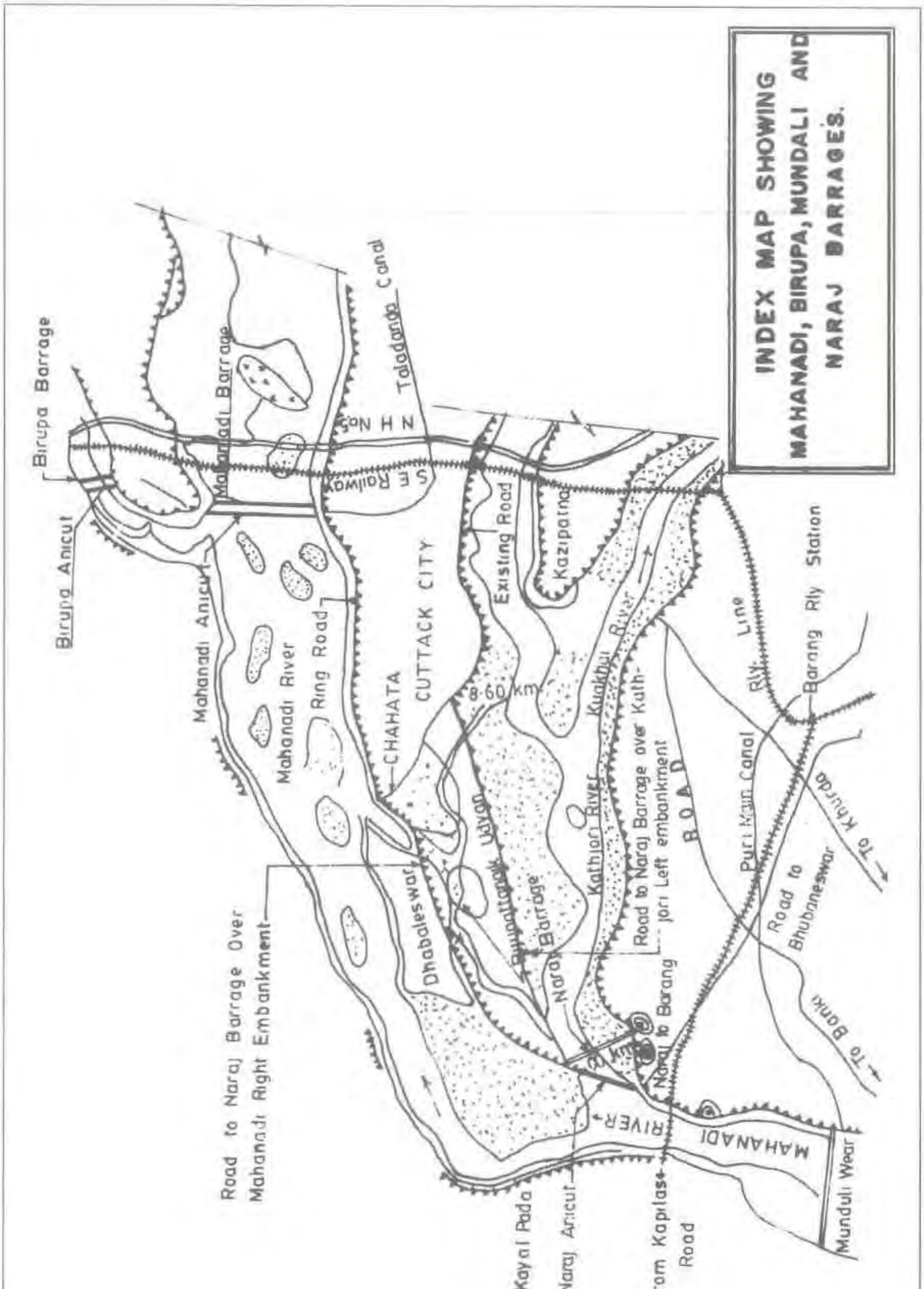

INDEX MAP SHOWING
MAHANADI, BIRUPA, MUNDALI AND
NARAJ BARRAGES.
Birupa Barrage
Birupa Anicut
Mahanadi Barrage
Mahanadi Anicut
Mahanadi River
Ring Road
CHAHATA
CUTTACK CITY
Taladanda Canal
N H No5
S E Railway
Existing Road
Kazipatna
Kuakhai River
Kathjori River
8·60 km
Road to Naraj Barrage over Kathjori Left embankment
ROAD
Puri Main Canal
Rly. Line
Barang Rly Station
To Khurda
Road to Bhubaneswar
To Banki
Naraj Barrage
Dhabaleswar
Naraj to Barang
Road to Naraj Barrage Over Mahanadi Right Embankment
Kayal Pada
Naraj Anicut
From Kapilas Road
RIVER
MAHANADI
Munduli Wear

Figure 5.6

Chapter VI

IRRIGATION DEVELOPMENT AFTER INDEPENDENCE

6.1 General

When India became independent on 15th August 1947 it inherited innumerable problems from British dynasty. The first and foremost of these problems was to eradicate poverty and to feed hungry millions by means of a planned socio-economic development. The country was fortunate to have Pt. Jawaharlal Nehru, a great visionary, as its first Prime Minister.

During 1936, the Indian National Congress had adopted an agricultural programme for economic development which resulted in setting up National Planning Committee in 1938. After independence the Planning Commission was established in 1950 with experts of outstanding caliber in various fields of activities for formulating Five Year Plans for overall development. The board objective of the Commission was to assess the potential of material and human resources with an eye to their optimum utilisation for development of infrastructures for nation building within a stipulated time frame. Subsequently, the Ministry of Irrigation & Power along with other apex organizations like Central Board of Irrigation and Power (CBIP) and Central Water & Power Commission (CWPC) were created. The function of these two bodies was to assist the Planning Commission (P.C) in the planning and formulation process of irrigation and power related projects.

The Planning Commission recognized the importance for exploiting irrigation potential of the country for increasing the food grain production. The country has to support a large population. The population was 361 million in 1951 when food grain production was 51 million tonne. In 2001, population has swelled to 1027 million with food grain production of 212 million tonne. There is tremendous pressure population on land. Table 6.1 indicates the pressure of population (1961) on land in some countries which is quite interesting.

Table 6.1 Pressure of Population on land, 1961

Name of the country	Population (million)	Average. population per sq.mile	Areable land including tree crops per capita (acres)	Irrigated area per capita	
				Acre	Ha
Argentina	20.78 (1960)	20.0	3.55	0.13	0.0526
Australia	10.40 (1960)	3.5	6.42	0.18	0.0728
Canada	17.81(1960)	5.0	5.68	0.07	0.0283
France	45.66(1960)	214.0	1.16	0.13	0.0526
India	438.00(1961)	322.0	1.10	0.14	0.0567
Italy	50.46(1961)	435.0	0.81	0.13	0.0526
Japan	93.41(1960)	656.0	0.16	0.08	0.0324
Pakistan	93.81(1961)	257.0	0.64	0.28	0.1133
U.A.R	26.06(1960)	67.5	0.25	0.26	0.1052
U.S.A	176.70(1960)	53.0	2.63	0.21	0.0850
U.S.S.R	216.15(1961)	25.0	2.52	0.15	0.0607

After experiencing successive droughts and famines, the British Govt. had setup First Irrigation Commission in 1901 and report published in 1903. The report had highlighted the need to extend irrigation as a protection against future famines. The wide spread suffering caused by successive famines in the closing decades of 19th century led to setting up, of a series of famine Commissions. The 2nd Famine Commission recommended that "Among the measures that may be adopted for giving direct protection from drought, the first place must unquestionably be assigned to the work of irrigation". In the report of First Irrigation Commission, the Govt. of India fully endorsed this view.

The Second Irrigation Commission was set up on 1st April 1969. The Commission after elaborate deliberations, questionnaires and visits to different States gave report in 1972. The Commission after reviewing the progress of irrigation in the country after partition set out certain policies and considerations for further development of irrigation for better standard of living and ensuring food security for the large population. The Commission has reaffirmed that the irrigation projects are to be so planned that 'the farmer is assured of getting designed supply in seventy five percent of the years'.

The Commission had recommended the establishment of National Water Resources council to be chaired by the Prime Minister as a policy making apex body with adequate technical support. The council was constituted in 1982 and adopted a National Water Policy in Sept.1987 which has been revised in 2002.They further recommended the development of Irrigation State by State and river basin wise. The report of Irrigation Commission (1972) brought in valuable input for the development of irrigation scenario since independence.

The C.W.P.C (now bifurcated as Central Water Commission & Central Electricity Authority) provides technical back up to the Planning Commission in planning and formulation of irrigation & power projects. CWC is the apex technical body in the country in Water resources sector which provides guidance to the States in formulating their projects from techno economic consideration and interstate angle. Though water is listed under item 17 in the State List, in the seventh schedule of the Constitution under entry 56 List I, i.e., the Union List, the 'regulation and development of interstate rivers and river valleys is the responsibility of the Union to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest'.

As India was passing through acute shortage of food grains, Irrigation projects started getting top priority in Five Year Plans. At the time of launching the 1st Five Year Plan in 1951, the net irrigated area was 20.85 million ha. With 1.71mha getting irrigation during more than one crop season, the gross irrigated area was 22.6mha. The country assigned great importance to irrigation development in the Five Year Plans. All over country major Irrigation Project works commenced within a very short span. A list of such projects is given in Table 6.2.

Table 6.2 Name of Major Rivers Valley Projects

States	Name of Projects	Year
Andhra Pradesh	Nagarjuna Sagar	1955-67
West Bengal	Mayurakshi	1946-56
Orissa	Hirakud	1948-56
Bihar	Damodar Valley Project	1950-58
	Kosi	
Uttar Pradesh	Rihand	1952-62
	Matatila	
Punjab	Harike	
Karnataka	Tungabhadra	1945-54
Maharashtra	Koyna	1954-61
Gujarat	Kakrapara	1949-55
M.P & Rajasthan	Chambal	
Tamil Nadu	Lower Bhavani	

With the rapid strides made in Irrigation sector, the gross irrigated area which was 22.6 m ha in 1950-51 increased to 60.4 m ha in 1984-85 i.e. at the end of sixth Five Year Plan period. Between 1985-90 another 11 mha was added, bringing the total irrigated area to 71.4 m ha. Table 6.3 shows the investment made on irrigation development for major, medium & minor schemes upto Tenth plan period in the whole country.

Table 6.3 Investment & Development of Irrigation Potential.

Sl.No	Plan Period	Investment (million Rs.)	Gross cumulative potential created (m ha)	Potential created during the period (m ha)
1	Pre- Plan	--	22.60	--
2	First Plan (1951-56)	4460	26.26	3.66
3	Second Plan (1956-61)	5220	29.09	2.83
4	Third Plan (1961-66)	9090	33.61	4.52
5	Annual Plan (1966-69)	7600	37.10	3.49
6	Fourth Plan (1969-74)	17500	44.20	7.10
7	Fifth Plan (1974-78)	30730	52.12	7.92
8	Annual Plan (1978-80)	25530	56.60	4.48
9	Sixth Plan (1980-85)	109299	67.90	11.30
10	Seventh Plan (1985-90)	165899	79.50	11.60
11	Eighth Plan (1992-97)	313989		
12	Ninth Plan (1997-2002)	630467		
13	Tenth Plan (2002-07)	1033150		

Source: Development of Irrigation, Drainage and F.C in India, Govt. of India, CWC, New Delhi, April 1991 Pg.11 and Economic Survey, 2002-03, Govt. of India Pg s-38 to 44.

In our country irrigation projects are classified into three categories viz. Major, Medium and Minor. Project which have culturable command area (CCA) of more than 10,000 ha are identified as major projects, projects having C.C.A between 2000 to 10,000ha are termed as medium and those which have CCA of 2000 ha or less are classified under minor category. Minor Irrigation Projects (MIPs) have both surface and ground water as their sources, while major and medium projects exploit surface water resources.

During early stage of irrigation development, emphasis was given for diverting the flow of the rivers through anicuts and weirs, i.e., Run-off the river schemes to utilise river flow during monsoon and to some extent in non-monsoon i.e. Rabi season. Such schemes were mainly developed in Indo-Gangetic plains as rivers are snow-fed during summer and to some extent in other river basins. After independence, it was thought of to undertake major storage works to firm up irrigation from Run-of-the river schemes and for generating hydropower. Multipurpose reservoir projects were also planned to include flood control and other benefits.

6.2 Development of Major and Medium Projects in Orissa

6.2.1 Introduction

It has been assessed that out of total irrigation potential of 59lakh ha, 39.49 lakh ha can be brought under major & medium irrigation projects and 9.70lakh ha through minor irrigation (flow). Details of rivers and River basin of Orissa have been described in Chapter III. Though Orissa has been blessed with relatively more water resources potential, there was little scope of development of the same prior to Independence. Table

6.4 shows the decade wise construction of large Dams (as per ICOLD specification) which clearly indicates the status of construction of dams in the State when compared with National figure.

Table 6.4 Decade wise Construction of Large Dams

Year	No of Dams in Orissa	No. of Dams in the country
Upto 1900	2	65
1901-50	Nil	281
1951-60	3	225
1961-70	6	481
1971-80	52	1263
1981-90	67	1186
1991-2000	33	351
Year not available	....	198
Under construction		475
Total	**163**	**4525**

Major & medium Projects completed during Pre-plan period, i.e., before 1950 given in Table 6.5 (a) & (b). List of 163 nos. of Large Dams in the State is furnished in Table 6.6. Between 1971 to 2000 total 152 large dams were taken up and completed, which can be considered as golden era of the State in dam construction.

Table 6.5 (a) Major projects completed during pre-plan period

Sl. no	Name of the project	Basin / River	Districts benefited	Type	C.C.A ('000) ha	Year of comp-letion	Potential ('000) ha	Utili-zation in 2002 ('000) ha	Remarks
1	Baitarani system	Baitarani	Cuttack Balasore	Diversion	32.70	1870	34.34	34.34	
2	Mahanadi system	Mahanadi	Cuttack J.S.Pur Kendrapara	Diversion	73.37	1895	78.72	78.72	Since modernized
3	Rushikulya system	Rushikulya	Ganjam	Storage cum diversion	59.62	1891	59.62	59.62	Since modernized
						Sub-total	167.33	167.33	
						Say	167	167	

Table 6.5 (b) Medium projects completed during pre-plan period

Sl. no	Name of the project	Basin / River	Districts benefited	Type	C.C.A ('000) ha	Year of comp-letion	Cost Rs. Crores	Potential ('000) ha	Utili-zation in ('000) ha
1	Jayamangal	Rushikulya	Ganjam	Diversion	7.35	1901	--	7.35	7.35
2	Baladiya	Burhabalong	Mayurbhanj	Diversion	3.83	1905	0.31	3.83	3.83
3	Haladia	Budhabalanga	Mayurbhanj	Storage	2.27		0.40	2.27	2.27
							Sub-total	13.45	13.45
							Say	13	13

The command area of Major and Medium Projects completed during preplan period is 1.80 lakh ha.

Table 6.6 Large dams in Orissa upto 2006 as per ICOLD definition

Sl.no	Name of the District	Large Dams			Total large Dams
		Major	Medium	Minor	
1	Angul	Rengali	Derjang	Jaiagarh Kansabansa Kukurpeta Laupal Raijharan	7
2	Balasore	--	--	Rissia	1
3	Bargarh	--	Jharabandha	Khandijharan Kumbho Magaranalla Padampurnalla Talkhole	6
4	Bhadrak	--	--	--	0
5	Bolangir	--	Gaikhai Upper Suktel	Bagijharan Mathanpal Dumerbahal	5
6	Boudh	--	--	Domkutch Laigam Lakhaparbat Parhal	4
7	Cuttack	--	--	Badabandha Jamunabandha Karada Kusunpur Nareijani Suhagi	6
8	Deogarh	--	Gohira	--	1
9	Dhenkanal	--	Dadaraghati Ramilal Sapua	Bedapada Gundurposi Jodabadia Kalijodi Panaspal Sarapa	9
10	Gajapati	--	Harabhangi	--	1
11	Ganjam	--	Baghalati Baghua dam Bhanjanagar Daha Dhanei Ghodahada Soroda	Alikuan Bhallughai Bhitribediguda Debijhara Ganianallah Jharanai Kanheinallah Lankagada Maharanisagar Ramaguda	17
12	Jagatsinghpur	--	--	--	0
13	Jajpur	--	--	Damsal Kalakala	2

14	Jahrsuguda	--	--	Jambonalla Hatianalla	2
15	Kalahandi	--	Bhatrajore	Behera Benikpur Kanteisir Karanjkote Kodabahal Pipal nallah Pratappur Pujiladu Tangarkana Tikarpara	11
16	Kandhamal	--	Pillasalki	Balaskumpa Kanganinalla Paitagam	4
17	Kendrapara	--	--	--	0
18	Keonjhar	Salandi	Kanjhari Remal	Ardei Bautianalla Garh Hanumantia Jagadala Juanria Kalimati Khajuria Kureijodi Raghubeda Sanamachakandana Sapua Sunaghai Tenar	17
19	Khurda	--	Salia	Ashokanalla Hanumantia Jhumuka	4
20	Koraput	Jalaput Muran Kolab	Satiguda (UKP)	Dasamantapur Kodigam Laximipur Malkangiri	8
21	Malakangiri	Balimela	Satiguda (Malkangiri)	--	2
22	Mayurbhanj	--	Bankabal Haladia Jambhira Kalo Khadakhai Kukudajodi Nesa Sunei	Arikul Badjore Chhamundia Paunsianalla Pokharia Sanasialinai	14
23	Nawarangpur	Kapur Podagada Indravati	Bhaskel	Kahneimunda	5

24	Nayagarh	--	Budhabudhiani Kuanria	Baghua Bhetabar Dhulipaunsia Gayapathar Ghagra Haguri Koska Mahisanallah Panaskhal Randa	12
25	Nuapara	--	Saipala Sundar Upper Jonk Dumerbahal	Khasbahal Liard Pendrawan	7
26	Puri	--	--	--	0
27	Rayagada	--	Badanallah	Bhagirijhola Bhaluguda	3
28	Sambalpur	Hirakud	--	Banksal Deojharan Sankundeswar Tikilipada	5
29	Sonepur	--	Hariharjore	--	1
30	Sundargarh	--	Kansabahal Mandira Pitamahal Sarafgarh Talsara	Chheteinjore Gurlijore Masinanallah Runugaon	9

Source: - State Dam Safety Organisation 'Report on Dam Safety Activities & Large Dams of Orissa'-May 2007.

Soon after independence, situation did not improve much due to various reasons. There was less irrigation in the State except old Mahanadi Delta and Rushikulya system. After independence, stress was given for planned development in the Water Resources Sector. In the beginning, focus was for development of projects in Mahanadi Basin, the largest one in the State; Brahmani basin, Baitarani basin and on the tributaries in the upper reaches of Godavari basin lying inside Orissa territory. There was no independent Department for Irrigation and Power in the State prior to 1962. Between 1947 and 1962 no projects were constructed independently by State engineers. Investigation of the projects were taken up earnestly in early sixties, after creation of the I & P Department. Major multipurpose and H.E projects such as Balimela, Rengali, Upper kolab and Upper Indravati were identified for implementation.

In Mahanadi basin, Hirakud project which was investigated earlier was taken up across Mahanadi during 1948-1957. Irrigation in new delta (stage-II) was completed in 1963. The Hirakud Dam was taken up by Central Water and Power Commission. Tikerpada another site at downstream of Hirakud, was also planned as a multipurpose project but due to submergence and R & R problem it could not see the light of day.

Fortunately, all tributaries in upper most reaches of river Godavari having tremendous potential for Irrigation and Hydropower generation flow through undivided Koraput District of Orissa. Koraput district was a part of Madras Presidency before April

1936 i.e. formation of Orissa State. Though the water potential attracted the authorities of Madras presidency, they could not develop the same. The projects remained as nonstarter due to interstate disputes over water of river Godavari (vide Ch. VIII of the book) until those were settled amicably in mid-seventies. There are three major tributaries where water resources projects have been implemented, viz. Machhkund (sileru), Kolab (sabari) & Indravati.

Once upon termed as 'Sorrow of Orissa' due its flood havoc, River Brahmani, the second biggest in the State starts from Bihar (Jharkhand) was tamed by construction of Rengali Multipurpose Project during 1972-1985. Five units of 50MW have been installed at the 71 m high concrete masonry dam toe. At about 35 km downstream of the dam a pick up Barrage at Samal has been constructed for irrigating about two lakh hectare land. Distribution system is in progress.

Though Baitarani is the next major river of the State having huge water potential, no major reservoir has been constructed on this. Bhimkund Multipurpose project was identified and planned in the basin during early seventies, but count not be implemented due to various reasons. Brief description of few dams of National Importance and major & medium projects of the State are described under Sec. 6.2.3.2.

6.2.2 Development of Major and Medium Projects in Plan Period

6.2.2.1 Development in Pre-plan Period

Until the great Bengal famine of 1866, there was no irrigation in the State. The Orissa Canal System was built as a sequel to the above said famine (refer Chapter V of the book) in 1866 and completed in 1883. Another major canal system, i.e., Rushikulya system was constructed in 1891 (vide Table 6.5 a) Before the plan period few other medium projects were also completed (refer Table 6.5 b).

6.2.2.2 First Plan Period (1951-56)

Hirakud and Hiradharbati projects had commenced before plan period. Subsequently those two schemes were included in the First plan. Works of both Mahanadi Delta and Salandi Delta were also taken up during this period. But no irrigation potential was created in the First plan from these major and medium irrigation projects.

6.2.2.3 Second Plan Period (1956-61)

During this plan period, irrigation development gained momentum. Medium projects viz. Salki, Dhanei, Salia, Ghodahado, Budhabudhiani and Derjang along with three major projects, i.e., Mahanadi Delta Stage-II, Hirakud Stage-II and Salandi irrigation were taken up. Irrigation potential of 1, 17, 080 ha (in kharif) was created through Stage I & II of Mahanadi Delta. Irrigation activities were also extended to undivided Dhenkanal, Phulbani and Keonjhar districts, by construction of Derjang, Salki and Salandi Projects, respectively. An ayacut map showing irrigation network of Stage I and Stage II, Delta is presented in Figure 6.1.

6.2.2.4 Third Plan Period (1961-66)

Besides Major and medium projects continuing from first and second Plans, Balimela Dam Project and one medium project, i.e., Bahuda in Ganjam district were taken up. Additional irrigation potential of 92680ha in Kharif and 93630 ha in Rabi were created. (vide 'Irrigation in Orissa' by A.K Dalua, Published by WALMI, Orissa, 1991 Chapter VI, Pg. 31)

6.2.2.5 Annual Plans (1966-69)

In addition to the continuing projects, works of two new medium projects namely Utei in Kalahandi and Pitamahal in Sundergarh districts taken up. Irrigation potential of 34500 ha in Kharif and 71540 ha in Rabi was achieved during this period. This was mainly due to stabilisation of irrigation in Mahanadi Delta Stage I and Hirakud Stage II.

6.2.2.6 Fourth Plan Period (1969-74)

Irrigation was given top priority during this plan period when major projects like Rengali Dam, Anandapur Barrage (only canal portion) and Potteru irrigation Projects took off. During this plan period a record development of 1, 74, 440 ha Kharif and 23, 640 ha Rabi Potential was achieved from the continuing projects (vide Irrigation in Orissa, 1991 by A.K Dalua Pg.32).

6.2.2.7 Fifth Plan Period (1974-78)

Balance work of 19 numbers of continuing projects including two major projects i.e. Upper Kolab and Rengali Irrigation Projects and 18 numbers of new major & medium projects were taken up for construction. Modernisation of Hirakud and Rushikulya irrigation system was also commenced during this period.

6.2.2.8 Annual Plan Period (1978-80)

During these two years, nine numbers of projects commenced, the major being Upper Indravati Project. Besides Indravati, replacement of century old anicuts of Mahanadi and Birupa with gated barrages were undertaken. Additional Khariff and Rabi potential created were respectively 36570 ha and 57270 ha.

6.2.2.9 Sixth Plan Period (1980-85)

A major breakthrough was commencement of Subarnrekha Irrigation Projects, a joint venture with Govt. of Bihar (now Jharakhand) after concluding Tripartite agreement with Bihar and West Bengal (vide Sec. 8.4.4 of the book) on 07-08-1978 alongwith 14 other projects. These included extension, renovation and modernization of four schemes namely Hirakud, Ghodahado, Bargarh canal and Bhaskel Projects. Khariff and Rabi achievements were 1, 11, 490 ha and 45, 450 ha respectively.

6.2.2.10 Seventh Plan Period (1985-90)

Mahanadi–Chitrotpala island irrigation, Birupa–Genguti island irrigation and extension of Remal canal were taken up. Creation of irrigation potential in Khariff and Rabi were, respectively, 78, 150 ha and 42, 150 ha.

6.2.2.11 Annual Plans (1990-92)

Works of ongoing projects continued. Achievement during these two years for Khariff and Rabi were respectively 38, 310ha and 15, 030ha.

6.2.2.12 Eighth Plan Period (1992-97)

Orissa Water Resources Consolidation Projects (OWRCP) started towards end of Eighth plan (vide Sec.12.1.2.1) which included eight projects under scheme completion, eighteen numbers under SIFT component and balance works of ex-NWMP schemes. Besides OWRCP, Rengali left canal from RD 30 km to 71.3 km funded by OECF (later renamed as JBIC) and Rengali Right canal from RD 0 to 79 km funded by AIBP were taken up. Works of Kanpur Irrigation Project, Bagh barrage, Gobardhanpur barrage, Baghalati, Titilagarh, Deo, Manjore and ERM of Sunei, Dhanei, Hiradharbati, Kanjhari and Salia commenced.

6.2.2.13 Ninth Plan Period (1997-2002)

OWRCP which had started during Eighth Plan came to an end creating irrigation potential of 79160ha under scheme completion and stabilising 255080ha under SIFT component. In addition to this, two major irrigation projects i.e. Lower Indra and Lower suktel in KBK region (undivided Kalahandi, Bolangir and Koraput district) of the State commenced. Other projects which commenced are Rukura, Rajua, 3 numbers of creek projects (i.e., Nagarighat, Guneimuhan and Prachikundhei) and ERM of Ghodahado, Budhabudhiani, Sundar and Dumurbahal.

6.2.2.14 Tenth Plan Period (2002-2007)

New projects included in 10th Plan were Upper Indravati canal extension beyond Sagada and Tel, Anandapur Barrage, Brutanga, Ong Dam and Ib. Even though Brutanga and Ong Dam were cleared by CWC way back in 2000 and Ib in 2003, the projects could not take off due to various reasons. Construction of these projects are likely to commence during Eleventh Plan.

Major, Medium and ERM projects completed up to end of Ninth Plan are shown in Table 6.7, 6.8 and 6.9, respectively.Irrigation Map of Orissa is given in fig. 6.7

Table 6.7 Major Projects Completed During Plan Period upto End of 9th Plan

Sl. No.	Name of Project	Year of approval	Approved cost (Rs. In Cr.)	Basin / River	Districts benefitted	Type	C.C.A ('000 ha)	Plan Period	Cost (Rs. In Cr.)	Potential ('000 ha)	Utilisation up to 3/02 (000 ha)
1	2	3	4	5	6	7	8	9	10	11	12
1	Hirakud	1948	70.78	Mahanadi /	Sambalpur, Bolangir,	Storage	157.81	1948/ II	100.02	261.26	261.26
				Mahanadi	Bargarh & Sonepur	Diversion	19.89	II / IV	2.32	21.92	21.39
2	Salki	1957	0.53	Mahanadi / Salki	Boudh						
3	Salandi	1955	4.65	Baitarani / Salandi	Balasore, Keonjhar & Bhadrak	Storage	45.73	II / VI	16.49	57.59	54.849
4	Anandapur Barrage (canal)	1977	9.65	Baitarani / Salandi	Bhadrak & Keonjhar	Diversion	40.178	V/ VIII	22.06	35.133	35.133
5	Mahanadi Birupa Barrage Project	1978	42.09	Mahanadi / Birupa & Mahanadi	Cuttack	Diversion	—	V/AP 1990-92	129.93	No direct benefit	
	Sub-Total		127.70				263.61		270.82	375.90	372.63

Table 6.8 Medium Projects Completed During Plan Period upto end of 9th Plan

Slno	Name of Project	Year of approval	Approved cost (Rs. Cr.)	Basin / River	Districts Benefitted	Type	C.C.A ('000 ha)	Planperiod	Cost(Rs. Cr.)	Potential ('000 ha)	Utilistion up to3/02 (000 ha)
1	2	3	4	5	6	7	8	9	10	11	12
1	Hiradharbati	1962	0.314	Rushikulya / Rushikulya	Ganjam	Diversion	5.717	III / V	3.981	5.717	5.717
2	Ghodahado	1960	0.404	Rushikulya / Ghodahado	Ganjam	Storage	7.203	III / V	17.195	8.203	8.203
3	Derjanga Stage-I	1960	0.850	Brahmani / Lingra, Matalia	Angul	Storage	5.951	II / V	5.489	7.893	7.893
	Derjanga Stage-II	1994	4.850	Brahmani / Lingra, Matalia	Angul	Storage	1.441	VIII / IX	6.601	1.499	1.499
4	Salia	1960	0.698	Mahanadi / Salia	Khurda & Ganjam	Storage	8.470	II / V	8.723	11.290	11.290
5	Dhanei	1959	0.321	Rushikulya / Dhanei	Ganjam	Storage	4.017	II / V	3.147	5.437	6.017
6	Budhabudhiani	1960	0.435	Mahanadi / Duant	Nayagarh	Storage	3.290	II / V	5.489	3.290	3.290
7	Bahuda	1962	0.574	Bahuda / Bahuda	Ganjam	Diversion	7.335	II / V	4.516	7.335	7.335
8	Pitamahal	1665	0.463	Brahmani / Pitamahal	Sundargarh	Storage	2.650	III / V	2.629	4.280	3.280
9	Baghua St-I	1968	0.656	Rushikulya / Baghua	Ganjam	Diversion	3.000	AP 1966-69 / V	3.930	3.000	3.000
10	Uttei	1968	0.902	Mahanadi / Uttei	Kalahandi & Bolangiri	Diversion	9.630	IV / V	6.440	10.830	10.830
11	Dahuka	1968	0.561	Mahandi / Dahuka	Nayagarh	Diversion	2.740	IV / AP 1978-80	1.430	2.270	1.580

Slno	Name of Project	Year of approval	Approved cost (Rs. Cr.)	Basin / River	Districts Benefitted	Type	C.C.A ('000 ha)	Planperiod	Cost(Rs. Cr.)	Potential ('000 ha)	Utilistion up to3/02 (000 ha)
1	2	3	4	5	6	7	8	9	10	11	12
12	Saipala	1972	1.120	Mahanadi / Saipala	Nuapada & Bargarh	Storage	3.090	IV / VI	2.186	3.280	2.950
13	Kalo	1972	1.970	Budhabalanga \ Kalo	Mayurbhanj	Storage	4.900	IV / VI	6.462	6.820	6.560
14	Khadkhai	1973	2.990	Subarnarekha / Khadkhai	Mayurbhanj	Storage	7.990	IV / VI	6.295	11.710	7.910
15	Ramanadi	1975	0.583	Rushikulya / Ramanadi	Ganjam	Diversion	1.600	V / VI	0.824	1.320	1.320
16	Nesa	1972	0.447	Sunarnarekha / Nessa	Mayurbhanj	Storage	1.200	V / VI	1.415	1.395	1.046
17	Sundar	1972	1.605	Mahanadi / Sunder	Nuapada	Storage	4.450	IV / VII	8.105	6.070	6.070
18	Raimala	1975	4.330	Brahmani / Ramila	Dhenkanal	Storage	7.325	IV / VII	19.283	9.330	9.330
19	Daha	1974	2.708	Rushikulya / Kalinga Nalla	Ganjam	Storage	4.760	V / VII	16.160	7.050	5.460
20	Dumarbahal	1973	1.398	Mahanadi / Tributary of Ong.	Baragarh	Storage	2.830	V / AP 1990-92	4.151	3.950	3.950
21	Pillasalki	1976	1.678	Mahanadi / Pilasalki	Kandhamala	Storage	2.388	V / VII	12.209	3.230	3.230
22	Kuanria	1976	4.300	Mahanadi / Kuanria	Nayagarh & Khurda	Storage	3.770	V / VII	13.796	5.750	5.270
23	Remal	1975	2.734	Baitarani / Remal	Keonjhar	Storage	3.700	V / VII	14.653	5.826	3.731
24	Safafgarh	1977	3.168	Mahanadi / Iccha	Sundargarh	Storage	2.750	V / VII	8.160	4.090	3.500
25	Jharabandha	1977	0.623	Mahanadi / Kakrijhara	Sambalpur	Storage	2.130	V / VII	3.406	2.550	2.430
26	Talasara	1977	4.657	Mahanadi / Badbandarjore	Sundargarh	Storage	3.580	V / VII	7.590	5.400	4.340
27	Gohira	1975	4.795	Brahmni / Gohira	Deogarh	Storage	8.170	V / VII	35.000	13.870	12.460
28	Aunli	1975	0.530	Brahmani / Aunli	Angul	Diversion	1.746	V / VII	2.997	2.250	2.250
29	Dadaraghati	1972	1.370	Brahmani / Dadaraghati	Dhenkanal	Storage	4.510	IV / AP-1990-92	9.887	5.770	5.770
30	Sunei	1975	4.450	Burhabalang / Sunei	Mayurbhanj & Balasore	Storage	7.900	V / AP 1990-92	33.321	13.065	9.269
31	Upper Suktel	1978	1.278	Mahanadi / Upper Suktel	Bolangir	Storage	1.350	AP 1978-80 / VIII	8.050	1.860	1.860
32	Bankabahal	1980	5.720	Subarnarekha / Bankabahal	Mayurbhanj	Storage	7.400	AP 1978-80 / AP 1990-92	29.410	10.370	7.830
33	Kansabahal	1980	6.679	Brahmani / Bandajore	Sundargarh	Storage	4.220	AP 1978-80 / VIII	33.412	5.870	5.000
34	Kanjhari	1978	7.370	Baitarani / Kanjhari	Keonjhar	Storage	9.300	AP 1978-80 / AP 1990-92	32.040	12.900	10.460
35	Satiguda	1962	2.023	Godavari / Satiguda	Malkangiri	Storage	9.060	III / VII	18.010	13.610	11.456
36	Birupa Genguti Island Irrigation	1995	4.580	Mahanadi / Mahanadi	Cuttack	Diversion	3.870	VII / IX	14.330	3.500	1.000
37	Bhaskel	1960	NA	Indravati / Bhaskel	Nowrangpur	Storage	2.870	III / VIII	0.780	4.020	4.020
38	Ong Diversion Weir	1972	2.881	Mahanadi / Ong	Bolangir	Diversion	9.831	IV / VIII	27.279	10.040	10.030
	Sub-Total		87.015				188.084		438.761	245.940	218.436

Table 6.9 ERM Projects Completed During Plan Period upto end of 9th Plan

Sl no	Name of Project	Year of approval	Approved cost (Rs. in Cr.)	Name of Original project	Basin / River	Districts benefitted	Plan period	CCA ('000 Ha)	Cost (Rs. in Cr.)	Additional Potential ('000 Ha)	Utilization up to 3/02 (000 Ha)
1	2	3	4	5	6	7	8	9	10	11	12
1	Extension of Mahanadi Delta (Stage I & II)	1957	14.920	Mahanadi Delta	Mahanadi / Mahanadi	Cuttack / J.S.Pur, Kendrapara, Puri, & Khurda	II / VI	194.600	70.560	343.780	320.850
2	Renovation of Mahanadi (Delta-I &II under IAP	1988	12.21	Mahanadi Delta	Mahanadi / Mahanadi	Cuttack / Puri	VII / VIII	29.680	22.55	43.020	43.020
3	Extension and improvement of Hirakud canal	N.A	N.A	Hirakud Dam	Mahanadi / Mahanadi	Baragarh	V / VI	1.30	5.679	1.95	1.95
4	Extension of Remal	N.A	N.A	Remal	Baitarani / Remal	Keonjhar	V / VII	1.01	1.472	1.01	1.01
5	Modernization of Rushikulya	1976	1.29	Rushikulya system	Rushikulya / Rushikulya	Ganjam	V / VII	2.17	2.817	2.17	2.17
6	Modernization of Bhaskel	N.A	N.A	Bhaskel	Godavari / Bhaskel	Nowrangpur	VII / VII	1.43	1.82	1.43	1.43
7	Sunei Extn.	1996	1.86	Sunei	Budhabalanga/ Sunei	Balasore	VIII / IX	2.10	2.11	1.90	1.90
	Sub-Total		30.280					232.290	107.01	395.260	372.330

Source: Engineer – in- Chief (W.R), Orissa

Major, medium and ERM projects which started earlier but could not be completed till end of Ninth Plan Period, and spilled over to the Tenth plan are shown in Table 6.10, 6.11 and 6.12 respectively. Similarly new projects under above category which been taken up in the Tenth plan are presented Tables 6.13, 6.14 and 6.15.

Table 6.10 Ongoing Major Projects in 10th Plan

SINo	Name of the Project	Year of Approval	Approved cost (Rs. in Cr)	Baisn / River	District Benefitted	Type	CCA ('000 ha)	Started in plan	Cost (Rs. in Cr) Latest Estimated	Expdr. upto 3/2006**	Benefit ('000Th. Ha) Ultimate potential	Potential created upto 3/2006**	Utilization upto 03/2006
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Potteru	1973 (P.C)	14.81	Godavari / Potteru (Saberi)	Malkangiri	Diversion	61.03	IV	220.24	220.24	109.88	109.3	55.91
2	Upper Kolab Dam (Irr. Share)	1975 (P.C)	7.58	Godavari / Kolab	Koraput	Storage	Nil	V	55.63	55.63	Irrigation & power generation		
3	Upper Kolab Irrigation project	1976 (P.C)	24.05	Godavari / Kolab	Koraput	Storage	44.50	V	333.97	333.97	85.89	73.14	44.03
4	M.C.I.I	1989 (P.C)	39.93	Mahanadi/ Mahanadi	Cuttack, J.S.Pur, Kendrapara	Diversion	15.34	VII	231.29	231.29	25.48	12.90	0.00
5	Naraj Barrage	1993 (P.C)	125.74	Mahanadi/ Mahanadi	Cuttack, J.S.Pur, Kendrapara	Diversion	-	VIII	215.96	215.97	Stabilizing irrigation in Stage I delta and partial flood relief in Stage II delta		
6	Rengali Dam	1973 (P.C)	57.92	Brahmani / Brahmani	Angul, Dhenkanal, Jajpur, Keonjhar, Cuttack	Storage	-	IV	169.86	169.86	Multipurpose i.e. Flood control, Power generation & Irrigation.		
7	Rengali Irrigation Project												
	(i) Samal Barrage							V	215.69	215.69			
	(ii) Left Bank Canal-I (RD 0.00 to 30km	1978 (P.C)	233.64	Brahamani / Brahamani	Anugul, Dhenkanal, Jajpur, Keonjhar, Cuttack	Off-takes from Samal Barrage	8.483 (flow only)	VIII	262.54	262.54	16.54	16.54	8.48
	(iii) Left Bank Canal-II (RD 30.00 to 71.313Km						93.501 (Flow Only)	VIII	686.00	411.17	55.44	0.28	0.00
	(iv)Left Bank Canal-II (RD 71.313 to 141.00Km						(Flow Only)	Not Started	870.00	0.00	122.21	0.00	0.00
	(v)Right Bank Canal (RD 0.00 to 79.00 Km)	1978 (P.C)	233.64	Brahmani / Brahmani	Angul, Dhenkanal, Jajpur, Keonjhar, Cuttack	Off takes from Samal Barrage	100.50 (Flow Only)	VIII	629.35	389.78	35.02	0.16	0.00
	(vi) Right Bank Canal (RD 79.00 to 95.00 Km)							Not Started	777.32	0.00	135.83	0.00	0.00
Sub-Total (7)			233.64				202.48		3440.90	1279.18	365.04	16.98	8.48

SlNo	Name of the Project	Year of Approval	Approved cost (Rs. in Cr)	Baisn / River	District Benefitted	Type	CCA ('000 ha)	Started in plan	Cost (Rs. in Cr)		Benefit ('000Th. Ha)		Utilization upto 03/2006
									Latest Estimated	Expdr. upto 3/2006**	Ultimate potential	Potential created upto 3/2006**	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
8	Subarnarekha Irrigation Project												
	(a) Subernarekha (under RIDF)	1995 (P.C)	790.32	Subernarekha/ Subernarekha	Mayurbhanj & Balasore	Storage (C.A.R)	109.63	VII	70.16	70.16	5.04	3.90	3.90
	(b) Subernarekha (under AIBP)								1068.87	324.76	63.11	1.00	0.00
	(c) Subernarekha (State fund & WB)								1269.49	237.90	119.33	0.00	0.00
	Sub-Total (8)		790.32				109.63		2408.52	632.82	187.48	4.90	3.90
9	Upper Indravati Dams	1978 (P.C)	34.92	Godavari / Indravati	Kalahandi	Storage	—	A.P 1978-8	125.35	125.35	Multipurpose Project		
10	Upper Indravati Irrigation												
	(i) Lift Canal System	1978 (P.C)	42.74	Deferred in 1998, Now, D.P.R has been submitted		From Hati	33.03*	A.P 1978-8					
	(ii) Barrage & Left Canal			separately to CWC for techno-economic approval		Barrage	49.08		219.29	219.29	80.49	83.38	80.49
	(iii) Right Canal System			Godavari / Indravati	Kalahandi		27.19				44.59	41.71	41.71
	(iv) Upper Indravati Extn	2003 P.C)	136.67	Included under Original Project in 2003-04			25.48	X			41.79	0.00	0.00
	Sub- Total (10)		214.33				101.76		596.06	538.75	166.88	125.09	122.20
11	Lower Indra	1999 (P.C)	211.70	Mahanadi/ Indra	Nuapada & Bolangir	Storage	29.90	IX	528.98	253.40	38.87	0.00	0.00
12	Lower Suktei	1999 (P.C)	217.13	Mahanadi / Suktel	Bolangir & Sonepur	Storage	31.83	IX	585.07	69.55	40.42	0.00	0.00
13	Kanpur	2002 (P.C)	428.32	Baitarani / Baitarani	Keonjhar	Storage	29.58	VIII	625.00	38.36	41.70	0.00	0.00
	Total	2400.38					626.05		9536.83	4164.36	1061.61	342.04	234.52

Table 6.11 Ongoing Medium Projects in 10th Plan

Slno	Name of Projects	Year of Approval	Approved cost (Rs. In Cr)	Basin / River	District Benefitted	Type	CCA ('000 ha)	Started in plan Estimated	Cost (Rs. In Cr) Latest 03/2006	Expdr. upto potential	Benefit ('000th. Ha) Ultimate	Total Potential created up 3/2006**	Utilization upto 03/2006
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Badanalla	P.C (1981)	13.36	Vamsadhara / Badanalla	Rayagada	Storage	8.65	VI	128.15	128.15	13.32	14.46	14.46
2	Upper jonk	P.C (1981)	12.78	Mahanadi / Jonk	Nuapada	Storage	9.43	VI	104.54	104.54	13.01	12.69	12.69
3	Hariharjore	P.C (1978)	7.26	Mahanadi / Hariharjore	Sonepur	Storage	9.45	A.P1978-80	92.26	92.26	13.70	13.70	12.78
4	Harabhangi	P.C (1979)	9.01	Vamsadhara / Harbhangi	Gajapati & Ganjam	Storage	9.15	A.P1978-80	151.56	151.56	17.66	13.79	13.29
5	Baghua St-II	P.C (1978)	6.23	Rushikulya / Baghua	Ganjam	Storage	3.24	VII	82.60	82.60	5.88	5.88	5.88
6	Sapua Badjore	P.C (1989)	14.57	Brahmani / Sapua	Dhenkanal	Diversion	2.52	VII	43.17	43.17	3.53	2.62	2.62
7	Kharakhara (Upper Jonk Extn.)	State TAC (1996)	18.00	Mahanadi / Jonk	Nuapada	Diversion	1.95	IX	24.42	24.42	1.70	1.70	1.20
8	Gobardhanpur	State TAC (1996)	7.23	Mahanadi / Bhargavi	Puri	Diversion	1.80	VIII	12.73	12.73	1.80	1.80	1.80
9	Creek Irrigation Project Nagarihat, Guneimuhan & Prachikundhei) *	State TAC (1997)	6.33	—	J.S. Pur	Creek	3.75	IX	5.40	5.40	3.75	3.75	3.75
10	Bagh Barrage Project	P.C (1995)	44.72	Mahanadi / Bagh	Boudh	Diversion	9.66	VIII	75.65	51.08	12.36	2.85	1.85
11	Baghalati Irrigation Project	P.C (1995)	45.44	Bahuda / Bahuda	Ganjam	Storage	5.05	VIII	121.89	88.96	6.05	4.42	2.41
12	Titlagarh Irrigation Project	P.C (1993)	21.12	Mahanadi / Kankadajore Jamunajore	Bolangir	Storage cum Diversion	2.60	VIII	56.44	42.64	2.67	0.47	0.47
13	Deo Irrigation Project	P.C (1992)	52.23	Baitarani / Deo	Mayurbhanj & Keonjhar	Storage	9.90	VIII	148.58	49.83	15.88	0.00	0.00
14	Manjore Irrigation Project	1993 (TAC CWC)	37.70	Mahanadi / Manjore	Anugul	Storage	6.78	VIII	99.53	91.68	10.44	2.30	0.00
15	Rukura Irrigation Project	1993 (TAC CWC)	52.24	Brahmani / Rukura	Sundergarh	Storage	5.75	IX	95.77	12.93	7.65	0.00	0.00
16	Rajua Irrigation Project	1999 (TAC CWC)	13.84	Mahanadi / Rajua Nalla	Khurda	Diversion	2.69	IX	14.31	3.58	2.69	0.00	0.00
	Total		362.06				92.36		1257.00	985.53	132.09	80.43	73.20

Table 6.12 Ongoing ERM Projects in 10th Plan

Sl.no	Name of the Project	Year of Approval	Approved cost (Rs. In Cr)	Name of the Original project	Basin / River	District Benefitted	Started in plan	Cost (Rs. in Cr) Latest Estimated	Expdr. upto 03/2006**	CCA **	Benefit ('000Th ha) Ultimate	Potential created up to 3/2006**	Utilization upto 03/2006
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	WRCP	1995 (P.C)	977.01	—	—	Whole State	VIII	464.84	464.84	Stabilization to 239.15 Th. ha of CCA achieved			
2	Dhanei Extn.	1996-97	0.94	Dhanei	Ruhikulya / Dhanei	Ganjam	VIII	2.79	2.79	0.57	0.57	0.57	0.57
3	Hiradharbati Extn.	1996-97	0.81	Hiradharbati	Ruhikulya / Ruhikulya	Ganjam	VIII	1.33	1.33	0.59	0.59	0.59	0.59
4	Kanjhari Extn.	1996-97	7.80	Kanjhari	Baitarani / Kanjhari	Keonjhar	VIII	7.55	7.55	1.30	1.60	1.60	1.60
5	Salia Extn.	1996-97	2.60	Salia	Mahanadi / Salia	Khurda	VIII	3.49	3.49	1.01	1.01	1.01	1.01
6	Ghodahada Extn.	1997-98	3.04	Ghodahada	Ruhikulya / Ghodahada	Ganjam	IX	5.28	5.28	0.56	0.56	0.56	.056
7	Budhabudhiani Extn.	1997-98	4.38	Bhudabudhiani	Mahanadi / Budhabudhiani	Nayagarh	IX	5.30	5.30	1.00	1.00	1.00	1.00
8	Alaka Hansua Drainage	1997-98	9.25	—	—	Cuttack	IX	6.71	6.71	No Direct Benefit			
9	Sunder Extn.	1997-98	1.59	Sunder	Mahanadi / Sunder	Nuapada	IX	2.00	2.00	0.63	0.63	0.63	0.63
10	Gobakunda H.L.Bridge	1998-99	5.23	Gobakunda Cut	—	Puri	IX	6.72	6.72	No Direct Benefit			
11	Salandi (AKD)	1998-99	4.78	Salandi	Baitarani / salandi	Bhadrak	IX	2.45		No Direct Benefit			
12	Dumerbahal Extn.	1998-99	3.71	Dumerbahal	Mahanadi / Dumerbahal	Baragarh	IX	3.58	3.58	0.77	0.77	0.77	0.77
13	Baghua Dhanei Doab	1999-00	12.11	Baghua Dhanei Doab	Rushikulya	Ganjam	IX	11.37	11.37	1.95	1.95	1.89	0
	Sub-Total		1033.25					523.40	520.96	8.36	8.68	8.62	6.73

Table 6.13 (a) New Major Projects in 10th Plan

Sl. No.	Name of the Project	Year of Approval	Approved cost (Rs. In Cr)	Basin / River	District Benefitted	Type	CCA (000 Ha)	Cost (Rs. in Cr) Latest Estimated	Expdr. upto 03/2006**	Benefit ('000Th ha) Ultimate Potential	Potential created up to 3/2006**	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Integrated Anandapur Barrage	2004 (P.C) & 2003 (P.C)	617.47(2000)	Baitarani / Baitarani & Salandi	Bhadrak, Keonjhar, Balasore	Diversion	65.88	617.47	37.51	62.60 & 7.11 (S)	5.88	***
	Sub total		617.47				65.88	617.47	37.51	62.60 & 7.11 (S)	5.88	

***Anandapur Barrage Ph-II (Approved Cost Rs.482.26 cr, CCA 60.00 Th. ha. Ultimate potential 56.72Th.ha. Approved by PC-2004) Salandi Sanskar (Approved cost Rs.99.14 cr, Stabilization -7.111 Th.ha. Approved by PC-2003) Anandapur Exten. (Approved cost Rs.36.07 cr, CCA-5.877 Th.ha. Ultimate potential-5.877 Th.ha P.C approved). Included under AIBP

Table 6.13 (b) Projects Proposed Under 10th Plan but could not Commence

Sl.no	Name of the Project	Year of Approval	Approved cost (Rs. In Cr)	Basin / River	District Benefitted	Type	CCA (000 Ha)	Cost (Rs. in Cr)		Benefit ('000Th ha)		Reasons for not Starting
								Latest Estimated	Expdr. upto 03/2006**	Ultimate Potential	Potential created up to 3/2006**	
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Brutang	2000 (CWC TAC)	227.25(2000)	Mahanadi / Brutang	Nayagarh	Reservoir	23.30	227.25	0.50	30.29	0.00	Not started due to funds constraint and P.C clearance. It will be posed to World Bank for funding.
2	Ong. Dam	2000 (CWC TAC)	304.66(2000)	Mahanadi / Ong	Baragarh	Reservoir	30.00	304.66	2.42	34.50	0.00	Not started due to funds constraint and P.C clearance. It will be posed to World Bank for funding.
3	IB Project	2000 (CWC TAC)	1140.00(2000)	Mahanadi / IB	Sundergarh, Jhasuguda Sambalpur	Reservoir	106.28	1140.00	0.39	106.28	0.00	Not started due to funds constraint and P.C clearance. It will be posed to World Bank for funding.
	Sub- Total		1671.91				159.58	1671.91	3.31	171.07	0.00	

Table 6.14 (a) New Medium Projects in 10th Plan

Sl.no	Name of the Project	Year of Approval	Approved cost (Rs. In Cr)	Price level	Basin / River	District Benefitted	Type	CCA ('000 ha)	Cost (Rs. In Cr)		Benefit in 000 ha		Remark(Details of Ultimate Potential)
									Latest Estimated	Expdr. Upto 03/2006**	Ultimate Potential	Potential created upto 03/06	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Telengiri	2003 (P.C)	106.18	1999	Godavari / Telengiri	Koraput	Reservoir	9.95	106.18	31.82	13.83	0.00	Started during 2003-04 under AIBP (Khariff-8.86 Th.ha, Rabi-4.97 Th.ha)
2	Chheligada	2003(P.C)	52.96	1999	Vamsadhara / Badjore	Ganjam	Reservoir	3.00	78.74	7.63	3.12	0.00	Started during 2003-04 under AIBP (Khariff-2.85 Th.ha Rabi-0.27 Th.ha)
3	Ret	2003(P.C)	86.14	1999	Mahanadi / Ret	Kalahandi	Reservoir	8.50	151.27	21.18	9.78	0.00	Started during 2003-04 under AIBP (Khariff-7.22 Th.ha Rabi-2.55 Th.Ha)
4	Dalak (Hadua)	2001 (P.C)	61.48	2000	Mahanadi/ Hadua	Cuttack	Reservoir	3.95	95.44	0.09	5.73	0.00	Ph-I of the project costing Rs.56.14 Cr. Started during 2005-06 (Khariff-1.25 Th. ha Rabi-0.85 Th.ha)
	Sub- Total		306.76					25.40	431.63	60.72	32.45	0.00	

Sl.no	Name of the Project	Year of Approval	Approved cost (Rs. In Cr)	Price level	Basin / River	District Benefitted	Type	CCA ('000 ha)	Cost (Rs. In Cr) Latest Estimated	Expdr. Upto 03/2006**	Benefit in 000 ha Ultimate Potential	Potential created upto 03/06	Remark(Details of Ultimate Potential)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
5	Creek Irrigation Projects												
	a) Malibasa Tantipal Creek	2001 (State TAC)	6.75	2001	—	Kendrapara	Creek	4.00	6.75	3.68	8.00	0.00	Started during 2002-03 under RIDF funding (Khariff-4.00 Th.ha, Rabi-4.00 Th.ha)
	b) Kathilogotha Creek	2001 (State TAC)	3.61	2001	—	Khurda	Creek	1.07	3.61	1.27	1.76	0.00	Started during 2002-03 under RIDF funding (Khariff-1.07 Th.ha, Rabi-0.69Th.ha)
	c) Weekhia Creek	2002 (State TAC)	4.78	2002	—	Khurda	Creek	1.70	4.78	0.04	2.30	0.00	Started during 2004-05 under RIDF funding (Khariff-1.07 Th.ha, Rabi-0.60Th.ha)
	d) Galiajore Creek	2002 (State TAC)	3.56	2002	—	Bhadrak	Creek	1.87	3.56	1.15	2.10	0.00	Started during 2005-06 under RIDF funding (Khariff-1.17 Th.ha , Rabi-0.92Th.ha)
	e) Arjunbindha Creek	2002 (State TAC)	2.60	2002	—	Bhadrak	Creek	1.57	2.60	0.00	2.80	0.00	Started during 2005-06 under RIDF funding (Khariff-1.228 Th.ha, Rabi-0.569Th.ha)
	f) Rajkanika Creek	2002 (State TAC)	3.72	2002	—	Kendrapara	Creek	1.79	3.72	0.05	3.58	0.00	Started during 2005-06 under RIDF funding (Khariff-1.79 Th.ha, Rabi-1.79Th.ha)
	g) Tikarpara Creek	2003 (State TAC)	1.19	2003	—	Puri	Creek	0.65	1.19	0.12	1.00	0.00	Started during 2005-06 under RIDF funding (Khariff-0.65 Th.ha, Rabi-0.35Th.ha)
	Sub- Total		26.21					12.65	26.21	6.30	21.54	0.00	

Table 6.14 (b) Projects Proposed Under 10th Plan but could not Continue

Sl.no	Name of the Project	Year of Approval	Approved cost (Rs. in Cr)	Price level	Basin / River	District Benefitted	Type	CCA ('000 ha)	Cost (Rs. In Cr)		Benefit in 000 Ha		Remark (Details of Ultimate Potential)
									Latest Estimated	Expdr. Upto 03/2006**	Ultimate Potential	Potential created upto 03/06	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Katra	2003 (CWC TAC)	87.98	1998	Bhudhabalanga / Katra	Mayurbhanj	Reservoir	8.00	87.98	0.00	11.44	0.00	Not started, R & R clearances are under process.
2	Mahendratanaya	2002 (CWC TAC)	100.98	2000	Vamsadhara / Mahendratanaya	Gajapati	Reservoir	7.94	100.98	0.00	9.51	0.00	Not started, forest, R & R clearances are under process.
3	Dhauragoth	1998 (CWC TAC)	16.80	1998	Brahmani / Sindholijore	Anugul	Reservoir	2.23	47.53	0.00	3.02	0.00	Not stared due to funds constraint. This project is now included in Mahanadi Basin Development Plan, which has been submitted to MOWR for clearance. After clearance it will be posed to World Bank funding.
	Sub- Total		205.16					18.17	236.49	0.0	23.97	0.00	

Table 6.15 New ERM Projects in 10th Plan

Slno	Name of the Project	Year of Approval	Approved cost (Rs. in Cr)	Name of Original Project	Basin / River	District Benefitted	Cost (Rs. In Cr)			Benefit in 000 Ha		Remark
							Latest Estimated	Expdr. Upto 03/2006**	Addl. CCA	Ultimate Potential	Potential created upto 03/2006	
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Poichandia Canal Extn.	2001-02	2.93	Bahuda	Baduda / Bahuda	Ganjam	4.23	4.23	0.73	0.73	0.73	Completed
2	Imp. To Baldiha D/W	2002-03	2.10	Baldiha	Budahbalanga /Baldiha	Mayurbhanj	2.32	2.32	No Direct Benefit			Completed
3	Imp. to Sason Canal	2002 (P.C)	34.92	Hirakud	Mahanadi / mahanai	Sambalpur	42.33	42.33	Stibilisation to 16.282 Th.Ha. of existing CCA			Completed
4	Imp. to Salki Project	2004 (P.C)	11.57	Salki	Mahanadi / Salki	Boudh	12.41	12.41	Stibilisation to 16.282 Th.Ha. of existing CCA			Completed
5	Imp. to Road to Saradhapur Kaniabadi Disty of Salia Irr.	2002-03	0.88	Salia	Mahanadi / Salia	Khurda	1.01	1.01	No direct Benefit			Completed
6	Salandi Main Canal (Ambahata)	2003	6.19	Salandi System	Baitarani / Salandi	Bhadrak	7.54	7.54	3.65	3.65	3.20	Completed
7	Sumandal Main Canal (Salia Extn.	2003	2.62	Salia	Mahanadi / Salia	Khurda	2.62	1.01	0.40	0.55	0.00	Under Progress
8	Daha Ectension	2005	10.24	Daha	Rushikulya / Daha	Ganjam	10.24	1.07	1.82	1.82	0.00	Started during 05-06
9	Bahuda Renovation	2005	9.54	Bahuda	Bahuda / Bahuda	Ganjam	9.54	1.28	0.00	7.335 (stabilization)	0.00	Started during 2005-06
10	Ong. Extn.	2005	26.88	Ong. Irr.	Mahanadi / Ong	Sonepur	26.88	0.00	5.13	5.13	0.00	Started during 2005-06
11	Satiguda MIP	2005	4.29	Satiguda	Godavari / Satiguda	Malkangiri	4.29	0.00	0.00	2.144 (stabilization)	0.00	Started during 2005-06
	Total		112.16				123.41	73.20	11.73	11.88	3.93	

Source: - Engineer in Chief (W.R), Orissa, Bhubaneswar

6.2.3 Description and Salient Features of few Completed & Ongoing Major & Medium Projects

6.2.3.1 Salient Features

Salient Features of few major and medium projects are furnished in Table 6.16.

Table 6.16 Salient Features of Some Selected Irrigation Projects of the State

SL No	Name of Projects	Hirakud	Rengali	Rengali Irrgn.	Balimela	Potteru	Jalaput	Upper Indravati H.E. Project*				U I Irrign.	Upper Kolab Project	
		Dam*	Dam*	Samal Barrage	Dam*	Barrage	Dam*	Indravati Dam	Podagada Dam	Kapur Dam	Muran Dam	Hati Barrage	UKP * Dam	UKP Irrgn.
1	Basin	Mahanadi	Brahmani	Brahmani	Godavari	Godavari	Godavari	Godavari	Godavari	Godavari	Godavari	Mahanadi	Godavari	Godavari
2	Sub-Basin	Mahanadi	Brahmani	Brahmani	Sileru	Potteru	Machhakund	Indravati	Podagada	Kapur	Muran	Hati	Kolab	Satiguda (Kolab)
3	District	Sambalpur	Angul	Angul	Malkangiri	Malkangiri	Malkangiri	Nawarangpur	Nawarangpur	Nawarangpur	Nawarangpur	Kalahandi	Koraput	Koraput
4	Catchment area in sqkm	83,400	25,250	4780	4912	210	1963	1153	389	60	1028	-	1630	-
5	Design flood (cumec)	15lakh cusecs	27,800	49,000	14300	1174.5	5660	23030	for the composite reservoir comprising all			1544	7650	334
6	M.W.L (m)	630ft(192.02m)	125.4	79.5	462.69	165.66	838.2	643	four dams. Reservoirs connected by two			265	858	595.2
7	F.R.L. (m)	630ft(192.02m)	123.5	76.2	462.09	163.97	838.2	642	Link channels. Water released from			265	858	593.5
8	D.S.L. (m)	590ft(179.83m)	109.72	-	438.89		818.39	625	powerhouse is picked up at Hati barrage			-	844	-
9	Gross storage cap (Mm3)	8136	4400	148.85	3822.8		970.36	2300	for Irrigation.			6.04	1215	334
10	Live storage cap (Mm3)	5818	3452	-	2880		892.54	1485.5				-	935	-
11	Area water spread (ha)	74300	414500	2888	17512		9712.0	11000				-	11350	-
12	Type of Dam	Composite	Masonry	Barrage	Earthfill	Barrage	Masonry	Masonry	Earth fill	Earth fill	Masonry		Masonry	Earth fill
13	Length of Dam(m)	4840	1040	560.5	1821		1425	555	462	537	494	117	630.5	942.5
14	Maximum height (m)	60.96	71	-	70	-	60.66	45	71	64	65		54.5	16.7
15	Type of spillway	Ogee	Ogee	-	Ogee	-	Ogee	Ogee	Not provided	Not provided	Ogee	Barrage	Ogee	Chute
16	Length (m)	947.88	464	-	152.4	97.97	146.3	129			91		255.5	44
17	G.C.A. (ha).	251454	Irrigation	4,36,179	Irrigation	101700	—	Barrage constructed across Hati river in Mahanadi				135740		55679
18	C.C.A. (ha)	1,55,660	from Samal	2,35,500	from	61035	—	basin, where discharge from Tail race channel is				109300		44544
19	Kharif Irr.(ha)	1,54,540	barrage	2,14,300	Potteru	61035	—	picked up for irrigation in Kalahandi				109300		44544
20	Rabi Irr. (ha)	108,385		2,09,300	barrage	51850	—					109300		35789
21	Year of commencement	1948	1973	1978	1962	1972	1946	1978-79	1978-79	1978-79	1978-79	1978-79	1976	1976
22	Year of completion	1957	1992	Ongoing	1977	complete	1959	1996	1996	1996	1996	ongoing	1991	On going

Salient Features Continued.....

SL No	Name of Projects	Sundar Dam	Saipala Dam	Dumer Bahal Dam	Ultei Dam	Upperjonk Dam	Lower Indra Dam	Ib Dam	Sarafgarh Dam	Talasara Dam	Jharbandh Dam	Ong dam Dam	Titilagarh Dam	Lower Suktel Dam	Hariharjore Dam	Upper Suktel Dam	Ong Stage-I Barrage
1	Basin	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi
2	Sub-Basin	Sundar	Saipala	Dumerbahal	Uttei	Jonk	Indra	Ib	Sarafgarh	Talasara	Kukurijhar	Ong	Kankadajore	Suktel	Hariharjore	Suktel	Ong Barrage
3	District	Kalahandi	Kalahandi	Kalahandi	Kalahandi	Kalahandi	Nuapada	Sundargarh	Sundargarh	Sundargarh	Sambalpur	Baragarh	Bolangir	Bolangir	Bolangir	Bolangir	Bolangir
4	Catchment area in sqkm	145	86	90	456	342	1093	5649	65.3	91	62	2321	71.2	1275	425	45	3445
5	Design flood (cumec)	312.5	639.58		2010	3555	6831	31900	695	820	489	12730	850	8540	3785	683	7500
6	M.W.L (m)	310	307.84	292	196.19	350.6	265	272.5	304.5	296.3	255.55	219	216.3	206	148.3	309.8	160.48
7	F.R.L. (m)	307.6	306.32	289.56	188.11	350.6	265	272.5	304.5	296.3	252.5	219	216.3	206	147.5	307.6	155.45
8	D.S.L. (m)	301.25		284.3		343.5	251	252.5	295.5	288.3	250.5	209.5	212	197	141.45	300.3	151.48
9	Gross storage cap (Mm3)	26.35	21.265	22.2		80.5	321.63	1610.11	85.64	19.85	5.73	330	13.38	320.28	79.88	12.3	
10	Live storage cap (Mm3)	23.55	18.33	19.32		64.5	314.25	1453.3	74.86	16.65	3.48	289	10.86	263.43	58.68		
11	Area water spread (ha)	698		755.75		1470	4766	12562	151.5	351	460	5100	435	5216	1845	460	
12	Type of Dam	Earthfill	Earthfill	Earthfill	Weir	Earthfill	Earthfill	Composite	Earthfill	Earthfill	Masonry	Earthfill	Earthfill	Earthfill	Earthfill	Earthfill	Weir
13	Length of Dam(m)	2810	289.56	2648.8	77.73	627	3780	3825	240.5	1095	44.8	1128	1940	1410	2296	1573	243.84
14	Maximum height (m)	18.34		21.75		24.81	22	44	30	21	18	30	14	30	18.5	20.19	
15	Type of spillway	Ogee	Chute	Ogee		Ogee	Ogee	Ogee	Chute	Ogee	Ogee	Ogee	Ogee	Ogee	Ogee	Ogee	
16	Length (m)	88.4	121.92	82		113.5	159	695	63	91.25	43	195	60	177	128	60	
17	G.C.A. (ha).	5790	3440	3590	12,746	11,670	37390	145588	3200	4340	2800	40000	3,400	37857	13,420	1930	15,600
18	C.C.A. (ha)	4530	3090	2800	9,626	9920	29900	106279	2240	3040	2130	30000	2600	31830	9950	1350	12,450
19	Kharif Irr.(ha)	4400	2060	2660	9,610	9430	26910	106279	2240	3030	2130	22500	2400	31830	9950	1010	12,450
20	Rabi Irr. (ha)	1620	1100	1120	2,430	4250	11960	10628	1340	1820	1230	12000	1500	13369	4250	510	2,410
21	Year of commencement	1972-73	1971	1972	1,971	1977-78	2001	Yet to	1978	1978	1977	Yet to		2001	1978-79	1978-79	1,975
22	Year of completion	1987	1974	1990	1,977	Complete	ongoing	Commence	1987	1988	1988	Commence	ongoing	ongoing	Complete	Complete	1,991

Salient Features Continued.....

SL No	Name of Projects	Manjore Dam	Bagh Barrage	Salki Barrage	Pilasalki Dam	Brutanga Dam	Gohira Dam	Ramial Dam	Mahanadi Delta Project: Mahanadi Barrage	Mahanadi Delta Project: Birupa Barrage	Mahanadi Delta Project: Munduli Weir	Mahanadi Chitrotpala Irr. Project	Birupa-genguti Irrigation Project	Budhabudhiani Dam	Dahuka weir	Kuanria Dam
1	Basin	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Brahmani	Brahmani	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi	Mahanadi
2	Sub-Basin	Manjore	Bagh	Salki	Pilasalki	Brutanga	Gohira	Ramial	Mahanadi	Birupa	Mahanadi	Mahanadi	Birupa-genguti	Budhabudhiani	Dahuka	Kuanria
3	District	Dhenkanal	Phulbani	Phulbani	Phulabani	Nayagarh	Sambalpur	Dhenkanal	Cuttack	Cuttack	Cuttack	Cuttack	Cuttack	Puri	Puri	Puri
4	Catchment area in sqkm	452	1106		87.36	725	236	328	1,32,085					725	417	124
5	Design flood (cumec)	4333	6165	-	709	5683	2550	1698	15300	2070		Canal off-takes	Canal off-takes	-	1803	1812
6	M.W.L (m)	120	141.9		544.2	165	237.35	110.64	21.2	21.2	24	from	from	147.29		135.7
7	F.R.L. (m)	120	141.9		540.5	165	237	109.73	-	-	-	Harichandanpur	Pattamundai	145.16		135.7
8	D.S.L. (m)	110	-			145	227	101.95	-	-	-	from Kendrapara	canlal and	138.07		130.3
9	Gross storage cap (Mm3)	100.77			17.53	242.5	79.4	86	-	-	-	canal and	crosses river	1500		22
10	Live storage cap (Mm3)	85.24			14.45	221.6	72	69.4	-	-	-	crosses river	Birupa through a	1251.6		17.5
11	Area water spread (ha)	1460.55			524.8	2210.0	1094	1669	nil	nil	nil	Chitrotpala	syphon to	71.7		4855
12	Type of Dam	Earthfill	Barrage		Earthfill	Earthfill	Earthfill	Earthfilll	-	-	Solid crest	through a syphon	enter the island.	Earthfill	Weir	Earthfill
13	Length of Dam(m)	2050	-		458	552	3450	475	1944.2	180	1365	to enter		1340	152.4	1576
14	Maximum height (m)	26	-		26.08	42	28	28.35	-	-	-	the island.				21
15	Type of spillway	Ogee	-		Ogee	Chute	Chute	Ogee						Ogee		Ogee
16	Length (m)	192	211		30	125.0	72.2	55.5		HLC	Irrigation			36.57		75
17	G.C.A. (ha).	5731	10900	31260	3320	31110	11750	14065	5,44,700	Range I	in stage II	27920	5160	3994	6270	4800
18	C.C.A. (ha)	4585	8500	19870	2390	23300	8100	9600	3,03,000	takes-off.		19540	3870	3290	2740	3600
19	Kharif Irr.(ha)	4126	8500	19870	2390	20970	8100	9600	3,36,300			16612	3830	3290	2740	3600
20	Rabi Irr. (ha)	4126	3920	2020	1200	9320	5700	6000	2,13,240			15438	4260	1090		1930
21	Year of commencement		**1984-85**	**1960**	**1974**	**Yet to**	**1977**	**1972**	**1980-81**			**1990**	**1988**	**1960**	**1973**	**1977**
22	Year of completion	**Ongoing**	**Complete**	**1977**	**1986**	**commence**	**1982**	**1988**	**1991-92**	**Complete**	**Complete**	**ongoing**	**ongoing**	**1967**	**1979**	**1988**

Salient Features Continued.....

SL No	Name of Projects	Khadkei	Subarnarekha Irrigation Project			Nesa	Bankbahal	Kanupur	Salandi**	Bidyadharpur	Anandapur	Remal	Deo	Kanjhari
			Haldia	Jambhira	Baura									
		Dam	Dam	Dam	Dam	Dam	Dam	Dam	Dam	Barrage	Barrage	Dam	Dam	Dam
1	Basin	Subarnarekha	Subarnarekha	Subarnarekha	Subarnarekha	Subarnarekha	Subarnarekha	Baitarani	Baitarani	Baitarani	Baitarani	Baitarani	Baitarani	Baitarani
2	Sub-Basin	Khadkei	Subarnarekha	Subarnarekha	Subarnarekha	Nesa	Bankbahal	Baitarani	Salandi	Salandi	Baitarani	Remal	Deo	Kanjhari
3	District	Mayurbhanj	Mayurbhanja	Mayurbhanja	Mayurbhanja	Mayurbhanja	Mayurbhanj	Keonjhar	Keonjhar	Keonjhar	Keonjhar	Keonjhar	Mayurbhanj	Keonjhar
4	Catchment area in sqkm	212.5	55	76.5	47.00	24.61	168.5	1560	673	673	8570	98.5	295	358
5	Design flood (cumec)	2240	1064.4	1457.8	893.60	351	1970	14450	5140	3256	15217	1037	2530	2286
6	M.W.L (m)	313.5	75.8	78.1	74.10	264.5	306	440	83.21	40.23	44	121	412	408.5
7	F.R.L. (m)	313.5	74.3	76.6	72.60	263	305	440	82.3	35.36	38	121	412	408.5
8	D.S.L. (m)	302.5	64.28	57.9	48.03	257.15	300	425	50.24			107.2	398.6	398
9	Gross storage cap (Mm3)	63.6	58.1	223.65	261.31	7.8	28.26	331.02	601			19.26	75.82	40.52
10	Live storage cap (Mm3)	56.22	46.87	204.77	227.31	6.58	25.78		556.5			15.7	68.44	34.52
11	Area water spread (ha)	980	968	2928	2759.00	169.17	770	2600	3182			198	847.5	5164
12	Type of Dam	Earthfill	Earthfill	Rock filled	Earth fill	Earthfill	Earthfill	Earthfill	Composite	Barrage	Barrage	Earthfill	Composite	Earthfill
13	Length of Dam(m)	204.5	420	736	995.00	720	1758	3247	640			1454	1343+160	1228.5
14	Maximum height (m)	32.5	23.1	30.4	38.00	18	23	36.02	48.77			34	31.7	29.5
15	Type of spillway	Ogee	Chute	Chute	Chute	Broad crested	Ogee	ogee	Ogee			Ogee	Ogee	Ogee
16	Length (m)	58.56	17	30	15	90	82	213	114.6	204.22	730	55.5	84.5	111.5
17	G.C.A. (ha).	10,560	170263	In respect of		1600	9600	39440	Irrigation from	107380	67500	5500	14,140	14410
18	C.C.A. (ha)	7990	109627	entire Subarnarekha		1200	7200	29580	Bidyadharpur	92987	60000	4705	9900	9800
19	Kharif Irr.(ha)	7990	104146	Project		1200	6840	24250	Barrage	92987	56720	4705	9570	9800
20	Rabi Irr. (ha)	4050	86217			400	2970	23150		12746	12400	2118	7330	3590
21	Year of commencement	**1973**	**1987**		**Yet to**	**1974**	**1980-81**	**2003**	**1,960**		**1973**	**1974**	**1984-85**	**1979**
22	Year of completion	**1979**	**On going**	**On going**	**Commence**	**1980**	**1993**	**ongoing**	**1,983**	**Complete**	**on going**	**1988**	**ongoing**	**1991**

Salient Features Continued.....

SL No	Name of Projects	Kansbahal	Pitamahal	Gohira	Sapua-Badjore Project		Dadaraghati	Aunli	Derjang	Daha	Baghua	Baghua Stg-II	Dhanei	Ghodahada	Ramanadi	Hiradhabati
					Sapua	Diversion										
		Dam	Dam	Dam	Dam	Weir	Dam	Weir	Dam	Dam	Dam	Dam	Dam	Dam	Weir	Weir
1	Basin	Brahmani	Brahmani	Brahmani	Brahmani	Brahmani	Brahmani	Brahmani	Brahmani	Rusikulya	Rushikulya	Rushikulya	Rushikulya	Rushikulya	Rushikulya	Rushikulya
2	Sub-Basin	Barjorinalla	Pitamahal	Gohira	Sapua	Badjore	Dadaraghati	Aunil	Lingara	Daha	Baghua	Baghua Stg-II	Dhanei	Ghodahad	Ramanadi	Hiradharbati
3	District	Sundargarh	Sundargarh	Sambalpur	Dhenkanal	Dhenkanal	Angul	Dhenkanal	Angul	Ganjam	Ganjam	Ganjam	Ganjam	Ganjam	Ganjam	Ganjam
4	Catchment area in sqkm	179	103.6	236	52	36	102.4	150.22	399	167	171	150	106	137	150.2	645
5	Design flood (cumec)	1745	716	2550	535.6	735	718.82	948	3592	1160	1315	NA	849.37	594.3	1008	
6	M.W.L (m)	228	246.88	237.35	171.5	-	120.5	198.75	150.91	118.6	101.3	113.85	91.74	112.78	110.44	25.3
7	F.R.L. (m)	228	246.88	237	168.5	-	118.87	195.9	150	118.6	99.7	113.85	88.7	112.78	106.8	20.8
8	D.S.L. (m)	220.5	NA	227	161.1	-	111.55		140.24	112.4	-	108.01	82.77	104.5		
9	Gross storage cap (Mm3)	40.415	23.62	79.4	8.5	-	27.75		51.13	28	33.9	37.5	15.326	22.109		
10	Live storage cap (Mm3)	28.72	20.16	72	6.46	-	24.05		46.48	21.95	27.4	--	13.127	20.128		
11	Area water spread (ha)	506	355	1094	110		759		943.37	552	1000	869	840	150		
12	Type of Dam	Earthfill	Earthfill	Earthfill	Earthfill	Weir	Rockfill	Weir	Earthfill	Earthfill	Earthfill	Earthfill	Earthfill	Earthfill	Weir	Weir
13	Length of Dam(m)	1050	660.2	3450	1175		-	68.5	1875	3370	1860	1600	1341.12	1667	-	207
14	Maximum height (m)	28	24.43	28	24.32		17.98		27.31	19.3	-	19.09	20.6	24		
15	Type of spillway	Ogee	Ogee	Chute	Ogee	-	Ogee		Ogee	Ogee	Broad crest	Ogee	Ogee	Ogee		
16	Length (m)	110	45.72	72.2	47	-	91.44		164.63	73	152.5	84.5	33.53	103.6		
17	G.C.A. (ha).	7,210	3,250	11750	1400	2070	5164	2830	14,532	7850	4050	10,000	4860	7280	1760	6360
18	C.C.A. (ha)	5050	2,630	8100	950	1570	4510	1750	8400	4760	3240	8000	3845	6630	1600	5090
19	Kharif Irr.(ha)	4610	2,610	8100	855	1413	4510	1750	7392	4760	3240	6400	3845	6200+1210	990	5680
20	Rabi Irr. (ha)	3500	1,620	5700	475	785	1810		1824	2290	810	1040	1420	nil	300	220
21	Year of commencement	**1980**	**1,967**	**1977**	**1984-85**		**1972**	**1977**	**1960**	**1975**	**1970**	**1978-79**	**1956**	**1963**	**1975**	**1946**
22	Year of completion	**Complete**	**1,977**	**1982**	**Complete**	**Complete**	**1988**	**1987**	**1978**	**1988**	**1978**	**ongoing**	**1975**	**1978**	**1985**	**1974**

Salient Features Continued.....

SL No	Name of Projects	Jayamangala	Salia	Badnalla	Harabhangi	Satiguda	Bhaskel	Bahuda Project			Sunei	Kalo	Baldiha
								Kalingdala	Poichandia (Budagada)	Surangi (Bogi)			
		Weir	Dam	Dam	Dam	Dam	Dam	Weir	Weir	Weir	Dam	Dam	Dam
1	Basin	Rushikulya	Salia	Vansadhara	Vansadhara	Godavari	Godavari	Bahuda	Bahuda	Bahuda	Budhabalang	Budhabalang	Budhabalanga
2	Sub-Basin	Jayamangal	Salia	Badnalla	Harabhangi	Satiguda	Bhaskel	Bahuda	Bahuda	Bahuda	Sunei	Kalo	Baldiha
3	District	Ganjam	Puri	Koraput	Ganjam	Malkangiri	Nawarangpur	Ganjam	Ganjam	Ganjam	Mayurbhanj	Mayurbhanj	Mayurbhanja
4	Catchment area in sqkm	1218		352	503.8	129.5	87	456	55.5	46.6	227	151	205
5	Design flood (cumec)	NA		4026	2842		566	2039	441	275	1865	2476	1448
6	M.W.L (m)	27.81	61.28	176	387.5	194.29	628.19	32	65.1	51.3	85	77.7	202
7	F.R.L. (m)	24.46	58.53	176	387.5	192.63	626.66	29.93	63.3		85	77.7	202
8	D.S.L. (m)	-	48.82	163.8	375		618.44	-	-		72	71.32	-
9	Gross storage cap (Mm3)	-	60.65	75.64	141.25	74.9	29.825	-	-		61.6	29.6	-
10	Live storage cap (Mm3)	-	52.75	67.14	100.25	67.2	27.65	-	-		55	24.15	-
11	Area water spread (ha)	-	984	930	1215	1177	642.26	-	-		682	534	
12	Type of Dam	Weir	Earthfill	Earthfill	Earthfill	Earthfill	Earthfill	Weir	Weir	Weir	Earthfill	Earthfill	Masonry Weir
13	Length of Dam(m)	82.3	423.67	325	690	1707	1535	174	53.6	56	2214	2388	NA
14	Maximum height (m)		32.91	48	48	24.6	22.86				30	21.33	NA
15	Type of spillway		Ogee	Ogee	Ogee		Ogee				Chute	Ogee	Broad creasted
16	Length (m)		98.68	110	113.5		87.78				84.5	59	173
17	G.C.A. (ha).	4580	9710	13,060	12,870		4820	11320			12,500	7155	3830
18	C.C.A. (ha)	4580	8310	9800	9650	9060	4250	8540	**For combined Project**		10,000	4800	3830
19	Kharif Irr.(ha)	4580	8310	8650	9150	9060	4250	8540			10,000	4800	3830
20	Rabi Irr. (ha)	nil	2730	5090	6820	4530	2250	610			5,200	1920	50
21	Year of commencement	**1955**	**1960**	**1981-82**	**1979-80**	**1962**	**1961**	**1960**			**1,976**	**1972**	**NA**
22	Year of completion	**1964**	**1980**	**Complete**	**Complete**	**Complete**	**1990**	**1978**			**Complete**	**1981**	**1912**

6.2.3.2 Description of few Major and Medium Projects

6.2.3.2.1. Hirakud Dam Project

Hirakud dam the 'Proud of Orissa' constructed across river Mahanadi, the largest one in the State is located 15 km upstream of Sambalpur town. The construction of the project started in 1948 and completed during 1956-57. Govt. of India through C.W.P.C took up the construction of the project and many of the State Engineers got real exposure in the design and construction activities of large river valley project.

The Original project report "Mahanadi Valley development: Hirakud Dam Project" (June 1947) contemplated for construction in three stages namely Hirakud Dam Project, Tikarpada Dam Project and Naraj Dam Project, each one having own canal system and hydropower generation for unified development of the valley. The hydrological study was based on works of Prof. P.C. Mahalanobis titled "Rain Storms and River floods of Orissa".

Initial design of the Main Dam was done by International Engineering Company, Denver, USA which was subsequently modified in the light of further acquired field data and studies. All designs have been scrutinized and approved by Dr. J.L.Savage, the world famous American authority on dams. The detailed designs were taken up by Central Water Commission.

It is a composite dam consisting of Earth fill, Concrete and Masonry having total length of 4.8km with maximum 60.96m height spanning between Lamta dunguri hills on the left and Chandidunguri hill on the right. It is flanked by earthen dykes of 10.579 km and 9.837 km length on left and right side respectively covering five gaps in left side. The dam primarily blocks two arms of Mahanadi; 600m on the left and 750 m on the right, where solid gravity type Ogee spillways are located. The earthen dam extends from the left bank to the left spillways and the portion between two spillways cover a length of 3651 m.

The 282.8m long power dam covers from the right abutment to the right spillway below which dam toe power house is located. Seven number of Penstocks; 5 nos of 7.6m dia and 2 nos of 6.1m dia have been embedded in the power dam to facilitate entry of water to powerhouse. Full supply discharge of Powerhouse-I at Burla is 990.50cumecs (35000 cusec), and carried through a 75.5m bed width power channel which has been reduced to 52.5m after surplus escape. The power channel of 22.4km length is designed to carry a discharge of 18000 cusecs beyond escape. The dam being the first Major Dam and the oldest in the State, a lot of deficiencies / problems are observed during passage of time.

Hydrology

Hirakud has been described by many experts as a hydrologically deficient Dam. In the project report 1947 (7), a flood reserve of 4345Mcum (3.51M Acft) was contemplated between RL 600 to 630.5ft though full reservoir level was RL 625ft. The provision envisaged to regulate a flood of the magnitude as in 1834 AD, (peak of 44,459 cumec or 15,71,000cusec at Naraj) within gauge of 27.432m (90.00ft) at Naraj with maximum flood flow of 34,356 cumec (12,14,000 cumec) as per Rhinds curve. For flood moderation studies flow of 26568 cumec (942000 cusec) was considered. Spillway was planned with flood release capacity of 31,413 cumec (11, 10,000 cusec). The regulated release from Hirakud dam was envisaged not to exceed 19,810 cumec (7, 00,000 cusec). This was expected to lower the maximum flood level at Sambalpur by 1.46m (4.8ft). The flood space was considered to be reserved upto 24th September, beyond which it could be safely filled up for power and irrigation use. It was mentioned that "there is always more than enough water in the river in late September and throughout October to fill the reservoir even in the worst year".

In the revised report of Hirakud Dam Project (1953), (9) the F.R.L and M.W.L was fixed at RL 630ft. with live storage of 4.51M.Acft between R.L 590 to 630ft. and gross storage of 6.75 M.Acft. On preliminary assessment, the maximum flood peak was estimated 51,789cumec (18,30,000 cusec) with volume of 16.9 inches of runoff (29.02M.Ac.ft), based on envelop curve of six major river of world, three from U.S.A, one from Philippines and two rivers, i.e., Mahanadi (at Mundali) and Godavari in India. Subsequently revised design flood was computed to be 42,450 cumec (1,500,000 cusec) and volume to be of 19.92M.Ac.ft. equivalent to 11.6" round off from the basin, from envelop curve considering 75 rivers of the World. As per frequency analysis this has a return period for 500 years only.

The maximum flood of 15 lakh cusecs on 500 year return period basis was considered adequately high flood and was adopted as the design flood for Hirakud Dam. The spillway was designed with gross capacity of 42.450 cumec (15, 00,000 cusec) and with allowance of 1/6th of the gate inoperative. Effective discharge was calculated to be 35, 177cumec (12,43, 000 cusec). Full live storage capacity of 4.51 M.Acft was reserved for flood absorption. The reservoir was to be maintained at D.S.L 590 ft. upto end of August. Reservoir filling was to be started around beginning of September and filled upto RL620 ft. by 15th September, further filling the Reservoir to F.R.L by end of October.

Arial View of Hirakud Dam

In 1974, a team of experts constituted by Govt. of India for formulating rules for flood conservation and flood control below Hirakud interalia estimated inflow design flood by hydro-meteorological approach and derived P.M.F as 28.74lakh cusec (81369cumec) and a flood volume of 17.11 M.Ac.ft (21, 140 M cum). After incidence of storm in 1982, the studies were reviewed in consultation with CWC and the flood was reassessed. This resulted in a hydrograph with a peak of 69 632cumec (24.51 lakh cusec).

The Hirakud Dam Project was originally contemplated with an emphasis on flood control. The present priorities are (i) Irrigation (ii) Flood Control (iii) Power generation and (iv) Navigation. In case of multipurpose reservoir, the success of joint use of storage space will depend upon the extent to which the various uses are compatible. Amongst above drinking water and navigation (which is obsolete now) need clear allocation of storage space where as power is compatible with other uses. But for flood control with empty storage space requirements is least compatible. In Hirakud, no clear space has been allocated for the purpose of flood control.

Hirakud reservoir

Hirakud Reservoir is envisaged for conservation uses of irrigation and power generation and as flood control reservoir for moderating floods in the deltaic region. This can be accomplished by keeping reservoir at low level during initial period and filling gradually towards end of monsoon. This is carried out with help of Rule Curve prescribed from time to time. The rule curve of 1976 works well when the inflow is good. If there is in flow in the later part of monsoon it is likely that reservoir may not get filled up as happened during 1976, 1979,1982 and 1984 up to FRL by 1st October which resulted in loss of power generation. The rule curve have been revised by different committees from 1955 to 1988 on various occasions from consideration of conservation and have reduced the flood reserve, the details of which are as follows:

Sl. No.	Name of the Report / Committee	Flood reserve capacity
A	Revised Project Report (1955)	100%
B	Manual of Reservoir operation (1959)	95%
C	Evaluation Committee (1962)	89.3%
D	National Planning Council (1967)	74.8%
E	Hirakud Co-ordination Committee (1970)	74.5%
F	Expert Committee (1976)	68.86%
G	Rule Curve Revision Committee (1988)	67.4% to 55.4%

In actual operation the reservoir is being kept at higher elevation than recommended filling schedule primarily for power generation and for the fear of non-filling of reservoir due to erratic rainfall condition. The reduction of flood reserve with different rule curves may be seen from Table given above.

Date	Recommended level in ft	
	Lower limit	Upper limit
Up to 1st July	595	595
Upto 1st August	590	590
Upto 11th August	605	615
Upto 21st August	610	622
Upto 1st September	619	627
Upto 11th September	624	629
Upto 21st September	629.50	630
Upto 1st October	630	630

In this study it has been recommended to adopt pre-depletion plan after knowing the formation of storm as satellite imagery and I.M.D forecast etc. are available. It may not be practicable to deplete as the discharge from the reservoir may coincide with contribution from independent downstream catchment thus aggravating the flood in delta.

All the rule curves have attributed importance for power generation reducing flood reserve in the reservoir. The author is of the opinion that as other reservoirs (viz. Balimela, Machhkund, Kolab, Indravati and Rengali) are available for hydropower generation, T.T.P.S at Talcher, Super Thermal at Kaniha and IB Thermal Plants are also supplying power, the lower limit of the rule curve may be adhered to, which will provide additional space for flood moderation and give relief to the delta.

Cracks in Dam Spillway

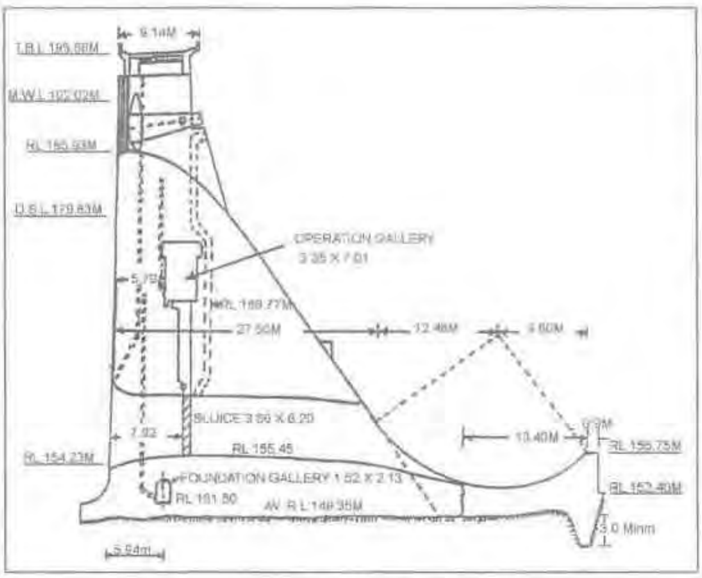
Initial filling of the reservoir was done on 21.7.1956, when seepage appeared at number of places in the dam, particularly in operation gallery, foundation gallery, power dam and right transition blocks. The seepage through the manholes of right spillway was of the order of 0.3 cusecs. Between June 1956 to June 1958, additional grouting was carried out in the right spillway and power dam. In the spillway blocks from 28 to 47, holes of 485.5 m were drilled in foundation gallery (RL 497 ft) and operation gallery (RL 557 ft) and grouted consuming 5406 bags of cement. In power dam blocks the length of drill hole was 1230.6 m and grout intake was 6186 bags.

On 01.05.69 Chief Engineer, irrigation in his inspection report stated that "Some horizontal cracks have developed in the operation gallery of right spillway right from the time of completion of the dam, i.e., 1957-58. The cracks are more or less near the construction joints and appear to be because of hydraulic pressure of the leakage water through the concrete dam. The cracks have been recently grouted and appear to have been sealed at present".

In 1974 investigations were made when difficulties were experienced with sluice gate operation and snapping of bolts supporting sluice gate tracks in the right spillway. As suggested by CWC epoxy grouting was carried in 1975 to seal the cracks. Cracks were observed in the (i) operation gallery (both horizontal and mosaic pattern cracks in blocks 35-36 and 46-47) (ii) in gate shafts (blocks 36-39, 41-42 and 44-46) (iii) sluice barrel walls (iv) foundation gallery (blocks 40-42 and 46) (v) downstream face and (vi) upstream face (between RL 540 ft to 560 ft). In additional to above (a) deflection in the adit gallery of block No.47 (b) vibration during lifting of crest gate No.22 and 34 (c) buckling of embedded frame of manhole opening on the road way slab over pier in block 35 and (d) snapping of bolts in sluice gate tracks etc. were observed.

As an interim remedial measures cracks were grouted with epoxy compound comprising of two parts of resin Debeckot 505C mixed with one part of hardner E.H.411 by weight. Maximum grout pressure was limited to 50 p.s.i. Average consumption of epoxy in gate shaft gallery and sluice wall were, respectively, 0.56 kg, 0.39 kg, and 2.59 kg per meter of crack. Total length of cracks mapped using under water videography as on date is 27138 m against which treated length of crack is 14324 m (52.8%). The Dam safety panel suggested that balance cracks may be grouted at the earliest.

Govt. of Orissa constituted a committee of experts in March 1981 under Dr.Y.K Murthy. State Govt. accepted the recommendation of the committee relating to remedial and precautionary measures in 1984 (for details, Report of the committee may be referred to). The committee opined that the Alkali aggregate reaction has resulted in pattern of cracking and other manifestations in the dams.



Cross section of Hirakud Spillway

This reactivity is found to vary from mild to moderate and may not cause more serious distress than what has been experienced so far but may continue for some time till the reactivity ceases. (Pg.64 of the report of committee of experts of Sept.1983). During August 1990 (Crack Review Panel was constituted under chairmanship of Sri G.S. Tandon (i) to review and analyse the distress condition arising due to cracks, honey combs and other defects (ii) to suggest remedial and rehabilitation measures both short term and long term and (iii) to review current measures taken up by Govt. for repair of cracks. Further, the dam was included under DSARP when Mr. David Stark from USA visited the dam and gave his expert opinion on Alkali-silica reactivity (April 1993) Following conclusion were drawn by him based on the observation and analysis (Pg.12 of his report).

(i) To date ASR has caused expansion and been a minor source of observed cracking.

(ii) Both diorite-granite gneiss and river shingles aggregate have participated in expansive ASR in the lean and rich mix concrete.

(iii) ASR has produced little to no damage in the mass concrete.

(iv) Deleterious ASR has not developed in power house concrete though the materials from same source were used as those in spillway construction.

(v) Restraint to movement by the mass of the concrete is a major factor suppressing or prevention expansion and cracking due to ASR.

(vi) Given the present 35+ year age of concrete. ASR should cause little or no expansion in future.

(vii) ASR will not endanger the safety of the dam, nor will limit the functional operation of the dam. These conclusions are based on the fact that no dam in the world has ever failed solely due to ASR.

The latest crack length survey was carried out in December 1995. From this it is seen that the total crack length in galleries, sluice barrels and gate shafts increased by 179 m during 1995 for the right hand spillway and now stands at 8484 m. For the left hand spillway the increase was 13 m and total length 3642 m. Five years moving average crack lengths are as follows.

Year	Right spillway		Left Spillway	
	5- year moving average (m)	Increase over previous period(m)	5- year moving average (m)	Increase over previous period(m)
1987-91	7490	—	2251	—
1988-92	7695	205	2549	298
1989-93	7865	170	2857	308
1990-94	8037	172	3073	216
1991-95	8176	139	3275	202

Above Table indicates that ASR activity is still active on both spillways.

Irrigation

Irrigation is provided through canals fed directly from the reservoir by gravity flow. The distribution comprises of two main canals, namely Baragarh Main Canal on Right bank and Sason Main Canal from left bank, two branch canals take off from Baragarh main canal named as Atabira and Retamunda. A large number of distributaries, minors, sub-minors and water courses exist to feed the command area. The canals are mostly unlined and method of irrigation is by flooding. During normal rainfall condition an area of 157018 ha is irrigated during kharif and 109912 ha in Rabi season. The irrigation intensity varies from 162% to 175%. The details of the Hirakud irrigation system is summarized below.

Sl. No	Name of Canal directly off taking from reservoir	Sill level of H.R	Discharge in cumec	Bed width (m)	F.S.D (m)
1	Baragarh Main Canal	176.93m	108.16	45.70	2.68
2	Sason Main Canal	178.33m	17.82	16.76	1.49
3	Sambalpur Disty	175.71m	3.59	4.57	1.06

Two principal crops grown in the area, i.e., in kharif (June to October), mainly paddy and sugarcane covering about 157018ha and in Rabi (from mid November to mid April) paddy, oil seeds and pulses covers about 109912ha. Crop diversification has become necessary in both Rabi and Kharif season for optimal use of the irrigation water and maximization of agricultural production.

6.2.3.2.2 Machhkund H.E.Project

Machkund hydroelectric project is the first major hydro project located in the State of Orissa. It was taken up as a joint project between the two States as per the terms of an inter-state agreement executed between Orissa and the then Madras Government (Present Andhra pradesh) on 4.01.1945. The execution of the project was entrusted to Madras Government. Both the Governments have the right to the use of 50% of the ultimate power developed at Duduma falls as well as that developed at each stage. Since the State of Orissa was not in a position to utilise its full share, it transferred its right to use 20% ultimate power to the Govt. of Madras for a period of 99 years from the date of signing of the agreement. Sharing of capital cost and the interest during construction was on 30:70 basis between Orissa and Madras Govt. On the strength of the supplementary agreement drawn up between the two Govt., Andhra Pradesh agreed to sell out of its share 20 % of total power generated at Machhkund at a rate of 8paise per Unit to Orissa limiting the total energy that could be drawn by Orissa to 50% of total generation in a year.

Important Events

Year	Events
May 1929	Preliminary reconnaissance of Machhkund catchment and falls
1940	Detailed reconnaissance
July 1943	Survey & field work completed
1946	Project work started
4th Jan,1947	Joint Board of Control constituted by Govt. of Madras
24th Feb,1950	First meeting of Joint Board of Control held at Machhkund
9th Aug,1954	Reconstitution of Joint Board of Control by Govt. of Andhra

Project features

The main project features includes a storage reservoir of gross capacity of 34 Million cft at Jalaput on river Machhkund. 3nos power outlets and 2 nos scour out lets were embedded in the Jalaput dam to release water from the reservoir. A diversion Dam was constructed at 14 miles down stream of the river diverting water to power channel. The Power channel consists of 526 ft open channel, 4912 ft tunnel ending in a balancing pond of one million cft storage capacity. From the balancing pond a pressure tunnel of 2015 ft long leads water to a 50 ft diameter surge shaft. From the surge shaft 6 nos penstock pipes feed water to 6 turbines in the powerhouse at Onkudelli.

Date of Commissioning

Date	Unit	Installed Capacity (MW)
19.08.1955.	Unit-1	17.0
12.12.1955	Unit-2	17.0
26.06.1956	Unit-3	17.0
15.01.1959	Unit-4	21.25
07.08.1959	Unit-5	21.25
08.08.1959	Unit-6	21.25

6.2.3.2.3 Balimela H.E. Project

In 1941-42, preliminary survey was done by Madras State Engineers and they have estimated that power potential at two sites, i.e., Upper Sileru and Lower Sileru to be 5060KW and 6260KW, respectively. Well aware of the great possibilities of the potential, Govt of Orissa soon after formation of its Irrigation and Power Department expeditiously investigated and proposed the Irrigation and Hydropower Generation, including utilization of 1400 cusecs tail water of Machhkund powerhouse which was running down wastefully. With inauguration of Dandkaranya scheme, and the urgent need for settling refugees in Malkangiri, irrigation and adequate power supply became essential. Also the low cost of the scheme justified its development. The execution of the project brought prosperity to vast area having enormous mineral resource potential.

Subsequent Proposal

As per the initial proposal, the project on full development would comprise an earth dam having reservoir with live capacity of 1,10,000mcft for providing a draft of 2650 cusec from the intermediate catchment of 1100 sq miles, where there would be a subsequent addition of 2600cusec from Jalaput and Kolab. The water conductor system with total capacity of 5250cusec could utilize total water resources of the valley including adjoining Kolab valley. Construction of powerhouse with installed capacity of 80MW at Balimela and new powerhouse of 160MW installed capacity at the downstream of Machhkund powerhouse was envisaged. Utilizing the surplus water for irrigation at two drops of 150ft and additional powerhouse with installed capacity of 120MW it was also contemplated to provide irrigation to 24000 acres of CCA in the Balimela valley. The above proposal gave birth to the present scheme which stands now.

6.2.3.2.3.1 Balimela Dam Project

Transbasin diversion project shares 50% of regulated flow from the reservoir for power generation at Balimela by Orissa and rest at Ghuntuwada (Known as Upper Sileru Project 13km down stream of Balimela dam) in Andhra Pradesh. Balimela dam has been constructed across river Sileru near village Chitrakonda in the district of Malkangiri (previously in undivided Koraput district). The reservoir with gross storage of 3610M cum and live storage of 2676M cum has been formed by construction of 70m high earth fill dam of 1821m length and three earthen dykes. The length of the Dyke-I, Dyke-II, and Dyke-III are respectively 660m, 612.64m and 812m, and height 37m, 36.57m and 46m. The spillway is located in the 4^{th} saddle. It is a straight, gravity, masonry, ogee crested spillway to pass the design flood of 14300cumec..

The dam at Chitrakonda utilizes 300m gross head for hydropower generation with ultimate installed capacity of 480MW (8x60MW). Six units of 60MW each have been commissioned since 1972. At present two units are under construction. The water conductor system consists of an open channel of 2062m length having bed width of 16m to carry discharge of 225cumec, followed by 4.0km long 7.62m diameter horse shoe tunnel. The surge shaft is of 19.81m dia and 74m height having two expansion galleries of 12m dia and 120m length. Open steel penstocks having 2.45m dia lead to the powerhouse from the valve house. The Gidroproekt Institute Leningrad, (the then USSR) have furnished the design of the powerhouse. It is a 129m length X 44m width x 40m-depth reinforced concrete structure with about 46920cum of concrete and 2200MT of steel. M/s OCC Ltd (A Govt. of Orissa undertaking) has the distinction of completing the same successfully.

The released water from Power House of Balimela is picked up by constructing a barrage at Suruli-konda to irrigate about 60,000ha of CCA. This project also helps in flood control of Godavari in Andhra Pradesh. Even though the project was originally contemplated for power generation only, ultimately it turned to a Multipurpose project.

6.2.3.2.3.2 Potteru Irrigation Project

Since commencement of the Balimela hydroelectric project there were several proposals for utilization of Balimela tailrace discharge for irrigation in Malkangiri valley, but ultimately Potteru irrigation project materialized. The regulated discharge of 59.43cumecs of tail water of Balimela powerhouse is conveyed through 2km long 25m width open channel and discharged to river Potteru, a tributary of Saberi at 2.5km down stream of Village Surlikonda, where the same is tapped for irrigation purpose by construction a barrage. Entire discharge of the powerhouse and the yield of 210sqkm catchment of river Potteru is being utilized by left and right main canals for irrigation of 38921ha and 22113ha CCA, respectively. Total irrigation distribution network is about 750km.

Prior to the project, the area was entirely dependent upon the natural cycle of rainfall, which is inadequate and unevenly distributed. Population of the area comprises mostly of tribal origin and the displaced (resettled) refugees from Bangladesh (erstwhile East Pakistan). Consequent upon the implementation of the project the economy of the region has improved considerably. The ground water table in the region has been raised and drinking water problem has been reduced to a great extent.

Balimela Powerhouse

Balimela Spillway

Balimela Dam

Balimela Powerhouse

6.2.3.2.4 Rengali Multipurpose Project

History of the Project

The recurring floods in Brahmani, brought severe economic deprivation to the people in the flood affected areas and from time to time proposals for flood control through detention reservoirs were made. However, the high cost of the scheme and the poor financial capability of the Govt. of Orissa precluded the construction of the project for long time.

The first concrete proposal was made in 1959, when it was proposed to construct a dam at Rengali to impound 3.25lakh ham of water for providing irrigation to12200ha of land and generate 38MW of firm power. This proposal was dropped, as the BC ratio was too low. Dr. A.N. Khosla (Khosla, 1963) the then Governor of Orissa proposed for construction of a Dam at Barkot to divert water of Brahmani to the proposed Tikerpada reservoir for additional generation of power at Tikerpada. Dr. Khosla in his 'Decade of Destiny' had sketched a very low profile of this scheme, which according to him was to be taken up after Madhya Pradesh starts abstraction from Mahanadi. Proposal of two dams; one at Lodani - to cater the water requirement of the proposed steel plant at Bonaigarh (which was subsequently shifted to Daitari) and another at Barkot for irrigation, which were dropped subsequently.

Rengali Project proposals were reviewed in 1970 and subsequently in July, 1972, when the fresh Project report was prepared with principal benefit as flood control considering the PMF derived on the basis of 1961 flood as the heaviest flood on record, having a peak flood of 27800cumec, a base period of 6.5days and a flood volume of 50.6lakh ham. This report envisaged the project in two phases; Phase-I as purely flood control and second Phase to take canals on either sides of the dam to cater 2.61 lakh ha irrigation. Hydropower production of 36.0 MW firm power was also considered with reduction of irrigation potential by 5000ha.

After deliberations at Govt. of India level in CWC and CEA, there was a major shift of the scheme in Project Report of October 1972, (Renagli Dam Project Oct. 1972) with inclusion of hydropower genration in the Stage-I and irrigation was differed to the Stage-II, where instead of providing the irrigation directly from the reservoir, it would be provided from the tail race discharge picked up at Samal by constructing a barrage. With increased spillway capacity as per updated PMF and revised installed capacity of Powerhouse, the project was finalized in its present executed form.

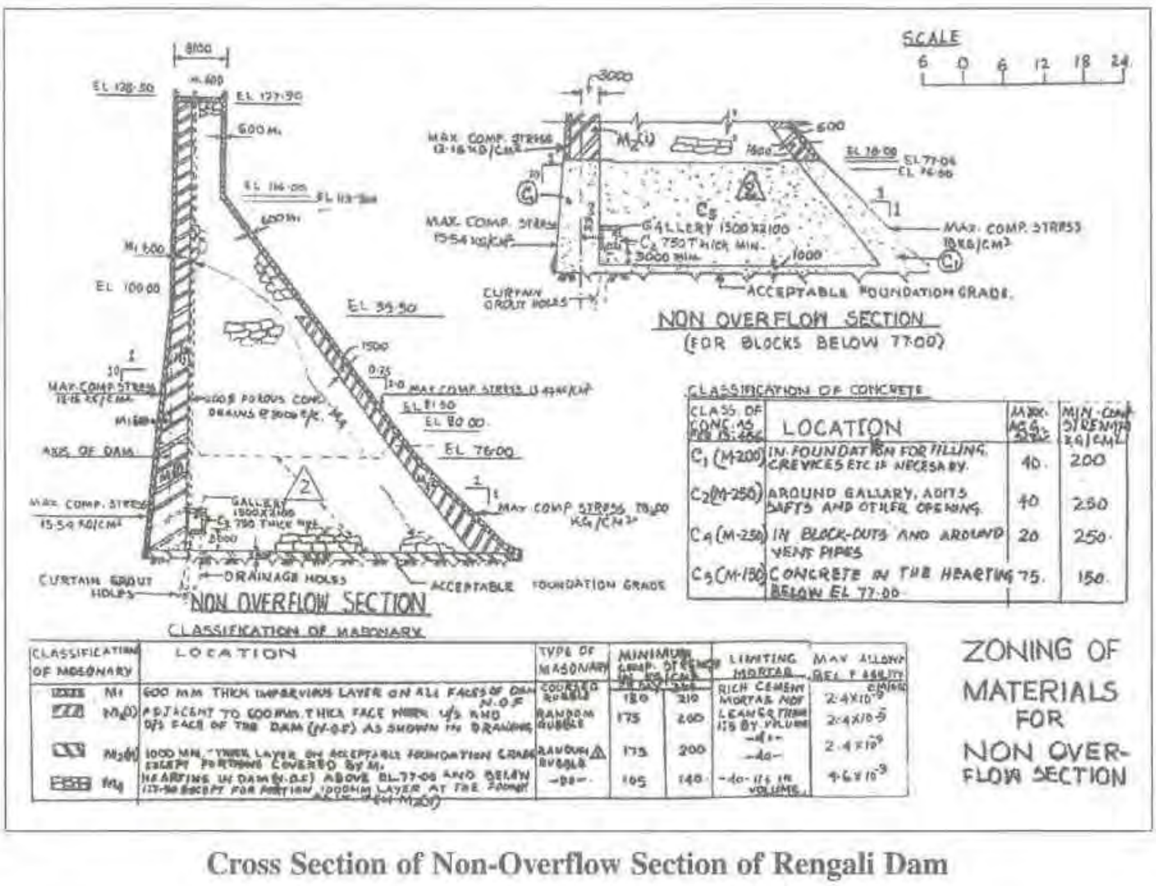
6.2.3.2.4.1 Rengali Dam project

The proposal to construct a Dam across River Brahmani came up for consideration to control flood in its Delta. Floods caused by River Brahmani and other two major Rivers of Orissa viz. Mahanadi and Baitarani devastate a large tract of coastal Orissa spread over Balasore, Cuttack and Puri Districts since time immemorial. This problem received serious attention of Government since 1927. It is a paradox that these three rivers, which have built a combined Delta and nourished it year after year by depositing silt by increasing agricultural productivity like a mother; have also become agents of destruction during flood. It was roughly estimated during 1938-39 by Mr. Shaw, the then Executive Engineer who rose a great eminence as an Flood Expert of Orissa, that during a period of 29 years from 1910 to 1938 total loss due to Floods in Orissa mostly caused by above three major rivers comes to Rs.3.5crores, the maximum loss being Rs.66 lakhs during 1919. The Deltaic area of Orissa is situated in the three undivided Districts of Balasore, Cuttack and Puri, which measures 2069, 3654, and 2492sqmiles respectively, out of which Deltaic Area of Mahanadi, Brahmani and Baitarani accounts for 2940, 854 and 659sqmiles.

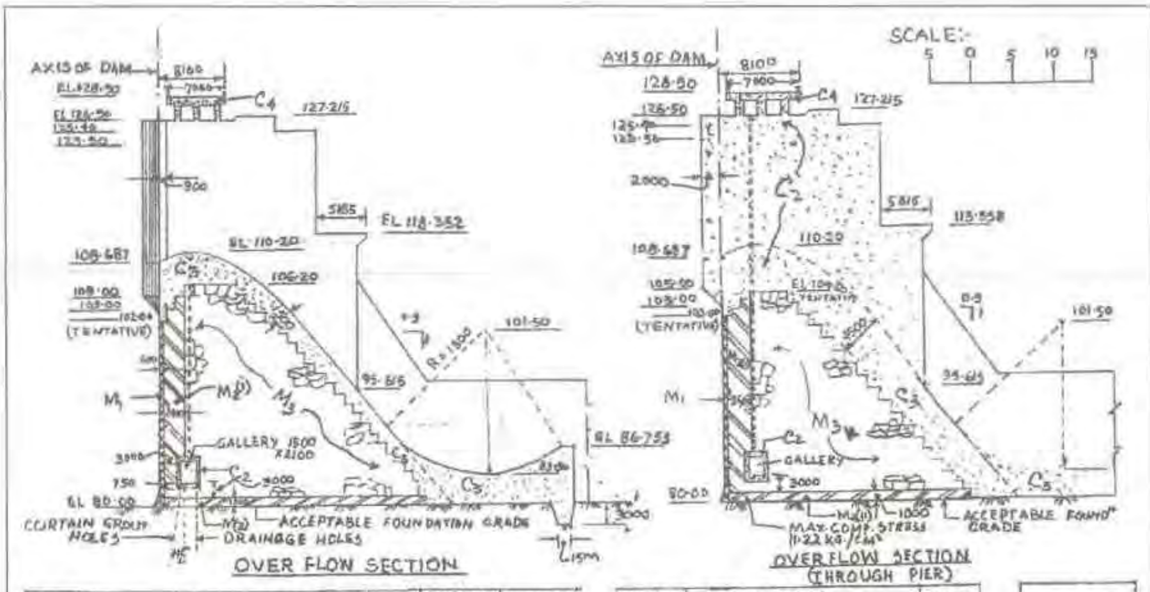
Ever since 1858, flood problems of Orissa have been a subject matter for active discussion. Committees were set up in 1928 and 1938. The 1928 committee generally considered the problem as disposal of excess flood whereas 1938 committee viewed the problem as one of the proper distribution and disposal of excess flood. Finally a storage reservoir across Brahmani at Rengali was conceived after devastating flood of 1971 to impound 0.285 million ham for complete flood control in Brahmani basin at estimated cost of Rs.94.42 crores.

The Rengali Dam site is located across river Brahmani at about 2km upstream of Rengali village at latitude 21°-17'N and longitude 85°-2'-00"E and about 64kms upstream of Talcher. The Project site is approachable by a 54km of existing road from Angul to Budhapal and 30 km. Project road from Budhapal to dam site. The nearest railhead is Talcher of S.E. Railway, which is 115 km. away from project site via Angul.

Rengali Dam was initially envisaged as a flood control dam. Later power generation and irrigation components were added. The dam is a masonry one founded on rocky bed. The total length of dam is 1040m and it's maximum height above foundation is 70.50m. The spillway is centrally located having a length of 464m in the main dam. It is an ogee shaped spillway with energy dissipation arrangement of skijump bucket surmounting 24 nos. of radial crest gates of size 15.5 m x 14.80 m with discharge capacity of 46960cumec. This project has an average firm power capacity of 160MW with 100% load factor and ultimate power generation capacity of 250MW (50 x 5 units). There is a very small length of dyke near village Khindoo.



Cross Section of Non-Overflow Section of Rengali Dam



TYPE OF MASONRY	LOCATION	TYPE OF MASONRY	STRENGTH OF MAS.	
			[illegible]	[illegible]
M1	600 MM THICK IMPERVIOUS LAYER FRONT FACE OF THE SPILLWAY.	COURSE RUBBLE	180	210
M2(I)	2400 MM THICK IN FRONT FACE OF SPILLWAY ADJACENT TO 600 MM FACE WORK	RANDUM RUBBLE	175	200
M2(II)	1000 MM DEPTH AT THE FOUNDATION FOR THE FULL SECTION OF DAM EXCEPT PORTION COVERED BY ITEM M1 & BLOCK 21	-DO-	175	200
M3	HEARTING IN SPILLWAY EXCEPT FOR THE PORTION 1000 MM DEPTH AT THE FOUNDATION AS IN ITEM M2(II) ABOVE	-DO-	105	140

TYPE OF CONCRETE	LOCATION	STRENGTH kg/cm^2
C1 M-200	IN FOUNDATION FOR FILLING CREVICES IF NECESSARY.	200 / [illegible]
C2 M250	ALL AROUND GALLERY AND PIER.	250 / [illegible]
C3 M-250	SPILLWAY CREST DOWN STREAM FACE AND BUCKET.	250 / [illegible]
C4 (M250)	IN BLOCK-OUTS, ROAD BRIDGE SLAB, BEAMS AND AROUND VENT PIPE.	250 / [illegible]

ZONING OF MATERIALS FOR OVERFLOW SECTION

Cross section of Overflow section of Rengali Dam

6.2.3.2.4.2 Rengali Irrigation Project

In the stage II of development, it was planned to provide irrigation to an ultimate ayacut of 4.23lakh ha under Phase–I and Phase-II. But under phase-I, irrigation will be provided to an extent of 2.36 lakh ha, bounded by Mahanadi on right and Baitarani on the left. The tailrace discharge will be picked up by constructing a barrage at Samal with pond level 76.20m. A 560m long barrage has been constructed having 24 bays out of which 3 scouring sluices are on left and 4 on right wing. The barrage is having storage capacity of 148.85Mcum at full pond level and submerges 288.8ha. Two main canals namely Right Main Canal (142 km) on the right and Left Main Canal (112km) with distribution net work will be fed from this pond, for irrigating 137500ha with 175% intensity and 69600ha with 170% intensity, respectively. The main reason for construction of a Barrage at Samal about 35km. downstream of Rengali Dam under Stage-II development is to get a higher and assured yield at Samal Barrage site by intercepting the two other tributaries of Brahmani, i.e., Tikira and Samakoi, downstream of Rengali Dam, in addition to tailrace discharge of Rengali Power House. Moreover the topography between Rengali & Samal Barrage does not permit to provide irrigation canals because of heavy cutting and consequently idle length.

Moreover provision for irrigation to the local area has been made in the right side. An irrigation sluice in block No. 49 in the right bank has been kept which will provide irrigation from the reservoir to this right ayacut to an extent of 2691ha of G.C.A. (1749ha of C.C.A.) in the downstream of Rengali Dam. The ayacut is mainly bounded by the hill range on one side and Balaramjhar nalla on the other side.

Phase II of the project envisages extension of the left main canal beyond river Brahmani upto river Budhabalanga, with distribution system so as to irrigate about 16400ha in Keonjhar and Mayurbhanj district. This has been deferred.

Rengali Dam

Samal Barrage

Source: Completion Report- Rengali Multipurpose Project, Rengali Dam (Vol-I)

6.2.3.2.5 Upper Kolab H.E. Project

Kolab River a tributary of Godavari, in Orissa territory, which is known as Saberi at its lower reaches. Govt. of Orissa started the preliminary investigation to utilize the water of Kolab only after 1961. Two intermediate project reports were prepared based on the investigations conducted from time to time. The first report envisaged the construction of the dam at Koranga village and four earthen dykes and a small length of water conductor system to utilize water resource potential of the river. The second project report prepared in 1966 envisaged the dam across river Kolab at Koranga, a diversion dam at Kendubeda nallah and two earthen dykes near Jatiguda and Lendiguda. Water from Kolab reservoir was to be diverted to Kendubeda pond through an open cut at Chakerliguda. For the water conductor system, there was a provision of two tunnels jointed by closed conduit in the proposal. Finally, after lot of deliberations and considering the geological aspects of the terrain, it was decided to take the water conductor system directly from the reservoir very near to the dam site.

6.2.3.2.5.1 Upper Kolab Dam and Powerhouse

Finally, it was decided to construct the main dam on River Kolab near village Korang (18° 47'N and 82° 37'E) and the construction was commenced during 1976. Catchment area at dam site is 1630sqkm. The dam is 630.5 m long including over flow section and the maximum height of dam is of 54.50m. The spillway is 255.5m long. Two earthen dykes were constructed. First one: at Landiguda with maximum height 5.45m and 257.0m length, and second one at Jhatiguda having maximum height of 9.85m and 466.0m length. The reservoir is a having gross storage capacity and live storage capacity of 1215Mcum and 935Mcum, respectively. At FRL the reservoir water spread area is 113.5sqkm.

The water conductor system starts with an approach channel of 270m length before 5.5m dia horse shoe shape head race tunnel of 3924m length, 18m dia and 108m depth surge tank from where four numbers of 3m dia 940m length steel penstocks lead to the powerhouse. The powerhouse is having four units of vertical Francis turbines operating at average 238m net head. These are coupled with four generators of rating 80MW/11000V, three phase with power factor of 0.90. At 100% load factor the rated power output (firm power) is 95MW.

6.2.3.2.5.2 Upper Kolab Irrigation system

A small earthen dam was constructed across Satinallah to form a balancing pond for diverting water for irrigation through canals. The earthen dam was constructed in 1986 across the river Satinallah near Jeypore town on the down stream of Upper Kolab Powerhouse which serves the purpose of maintaining the tail water level as well as the necessary head for irrigation. The live storage capacity of FRL is only 1.519 Mm^3. The catchment area is 18.15 km^2.

The canals of Upper Kolab Project are: Jeypore Main Canal, 58.83km long with irrigation coverage of 46279ha CCA & Padmapur Distributary, 12.66km long covering 1436 ha CCA are off-taking from this pond which provides irrigation to the command in Koraput district. The Irrigation scheme when fully developed would irrigate CCA of 47715ha with irrigation intensity of 193%, comprising of 100% Kharif, 54% Rabi and 39% summer crops. There is also a provision of lift command of 22600ha.

Upper Kolab Powerhouse

D/S Upper Kolab Spillway

6.2.3.2.6 Upper Indravati Project

The Upper Indravati Multipurpose Project is one of the largest multipurpose river valley projects in the State of Orissa. The foundation stone of Upper Indravati Project was laid by the then Hon'ble Prime Minister of India, Sri Morarji Desai on 4th April, 1978 at Mukhiguda in the district of Kalahandi.The Primary objectives of the project are to generate 600 MW of electricity and to provide irrigation to 1.28 lakhs ha of land in drought prone Kalahandi district.

The project comprises of four dams, eight dykes and two link channels (within the reservoir). In the power side there is an intake structure, one head race tunnel, surge shaft; two pressure tunnels, valve house, four penstocks, power house and tail race channel, barrage on the Hati river with head works, and three main canals, with a distribution network. The reservoir has combined catchment of 2630 km^2 and at full reservoir level (FRL) of RL 642.00m will have a water spread of 110 km^2 with about 1500 Mm^3 live storage and 800 Mm^3 dead storage. The reservoir has a maximum depth of 71m. The reservoir is approximately 43 km long in the NNE-SSW direction, and 9 km wide at its widest point. The essential characteristics of the four dams of the project are described below.

Indravati Dam

This is a masonry gravity dam on the Indravati river. The dam has a maximum height of 45m and length 539m. It is provided with seven spillway gates (total capacity

11,430 m³/sec) and four low-level depletion sluices (total capacity 555 m^3/s). A total quantity of 2,06,340 cum of masonry and 1,15,000 cum of concrete has been used and the dam has been completed.

Podagada Dam

This is a homogeneous earth fill dam with a maximum height of 77.5 m and length of 462 m. It impounds the Podagada River, a major tributary of Indravati river. Podagada Dam is provided with a Diversion cum depletion sluice of 650 m^3/s capacity but no spillway.

Kapur Dam

Kapur is a homogeneous earthfill dam of maximum height of 64m and crest length of 537m. It closes the Kapur River. It has no spill way or sluice. All the works of this dam has been completed. The TBL of both Kapur and Podagada Dams have been kept one metre higher than that of Indravati and Muran Dam.

Muran Dam

Located on the Muran River, a major left - bank tributary of river Indravati, this dam is a masonry gravity structure with a maximum height of 65m and a crest length of 494 m. It is provided with five spillway bays having total discharge capacity of 8,060m^3/sec. It has four depletion sluices of total capacity 588m^3/s.

6.2.3.2.6.1 Upper Indravati Powerhouse

The Upper Indravati Project is the first step in development of the power potential of the Indravati river in Orissa. The project features are favourable for a very economical hydroelectric development such as good water availability, low dams to form a large regulating storage, less submergence and short water conductor system to concentrate a high head for power generation. The main works involved in the Upper Indravati project are:

- Water conductor system comprising of 165 m long head race channel, 4.32 km. long and 7 m dia head race tunnel designed for a discharge capacity of 210 cumecs and terminating in a surge shaft.
- 2 pressure shafts 330 m long and 5.25 m dia bifurcating near the valve house;
- 4 surface penstocks, 790 m long and 3.5 m dia to lead the water to the power house;
- an surface power house with an installation of 4 units of 150mw each operating under an average gross head of 371.00m (1218 ft.);
- a 9 Km long tail race channel to discharge tailrace water into the Hati river where a barrage has been constructed for Irrigation.

Upper Indravati Water Conductor System

6.2.3.2.6.2 Upper Indravati Irrigation Project

The project envisages diversion of water from Indravati basin to Mahanadi basin fed by the tailrace discharge of Upper Indravati Powerhouse at Hati barrage. Left Main Canal and Right Main canal off-take from either sides of Hati barrage for irrigating commands in Kalahandi District with their distributaries. The salient features of the barrage have been stated in Sec 6.15. The right main canal is 83km long with CCA coverage of 27191 ha, and the left has a length of 52km covering 49078 ha. Besides a lift scheme has been contemplated which would have a CCA of 33,027ha. Presently, keeping the lift scheme pending the left canal is being extended beyond river Tel and right canal beyond river Sagada to provide additional irrigation coverage to 25000 ha CCA.

6.2.3.2.7 Subarnarekha Irrigation Project

Subarnarekha Irrigation Project is an inter-state project in the Nothern Orissa with other beneficiary State Jharkhand (erstwhile, Bihar) and West Bengal. The joint works related to Bihar and Orissa are under execution in Jharkhand territory in keeping with the Tripatiate agreement of 07.08.1978. The total catchment area of 18951sqkm is shared as: Jharkhand-13590sqkm, Orissa-2160sqkm and West Bengal-3201sqkm. The main dam is located across river Subarnarekha at Chandil, intercepting catchment area of 5646sqkm. The second, Ichhadam constructed over a tributary of Subarnarekha, intercepts a catchment area of 2849sqkm. A barrage has been constructed at Galudihi across Subarnarekha where the catchment is 13629sqkm. The general layout of the project is shown in Figure 6.2. The project would provide irrigation in Jarkhand and Orissa, power to Jharkhand and would control flood in both Orissa and West Bengal. Orissa would get water for irrigation from Jharkhand-Orissa boarder through Galudihi Right Bank Canal that leads to 3 command area reservoirs namely Haldia, Jambira and Baura, and would irrigate through network of distribution system. The command area reservoirs have been described later. The project is in progress.

Galudihi Right Bank Canal is 63.38km long having a head discharge of 111.16cumec and at Orissa boarder is 108.0 cumecs. Length of the major canals are: Subarnarekha main canal - 46.5km, Betnoti main canal- 27.49km, Baisinga branch canal- 73.32km, and Distributaries, Minors and sub-minors- 800.70km.

The project would irrigate total CCA of 1,09,627ha out of which 37113ha is under direct command and 72314 ha through distribution system of three intermediate reservoirs. The ultimate irrigation would cover command in Mayurbhanj District, 94655ha in Kharif and 59890ha in Rabi and in Balasore District: 14972 in Kharif and 3190ha in Rabi.

Jambhira Dam

Presently the dam has been constructed as a truncated one. The major portion of work completed in the year of 1998 across Jambhira river in Subarnarekha Basin and located a Latitude 22^0-02'-32"N and Longitude 86^0-48'-45"E near village Deuli in Baripada town of Maurbhanja district. The length and height of the dam are 3450m and 26.00m respectively. Gross storage capacity at FRL is 17.99 Mcum. Kharif ayacut is 31868ha and Rabi ayacut is 22169ha. CA is 76.5sqkm. The spillway is ungated and stepped with discharge capacity of 510 m^3/sec.

Haldia Dam

Haldia Dam was constructed by Raja of Mayurbhanj during the 1st decade of twentieth century in the Budhabalanga Basin across Chipat nalla for providing Irrigation to 2429 ha (CCA), mostly inside Kuliana Block of Mayurbhanj district. As mentioned in the "Report on the administration of Mayurbhanj" for the year 1909 – 10, Haldia bund was almost completed. It is an earth dam constructed of local materials with the state of the art prevailing at that time. For nearly a century, the project has been providing irrigation. After merger of the Mayurbhanj State with Orissa in 1949, the maintenance of the project came under Works Department first and then to Irrigation Department, after its ceation. Haldia project will now become a part of the Interstate Subarnarekha Irrigation project (SIP), which is under execution in Mayurbhanj district to irrigate 1,09,627 ha of CCA in Mayurbhanj & Balasore Districts. As per the present scheme, the Haldia Dam will be upgraded to enhance its height, storage capacity & ayacut area. The present dam will be a part of the new upgraded dam at the upstream toe and this will have a maximum height of 23.10m and the live storage capacity will be enhanced from 716ham to 4688 ham. As per the proposed up-gradation programme, Haldia Reservoir will be directly fed by Subranarekha Main Canal through a link channel upstream of the Head Regulator of Betonati Branch canal. The length of the dam, as constructed originally is 1745.6m with at least four kinks. The spillway is located towards the left abutment in a straight reach having a length of 137.2m. After up-gradation, the dam length would become 4.2 km, the extension being affected from left flank for a considerable length even though the height is less. The original spillway was provided with 52 nos of automatic falling shutters of 1m height.

Baura Dam

Baura reservoir is located near village Bagnasal (close to Lakhmiposi) on Baura stream and is fed with Subarnarekha water during monsoon through Baura feeder off-taking from Betanati Branch Canal. Baisinga branch canal off-takes from Baura reservoir. The reservoir is having gross storage capacity of 26180.67ham and live storage capacity of 25970.67ham. It will irrigate net CCA of 32355ha. At FRL the submergence area due to formation of this reservoir is 2525ha. Construction of the dam has not yet commenced.

6.2.3.2.8 Salandi Irrigation Project

Salandi Irrigation project comprises a reservoir by construction of a dam across river Salandi, a tributary of Baitarani, near Hadagarh at Latitude 21^0-17'-18" N and longitude of 86^0-18'-00" E. Salandi dam is a composite dam with 640m length earth dam and 114.6m long masonry dam having spillway gates of 8 spans of 12.2m each. The height of the dam is 51.82m. The catchment area of the reservoir is 673 km^2 and design flood discharge is 5140 m^3/sec. The water spread area of the reservoir is 31.82 km^2 at FRL (82.3m) with gross storage capacity of 601 Mm^3. The project was started in 1960 and completed in 1983.

Irrigation is not provided from the dam directly. Water let out through the river is diverted for irrigation at Bidyadharpur by constructing a barrage. One main canal namely Salandi main canal was constructed as per the original proposal. Subsequently, the FRL of the reservoir was raised by 6.1m (20feet) installing 8 number of radial gates. The additional storage available was planned for utilization by extending irrigation on the right bank by Right Bank Canal called Anandpur Canal. The Salandi Main canal is functioning since 1973. Network of distribution systems taking off from each of the main canals supply water from Bidyadharpur barrage to a total command of 92987ha.

D/S View of Salandi Spillway

D/S View of Bidyadharpur Barrage

6.2.3.2.9 Harabhangi Irrigation Project

Harabhangi irrigation project is an inter-basin irrigation project in Orissa, which transfers water from Vansadhara Basin to Rushikulya Basin. Although, the conceptual planning of the Harabhangi irrigation project was initiated way back in1962, the recent implementation of the project is a step forward in such direction.

The command area of the irrigation project lie under the sub-basins of river Padma and Joro, the two upper most tributaries of river Rushikulya in Rushikulya basin. Harabhangi reservoir, which serves as source of water for the irrigation project, is formed by construction of a dam on river Harabhangi a tributary of river Vansadhara in Vansadhara basin. The water is diverted from the Harabhangi reservoir through a tunnel to river Padma, which serves as a carrier for the transferred water for the said irrigation project. For utilizing the geo-physical advantage of the project location, it was proposed first, to pass the quantum of irrigation based regulated release through a diversion channel as per the withdrawal rate of power requirements, and establish seven number of small hydropower schemes in cascade form, that will utilize natural total gross water head of 230 m with a proposed total installed capacity of 24.75 MW, second, the power discharge after generation is routed through a proposed balancing pond for irrigation supplies.

Sequential Development of the Project

The entire sequencing of the project is being presented here in phases, as per different phases of project concept evolution, and implementation at different time.

a. Pre-conceptual status of the project,
b. Present status of the project

Pre-conceptual status of the present project (Soroda dam project)

Soroda reservoir served as a part of the old Rushikulya irrigation project, is utilizing water potential of River Padma, a tributary of river Rushikulya. River Padma, a right tributary of river Rushikulya lies in the upper middle portion of the basin. Another river Joro joins river Padma, at the down stream of Soroda. A weir was constructed over river Padma near Soroda to divert water by a link channel for feeding Soroda reservoir, which was built over a small drain having catchment area of 19.42 sq km.

The surplus water was allowed to spill to the river Rushikulya through a surplus escape to Bantulinala, a drain connecting river Rushikulya. The reservoir is having a designed live storage capacity of 3272 ham. The project was planned and implemented before 100 years, when population of this zone was very less, for which development of irrigation command area was not felt necessary. All irrigation command area was developed towards downstream of the river, near to the coast (plain area). Therefore this project was implemented as the storage reservoir for projects at the downstream of the river Rushikulya. The stored water was released again to river Padma through a head regulator to supplement the irrigation requirement of the Rushikulya irrigation system, at further down stream of the confluence of river Padma with Rushikulya, having a weir at Janivilli.

Thus, the reservoir at Soroda, which was mainly fed from river Padma, was acting as a balancing reservoir of Rushikulya Irrigation system.

Present status (i.e., Harabhangi Irrigation Project)

Subsequently, when the irrigation authority planned to develop irrigation command area in the upper zone of Rushikulya basin (Padma valley), the water resources of river Padma, which were being utilized for the downstream projects as stated above, was not available for this purpose. To develop the command area in the Padma valley water resources of Harabhangi river in the adjacent Vansadhara basin were chosen for transferring into this basin as an alternate water resource.

Downstream View of Harabhangi Spillway

River Harabhangi is the upper most and major potential tributary of river Vansadhara. It originates from Ramgiri hills of southern Orissa at an elevation of about 1100 m. A dam has been built to harness water, at village Adava, about 90 km down stream of its origin. The catchment area intercepted at the dam site is of 503 sq km. Consequent upon the completion of the dam; a reservoir has been formed having live storage capacity of 100.25Mcum between DSL (375.000 m) to FRL (387.500 m).

The stored water is being utilized by inter-basin transfer from Vansadhara basin to Rushikulya basin, cutting across the dividing line through a lined D-shaped tunnel of 3 m diameter and 2.2 km long, along with the approach and exit channel, for irrigation supplies. At the exit end, the water emerges out at RL 367.00 m and it flows into river Padma, which is a tributary of river Rushikulya. A pickup weir has been constructed over river Padma at Gokulpur with FRL (137.00 m) at about 33 km down stream of tunnel exit to tap the transferred water from Harabhangi reservoir for irrigation of area between Soroda and Badagada. This new pick up weir is located at upstream of the old Padma weir. The discharge of river Padma is being diverted to the renovated Soroda reservoir through a new link channel, and the Soroda reservoir functions as a balancing reservoir for the Rushikulya irrigation Projects at the downstream as stated earlier.

Thus, the portion of the river Padma from the diversion tunnel exit to Gokulpur Barrage is being used as a carrier or natural water conductor system for Harabhangi irrigation system only, because the water of the river Padma is not being practically utilized by the Harabhangi irrigation project. Construction work of the irrigation system is complete, and water is being released from Harabhangi reservoir as per the irrigation requirement.

6.2.3.2.10 Badanalla Irrigation Project

Downstream View of Badanala Spillway

Badanala Irrigation Project is an important medium irrigation project contemplated for development of the Vansadhara basin in undivided Koraput District. The project is located in Gunpur sub-division of Rayagada district. Badanala river is one of the important tributaries of River Vansadhara. Only the upper portion of the Vansadhara basin lies in Orissa and the basin topography does not permit large utilization of its resources due to its hilly terrain.

To develop the area with about 63% tribal and schedule caste population Badanala medium irrigation project was implemented by construction of the dam across the small Badanala stream and a distribution system from the impounded reservoir.

The earlier proposal by Govt. of Orissa for extending irrigation facilities to this area was to put a dam at Gotta and a barrage at Singidi as a joint venture scheme with Govt. of Andhra Pradesh for utilization of water resources of Vansadhara. Preliminary investigation was carried on but subsequently the proposal was dropped on due to un-remunerative cost considerations.

The present project consists of an earth dam across river Badanala at a little down stream of village Sakonda to impound water for irrigation purpose. This is a homogeneous earth fill dam with vertical chimney constructed in the year 1992 across river Badanalla and located at Latitude 19^0-19'-15"N and Longitude 83^0-52'-30" E near village Kenduguda in the district of Rayagada. The length and height of the dam are 325m and 48.00m respectively. Gross storage capacity at FRL is 75.64 Mm^3. Catchment area is 352 km^2. The spillway is ogee type and provided with 8 numbers of radial gates of size 12 x 8m having total discharge capacity of 4026cumec.

Gross command area of Badanala Irrigation Project is 13060ha distributed in fifty-one villages with 9800ha CCA. The intensity of kharif and rabi irrigation is 88% and 52%, respectively. Paddy is the principal crop, which is generally taken up during kharif in medium and low lands. Uplands are covered with Ragi, Arhar, Black gram, groundnut and cotton etc. and winter vegetables are widely cultivated.

6.2.3.2.11 Derjang Irrigation Project

In the early part of twentieth century, the scheme was first contemplated primarily to provide irrigation to the drought stricken area around Angul and to supply drinking water to Angul town. Numbers of sites were investigated. Finally during 1956, a preliminary report was submitted to CW&PC, which envisaged constructing a dam across Lingra only. The proposal was subsequently modified to include the runoff of river Matalia by changing the alignment of the dam. By changing the alignment the spillway could be accommodated in the Matalia riverbed where good sheet rock were available. This change not only increased the scope of the project but was cost effective. A diversion weir was existing near Ragadiapur. The present scheme was planned in such a way that it did not interfere with the D/W scheme.

A panoramic view of Derjang Dam

This was the first medium irrigation Project in the State after independence. Old earth moving machineries of Hirakud dam project were utilized in this project by importing only spares. Cost of the project per acre of irrigation was Rs. 575.00.

The reservoir scheme constructed across Twin Rivers Matalia and Lingra intercepts a catchment area of 399sqkm. The project comprises of 1875m long main dam, 1830m long Right dyke and 1220m long left dyke. The project provides irrigation to an area of 7392ha in Kharif and 1824ha in rabi. The project was chosen to be one of the four pilot schemes of the State for formation of WUA. In March 1996FOT was introduced.

6.3 Development of Minor Irrigation (Flow) Project:

Until formation of R.E.O (Rural Engineering Organization) in 1962, minor irrigation (flow) projects were constructed by Revenue Department through engineering personnel posted under them. In 1971, Rural Development Department was created after abolishing R.E.O when construction of M.I (flow) projects became their responsibility. Again in 1980, R&D Dept. (only development of M.I) merged with Irrigation Department and the situation reversed in 1990. Since 1996, M.I (flow) is under renamed Water Resources Department.

Irrigation potential to be developed from various sources has been indicated in Chapter XI, Sec.11.1 which states that out of total potential of 49.19 lakh ha from surface flow; major & medium projects account for 39.49 lakh ha. learning a balance of 9.70 lakh ha for M.I (Flow) schemes. Over the years, efforts have been made to construct a number of M.I projects throughout the State. Under M.I (Flow) irrigation potential created upto end of ninth Five Year Plan (1997-2002) is 455631 ha. In the first three years of tenth Five Year Plan (i.e. 2002-2003 to 2004-05) another 50567 ha of irrigation potential (in Khariff only) has been added, thus increasing the total irrigation potential to 506198 ha by June 2005. (Source: Chief Engineer, Minor Irrigation, Orissa).

Out of total 3646 M.I.P.s vide Table 6.16, there are 2688 nos (73.4%) reservoir schemes commanding ayacut of 318239 ha (i.e., 58% of total ayacut area) and the rest are diversion weirs. From 2688 nos. of reservoir schemes, 108 numbers are Large Dams as per ICOLD specification (vide Table 6.6). Abstract of Present condition of total 3646 M.I.P.s are furnished in Table 6.17.

Table 6.17 Present Conditions of MIPs

Sl. No.	Category of Projects	No. of MIP	As on 30.6.2005 ayacut (ha)		Remarks
			Designed	Certified	Lost ayacut of 1384 nos. of PD – CD Projects are being restored in phases under various schemes.
1	Completed & functional	2082	336899	324454	
2	Partly Derelict (P.D)	844	102763	68563	
3	Completely Derelict (C.D)	540	44652	746	
4	Ongoing	180	63037	7774	
	Total	3646	547351	401537	

There is a thinking that M.I.Ps are unable to provide full irrigation. But M.I.Ps are mostly designed under class III (i.e. 460 mm depth of water supply) or class IV type of irrigation (i.e., 230mm depth of water) which provide only protective irrigation during critical period. MIPs are popular and demanding all over the State due to following advantages which are as follows.

- Low gestation period (about 3 to 4 years)
- Less investment cost and early creation of potential
- Adaptability to entire region of the state
- Less R & R and Forest problem

The major disadvantages are

- Provides only protective irrigation limiting to 230mm or 460 mm which is not the case for major & medium projects.
- Reservoir being shallow, more evaporation loss when compared with major & medium schemes.
- Diversion weirs become non functional during scanty rainfall in catchment.
- Procedure being same for all category of projects, forest clearance and L.A. process take considerable time even for MIPs.
- Being located in remote and interior areas, the sites are unapproachable as more funds can not be invested for development of infrastructure.

Ending June 2001, there were 4808 numbers of MIPs in the State with ayacut ranging from 24 ha to 2000 ha. Ayacuts less than 40ha, numbering 1181 having 33178 ha. ayacut were transferred to the control of Panchayat Raj Department. The details of 3646 numbers of MIPs under W.R Dept. have been shown in Table 6.16. Initiatives have been taken to renovate completely derelict (C.D) and partly derelict (P.D) schemes in phased manner by obtaining financial assistance from NABARD, AIBP, RSVY, NFFW (now NREGS), Additional Central Assistance (ACA) and Biju Krushak Vikash Yojana (BKVY) etc. With funding from European Commission, 49 MIPs have been renovated and turned over (IMT) to Water Users Association (WUA).

District wise abstract of M.I.P.s (Flow) as on 30.06.2005 is given in Table 6.17 (A).

Table 6.17- (A) District Wise Abstract of M.I.Ps

Sl.no	Name of the District	Numbers of M.I.Ps					Designed Ayacut in hectares							
							Completed		Partly Derelict		Completely Derelict		On-going	
		C	P.D	C.D	On going	Total	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Angul	54	19	77	6	156	16282.00	2879.00	1757.00	77.00	7263.00	442.00	2869.00	310.00
2	Balasore	33	1	3	11	48	7017.00	3143.00	85.00	—	159.00	35.00	1192.00	220.00
3	Baragarh	99	32	36	10	177	14570.00	1993.00	5493.00	639.00	2400.00	—	7050.00	925.00
4	Bhadrak	11	0	2	4	17	1254.00	60.00	—	—	160.00	—	1352.00	800.00
5	Bolangir	52	88	12	13	165	7627.00	1505.00	9324.00	1413.00	1475.00	8.00	5995.00	302.00
6	Boudh	51	4	7	2	64	11127.00	1017.00	348.00	80.00	368.00	12.00	1109.00	—
7	Cuttack	47	26	18	15	106	12681.00	3407.00	2868.00	272.00	2091.00	92.00	3857.00	630.00
8	Deograh	15	8	6	2	31	2022.00	117.00	2012.00	52.00	504.00	—	364.00	40.00
9	Dhenkanal	80	12	69	4	165	16670.00	3918.00	1774.00	121.00	7418.00	340.00	1072.00	20.00
10	Gajapati	68	64	13	4	149	12138.00	2067.00	7102.00	486.00	1689.00	121.00	1314.00	890.00
11	Ganjam	708	252	31	3	994	73038.00	6540.00	24960.00	589.00	2456.00	24.00	1316.00	47.00
12	Jagatsingpur	—	—	—	—	—	—	—	—	—	—	-	—	—
13	Jajpur	41	38	43	11	133	5340.00	1975.00	1996.00	108.00	3616.00	211.00	4217.00	134.00
14	Jharsuguda	33	1	18	2	54	4404.00	1124.00	95.00	20.00	1552.00	—	193.00	57.00
15	Kalahandi	82	21	18	10	131	19073.00	4543.00	1637.00	148.00	1016.00	24.00	4187.00	1088.00
16	Kandhamal	50	1	4	2	57	8554.00	3392.00	80.00	—	248.00	77.00	430.00	—
17	Kendrapara	1	8	6	—	15	202.00	—	447.00	80.00	350.00	—	—	—
18	Keonjhar	95	20	21	12	148	20843.00	4843.00	1655.00	226.00	1983.00	152.00	3195.00	457.00
19	Khurda	104	40	29	7	180	14159.00	2244.00	2960.00	20.00	1382.00	—	3381.00	302.00
20	Koraput	16	28	3	3	50	1459.00	228.00	4743.00	1350.00	163.00	—	847.00	344.00
21	Malkangiri	0	14	4	10	28	—	—	1238.00	303.00	195.00	20.00	1801.00	380.00

Remarks : C – Completed, P.D. – Partly Derelict, C.D. –Completely Derelict

Sl.no	Name of the District	Numbers of M.I.Ps					Designed Ayacut in hectares							
							Completed		Partly Derelict		Completely Derelict		On-going	
		C	P.D	C.D	On going	Total	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
22	Mayurbhanj	142	31	28	1	202	26753.00	3149.00	3185.00	390.00	2072.00	192.00	668.00	202.00
23	Nawarangpur	20	10	1	21	52	4076.00	493.00	772.00	182.00	40.00	—	5595.00	176.00
24	Nayagarh	84	26	38	5	153	16404.00	4345.00	2992.00	294.00	1761.00	93.0	1415.00	440.00
25	Nuapada	23	4	1	5	33	4775.00	1514.00	956.00	336.00	81.00	—	3800.00	1169.00
26	Puri	2	3	4	—	9	82.00	16.00	208.00	—	211.00	8.00	—	—
27	Rayagada	33	42	—	6	81	3746.00	926.00	16858.00	3670.00	—	—	1961.00	308.00
28	Sambalpur	55	15	34	2	106	14633.00	1734.00	1330.00	343.00	2057.00	52.00	364.00	142.00
29	Subarnpur	17	32	2	2	53	1367.00	96.00	5195.00	373.00	161.00	—	279.00	—
30	Sundaragarh	66	4	12	7	89	16603.00	4530.00	693.00	211.00	1781.00	101.00	3213.00	646.00
	Total	2082	844	540	180	3646	336899.00	61798.00	102763.00	11783.00	44652.00	2004.00	63.037.00	10029.00

Source: Chief Engineer, Minor Irrigation, Orissa

6.4 Development of M.I (Lift) Project

6.4.1 Groundwater Resources & Irrigation potential

'The annual replenishable groundwater recharge of the state has been estimated to be 2.00 m.ham, out of which the utiliziable quantity is 1.53 m.ham. The utilizable irrigation potential of the state has been estimated as 4.203 m.ha based on crop water requirement and availability of cultivable land.'

The overall level of ground water development in the state has been 18.31% by March 2004. The highest level of development is in Balasore district (47.46%), followed by Bhadrak district (45.25%) The level of ground water development in other districts is very low. It is only in Bhograi and Baliapal blocks of Balasore district, the level of ground water development has exceeded 60%. This leaves a huge balance of ground water resources and irrigation potential to be developed. The numbers of additional abstraction structures feasible in the state have also been worked out keeping in view the hydrological situations; terrain condition and designed ayacut per unit structure vide Table 6.18. Table 6.19 gives the existing ground water structures for irrigation as on 31.3.2004. Year wise area irrigated through Lift irrigation points from 1973-74 to 2005-06 is furnished in Table 6.20.

Directorate of Economics & Statistics, Govt. of Orissa conducted census of M.I schemes for the third time during 2001-2002 with reference year 2000-2001. The census of M.I schemes was conducted in 50099 revenue villages of the State on complete enumeration basis (1st census in 1987-88 and 2nd in 1995-96). The abstract of 3rd M.I census is presented in Table 6.21 & 6.22, which has been discussed under Sec.6.5 of this chapter.

Table 6.18 Stage of Ground Water Development of Orissa, as on 31^{ST} March 2004

Sl no	Assessment Unit / District	Total ground water recharge (ham)	Natural discharge during non monsoon season (ham)	Net annual ground water availability (3-4) (ham)	Existing gross ground water draft for irrigation (*)	Existing gross ground water draft for domestic & industrial water supply	Existing gross ground water draft for all uses (6+7) (ham)	Allocation for domestic and industrial requirement supply upto nest 25 years	Net ground water availability for future irrigation development (5-6-9)	No. of additional GW structures feasible for irrigation use				Stage of ground water development {(8/5) * 100)}	Balance irrigation potential(ha)
										MDTW	SDTW	FPTW	DW		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Angul	94870	8197	86673	11881	3279	15160	3935	70857	0	0	0	44377	17.49	58578
2	Balasore	110304	10422	99882	43018	4386	47404	5556	51308	155	489	1411	4293	47.46	23984
3	Baragarh	61227	5151	56076	5105	2924	8029	3687	47284	0	0	0	10226	14.32	13498
4	Bhadrak	56294	5084	51210	20294	2878	23172	2946	27970	195	308	666	2377	45.25	15942
5	Bolangir	78656	7308	71348	9049	2913	11962	4051	58248	0	0	0	4430	16.77	5848
6	Boudh	40723	3749	36974	5350	820	6170	1359	30265	0	0	0	23128	16.69	30529
7	Cuttack	116573	11207	105366	14635	5006	19641	6747	83984	401	619	3334	13770	18.64	53708
8	Deogarh	23180	1956	21224	1859	566	2425	786	18579	0	0	0	11459	11.43	15126
9	Dhenkanal	72199	7007	65192	8040	2354	10394	3479	53673	0	0	0	37432	15.94	49410
10	Gajapati	30362	2606	27756	4033	1029	5062	1202	22521	0	0	0	13983	18.24	18458
11	Ganjam	123860	10060	113800	22548	6433	28981	8948	82304	0	248	443	45340	25.47	65943
12	Jagatsingpur	152942	13245	139697	18378	1971	20349	2765	118554	195	745	5703	10011	14.57	57189
13	Jajpur	65553	6554	58999	17267	3874	21141	8542	33190	187	30	1336	8615	35.83	22753
14	Jahrsuguda	18673	1407	17266	2733	1143	3876	1849	12684	0	0	0	8279	22.45	10928
15	Kalahandi	99260	9740	89520	9530	3230	12760	6354.2	71652.6	0	0	0	54120	14.25	71438
16	Kandhamal	69330	6933	62397	5159	1478	6637	2170	55068	0	0	0	38929	10.64	51386
17	Kendrapara	35690	3543	32147	8852	1395	10247	794	22501	0	73	269	7242	31.88	12019
18	Keonjhar	143188	10904	132284	13977	3600	17577	4954	113353	0	217	0	83799	13.29	114087
19	Khurda	99990	9806	90184	7728	4736	12464	8542	73914	7	188	1133	40064	13.82	61499
20	Koraput	89781	7646	82135	2116	3349	5465	4033	75986	0	0	0	57159	6.65	75450
21	Malkangiri	36289	3409	32880	914	1065	1979	1281	30685	0	0	0	25339	6.02	31071

Sl no	Assessment Unit / District	Total ground water recharge (ham)	Natural discharge during non monsoon season (ham)	Net annual ground water availability (3-4) (ham)	Existing gross ground water draft for irrigation (*)	Existing gross ground water draft for domestic & industrial water supply	Existing gross ground water draft for all uses (6+7) (ham)	Allocation for domestic and industrial requirement supply upto nest 25 years	Net ground water availability for future irrigation development (5-6-9)	No. of additional GW structures feasible for irrigation use				Stage of ground water development {(8/5) * 100)}	Balance irrigation potential(ha)
										MDTW	SDTW	FPTW	DW		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
22	Mayurbhanj	166948	14882	152066	27553	5466	33019	6641	117872	249	103	0	69120	21.71	98862
23	Nawapara	40810	4080	36730	4702	1135	5837	1528	30500	0	0	0	17593	15.89	23223
24	Nayagarh	56986	5556	51430	6082	1898	7980	2418	42930	0	0	0	14732	15.52	19446
25	Nawarangpur	51974	3873	48101	3145	2226	5371	3809	41147	0	20	48	25390	11.17	34065
26	Puri	97890	9539	88351	5946	3341	9287	3187	79218	110	383	2343	9086	10.51	32008
27	Rayagada	69424	6541	62883	4699	3311	8010	3389	54795	0	228	387	35715	12.74	52649
28	Sambalpur	72712	6375	66337	4432	2425	6857	2921	58984	0	0	0	35926	10.34	47422
29	Subarnapur	32866	2923	29943	2196	1167	3363	1827	25920	0	0	0	20224	11.23	26696
30	Sundargarh	100061	7984	92077	9680	4468	14148	5590	76807	0	0	0	55142	15.37	72787
	Total	2308615	207687	2100928	300901	83866	384767	115290.2	1682753.6	1499	3651	17073	825500	18.31	1266002

N.B: GW=Ground water, DW= Dug Well, TW=Tube Well, STW= Shallow, TW, FPTW= Filter Point, TW, BW= Bore Well, MDTW=Medium Deep TW, DTW= Deep TW.

Unit draft of GW structures (HM) DW (tenda) =0.30, DW (pump set) =1.00, STW (RIDF) =2.00, FPTW=3.00, BW=4.50, STW=10.00, MDTW=15.00, DTW=25.00.

All GW structures / draft figures are as on 31st March 2004.

(*) For details of GW draft, refer Table No-6.21 col.12

Source: Dynamic Ground Water Resources of Orissa, March 2004, GWSI, Orissa & CGWB, Govt. of India.

Table 6.19 Ground Water Draft of Orissa (2004)

Sl. No.	District	Nos. of existing GW structures for irrigation use as of 31.03.2004								Annual GW draft (HM) as of 31.03.2004				Ground water resources assessed 1999 (ham)	Stage of GW development (%)
		DW with tenda	DW with pump set	STW (RIDF)	FPTW	BW	STW	MDTW	DTW	Irrigation use	Domestic use	Industrial use	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Angul	27718	2454			247				11881	2509	770	15160	86673	17.49
2	Balasore		5708	770	5010		256	1212		43018	4146	240	47404	99882	47.46
3	Baragarh	6444	436			608				5105	2777	147	8029	56076	14.32
4	Bhadrak	108		2368			1398	103		20294	2387	491	23172	51210	45.25
5	Bolangir	20189	2671			71				9049	2727	186	11962	71348	16.77
6	Boudh	13772	1191			6				5350	789	31	6170	36974	16.69
7	Cuttck	10971	999	3327				246		14635	4790	216	19641	105366	18.64
8	Deogarh	4195	56			121				1859	535	31	2425	21224	11.43
9	Dhenkanal	13496	3590			89				8040	2207	147	10394	65192	15.94
10	Gajapati	3319	2334			5	68			4033	962	67	5062	27756	18.24
11	Ganjam	29976	4042	84	9	30	918			22548	5966	467	28981	113800	25.47
12	Jagatsinghpur	421	2171	1480	1304		870	34		18378	1919	52	20349	139697	14.57
13	Jajpur	7109	263	1778	1144	24	272	337		17267	3437	437	21141	58999	35.83
14	Jharsuguda	6306	557			63				2733	915	228	3876	17266	22.45
15	Kalahandi	24861	1646			94				9530	2826	404	12760	89520	14.25
16	Kandhamal	10360	2050							5159	1373	105	6637	62397	10.64
17	Kendrapara	878	58		11		896		15	8852	1348	62	10247	32147	31.68
18	Keonjhar	22562	3889		657	57	109			13977	3360	240	17577	132284	13.29
19	Khurda	16455	311	333		143	97		8	7728	4106	630	12464	90184	13.82
20	Koraput	4118	658		5	46				2116	2052	1297	5465	82135	6.65
21	Malkangiri	2211	252							914	909	156	1979	32880	6.02
22	Mayurbhanj	9075	11518	193	2225	6	108	343		27553	4583	883	33019	152066	21.71
23	Nawapara	8599	1326			177				4702	1102	33	5837	36730	15.89
24	Nawarangpur	7095	892			28				3145	2169	57	5371	51430	11.17
25	Nayagarh	13548	707	396	14	106				6082	1803	95	7980	48101	15.52
26	Puri	3300	1407	111	791	12		60		5946	3133	208	9287	88351	10.51
27	Rayagada	3851	619	37	15	41	262			4699	1541	1770	8010	62883	12.74
28	Sambalpur	9084	1126			129				4432	1941	484	6857	66337	10.34
29	Subarnapur	5282	512			22				2196	1127	40	3363	29943	11.23
30	Sundargarh	13892	4899			136				9680	3980	488	14148	92077	15.37
	State Total	299195	58341	10877	11185	2261	5254	2335	23	300901	73419	10462	384767	2100928	18.31

Table 6.20 Year Wise Area Irrigated Through LIPs

Sl.no	Year	Khariff		Rabi	
		Nos. operated	Area (ha)	Nos. operated	Area (ha)
1	1973-74	328	1509	958	7508
2	1974-75	432	2416	1238	11900
3	1975-76	355	1764	1621	14735
4	1976-77	1134	8930	1972	18320
5	1977-78	726	4925	2148	18943
6	1978-79	560	3140	2347	17409
7	1979-80	2612	13894	3042	24823
8	1980-81	1539	6779	3337	24054
9	1981-82	2210	10469	3906	29050
10	1982-83	4284	35309	5355	54364
11	1983-84	3287	20400	5314	48617
12	1984-85	4191	27016	5829	69410
13	1985-86	3627	27550	5620	49480
14	1986-87	3746	25878	6197	49582
15	1987-88	7132	46530	8148	80176
16	1988-89	5249	28052	7796	80004
17	1989-90	3018	25721	7338	74820
18	1990-91	3624	29821	8045	80582
19	1991-92	6175	46574	8625	82294
20	1992-93	3635	31809	6921	45629
21	1993-94	1660	13689	6968	50285
22	1994-95	1837	15642	8909	108196
23	1995-96	2572	21125	7530	61649
24	1996-97	7606	79476	9572	113495
25	1997-98	2640	16114	7426	71751
26	1998-99	7592	37939	8771	69905
27	1999-00	1903	12534	9165	94687
28	2000-01	4998	28489	5116	31743
29	2001-02	693	5606	1588	10736
30	2002-03	2027	24691	2674	21152
31	2003-04	1364	14422	3659	37142
32	2004-05	4053	40829	4943	60207
33	2005-06	4964	76449	6838	100152

Table 6.21 Abstract of 3rd M.I Census (2000-01) at a Glance

Sl. No	Item	Ground Water			Surface Water	
		Dug well	Shallow tube well	Deep tube well	Surface flow	Surface lift
1	2	3	4	5	6	7
1	Total M.I Schemes (No)	3,57,669	43,881	4,592	28,303	32,844
2	Village with M.I Schemes (%)	58	16	6	27	21
3	M.I Schemes per village (No)	12	1	0	1	1
4	M.I Schemes per '000 hectares of cultivable area (No)	60	7	1	5	6
5	Status of M.I Schemes					
	a. In use (%)	79.27	80.67	37.22	82.61	79.52
	b. Not in use					
	i. Permanently (%)	1.34	4.23	25.39	4.17	5.97
	ii. Temporarily (%)	19.39	15.10	37.39	13.22	14.51
6	Schemes as per holding size					
	a. Marginal farmers (%)	37.55	29.33	0.39	2.59	18.79
	b. Small farmers (%)	39.04	38.97	2.03	4.93	20.06
	c. Medium farmers (%)	21.37	27.02	5.90	8.61	15.40
	d. Big farmers (%)	1.73	2.00	2.20	7.23	12.27
	e. Others (%)	0.32	2.68	89.48	76.65	33.48
7	Schemes as per Social Group					
	a. Schedule caste %)	12.31	12.09	0.11	2.06	5.83
	b. Scheduled tribes (%)	30.43	2.61	--	5.07	12.82
	c. General (%)	57.26	85.3	99.89	92.87	81.35
8	Location of the M.I Schemes					
	a. within command of major / medium (%)	0.67	2.27	0.57	3.76	0.58
	b. outside command of major / medium (%)	99.33	97.73	99.43	96.24	99.42
9	Culturable Command Area (CCA) (Lakh ha)	1.43	1.18	0.69	5.98	2.21
10	Average CCA per Scheme (ha)	0.40	2.69	15	21.13	6.72
11	Gross Irrigation potential created (IPC) (Lakh ha)	1.82	1.53	0.94	6.90	3.03
12	Average I.P.C per scheme (ha.)	0.51	3.48	20.52	24.36	9.23
13	Gross Irrigation potential utilized (IPU) (Lakh ha)	0.77	0.66	0.11	3.65	1.03
14	Average I.P.U per scheme (ha.)	0.22	1.51	2.44	12.88	3.14

Source: Director of Economics & Statistics, Orissa.

Table 6.22 District wise Details of D.W, Shallow T.W, Deep T.W, Surface lift & Surface flow Schemes in the State.

Sl.No	Name of the District	Total number of Dug wells (G.W)	Total no. of shallow Tube wells (G.W)	Total no. of deep T.W (G.W)	Total no. of surface lift	Total no. of surface flow (*)
1	2	3	4	5	6	7
1	Angul	26232	10	2	583	595
2	Bolangir	55566	48	33	1621	2085
3	Balasore	1659	13345	1636	399	129
4	Baragarh	18463	1461	69	1186	2973
5	Bhadrak	250	3902	564	822	232
6	Boudh	10356	0	0	158	326
7	Cuttck	14059	4578	295	2767	468
8	Deogarh	7489	1	5	719	306
9	Dhenkanal	10972	12	5	472	1207
10	Gajapati	3310	141	2	217	1313
11	Ganjam	30751	1959	91	1674	4586
12	Jagatsingpur	934	4002	262	98	7
13	Jajpur	2583	3145	699	885	218
14	Jharsuguda	6900	10	146	575	535
15	Kalahandi	17139	38	13	460	1027
16	Kandhamal	7760	1	0	171	600
17	Kendrapara	298	1253	60	2145	7
18	Keonjhar	20149	785	46	1528	737
19	Khurda	13635	858	41	529	566
20	Koraput	4406	5	2	2004	1627
21	Malkangiri	1225	0	8	162	574
22	Mayurbhanj	11341	1841	405	2230	954
23	Nawapada	13211	11	5	203	848
24	Nayagarh	15082	260	10	224	523
25	Nawarangpur	10231	11	6	2191	185
26	Puri	767	5747	96	5252	745
27	Rayagada	1756	381	12	529	3411
28	Sambalpur	16333	23	33	1424	843
29	Sonepur	12010	20	3	306	430
30	Sundargarh	22802	33	43	1310	246
	ORISSA	**357669**	**43881**	**4592**	**32844**	**28303**

(*) Includes Tanks, Reservoirs, Diversion weirs & Water harvesting structures.
Source: 3rd M.I census, Director of Economics & Statistics, Orissa 2000-01.

6.5 Discussion on 3rd M.I Census

The ground water schemes viz. Dug well, Shallow Tube well and Deep Tube well and the surface water schemes viz. Surface Flow and Surface Lift are covered under the folds of the 3rd M.I Census. It would be pertinent to disseminate the important characteristic of these schemes.

6.5.1 Dug Well

The result of the 3rd M.I census reveals that there were 3.58 lakh number of dug wells in the State. The total number of schemes under dug wells have increased from 3.23 lakh during the 2nd M.I census in 1993-94 to 3.58 lakhs during the present census in 2000-01 showing as increase of 1084% over the 2nd census.

The CCA created through the dug well schemes was 1.43 lakh hectares during 2000-01 corresponding to 1.38 lakh hectares during 1993-94 showing an increase of 3.62 % over the 2nd census. Out of the total 3.58 lakh dug wells 2.84 lakh were in use, 0.69 lakh were temporarily defunct and 0.05 lakh were not in use due to other reasons. The Gross Irrigation Potential created was under-utilised in the case of 2.07 lakh dug wells due to reasons such as less discharge of water, mechanical break down of lifting devices, non availability electric power in time.

6.5.2 Shallow Tube Well

Number of shallow T.Ws (i.e., less than 30 m depth) presented in 3rd M.I. Census stands at 43881 corresponding to 18095 during 2nd census showing an increase of 142.5% between 1993-94 to 2000-01 in the State. C.C.A. created through shallow T.Ws was 1.18 lakh ha during 2000-01 as against 0.71 lakh ha during 1993-94. This shows an increase of 66.18% over the said period. Various lifting devices were used in the shallow T.W.s for pumping water. About 34.92% cases used electric pumps, 57.91% diesel pumps, 1.29% use wind mills and only 0.05% solar pumps as lifting device.

6.5.3 Deep Tube well

There were 4,592 numbers of deep tube well (i.e. more than 100m depth) schemes in the State during 2000-01 corresponding to 2. 911 during 1993-94 showing an increase of 57.75% during the said period.

The CCA created by the deep T.Ws in the State during 3rd M.I census was 0.69 lakh hectares as against 0.52 lakh hectares during 2nd M.I census showing as increases of 33.27% over the period. Most of the deep T.W.s used electric pumps (86.85%). Diesel pumps were used in 5.03% and wind mills in 8.12% cases.

6.5.4 Surface Flow

The total number of surface flow schemes in the State during the 3rd M.I census was 28, 303 as against 24,103 during 2nd M.I census showing an increase of 17.43% over the period from 1993-94 to 2000-01.

The C.C.A created by the surface flow schemes in the State during the 3rd M.I census was 5.98 lakh hectares corresponding to 5.69 lakh hectares during 2nd M.I census showing an increase of 5.16% over the period. 3.65lakh hectares of different crop area was irrigated through surface flow schemes during 2000-01. Kharif crops account for 90.14% of irrigation, Rabi crops 9.53%, Perennial crops 0.26% and other crops 0.07% of the total irrigated area.

6.5.5 Surface Lift

A novel means of irrigating large crop fields nearby riverrine tracts was developed in the early '70's in the State; that was the floating pump scheme. There pumps were kept on large floating barges which used to sail upstream and downstream for some particular hours and used to pump required quantum of water to irrigate nearby agricultural land. An electric line drawn along the river bank used to supply electric power to the floating pumps. (Refer 'Irrigation in India–History of Potential of Social Management' by K.S.Bagchi, 1995, Pg.58). This was extremely successful in Banki and Pattamundai area of undivided Cuttack districts. Unfortunately those have become defunct at present.

The total number of surface lift schemes as per the 3^{rd} M.I census was 32844 in the State corresponding to 20604 numbers during the 2^{nd} M.I census showing an increase of 59.41% over the period. The C.C.A created through surface lift schemes was 2.21 lakh hectares during 3^{rd} census corresponding to 1.94 lakh hectares during the 2^{nd} census showing an increase of 13.50% over the period.

Different lifting devices were used in surface lift schemes as found during the 3^{rd} M.I census. Use of electric pump constitutes 27.75%, diesel pump 37.21%, wind mills 0.94%, solar pump 0.29% and other devices in 33.81% of the total surface lift schemes in the State. The total area irrigated through surface lift schemes in the State during 2000-01 was 1.03 lakh hectares. Khariff crop utilised 53.18% of irrigation, 44.28% by Rabi crops, 2.19% by Perennial crops and 0.35% by other crops through surface lift schemes in the State.

Few Creek Irrigation Projects have been taken up in the State by renovating the existing creeks for arresting saline ingress, removing drainage congestion, recharging the ground water table and providing irrigation. The details of schemes have been furnished in Table 6.23 (a) & (b).

Table 6.23 (a) Details of Completed & Ongoing Creek Irrigation Projects.

Sl. no	Name of the Creek Irrigation Project	District	Estimate Cost (Rs. in lakh)	Achieved Ayacut (ha).	Remark
1	2	3	4	5	6
1	Haladiganda	Bhadrak	232.28	2708	Sl. 1 to 8 completed under CGWB assistance. Sl. 9 and 10 were taken up under RIDF IV and since completed.
2	Nuanai	-do-	114.49	1456	
3	Karanji	-do-	89.48	810	
4	Kaudia	-do-	62.20	1429	
5	Badaharipur	-do-	40.95	1200	
6	Kani	Kendrapara	80.00	500	
7	Talasuan	Puri	20.00	250	
8	Arresting salinity ingress and ground water recharge in Basudevpur and Chandabali block	Bhadrak	609.50	5332	
	Total through CGWB		1248.90	13685	
9	Nagarighat	Jagatsinghpur	224.88	1950	
10	Guneimuhan	Jagatsinghpur	106.00	1800	
	Total through NABARD		330.88	3750	

Table 6.23 (b) Ongoing Projects with NABARD Assistance

Sl. No	Name of the Creek Project	Scheme	District	Estimate Cost (Rs in lakh)	Achieved Ayacut (ha)
1	Malibasa – Tantiapal	RIDF-VIII	Kendrapara	674.93	4000
2	Kathilogotha	RIDF-VIII	Khurda	360.75	1070
3	Weikhia	RIDF-X	Khurda	478.00	1700
4	Tikarapara	RIDF-X	Puri	119.10	1050
5	Rajkanika	RIDF-X	Kendrapara	371.60	1790
6	Galiajore	RIDF-X	Bhadrak	356.04	1177
7	Arjunbindha	RIDF-X	Bhadrak	260.43	4569
8	Mahulia – Harishpur	RIDF-XII	Kendrapara	249.10	924
9	Aul	RIDF-XII	Kendrapara	808.18	7000
10	Andanga Nalla	RIDF-XII	Puri	151.31	1200
11	Suhagpur Nalla	RIDF-XII	Puri	170.97	2300
			Total	**4000.41**	**26780**

Source: Chief Engineer, Lower Mahanadi Basin, Orissa, Bhubaneswar.

6.6 Problems and suggestion regarding M.I schemes

Constraints and suggestion for improvement in respect of M.I schemes as revealed from 3rd M.I census have been briefly narrated as under.

6.6.1 Problems

The problems encountered in course of 3rd M.I census are heterogeneous in nature. However, it would be pertinent to jot down few issues for eradication of the same.

a) Lack of regular maintenance of the M.I schemes lead to defunct / disuse of the project in short time.

b) Sustenance of M.I schemes solely depend upon feasibility and economic viability of the project. Hydrological studies may be carried out prior to taking up any new project.

c) The right choice for the right beneficiary should be explored for successful implementation of M.I schemes. Soon after completion, the schemes may be handed over to the Pani Panchayats except headwork of M.I (Flow) schemes.

d) Few M.I.P.s have been constructed at the site where medium projects were feasible. By doing so, potential is underutilised. Further some M.I.P.s were constructed within the ayacut of major & medium projects which have been subsequently abandoned.

6.6.2 Suggestion for improvement

i) All out effort should be made for development of M.I schemes as an integral part of irrigation to increase agricultural production, to increase employment potential and to push forward the value of cultivated land.

ii) Special emphasis should be given in the private sectors to accelerate irrigation potential to a considerable extent with the help of M.I projects particularly Tube wells, Dug wells and lift schemes.

iii) Manufacturing synergy between the development and public.

iv) Installation of M.I schemes may be under taken by considering the source of ground water, feasibility and economic viability of the scheme.

v) The gap between the irrigation potential created and utilised should be minimized and farmers encouraged for crop rotation.

vi) Efforts should be made to diversify the cropping pattern.

vii) Irrigation management may be transferred to the beneficiaries by forming W.U.A to bring a sense of belongingness in them.

viii) Irrigation is the vital input for development of agriculture. As development of rural economy depends upon agriculture, a lion's share of arid land of the State can be converted to green field with the help of M.I schemes.

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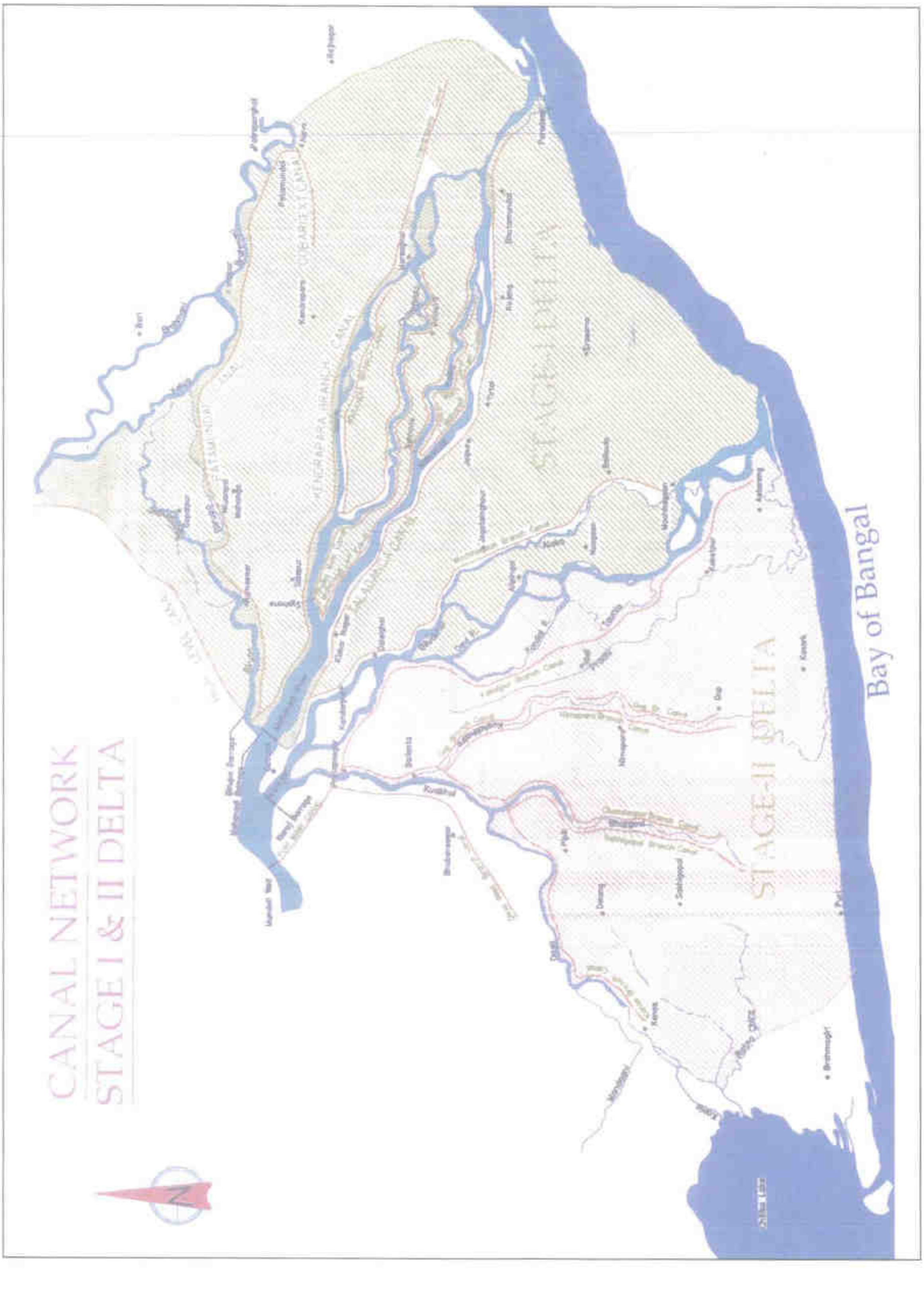
CANAL NETWORK
STAGE I & II DELTA
STAGE-I DELTA
STAGE-II DELTA
Bay of Bangal

Figure 6.1

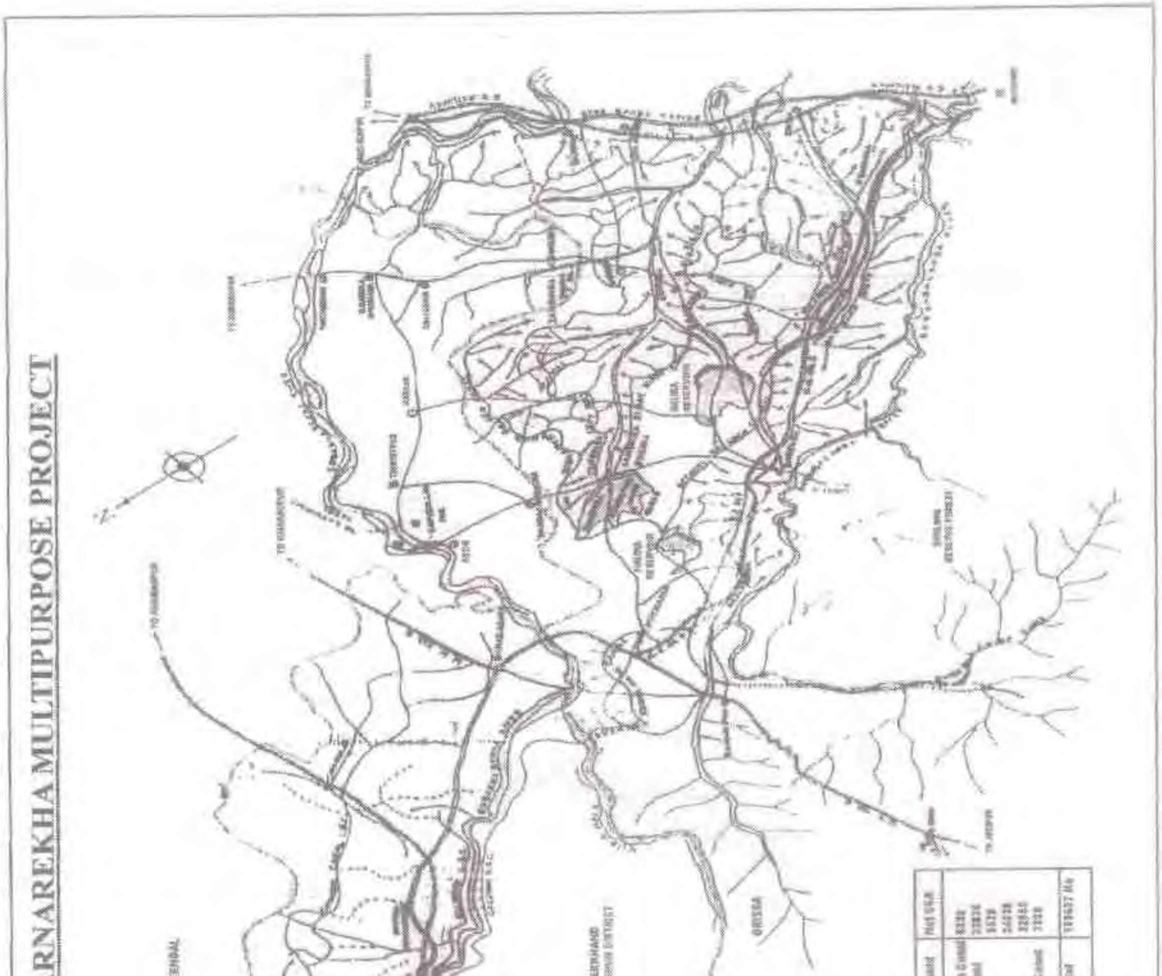
INDEX MAP OF SUBARNAREKHA MULTIPURPOSE PROJECT
REFERENCES
WEST BENGAL
JHARKHAND
ORISSA
TO RANCHI

Figure 6.2

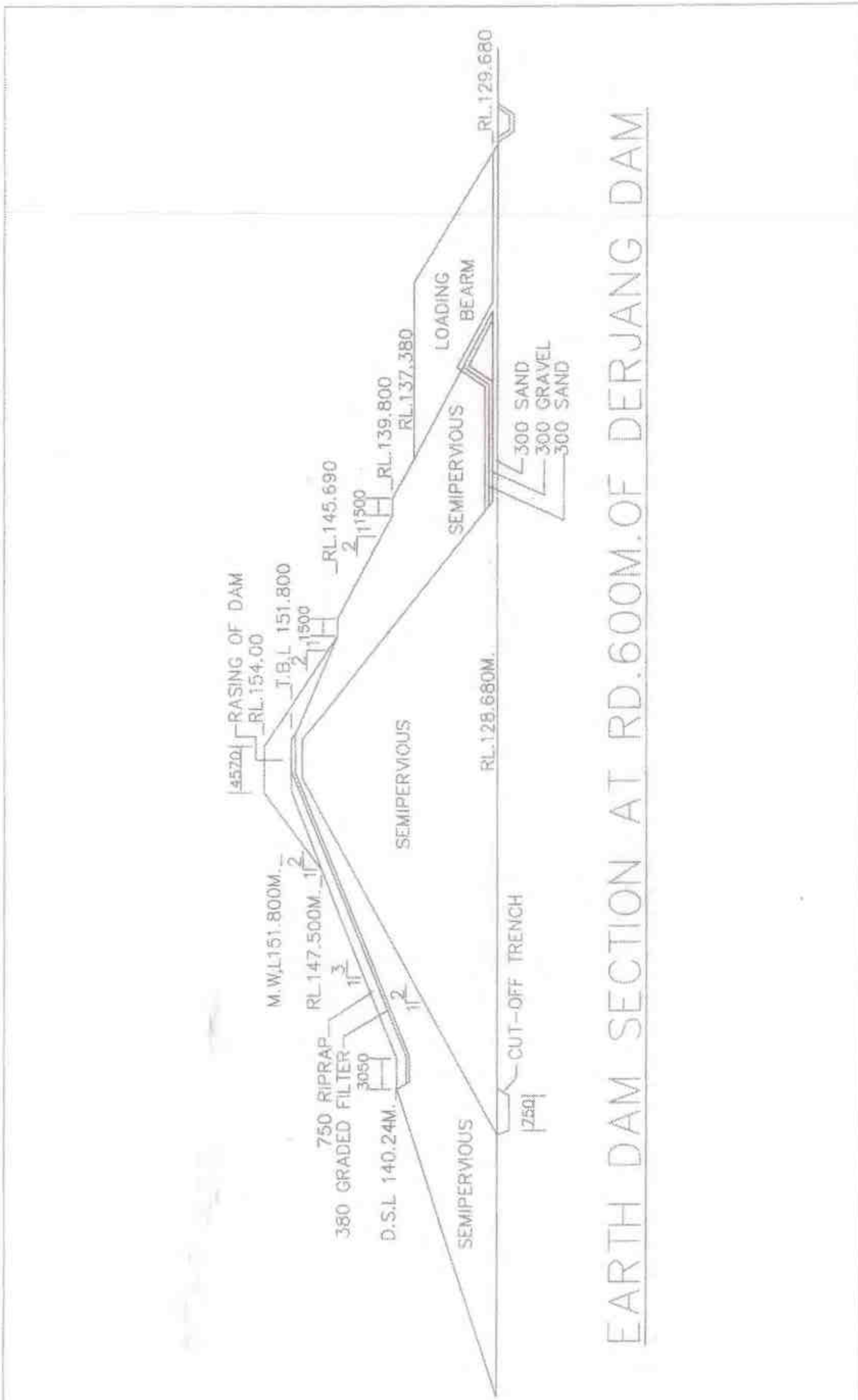
EARTH DAM SECTION AT RD.600M.OF DERJANG DAM
RL.129.680
LOADING
BEARM
RL.137.380
RL.139.800
300 SAND
300 GRAVEL
300 SAND
SEMIPERVIOUS
RL.145.690
1500
RL.128.680M.
RASING OF DAM
RL.154.00
T.B.L 151.800
1500
4570
SEMIPERVIOUS
M.W.L151.800M.
RL.147.500M.
CUT-OFF TRENCH
750 RIPRAP
380 GRADED FILTER
3050
D.S.L 140.24M.
SEMIPERVIOUS
750

Figure 6.3

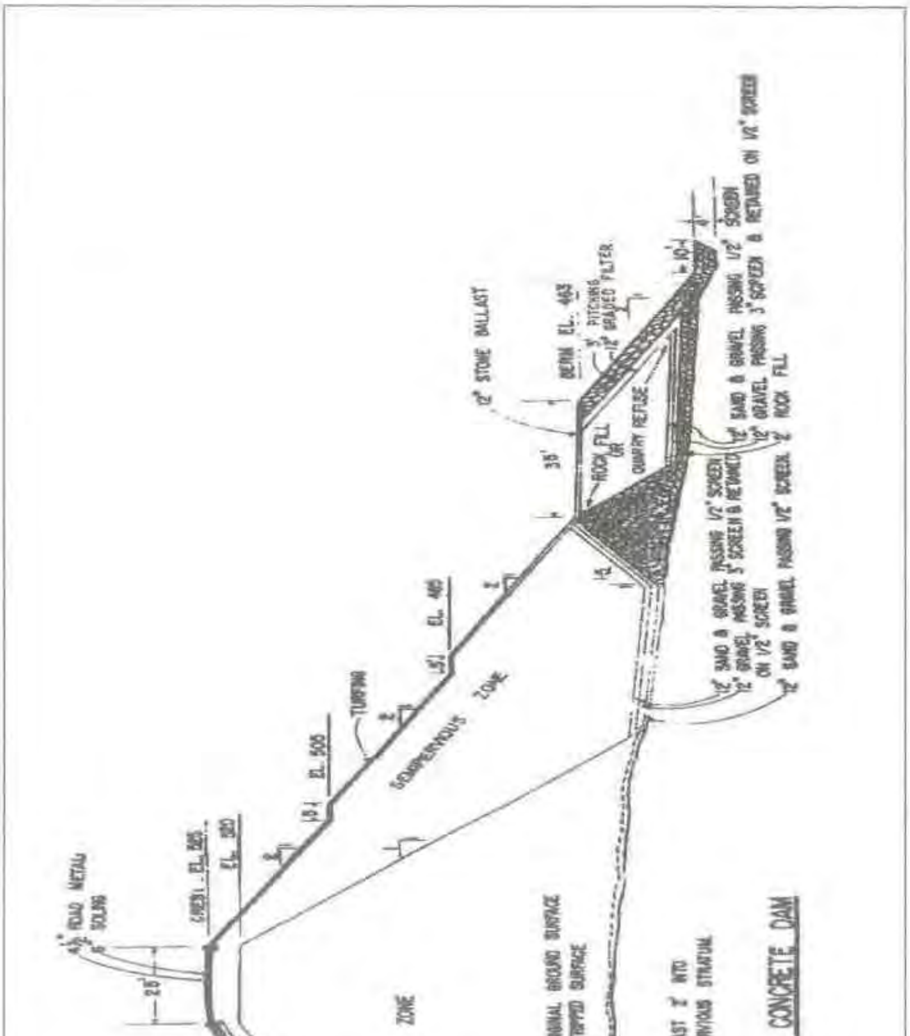
SECTION FROM R.D.22150 TO CONCRETE DAM
IMPERVIOUS ZONE
SEMIPERVIOUS ZONE
ORIGINAL GROUND SURFACE
STRIPPED SURFACE
ROCK FILL OR QUARRY REFUSE
12" STONE BALLAST
TURFING

Figure 6.4

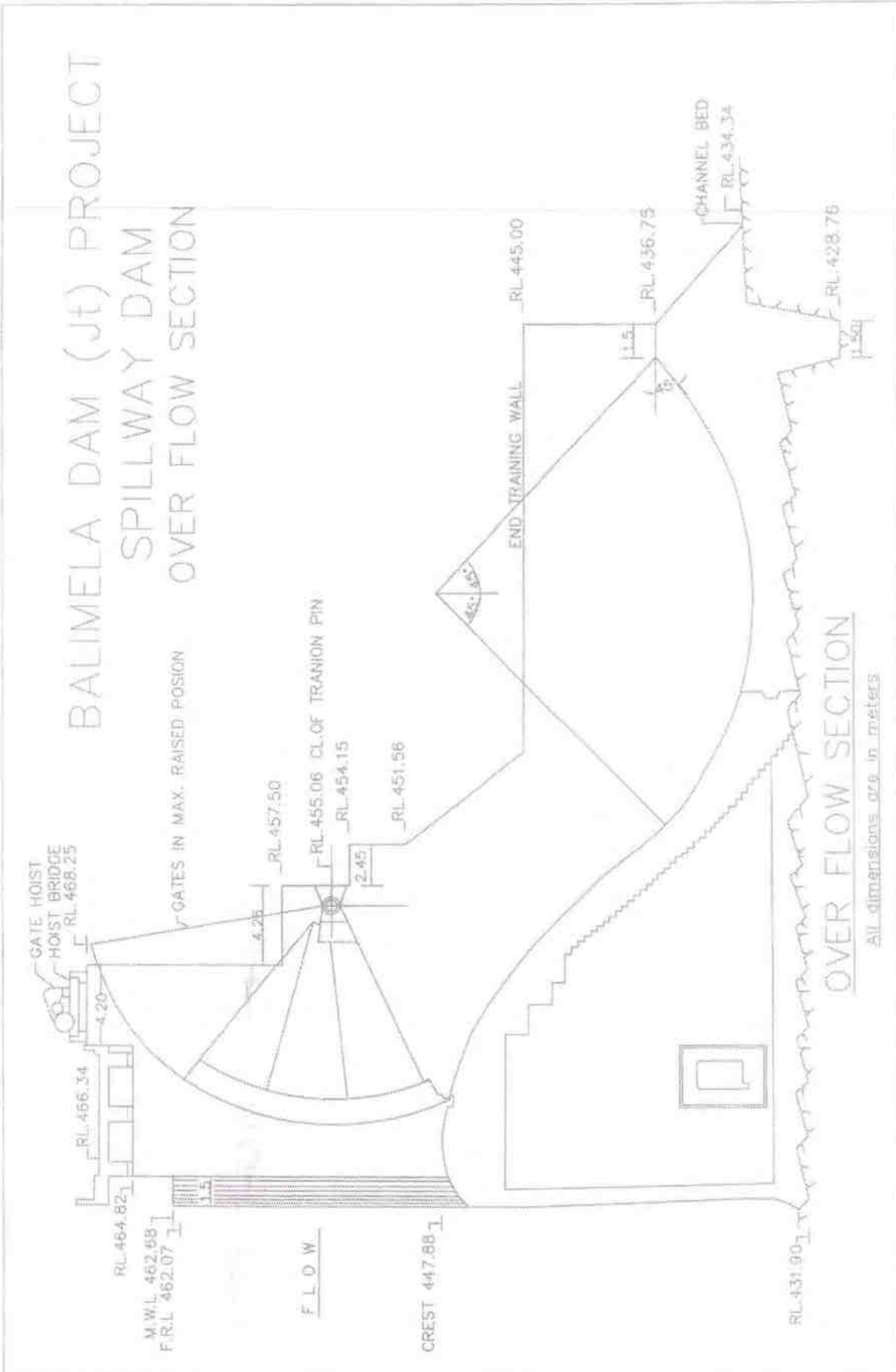
BALIMELA DAM (Jt) PROJECT
SPILLWAY DAM
OVER FLOW SECTION
GATE HOIST
HOIST BRIDGE
RL 468.25
GATES IN MAX. RAISED POSION
RL 457.50
RL 455.06 CL OF TRANION PIN
RL 454.15
RL 451.56
4.20
4.25
2.45
END TRAINING WALL
RL 445.00
45°
RL 436.75
1.5
CHANNEL BED
RL 434.34
RL 428.75
1.50
RL 466.34
RL 464.82
M.W.L 462.68
F.R.L 462.07
1.5
FLOW
CREST 447.88
RL 431.90
OVER FLOW SECTION
All dimensions are in meters

Figure 6.5

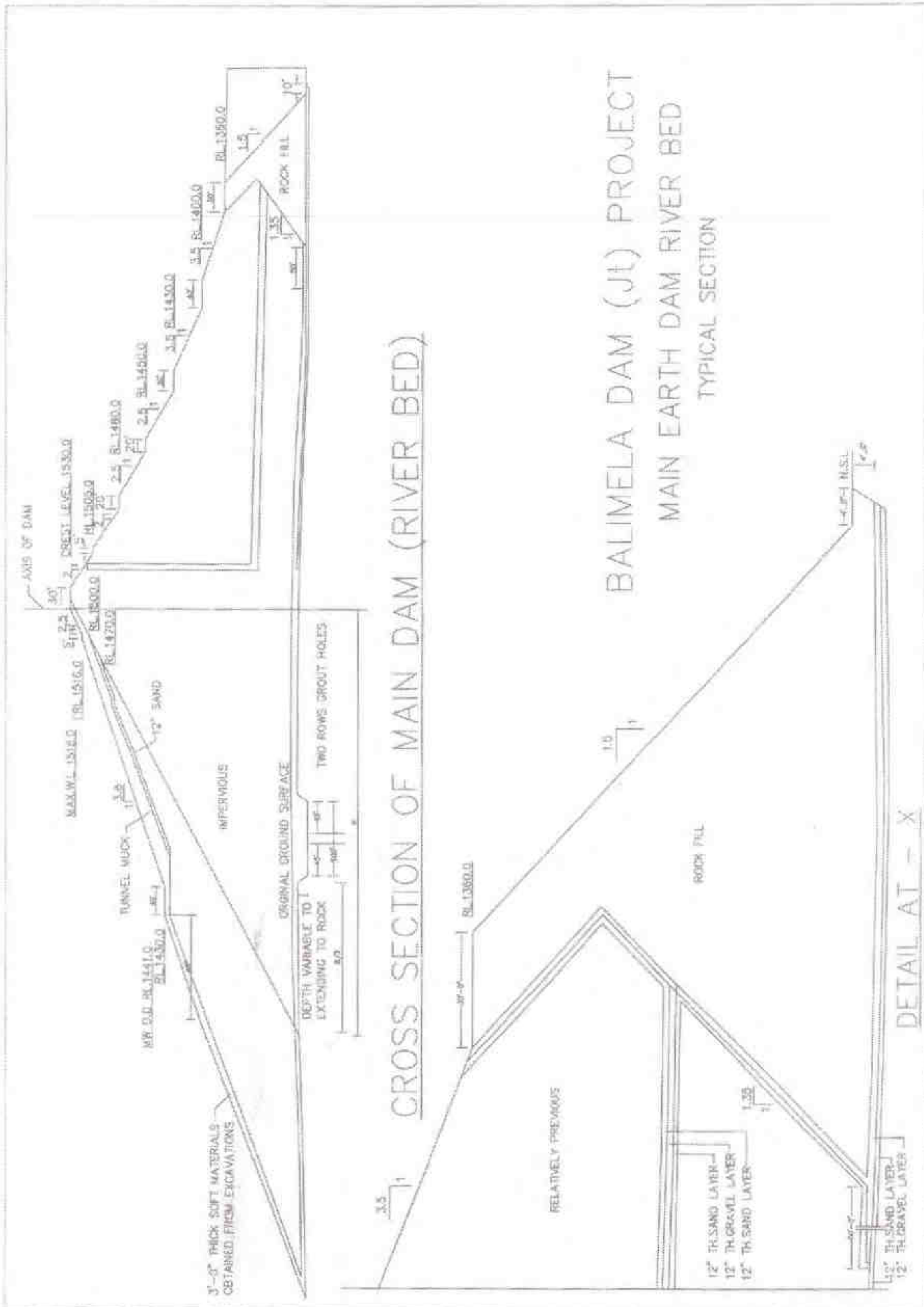
BALIMELA DAM (Jt) PROJECT
MAIN EARTH DAM RIVER BED
TYPICAL SECTION
CROSS SECTION OF MAIN DAM (RIVER BED)
DETAIL AT - X
IMPERVIOUS
ROCK FILL
RELATIVELY PREVIOUS

Figure 6.6

Chapter VII

FLOOD, DRAINAGE & DROUGHT

7.0 Introduction

Almost every year, vast stretches of land in the delta and fertile areas of Cuttack, Puri, Balasore and Ganjam are severely affected either by flood, cyclone or drought. Sometimes two or more such natural phenomena have occurred in one year in different parts of the State (vide Table No-2.9). The nature has become the potent enemy in the economic development of Orissa. The flood, drought and cyclone are recurring features, which have broken the backbone of its people. There is hardly a year when the state has not experienced such natural calamity. Attempt has been made by some scholars to study the intensity of natural calamities and its impact on the socio-economic condition of the people. Few of them are described here.

'History of Orissa' written by William Hunter published in 1872 provides an extensive coverage on natural calamities like flood, famine and consequent socio-economic problems. Similarly 'A sketch of History of Orissa' by George Toynbee published in 1873 highlights the administrative aspects of East India Company from 1803 to 1828 with a brief description of scarcity of food grains from 1806 to 1809. N.N Banerjee's 'Report on Agriculture of the districts of Cuttack' (1898) throws some insight into the history of natural calamities in Cuttack district. Two other coastal districts, i.e., Puri and Balasore, which are prone to cyclone, have been ignored. But S.L.Maddox's 'The Final Report on Survey and Settlements of Province of Orissa (1890-1900)' gives a brief outline of the natural calamities in the State. The autobiography written by Fakir Mohan Senapati (1917) in Oriya describes an eyewitness account of the terrible famine of 1866. This aspect has been briefly narrated in Chapter II under Sec.2.7.1.1. Causes and consequences of 1966 famine has also been analysed by Dr. H.K. Mahatab in his 'History of Orissa' Vol. II, 1960. 'History of Orissa' Vol. VI (1964) written by P. Mukherji provides an outline on natural calamities in Orissa and the infamous famine of 1866. 'The famine and some aspects of British Economic Policy in Orissa 1866-1905' written by G.C.Patnaik (1980) reviews the socio-economic condition of the State before and after 1866 famine. He also mentions regarding the remedial measures undertaken by the British Govt. for rehabilitating the people affected due to 1866 famine. B.B. Bhatta in his book 'Natural calamities in Orissa in the 19^{th} century' (1997) focuses on historical perspectives, examines the causes, nature and consequences of frequent natural calamities in Orissa and their impact on the State's economic set up. 'Irrigation, Inland Navigation and Flood problems in North Orissa during British Rule' written by P.Mukherjee (1967) gives a picture of the river system of Orissa, their specific problems and how these problems were dealt in the past. Super cyclone, which devastated the State in October 1999, has been described in Chapter II, Sec.2.7.1.2 in nutshell. As cyclone does not come under the purview of this book, Flood and drought is being discussed in the following paragraphs.

7.1 Flood

Two factors are primarily responsible for occurrence of flood viz. (a) flow of excess water resulting from the increased runoff in the catchment and (b) reduction in the carrying capacity of channels. Other factors, which contribute for creating flood havoc, are topography, size and shape of the basin, number of tributaries joining the main stream, condition of the ground and season etc. Of all the factors, precipitation frequency and intensity are of utmost importance in determining the magnitude and extent of flood

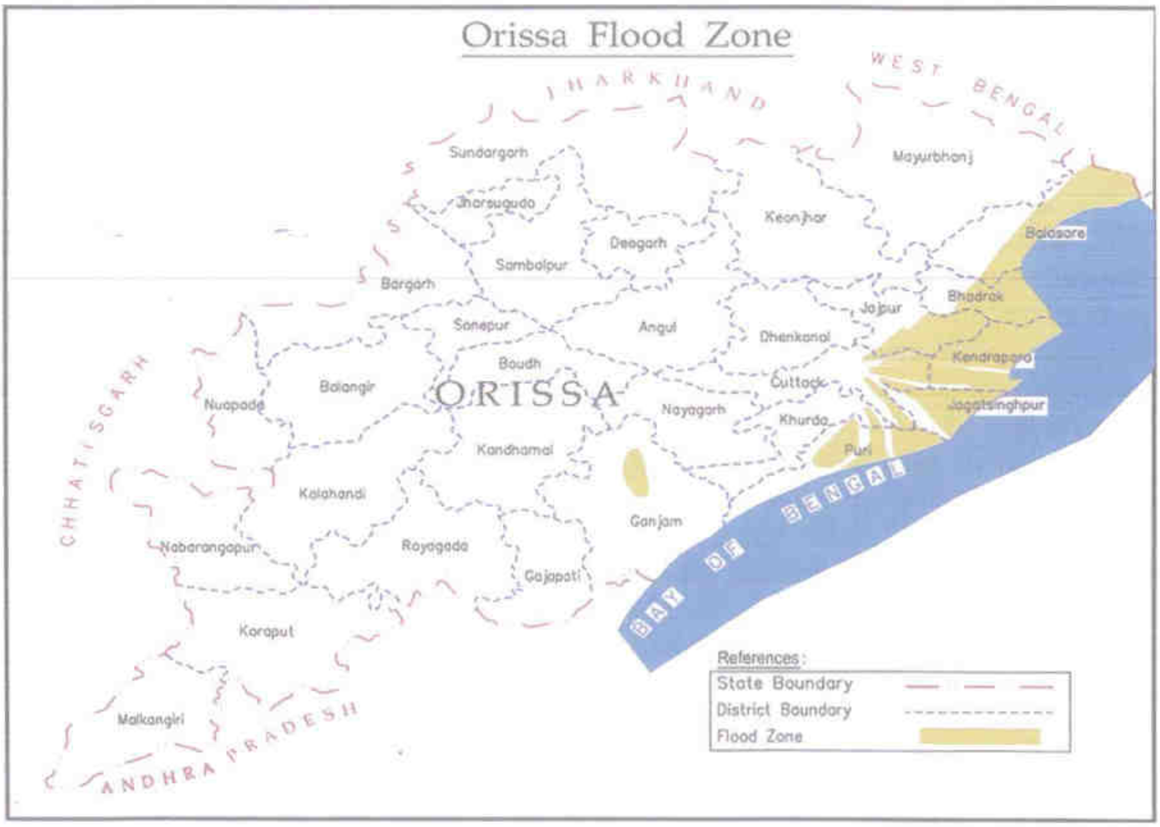

Figure 7.1

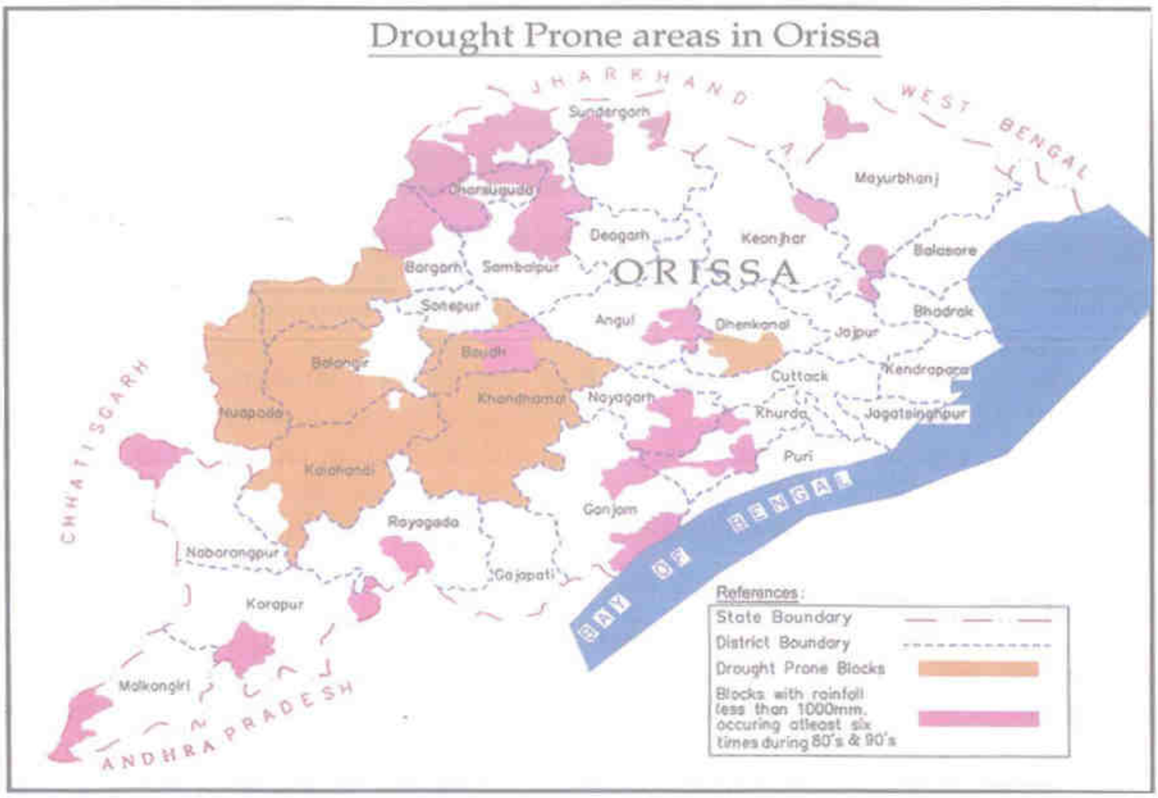

Figure 7.2

damage. According to P.C.Mahalnabis "the heaviest rainfall in the catchment area of Orissa Rivers are given by storms and depressions which move inland from the Bay of Bengal during the monsoon season". Floods in the State mainly occur due to following reasons:

- i) Cyclonic heavy down pour for longer duration
- ii) Depression in Bay of Bengal causing wide spread rainfall.
- iii) Tidal wave in Bay of Bengal and Chilika Lake preventing quick discharge of floodwater into the sea.
- iv) Breach in flood protective embankments
- v) Deterioration of river channel due to silting and encroachment by people.
- vi) Inter connection of rivers such as Birupa with Brahmani and Brahmani with Baitarni.
- vii) Large scale deforestation in the upper reaches.
- viii) Configuration and characteristic of basins.

The rivers which causes flood in the state are mainly the Mahanadi and its tributaries, the Brahmani, the Baitarni, the Salandi with Kapali and the Subarnrekha. The deltaic area is about 6.02% of the catchment area of above rivers. 'Total annual precipitation in the deltas of the Mahanadi, the Brahmani along with Baitarani and the Subarnrekha are respectively 5.7, 7.7 and 2.2% of the total volume of water received in the drainage basins. During monsoons, these percentages are 4.9, 8.4 and 1.9 for an average rainy day during the season. Thus 94.3, 92.3 and 97.8% of the annual total and 95.1, 91.6 and 97.1 % of the monsoon total is drained through the Mahanadi, Brahmani and Baitarani deltas' (vide 'Geography of Orissa' by B.N.Sinha, Published by N.B.T, New Delhi, 3rd edition, 1999 Pg.145 and 147). It is seen from above that an enormous quantum of water is drained over the deltas during monsoon which cause flood in lower reaches. But the Mahanadi and its branch Kathjori, Brahmani & Baitarani frequently create flood havoc in the deltaic region of the State. Seeing the devastation and suffering of human beings almost every year, Mahatma Gandhi rightly observed that 'Flood is a permanent disease in Orissa. 'Historian William Hunter stated that 'Flood is the scourge of the Orissa Province'. Due to frequent floods, the economic background of the people got crippled or ruined. For rendering relief to the flood affected destitute of the State Utkalmani Gopabandhu Das scarified his life and life of his beloved son, which made him immortal.

7.1.1 Formation Delta and Drainage channels

Worst flood affected areas are the deltaic region which, is traversed by a network of tributaries originating from three rivers i.e. the Mahanadi, the Brahmani and the Baitarani. Catchment area of the Mahanadi is almost twenty times larger than its delta. Similarly catchment of both the Brahmani and Baitarani together is about 25 times more than the combined delta of two rivers.

All the three rivers resemble one another in many ways. They all run nearly parallel and all originate in the hilly region. Each river enters the delta as one simple stream but immediately number of branches takes off due to deltaic action. As these rivers originate from hills, they have high velocities and laden with large volume of silt. On reaching the plains, the velocity gets suddenly reduced. The quantity of materials which current can carry varies approximately as the sixth power of its velocity. A small reduction in the velocity is accompanied by a large reduction in the carrying capacity of the channel as a result excess material is deposited in bed and banks. Thus silt gets deposited in riverbeds. In this way, the riverbed rises. Gradually a shallow ridge is built up, over which the river flows. At the same time gradient along the river channel decreases which reduces velocity further. Consequently more silt is deposited until the bed of the river is raised very high. Due to such action, the river outflanks its banks creating branches which flow in the valleys lying between two successive river ridges. Again new ridges are formed by the deposit of the silt along the newly created channels. This process is repeated with the formation of new ones. During heavy flood, water spills over banks and the silt spreads over surrounding land mass. This slowly raises the level of deltaic land. But this is relatively slower than the rise in river bed. Thus formation of new branches is the characteristic feature of all the deltas. It is seen that the Mahanadi, the Brahmani and the Baitarani have been divided into about 15 main branches and innumerable sub-braches before meeting the sea. These branches are interlaced in a very intricate manner so that floodwater from different rivers becomes inextricably mixed on their way to the sea.

'Deltaic action is, however, still at work in the plains which causes considerable fluctuations in the relative discharge through different channels from time to time. For example, the main Mahanadi channel appears to have been considerably silted but the Paika is taking the increased discharge thrown on it. Again the Devi and Daya are improving while Kushbhadra and Bhargavi are becoming silted at present' (Refer Orissa Flood Committee, 1928 Pg.38 and Mahalanabis Report, Irrigation and Power Dept. Pg.61). At present, this discharge distribution has also undergone change.

Further, along the Orissa sea-coast, there exists a steady northward littoral sand drift. 'This drift tends to form bars across the river mouth from south to north. A bar of this nature is often raised in hot weather by the prevalent wind so as to form an unbroken sand dune across the mouth some 25 to 30 ft. high above sea level. It is not uncommon to find a river pursing a fairly straight course to the sea, there to be diverted parallel to the coast for several miles before it can succeed in obtaining an outlet. The sonamuhi for instance, rising in the 'Samanga Pat' behind Puri runs parallel with the coast behind the dunes for about thirteen miles and in some years has a common mouth with the Chilika Lake though independent mouths have been opened on occasion as high up as Harachandi' (Refer O.F.C 1928 Pg.8-9 and Mahalanabis Report, Pg.61). During high floods direct mouths are sometimes opened across the sand dunes, but such opening are again closed soon by littoral drift. The O.F.C of 1928 opined that the shortness of Orissa delta was probably due to this drift.

'The heads of the deltas of such rivers as the Ganga and Indus are situated about 400 miles from the sea where as the deltas of the Mahanadi, Brahmani and Baitarani are little more than fifty mile long. It is probable that these rivers are continually striving, by deposit of silt, to form new land on the sea edge but that this silt is continually being forced towards north by littoral drift. We consider it likely that to this drift is due to on the one hand, the long shallow shelf stretching into the Bay of Bengal in front of the Orissa Rivers, and on the other, the progressive filling in Balasore. This rising of the sea bed in the north-west angle of the Bay has affected the estuaries of the rivers flowing into Balasore, the Subarnrekha bed has deteriorated, and the Dhamara estuary and its outer bar have several feet less water now than they had in 1885' (Refer OFC 1928, Pg.9).

The rivers of Orissa are becoming shallow and cannot contain the immense volume of floodwater brought down from the catchment areas. The main channel of Brahmani has deteriorated appreciably. The flood in the Brahmani lasts longer than in the Baitarani and on the whole causes more damage than the floods in the Baitarani and Mahanadi. That is why, the Brahmani was known as 'sorrow of Orissa' before construction of a storage reservoir across it at Rengali. The river from Alva flows in a very circuitous route up to Dhamra. The flood slope of Brahmani from upstream of Aul ring bund up to sea is only 0.38ft per mile due to which it takes longer time for the flood discharge to pass to the sea.

The Mahanadi takes more time to rise and remains in spate for longer period than other rivers. During 1896, the flood in Mahanadi lasted from 24th July to 5th August. The Chitrotpala branch receives excess volume of water from Mahanadi which its narrow tortuous channel can not pass off to the sea.

The Kuakhai, a 2nd order tributary of the Mahanadi, can not contain water from the Kathjori and even spill during low floods. The Kuakhai branches off to Daya, Bhargavi and Kushabhadra. The Kushabhadra over flows its banks even during moderate floods. "After the first mile of its course, the Kushabhadra narrows considerably and the pressure of flood is greatly felt, so that breaches may occur any where, in the embankments, situated on either bank, between, the second and tenth mile. "(Source: 'River of Orissa', 1905 Pg.15 by Arnott). "There is a constant struggle at the mouth of the Kushabhadra between the river current and the tide. The struggle has resulted in the formation of a sandy bar which effectively checks the discharge at the time of heavy flood. xxx.... The left embankment is so aligned that breaches are inevitable in the year of high flood. The embankments are funnel shaped from the head of the stream downwards". (Source: Maddox Report, 1900 Vol. I & II).

The united water of the Brahmani, Baitarani and Kharsuan cover the country with vast expanse of flood water, which their respective channels cannot carry. "When the Brahmani floods come down, they back up the Baitarani water at the junction of the two rivers and thus impede the discharge of latter, diverting it into the low lying plains of Dhamnagar" (Source: Irrigation, Inland Navigation and Flood Problems in North Orissa during British rule, Pg.44 by P. Mukherjee).

7.1.2 Flood in the 19th and 20th century

In 19th century, Orissa suffered from floods almost once in every two years. This can be seen from the Table 7.1 furnished as under.

Table 7.1 Floods and inundations (1803 –1900)

1804, 1806 &07, 1809, 1812, 1814, 1817, 1820, 1823, 1826, 1831, 1834 &35, 1837 & 38, 1840 to 42, 1844 to 48, 1851 to 1859, 1862 to 64, 1866, 1868, 1870 to 72, 1874 & 75, 1877, 1879 to 86, 1888 & 89, 1892 to 96 and 1900 (Total 59 times in 98 years).

Source: Bihar & Orissa Documents, File No. NF 21/1929 Revenue Department, March 1930.

The first half of twentieth century witnessed a series of floods. In August 1907, the Brahmani, Baitarani and Mahanadi rose to floods. In August 1911, the flood was confined to the Mahanadi, Kathjori and its branches. Puri district suffered from heavy flood in November 1917 (Source: Census of India, 1951 Vol. XI, Part I, Orissa Pg.57). Another incident of major flood havoc was in August 1920 in all the rivers. During 1962, Cuttack, Puri and Balasore were affected by flood. Due to loss of human life and livestock, severe flood of 1933 is remembered. Again major floods occurred in 1937 in three coastal districts of Cuttack, Puri and Balasore, in 1944 in the district of Puri and in 1946 in Balasore and Cuttack districts.

Some of the worst devastating floods and damages caused are discussed here in nutshell.

7.1.2.1 Flood of 1866

During this flood, water levels at Naraj I.B in Mahanadi rose to 90.52ft (27.6m) and at Bellevue in Kathjori to 80.80ft (24.63m). The flood discharge in Mahanadi at Naraj I.B was 12, 83, 600 cusec (36, 342cumec) as computed from Rhinds table. The flood continued for longer duration. In the district of Puri, 300 sq mile (777sqkm) area remained submerged from 5 to 45 days. The depth of inundation varied from 1 m to 3 m and four lakhs people were rendered homeless.

In 1866, Dr, Smith Sanitary Commissioner came to Cuttack by boat from False Point. Eye witness account has been described by him in his book 'Pilgrimmage to Juggernaut'. He wrote "The Mahanadi was immensely flooded. It had entirely inundated its banks and high trees were half submerged in its water. xxxxx…. The dense foliage on either bank appeared as though it were afloat on an endless and terrible swamp. The whole face of the country was under water to a depth of four or five feet. The rice fields were entirely submerged and villages were inundated. In some of these, the villagers had constructed stages inside their houses, on which they sat, waiting for the subsidence of flood which was still rising".

In Cuttack district, there were 413 breaches in the embankments submerging 642 sq miles (1663sqkm) for 3 to 60 days. Depth of inundation varied from 1 m to 5 m. All the crops in the submerged area were destroyed. About seven lakhs people lost their shelter and belongings. This led to occurrence of 'Na-anka Durbhikshya', which has been described under Sec.2.7.1.1.

7.1.2.2 Flood of 1896

The Mahanadi remained above danger level from 24th July to 7th August with peak flood level of 92.10 ft (28.07m) at Naraj. The flood discharge in the river as computed from Rhinds table was 15, 02, 124cusec (42529cumec). The flood level at Bellevue in Kathjori rose to 82.87 ft (25.27m).

As per report of Mr. W.A.English, the then Superintending Engineer, Orissa circle, there was a total devastation in the delta due to flood. There were breaches of 300 m length with 10m depth of scour. Besides heavy damage to crops and houses, the communication was badly affected, the irrigation system in Kendarpara and Pattamundai area suffered to a great extent.

7.1.2.3 Flood of 1926

Water level at Naraj I.B rose to 28.0 m with a flood peak of 14, 73,233 cusec (41711 cumec). According to the letter No.725 SG dated 19.11.1926 of Mr. J.A.Hubback Commissioner of Orissa Division addressed to the Secretary, loss of human life in Cuttack was 15. About 3000 houses were severely damaged. Crops in flood affected areas of Cuttack and Puri were completely destroyed.

7.1.2.4 Flood of 1937

The peak flood discharge in Mahanadi at Naraj was 14, 19, 476 cusec (40189 cumec). The flood level of Bellevue was 82.15 ft (25.04m). Loss of life in Cuttack and Puri was six. Number of villages affected in Cuttack and Puri were respectively 758 and 556. Crops grown in 80531 ha (1, 98,912 ac) in the districts of Cuttack, Puri and Sambalpur were damaged (Source: File No.XIIE-9/38 & XIIE-7/37 of Revenue Commissioner).

7.1.2.5 Flood of 1955

In the year 1954-55 acute distress situation prevailed in certain parts of the State on account of drought. The intensity of drought and distress aggravated due to failure of rains in the month of July & August of 1955. On 2nd and 3rd September 1955, there was 8 inches of rainfall in Cuttack city with continuous downpour for 26 hrs. In Sambalpur, which is on the upper reach of Mahanadi, there was 14.5 inches of rainfall within 48hrs ending at 8 AM of 04.9.55. Titilagarh also received a rainfall of 5.5 inches within 24hrs during the same period. Similarly in the mountainous region of Madhya Pradesh, there was heavy rainfall. What has been unusual this year is that in addition to very heavy rainfall spread over a space of about 48 hours in the catchment area of rivers, there was wide spread rain throughout the State including the delta simultaneously, adding to the volume of water all along the course of the Mahanadi and its branches and the Brahmani and Baitarani. The Mahanadi gauge at Cuttack rose up to RL76.20ft in the early hours of 06.9.1955, the highest recorded so far in the history of Mahanadi in about a hundred years. Within 42 hours up to midnight of 5th/6th Sept.1955, the Mahanadi rose by a height of 5.02 ft.

There was heavy and wide spread rain in Brahmani catchment which caused worst flood ever recorded in the history of the river which started rising from 03.9.1955 and within 24 hours reached the highest point at Jenapur in Cuttack district. The gauge at Jenapur where Brahmani crosses the Madras-Calcutta railway line rose to RL 72.20ft at 2 AM on 04.09.55 against the highest record of RL 71.03 ft in 1920. In about 18 hours ending 2 AM of 04.9.55, river Brahmani rose by nearly 10 ft.

So far as the river Baitarani is concerned, it did not surpass the highest level recorded so far. It was in very high floods simultaneously with other two rivers. Baitarani recorded the worst flood in 1927 when Akhuapada gauge shot up to RL61.20 ft.

As if drought in two successive years and drought followed by flood in the current year were not enough, a cyclone of moderate intensity swept on 21st and 22nd Sept. parts of Cuttack, Puri and Ganjam where the distress of drought and fury of floods were still afresh. The cyclone was associated with heavy rainfall at Nayagarh and Rushikulya river system. River Kusumi and Dahuka in Nayagarh sub-division over flowed and there was high flood in river Badanadi of Ganjam.

The devastation caused by these unexpected floods has been relatively very high because of the breach for a width of 610 m (2000 ft) at 'Daleighai' in the Sadar sub-division of Cuttack district (now Jagatsinghpur district) which inundated a large tract not only thickly populated but of which 200 sq miles (518 sq. km) were considered protected and was granary of Cuttack district. Equally intensive devastation was caused in Binjharpur where the breaches near Kamalpur completely washed off some villages and sand cast a large area. Like wise Pattamundai and Kendrapara suffered from heavy losses where irrigated land was inundated and damaged by several breaches in Brahmani. At Chandanpur near Puri, the Bhargavi embankments also gave way.

Out of cultivated area of 15, 35, 290 acres about 5, 56, 290 acres (36%) in the undivided district of Cuttack and 1, 55, 846 acres out of cultivated area of 10, 70, 338 acres i.e. 14.6% in undivided Puri district were damaged. Communication for four days from 6th to 10th September was completely paralyzed in the flood affected areas of Cuttack, Puri and Balasore. Roads were submerged under water. The portion of the National Highway No.5 between Cuttack and Bhubaneswar was under more than 2 ft of water for 48 hours. The boat communication could not be established for 3 to 4 days due to swiftness in the current of flood water. Movement of trains was suspended on Calcutta –Madras line due to floods in Brahmani. Number of breaches in the river embankment of Stage I and Stage II delta area were 263. About 14.15 lakhs of population were affected. Loss of human life was 43 in Cuttack, 8 in Dhenkanal, 13 in Puri and 5 in Keonjhar and one in Ganjam district (Source: Preliminary Report on 1955 Orissa Flood' by Revenue Department, Govt. of Orissa).

7.1.2.6 Flood of 1980

This year an unprecedented flood occurred during the 2nd half of September which created havoc at lower part of Mahanadi system. The maximum flood height rose to 27.80m at Naraj Railway Bridge on 22.9.80 against danger level of 26.52m. Peak flood discharge was measured as 12, 27, 476 cusec (34753 cumec). Kathjori system took a major share of 64% and Mahanadi system only 36%. This caused sever damages mainly in Devi river embankments.

There were 92 breaches in the river embankments of Cuttack district. The worst breach occurred at Birabarpatna in the left bank of river Biluakhai for a width of about 400 m. In Stage I & II deltas of Cuttack & Puri districts 54 blocks comprising 3140 villages were affected. Human life lost was 5 (five). Total 1,35,726 houses were collapsed, swept away and partly damaged.

This flood was mainly from the catchment lying upstream of Hirakud dam. The contribution from the free catchment below the dam was negligible. Even with partial routing effect of Hirakud dam, the magnitude of flood was so high. This shows the weakness of Hirakud reservoir to route late monsoon floods when operated according to the rule curve. As there is no reserved flood space in Hirakud, the storage capacity gets gradually reduced due to proportionate storage of water with an aim to fill up the reservoir by 31st October.

7.1.2.7 Flood of 1982

The flood was more serious in nature than any recorded in history. The damages resulting from this flood were more severe than the damages caused by floods in 1955 and 1980 taken together. Special feature of this flood is that the peak discharge of 15.84lakh cusec at Mundali was mainly due to the rainfall over uncontrolled catchment down stream of Hirakud dam as there was only 0.09lakh cusec release of water from the reservoir since the gates were kept closed from 16.0 hrs of 29.8.82 to 11.0 hrs. of 31.8.82. Flood situation would have become more alarming, had there been release of water from the reservoir. Downstream of Hirakud, the river started rising rapidly on 28.8.82. The peak at the head of Mahanadi delta at Naraj Railway Bridge attained a level of 28.53 m at 17 hrs. of 31st August against danger level of 26.52 m. The peak level in Kathjori at Bellevue was 83.65 ft (25.50m) against danger level of 75.9 ft (23.14m). The flood discharge at Naraj railway bridge was 44827cumec (15.84lakh cusec) of which Mahanadi share was 42% where as Kathjori system carried 58%. There were severe damages in Devi River embankments. The National Highway No.5 breached near Balikuda due to breaches in Kathjori right embankment thereby dislocating the traffic for about a month.

The flood intensity was so severe that historic river such as Prachi (Silted up about 100 years back) and Alaka (silted about 200 years back) opened up during this flood.

Total no. of breaches and damages caused due to this flood are as follows:

No. of districts affected	8
Total population affected	54 lakhs
Number of human casualty	127 + 49 (missing)
Number of livestock lost	26359
Principle crops damaged	Paddy, Pulses, Jute, Oil seed, Vegetables
Cropped area affected	12lakh ha.

Sand cast area	75000 ha.
No. of houses swept away	26500
No. of houses fully collapsed	1, 58, 322
No. of houses partially collapsed	3, 25, 227
No. of breaches in river embankments	500
No. of M.I projects damaged	733
No. of L.I projects damaged	1677
Length of roads damaged P.W.D road	5000 Km
Gram Panchayat road	30000 Km
Forest road	720 Km
Canal road	4214 Km

(Source: - Memorandum on Floods in Orissa, 1982, Revenue Department)

7.1.2.8 Flood of 2001

Before the bitter experience of 1999 super cyclone (vide sec.2.7.1.2 of the book) disappeared from memory, the State had to bear brunt of severe drought during 2001. With poor economic condition of the State when the restoration works were still incomplete, grave flood situation prevailed almost in all the river systems.

Hirakud reservoir rose from RL 600 ft to 628.54 ft on 18.7.2001 within a period of 18 days consequent upon intense rainfall over upper catchment in Chhatisgarh and Orissa. For safety of the dam, 51 gates were opened on 18.7.01. With downstream contribution, from the tributaries viz, Ib, Ong, Tel, Hariharjore, Salki, Manjore, Brutang, Kusumi and Sapua, the flood peak in undivided Mahanadi at the head of the delta, i.e., Naraj was 14.0 lakh cusec (39638cumec) from 17.7.01 to 20.7.01. Consequently there was heavy flood in all the branches, i.e., Kathjori, Kuakhai, Kusabhadra, Daya, Bhargavi, Devi, Kandal, Tanla, Sorua, Biluakhai, Birupa, Genguti, Gobari, Chitrotpala, Luna and Karandia. All these rivers were in spate.

Brahmani, the 2nd largest river of the State experienced very high flood even before flood in Mahanadi system completely receded. Due to intense rainfall in the upper catchment, the Rengali reservoir attained FRL 123.50 m on 23.7.01 when five gates were opened to release flood water. The outflow of 10328cumec (3, 64, 785 cusec) from Rengali reservoir had adverse effect on the deltaic area of Jajpur and Kendrapara. Due to interconnection of Brahmani with Birupa, a minor arm of Mahanadi, the flood situation became grave and inundated the head quarter town of Kendrapara. There were several breaches in the embankments in Jajpur, Kendrapara and Bhadrak. Almost during the same period i.e. from 4.7.01 to 6.7.01 and 11.7.01 to 13.07.01, the river Baitarani also remained in spate. On 13.7.01, gauge at Akhuapada was at 18.86 m against danger level of 17.83 m i.e. river flowing 1m higher.

Hirakud reservoir level and downstream discharge from 16.7.01 to 21.7.01 is shown in Table 7. 2, FRL of Hirakud is RL 630 ft.

Table 7.2 Hirakud Reservoir Elevation and Down Stream Flood Discharge

Date	Time	Res. Level (in ft)	Inflow (Lakh cusec)	Outflow (Lakh cusec)	No. of gates opened	Flood peak at Khairmal (lakh cusec)	Flood discharge at Barmul (lakh cusec)	Flood discharge at Mundali (lakh cusec)
16.7.01	09hrs	617.97	3.58	4.58	28	8.30	9.60	5.92
16.7.01	15hrs	618.95	4.23	0.23	Nil	8.50	10.86	7.72
17.7.01	11hrs	624.50	9.20	0.23	Nil	6.78	12.10	12.99
17.7.01	20hrs	627.04	7.82	5.09	30	6.54	10.70	**14.00**
18.7.01	08hrs	**628.54**	8.72	8.04	48	10.44	9.28	12.75
18.7.01	09hrs	**628.54**	8.69	8.53	**51**	10.76	9.28	12.58
18.7.01	19hrs	627.93	6.90	8.41	**51**	11.90	11.22	11.29
19.7.01	09hrs	626.97	5.00	6.02	36	10.60	**14.92**	12.18
20.7.01	03hrs	625.79	3.15	4.52	27	7.10	12.38	**14.09**
21.7.01	10hrs	623.0	3.01	4.54	27	5.90	8.07	10.58

Maximum recorded gauge and discharge of rivers Mahanadi, Brahmani, Baitarani and Subarnrekha from 1964 to 2006 are given in Table 7.6 to Table 7.9. Impact of 2001 flood on life and livelihood of people is furnished in Table 7.3.

Table 7.3 Impact of 2001 Flood

Sl.No	Indicators	Unit	Loss
1	Villages affected	Nos.	15584
2	G.P affected	Nos.	2429
3	C.D Blocks affected	Nos.	199
4	District affected	Nos.	22
5	ULBs affected	Nos.	84
6	People affected	Lakh	85
7	Crop area lost (Rs)	Lakhs	7.0
8	Cost of crop loss (Rs)	Crore	60.0
9	Houses affected	Lakhs	3.0
10	Cost of affected houses (Rs)	Crore	40.0
11	PWD roads affected	Km	5000
12	N.H affected	Km	700
13	PWD, CD works damaged	Nos	1102
14	N.H, CD works damaged	Nos.	265
15	Breaches on PWD road	Nos.	102
16	Breaches on N.H road	Nos.	13
17	Breaches on canal embankment	Nos.	223
18	Breaches on river embankment	Nos.	346
19	Pipe water supply		
	In urban areas	Nos.	61
	In rural areas	Nos.	82
20	Tube well damaged	Nos.	25555
21	Person dead	Nos.	93

(Source: Orissa Development Report, Planning Commission GOI, 2002 Pg 431, Table 14.8)

Table 7.4 shows the losses due to flood from 1972 to 2001.

Table 7.4 Flood Damage from 1972 to 2001

Sl. no	Years / Months of occurrence	No. of district affected	No. of village affected	Population affected	Cultivated area affected (ha)	No. of house damaged / collapsed/ washed away	No. of human casualties	No. of livestock casualties
1	1972 (July)	5	3,514	1,738,400	NA	18,754	8	3,506*
2	1975	8	7,527	3,140,524	1,048,05*	144,153	74	4,996
3	1976	6	4,358	253,910	40,375*	2,448	8	68*
4	1977 (Nov)	10	4,680	2,161,000	458,612*	18,179	41	202*
5	1978	12	3,727	2,601,379	627,076*	19,965	21	262
6	1980	10	3,620	2,639,200	305,466	163,526	73	8,280*
7	1981 (Jun)	1	1,017	NA	26,655	NA	NA	NA
8	1981 (Aug)	4	NA	NA	3,690.45	1,717	15	NA
9	1982(Aug/ Sept)	8	NA	5,400,000	1,200,000	510,049	127	26,359*
10	1984	8	6,960	3,511,177	392,448	19,394	27	459
11	1985 Sept.)	7	7,609	1,937,979	102,272	69,831	2,401	NA
12	1985 (Aug)	11	17,955	3,779,506	310,499	12,974	10	2,880
13	1985 (Oct)	5	2,571	5,700,000	326,608	40,029	47	1,073
14	1990 May)	1		361,868	4,984,88	9,379	1	NA
15	1991 (Jul)	11	9,649	3,786,544	123,000	32,389	29	449
16	1991 (Aug)	7	12,572	6,997,637	539,000	64,381	23	696
17	1992 June)	5	3,396	1,835,529	47,394	14,845	7	107
18	1992 (July)	10	9,281	2,716,000	168,676	72,479	25	222
19	1992 (Aug)	7	7,866	3,048,000	201,000	73,224	11	1,068
20	1994 (July)	16	4,540	2,832,247	527,696	NA	29	NA
21	1994 (Aug)	5	1,336	1,097,361	138,432	NA	24	NA
22	1994(Sept.)	18	5,368	3,116,364	351,531	NA	20	NA
23	1995(May)	23	31,796	7,184,264	222,840	152,542	50	372
24	1995 (Nov)	20	23,945	**11,346,000**	1,386,800	35,683	26	NA
25	1997 June)	4	800	594,646	NA	7,765	-	14
26	1997 (Aug)	13	5,652	2,140,648	NA	35,955	17	16
27	1999 (July / Aug)	7	2,486	1,772,788	149,848	7,488	10	NA
28	2001 (July / Aug)	24	18,790	9,678,000	8,087,000	212,296	102	18,149

Source: Board of Revenue, Cuttack and Special Relief Commissioner, Government of Orissa, Revenue Department Secretariat, Bhubaneswar.

The disasters viz. flood, drought and cyclone have not only taken human lives but also resulted in damage to and loss of property. The value of properties lost and damaged due to these natural disasters has been increasing over decades. These have led to serious fiscal imbalance by placing heavy demands on revenue expenditure. Properties damaged due to disasters and amount spent on relief are given in Table 7.5.

Table 7.5 Properties Damaged and Relief Expenditure

Year	No. of persons affected	No. of human lives lost	No. of human beings injured	Value of properties damaged (lakh)	Financial year	Relief expenditure (lakh)	Grand (Rs. Lakh)
1972	474780	139	2	1289			
1973	434877	17	11	291			
1974	1072160	24	5	1289			
1975	432902	45	7	344	1974-75	385	0
1976	2859402	65	14	1791	1975-76	388	0
1977	1194550	71	8	922	1976-77	369	0
1978	1530368	101	383	959	1977-78	409	2
1979	6323461	51	11	3257	1978-79	403	0
1980	2913000	82	53	3649	1979-80	871	0
1981	616834	109	966	1256	1980-81	1688	56.55
1982	7323000	245	493	10711	1981-82	1480	
1983	2103578	119	29	4939	1982-83	17180	12158
1984	3511000	27	75	11889	1983-84	1798	1526
1985	2782289	194	558	13888	1984-85	3024	0
1986	7348781	81	59	9381	1985-86	3066	0
1987	6932347	171	192	6646	1986-87	2775	59.36
1988	2785765	357	105	2701	1987-88	1450	500
1989	6369689	285	75	3710	1988-89	1806	1313
1990	15499135	455	82	19949	1989-90	4598	0
1991	7610509	363	62	22925	1990-91	4714	5713
1992	10817455	218	172	154970	1991-92	4919	0
1993	6079666	353	46	77908	1992-93	4691	2978
1994	10775481	N.A	N.A	15326	1993-94	7742	2978
1995	3941351	197	142	10995	1994-95	3906	30.75
1996	6331974	226	80	14323	1995-96	7946	7708
1997	3486481	985	140	6855	1996-97	7528	50.0
1998	9822975	943	240	203219	1997-98	8991	4.0
1999	12569000	9885	2507		1998-99	4558	828.15
					1999-00	82764	49.62

(Source: - Human Development Report, 2004, Govt. of Orissa, Table 7.2 & 7.3, Pg.164-165)

Table 7.6 Year wise Peak Gauge and Discharge at Naraj Rly. Bridge of River Mahanadi.

River Basin: Mahanadi
River: Mahanadi — Danger Level: 88.00ft (26.82m)
Gauge Station: Naraj Railway Bridge — Zero Value: 0.00m

Year	Date	Gauge (ft)	Gauge (m)	Discharge (cumec)	Discharge (cusecs)
1	2	3	4	5	6
1964	08.7.64	96.50	29.41	19833	700501
1965	31.07.65	89.00	27.13	8864	313076
1966	31.07.66	94.30	28.74	16562	584970
1967	07.08.67	88.83	27.08	22145	782161
1968	16.08.68	85.80	26.15	21342	753799
1969	01.08.69	88.65	27.02	27664	977092
1970	28.08.70	86.90	26.49	18520	654126
1971	10.08.71	86.50	26.37	21227	749738
1972	15.09.72	85.60	26.09	20210	713817
1973	28.09.73	88.15	26.87	26245	926973
1974	19.08.74	86.50	26.37	21577	762100
1975	24.08.75	86.80	26.46	23146	817517
1976	15.08.76	87.70	26.73	26427	933402
1977	14.09.77	87.70	26.73	26464	934708
1978	29.08.78	88.45	26.96	27865	984192
1979	10.08.79	84.20	25.66	17716	625729
1980	22.09.80	91.20	27.80	34748	1227299
1981	11.08.81	84.20	25.66	17532	619230
1982	31.08.82	93.58	28.52	**44750**	**1580570**
1983	09.09.83	87.31	26.61	25088	886108
1984	17.08.84	86.78	26.45	23383	825888
1985	07.08.85	87.35	26.62	25213	890523
1986	22.07.86	87.38	26.63	25493	900413
1987	24.07.87	80.43	24.52	9813	346595
1988	09.08.88	79.90	24.35	8951	316150
1989	19.08.89	78.10	23.80	6563	231805
1990	06.09.90	85.94	26.19	20623	728398
1991	14.08.91	89.02	27.13	33028	1166549
1992	21.08.92	89.80	27.37	34219	1208608
1993	28.08.93	85.28	25.99	23065	814638
1994	06.09.94	89.30	27.22	31576	1115264
1995	25.07.95	87.66	26.72	26776	945732
1996	23.08.96	81.63	24.88	13213	466686
1997	06.08.97	87.01	26.52	24127	852168
1998	13.09.98	86.15	26.26	22907	809088
1999	11.08.99	84.12	25.64	17972	634775
2000	28.07.00	76.92	23.45	5049	178349
2001	20.07.01	89.28	27.21	39887	1408798
2002	14.09.02	83.53	25.46	16632	587478
2003	30.08.03	91.01	27.74	38223	1349844
2004	12.08.04	85.07	25.93	21695	766139
2005	31.07.05	--	--	25577	903266
2006	31.08.06	--	--	36340	1283528

Table 7.7 Year wise Peak Gauge and Discharge of River Brahmani at Pankapal.

River Basin: Brahmani

River: Brahmani Danger Level: 75.5ft (23.0m)

Gauge Station: Expressway Bridge Pankapal Zero Value: 0.00m

Year	Date	Gauge in ft	Gauge in mt	Discharge in cumecs	Discharge in cusecs
1	2	3	4		6
1964	23.08.64	72.10	21.98	12475	440617
1965	31.07.65	68.60	20.91	6549	231311
1966	26.06.66	68.70	20.94	5774	203938
1967	05.09.67	70.50	21.49	9505	33571
1968	15.08.68	70.60	21.52	8410	297041
1969	15.08.69	78.25	23.85	11833	417942
1970	01.07.70	69.50	21.18	8786	310322
1971	09.08.71	79.24	24.15	15791	557738
1972	15.07.72	75.70	23.07	9574	338154
1973	21.07.73	79.60	24.26	18599	656917
1974	19.08.74	77.00	23.47	12393	437721
1975	20.08.75	81.30	24.78	**24246**	**856369**
1976	14.08.76	75.90	23.13	10341	365244
1977	08.08.77	76.40	23.29	10700	377924
1978	03.09.78	76.90	23.44	11844	418330
1979	08.08.79	74.30	22.65	6599	233077
1980	25.06.80	70.58	21.51	4105	144989
1981	14.07.81	70.30	21.43	3924	138607
1982	22.08.82	73.77	22.49	5712	201746
1983	07.09.83	75.96	23.15	8069	284997
1984	18.08.84	77.70	23.68	9825	347013
1985	29.08.85	74.99	22.86	8587	303306
1986	22.07.86	74.19	22.61	8128	287065
1987	31.08.87	70.52	21.49	4576	161608
1988	04.08.88	74.20	22.62	7235	255535
1989	28.07.89	71.04	21.65	4582	161850
1990	15.10.90	72.09	21.97	5488	193855
1991	13.08.91	76.98	23.46	11809	417110
1992	29.07.92	72.78	22.18	5525	195131
1993	16.07.93	69.24	21.10	3645	128730
1994	19.09.94	76.16	23.21	8550	302001
1995	21.09.95	71.17	21.69	5165	182428
1996	23.06.96	72.39	22.06	6036	213196
1997	06.08.97	74.69	22.77	7370	260315
1998	14.09.98	73.27	22.33	6422	226833
1999	30.10.99	76.42	23.29	9909	350008
2000	19.08.00	60.50	18.44	1922	67885
2001	25.07.01	77.30	23.56	13571	479328
2002	09.09.02	66.70	20.33	2133	75339
2003	11.10.03	73.69	22.46	6995	247044
2004	24.03.04	71.10	21.67	5116	180664
2005	31.07.05	76.31	23.26	10677	377058
2006	24.08.06	76.64	23.36	11342	400548

Table 7.8 Year wise Peak Gauge and Discharge of River Baitarani at Biridi.

River Basin: Baitarani

River: Baitarani — Danger Level: 74.80ft (22.80m)

Gauge Station: Biridi Railway Bridge — Zero Value: 0.00m

Year	Date	Gauge in ft	Gauge in mt	Discharge in cumecs	Discharge in cusecs
1	2	3	4	5	6
1964	23.08.64	74.65	22.75	3763	132923
1965	29.07.65	76.29	23.25	4800	169522
1966	20.07.66	71.30	21.73	1731	61133
1967	04.09.67	79.90	24.35	10586	373915
1968	05.08.68	77.01	23.47	6227	219935
1969	14.08.69	77.63	23.66	6578	232338
1970	01.09.70	75.44	22.99	4097	144694
1971	08.08.71	78.40	23.90	6531	230683
1972	15.07.72	78.40	23.90	5856	206850
1973	03.09.73	79.00	24.08	7073	249824
1974	17.08.74	79.00	24.08	6479	228831
1975	19.08.75	81.70	24.90	10483	370259
1976	14.08.76	73.60	22.43	2865	101175
1977	06.08.77	72.10	21.98	1934	68318
1978	03.09.78	76.10	23.20	4990	176264
1979	08.08.79	76.50	23.32	5424	191583
1980	20.09.80	71.11	21.67	1752	61881
1981	14.07.81	68.88	20.99	966	34116
1982	22.08.82	72.06	21.96	2003	70754
1983	07.09.83	76.03	23.17	4174	147426
1984	28.08.84	76.19	23.22	4463	157631
1985	17.10.85	76.60	23.35	8512	300629
1986	07.10.86	71.30	21.73	1536	54249
1987	18.07.87	69.20	21.09	1019	36011
1988	03.08.88	77.11	23.50	5164	182392
1989	05.09.89	78.16	23.82	7121	251497
1990	15.07.90	80.22	24.45	2068	73058
1991	13.08.91	76.71	23.38	9189	324555
1992	09.08.92	68.88	20.99	8080	285401
1993	17.09.93	72.59	22.13	1145	40439
1994	04.08.94	74.00	22.56	2285	80723
1995	10.08.95	74.09	22.58	3538	124947
1996	08.08.96	73.98	22.55	3830	135278
1997	06.08.97	77.23	23.54	2658	93884
1998	13.09.98	60.07	18.31	1210	42724
1999	30.10.99	70.77	21.57	**11578**	**408942**
2000	19.07.00	61.45	18.73	1709	60378
2001	13.07.01	63.12	19.24	2925	103310
2002	06.09.02	58.07	17.70	2259	79772
2003	11.10.03	59.35	18.09	5445	192275
2004	22.08.04	61.71	18.81	2579	91077
2005	30.06.05	63.29	19.29	3517	124200
2006	24.08.06	64.04	19.52	4295	151665

Table 7.9 Year wise Peak Gauge and Discharge of River Subarnrekha at Rajghat.

River Basin: Subarnarekha

River: Subarnarekha Danger Level: 10.36m (34ft)

Gauge Station: Rajghat Zero Value: 0.00m

Year	Date	Gauge in ft	Gauge in mt	Discharge in cumecs	Discharge in cusecs
1	2	3	4	5	6
1964	08.09.64	15.55	4.74	2900	102420
1965	30.07.65	19.05	5.81	5441	192170
1966	08.08.66	15.35	4.68	2701	95388
1967	05.09.67	20.00	6.10	5537	195553
1968	04.08.68	19.80	6.04	6840	241596
1969	15.09.69	17.00	5.18	4454	157331
1970	05.09.70	39.10	11.92	5516	194834
1971	28.07.71	37.40	11.40	7675	271077
1972	14.08.72	37.10	11.31	7080	250071
1973	03.09.73	39.30	11.98	8821	311574
1974	18.08.74	38.80	11.83	**9788**	**345709**
1975	20.08.75	38.80	11.83	7179	253578
1976	19.09.76	38.60	11.77	6851	241987
1977	07.08.77	39.00	11.89	7252	256138
1978	03.09.78	39.80	12.13	7544	266461
1979	10.08.79	31.90	9.72	1982	70003
1980	07.09.80	30.80	9.39	2348	82940
1981	26.07.81	32.76	9.99	2180	77012
1982	13.09.82	31.78	9.69	1980	69934
1983	07.09.83	32.47	9.90	2233	78876
1984	09.08.84	38.08	11.61	7990	282216
1985	17.10.85	39.70	12.10	6180	218265
1986	06.06.86	32.20	9.81	1626	57416
1987	29.08.87	37.00	11.28	4246	149971
1988	29.06.88	39.19	11.95	5642	199271
1989	06.08.89	38.04	11.59	4974	175690
1990	04.08.90	36.24	11.05	3641	128595
1991	24.08.91	34.50	10.52	2984	105408
1992	28.09.92	32.80	10.00	2611	92217
1993	16.09.93	32.50	9.91	2306	81463
1994	06.08.94	65.62	20.00	4834	170736
1995	05.09.95	35.66	10.87	3142	110984
1996	27.07.96	36.78	11.21	4304	152025
1997	07.08.97	40.03	12.20	7099	250731
1998	12.09.98	34.48	10.51	3069	108380
1999	09.08.99	38.12	11.62	4233	149501
2000	28.07.00	32.25	9.83	1682	59392
2001	13.07.01	36.75	11.20	4671	164974
2002	13.09.02	32.58	9.93	2410	85127
2003	10.10.03	32.02	9.76	2580	91131
2004	22.03.04	37.73	11.5	3958	139810
2005	16.09.05	28.58	8.71	1637	57810
2006	01.08.06	38.32	11.68	4900	173055

7.1.2.9 Impact of Hirakud Reservoir on Flood Moderation

Hirakud has preformed to its best to moderate the floods in delta. Most of the high floods during post period (1958 to 2003) are due to flood flow from the free catchments of 48700sqkm downstream of Hirakud dam on which Hirakud has no role. Highest recorded post –construction flood at Naraj is 44,827cumec (15.84lakh cusec) at 15 hrs of 31st August 1982, which was absolutely from the downstream catchment only without any contribution from the dam. Without the dam the possible flood would have been around 48,110cumecs (17.0lakh cusec). Similarly the flood peak of 39,638cumec (14.00lakh cusecs) in July 2001 would have been 53,794cumecs (19.00lakh cusec) without control from Hirakud reservoir.

During per-construction period (i.e., from 1868-1946) there were 63 ft floods in 79 years exceeding 10.0lakh cusec (35,300cumec) at Naraj, which works out to about 8 floods in 10 years. The highest recorded peak flood was 15.71lakh cusec (44,431cumec) in September 1934.

During post construction period of 46 years, i.e., from 1958 to 2003, there are 16 flood events of magnitude exceeding 10lakh cusecs i.e. average 3.5 floods in 10 years. It has been experienced that most of post flood are due to contribution from downstream catchments of 48,700sqkm (18,800 sq mile) on which Hirakud has no control. Table 7.10 gives the clear picture.

Table 7.10 Peak Discharge at Mundali Showing Contribution from Downstream Catchments

Sl. No	Flood Period	Peak discharges at Mundali (lakh cusec)	Contribution from downstream catchments (lakh cusec)			Release from Dam in lakh cusec
			Dam to Khairmal	Khairmal to Mundali	Total dam to Mundali	
1	29/08/82	15.84	12.81	2.94	15.75	0.09
2	12/08 to 21/08/91	12.71	6.74	4.81	11.55	1.16
3	16/08 to 26/08/92	11.05	9.80	0.85	10.65	0.40
4	14/07 to 22/07/01	14.0	4.23	1.60	12.83	1.17
5	29/08 to 05/09/03	13.50	11.23	1.62	12.85	0.65

It is not possible to moderate flood of 16lakh cusecs by more than 2lakh cusecs. When the reservoir is full and another storm approaches in quick succession it will not be possible to hold water in the Dam. It may be noted that the Hirakud reservoir is small compared to its catchments.

In the present scenario it may not be possible to construct a second flood control reservoir (at Tikarpara as was envisaged in the Original Project Report or at Manibhadra) due to submergence and R&R problem. To moderate flood up to its safe limit at the head of delta, it may be prudent to follow lower band of Rule Curve, which will provide some flood space in the reservoir. By adopting this, we may loose some power but irrigation is not affected.

Details of inflow and outflow from and to Hirakud Reservoir from 1961 to 2003 are furnished vide Table 7.11

Table 7.11 Details of Inflow & Outflow

Year	Month	Duration	Peak inflow to Hirakud Reservoir			Maximum release from dam		
			Date	Time	Inflow (lakh cusec)	Date	Time	Spillway discharge (lakh cusec)
1	2	3	4	5	6	7	8	9
1961	July	4/7 to 13/7	10/7	03	15.25	10/7	15	11.56
	July	16/7 to 26/7	17/7	15	8.16	17/7	21	06.33
	August	23 to 27/8	26/8	06	5.55	26/8	18	04.32
	Sept.	1/9 to 11/9	8/9	21	9.10	09/9	00	7.34
	Sept.	14/9 to 17/9	16/9	12	6.95	14/9	15	6.22
1962	August	3/8 to 6/8	4/8	06	2.78	04/8	06	2.18
1963	August	10/8 to 13/8	11/8	00	6.50	11/8	01	5.55
1964	July	30/6 to 8/7	8/7	08	7.60	06/7	23	6.16
	August	16/8 to 19/8	18/8	08	8.61	20/8	01	5.82
1965	August	22/8 to 26/8	25/8	06	10.52	27/8	10	6.05
	Sept.	23 to 29/9	24/9	03	5.95	24/9	00	5.87
1966	July	29/7 to 2/8	31/7	03	5.09	02/8	00	3.57
1967	August	2 to 5/8	3/8	12	8.30	05/8	01	5.79
	August	20 to 26/8	24/8	06	6.38	24/8	18	4.14
1968	August	11 to 23/8	14/8	03	7.29	14/8	18	5.87
1969	August	1 to 6/8	02/8	12	2.79	02/8	09	3.05
1970	July	30/6 to 11/7	03/7	21	6.66	03/7	22	4.93
	August	23/8 to 18/9	26/8	06	4.92	26/8	16	4.65
1971	July	27 to 30/7	28/7	21	8.25	29/7	16	5.09
	August	3 to 5/8	03/08	12	5.71	03/8	21	3.63
	August	30/8 to 2/9	31/8	00	6.29	31/8	20	4.54
1972	Sept.	12 to 18/9	13/09	15	4.15	13/9	14	5.12
1973	July	9 to 17/7	10/7	12	6.48	13/7	06	4.73
	August	19 to 22/8	20/8	06	6.37	21/8	00	4.00
	Sept.	2 to 6/9	03/9	06	6.61	04/9	23	6.54
	October	28 to 31/10	29/10	15	5.10	29/10	08	5.11
1974	August	17 to 21/8	17/8	19	6.14	19/8	12	4.75
1975	August	20 to 30/8	21/8	13	7.98	21/8	17	6.18
1976	August	4 to 8/8	6/8	08	4.46	06/8	08	1.94
	August	11 to 18/8	15/8	15	7.54	16/8	15	4.95
1977	July	27/7 to 02/08	30/7	08	4.40	30/7	08	2.50
	August	7 to 11/8	08/8	06	6.35	10/8	08	3.88
1978	August	17 to 21/8	18/8	03	5.87	20/8	09	3.70
	August	26/8 to 03/9	30/8	08	6.53	27/8	12	4.88
1979	August	9 to 13/8	10/8	03	5.40	10/8	00	3.13
1980	Sept.	12 to 16/9	15/9	03	4.64	15/9	03	3.82
	Sept.	19 to 30/9	20/9	12	13.32	20/9	14	11.79
1981	August	16 to 26/8	23/9	15	4.74	22/8	12	3.10
1982	August	7 to 28/8	19/8	06	6.00	14/8	18	3.65
	August	30/8 to 4/9	31/8	09	9.50	01/9	03	5.54
1983	Sept	1 to 13/9	07/9	03	5.6	07/3	03	3.73
1984	August	9 to 11/8	10/8	06	5.55	11/8	18	4.38

	August	16 to 25/8	18/8	06	5.64	20/8	12	5.57
1985	August	30/7 to 14/8	09/8	03	5.20	11/8	09	3.40
1986	June	25 to 30/6	29/6	19	8.60	30/6	18	4.29
	August	21 to 22/8	22/8	00	4.60	22/8	12	3.71
1987	August	28 to 31/8	28/8	06	5.20	--	--	Nil
1988	August	03 to 10/8	04/8	14	4.96	06/8	10	3.10
1989	July	27/7 to 01/8	29/7	03	2.85	--	--	Nil
1990	August	29/8 to 10/9	06/9	21	4.46	07/9	03	3.41
	Sept.	10 to 21/9	16/9	00	5.40	16/9	00	5.38
1991	July	20/7 to 04/8	24/7	12	5.37	02/8	03	2.14
	August	12 to 21/8	14/8	03	6.76	14/8	18	2.80
	August	22/8 to 01/9	25/8	03	4.94	25/8	15	3.40
1992	July	28/7 to 02/8	30/7	06	4.76	01/8	15	2.29
	August	16 to 30/8	22/8	15	5.85	23/8	06	5.22
1993	August	14/8 to 26/8	21/8	15	4.17	21/8	21	3.40
1994	June	19/6 to 25/6	21/6	18	7.27	23/6	21	3.76
	July	8/7 to 19/7	10/7	12	9.09	14/7	3	7.33
	July	20/7 to 25/7	21/7	06	7.05	21/7	3	6.19
	August	3/8 to 9/8	04/8	17	6.50	07/8	0	3.89
	August	18/8 to 26/8	20/8	21	4.66	21/8	15	3.91
	Aug-Sept.	27/8 to 10/9	01/9	06	6.08	01/9	18	05.73
1995	July	18/7 to 29/7	25/7	18	5.84	26/7	18	4.60
1996	July	21/7 to 30/7	27/7	09	4.75	27/7	6	3.26
1997	August	17/8 to 28/8	23/8	18	4.75	23/8	18	4.75
1998	Sept.	7/9 to 17/9	11/9	21	6.85	12/9	3	6.85
1999	August	4/8 to 15/8	09/8	15	4.92	9/8	21	4.53
2000	August	15/8 to 23/8	18/8	09	3.16	--	--	--
2001	July	4/7 to 31/7	18/7	07	9.54	18/7	12	8.54
	August	19/8 to 28/8	22/8	21	4.79	22/8	21	4.22
2002	Sept.	7/9 to 15/9	12/9	15	3.65	12/9	18	3.43
2003	Aug-Sept.	26/8 to 15/9	30/8	12	8.72	31/8	0	8.85

7.1.3 Flood Protective Embankments

7.1.3.1 Background: Cuttack town is surrounded by the river Mahanadi on left and Kathjori on right. The stone revetment constructed by imperial King Markat Kesari protects the town from fury of flood of Kathjori. Under the Marathas, the zamindars were bound to maintain the embankments and for this purpose were permitted to make certain deduction from the revenue; but they only cared for the embankments within their zamindaries.

"By Regulation VI of 1806, an embankment committee was formed to supervise all the embankments. xxx In 1828, the Cuttack revetment needed repair. In July 1828, the Military Board in Calcutta allowed Thomas Pakenham, Commissioner, to remove stones from Barabati Fort for repair of the revetment" (Source: Irrigation, Inland Navigation & Flood Problems in North Orissa during British Rule by P.Mukherjee). During 1831, the P.W.D took over the embankments. The surveyor was designated as the 'Superintendent of embankments'.

In January 1847 the Military Board suggested that all the embankments in Orissa should be razed to the ground for passage of flood water which was opposed by Moffat Mills, commissioner. He stated "the system has too long prevailed to admit of so sweeping a remedy". He further wrote "It also appears to me extremely doubtful whether the removal of the bunds would be attended with loss or gain to Govt. Some estates might be improved from alluvial deposits, but I am led to think that the good would be more than consumed by the injury which the sandy deposits, so common in Cuttack Rivers, would do to the soil".

Govt. of Bengal took time for a decision as a result the annual repairs of the embankments were stopped which deteriorated their conditions further. This was followed by another mistake. In 1850, the superintendent in charge of embankments discarded about half of the existing embankments as useless and spent a little or nothing on what remained (vide: Despatch of the court of Directors, Dt 04.8.1885).

7.1.3.2 Construction of Embankments

After the disastrous floods of 1866, a committee was appointed under Chairmanship of T.E Ravenshaw: to suggest how far inundation could be prevented. The committee recommended on outlay of about Rs.75lakhs for embankments and protective works in three districts with a protection rate of eight annas per acre in the areas liable to inundation. The report of this committee marked a departure from previously advocated policy of abandoning the embankments. Accordingly Govt. of India advised the Govt. of Bengal to proceed gradually with flood embankments as the canal system would develop. The General Embankment Act was passed in 1873. Few important embankments are disused as under:

i) The Aul Ring Bund surrounds 50 sq. miles (80.5 sq. km) of country of the Aul estate. It stretches from the left bank of Brahmani, six miles above Indupur to the river Kharsuan. In the south, it extends up to Alva. This ring bund is in existence for more than a century. When the lands outside the bund rose due to silt deposit every year, the inside land remained lower by an average six feet than the country outside, forming a cup like depression with a low saucer inside similar to that of Cuttack city. The progressive deterioration of river channels and confinement of spread of flood water by river embankments raised the beds of rivers to some extent above the level of surrounding country.

The Ring bund is situated between the Raj Kanika embankment on the north along Kharsuan and Utikan & Gajaria embankment on the south. As the Ring bund obstructs the spill, thus volume of water from Kharasuan overtops the banks and spreads over the tracts between the Baitarani and Kharasuan. The Utikan embankment is continuation of Patamundi embankment of which Gajaria embankment is further extension. The Utikan and Gajaria embankments have raised the flood levels in the vicinity by reducing the flood slope in the lower reaches of Brahmani.

ii) The embankments along the right bank of Brahmani and left bank of Kharsuan raised the flood level of the protected area. The liability of inundation of the country on the left bank of Baitarani increased due to construction of flood protective embankments to protect the right bank.

iii) The flood levels of Luna and Chitrotpala rose after construction of embankments in Luna-Chitrotpala Island. Due to rise in flood levels in rivers and obstruction of free flow to drainage, the Flood Enquiry Committee of 1928 had recommended abandonment of certain embankments. Never the less, one may not agree with opinion of 1928 Flood

Enquiry Committee that the flood problem in Orissa has been made acute by efforts made towards it protection.

iv) The Bhograi and Joki embankments in north Balasore meet almost at right angle, creating a low lying pocket in between which gets filled by flood water of Subarnrekha even up to a depth of ten feet. The flood water of the Subarnrekha is further affected from flowing down by the alignment of Bhograi embankments. During high floods, Subarnrekha remains high near its mouth and the entire area along Chitai nallah up to Joki remains submerged for some days (Source: Irrigation, Inland navigation and Flood problems in North Orissa during British Rule by P.Mukherjee, Pg. 38).

v) Cuttack city protective embankments

The embankments to protect the capital (which was shifted to Bhubaneswar during 1949-50) was constructed by Keshari King for a length of 17 km. It started from Chahata on the right bank of Mahanadi and was taken to Hariharghat on the left bank of Kathjori via. Satichaura for 3 Km length. From Hariharghat, it extended up to Khannagar burial ground via Ganeshghat and Purighat covering a length of 3.6km. Thereafter, the embankments from Khannagar joined Jobra on the right bank of Mahanadi through Dolomundei and Ranihat. Jobra to Chahata was connected by 7.3km embankments via Matamatha and Gadagadiaghat. This was providing protection to about 15 sq. km area, which was the inner city. Subsequently the city extended toward east beyond Khannagar-Jobra bund. The Taladanda canal, Railway line and N.H-5 lie in the extended part of the city. Accordingly, the embankments beyond Khannagar burial ground on Kathjori left and from Jobra on Mahanadi right have been constructed. At present the city is fast growing on western side beyond Chahata-Harihargaht up to Naraj. This area between Balubandh and Bidanasi was a low land exposed to inundation by Mahanadi spills, which was protected by bund on both sides of Mahanadi & Kathjori known as Bidanasi gherry. This gherry was raised and strengthened during construction a new barrage at Naraj under OWRCP funded by World Bank.

Out of original embankment of 17 Km, stone revetment was provided for a length of 8 km from Matamatha to Chahata on Mahanadi side and then to Hariharghat and Purighat on Kathjori side. The stone protection wall was constructed with laterite stone having dimensions of 80 cm in length x 40 cm in width x 30 cm thickness. At strategic locations sand stones were used. This revetment built by Markat Keshari stood high in its original alignment and grander with minor repairs for about one thousand years. Most of the original stone revetment is no longer open to the view as the embankments around the city have been widened by extending the section into the river on Mahanadi and Kathjori sides, there by covering the old revetment.

After devastating flood of 1982, the embankment from Bellevue up to N.H-5 on Kathjori left has been widened and strengthened with stone revetment on the slope. Toe wall with armour stones at specific locations has also been provided. Similar widening and strengthening works on Mahanadi right has also been done from Chahata to Matamath and later extended up to N.H-5. The city protective embankment is designed to withstand up to a flood of 15 lakh cusec in undivided Mahanadi.

An idea of the protection from floods given by the embankments up to end of eighteenth century can be visualized from Table...7.12 (Source: Rivers of Orissa by A.S.Thomson, 1905 Pg.40-52 and Mahalanabis Report Pg.62).

Table 7.12 Embankments of Orissa Rivers

Name of River	Deltaic area (sq.mile)		Length of embankments	
	Total	Protected	Mile	Km
Mahanadi	2525	1327	540	869
Brahmani	855	263	131	211
Baitarani,		289	75	121
Others (Salandi, Kapali, Subarnrekha & Saline)		156	58	93
Total	3380	2035	804	1294

Out of 3380 sq mile (8754sqkm), about one-third was fully protected, one – third partially and the rest was open to all floods. The doab wise distribution of flooded area in stage I (Old delta) and stage II (New delta) are furnished in Table 7.13 (Refer 'Delta Development Plan' –Mahanadi Delta command area, Vol.VI, Hydrology and F.C scheme, 1986, Pg.113)

Table 7.13 Doab wise distribution of flooded area (lakh ha)

Name of Doab	G.C.A	C.C.A	Depth of inundation up to 0.5m	Depth of inundation up to 0.5m to 1m	Depth of inundation from 1m to 1.5m	Total (Lakh ha)
Stage I (Old delta) Mahanadi-Kathjori-Devi	1.00	0.61	0.162	0.043	0.010	0.215
Mahanadi-Chitrotpala-Luna-Birupa-Brahmani	1.27	0.83	0.180	0.059	0.070	0.309
Luna- Chitrotpala	0.15	0.09	0.018	0.006	0.003	0.027
Area to the East of H.L.C Range-I	0.23	0.14	0.019	0.009	0.004	0.032
Total stage I	2.65	1.67	0.379	0.117	0.087	0.583
Stage II (New delta) Kathjori-Kusabhadra	1.0	0.53	0.212	0.074	0.051	0.337
Kusabhadra-Bhargavi	0.52	0.28	0.092	0.031	0.019	0.142
Daya-Bhargavi	0.89	0.47	0.076	0.028	0.023	0.127
Area to the west of Daya	0.14	0.08	0.011	0.005	0.003	0.019
Total stage II	2.55	1.36	0.391	0.138	0.096	0.625

Depending on the quantum of rainfall, intensity of flood and outfall conditions, the duration of inundation varies from 5 to 20 days in stage I delta and 5 to 30 days in stage II delta, which damages the standing crops and affects the yield.

7.1.3.3 People and Embankments

"Opinions have lately veered round embankments for protection against floods. The present policy is to confine the flow of each main river to a single channel by double embankments with high level escape and control sluices, and to improve the mouths of the rivers by efficient cuts". Embankments in Orissa are associated with public opinion. Unprotected area inhabitants demonstrate against discrimination while people of protected areas demand for raising and strengthening of their embankments. People of Binjharpur seek removal of Aul Ring bund while Aul inhabitants demand for further strengthening. Similarly Rajnagar area people want that Gajaria embankments be strengthened when people of Patamundai want for its removal. For raising and strengthening of embankments in stage I &II delta, detailed Project Report has been prepared and submitted to C.W.C for according technical approval. The proposed embankments have been designed to withstand a flood of 14.0 lakh cusec (39638 cumec) at the head of delta of river Mahanadi.

The embankments are of four types i) Capital embankments ii) Other agricultural embankments (O.A.E) iii) Saline embankments and iv) Test relief embankments (T.R.E). These four types are in order of importance. Most saline embankments are in non irrigated areas which are constructed to check the saline inundation due to the tidal and surge effects of the sea and through the tidal channels and creeks. Basin wise list of embankments constructed in the state up to 2006 is shown in Table 7.14.

Table 7.14 Basin Wise List of Flood Embankments (km)

Sl.No	Name of the Basin	C.E	O.A.E	T.R.E	Saline	Total in Km
1	Vamsadhra	4.98	1.70	82.91	--	**88.59**
2	Rushikulya	--	486.40	--	30.00	**516.46**
3	Mahanadi	1281.14	1205.78	428.69	961.72	**3877.33**
4	Brahmani	144.21	218.67	258.35	323.20	**944.43**
5	Baitarini	127.87	122.13	184.54	161.80	**596.34**
6	Burhabalanga	--	20.50	144.85	12.95	**178.30**
7	Subarnrekha	30.00	28.70	225.60	28.00	**312.30**
	Total	**1588.20**	**2083.94**	**1324.94**	**1517.67**	**6514.75**

There exists number of drainage channels in each doab area of Mahanadi delta. These drainage channels play vital role in disposing the excess water of the doab. Besides river embankments, there are some flood protection embankments along the drainage channel for discharging the flood water.

The erosion to river banks in Mahanadi system is a common phenomenon in view of soil characteristics through which the river passes. During monsoon, the velocity of water in the river increases which causes erosion to the river banks.The deltaic region being fertile is thickly populated. Villages have grown by the sides of the rivers even encroaching into their flood plains. The bank erosion causes damages to the dwelling houses and the villages are susceptible to flooding. To prevent erosion to the river banks, river training measures like high & low level spurs, bed bars, lunching apron and stone revetment are taken up.

The river mouth of the Mahanadi and its branches are subjected to littoral drift along the coast from south to north. In the process, spits and bars are formed in front of river mouth. This makes the river to flow north ward after meandering for a considerable distance almost parallel to the shore line. This increases the river length and creates further drainage congestion. The rise in bed due to decrease in velocity of flow consequently raises the flood level. The river becomes inefficient in discharging its flood flow. This situation is aggravated by the sea tide. During very high floods, sometimes sand bars formed at the mouth gets washed away and direct out let is established with sea. This has been the practice with the river system of Mahanadi and the Devi mouth which are critical mouths in the system. It is desirable to dredge out the spit and sand bar formations so that the river mouth is kept directly open to the sea; which needs regular maintenance. This will improve the carrying capacity of the river in the tidal zone, and turn an aggrading river into a degrading one. Besides meandering can be prevented to some extent. In

February 2007, I.I.T, Madras has suggested dredging and resectioning of Daya, Nuna, Makara and Ratnachira for discharging flood water at a faster rate in short duration to minimize flooding and water logging.

7.2 Drainage

7.2.1 Introduction

Land drainage is the removal of excess water from the land surface by artificial means to make it more suitable for agricultural use. The excess is the amount of water which adversely affects the production of crops by reducing the soil volume accessible to roots. This water source may be due to precipitation, excess quantum of water supplied for irrigation, flow or under ground seepage from adjacent area or flood water entering into fields.

Plant roots require a favorable environment to be able to extract water and soluble nutrients. Excess of water or of salts into root zone or at the land surface does not allow the plant roots to function normally. As a result, the plant grown and yield are adversely affected. In the extreme cases of water logging and salinity, the seeds may not germinate and the plants may wilt permanently. This results in loss of agricultural production. Adoption of agricultural drainage in time prevents physical and chemical degradation of soil.

Water logged areas estimated in the country vary widely from one source to another which is given in Table 7.15.

Table 7.15 Estimates of Water Logged Area in India

Sl.No	Source	Water logged area (million ha)
1	Irrigation Commission 1972	4.75
2	National Commission of Agriculture 1976	6.00
3	Ministry of Agriculture 1984-85	8.53
4	Working Group of M.O.W.R 1991 (only in irrigated command)	2.46
5	Singh 1994	4.50
6	Abrol 1994	16.00
7	Singh and Bandyopadhyay, 1996	3.95
8	Sehgal 1996	5.2

(Source: Drainage of Agricultural lands by A.K.Bhattacharya, WTC, IARI, New delhi-12 ('5o years of Natural Resources Management Research Pg.347')

Similar variation also exists in the estimates of saline areas though in the context of agriculture; the definition of saline area is more comprehensive in comparison of a water-logged area. The estimated figures are shown in Table 7.16.

Table 7.16 Estimated Saline Area

Sl.No	Source	Saline area (million ha)
1	Chauhan, 1996, based on information of 1990	7.2
2	Sewa Ram 1996 based on information of 1993	3.3
3	Abrol 1994	10.9
4	Singh 1994	8.6
5	Singh and Bandyopadhyay 1996	8.6
6	Sehgal 1996	10.1

'The degree of variation in the estimates of physically and chemically degraded agricultural lands in the country indicates lack of effort and proper criteria to assess the condition of land resources, relation to these conditions with their agricultural production potential and finding out the causes of their deterioration to enable planning for suitable ameliorative measures'.

Due to heavy and concentrated rainfall, flat topography and low hydraulic conductivity of soils, the coastal areas are subjected to water logging. To reclaim these soils, dykes or protective embankments with sluice arrangements are constructed along coast, estuaries and rivers. Table 7.17 and 7.18 show the drainage characteristics and water balance of coastal areas of the country.

Table 7.17 Drainage Characteristics in Coastal Belt

Place	Soil characteristics		Drainage properties		Monsoon rainfall (mm)	Water table (m)
	Texture	pH	Surface	Sub-surface		
Uphart (Gujarat coastal saline soil)	Top 30 cm clay loam, below clay mixed with it	7.4-8.5	Good with slope 0.5 to 1%	Poor, 1.8 cm per day basis infiltration rate	1400	1-3.0
Chodbunder (Maharashtra coastal saline soil)	Top 30-45 cm clay and below moorum	7.3-5	Good with slope 0.5 to 1.2%	Poor, 1.2cm/day basis infiltration rate	2100	0.5-2.5
Guntur (A.P. heavy soil)	Few cm. sandy soil and below heavy clay	7.8-8.9	Surface water stagnation during monsoon	Poor, infiltration & poor G.W quality	800	02.-1.25
Canning (W.B. coastal saline soils	Silty clay loam	6.5	Surface drainage not present	Low infiltration. G.W shallow depth	1600	<1.0

Table 7.18 Water Balance Statement of Coastal Areas

State	June – September			Oct. - December		
	Rainfall (mm)	Potential evapo - transpiration (mm)	Water Surplus/ deficit (mm)	Rainfall (mm)	Potential evapo - transpiration (mm)	Water Surplus/ deficit (mm)
Orissa	1140	477	663	180	280	-100
West Bengal	1325	519	806	177	310	-123
AP	570	590	-20	330	337	-7
Tamilnadu	340	640	-300	480	357	-123
Kerala	2010	395	1614	550	335	-215
Maharashtra	2700	475	2225	130	344	-214
Gujarat	930	556	365	30	357	-327

(Source: Fifty years of Natural Resources Management Research, 'Coastal areas & their management' Pg.37)

During initial phase of irrigation development, majority of funds were diverted for creation of irrigation infrastructure and no efforts were made for providing matching drainage facilities in the irrigation commands. The most glaring example is the waterlogged areas of Ganganagar, Humangarh and Bikaner district because of Indira Gnadhi Nahar Pariyojana. This has resulted in problem of water logging and salinity in some of the irrigation commands. Seepage from conveyance system of the irrigation project, excessive application of irrigation water to crops, lack of conjunctive use of surface and ground water, poor on farm water management, deficient maintenance etc. only added to the problem. Working Group of MOWR in their report of 1991 estimated waterlogged area and salt affected area in commands of major and medium irrigation schemes as 2.46mha and 3.3mha, respectively. These areas need to be reclaimed to the extent feasible. Suitable cropping pattern for areas being reclaimed, need to be developed.

7.2.2 Causes of Drainage Congestion in Orissa

Several causes contributed to drainage congestion particularly in Mahanadi delta command. Heavy rainfall during very short period, long drains with flatter slope running almost entire length of the doab, flat terrain having low gradient and inefficiency of the drainage channel cross section etc are major reasons for poor drainage which are summarized as under:

i) Deterioration of drainage channel due to silting

ii) Encroachment due to high population density, which puts more pressure on agricultural lands. The increase in rural road network by various departments without adequate ventage in culverts creates afflux and aggradations of the channels

iii) Providing earthen cross bunds by villagers across drainage channels during lean season for catching fish and storing water for lift irrigation when canal water supply is inefficient. These bunds are never removed during monsoon.

iv) Poor of maintenance of drainage channel

v) Obstruction of flow due to growth of aquatic weeds.

vi) Coincidence of rainfall in the doab when the river is in spate.

vii) Widely varying out fall conditions of the drains meeting river, sea or Chilika Lake. During monsoon, the water level in the lake remains about 1.5 m high above M.S.L. which creates drainage problem. Tidal fluctuation of the sea two times a day pushes sea water inland during high tides. During this period, the drainage water does not get chance to be discharged to the sea. Some drains also outfall into rivers within tidal reaches. All these outfall into rivers within tidal reaches. All these factors contribute to the water logging.

Geomorphologically, the coastal planes are the product of sediment deposit continuously transported from the erosive high land by the river over the years. This delta is bounded by the high land on the right of Kuakhai from Bhubaneswar extending up to Khurda and then to Chilika; and on the left bounded by high land of Chaudwar and the hill range parallel to National Highway No-5.

The Mahanadi delta has entirely been brought under irrigation by canal system, which originates from barrages across river Mahanadi and its branches. This delta having been formed only through metamorphosis of sediment deposits, there exists a medium to thick layer of clay underneath the surface. This makes the infiltration into the ground poor. The obstruction due to alluvial sand dune at the coast, create difficulties for drainage. The situation aggravates with the release from the irrigation canal, poor sub surface drainage and high tide during the floods and a large part remains water logged for weeks together.

Details of the drainage system in various doabs of Mahanadi delta has been given in Table 3.4 of the book. The poor drainage areas are broadly classified into four categories depending upon severity and effect on cultivations. Table 7.19 shows the degree and extent of water logging in different doabs (vide Delta Development Plan Vol. I, Oct. 1989, E.I.C, Irrigation Pg.189).

Table 7.19 Extent of water logging

Name of the Doab	Area affected due to poor drainage (lakh ha)				
	Unsuitable for cultivation throughout the year	Unsuitable for cultivation in Khariff only	Suitable for cultivation in both seasons but with poor yield	Area which cannot be economically retrieved	Total (Lakh ha)
Stage I (old delta) i) Mahanadi-Kathjori-Devi	0.029	0.081	0.095	0.010	0.215
ii) Mahanadi-Chitrotpala-Luna-Birupa-Brahmani	0.035	0.114	0.146	0.014	0.309
iii) Luna-Chitrotpala	0.001	0.012	0.013	0.001	0.027
iv) Area to the east of HLC Range I	0.004	0.010	0.016	0.002	0.032
Stage II v) Kathjori-Kushabhadra	0.021	0.076	0.103	0.003	0.203
vi) Kushabhadra-Bhargavi	0.014	0.042	0.054	0.002	0.112
vii) Daya- Bhargavi	0.024	0.074	0.102	0.003	0.203
viii) West of Daya	0.004	0.012	0.024	0.001	0.041
Total stage I + II	0.132	0.421	0.553	0.036	1.142

7.2.3 Remedial Measures through Cuts and Escapes etc

'The problem of Orissa is not how to prevent flood but how to pass them as quickly as possible into the sea' (vide Flood Enquiry Report, 1928 Pg.13). In the State, the rivers flowing have insufficient capacity to carry even a fraction of total volume of water. The excess water was passing to the sea over land mass before construction of flood embankments. After this situation quick drainage of flood water became primary concern to prevent stagnation of water.

In the 2nd half of 19th century, it was observed that artificial cuts would be required to supplement natural drainage channels. But the other opinion was to constrict flood control reservoirs. Captain Harris suggested an escape channel from Mahanadi near Banki by cutting through a low ridge which separates the water spreads of Rana nallah with that of Malaguni. Rana is a tributary of Mahanadi while Malaguni joins river Daya. Harris pointed out that the cut (known as Daltala cut) would divert excess flood of Mahanadi into Chilika. Though this proposal was favoured by Captain Short, Lt. Colonel Young, the then Chief Engineer reviewed the report of 28th May 1860 and opined that Daltala escape would lower the maximum flood of Mahanadi by only four inches (10cm).

Again after 68 years, the Daltala scheme was examined by Flood Enquiry Committee in 1928. They opined that 'It would pour a huge volume of water into a lake having inadequate discharging capacity which is one of the causes of flood'. This criticism was made prior to construction of Hirakud Dam. But 1959 Flood Enquiry Committee recommended the Daltala cut so as to divert one and half lakh cusec through the Chilika to the sea. But this could not materialize.

In 1857, Lt. Short proposed a cut from Bhargavi to Sur Lake for diverting excess flood water of the Bhargavi. But Captain Beadle, Supt. Of embankments suggested in his letter of 22nd June 1859 for an additional escape to the sea by connecting Kushabhadra with Sur Lake. A cut was excavated in 1930 to connect Sur Lake with sea which is performing satisfactorily not withstanding the effects of littoral drifts. Due to poor outfall condition at the mouth and increased length because of meandering, the flood discharges in rivers are sluggish. This creates afflux in the upstream reaches and inundates vast cultivated areas. To minimize this problem a diversion cut known as 'Gabkund cut' was made from Bhargavi for partial flood relief. Towards end of 19th century, the Hansua creek was connected with Brahmani for quick passage of Brahmani into the sea. A large loop of Brahmani was cutoff at its outfall during 1926 and has now become the main channel.

Another cut through the sand dune was made which covered the mouth of Kushabhadra. This was closed considerably in 1927. During flood of 1928, it was reopened with more width. During 1862, Col. Rundall, Chief Engineer of canal and Irrigation Company suggested of permanent flood escape with stone revetment. Such escapes should be high enough such that sand is not carried and spreaded over adjoining county. These masonry escapes would act as safety valves for passing out a part of the peak flood.

The important flood escapes in stage II area (i.e. undivided Puri district) of Mahanadi command are located at the head of the doabs at Mancheswar, Ramachandrpur, Jogisahi, Achyutpur, Kanti and Madhipur. But the escape channel leading from these escapes don't have continuous embankments on both sides upto outfall point. Even the Gabkund cut does not have embankment on left. This creates flood inundation in Puri district. Improvement to these channels to carry flood discharge is not practicable as it's has been seen that it will create new manmade rivers inside the doabs. This idea mooted by Majumdar committee was subsequently abandoned. Thereafter it was contemplated to have a control structure across Kuakhai at its off take and progressively close the escapes in the river embankments. But the model study at CWPRS, Pune dictated construction of a new barrage across Kathjori as a replacement to the century old Naraj anicut under OWRCP (vide CWPRS specific note no.2216 Dt.9.10.84).

In his note of May 1902, W.A Inglis advocated construction of escapes to pass out the surplus flood, which cannot be retained within embankments. In this regard, he wrote "In the interest of the land which is liable to inundation taken as a whole, it would be better, that the excess volume of flood should be passed out from the rivers at fixed places and in more or less fixed proportions, rather than, as at present it should pass through breaches, the position of which is uncertain, and which once they have opened, can as a rule neither be controlled nor closed till the end of the flood seasons".

Commonly practiced measures are a) Surface Drainage b) Subsurface drainage c) Bio-drainage and d) Conjunctive use etc. to minimize drainage congestion. Surface drainage system has mostly been taken up in the State in piecemeal under 'food for works programme'. But a consolidated scheme amounting to Rs.834.00 Cr. has been submitted to C.W.C for technical clearance for retrieving an area of 1.90 lakh ha. Other three measures have not been undertaken in the state.

7.2.4 Conjunctive use of Surface & Ground Water

Integrated and coordinated development of surface and ground water commonly known as conjunctive use is now widely recognized as a most suitable strategy for irrigation development in alluvial plains. Conjunctive use of surface and ground water whereas on one hand increases the irrigation potential also mitigates the problem of water logging to a great extent. It also facilitates use of high salinity ground water by dilution, which cannot otherwise be used directly. The coordination in use of surface and ground water depends on hydrologic, topographic, agroeconmic, economic, management and social factors.

'Studies for conjunctive use planning were carried out for existing Indira Gandhi Nahar Project stage-I in which water level was rising at an alarming rate of 1.0 m per year. The studies revealed that provision of additional 10023 shallow tube wells will not only help in lowering of water table but at the same time increase the area under irrigation by 0.1 m.ha. Studies for conjunctive use planning have also been carried out in Hindon-Kali Nadi Doab in Saharanpur and Muzaffar Nagar in U.P and Mahi-Kanada Canal Command (Gujarat).

It is suggested that similar studies may be carried out in the State to reduce water logging in deltaic region particularly in Luna- Chitrotpala, Mahanadi-Chitrotpala, Daya-Bargavi, Kushabhdra-Bhargavi doabs and other water logged areas where the situation is grave.

7.2.5 Cost & Benefits of Drainage

The extent of waterlogged and salined agricultural land in the county, for which adoption of drainage technology is essential to reclaim such physically and chemically degraded lands and increase their crop productivity, may be to the tune of 8.5 and 5.5 million ha, respectively. The average capital investment required for drainage of agricultural lands may vary from Rs.5, 000 –Rs.10, 000 per hectare for surface drainage to Rs.25, 000 – Rs.35, 000 per hectare for subsurface drainage.

Making such huge investments is beyond the paying capacity of the farmers in possession of the low-potential, physically and chemically degraded lands. Besides the financial aspect, other important issues involve in adopting the drainage technology on a large scale are the lack of suitable design information, which may necessitate undertaking pilot scale adoption, and the slow rate of commissioning the system, if taken up manually. However, this can be overcome by use of construction machinery available in the county.

However, it is urgently necessary to bring in strict discipline in the irrigation water use, which alone will be instrumental in reducing the problems of drainage congestion, salinity etc. It is equally important to adopt remedial measures, particularly through the intervention of agricultural land drainage technology in the large areas suffering from drainage and associated problems. Experimental evidence on the beneficial effects of drainage on the soil and crop improvement is quite conclusive. Surface drainage removes accumulated run-off from the cropped area, arrests the rising trend of ground water table and makes the field workable sooner after heavy rain or irrigation compared with an undrained area. Surface drainage controls water table and removes harmful chemical from the soil profile. If a drainage system functions satisfactorily in the Kharif (rainy season), it allows maintaining timeliness in the next following Rabi (winter season).

Adoption of drainage technology saves valuable agricultural lands from physical and chemical degradation; transforms a barren land into productive agricultural land and improves the productivity of the low producing agricultural lands. Economic viability of even the initially expensive subsurface drainage has also been proved with the benefit: cost ratio greater than 2 (two). Besides, drainage helps local employment generation, reduce migration from the villages to the cities and increase the land value. However individual farmers cannot adopt it. Therefore, organized efforts through the Water Resources and Agriculture department are needed to provide the drainage infra-structure comprising proper land leveling, the drainage system network, the associated structures and an effective maintenance programme on a command or watershed basis.

Environmental benefits of drainage include its positive impact on improving the health of humanbeings, plants and farm animals. Besides, the principal benefit of providing drainage to irrigated land is that it facilitates prevention / reclamation of water logged area and soil salinity leading to sustained soil and crop productivity.

7.3 Drought

7.3.1 Drought Scenario in Various River Basins of the State

A drought is defined as a failure of monsoon which is the cause of drying the water bodies, soil moisture and depletes the ground water table. Failure of crops and shortage of drinking water for humanbeings and livestocks brings untold miseries. If drought situation persists for a longer period, misery gets worsened causing damage to the environment and threatens the social fabric of society. According to IMD, if the annual rainfall of an area is 75% of the normal value (long term) average, the area is considered to be affected by drought. The severity of drought is measured by crop cutting experiment and accordingly declaration on drought area is made.

The failure of monsoon is associated with late onset, early termination and low & intermittent rainfall. The study of rainfall pattern of the last decade has brought out that Orissa has been receiving lower rainfall than the rest of the country. Table 7.20 shows that the State has bad years once in every three years. Shortage of rainfall below average is one of the major reasons of drought situation in the State.

Table 7.20 Percentage of Deviation of Rainfall from Normal

	1994	1995	1996	1997	1998	1999	2000	2001
Orissa	+12	+4	-34	-4	-16	-5	-31	+6
All India	+10	+0	+03	+2	+06	-4	-08	-8
% variance	+2	+4	-37	-6	-22	-1	-23	+14
Deficient			D		D		D	

Less than 1100 mm of rainfall occurred during 1965, 1974, 1976, 1979, 1987, 1996 and 2002 which are severe drought years when there was considerable reduction in Khariff rice production. This shows that there is at least one severe drought year in every decade thus underlining a high degree of vulnerability of the State to drought.

As defined by the India Meteorological Department if the rainfall over an area is below 75% of the normal value, then the area is considered to be drought affected. The drought is classified as follows:

Table 7.21 Classification of Droughts

Classification	% of departure from normal rainfall	Intensity of Drought
Mo	0 or above	No drought
M1	< 0 to (-) 25%	Mild
M2	< (-)25% to (-)50%	Moderate
M3	< (-) 50%	Severe

Probability of occurrence of droughts has been studied for twenty years (i.e. 1981 – 2000) for different localities of the State, which is given in Table 7.22.

Table 7.22 Probabilities of occurrence of droughts (1981-2000)

Sl.No	Station	No. of years	% of frequency of occurrence of droughts				Probability of occurrence (%)
			M0	M1	M2	M3	
1	Angul	19	52.6	26.3	21.1	--	47.4
2	Balasore	20	30.0	50.0	20.0	--	70.0
3	Baripada	18	33.4	61.1	5.5	--	66.6
4	Bhawanipatna	10	40.0	60.0	--	--	60.0
5	Bhubaneswar	20	60.0	30.0	10.0	--	40.0
6	Bolangir	18	38.9	44.4	16.7	--	61.1
7	Chandbali	20	45.0	40.0	15.0	--	55.0
8	Cuttack	20	60.0	30.0	5.0	5.0	40.0
9	Gopalpur	20	35.0	30.0	30.0	5.0	65.0
10	Jharsuguda	20	45.0	35.0	15.0	5.0	55.0
11	Keonjhar	19	55.0	30.0	15.0	--	45.0
12	Koraput	9	55.6	11.1	33.3	--	44.4
13	Phulbani	20	55.0	25.0	15.0	5.0	45.0
14	Puri	20	75.0	20.0	5.0	--	25.0
15	Sambalpur	19	47.4	36.8	15.8	--	52.6
	Range		30-75%	11-61%	0-21.1%	0-5%	25-70%
	Average		49.0	35.0	15.0	1.3	51.0

Source: Tenth National Water Convention, Bhubaneswar 5-7 November 2003, Pg.173.

7.3.1.1 Basin wise study

It is found that the upland portion of the Mahanadi basin in western part of the State are more affected by drought. Sinapalli with average annual rainfall of 940 mm and Patnagarh with 947 mm are the badly drought affected areas. The other places in order of severity are as follows (Refer Table 7.23).

Table 7.23 Average Annual Rainfall of Drought Prone Areas

Place	Avg. annual rainfall (mm)	Place	Avg. annual rainfall (mm)	Place	Avg. annual rainfall (mm)
Subdega	995	Gaisilet	1064	Khariar	1107
Odagaon	1026	Boden	1085	Khaparakhol	1111
Belpara	1044	Tureikela	1104	Laikera	1127
Binka	1056	Golamunda	1106	Nayagarh	1138

Source: Mahanadi Basin Plan, OWPO, Pg. 89-90.

It is seen that severe drought prone area in Mahanadi basin are Bijepur, Binka, Bongomunda, Chakapada, Golmunda, Hemagiri, Kesinga, Narla, Phiringia, Sonepur, Titlagarh and Bolangir. In these areas mild drought occur with a return period of 2 to 4 years, moderate with a return period of 7 to 12 years and severe drought having return period of 12 to 15 years (Source: Mahanadi Basin plan, OWPO, Pg.88).

In Rushikulya basin, severe drought is expected once in 17 years in the blocks like Chhatrapur, Dharakote, Jagannath Prasad, Rangeilunda and Sheragad, once in 20 years in Chakapada block and once in 39 years in Digapahandi, Ganjam, Kodla, R.Udayagiri and

Tanganapalli blocks (Source: Rushikulya Basin plan-3rd Spiral study, OWPO, Dec.2001 Pg.73 Sec.5.7.2.3).

Based on results of annual rainfall data analysis, it is seen that in Subarnrekha basin, moderate drought occurs once in every 2 to 18 years and severe drought once in 22 to 26 years (vide Basin Planning Report of Subarnrekha, Aug.2004, 3rd spiral study, OWPO Pg.70).

Similarly in Baitarani basin, moderate and severe drought occurs respectively once in every 4 to 13 years and once in every 20 to 26 years (Refer Baitarani Basin plan, 3rd spiral study, OWPO, April 2003, Pg.76)

From the studies of Brahmani basin it is seen that the upland portion of basin in the State particularly the western part are more affected by drought. Average annual rainfall of the basin is 1357.88 mm Places where rainfall is less than basin average are Talcher-1145 mm, Rajgangpur-1035 mm, Naktideul-1184 mm, Chhendipada-1074 mm and Bisra-1129 mm. Area covering Kutra, Kuanrmunda, Lathikata, Riamal and Naktideul may be affected by severe drought once in every 10 to 20 years. Area covering Kankadahada, Sukinda, Parjanga and Kamakshyanagar may suffer from severe drought once in 20 to 30 years (vide Brahmani Basin plan, 3rd spiral study, OWPO, Nov.2002 Pg.72).

7.3.2 Drought in Earlier Periods:

Before British rule, drought leading to crop failure, scarcity and famine occurred in almost every fifty years. From 11th to 17th centuries, there were 14 drought situations leading to famines in India and from 1765 to 1858 AD, there were 12 famines. During 1860 to 1908, country experienced 20 famines twenty times.

The Marathas ruled Orissa from 1751 to 1803 till British occupation. There occurred three famines during Maratha period i.e. in 1770, 1780 and 1792. The great famine of 1770 AD was devastating in nature, which was felt grievously throughout Orissa. This famine caused widespread havoc and it left behind a dark trail of death, misery and disorder in the administrative system.

In the very first year of British occupation i.e. in 1803 a famine occurred. In between 1803 to 1864,there were drought and famine in 1803, 1806, 1807, 1809, 1817, 1828, 1834, 1836, 1837, 1839, 1840 and 1863 (Source: The Natural calamites in Orissa in the 19th century by B.B Bhatta, 1997 Pg.92). The province of Cuttack 'is subjected to seasons of extreme uncertainty liable to the most vicissitudes of drought and inundations'. The immediate cause of drought was the repeated failure of monsoon. During 1840, there was severe drought in the province. The commissioner Cuttack proposed to sanction the remission of revenue amounting to Rs.587, 146-9-51/4 on account of loss of crops by early cessation of last periodical rains. Similarly during droughts of 1841-42 and 1842-43, revenue remitted was Rs.2, 09,290 and Rs.4, 86,625 respectively. Above drought situations were also due to early cessation of rains. During 1850-51, revenue of Rs.18, 465-4-8 was remitted on account of drought (Refer Drought in Orissa, 1954-55, Final Report, Govt. of Orissa.)

In the first half of 19th century Orissa suffered to a great extent from famine and drought. The financial condition of the people deteriorated gradually. Table 7.24 shows the average availability of rice per rupee during different periods.

Table 7.24 Average Price of Rice (in seers)

Year	Rice per rupee	Year	Rice per rupee
1836-46	48	1869-70	2
1846-56	58	1875	1.5
1856-66	29	1876-87	22
1866-67(*)	5	1886-96	19

(*) For Na-anka 'Durvikhya' (Refer sec. 2.7.1.1 of the book).

(Source: The Natural Calamities in Orissa in the 19th century by B.B.Bhatta, 1997 Pg.97)

The colonial policy of the British changed after great famine of 1866. However, this taught a good lesson and thereafter Govt. made guide line for the remedy from drought and famine. Sir W.Gery addressed the Supreme Govt. urging "the extreme importance of carrying on irrigation woks to completion without delay and at the same time expressing his opinion that this province would never be thoroughly safe from one of two calamities either drought or inundation till those works were completed".

7.3.3 Drought in Recent Memory

In 1954-55, the rainfall was low, ill timed, ill distributed and sporadic throughout the State. The scanty rainfall in June and July was unfavorable for the germination of paddy crop from the beginning. After middle of August 1955 there was unusually heavy rainfall. This created high flood in the principal river systems causing severe damage of crops, lives and properties in the districts of Cuttack, Puri and partly in Balasore, Dhenkanal and Keonjhar. Similar situation had also occurred during 1865-66 (i.e. the year of Na-anka 'Durbhikshya'). A statement showing the Districts wise area and Population affected due to drought is presented in Table No.7.25.

Table 7.25 District wise Area and Population Affected During 1954-55

District	Area Affected (in acres)	Population Affected
Cuttack	601838	10, 11, 900
Puri	108277	2, 40, 000
Balasore	425500	5, 32, 469
Keonjhar	168492	2, 00, 129
Mayurbhanj	425000	2, 37, 930
Dhenkanal	304560	2, 15, 071
Ganjam	37544	47, 773
Koraput	55000	1, 88, 224
Phulbani	37530	78, 000
Sundargarh	166000	1, 68, 223
Bolangir	104782	1, 20, 200
Kalahandi	97960	2, 12, 000
Sambalpur	88560	3, 30, 000
Total	26, 19, 920 or 26, 20, 000	35, 81, 919 or 35, 82, 000

During 1996-97, almost all the districts of Orissa excepting Malkangiri and Koraput were affected by drought. About 84% of the blocks were affected. In twenty districts, almost all the blocks were affected. Worst suffered districts were Bolangir, Dhenkanal, Jharsuguda and Nayagarh followed by Sambalpur and Boudh. Table 7.26, 7.27, and 7.28 show the crop loss of 50% and more from 1696-97 to 2000-2001. Blocks covered under DPAP and deficient rainfalls are given in Table 7.26.

Table 7.26 Crop loss of 50% or more due to Drought

Sl No	Affected areas	Year			
		1996-97	1997-98	1998-99	2000-01
1	No. of districts	28 (99.33)	15 (50.00)	26 (90.00)	29 (96.67)
2	No. of blocks	263 (83.76)	86 (27.39)	163 (51.91)	216 (68.79)
3	No. of GPs	3762 (71.51)	849 (16.14)	1686 (32.03)	2511 (47.74)
4	No. of villages	28,837 (55.96)	4688 (9.10)	11,431(22.18)	16,219(31.72)

Note: Figures in parentheses indicate percentage share.

Source: Govt. of Orissa, Revenue Department.

Table.7.27 District wise Statement Showing Crop Loss of 50 percent or more due to Drought

Sl no	District	1996-97			1997-98		
		% of blocks affected	% of GPs affected	% of villages affected	% of blocks affected	% of GPs affected	% of villages affected
1	Angul	100.00	100.00	79.41	--	--	--
2	Bolangir	100.00	100.00	99.61	--	--	--
3	Balasore	100.00	88.72	75.98	16.67	06.23	02.86
4	Bargarh	83.33	69.39	71.78	--	--	--
5	Bhadrak	71.43	39.16	37.24	14.29	01.20	0.61
6	Boudh	100.00	96.55	85.09	--	--	--
7	Cuttack	100.00	62.95	50.00	--	--	--
8	Deogarh	66.67	16.98	03.53	--	--	--
9	Dhenkanal	100.00	100.00	95.71	--	--	--
10	Gajapati	100.00	81.13	38.87	85.71	51.89	42.89
11	Ganjam	100.00	94.37	72.92	100.00	52.70	35.67
12	Jagatsinghpur	100.00	36.97	22.17	75.00	32.73	19.57
13	Jajpur	100.00	98.35	79.13	--	--	--
14	Jharsuguda	100.00	98.33	92.84	--	--	--
15	Kalahandi	84.62	63.08	45.68	15.38	11.28	01.00
16	Kendrapara	100.00	72.20	51.01	77.78	40.49	19.22
17	Kandhamal	100.00	95.83	51.14	--	--	--
18	Keonjhar	100.00	90.98	74.25	--	0.41	--
19	Khurda	80.00	75.97	69.49	--	--	--
20	Koraput	--	--	--	78.57	62.94	53.56
21	Malkangiri	--	--	--	100.00	98.70	32.48
22	Mayurbhanj	100.00	97.15	71.08	07.69	01.58	0.98
23	Nabarangapur	10.00	8.78	07.02	30.00	05.41	01.45
24	Nayagarh	100.00	98.60	90.64	--	--	--
25	Nuapada	100.00	60.22	37.73	--	--	--
26	Puri	100.00	56.86	36.88	63.64	46.57	27.07
27	Rayagada	90.91	51.43	21.29	54.55	26.43	04.79
28	Sambalpur	100.00	91.73	87.04	22.22	05.26	03.31
29	Sonepur	100.00	65.00	69.87	33.33	37.50	19.61
30	Sundargarh	35.29	5.88	01.62	--	--	--
	Total	**83.76**	**71.51**	**55.96**	**27.39**	**16.14**	**9.10**

Table 7.27 Contd....

Sl. no	Districts	1998-99			2000-01		
		% of blocks affected	%of GPs affected	% of villages affected	% of blocks affected	%of GPs affected	%of villages affected
1	Angul	100.00	64.09	36.37	100.00	94.44	82.20
2	Bolangir	78.6	75.9	66.4	100.00	100.00	99.22
3	Balasore	100.00	87.5	69.00	16.67	01.17	0.30
4	Bargarh	66.7	46.9	24.2	91.67	70.41	24.17
5	Bhadrak	28.6	03.6	0.7	--	--	--
6	Boudh	100.00	96.6	86.9	100.00	98.28	77.51
7	Cuttack	--	--	--	85.71	20.50	04.10
8	Deogarh	100.00	54.7	09.3	100.00	100.00	84.78
9	Dhenkanal	50.00	16.9	09.6	87.50	73.26	57.78
10	Gajapati	--	--	--	71.43	23.58	06.22
11	Ganjam	50.0	17.8	06.8	100.00	51.80	13.38
12	Jagatsinghpur	37.5	22.4	12.4	62.50	35.15	18.76
13	Jajpur	10.00	05.8	03.4	100.00	96.28	75.74
14	Jharsuguda	80.00	39.7	27.2	100.00	100.00	94.24
15	Kalahandi	76.9	55.4	23.9	61.54	49.74	26.99
16	Kendrapara	55.6	24.9	12.0	77.78	52.68	34.54
17	Kandhamal	83.3	21.5	08.4	58.33	53.47	23.14
18	Keonjhar	92.3	68.9	48.6	53.85	16.39	05.63
19	Khurda	--	--	--	100.00	55.56	46.43
20	Koraput	14.3	03.0	0.3	07.14	04.57	05.63
21	Malkangiri	--	--	--	85.71	89.61	71.15
22	Mayurbhanj	92.3	76.6	56.4	15.38	03.16	01.93
23	Nabarangapur	40.00	08.8	03.0	20.00	14.19	07.04
24	Nayagarh	37.5	07.00	03.0	100.00	41.96	16.99
25	Nuapada	60.00	23.7	09.3	100.00	97.85	82.02
26	Puri	18.2	08.3	03.1	36.36	06.86	05.09
27	Rayagada	--	--	--	90.91	72.86	34.12
28	Sambalpur	44.4	15.8	09.8	100.00	93.28	91.19
29	Sonepur	66.7	60.00	61.00	100.00	36.25	28.05
30	Sundargarh	52.9	34.7	19.9	88.24	72.94	53.67
	Total	**51.9**	**32.03**	**22.18**	**68.79**	**47.74**	**31.72**

Source: Board of Revenue, Cuttack and Special Relief Commissioner, Govt. of Orissa, Revenue Department Secretariat, Bhubaneswar and Human Development Report 2004, Govt. of Orissa Pg.168-169.

Table 7.28 Blocks Covered Under DPAP & Deficient Rainfall

Sl no	District	Block covered under Drought Prone area programme		Sl no	District	Block with rainfall < 1000 m.m occurring at least six times during 80's &90's	
		Sl. no	Block			Sl. no	Block
1	Boudha	1	Harbhanga	1	Boudh	1	Boudh
		2	Kantamal	2	Ganjam	2	Buguda
2	Phulbani	3	Tikabali			3	Chhatrapur
		4	Khajuripada			4	Ganjam
		5	Phiringia			5	Rangeilunda

		6	Baliguda
		7	Chakapada
		8	Nuagaon
		9	Kothagarh
		10	Tumudibandh
		11	Daringibadi
		12	G.Udaygiri
		13	Raikia
		14	Phulbani
3	Kalahandi	15	Kesinga
		16	Golmunda
		17	Narla
		18	M. Rampur
		19	Th. Rampur
		20	Lanjigarh
		21	Bhawanipatna
		22	Dharamgarh
		23	Junagarh
		24	Kalampur
4	Nuapada	25	Khariar
		26	Sinapali
		27	Boden
		28	Nawapada
		29	Komna
5	Bolangir	30	Patnagarh
		31	Khaprakhol
		32	Belpada
		33	Titilagarh
		34	Tureikela
		35	Bangamunda
		36	Muribahal
		37	Saintala
6	Sonepur	38	Tarva
		39	B. Maharajpur
7	Bargarh	40	Padampur
		41	Bijepur
		42	Paikamal
		43	Sohella
		44	Jharbandh
		45	Gaisilat
8	Dhenkanal	46	Dhenkanal
		47	Odapada

3	Keonjhar	6	Saharpada
		7	Hatadihi
4	Nawarangpur	8	Raighar
5	Rayagada	9	Kolnara
6	Malkangiri	10	Podia
7	Mayurbhanj	11	Jamada
	Nayagarh	12	Khandapada
		13	Nayagarh
		14	Odagaon
8	Khurda	15	Bolgarh
		16	Tangi
9	Sundargarh	17	Rajgangpur
		18	Bisra
		19	Baragaon
		20	Hemagiri
		21	Subdega
		22	Tangarpali
10	Angul	23	Banarpal
		24	Talcher
11	Bargarh	25	Ambabhona
		26	Bhatil
12	Koraput	27	Bandhugaon
		28	Lamtaput
13	Sambalpur	29	Kuchinda
		30	Jamankira
14	Jharsuguda	31	Kirmira
		32	Laikera
		33	Lakhanpur

Slno	District	With deficient Rainfall Blocks during 90's
1	Angul	Chendipada
		Banrpal
2	Ganjam	Buguda
		Sorada
3	Keonjhar	Saharpada
		Patna
		Hatadihi
4	Nawarangpur	Raighar
5	Rayagada	Padampur
		Ramnaguda
		Chandrapur
6	Malkangiri	Podia
7	Nayagarh	Khandapada
8	Khurda	Bolgarh
9	Mayurbhanj	Betanati
10	Sundargarh	Rajgangpur

Flood zones and Drought prone areas of the State are shown in Fig 7.1 and Fig 7.2

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Chapter VIII

INTERSTATE ISSUES

8.1 Interstate Agreements & Disputes

India is a Union of States. Under Entry 56 of List I of the Seventh Schedule of the Constitution, Parliament has overriding power of legislation for regulation of Inter-State rivers and river valleys in the public interest. Subject to this provision, under Entry 17 of List II, the State has exclusive power over water. Under Article 262 of the Constitution, adjudication of any dispute or complaint in respect of the use, distribution or control of water of any Inter-State river or river valley is provided for. The Inter-State Water Dispute Act of 1956 has already been enacted for this purpose, and has been amended from time to time. The River Boards Act of 1956 was also enacted under Entry 56 of the Constitution. However, there are no guidelines in these acts or any policy for sharing or distribution of Inter-State river water. Irrigation Projects especially major and medium projects are very much location specific. Hence it may not be possible to avoid construction of such projects on Inter–State Rivers. However, it is heartening that our constitution vide Article 262 provides for the adjudication of any dispute. It may be mentioned here "neither the Supreme Court, nor any other Court shall exercise Jurisdiction in respect of any such dispute or complaint". In this context it is necessary to make brief reference to the River Boards Act of 1956 and the Inter-State Water Dispute Act of 1956 (vide Sec.8.2 and 8.3 of this chapter). The sharing / distribution of a river basin amongst its constituent States or countries competing for its use is a universal problem. This matter has been dealt within various International Treaties, in various inter-State agreements amongst constituent States of a nation and in judgments of various Courts and Tribunals etc. The Helsinki Rules on the use of water of International River adopted by the International Law Association in August 1966 lay down the guiding principles and indicate an elaborate procedure of resolving the issues through negotiations, arbitration, tribunal or the International Court of Justice.

As per Helsinki Rules, an international drainage basin is a geographical area extending over two or more sovereign State determined by the watershed limits of the system of water including that flowing into a common terminal. In general, the opening of a river into the ocean system is taken as the common terminus.

For the purpose of this policy an Inter-State river basin is a geographical area extending over two or more State/Union Territories of India determined by the watershed limit of the system of waters, flowing into the ocean/sea either directly or through another sovereign nation or into a natural lake/depression having no outlet. The whole river basin up to its terminus or upto the International boundary would be considered as a single unit for sharing/distribution of waters of an inter-State river or river valley.

As per National Water Policy 2002 (revised), water resources development should be planned for a hydrological unit such as drainage basin as a whole or for a sub-basin, multi-sectorally, taking into account the entire water for sustainable use.

A co-basin State of an Inter–State River is a State or Union Territory in India the territory of which includes a portion of the Inter State basin. An upstream or downstream sovereign nation, the territory of which includes a portion of the concerned Inter-State river basin, would not be considered as a basin State for the purpose of these guidelines.

Every effort shall be made to protect the existing utilization in the pre-plan period as well as through project implemented following due procedure and approval.

8.2 River Boards Act. 1956

'It is a Central Act. According to the Act the Central Government, on request received from a State Government or otherwise, by notification may establish a River Board for advising the Government interested in relation to such matters concerning the regulation or development of an Inter State river valley or any specified part thereof.

The River Board shall consist of a Chairman and such other members as the Central Government think fit to appoint. The member eligible for such appointment shall have special knowledge and experience in irrigation, electrical engineering, flood control, navigation, water conservation, soil conservation, ad-ministration or finance. The Board shall perform all or any of the following functions.

a) Advising Governments interested on any matter concerning the regulation or development of any specified Inter State river or river valley within its area of operation and in particular, advising them in relation to the co-ordination of their activities with a view to resolving conflicts among them and to achieve maximum result in respect or measures undertaken by them in the Inter State river or river valley or the purpose of (i) Construction control and optimum utilization of water resources of the interstate river, (i) promotion and operation of schemes for irrigation, water supply: hydro power, flood control navigation, control of soil erosion, prevention of pollution of water etc.
b) Preparing scheme for regulating or development in Inter State River or river valley.
c) Allocating among the Governments interested the costs of executing any scheme,
d) Watching the progress of measures undertaken, and
e) Any other matter, which is supplemental, incidental or consequence to any of the above functions.

The River Board shall have the power also to acquire, hold and dispose such property, both movable and immovable, as it deems necessary to undertake such investigation, survey, inspect or cause to be inspected any works undertaken by any Government interested concerning the regulation of development of the Inter State river or river valley, conduct and coordinate research on various aspects of conservation, regulation or utilization of water resources: collect data and publish them etc.

The Board shall have its own fund to be paid by the Central Government or State Government'. (Refer: 'Irrigation in Orissa', published by WALMI, Orissa, Dec. 1991, Pg.155).

8.3 Inter- State Water Disputes Act, 1956

It is also a Central Act. Section 3 of the act provides that if it appears to a State Government that a water dispute with another State Government has arisen or is likely to arise, prejudicial to the interest of the said State; the aggrieved State Government may make request to the Government of India to refer the matter to a Tribunal for adjudication. It is relevant here to give a brief outline of the Inter State Water Dispute Act, 1956. (Term water dispute here refers to any dispute or difference between two or more State Governments with respect to use, distribution or control of water in any interstate river or river valley or interpretation of the terms of any agreement relating to the use, distribution or control of such water or the implementation of such agreement, or the levy of any water rate in contravention of the prohibition contained in the Act.)

Section–4: On being satisfied that the dispute cannot be settled amicably, the Central Government shall constitute a Water Dispute Tribunal by notification in official gazette. The tribunal shall consist of a Chairman and two other members nominated by the Chief Justice of India from among those persons who at the time of nomination are judges of Supreme Court/High court. Tribunal may also appoint two or more persons as assessors to advise it in the proceedings before it.

Section-5: Central Government will refer the dispute to the Tribunal for adjudication and after due investigation, Tribunal will report to Central Government indicating therein its decision. There is scope for referring the matter again to the Tribunal in case either the Central Government or any particular State Government feels the need for clarification, guidance etc. within three months from the date of decisions of Tribunal. After due consideration the Tribunal will give its award.

Section–6: Central Government will publish the decision of the Tribunal in official gazette. The decision will be final and binding on the parties to the dispute and shall be given effect to by them.

Section-6A: A scheme shall be formulated to give effect to the award of the Tribunal. This scheme initially provides for establishment of an Authority to give effect to the award. Justice Sarkaria Commission has made several recommendations to improve upon the existing provision.

Orissa is richly endowed with water resources. It has several Inter-State rivers namely, Subaranrekha, Brahmani, Mahanadi, Indravati, Kolab, Sileru, Nagavali, Vansadhara and Bahuda. Excepting in case of **Godavari Water Disputes Tribunal**, that too at a very late stage of the proceeding, no water dispute was referred to any Tribunal under the Interstate Water Dispute Act, 1956. Matters relating to allocation and utilization of water of Inter-State Rivers have been resolved peacefully through agreement reached at different times.

8.3.1 Award of Godavari Water Dispute Tribunal

'In July, 1951, Planning Commission held a conference with Government of Bombay, Madras, Hydrabad, Madhya Pradesh and Mysore to discuss the utilisation of water of Krishna and Godavari basin. Orissa was not invited to the conference. A memorandum of agreement valid for 25 years was drawn up allocating the flows of Godavari basin. Orissa was not a party to the agreement. Latter there were significant territorial changes in the State covered by Godavari basin. Bombay, Madhya Pradesh, Andhra Pradesh became new riparian states. No settlement could be reached at the Inter-State conference held in September 1960. In January 1962, Mysore applied to refer the dispute to Tribunal under Inter State Water Dispute Act, 1956. Madhya Pradesh, Orissa, Maharashtra and Mysore made fresh application in 1968 to constitute the Tribunal as negotiation to arrive at a consensus failed. Award of the Tribunal was submitted in November 1979 and published in the gazette in July 1980. The following are the decision relating to Orissa.

i) All States can use underground water within their respective territories in the Godavari basin.
ii) Any State can use waters of river Godavari and its tributaries for domestic, industrial irrigation, production of power, pisciculture uses etc.
iii) Each of the State concerned will be at liberty to divert any part of its share from Godavari basin to any other basin.
iv) Besides above, it was agreed that the following agreements reached earlier between different States regarding clearances of projects for utilization of the

Godavari river and its tributaries should be implemented'. (Refer: 'Irrigation in Orissa', Published by WALMI, Pg.157, and Dec.1991).

8.4 Inter State Agreements

Agreements have been reached at different times between Orissa and its neighboring States. The extracts of those documents have been taken from the book 'Documentation of Interstate Agreement's Published by WALMI, Govt. of Orissa, 1993). Those have been appended vide Annexure I to XIV. But there exists no agreement for sharing the waters of Mahanadi between Orissa and Chhatisgarh (which has been carved out of M.P). Hirakud Dam was constructed during 2nd plan period by Govt. of India. After construction of Hirakud, M.P (now Chhatisgarh) has constructed no. of major and medium irrigation Projects like Ravi Shankar and Bango Dam etc. Construction of reservoirs in the upstream without considering the riparian rights in the down stream (i.e. irrigation in Sambalpur, Balangir, Baragarh, stage I & II delta) will affect the irrigation and power generation from Hirakud Dam. Besides sudden release of water from the upstream reservoir during monsoon may create flood havoc in the flood prone coastal districts of the State. This sensitive issue may be resolved early by entering into Inter State agreement between Orissa & Chhatisgarh. Machhkund, Balimela, Upper Indrvati, Upper Jonk, Kolab, IB, Ong and Subarnrekha Irrigation projects would not have seen the light of the day without concluding the inter-State agreements.

8.4.1 Agreement with Andhra Pradesh

- The agreement between Government of Madras and Government of Orissa regarding the development of hydroelectric power at Duduma falls on Machhakund river signed on 14-1-1946 (before independence and formation of Andhra Pradesh) is appended vide Annexure. I.
- Decisions arrived at the meeting held at New Delhi on 07-9-1959 Annexure. II.
- Discussion held at the Inter State conference held on 17th July 1961 between the chef Ministers of A.P and Orissa regarding Upper Sileru Project, Machkund H.E Project, Generation of power at Jalput Dam and Neradi Project on Vansadhara River enclosed vide Annexure. III.
- Final agreement dated 4th Sept. 1962 between Government of Orissa and A.P in relation to the use of waters of Sileru River which paved way for construction of Balimela Dam - furnished vide Annexure. IV.
- Proceedings of the meeting held on 15th Dec. 1978, between the Chief Ministers of A.P and Orissa on Nagavali River, Jhanjavati River, Bahuda River and Minor irrigation schemes - appended vide Annexure. V.
- Minutes of meeting held on 15.1.87 between Union Minister of W.R and Chief Minister of Orissa & A.P on interstate issues relating to Vansadhara Project stage II of A.P – enclosed vide Annexure. VI.
- Minutes of discussion held on 10th June 1992, between the Chief Ministers of Orissa and A.P – furnished vide Annexure. VII.

8.4.2 Agreement with Madhya Pradesh

- Agreement between Orissa and Madhya Pradesh on 9th Dec.1975 for use of waters of Godavari basin and clearance of Projects of M.P and Orissa. This was pending final allocation of Godavari water – vide Annex.VIII.

- ➢ Agreement between Orissa and M.P on 11th July 1979 regarding use of waters of Indravati sub-basin and Sabari (Kolab) sub-basin – appended vide Annex.IX.
- ➢ Agreement between Orissa and M.P on 2ndth April 1980 relating to Polavaram Project – furnished vide Annex. X.
- ➢ Agreement reached on 28th April 1983 between Orissa and M.P for construction of Ib Project (Orissa), Sapni (M.P), Kurnala (Joint Project), Upper Jonk (Orissa) Lower Jonk (Joint Project), Ong (Orissa) Jira (Orissa), Sahajbahal (Joint), Lower Kolab (Joint Project) and Back water studies of Hirakud Dam etc. The extract is enclosed vide Annex. XI.

8.4.3 Agreement between Orissa and Bihar

- ➢ Agreement for utilising waters of Subrnrekha and Kharkai rivers signed on 17th Jan. 1976 – enclosed vide Annex. XII.

- ➢ Agreement reached between Chief Ministers of Orissa and Bihar on 25th Oct. 1976 for execution of Chandil Dam, its left bank canal and Galudih barrage vide Annex.XIII.

8.4.4 Tripartite Agreement among Orissa, Bihar and West Bengal

Tripartite agreement was drawn for utilising waters of Subarnrekha–Kharkhai basin on 7th Aug. 1978 amongst Orissa, Bihar and West Bengal – appended vide Annex. XIV. The gist of the tripartite agreement is described here in nutshell.

An agreement was reached between the Chief Ministers of Orissa, Bihar and West Bengal on 7.8.1978; which states as follows:

"75% dependable yield at Kokpara which is assessed to be 4.5 million acre ft. will be apportioned between the three States-Bihar (3.2 million acre ft), Orissa (1.2 million acre ft) and West Bengal (0.1 million acre ft.) Below Kokpara 75% dependable yield will be shared by Bihar (2.7 lakh acres ft), Orissa (2.9 lakh acre ft) and West Bengal (5.9 lakh acres ft.) In the event of any surplus water at Kokpara, the surplus will be allocated in the proportion of 8:1:1 between Bihar, Orissa and West Bengal. On the other hand in the event of shortage it will be apportioned in the ratio of 32:12:1. In the area below Kokpara both surplus and shortage will be shared in the proportion of 2.7, 2.9 and 5.9, respectively.

The joint works of Orissa & Bihar under execution in Bihar are Kharkei or Icha dam, Galudih barrage, Galudih right bank canal and Chandil dam. Orissa has to pay the cost of three works at the proportion of 26.4%, 86.2% and 94% for Icha, Galudih barrage and right bank canal respectively. The share for Chandil dam (towards flood control component) has not been spelt out. In the Technical Committee meeting Dt.20.2.91, attended by the engineers of both the states it was decided that Orissa will draw from Icha reservoir 28% in monsoon and 72% in non-monsoon period". (Source: Irrigation in Orissa Published by WALMI Orissa, Dec.1991, Pg.157).

Annexure-I

THE MACHKUND POWER AGREEMENT

AGREEMENT BETWEEN THE GOVERNMEMNT OF MADRAS AND THE GOVERNMENT OF ORISSA REGARDING THE DEVELOPMENT OF HYDRO-ELECTRIC POWER AT THE DUDUMA FALLS ON THE MACHKUND RIVER

(I) The Government of Madras and the Government of Orissa agree that the power resources at the Duduma Falls should be developed without delay to fullest extent and for the maximum benefit of both provinces.

(II) (a) The Government of Madras shall have full right to the use of 50 percent of the ultimate power developed at the Duduma Falls as well as of that developed at each stage.

(b) The Government of Orissa shall have full right to the use of 50 percent of the ultimate power development at the Duduma Falls as well as of that developed at each stage.

(III) The two Governments agree that based on present conditions and knowledge, the Govt. of Madras will be in a position to use power to a greater extent and at a much earlier date than the Govt. of Orissa. The two Governments accordingly agree to develop power jointly at the Duduma Falls on the terms and conditions laid down herein after.

(IV) The Govt. of Orissa shall transfer to the Govt. of Madras for a period of ninety-nine years from the date of signing of this agreement its right of use of 20 percent of the ultimate power developed as well as of that developed at each stage.

(V) In consideration of the transfer of the said 20 percent the Govt. of Madras shall pay annually to the Govt. of Orissa for thirty years commencing from the date of operation of the power plant an amount calculated at the rate of Rs.20 per kilowatt on 20 percent of the actual maximum demand recorded at the power house during each financial year. After the expiry of 30 years the terms of payment shall be liable to revision in such manner as may be mutually agreed upon between the two Govts.

(VI) On the expiry of the said period of 99 Years, it shall be open to the Govt. of Orissa to take over the said 20 percent on payment to the Govt. of Madras of the proportionate share of the Capital cost as specified in the Schedule, less depreciation.

(VII) The Govt. of Madras shall be responsible for the construction, maintenance and operation of all civil works including dam and appurtenant works and of hydro-electric installations including power plant and switch gear at the Duduma Falls whether situated in the province of Madras or Orissa. Each Govt. shall be separately responsible for the construction, maintenance and operation of the power transmission lines and distribution system within their respective territories.

(VIII) The general proposal of the Govt. of Madras for the construction and development of the Scheme as contained in their printed Report of 1944 are hereby accepted by both Govts. subject to such modifications as may be made by the Govt. of Madras in the interest of economy. The Government of Orissa agree that the Govt. of Madras may proceed forthwith with the execution of the scheme in a manner which is in the opinion of the Govt. of Madras best suited to meet the demand for powers as and when it arises. Both Govt. further agree to permit all engineers and employees to enter freely into all lands and property for the purposes of the scheme and of the transmission system. Each Govt. shall grant free right of way of all transmission lines which may be necessary to transmit power form the scheme to place within the territory of the other Govt.

(IX) (a) The Govt. of Madras shall provide 70 percent and the Govt. of Orissa shall provide 30 percent of the Capital Cost of the Scheme. Interest during construction of any part of the scheme, till such time as that part comes into operation for generation of power shall be born by the Govt. of Madras and Orissa in the ratio of 70:30 respectively.

(b) The cost of maintenance and operation charges as specified in the Schedule shall be paid by the two Govts. every year in proportion to the maximum demand utilised by each Govt. in that year. Each Govt. shall contribute to the maintenance an operation cost as specified in the schedule every year in ratio of the maximum demand utilized by it in that year and from such contribution shall be paid the interest due to each Govt. in respect of its capital investment.

(X) The Govt. of Madras shall maintain accounts of capital expenditure and of maintenance and operation charges incurred by both the Govts. and attributable to the scheme. The Auditor General of India will be requested to arrange for the audit of the accounts relating to the scheme and prescribe the manner in which the accounts shall be kept. In respect of matters relating to accounts or the inclusion or the exclusion of any particular item of expenditure and of any dispute connected therewith the decision of the Auditor General shall be final and binding on the two Govts.

(XI) The Govt. of Madras and Orissa shall be at liberty to fix or modify their tariff rates for power supplied within their respective territories without interference from the other Government.

(XII) During construction as well as subsequent maintenance and operation, 30 percent of the executive and supervisory staff as well as contractors and laborers shall be drawn from Orissa, provided that suitable persons are available. The Govt. of Madras shall further afford full facilities for the training of Engineers and other personnel deputed by the Govt. of Orissa on construction, maintenance and operation of the scheme.

(XIII) A joint Board of Control shall be setup as soon as practicable and all matters of major policy shall be referred to that Board. Representation on the Board shall be in proportion to the capital contribution made by each Govt.

(XIV) Both Govts. and the joint Board of Control may at any time call for such information as may be required relating to the scheme direct form either Govt. or from the joint Board of Control and such information shall be furnished.

(XV) An advisory committee may be formed to advice the two Govts. in respect of the incidental matters connected with the resettlement of the dispossessed inhabitants, afforestation of the reserved areas in the catchment, construction of silt traps along the water course terracing, podu cultivation and formation of thick forest belts near the river margins and such other matters as may be referred to it for advice by either Govt. The committee shall consist of two representatives nominated by the Govt. of Orissa, two nominated by Govt. of Madras and one representative nominated by proprietor of Jeypore and Madgola Estates.

(XVI) (a) The Govt. of Orissa consent to the development of power by the Govt. of Madras at the end two power sites on the Sileru River at the expense under the sole control of the Govt. of Madras and to its full utilization by the Govt. for a period of 99 years.

(b) During this period the Govt. of Madras shall make power available from these two sites to the consumers in Orissa on the same terms and condition as may be applicable from time to time to the consumers in Madras.

(c) Subject to the provision of clause VIII, the Govt. of Madras undertake that the development at either of the two power sites on the Sileru River shall not affect adversely the Machkund Hydro Electric Scheme as generally outlined in their Report of 1944.

(d) The Govt. of Madras shall keep separate accounts for the two Sileru schemes and shall furnish copies of accounts and progress report to the Govt. of Orissa every year.

(XVII) At the expiry of the period of 99 years the Govt. of Orissa shall be entitled to claim up to 50 percent of the total output at these sites on payment of proportionate share of the Capital cost. Thereafter the two Govt. shall pay maintenance and operation charges in proportion to the power taken by them.

(XVIII) The Govts. of Madras and Orissa agree that any dispute arising in respect of this agreement, including the interpretation of any, of it clauses, shall be referred to the Governor- General and his decision shall be final and binding on the two Govts.

SCHEDULE

1. For purposes of this agreement all works necessary for the generation of power at the Duduma Falls on the Machkund River and matters incidental there to shall be known as the scheme.
2. The capital expenditure relating to the scheme shall consist of the following:
   a) Cost of acquisition of land and other rights if any.
   b) Costs of incidental to the scheme connection with the resettlement of the hill men, afforestation of the reserved areas in the catchment, construction of silt traps along water course, terracing, control of podu cultivations and the formation of a thick forest belt near the river margins.
   c) Cost of construction and improving communication for the scheme.
   d) Cost of preliminary surveys, construction camps, staff quarters colony as may be necessary to accommodate the personnel engaged in the construction and operation of the generating station.
   e) Cost of all hydraulic works, control dams, weirs, flumes, tunnels pipe lines, power station building and any other civil work required to establish [and extend from time to time] the generating station.
   f) Cost of all plant machinery required for generation and sale of power at the generating station excluding step up transformer and their associated switch gear and any equipment required for transmission purposes.
   g) All other incidental expenditure of a capital nature directly attributable to the scheme.

I. The maintenance and operation charges shall consist of :

(i) All expenditure incurred on maintenance and operation of the scheme.

(ii) Interest on capital

(iii) Depreciation, and

(iv) A margin not exceeding one percent on the capital expenditure at the end of each financial year.

- * -

Copy of Telegram O.D.No. 20 dated 26-1-1946 from (Govt. Of Orissa) Cuttack, marked immediate decodes as follows:

"GOVERNMENT OF ORISSA ACCEPT AND RATIFY DRAFT AGREEMENT REGARDING DUDUMA PROPOSED AT CUTTACK CONFERENCE ON JANUARY 14TH"

SD/-
26-1-46

- * -

Copy of Telegram No.33 dated 12.2.1946, from Govt. of Madras.

To
(GOVERNMENT OF ORISSA, CUTTACK REF: YOUR TELEGRAM (NO.77C) 1ST FEBUARY STOP. MACHKUND AGREEMENT . STOP.

MADRAS GOVERNMENT ACCEPTS AND RATIFY (THE) DRAFT AGREEMENT PROPOSED AT THE SUTTACK CONFERENCE ON 14TH WITH DELETION OF CLAUSE X (B) STOP. PLEASE SUGGEST A SUITABLE DATE FOR PRESS CONFERENCE STOP. 21 FEBUARY WOULD SUIT MADRAS STOP SECRETARY TO GOVERNOR GENERAL (IS) BEING INFORMED

SD/-
26-1-46

(Clause X (b) Read as follows:
"The cost of audit shall be debited to the scheme"

Annexure-II

SUMMARY OF THE DECISION ARRIVED AT THE CONFERENCE IN NEW DELHI ON 7TH SEPTEMBER, 1959

The following decisions wee arrived at in a Meeting held at 3.00 P.M on 7th September, 1959 in Udyog Bhavan, between Sri C.M Trividi, Member Planning commission, Shri Sanjiv Ready, Chief Minister Andhra Pradesh and Dr. H.K. Mahtab, Chief Minister Orissa and Sri S.N.Bhanjdeo, Minister, Irrigation and Power. Orissa in connection with the development of power on the Sileru River. Officials concerned of Andhra Pradesh and Orissa as also Chairman, C.W & P.C and Adviser (I&P) Planning Commission were present.

(1) Andhra Pradesh Govt. can proceed with Upper Sileru Stage I Project subject to the condition that it will not interfere with the construction of Balimela Dam.

(2) For storing the yield of the river at Guntawada or Balimela the economics of the alternative dams will examined, and the cheaper of the two will be undertaken.

(3) The storage to be created by either Guntawada Dam or Balimela Dam (roughly estimated to be of the order of 4, 200 cusecs regulated flow) will be shared between Andhra Pradesh and Orissa in equal proportion.

(4) Either State will be free to utilize its share of water for generating power.

(5) Andhra Pradesh will submit Upper Sileru stage II scheme envisages dam at Guntawada and Orissa will submit its scheme for a Dam at Balimela as soon as possible so that a choice can be made in good time for the Third Five Year Plan.

(6) When either Andhra Pradesh or Orissa Govt., decided to proceed with the construction of the selected Dam the other state will make appropriate provision in the Plan.

Sd. C.M.TRIVEDI,
Dt.7-9-1959

Sd. H.K.MAHATAB
Dt.7-9-1959
Sd. N. SANJIV REDDY
Dt.7-9-1959

Annexure-III

GOVERNMENT OF ANDHRA PRADESH PUBLIC WORKS DEPARTMENT

At the Interstate Conference held between the Chief Minister of Andhra Pradesh and Orissa at Hyderabad on 17th and 18th July, 1961, at which the Minister, Finance and Public Works of Andhra Pradesh and the officials of the two State Govts. were also present the following decisions were taken:

(1) **UPPER SILERU PROJECT:** The Chief Engineer of the two State Govts. would prepare revised estimates of the Balimela and Guntawada dams in the light of the discussion held between the officials of the two State Govts. on the morning of 18th July, 1961. The Chief Engineer, Andhra Pradesh, would forward the revised estimates for Guntawada Dam to the Chief Engineer, Orissa within one month from today i.e. 18th July 1961. Similarly, the Chief Engineer of Orissa would forward the revised estimates for the Balimela dam to the Chief Engineer A.P. within the same period. Therefore, the two Chief Engineers would meet and discuss any outstanding points of difference emerging from the two estimates and submit their joint report before the end of August, 1961. Immediately thereafter final decision would be taken regarding the location of the dam at a conference of the Chief Ministers of the two States.

(2) **MACHKUND HYDRO ELECTRIC PROJECT:** The representatives of the Govt. of Orissa claimed half the share of the additional power potential created at the Machkund Hydro Electric Project as a result of raising the height of the Jalaput Dam. They also indicated that they would be prepared to pay half the additional cost of raising the height of the Jalaput Dam by 10 feet. It was decided that the Chief Engineers in charge of Electricity of the two states would examine and formulate proposals on the basis of the additional power that may be generated as well as the additional power potential created and submit their recommendation before the end of August, 1961.

(3) **GENERATION OF POWER AT JALAPUT DAM SITE:** It was decided that the project report should be prepared immediately by the Chief Engineer (Electricity) Andhra Pradesh for generation power at Jalaput Dam. The cost of generation of powers as well as benefit would be shared equally by the two State Govts.

(4) **NERADI PROJECT ON THE VANSADHARA RIVER**: The Andhra Pradesh representative stated that they wanted to execute the irrigation project at Neradi, which entails the acquisition of 106 acres of land in Orissa territory and they wanted Orissa Govt.'s concurrence to go ahead with the project. It was indicated that it might be possible to irrigate some area of Orissa from this project. On behalf of Orissa it was stated that while Orissa Govt. had no objection, they wanted to safe guard against the water logging of their area and therefore had asked for certain details. As soon as these details are received, Orissa Govt. would communicate their concurrence to the project.

Sd/- D.Sanjivayya	Sd/- Bijoyananda Patnik
Chief Minister of Andhra Pradesh	Chief Minister of Orissa
18-7-1961	18-7-1961

Annexure-IV

FINAL AGREEMENT BETWEEN THE GOVERNMENT OF ORISSA AND ANDHRA PRADESH IN RELATION TO THE USE OF WATERS OF THE SILERU RIVER

1. A dam on Sileru with F.R.L 1516 shall be constructed at Balimela.

2. The weir at Guntawada, to be built entirely at the cost of Andhra Pradesh Govt. shall have specified heights as follows:

   (a) The construction of weir at Guntawada will be as follows:
   1st June, 1963: Spillway Section 600 feet at 1332 and 400 feet at 1320.
   15th April, 1964: Spillway Section 800 feet at 1332 and 200 feet at 1320.
   15th May, 1964: Spillway Section 1000 feet at 1332.
   Construction of sluices for 4000 cusecs discharge with water at 1320 will be provided.
   By December, 1964: Spillway section will be raised to crest level of 1340.
   (b) RL 1340 feet when this power plan is due to go into operation.
   (c) RL 1360 feet with 20 feet gates over 1340 feet RL crest when Balimela Dam has reached a height of at least 1400 feet RL.

Provided that in no case the height of water level at Guntawada, during floods or otherwise, shall exceed about 1360 feet RL for maximum designed discharge of 2.5 lakh cusec.

3. The cost of Balimela Dam for common works shall be shared equally by Govt. of Andhra Pradesh and Govt. of Orissa.
   Provided however that the share of Andhra Pradesh Govt. shall not exceed Rs.12.00 crores.

4. As requested by the Andhra Pradesh Govt., Orissa Govt. agrees to bear the Andhra Pradesh Govt.'s share of expenditure over and above Rs.3 crores (as provided by Andhra Pradesh Govt.) during the 3rd plan period. Such amount as is advanced by Orissa Govt. on account of Andhra Pradesh Govt. will bear interest at the average rate of Public loans floated by Orissa State during 1962-65 to be repaid to Orissa Govt. during the first year of the Fourth Plan period.

   Andhra Pradesh Govt. also undertakes to place the balance of the funds required as their share, during the fourth plan period to the extent of the work actually done every year.

5. The design and specification of the Balimela Dam would be authorised by a committee of three experts, consisting of the following: -

   1. Dr. A.N.Khosla, Member Planning Commission
   2. Dr. K.L. Rao, Member of Parliament.
   3. Member, Designs, Central Water & Power Commission.

   When vacancies arise they shall be filled by the Central Board.

6. Half the total inflow into Balimela Reservoir at Balimela dam will be let down towards the Andhra Pradesh share and the other half into the Balimela High Head Power House of the Orissa Govt. The flow to either power station will be as per the actual requirements. In any year from July 1st to June30th, the draw off of either party from storage shall not exceed half the allowed draw off from the year inclusive of evaporation losses but exclusive of surpluses due to filling of reservoir. Rules for regulations of the reservoir after it is in operation shall be drawn up by the Central Board.
7. Full facilities for investigation, construction and operation of weir at Guntawada and Lower Sileru site as also Lower Sileru Dam at Donkaraj or nearby by will be given by the Oirssa Govt. to the Andhra Pradesh Govt. Necessary land will be acquired in Orissa territories by the Orissa Govt. under the provision of the land Acquisition Act. Similar Assistance for the Balimela Reservoir will be given by the Andhra Pradesh Govt. to the Orissa Govt. for the areas in the Andhra Pradesh State.
8. The construction of Balimela Dam will be under a Joint Control Board on which Orissa and Andhra Pradesh will have equal representation. The Chairman of the Board will be the Chief Minister of either state alternatively for terms of a year, the first Chairman being the Chief Minister of Orissa, Works on the Balimela High Head Power House will be done by Orissa Govt. and on Guntawada weir by Andhra Pradesh Govt.
9. The Power House at Balimela Dam utilising the Andhra Pradesh share of waters will be constructed by and at the cost of Andhra Pradesh and will be operated and be under full control of Andhra Pradesh authorities. This cost include the cost of Penstocks, Trash rack and intake structure. The high Head Balimela Power house will be operated and be under the full control of the Orissa Govt. which will bear all the relevant costs.
10. Below Balimela Dam, the entire flow of river Sileru and tributaries is left to the exclusive use of Andhra State in such manner and at such times as they think it. The Andhra Pradesh Govt. will construct the necessary works. Similarly below the High Head Power House, the entire waters will be for the exclusive use of the Orissa state.
11. If and when any additional water is diverted into Machkund basin from other basins, half the waters will be given to Andhra Pradesh State and Andhra Pradesh State should bear half the cost of diversion and storage works.
12. With the signing of this Agreement the Andhra Pradesh Govt. may proceed with the construction of the Guntawada weir and ancilliary works as per the programme specified in clause (2) in the Orissa portion of the river and territory. Similarly works connected with the Balimela Dam may be taken up immediately.
13. Any alternation in the terms of this agreement can be made only with mutual consent of both the parties.

Hyderabad, A.P
Dt.4th Sept. 1962.

Signed on behalf of the Govt. of Orissa

1. Biju Patnaik, Chief Minister.
2. B. Sivaraman, Chief Secretary

Signed on behalf of the Govt. of Orissa

1. N. Sanjiva Reddy, Chief Minister.
2. M.P. Pai, Chief Secretary

Annexure-V

PROCEEDINGS OF THE MEETING BETWEEN THE CHIEF MINISTERS OF ANDHRA PRADESH AND ORISSA AT HYDERABAD ON THE 15TH OF DECEMBER, 1978.

The following were present:

Andhra Pradesh

1. Dr. M.Channa Reddi, Chief Minister
2. Sri. G. Raja Ram, Minister for Finance & Power
3. Sri G.V. Sudhakar Rao, Minister for Major Irrigation & Commercial Taxes
4. Sri. I.J. Naidu, I.A.S, Chief Secretary
5. Sri. S.R. Rama Murthy, IAS Secretary to Chief Minister & other officials

Orissa

1. Sri Nilamani Routray, Chief Minister
2. Sri Pratap Ch. Mohanty Minister for Revenue & Power
3. Sri Prahhallad Mallik, Minister for Irrigation.
4. Sri. B.M. Patnaik, Advocate General
5. Sri B.Ramadorai, IAS Secreatary, Irrn, & Power Dept. & other officials.

After full discussions, the following agreement was reached:

I. NAGAVALI RIVER

Gauging are being done at the Orissa and Andhra Pradesh State board to determine the yield from Nagavali River. However, it is agreed on adhoc basis that Orissa can plan its projects utilising upto 20 TMC on Nagavali River. The proposed utilisation by Orissa affects the existing irrigation through diversion works and river channels in Andhra Pradesh territory. To protect the existing irrigation and develop some additional ayacut it is agreed on adhoc basic that Andhra Pradesh can plan Thotapalli storage reservoir scheme utilising 16 TMC of water including lake losses. This scheme does not involve any submersion of Orissa territory.

II. JHANJAVATI RIVER

In regard to Jhanjavati River the yield will be shared on 50:50 basis between Andhra Pradesh and Orissa. This yield is approximately assessed as 8 tmc. A revised project report for Jhanjavati utilising approximately 4 tmc of water will be prepared by Andhra Pradesh providing gated spillway to keep submersion in Orissa territory to the minimum. The Govt. of Orissa agree to submersion subject to Andhra Pradesh paying compensation for land and property and rehabilitation expenditure according to Orissa Govt. norms prevailing during the period of acquisition and rehabilitation.

III. BAHUDA RIVER

(a) The State of Orissa seeks clearance for utilisation of water in its territory from Bahuda River.

(b) As utilizations in Orissa territory affects existing irrigation system through river channels and development of new ayacut in Andhra Pradesh territory, it is necessary to provide appropriate storage to protect such existing irrigation. Andhra Pradesh agrees to construct at its own cost such storage in its territory without involving any submersion of Orissa territory. The storages scheme, however needs some other ancillary works for its functioning and as such Andhra Pradesh seeks concurrence of Orissa for the following:

(i) The construction of regulator across Bahuda River below Kalingadola anicut near about Kalabad village in Orissa territory with submersion in river bed and protected by flood banks.

(ii) The construction of a second regulator on Boginadi near Sappanga village in Orissa territory with submersion in river bed and protected by flood banks.

(iii) The construction of a diversion channel of appropriate capacity connecting the regulator (i) and (ii) above:

(iv) The construction of a flood flow channel of appropriate capacity not exceeding 2,000 causes capacity from the regulator at Kalabad village up to Andhra Pradesh – Orissa border within Orissa Territory.

(v) Orissa to make available to Andhra Pradesh 1.5 tmc (including Lake Losses) of water during June to December every year through the flood channel.

(c) The state of Andhra Pradesh agrees to the construction of scheme as at (a) by Orissa subject to protection of 1.5 tmc for schemes at (b) and the State of Orissa agrees to the scheme as at (b) subject to Andhra Pradesh meeting the cost of construction including land acquisition.

(d) Andhra Pradesh also agrees to utilisation of the flood canal in Orissa territory for irrigation in its territory provided the extra water for such irrigation will be out of the share of Orissa and Orissa pays to Andhra Pradesh proportionate cost of flood flow channel.

IV. NERADI JOINT PORJECT (VANSADHARA)

Regarding Neradi Joint Project, Andhra Pradesh should immediately send the project report to Orissa for incorporating Orissa's requirements.

V. JOINT MINOR IRRIGATION SCHEMES

(a) There are some minor irrigation schemes with head works in Orissa State and ayacut in Andhra Pradesh. In some cases, the ayacut is partly in Orissa and Partly in Andhra Pradesh. The Orissa Govt. has claimed a sum of Rs.6.49 lakh from 1953 to 1972 and Rs.3.04 lakh from 1972-77 towards the share of Andhra Pradesh for maintenance and repair of the Irrigation system in their territory. A sum of Rs.6.00 lakh has been paid to Orissa by Andhra Pradesh on adhoc basic subject of final adjustment.

(b) The ayacut served in Orissa and Andhra Pradesh under the joint schemes is in the ratio 2:1 approximately. It is agreed that Andhra Pradesh will pay Orissa State for maintenances and repairs of joint minor irrigation schemes a sum calculated for the irrigated area in Andhra Pradesh territory under this system at the 2/3rds per acre rate fixed by the Govt. of Orissa as a State norm plus 16% towards establishment charges from 1953 onwards in full and final settlement of the share of A.P, in the expenses incurred by Orissa State on the maintenance and repairs of these joint sources. The amount of Rs.6.00 lakh will be adjusted against the share of cost up to 1977.

(c) Any outlay on improvements and capital works of the system will be subject to prior concurrence of both the States and will be shared prorata to the benefits.

Sd /-	Sd /-
N. Routray,	Dr. M. Channa Reddi,
Chief Minister, Orissa	Chief Minister, Andhra Pradesh

Annexure-VI

MINUTES OF THE MEETING CONVENED BY UNION MINISTER OF WATER RESOURCES WITH THE CHIEF MINISTERS OF ANDHRA PRADESH AND ORISSA ON 15.1.87 TO DISCUSS VAMSADHRA PROJECT STAGE-II OF ANDHRA PRADESH

Shri N. T. Rama Rao, the Chief Minister of Andhra Pradesh and Shri J.B. Patnanaik, the Chief Minister of Orissa, in the meeting convened by Shri B. Shankaranand, Union Minister of Water Resources on 15[th] January, 1987 at Shram Shakti Bhavan, New Delhi, were agreeable to taking up the Neradi Project on Vamsadhra River, if it could be found feasible by the engineers of both the States and the engineers of the Central Water Commission that the project could be implemented by acquiring only 106 acres of land in Orissa keeping in view the interest of Orissa as envisaged in the agreement of 1961 between the two states. The Chief Minister of Andhra Pradesh even agreed to redesign and modify the parameters of the project so as to limit the land acquisition in Orissa to the extent of 106 acres only.

(N.T. Rama Rao) Chief Minister, Andhra Pradesh 15-1-1987	(J.B. Patnaik) Chief Minister, Orissa 15-1-1987	(B. Shankaranand) Union Minister Water Resources 15-1-1987

Annexure-VII

MINUTES OF DISCUSSION BETWEEN HON'BLE CHIEF MINISTER, ORISSA AND HON'BLE CHIEF MINISTER, ANDHRA PRADESH AT BHUBANESWAR ON JUNE 10, 1992.

Initiating the discussion, Hon'ble Chief Minister, Orissa gave a brief resume of the unresolved issues between Orissa and Andhra Pradesh and suggested that the issues should be settled in a sprit of amity. Hon'ble Chief Minister Andhra Pradesh reciprocated these feelings. Thereafter, each issue was discussed in detail and the following decisions were taken.

1. Neradi Barrage

Hydrology data up to 1991 and mathematical models studies will be supplied by the Irrigation Department Andhra Pradesh within 10 days. Mathematical model has a linkage with the aggradation of the river bed which in turn will affect the Orissa portion by floods beyond the stipulated 3 kms. Andhra Pradesh Engineers however, assured that the backwater effect will be limited to 3 kms. Sharing of water would be on 50:50 basis. It was agreed in principle that Orissa Govt. would have no objection to the Govt. of Andhra Pradesh going ahead with construction of the barrage, but the height of the barrage would be subject to mathematical model studies and hydrological data.

2. Jhanjavati Project

A copy of the Project report will be supplied by the Irrigation Department, Andhra Pradesh to Chief Secretary, Orissa. Joint boundary survey of the 10 villages involved in submergence including the 3 villages under dispute will start immediately.

3. **Bahuda Project**

It was agreed that the head works of the project will be located in Andhra Pradesh in modification of the 1978 agreement, which stipulated location of the head works in Orissa. Since, a portion of the canal will pass through Orissa, adequate water will be allocated from the canal system for Irrigation inside Orissa.

4. **Kalingadala Project**

It was agreed that pending finalization of the joint survey which will be taken up immediately, the land in dispute will be treated provisionally as Orissa Govt. land and will be leased out to the Govt. of A.P. The Govt. of A.P can go ahead with construction on that basis.

5. **Puriasahi M.I Project**

It was clarified that Madala river is not Mahendratanaya for which there is an inter State agreement. No inter State agreement exists for the sub- basin of Madala river. However, Puriasahi M.I.P. in Orissa will continue to be a diversion weir and there will be no impounding of water to affect the Padhigaon Project in Andhra Pradesh adversely.

6. **Power Project**

The question of harnessing hydro power potential of the inter state Machkund – Sileru river system for the benefit of both the States was discussed. It was agreed in principle that the generation capacity of the existing power station and the new station proposed to be executed on the inter State Sileru Machkund river shall be shared on 50:50 basis. For this purpose a statutory Board along the lines of Tungabhadra Control Board shall be constituted and the existing power project (on Machkund – Sileru river system) both in Andhra Pradesh and Orissa shall be transferred to the control of this Board for management. This Board will be constituted with the representatives of both the State Govts. as well as the Govt. of India. No cost shall be paid by either of the State Govt. for transfer of the existing projects. The Board shall also take up construction of new Power Project on 50:50 cost sharing basis between both the State Govts.

It was felt that constitution of this Board will not only ensure optimum utilisation of the hydro power potential of the inter state Machkund – Sileru river system, but also facilitate amicable settlement of outstanding disputes between both the State Govts. as well as the State Electricity Boards.

Shri N. Tata Rao, Adviser , Energy to Chief Minister, Andhra Pradesh will immediately formulate a paper on this arrangement whereafter details shall be worked out by the Chief Secretary of both the States and will be put up to both the State Govts. for ratification.

It was agreed that works on the 2 x 30 MW power station at Chitrakunda (Balimela) may be resumed immediately by A.S.P.E.B. This will form part of the proposed joint control Board.

Sd /-	Sd /-
N.J.Reddy,	B. Patnaik,
Chief Minister of Andhra Pradesh	Chief Minister of Orissa
Dt.10-6-92	Dt.10-6-92

Annexure-VIII

AGREEMENT BETWEEN THE STATES OF ORISSA AND MADHYA PRADESH ON 9-12-75

PROCEEDINGS OF THE MEETING BETWEEN THE CHIEF MINISTER OF ORISSA AND MADHYA PRADESH HELD AT NEW DELHI ON THE 9TH DECEMBER, 1975

The following were present: -

	ORISSA		MADHYA PRADESH
1.	Smt. Nandini Satpathy, Chief Minister	1.	Shri P.C. Sethi, Chief Minister
2.	Shri Dibyalochan Shekhar Deo Minister for Irrigation & Power	2.	Shri V.R. Uiko Minister of Irrigation & Electricity
3.	Shri B.K. Mishra, Additional Development Commissioner	3.	Shri Aziz Qurehsi Minister for state for Irrigation & Electricity.
4.	Shri N.R. Hota, Secretary, Irrigation & Power	4.	Sri Manish Bahl, Secretary, Irrigation & Electricity
5.	Shri Suresh Chandra Triphaty Chief Engineer, Irrigation & others	5.	Sri K.L. Handa, Irrigation Adviser & others.

The discussion related to the use of water of the Godavari basin and the clearance of Project of Madhya Pradesh and Orissa.

2. After full discussion, the following agreement was arrived at:

I. Pending final allocation of the Godavari water Madhya Pradesh and Orissa will be free to use additional gross quantity of 300 tmc & 200 tmc respectively out of the water of the Godavari basin below Pochampad Dam site for new projects in such manner as they deem fit.

II. In agreement to 200tmc referred to in clause-I for Orissa, Madhya Pradesh on its part has taken into account the estimated requirements within the basin only. All the utilisation by Orissa and Madhya Pradesh contemplated in the various clauses shall be only as a part of the 200 tmc and 300 tmc respectively agreed to in Clause-I above. The states of Orissa and Madhya Pradesh will not be entitled on the basis of the subsequent clauses to utilise in any way more then 200 tmc and 300 tmc respectively.

III. Below the dam sites of the Upper Indravati Project, as proposed by Orissa there is a catchment area of about 1855 sq. miles in the Indravati sub basin up to Orissa border with Madhya Pradesh. From this catchment there is some natural flow across the Jaura Nallah to Sabari (Kolab) River. It was agreed that Orissa will ensure at its border with Madhya Pradesh a flow of

45 tmc in the Indravati and its tributaries at 75% dependability for use by Madhya Pradesh. In the years of shortage the shortage will be shared proportionately between the two states and the assurance of flow in the Indravati and its tributaries, referred to above will stand proportionately reduced. Both the States agree to joint gauging at suitable points to ascertain the yield data and to ensure the flow of 45 tmc at 75 percent dependability of the proportionately reduced flow in years of shortage that has to flow below the common border. The figure of 45 tmc is on the assumption of total yield of 204 tmc from the Indravati sub basin in Orissa and 91 tmc utilisation for the Upper Indravati Project. If the assessment of utilisation for the Upper Indravati Project gets reduced from the figure of 91 tmc and the figure of 45 tmc will get reduced in the same proportion as the reduction in the figure of 91 tmc.

IV. In view of the agreement incorporated in the above clauses, Madhya Pradesh agrees to the clearance and execution of Upper Indravati Project, as proposed and submitted by Orissa to the Govt. of India. Orissa also agrees to the clearance and execution of Bodghat Project, as may be modified by Madhya Pradesh taking into account the water availability specified in clause III.

V. It is agreed that Madhya Pradesh and Orissa will consider the feasibility of taking up joint projects in the Sabari Sub Basin from the point Sabari (Kolab) River forms the common boundary between both the States up to the point where it joins the Sileru River, on the basis of common agreements to be drawn up at appropriate time. The hydel power and the cost debitable to generation of such power will be shared equally between the two States in these projects. The cost and benefits of irrigation, if any from these projects will also be equitably shared among both the States. Orissa will be free to make beneficial use of the water of this river above the common boundary point and lying in its territory in such manner as it deems fit.

VI. Notwithstanding the agreement on the joint projects on the river Sabari (Kolab) mentioned in clause-V. if there is any submersion of land and properties of either State by other projects sponsored by the other State or any other State in the Godavari basin, the question of submersion and the problems connected therewith will have to be mutually settled before execution of such project.

VII. Madhya Pradesh and Orissa agree that nothing in this agreement will be treated as a concession by either State in respect of any of their contention in any other water dispute with any other State or with respect to the dispute regarding the sharing of the balance of water in Godavari and its tributaries.

VIII. Madhya Pradesh and Orissa agree that this agreement will be furnished to the Govt. of India and they would be requested to expedite the clearance of the new projects. This agreement will also be jointly filed before the Godavari Water Disputes Tribunal at the appropriate time.

Sd /-
(Nandini Satpathy)
Chief Minister, Orissa
Date: - 9-12.75

Sd /-
(P.C.Sethi)
Chief Minister, Madhya Pradesh
Date: - 9-12.75

Annexure-IX

AGREEMENT ENTERED INTO BETWEEN THE STATES OF ORISSA AND MADHYA PRADESH

After full discussion, the following agreement was reached at Bhopal on 11th July 1979.

G - 11 INDRAVATI SUB-BASIN

1. ORISSA

(a) The State of Orissa can use all the waters up to Upper Indravati Projects site comprising:

   (i) Indravati Dam Site (Lat 19^0-16' N and Long 82^0-50' E)

   (ii) Podagad Dam Site (Lat 19^0-14' N and Long 82^0-49' E)

   (iii) Kapur Dam Site (Lat 19^0-06' N and Long 82^0-47' E)

   (iv) Muran Dam Site (Lat 19^0-06' N and Long 82^0-46' E)

(b) Out of the balance flows available below the Upper Indravati Project within its territory, the state of Orissa shall ensure forty five (45) tmc of water to flow down at the Orissa- Madhya Pradesh border in the Indravati sub-basin. In the years, when the diversion of water outside the Godavari basin at the Indravati Project is less than eighty five (85) tmc, (exclusive of evaporation losses), this quantum of forty five (45) tmc at the Orissa –Madhya Pradesh border in the Indravati sub-basin will be reduced in the same proportion as the reduction in the quantum of eighty five (85) tmc. The State Orissa can use all the balance water thus left within its territory for its existing, under construction and proposed projects /schemes.

(c)

   (i) The State of Orissa and Madhya Pradesh agree to measure this quantum of forty five (45) tmc at Jagdalpur gauge site across Indravati River, which is maintained at present by the Central Water Commission, subject to adjustment as mentioned in sub-paragraph

   (ii) The catchment area of the state of Orissa contributing to the flow in Indravati River below Jagdalpur gauge site is two hundred and thirty eight (238) square miles, while the catchment area of the State of Madhya Pradesh up to the gauge site is about one hundred and ninety eight (198) square miles. The seventy five (75) percent dependable yield from this area of forty (238 – 198 = 40) square miles may be taken as two point eight (2.8) tmc. This quantum of two point eight (2.8) tmc will be added to the observed flow at Jagdalpur gauge site for estimating the flows available at the Orissa-Madhya Pradesh border specified in sub-paragraph 1 (b). The quantum of two point eight (2.8) tmc. will be reduced proportionately in the lean years in the same portion to the reduction of seventy five (75) percent dependable yield of eighty nine point five (89.5) tmc at Upper Indravati Project site as cleared by Planning Commission.

   (iii) At any time if the Central Water Commission closes Jagdalpur gauge site, the two States shall maintain the gauge site jointly or any other site (s) as may be mutually agreed upon for the purpose.

2. MADHYA PRADESH

(a) The state of Madhya Pradesh can use two hundred and seventy three (273) tmc of water for its various existing, under construction and proposed projects / schemes, subject to the agreed uses in paragraph (1) up to the Bhopalpatnam-I Hydroelectric project site (Lat 19^0 – 03' 45" N and Long 80^0 – 19' – 05" E) across Indravati river, a joint project between the state of Madhya Pradesh and Maharashrra. This quantum includes the share of evaporation loss of the state of Madhya Pradesh at the Bhopalpatnam – I reservoir.

(b) The state of Madhya Pradesh in addition to the uses as agreed to in paragraph 2 (a) can use all the waters upto the following project sites on the tributaries joining the Indravati downstream of Bhopalpatnam – Hydro- electric project site:

(i) Chintavagu dam site on Chintavagu near village Pavrel (Lat 18^0 – 41' – 25" and Long 80^0 -40' – 47" E)

(ii) Jallavagu dam site on Jallavagu near village Chillamarka (Lat 18^0 – 56' – 34" N and Long 80^0 -21' – 34" E)

(iii) Kothapalli integrated Project across tributary of Chintavagu comprising:

1) Kothapalli Dam site:(Lat 18^0– 40'–54"N and Long 80^0 -34'– 54" E)

2) Minur Dam site: (Lat 18^0–45'– 24"N and Long 80^0-28'– 13" E)

(c) The state of Madhya Pradesh can use an additional quantity of nineteen (19) tmc of water downstream of the project sites specified in paragraph 2 (a) and paragraph 2(b) for its existing , under construction and proposed project / schemes each using not more than one point five (1.5) tmc annually.

G - 12 SABARI SUB-BASIN

3. **ORISSA**

a) The state of Orissa can use all the waters of Sabari (Kolab) river up to a point near abut Lat 18^0 -55' -04" N and Long 82^0 – 14' – 53" E where Sabari river forms the common boundary between the states of Orissa and Madhya Pradesh.

(b) In addition to the above the State of Orissa can use all the waters up to the following project sites on the tributaries of Sabari (Kolab) river:

i) Govindpalli Project site comprising:

1) Dharamgedda nalla near Lingiyaput village (Lat 18^0 – 36' – 07" N and Long 82^0 – 16' – 11" E)

2) Jamnadi near Govindpalli village (Lat 18^0 – 36' – 13" N and Long 82^0 – 16' – 48" E)

3) Garia nadi near Doraguda village (Lat 18^0 – 34' – 03" N and Long 82^0 – 17' – 18" E)

(ii) Satiguda project site on the tributary of Potteruvagu (Lat 18^0 – 18' – 57" N and Long 81^0 – 56' – 24" E)

(iii) Parasanapalle project site on the tributary of Sabari River near village Parasanapalle (Lat 18^0 – 16' – 44" N and Long 81^0 – 36' – 44" E)

(iv) Potteru Project on Potteruvagu near Surlikunda village (Lat 18^0 – 12' – 30" N and Long 82^0 – 01' – 30" E)

(c) The state of Orissa can use an additional quantity of forty (40) tmc of water downstream of projects specified in paragraphs 3 (a) and 3 (b), for its existing, under construction and proposed project / scheme each using not more than one point five (1.5) tmc annually.

(d) Downstream of the point where Sabari river forms the common boundary between the states of Orissa and Madhya Pradesh (near about Lat 18^0 – 55' – 04" N and Long 82^0 – 14' – 53" E) and upto the confluence of Sileru and Sabari river, the states of Orissa in addition to the use specified in paragraph 3 (a) to 3 (c) can use not more than twenty seven (27) tmc of water for irrigation by withdrawals from the main river for its existing, under construction and proposed projects / schemes.

(e) The state of Orissa agrees to exploit Sabari (Kolab) river waters by joint projects on the main Sabari river with the state of Madhya Pradesh from a point on Sabari (Kolab) river near about (Lat 18^0 – 55' – 04" N and Long 82^0 – 14' – 53" E) where it forms the common boundary between the two states up to the confluence with Sileru river on the basis of agreement (s) to be drawn up at appropriate time, except for use as mentioned in sub-paragraph 3(d). At present, Lower Kolab and Konta projects are under investigation and the sites of these projects will be decided mutually by the two State Govts. The hydel power and the cost debitable to generation of such power will be shared equally between the two states in these or such other projects. The cost and benefit of irrigation, if any from these projects will also be equitably shared between the two states.

(f) The share of evaporation losses for the projects specified in paragraph 3 (e) for the state of Orissa to the extent of 10 tmc will be in addition to the quantum specified in paragraphs 3 (a) to 3 (d) and excess if any, will be met from the use specified in paragraphs 3 (a) to 3 (d).

(g) The use specified for the State of Orissa in paragraph 3 (a) to 3 (d) and3 (f) is exclusive of the use in Sileru river as per the agreement dated 15.12.1978 between the states of Orissa and Andhra Pradesh.

4. MADHYA PRADESH

(a) The State of Madhya Pradesh can use all the waters of the tributaries of Sabari river downstream of a point where Sabari river forms the common boundary between the State of Orissa and Madhya Pradesh near about (Lat 18^0 – 55' – 04" N and Long 82^0 – 14' – 53" E) and up to the following projects sites:

- i) Barunadi Integrated Project comprising:
  - 1) Barunadi site across Baru River near village Tankavada (Lat 18^0 – 45' – 33" N and Long 81^0 – 48' – 50" E).
  - 2) Bhimsen storage site across Bhimsen River near village Bodavada (Lat 18^0 – 45' – 0" N and Long 81^0 – 55' – 46" E
  - 3) Kudripal pick-up weir site across Baru River near village Kudripal (Lat 18^0 – 40' – 42" N and Long 81^0 – 51' – 30" E
- ii) Mupari project site across Mupari (Jaimer) river, near village Jaimer (Lat 18^0 – 42' – 30" N and Long 81^0 – 45' – 0" E).
- iii) Gorali Nadi projects comprising:
  - 1) Gorali dam site across Gorali nadi near village Kanjipani (Lat 18^0 – 32' – 50" N and Long 81^0 – 40' – 55" E)
  - 2) Andumpal dam site across Pulnadi near village Andupal (Lat 18^0 – 34' – 43" N and Long 81^0 – 42' – 04" E)

iv) Sailervagu integrated project comprising:

1) Mankapal dam site across Malengar River near village Mankapal (Lat $18^0 - 32' - 06"$ N and Long $81^0 - 29' - 26"$ E)

2) Sailervagu dam site across Sailervagu near village Paila (Lat $18^0 - 26' - 12"$ N and Long $81^0 - 31' - 38"$ E)

v) Ordeltong Integrated Project comprising:

1) Ordeltong dam site across tributary of Tinarayavagu near village Ordeltong (Lat $18^0 - 13' - 24"$ N and Long $81^0 - 24' - 06"$ E)

2) Tinarayavagu dam site across Tinarayavagu near village Korrapal (Lat $18^0 - 11' - 0"$ N and Long $81^0 - 18' - 56"$ E)

vi) Janavagu Integrated project comprising:

1) Janavagu dam site across Janavagu near village Gorkha (Lat $17^0 - 57' - 24"$ N and Long $81^0 - 20' - 15"$ E)

2) Elammaduguvagu dam site across Elemmaduguvagu near Jarput village (Lat $18^0 - 03' - 42"$ N and Long $81^0 - 18' - 09"$ E)

(b) The state of Madhya Pradesh can use an additional quantity of eighteen (18) tmc of water downstream of the project sites specified in paragraph 4 (a) for its existing, under construction and proposed projects / schemes each using not more than one point five (1.5) tmc annually.

(c) (i) The share of evaporation losses of the power projects across Sabari river specified in paragraph 3 (e) for the state of Madhya Pradesh to the extent of ten (10) tmc will be in addition to the quantum specified in paragraph 4 (a) and 4 (b) and excess, if any shall be borne by the State of Madhya Pradesh out of its share specified in paragraph 4 (a) and 4 (b).

(ii) The quantum of water for the use by the State of Madhya Pradesh in the State in paragraph 4 (a).

(iii) Further, the quantum of water to meet the evaporation losses of the joint projects/ schemes specified in the paragraph 3 (e) shall be shared equally between States of Orissa and Madhya Pradesh.

Sd /-
(B. Ramadorai)
Secretary
Irrigation & Power Department,
Government of Orissa.

Sd /-
(Dr. Ishwar Das)
Secretary
Irrigation & Power Department,
Government of Madhya Pradesh.

Annexure-X

AGREEMENT DATED THE 2ND APRIL, 1980 BETWEEN THE STATES OF ANDHRA PRADESH, MADHYA PRADESH AND ORISSA.

To enable clearance of Polavaram project, the following is agreed to: -

1. The Polavaram Project spillway shall be designed for a flood discharging capacity of 36 (thirty six) lakh cusecs at pond level of RL + 140 (One hundred and forty) feet and not less than 20 (twenty) lakh cusecs at pond level of RL+ 130 (One hundred thirty) feet.

2. The pond level shall not be kept higher than RL+ 145 (one hundred and forty five) feet in the month of June if the inflow into the Polavaram reservoir exceeds 3 (three) lakh cusecs.

3. On receipt of flood warning from the upper sites and / or due to anticipated flows into the reservoir requiring regulation, the pond level shall be regulated as follows:

    a) The pond level of RL+ 145 (one hundred and forty five) feet shall be lowered progressively as the inflows exceed 3 (three) lakh cusecs so as to restrict the pond level to RL+ 140 (one hundred and forty) feet for an inflow of 10 (ten) lakh cusecs.

    b) For inflow higher than 10 (ten) lakh cusecs the pond level shall be further lowered, so that it does not exceed RL+ 130 (one hundred and thirty) feet for an inflow of 20 (twenty) lakh cusec.

    c) For inflow higher then 20 (twenty) lakh cusecs, all the gates shall be opened fully.

    d) The pond level can be built up progressively in the receding floods to RL+ 140 (one hundred and forty) feet if the inflow drops down to 10 (ten) lakh cusecs and to RL+ 145 (one hundred and forty five) feet if the inflow drops to 3 (three) lakh cusecs or less, but during the months of July and August, the pond level shall not exceed RL+ 145 (one hundred and forty five) feet.

    e) On or after first September, whenever the inflow in the Polavaram reservoir is 1 (one) lakh cusecs or less, the storage at Polavaram can be built up beyond RL+ 145 (one hundred and forty five) feet, subject to aforementioned depletions at (a) to (c) in case of higher inflows.

4. In order to protect the land and properties above RL+ 150 (one hundred and fifty) feet in the territory of the State of Orissa likely to be affected due to construction of Polavaram Project, protective embankments with adequate drainage sluices, shall be constructed and maintained at the cost of Polavaram Project. However, the State of Orissa may exercise an option at the time of construction of Polavaram Project for compensation to land and property likely to be affected above RL+ 150 (one hundred and fifty) feet as agreed to in the cases of state of Madhya Pradesh in paragraph 5(five) below.

5. In respect of the properties in the territory of State of Madhya Pradesh likely to be affected above RL+ 150 (one hundred and fifty) feet, because of the construction of the Polavaram Project, the State of Andhra Pradesh shall:

a) Pay compensation towards all buildings with their appurtenant lands situated above RL+ 150 (one hundred and fifty) feet which will be affected due to all effects including back water effect and rehabilitate the oustees, etc. on the same pattern as below RL+ 150 (one hundred and fifty) feet at the project cost; or

b) Construct and maintain at the cost of the State of Andhra Pradesh, the necessary protection embankments with adequate pumping arrangement and / or drainage sluices.

The said option for alternative (a) or (b) being exercised by the state of Madhya Pradesh, at the time of construction of Polavaram Project depending upon the location of each affected site.

c) For damages or injury to lands beyond RL+ 150 (one hundred and fifty) feet in the territory of the State of Madhya Pradesh, in any event, the State of Andhra Pradesh shall pay full compensation for such damage or injury as may be assessed by the District Collector of the said District of the state of Madhya Pradesh.

d) The State of Andhra Pradesh agrees to fix permanent Bench Marks connected to G.T.S. Bench Marks in the territory of the State of Madhya Pradesh for RL+ 150 (one hundred and fifty) feet as well as for the back water effect, in both cases, at an interval of approximate one kilometer all along the periphery of the Polavaram reservoir.

Sd/- Date.2.4.80 Representative for the State of Andhra Pradesh	Sd/- Date.2.4.80 Representative for the State of Madhya Pradesh	Sd/- Date.2.4.80 Representative for the State of Orissa
Sd/- P. Ramachandan Reddy Advocate General for the State of Andhra Pradesh	Sd/- M.K. Ramamurthy Senior Counsel, the State of Madhya Pradesh	Sd/- G.B. Patnaik Govt. Advocate.

Annexure- XI

ORISSA- MADHYA PRADESH INTER – STATE MATTERS – IRRIGATION AND POWER PROJECTS – MEMORANDUM OF AGREEMENT ENTERED INTO BETWEEN THE STATE OF MADHYA PRADESH AND ORISSA ON 28.4.1983 AT BHUBANESWAR

In pursuance of discussion held on 27th April, 1993 at Bhubaneswar attended by Sri Arjun Singh, Chief Minister, Madhya Pradesh, Sri Janaki Ballav Pattnaik, Chief Minister Orissa and Nirajan Pattnaik, Minister of State for irrigation and Power, Orissa along with the Officials of the two State (as per list enclosed), the following agreement was reached.

1. Ib Project (Orissa Project)

Madhya Pradesh agrees to spare 25 percent run off from the catchment area drained by Ib River and lying in its territory under the proposed Ib dam project (Approximately Lat 23^0 – 12' N, Long 84^0 – 06' E). Orissa agrees to fix full reservoir level of Ib dam at R.L 272.50m. The land in Madhya Pradesh would, however, be acquired up to R.L 273.0 meters to allow for backwater impact. In exceptional cases, if areas lying above R.L 273.0 meters in the foreshore area of the reservoir in Madhya Pradesh are damaged due to floods, the damage being solely attributable to the construction of Ib dam, suitable compensation will be paid by Orissa. Madhya Pradesh may generate hydro-power at the headworks of Ib project entirely at its own cost without paying for the cost of storage, but bearing the full cost of all additional civil and electrical works required for generation of hydro-power. Madhya Pradesh will make its own arrangement for operation and transmission of power generated. Project report for power part will be prepared by Madhya Pradesh for which Orissa will extend necessary co-operation. However, the regulation of Ib reservoir shall be done by Orissa as per operational and irrigation requirements.

2. Sapnai Project (Madhya Pradesh)

Orissa agrees to spare 70 percent of run off from its catchment area for use in Madhya Pradesh at Sapnai dam (Approximately Lat 21^0 – 53 – 45" N, Long 83^0 – 30' -05" E). Madhya Pradesh may formulate Sapnai Project leaving an upstream reserve to the extent of 30 percent of run off from Orissa catchment for use in Orissa State. Submergence due to project is limited to Madhya Pradesh territory only.

3. Kurnala Project (Joint Project)

Madhya Pradesh and Orissa agree to implement the Kurnala Project as a joint irrigation scheme, where the catchment area of Kurnala is about 45 sq.miles (Approximate Lat 21^0 – 55' N, Long 83^0 – 33' E) to irrigate about 3000 acres in Madhya Pradesh and about 9000 acres in Orissa. The cost of head work of the project shall be shared in proportion of the ultimate irrigation benefits derived by each state.

4. Upper Jonk Project (Orissa Project)

Orissa agrees to supply water through left bank canal of upper Jonk Project at Orissa- Madhya Pradesh border to support irrigation in an area of 2000 acres in Madhya Pradesh territory on charges to be determined. The requirement of rest of the areas in Madhya Pradesh may be met by Madhya Pradesh by utilising the waters of the tributaries of Jonk river upstream of lower Jonk Project (Orissa) draining that area subject to a maximum utilization of 40 square miles of catchment. Orissa agrees to consider request by

Madhya Pradesh for submerging Orissa land for above project (s) if any.

5. Lower Jonk Project (Joint Project)

Orissa and Madhya Pradesh agree that a dam across Jonk river near Girina (Approximate Lat $21^0 - 10'$ N, Long $82^0 - 37'\ 30''$ E) should be constructed as a Joint Project and share the cost of dam, reservoir and available run off in the ratio of 30 percent (Orissa) and 70 percent (Madhya Pradesh). The cost of head regulator and canal system will be borne by the respective beneficiary states. The surveys and investigation of Girina dam will be carried out by Madhya Pradesh.

6. Ong Project (Orissa Project)

Madhya Pradesh agrees to spare 20 percent of runoff from its catchment area lying in Ong Sub-basin for use by Orissa at the proposed dam site across Ong river near its confluence with Surangi river (Approximate Lat $21^0 - 05' - 29''$ N, Long $83^0 - 03'$ -06" E). Orissa agrees to fix the Full Reservoir Level of Ong reservoir at R.L 219.0 meters. Orissa may however fix the full reservoir level at R.L 220 meters provided the reservoir does not submerge existing irrigated area in Madhya Pradesh for which necessary field verification will be carried out jointly.

7. Jira Project (Orissa Project)

Madhya Pradesh agrees to spare run off from 14.25 sq. miles of its catchment lying in Jira sub basin for use by Orissa at proposed Jira dam project (Approximate Lat 21^0 – 23' N, Long $83^0 - 26'$ E) with full reservoir level fixed at R.L 697.5 feet.

8. Sahajbahal Project (Joint Project)

Orissa and Madhya Pradesh agree to implement Sahajbahal Project as a joint irrigation scheme where the catchment area of the river is about 22 sq. miles (Approximate Lat 20^0 –21'- 15" N, Long $83^0 - 21'$ -15" E), in Madhya Pradesh. The cost of joint works and irrigation benefit shall be shared in the ratio of 70% (Madhya Pradesh) and 30% (Orissa). Surveys and investigations of this joint project will be carried out by Madhya Pradesh.

9. Lower Kolab Project (Joint Project)

Orissa and Madhya Pradesh agree to re-investigate the lower Kolab Project with alternative possibilities of irrigation and hydro- power generation. If found feasible, the project shall be taken up as a joint project. Survey and investigation will be carried out by Orissa in consultation with Madhya Pradesh and the first preliminary report will be finalised by June, 1984.

10. Back water studies for Hirakud Dam

Both the States agree to carry out fresh back water studies for the Hirakud reservoir with a view to ascertaining the extent of submergence caused by Raigarh District of Madhya Pradesh at the times of high flood. The Central Water Power Research Station, Pune may, if necessary, be associated with these studies.

11. Establishment of Joint Control Board

Madhya Pradesh & Orissa agree to establish a joint control Board to review the progress, from time to time of survey, investigation, planning, execution and operation of Joint Inter State Irrigation and or Power Project (s) and to discuss and resolve any issues.

12. Supply of Power:

It is agreed that supply of 5 MW powers which was committed by the Govt. of Orissa previously will be resumed. As the M.P Electricity Board is keen to have power from Hirakud, this will be supplied at Hirakud Bus bar. The cost of power will be the cost of generation at Hirakud Power House. The cost would be reviewed annually by the representative of the two Boards. The question of payment of Electricity Duty by M.P Electricity Board for future supply by Orissa State Electricity Board of 5 MW power would be referred to the Department of Power, Govt. of India for their guide lines.

Sd/-
(J.B.Patnaik)
Chief Minister, Orissa
28th April, 1983

Sd/-
(Arjun Singh)
Chief Minister, Madhya Pradesh
28th April, 1983

Annexure-XII

AGREEMENT REGARDING UTILISAION OF THE WATERS OF THE SUBARNAREKHA AND THE KHARKAI REACHED BY THE CHIEF MINISTERS OF BIHAR AND ORISSA AT PATNA ON THE 17TH JANUARY, 1976

Present:

Shrimati Nandini Satpathy	**Dr. Jagannth Mishra**
Chief Minister, Orissa	Chief Minister, Bihar

The Chief Ministers of Bihar and Orissa took note of the discussion at the official level held at Calcutta on the 12^{th} December, 1975 and at Patna on the 5^{th} & 6^{th} January, 1976. They agreed that the waters of the Subernarekha and the Kharkai may be utilised by either State in the manner and subject to the conditions set forth below, namely:

1. The Subernarekha Multipurpose Project as planned by Bihar may be implemented without any curtailment in its scope consistent with the terms of this agreement. Each State may also implement other projects planned by it subject to the condition that its total utilisation will not exceed the allocated share of 3.20 MAF for Bihar and 1.20 MAF for Orissa on the basis of 75% dependable yield of the Subernrekha basin at Kokpara.
2. In regard to flood moderation portion of the Chandil Dam, it was agreed that flood storage of 0.40 MAF should be provided. Both Bihar and Orissa will urge the Govt. of India to meet the cost of flood moderation portion of the dam fully. The final decision in this regard will be taken in a meeting of the Chief Ministers of Bihar and Orissa.
3. The storage capacity of the dam as proposed by Bihar on the river Kharkai (herein – after referred to as the Kharkai Dam) may be 0.68 MAF out of which Bihar and Orissa will be entitled to 0.50 MAF and 0.18 MAF respectively.
4. The cost of the Kharkai Dam and appurtenant works will be shared between Bihar and Orissa in the proportion of 5.00: 1.80.
5. Orissa will extend the required assistance and cooperation in acquiring the land in Orissa that will be submerged by the Kharkai Dam. The cost of such acquisition and of consequential rehabilitation will be included in the cost of the Kharkai dam. The scale and standard of rehabilitation will be fixed in due course by mutual agreement.
6. Upstream of the Kharkai Dam, Bihar and Orissa will limit their utilisation to 0.05 MAF and 0.20 MAF respectively.
7. The management of the Kharkai Dam will be as follows:

    a) For sharing the water in the dam, the year being from the first day of July.

    b) The need for Khariff irrigation in each state will be given first priority and water released against its share on such needs indicated by each State.

    c) The balance water available out of the allocations of each state after the Kharif season will be drawn by the respective states for Rabi and summer irrigation.

    d) Each State will be free to fix the priority for utilisation of its share for industrial and other uses without affecting the interests of the other State.

    e) The shortage or surplus over the estimated annual yield at 75% dependability, if any during the water year will be shared by the two states in proportion to their respective interests in the storage.

f) There will be a Committee for joint operation of the reservoir. The Committee will be constituted in the manner provided in clause – 14.

g) To achieve flexibility in the operation of the Kharkai and Chandil reservoirs within the Subarnarekha Multipurpose Project in the best interest of both the States, this Committee may make diversion of supplies from one or the other reservoir subject to the condition that the share of each State during the water year will not be affected adversely.

8. Bihar proposes to construct a barrage at Galudih with one canal on each side. Orissa will be entitled to draw through this barrage its share of water in the Kharkai dam. In addition, Orissa can also draw from this barrage the run of the river flow as available for utilisation in its territory out of which up to 0.10 MAF will be during the non – monsoon period. The drawal from this barrage by Bihar in the non- monsoon period will be up to 0.06 MAF.

Provided that if the flow in any non- monsoon period is less than 0.16 MAF, the shortage shall be shared between Bihar and Orissa in the proportion of 3:5.

9. Orissa will draw its share of water from the Galudih barrage through the right bank main canal.

10. The cost of the Galudih barrage and the appurtenant works shall be shared between Bihar and Orissa in proportion to the annual designed withdrawal, which is to say on cusec day basis.

11. The cost of the right bank main canal shall be shared between Bihar & Orissa on cusec-mile basis.

12. The right bank main canal will be a lined one and will be so designed as to involve minimum land acquisition, in Bihar.

13. Execution of the Kharkai dam and the Galudih barrage along with the right bank main canal will be taken up together at a time. The arrangement for their execution will be as may be decided b the Chief Minister of Bihar & Orissa.

14. There will be joint regulation of the Kharkai dam and Galudih barrage along with the right bank main canal by a committee consisting of a Chief Engineer nominated by Bihar, a Chief Engineer nominated by Orissa and a member of the Central Water Commission who will be its chairman. The committee will formulate its rules of procedure.

15. Orissa can utilise the surplus water from the free catchment in Orissa below Kokpara.

16. Orissa agrees in principle to the development of the Subarnarekha for inland water transport as it will provide direct sea-face to Bihar.

Sd/- **Dr. JAGANNATH MISHRA**	Sd/- **NANDINI SATPATHY**
17-1-76	17-1-76
Chief Minister, Bihar	Chief Minister, Orissa

FURTHER AGREEMENT REGARDING UTILISATION OF THE WATERS OF THE SUBARNAREKHA AND KHARKAI REACHED BY THE CHIEF MINNISTERS OF ORISSA AND BIHAR AT BHUBANESWAR ON THE 25TH OCTOBER, 1976

Present:

Dr. Jagannath Mishra Chief Minister, Bihar	**Smt. Nandini Satpathy** Chief Minister, Orissa

An agreement regarding utilization of the waters of the Subarnarekha and the Kharkai was reached between the two Chief Ministers and the agreement was finalised at Patna on the 17th January, 1976. With a view to taking positive steps towards implementation of the provisions of this agreement, the Chief Ministers of both the States discussed certain aspects of the question at Bhubaneswar on the 25th October, 1976. The Govt. of Bihar would like to execute the Chandil Dam and its left bank canal on a priority basis and would need the concurrence of the Govt. of Orissa. Orissa is interested in expeditious execution of the Galudih barrage with a view to utilising its share of Subarnarekha waters for irrigation. The Chief Ministers of both the States recognised that both these objectives were complementary to each other and it was necessary to move towards realisation of these objectives. It was accordingly agreed as follows:

1. Orissa agreed to the execution of the Chandil Dam and its left bank canal as conceived in the Subarnarekha Multipurpose Project. It was stipulated in the agreement, dated the 17th January, 1976 that both Bihar and Orissa will urge the Govt. of India to meet the cost of flood moderation portion of the dam fully. Orissa, in pursuance of this agreement, has moved the Govt. of India accordingly. It was agreed that Bihar will do like wise and both the Chief Ministers will also jointly move the Union Minister for Irrigation for a favourable decision.

2. Bihar agreed to the construction of the Galudih barrage project along with the right bank main canal up to Orissa border (hereinafter referred to as the Galudih Joint Project) simultaneously with the construction of the Chandil Dam. The Govt. of Bihar have already accorded permission to the officials of Orissa Govt. for survey and investigation work within their territory. It was agreed that contour maps prepared by the Survey of India and other maps and data would be supplied by the Govt. of Bihar as expeditiously as possible. The other facilities referred to in letter No.3/KA-1-102/76-3215, dated the 25th September, 1976 from the Irrigation Commissioner cum Principal Secretary to Govt. of Bihar would be provided by Bihar so that Orissa is enabled to complete necessary survey and investigation. The Govt. of Orissa on their part permit the officers of Bihar Govt. to undertake survey and investigation works within their territory in so far as the likely submersion area of the proposed Kharkai Dam is concerned.
3. For facility of study and formulation of the Galudih Joint Project by Orissa, the Chief Minister, Bihar presented the detailed project report of Bihar's Subarnarekha Multipurpose project in nine volumes to the Chief Minister, Orissa. Orissa will complete survey and investigation for Galudih Joint Project by the end of June 1977 to correspond to Orissa's irrigation requirement as envisaged in the agreement dated the 17th January 1976. A joint report for this project on the basis of the data collected by both the states in the course of the survey and investigation undertaken by them shall be prepared by the Chief Engineer, Irrigation, Orissa with the concurrence of the Chief Engineer Irrigation Bihar. Both the Govts. shall

then move the Central Water Commission and the Govt. of India for early clearance of the Galudih Joint Project within the ambit of Subarnarekha multipurpose Project. In the meantime Orissa will furnish to Bihar tentative monthly schedule of drawals from the Galudih barrage (inclusive of drawals from the Kharkai Dam) preferably by the end of March 1977 to enable Bihar to obtain clearance from the Central Water Commission to the Multipurpose Project. This will be without prejudice to the joint report that will be prepared in pursuance of the provision of this clause.

4. It was agreed that if the non-monsoon flow available at Galudih barrage is more than 0.16 MAF, the excess beyond 0.16 MAF shall be shared between Bihar and Orissa in the proportion of 3:5.

Provided that until the Khakai Dam is constructed and put into operation, all excess over 0.16 MAF in the non-monsoon flow at Galudih barrage shall be utilised by Orissa. Clause 8 of the agreement, dated the 17th January 1976 will stand supplemented to this extent.

5. The agreement dated the 17th January 1976 stipulated storage of 0.18 MAF in the Kharkai Dam of Bihar on Orissa's account. It further stipulated that Bihar and Orissa will draw water from the Kharkai reservoir according to their needs as adjudged by them subject to priority being given for Khariff irrigation. Since the execution of the Kharkai Dam will be somewhat staggered, Orissa would not be able to draw on its quota according to its need, But Orissa will get some more non-monsoon flow in pursuance of clause 4. If this does not come to 0.23 MAF at Galudih barrage the balance shall be made available to Orissa at Galudih barrage in the non-monsoon period by a judicious operation of the Chandil reservoir until the Kharkai dam is executed and put into operation. The operation of the Chandil reservoir to provide this support shall be subject to such approval as the Joint Control Board may give. The figure of 0.23 MAF has been arrived at as follows.

0.1 MAF from the non-monsoon flow as stipulated in the agreement, dated the 17th January 1976.

0.13 MAF from the non-monsoon flow and / or Chandil reservoir till construction of Kharkai dam after deducting 0.05 MAF notionally from 0.18 MAF towards Khariff use.

6. There shall be a joint Control Board for execution of the Galudih Joint Project and for regulating drawal from the Chandil reservoir as stipulated above. The composition of the Joint Control Board shall be as follows:

i) Chief Minister of both the States.
ii) Irrigation Ministers of both the States.
iii) Chief Engineer of Irrigation of both the States.
iv) Irrigation secretaries of both the States.
v) Finance secretaries of both the States.
vi) Collector of Mayurbhanj & Deputy Commissioner of Singbhum.
vii) Other Officers as may be nominated not exceeding two by each State.

viii) The Project Engineer of the Joint Project (by whatever designation he may be called) Non-Member- Secretary.

7. The Chief Minister, Orissa invited the Chief Minister, Bihar to be the first Chairman. The Chief Minister accepted the invitation.

8. The Joint Control Board shall be competent to appoint one or more functional committees as may be necessary and to delegate administrative and financial powers in favour of any of these committers or to any of the officers of the Joint Project as it considers necessary. The Joint Control Board shall set up immediately a Technical Committee comprising the Chief Engineer of Irrigation of both the States and two other officers, one each to be nominated by each State. The Project Engineer shall be the non member secretary of the Technical Committee.

9. There shall be a Project Authority for execution of the Galudih Joint Project. As regards the staffing of the Project Authority, it was agreed that details will be worked out by the Technical Committee referred to in clause 8. The recommendation of the Technical Committee shall be put to the Control Board which shall decide the question. Both the Technical Committee and Control Board shall among other things take into account the financial involvement of the two States in the Joint Project in deciding this question.

10. It was clarified by Bihar that Bihar Govt. has marginal interest in the water resources below Kokpara. It was also clarified that Bihar has not agreed to exclusive use of water from Bihar's free catchment of the Subernarekha below Kokpara by West Bengal. In fact water resources of the Subernarekha below Kokpara have not yet been assessed and apportioned among the three riparian States keeping in view their needs. It was agreed that a Committee under the Chairmanship of the Chairman of C.W.C and consisting of the Chief Engineers of the three States may be constituted to make a final assessment of the water resources below Kokpara at 75% dependability and recommend allocations between the three States taking into consideration their needs for irrigation, salinity control and other uses.

11. Bihar and Orissa are major beneficiaries from the waters of the Subarnarekha up to Kokpara. It was, therefore agreed that the Chief Ministers of Bihar and Orissa would jointly request the Union Minister for Agriculture and Irrigation to clear the projects concerning Bihar and Orissa upstream of Kokpara without awaiting finalisation of the allocation below Kokpara (which should be preceded by the assessment referred to in clause 10 above) and / or the finalization of the overall agreement among the riparian States.

12. It was agreed that the execution of the Kharkai barrage by Bihar shall be according to the schedule to be mutually agreed upon by both the States. It was further agreed that the concept of joint management and control as developed in this agreement shall be extended to the Kharkai Dam when this project is taken up.

Sd/. Dr. JAGANNATH MISHRA
Chief Minister, Bihar

Sd/. NANDINI SATPATHY
Chief Minister, Orissa

Annexure-XIV

TRIPARTITE AGREMENT ON SUBARNAREKHA

AGREEMENT ON THE UTILISATION OF THE WATER RESOURCES OF SUBARNAREKHA-KHARKAI BASIN, WHERE BIHAR, ORISSA AND WEST BENGAL ARE CO-BASIN STATES, REACHED BY THE CHIEFMINISTERS OF BIHAR, ORISSA AND WEST BENGAL AT NEW DELHI ON 7-8-1978

The State Govts. of Bihar, Orissa and West Bengal being desirous of attaining the optimum utilization of the water resources of the Subarnarekha Kharkai Basin and recognizing the need thereof for fixing and delimiting the rights and obligations of each State in relation to others concerning the use of these waters and taking note of the agreements, dated 17th January 1976 and 25th October 1976 reached by the Chief Ministers of Bihar and Orissa and the agreement, dated 19th July 1978 reached by the Chief Ministers of Bihar and West Bengal approve the tripartite agreement set out hereinunder:

1.1 The 75% dependable annual yield has been assessed at Kokpara to be 4.5 million acre feet. The Eastern Zonal Council in their 9th meeting on 28th January 1965 allocate 3.2 million acre feet to Bihar, 1.2 million acre ft to Orissa and 0.1 million acre feet to West Bengal. These allocations are accepted by the respective three States.

1.2 The three States take note and accept the recommendations of the Committee set up under the Chairmanship of the Chairman, Central Water Commission and consisting of the Chief Engineer of Bihar, West Bengal and Orissa according to which the water resources of the Subarnarekha basin below Kokpara at 75% dependability have been allocated to the co-basin states as below:

1.	Bihar	2.7 lakh acre feet
2.	Orissa	2.9 lakh acre feet
3.	West Bengal	5.9 lakh acre feet

1.3 The resources apportioned amongst the three riparian States, above and below Kokpara can be utilised by the respective States in any manner they choose, without exceeding the respective limits of their allocated resources.

1.4 If there is any shortage or surplus over the currently estimated annual yield at 75% dependability at Kokpara in any water year, then this shortage or surplus will be shared by the three co-basin states of Bihar, Orissa and West Bengal. According to the agreement already entered into by the 3 co-basin States, the water resources at Kokpara at 75% dependability have been distributed between Bihar, Orissa and West Bengal in the proportion of 32:12:1. It is agreed that in event of surplus over the currently estimated annual yield at 75% dependability at Kokpara, the surplus water will be allocated between Bihar, Orissa and West Bengal in the proportion of 8:1:1. However in case of shortage it will be shared by the States of Bihar, Orissa and west Bengal in the proportion of 32:12:1. In the area below Kokpara both shortage and surplus will be shared by the three States of Bihar, Orissa and West Bengal in the proportion of 2.7: 2.9: 5.9, respectively.

2.0 Utilisation of Water Resources at Kokpara

2.1.1 The storage capacity of the dam as proposed by Bihar on the river Kharkai (herein after referred to as the Kharkai dam) will be 0.68 million acre feet out of which Bihar and Orissa will be entitled to 0.50 million acre feet and 0.18 million acre feet respectively. The cost of the Kharkai dam and its appurtenant works will be shared between Bihar and Orissa in the proportion of 5.00:1.80.

2.1.2 Orissa will extend the required assistance and cooperation in acquiring the land in Orissa that will be submerged by the Kharkai dam. The cost of such acquisition and of consequential rehabilitation will be included in the cost of the Kharkai dam. The scale and standard of rehabilitation will be fixed in due course by mutual agreement between Bihar and Orissa.

2.1.3 Upstream of the Kharkai dam, Bihar and Orissa will limit their utilization to 0.05 million acre feet and 0.20 million acre feet respectively.

2.1.4 The management of the Kharkai dam will be as follows:

i) For sharing the water in the dam the year will begin from the 1st day of July.

ii) The need for Kharif irrigation in Bihar and Orissa will be given the first priority and water released against their share on such needs as indicated by Bihar and Orissa.

iii) The balance water available out of the allocations of Bihar and Orissa after the Khariff season will be drawn by the respective States for Rabi and summer irrigation.

iv) Bihar and Orissa will be free to fix the priority for the utilization of its share for industrial and other uses, without affecting the interest of the other State.

v) The shortage or surplus over the estimated annual yield at 75% dependability, if any, during water year will be shared by Bihar and Orissa in proportion to their respective interests in the storage.

2.2.1 Over and above the conservation storage, the Chandil dam will have flood storage of 0.375 million acre feet for flood moderation benefits in West Bengal and Orissa. The three co-basin States of Bihar, Orissa and West Bengal will jointly request the Govt. of India to meet the cost of the flood moderation portion of the dam fully.

2.2.2 Of the allocated resources of 1 lakh acre feet for West Bengal at Kokpara, 50, 000 acre feet will be utilised upstream of the Chandil Dam. For the remaining 50, 000 acre feet, 10, 000 acre feet for Khariff and Rabi irrigation will be made available by Bihar, free of charge to West Bengal through the left bank high level canal system of the Chandil dam. The balance 40, 000 acre feet shall be utilized by West Bengal below Kokpara. To facilitate this utilisation, storage space of 25000 acre feet shall be provided for West Bengal in the Chandil dam, a limit which will not be exceeded in any water year and for which the proportionate cost of the dam and appurtenant works shall be borne by West Bengal. The component of 15, 000 acre feet of water will be utilized by West Bengal from the run of the river.

2.3.1 Bihar will construct a barrage at Galudih with one canal on each side. Orissa will be entitled to draw through the right bank main canal its share of water in the Kharkai dam. In addition Orissa will also draw from this barrage the run of the river flow as available for utilization in its territory, out of which up to 0.10 MAF will be during the non-monsoon period. The drawal from this barrage by Bihar in the non-monsoon period will be upto 0.06 MAF. Provided that if the flow in any non-monsoon period is less than 0.16 MAF the shortage shall be shared between

Bihar and Orissa in the proportion of 3:5. Further provided that until the Kharkai dam is constructed and put into operation all excess over 0.16 MAF in the non-monsoon flow at Galudih barrage shall be utilized by Orissa. This will be exclusive of the releases to be made from Chandil dam for West Bengal as per para.2.2.2 above.

2.3.2 The cost of the Galudih barrage and its appurtenant woks shall be shared between Bihar and Orissa in proportion to the annual designed withdrawals, that is to say, on cusec- day basis.

2.3.3 The right bank main canal from the Galudih barrage will be lined one and will be so designed as to involve minimum land acquisition in Bihar. The cost of the canal shall be shared between Bihar and Orissa on the cusec-mile basis.

2.3.4 The execution of the Kharkai and Chandil dam and Gludih barrage project along with the right bank main canal upto Orissa border will be taken up together at a time. The arrangements for the execution of the Kharkai dam will be as may be decided by the Chief Ministers of Bihar and Orissa.

2.3.5 Until the Kharkai dam is constructed and put into operation, Orissa may not be able to draw its quota according to its need. If such withdrawals by Orissa during the non-monsoon period does not come to 0.23 million acre feet at Galudih barrage, the balance shall be made available to Orissa by Bihar at the Galudih barrage in the non-monsoon period by a judicious operation of the Chandil reservoir, until the Kharkai dam is executed and put into operation.

2.4 Since the interests of more than one State have been admitted within each of the utilities of Kharkai dam, Chandil dam and Galudih barrage, their regulation shall be conducted as under.

2.4.1 There will be a joint regulation of the Kharkai dam by a committee of a Chief Engineer nominated by Bihar, a Chief Engineer nominated by Orissa and a member of the Central Water Commission who will be its Chairman. The committee will formulate its rules and procedure.

2.4.2 There will be joint regulation of the Chandil dam and Galudih barrage by a Committee consisting of the Chief Engineer, each nominated by the three co-basin States and a member of the Central Water Commission who will be its Chairman.

2.4.3 To achieve flexibility in the operation of the Kharkai and the Chandil reservoir and the Galudih barrage in the best interest of all the States, these two committees as per clause 2.4.1 and 2.4.2 may make diversion of supplies from one or the other reservoir subjected to the condition that the share of each State during the water year will not be affected adversely.

2.4.4 There shall be a joint Control Board consisting of the following members for execution of the Galudih Joint Project which comprises of the Galudih barrage and the right bank main canal up to Orissa border:

i) Chief Minister of Bihar and Orissa (alternate Chairman for oe year).
ii) Irrigation Minister of Bihar and Orissa.
iii) Chief Engineers of Irrigation of Bihar and Oirssa.
iv) Irrigation Secretaries of Bihar and Orissa.
v) Finance Secretaries of Bihar and Orissa.
vi) Collector of Mayourbhanj and Deputy Commissioner of Singhbhum.
vii) Other Officers as may be nominated not exceeding two each by Bihar and Orissa.
viii) The Project Engineer of the Joint Project (by whatever designation he may be called) Non-Member-Secretary.

The Joint Control Board of the Galudih Joint Project will function as per the provisions made in the Bipartite Agreements between Orissa and Bihar, dated 17th January 1976 and 25th October 1976.

3.0 The water resources below Kokpara allocated amongst the three riparian States shall be utilised subjected to the provisions as under:

3.1 West Bengal shall construct a barrage across the Subarnarekha at or near Jhareswarpur to irrigate lands during the Khariff and Rabi season in the district of Midnapur by utilising its allocated resources of 40, 000 acre feet of water above Kokpara (vide clause 2.2.2) together with its allocated resources below Kokpara.

3.2 Orissa will be entitled to draw any part of its share as per clauses 1.1 above by releases in the river through all the hydraulic structures.

3.3 Regarding flood moderation and the recognised need for flood relief, Orissa and West Bengal agree to discuss and plan for a simultaneous and co-ordinated execution of an embankment system on either side of Subarnarekha in consultation with C.W.C, Ministry of Railways and Ministry of Transport, Govt. of India.

4. Bihar may also develop the Subarnarekha Valley for inland water transport as this will provide a direct sea- face to the State.

5. West Bengal may construct a weir on the Subarnarekha above Chandil for meeting West Bengal's need within their allocated share.

6. West Bengal shall not construct any dam on the main Subarnarekha River above the Chandil dam.

7. It is agreed that all these three Co-basin States will take effective steps to control pollution in the river originating in their respective territories.

8. This tripartite agreement shall be given effect to in conjunction with the other agreements already reached and appended hereto by co-basin States, and in the event of any repugnance the terms of this tripartite agreement will prevail.

9. It is also decided that in the event of any dispute relating to this agreement and the inability of the three States to settle the matter amicably through mutual discussions a sole arbitrator of the standing of a Supreme Court Judge would be appointed by the President of India to settle the matter and his decision shall be final and binding on all the three States.

NEW DELHI
August 7, 1978

Signed on behalf of the Government of Bihar	Signed on behalf of the Government of Orissa	Signed on behalf of the Government of West Bengal
(KARPOORI THAKUR)	**(NILAMONI ROUTROY)**	**(JYOTI BASU)**
Chief Minister	Chief Minister	Chief Minister

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Chapter IX

WATER POLICY

9.1 National Water Policy

Water being a scarce and precious natural resources, it is to be planned, developed, conserved and managed in a scientific manner on an environmentally sound basis keeping in view the socio-economic aspect and requirements of the States. As the country has stepped into 21st century, efforts to develop, conserve, utilise and manage this vital resource in a sustainable manner, have to be guided by the national perspective.

In view of the need for careful planning of water resources for optimum utilization, the G.O.I adopted a National Water Policy in September 1987.

The Policy recommended that resource planning in the case of water has to be done for a hydrological unit, such as a drainage basin, as a whole or for a sub-basin. It further recommended that special multi-disciplinary units should be set up in each state to prepare comprehensive plans taking into account the needs of not only irrigation, but also the various other water uses such as, drinking water, hydropower generation, navigation and industrial uses etc, so that available water can be put to optimum use. The policy has also emphasized the need for the inter basin transfer of water. It states "Water should be made available to water shortage areas by transfer from other areas including transfer from one river to another, based on national perspectives after taking into account requirement of the areas / basin". The Govt. of India thus amply emphasized the importance of River Basin Master Plan.

Basing on the National Water Policy, Central Water Commission formulated a guideline for preparation of river basin master plan (April 1990). Since adoption of the above said policy a number of issues / challenges have emerged in the development and management of the water resources. Therefore the National Policy 1987 has been reviewed and updated as National Water Policy April 2002.

9.1.1 Salient Features of the National Water Policy (April 2002)

- The water resources planning, development and management will have to be done for hydrological unit, such as drainage basin as a whole or for a sub-basin multi-sectorally, conjunctively for both surface and ground water incorporating quantity and quality aspect as well as environmental consideration.

- In planning and operation of system, water allocation priority should be broadly as follows – Drinking water, Irrigation, Hydropower, Ecology, Agro-industry and non- agricultural industries, navigation and other uses and priority could be modified if warranted by the area / region specific consideration.

- Special effort should be made to investigate and formulate project either in or for the benefit of area inhabited by tribal population or socially weaker section.

- Conjunctive use of surface water and ground water should be envisaged right from the project planning stage and should form an essential part of the project. Right from the planning stage, drainage system should also from an integral part.

- Over exploitation of ground water should be avoided. It should be strictly followed in coastal area to prevent saline ingress into sweet water aquifers.

- The water resources should be conserved, and the availability augmented by measures for maximizing retention, eliminating pollution and minimizing losses.

- Irrigation planning of individual project or of a basin as a whole should take into account the irrigability of land, cost effective irrigation options possible from all available sources of water and appropriate irrigation techniques.

- The irrigation intensity should be such as to extend the benefit of irrigation to as large number of farm families (i.e. extensive irrigation) as possible.

- Water zoning: Economic development and activities including agricultural, industrial and urban development should be planned with due regard to the constraints imposed by the configuration of water availability. There should be water zoning of the country and the economic activities should be guided and regulated in accordance with such zoning.

- Flood forecasting, flood drainage and drought management are integral part of River basin planning.
- Success rate for different uses i.e. (i) drinking water 100%, (ii) industry 100%, (iii) hydropower 90% are to be achieved. Drinking water need of human beings and animals should be the first preference of any available water.
- Wherever land resources are available and water is scare, if economically advantageous, deficit irrigation may be practiced.

- The management of the water resources for diverse uses should be done by adopting participatory approach by involving not only the various Govt. agencies but also the users and other stakeholder in an effective and decisive way in various aspects of planning, design, development and management of the water resources scheme. Necessary legal and constitutional changes should be made at various levels to ensure the implementation of said objective.

- Effluents should be treated to acceptable levels and standard before discharging them to natural streams.

- Minimum environmental flow should be ensured in the perennial streams for maintaining ecology and regime of the watercourse.

- Reclamation of water logged and saline affected land by scientific and cost effective methods should form a part of CAD programme.

- There should be a master plan for flood control and management for flood prone areas. In highly flood prone areas flood control should be given over riding consideration in reservoir regulation policy, sacrificing some irrigation or power benefits.

- Drought prone area should be made less vulnerable to drought associated problem through soil moisture conservation measure, water harvesting practice, minimization of evaporation loss, development of the ground water potential including recharging and transfer of surface water from surplus areas where feasible and appropriate.

- Water should be made available to water shortage areas by transfer from other area including transfer from one river basin to another based on a National prospective after taking into account the requirement of the areas and basins.

- On adaptation of advance science and technology, a perspective plan for standardized training should be an integral part of water resources development. It should cover training in information system, sectoral planning, project planning & formulation, project operation & maintenance. The training should extend to all categories of personnel including water users.

- The water allocation among the basin states should be guided by a national perspective with due regard to water resources availability and demand within the river basin.

- The Inter-state Water Disputes Act, 1956 may be suitably reviewed and amended for timely adjudication of water disputes referred to the Tribunal.

- Formation of Water Users Association (WUA), should be encouraged to facilitate maintenance of water distribution system.

9.2 The State Water Policy of Orissa

Water is a state subject. The multi-disciplinary approaches to water resources planning for optimal utilization within the permissible environmental limit become the policy of the State Govt. In consistence with National Water Policy, the Govt. of Orissa formulated its State Water Policy of Orissa (1994) so that the state would be able to utilise this renewable energy to its optimal benefit. The ultimate aim of the State Water Policy is to develop a State Water Plan, which will be a blueprint for future Water Development in the State.

The objective of State Water Policy, Orissa (1994) with revised draft policy of 2007 are:

- Development of Water Resources available, within the category of utilizable resources to the maximum possible extent for economic development, especially by efficient use of water for agriculture. It will take into account all available options i.e. surface water, ground water and rain water harvesting etc. including inter-state inter-basin transfer.

- Interlinking major and medium irrigation projects for a holistic development of the system would also be kept in view.

- Maximum economic benefits through judicious conjunctive use of both surface and ground water. Quality of both surface and ground water will be regularly monitored.
- Judicious allocation of water resources to different sectors with drinking water occupying top priority in order to satisfy the basic need of human beings and live stock followed by Ecology Irrigation, Hydropower, Industries including agro industries, Navigation and others.
- Promotion of equity, social justice and balance regional development. Special efforts should be made to extend the benefits of water use primarily by extending irrigation facilities to economically backward areas and chronically drought prone areas. The expansion of irrigation coverage would aim at balanced growth of the infrastructure throughout the sate.
- Provision of adequate drainage measures not only through engineering interventions alone but also through biological and land use plan for waterlogged areas.
- The importance of water for maintaining the ecological balance of the river system would be an integral part of the State Water Policy. Wet lands like lakes, lagoons, mangroves, marshes etc would be sustained and conservation measured would be undertaken.
- Water will be supplied to industries within the overall purview of the plan. Incentives will be given for recycling of water. Effluents should be treated to acceptable levels and standard before discharging to natural streams.
- Measures such as selective linking of the conveyance system, modernization and rehabilitation of existing systems including tanks etc. and techniques like drip and sprinkler irrigation will be promoted. Planning will encompass uniform development of field channels through CAD activities with people's participations.
- Optimization of economic benefits by multipurpose use of water for hydropower generation. But riparian rights of the people downstream are to be protected.
- Preservation and enhancement of fisheries and wild life.
- Provision of social justice and adequate rehabilitation measures for persons displaced or adversely affected by project construction so that project affected person are as well or better off than that of previous situation. The resettlement of displaced persons will precede completion of a project.
- Ground water potential would be harnessed in a sustainable manner for supply of drinking water and irrigation in water scarce areas. Ground water recharge would be a conscious policy of all stakeholders. Over exploitation of ground water would be effectively prevented by legislation.
- Master Plan for flood control and drainage facilities would be prepared. River training works will be taken up for protection of embankment and maintenance of river regime.
- Regulation of land use in flood and drainage prone areas. In highly flood prone area, flood control should be given overriding consideration in reservoir regulation policy even at the cost of sacrificing some irrigation or power benefits, Control of urban flooding should be given due importance.

- Saline ingress through tidal action will be tackled by suitable structural interventions i.e. construction of sluices and embankments. Over exploitation of ground water in coastal areas to be avoided to prevent saline ingress into sweet water aquifers.
- Salt production in the State would be encouraged.
- Promotion of people's participation in all aspects of water planning and management.
- Handing over of operation and maintenance of irrigation system to the users in due course.
- Economic, financial and physical sustainability through effective operation, maintenance and management and also based on the principle that the beneficiaries pay for the services provided.
- The polluters of water will have to pay so that adequate measurers can be taken for pollution mitigation.
- The treatment of catchments of all reservoirs will be taken up in an expeditious, systematic and scientific manner.
- Planning process and mechanisms should aim at resolution of conflicts between users within and between inter state river basins.
- Participation of NGO's in campaigns for water management, water conservation and P.I.M. They may also be associated with R & R of displaced person for greater transparency and stakeholder participation.
- Observance of safety standards in respect of storage dams and other water related structures.

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Chapter X

PARTICIPATORY IRRIGATION MANAGEMENT

10.1 Introduction

Inequitable distribution of water amongst beneficiaries over space and time leads to injudicious use of precious water in irrigation commands. Farmers, whose lands are located in the head reach of canal system, get an advantage over their fellow farmers whose lands are in the tail reach in terms of water allocation. Anticipating unpredictable water supply, the head reach farmers draw more than their actual requirement as a measure against future uncertainty. This not only results in wastage of water but tail- enders are deprived of getting their due share. This leads to inequality within the same command.

This fact was realised, when it was observed that even after huge investments made in the water resources sector, there remains a wide gap between the potentials created and potentials utilized. By the end of 9th Five year plan (1997-2002), the potentials created in the country was 94 million ha against which, there remained substantial gap of 14 million ha un/ under utilised. Thus for better irrigation management Govt. of India lunched CADA programme in 1977 through State Govt. But through CADA, the desired objective of water distribution and maintenance of canal system could not be achieved. This led to the involvement of beneficiaries for better operation and maintenance of the system as they will gradually develop a sense of belongingness. With this in view, PIM programme was implemented by Govt. with formation of Water Users Association (WUA) or Pani Panchayat (PP) for participation of farmers in water management, irrigation scheduling, distribution and maintenance of canal system at micro level, economic water use, selection of crop, cropping sequence and timely water supply. It will further delineate responsibility in water distribution and maintenance of system between the end user and the department for attaining better serviceable standards and will create a congenial atmosphere between the managers and the users in the entire operation.

10.2 Management Transfer Process:

According to Chambers, "Irrigation system are not physical entities constructed to blue prints: they are more like organisms which grow, spreading over time, fitting the physical terrain pulled here and there by human activity, decaying and being restored". With Colebrook-Cameron reforms in 1832, the people's management of irrigation system in India got a set back which abolished the compulsory labour and hereditary headmanship.

An ordinance was enacted in 1856 which entrusted the Govt. responsibility of irrigation development to Govt. Agent who was the head of the administration of the province. The colonial Govt. assumed responsibility for development of irrigation removing local systems. The 1856 ordinance was revised in 1867 which provided selection of one or more headmen by the owner to ensure maintenance of rights and prevention of any action that may sabotage the ancient custom and damage the system. But the basics remained that the owners would manage the system. The Provincial Director of Irrigation was created by transferring some functions of Govt. Agent. Towards 1930s changes in national perspective regarding development of irrigation ushered. During 1948, the central amendment through irrigation ordinance emphasized four main issues. Those are (a) effective participation, (b) removal of irrigation headman (c) conflict resolution and (d) maintenance of irrigation. The 1958 Paddy land Act of Central Govt. increased its control over irrigation management and cultivation committee replaced irrigation headman (Refer: Irrigation Management Policies and Practices, 20-21 June 2005, Bhubaneswar, pp 33). The village committee expected to resolve conflicts but they had no punitive power. The introduction of modern technology alienated farmers from decision making process.

The participatory approach towards development and management of irrigation is not new in our country. Prior to British rule, the kings and rulers of different regions used to provide assistance for capital costs involved for construction water sources viz. tanks, check dams and diversion weirs while O & M of canal system and distribution of water was entrusted to farmers. Such examples are found in Maharashtra near Nasik and Dhule as Phad system, in Vijaynagar Canal of Karnataka, in several tanks of Tamilnadu and A.P and also in neighboring countries like Nepal and Srilanka. Throughout the world, for irrigation reforms, now the stress is on PIM. PIM has been refined to Irrigation Management Transfer (IMT) and is being practised in Turkey, Mexico, Phillipines and the states like Maharashtra, M.P., A.P., Tamilnadu, Karnataka and Orissa.

Under USAID assisted Water Resources Management and Training (WRM & T), PIM has been introduced in several states of the country from 1980s. Towards later part of nineties, A.P., M.P., and Karnataka enacted legislation making PIM a statutory requirement to access irrigation water. Orissa adopted the 'Pani Panchayat Act' in 2002.

In A.P, a big-bang approach was followed by forming about ten thousand WUAs within a year of implementation of the programme by legislating 'Farmers Management of Irrigation system Act' in 1997. At present the performance of WUA is poor due to unwarranted interference from outside. On the contrary, Maharashtra and Gujarat have adopted motivational approach. Though they have not achieved quick success, it is progressing steadily.

10.3 PIM scenario in Orissa

10.3.1 Pani Panchayat Programme

PIM is being implemented in the state in the name of 'Pani Panchyat' programme. The principal objectives of Pani Panchyat are 'to promote and secure distribution of water among its users, adequate maintenance of the irrigation system, efficient and economical utilization of water to optimize agricultural production, to protect the environment and to ensure ecological balance by involving the farmers, inculcating the sense of ownership of the irrigation system in accordance with the water budget and the operational plan'.

Initially it was a difficult task to motivate the reluctant farmers to forego their traditional attitude and to accept the PIM concept. The concept was introduced in the State during 1996 under the World Bank assisted Orissa Water Resources Consolidation Project (OWRCP) in four flow irrigation projects i.e. Derjang, Aunli, Ghodahado and Rushikulya Distributory No.II covering an area of 0.21 lakh ha. on pilot basis. WALMI, Orissa along with two NGOs were entrusted to motivate the farmers to form WUA by registering the Associations under the Societies Registration Act, 1860. With a lot of persuasion, it was possible to form only 50 nos of WUAs by 1997 and another 113 nos. by August 2000. Further a decision was taken for providing financial assistance of Rs.35.00 per ha initially in 2002 as grant in aid to the PPs which was subsequently enhanced to Rs.100.00/ ha in 2003-04.

Govt. started a new programme under 'Biju Krushak Vikash Yojana' (BKVY) for development of irrigation potential in 2001. The programme aimed for revival as well as construction of new M.I and L.I projects with a financial assistance to WUAs to the extent of 80 to 90% of the project cost. The progress of Pani Panchyat in the state upto April 2005 in furnished in Table 10.1

Table 10.1 Formation of Pani Panchayat (April 2005)

Type of Irrigation Projects	Potential created in '000ha	No. of PP formed	Area in '000 ha	Irrigation management transferred	
				No. of PPs	Area '000ha
Major & Medium	1234	1253	558	845	382
Minor (Surface)	364	1349	203	770	120
Minor (European Commission)		56	09	20	04
Minor (Lift)	227	10030	225	9129	205
Total	1825	12688	995	10764	711

Source:Irrigation Management, Policies & Practices, 20-21 June 2005,Bhubaneswar

Upto end of December 2006, irrigation management transferred to Pani Pnachayat is 12500 nos. covering an area of 880281 ha (including major, medium and minor flow & lift schemes). The Organisational chart of Farmers Organisation is given in Figure 10.1.

Organizational Setup

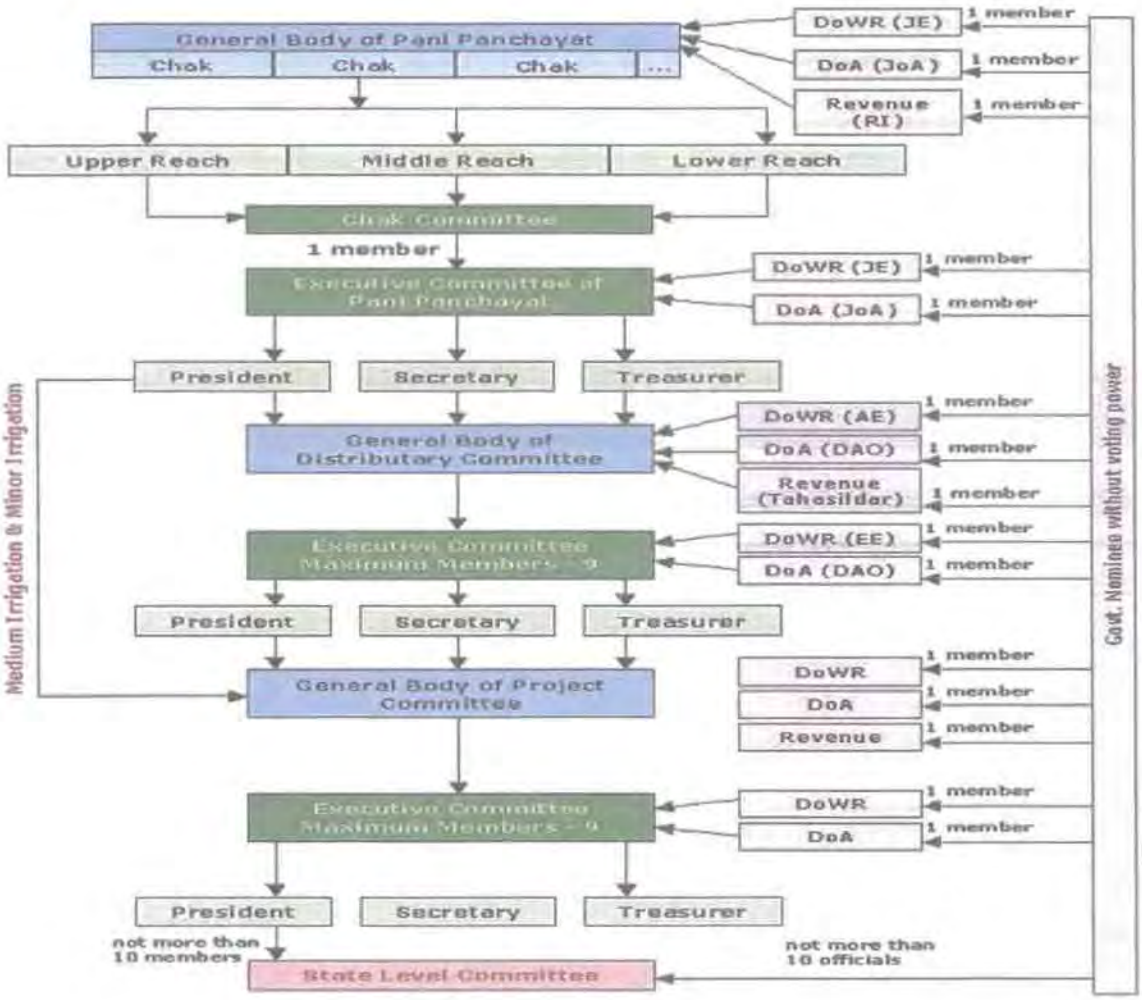

Figure 10.1

10.3.2 Strength and Weakness of PIM in the State.

10.302.1Success stories

After introduction of Pani Panchayat in the state, following benefits have been achieved.

i) Farmers at the tail end of the canal system are satisfied as their problems have reduced.

ii) The gap between potential creation and utilization has narrowed down.

iii) Crop diversification has been achieved to some extent.

iv) Increase in productivity and production thus improving the financial condition of the farmers

v) Number of canal cuts and damages minimised due to involvement of beneficiaries.

vi) Better O & M observed.

vii) Involvement of only women farmers in the formation of 'Maa-Hingula' W.U.A of Aunli Irrigation Project of Angul district. This was exclusively first women Pani Panchayat in the country. This has set an example for women empowerment.

10.3.2.2 Weakness of PIM in the State

a) As Pani Panchyat are decided on hydraulic basis, one P.P may cover more than one village. If villages coming within the P.P have earlier hostile relationship, this may have a serious set back in achieving the objectives and its smooth functioning.

b) Now politics is deep rooted and the political affiliations are responsible for spoiling the tranquil atmosphere even in remote villages. The situation is aggravated due to community heterogeneity and cast antagonism. Thus many problems crop up during election of office bearers of chak committee, Executive committee and project committee of PPs. Therefore the inherent conflicts among the members surface and hinders the collective effort required for management of the system.

c) The Pani Panchyat Act 2002 does not have scope for landless to become members of PPs. Women do not hold title to the land and the landless tenant do not have any right over water. Thus the inequity in property rights is more pronounced than ameliorated. This necessitates amendment of the Act to give equal opportunity of participation of women jointly with their spouse and informal tenants in the management of water resources.

d) In lift irrigation schemes, unreliable electric supply is a common complaint which affects the crop yield. This needs to be addressed as PP members blame electricity authority and vice versa.

e) Non availability of credit in time to the small farmers for purchase of seeds, fertilizer, pesticides etc. and lack of extension facilities affects crop production.

f) A 'Learning –while-doing' approach should be followed to determine the modalities of organising PPs depending on the socio- economic condition, psychology and cultural heritage of the local farmers.

10.4 Water Rates in the State

National Water Policy (2002) stipulates that water charges should cover at least O & M cost of providing the services initially and a part of capital cost subsequently. The subsidy on water rates to the disadvantaged and poor sections of the society should be well targeted and transparent.

In 1992 Vaidyanathan committee recommended full recovery of O & M cost plus one percent of capital cost at the initial phase. This would have increased the water rate five times at all India level. 2nd Irrigation commission in 1972 recommended that water rate should cover the working expenses and interest on capital. All the Finance Commissions have recommended complete recovery of O & M cost plus interest or some percentage of capital investment. Eleventh Finance Commission has suggested for a fixed rate of Rs.450.00 per ha potential utilized and Rs.150.00 per ha for unutilized. Irrigation being a state subject, the matter has been left to States for Enforcement.

10.4.1 Irrigation Water Levy

Water rates in major & medium Projects in the State are assessed on basis of area irrigated and the type of crop grown. The charges are levied per unit area (i.e., ha) basis separately for Khariff and Rabi crops. For Kharif crops, it is compulsory basic water rate on the basis of depth of water (or the class of irrigation) that the project is designed to supply which is to be paid irrespective of it use. But, during Rabi, it is not compulsory and payable on use. Irrigation water rate for Kharif is shown in Table 10.2.

Table 10.2 Compulsory Basic Irrigation Water Rate

Sl.No	Class of Irrigation	Depth of water supply (inches/ mm)	Water Rate for Flow irrigation (Rs/ha)					
			1961-62	68-69	75-76	81-82	98-99	2002-03 (*)
1	Class I	28/710	19.77	9.88	19.77	39.54	100.00	250.00
2	Class II	23/585	14.83	7.41	14.83	29.65	75.00	188.00
3	Class III	18/460	9.88	4.94	9.88	19.77	50.00	125.00
4	Class IV	9/230	4.94	2.47	4.94	9.88	25.00	63.00

Source: Govt. of Orissa, Revenue Department Notification 5th April 2002.

The Water charges for Rabi crop have been fixed according to the water requirement of crops. Water requirement is considerably high for water intensive crops like Ganja, betel leaf and 'Saru' (Arum). The water charges for different crops as revised from time to time are furnished in Table 10.3.

Table No 10.3 Rabi Water Rate for Crops (Rs / ha)

Sl.No	Name of crops	1968-69	73-74	74-75	81-82	98-99 (*)	2002-03 (**)
1	Paddy(Dalua)	19.77	39.54	59.30	88.96	225.00	450.00
2	Tabaco	37.07	37.07	55.60	83.40	210.00	420.00
3	Potato	24.71	24.71	37.07	55.60	140.00	280.00
4	Vegetables	19.77	19.77	29.65	44.48	115.00	230.00
5	Onion	24.71	24.71	37.07	54.36	140.00	280.00
6	Wheat	4.94	14.83	22.24	32.12	85.00	170.00
7	Maize	12.36	12.36	18.53	27.80	70.00	140.00
8	Mung	2.47	2.47	3.71	5.56	14.00	28.00
9	Groundnut	12.36	12.36	18.53	27.80	85.00	170.00
10	Orchards	29.65	29.65	44.48	66.72	167.00	334.00
11	Sugarcane	34.59	44.48	66.72	100.08	250.00	500.00
12	Jute	7.41	7.41	11.12	16.68	42.00	84.00

Sl.No	Name of crops	1968-69	73-74	74-75	81-82	98-99 (*)	2002-03 (**)
13	Fodder	12.36	12.36	18.53	27.80	85.00	170.00
14	Pulses	4.94	4.94	7.41	11.12	30.00	60.00
15	Cotton	24.71	24.71	37.07	55.60	140.00	280.00
16	Til(Oil seed)	4.94	4.94	7.41	11.12	30.00	60.00
17	Betel Leaf	74.13	74.13	111.20	166.79	420.00	840.00
18	Arhar	12.36	12.36	18.53	27.80	85.00	170.00
19	Sunhemp	17.30	17.30	25.95	38.91	100.00	200.00
20	Chilly	12.36	12.36	18.53	27.80	85.00	170.00
21	Saru (Arum)	74.13	74.13	111.20	166.79	420.00	840.00
22	Ragi	6.18	6.18	9.27	13.99	35.00	70.00
23	Mustard	2.47	4.94	7.41	11.12	30.00	60.00
24	Ganja	—	123.55	123.55	185.33	465.00	930.00

(*) Govt. of Orissa, Revenue & Excise Department Notification Dt.18th July 1998.

(**) Govt. of Orissa, Revenue Department Notification Dt.5th April 2002.

Water rates for various crops in Lift irrigation projects are different from flow irrigation. The water charges are given in Table 10.4.

Table No 10.4 Water Rate for Different Crops in Lift Ayacut

Sl.No	Name of crops	Water Rate Rs per acre				
		Up to Oct. 92	From Nov 92 to Oct 96	From Nov. 96 to June 97	From July 97	Revised rate from 2000
1	Kharif Paddy	28.80	76.92	149.04	209.16	269.28
2	-do- (Rabi)	120.00	320.50	621.00	871.50	1122.00
3	Tabaco	57.60	153.84	298.08	418.32	538.56
4	Potato	57.60	153.84	298.08	418.32	538.56
5	Vegetables	72.00	192.30	372.60	522.90	673.20
6	Onion	48.00	128.20	248.40	348.60	448.80
7	Wheat	36.00	96.15	186.30	261.45	336.60
8	Hy.Maize	57.60	153.84	298.08	418.32	538.56
9	Mung	9.60	25.64	49.68	69.72	89.76
10	Groundnut	36.00	96.15	186.30	261.45	336.60
11	Orchards	72.00	192.30	372.60	522.90	673.20
12	Sugarcane	108.00	288.45	558.90	784.35	1009.80
13	Jute	24.00	64.10	124.20	174.30	224.40
14	Fodder	48.00	128.20	248.40	348.60	448.80
15	Pulses	12.00	32.05	62.10	87.15	112.20
16	Cotton	48.00	128.20	248.40	348.60	448.80
17	Til(Oil seed)	19.20	51.28	99.36	139.44	179.52
18	Betel Leaf	192.00	512.80	993.60	1394.40	1795.20
19	Arhar	36.00	96.15	186.30	261.45	336.60
20	Sunhemp	24.00	64.10	124.20	174.30	224.40
21	Chilly	115.20	307.68	596.16	836.64	1077.12
22	Saru (Arum)	216.00	576.90	1117.80	1568.70	2019.60
23	Ragi (Rabi)	52.80	141.02	273.24	383.46	493.68
24	Ragi (Khariff)	14.40	38.46	74.52	104.58	134.64
25	Mustard	7.20	19.23	37.26	52.29	67.32

Water rates for purpose other than irrigation are as follows (vide Govt. of Orissa and Excise Department Notification dated 18th July, 1998)

Table 10.5 Revised Water Rates for Uses other than Irrigation

Sl. No	Purpose	Unit	Rate (Rs.)
1	Brick or Tile making	1000 nos.	6.00
2 (i)	Water consumed and used for industrial/ commercial purpose	One lakh gallon	250.00
(ii)	Water temporarily used for industry / commerce and discharged back unpolluted or after purification into irrigation project	One lakh gallon	60.00
3	Bulk supply to N.A.C and municipalities for drinking and washing etc.	10, 000 cft	30.00
4	Construction of buildings	100 cft	4.00
5	Filling of tanks	10, 000 cft	30.00
6	Filling tanks mainly for drinking purposes	10, 000 cft	15.00

10.4.2 Realisation of Water Rate

Vaidyanathan Committee Report (1992) indicates the wide gap between the demand raised and actual collection of water charges in the State from 1986-87 to 1991-92. Situation is no way better today. Huge arrear in water dues may become bad debt of the Govt. One of the reasons for such arrear is that water to farmers is supplied by Irrigation / W.R Department where as water charges are collected by Revenue authorities. Demand and realization of Water charges are shown in Table 10.6.

Table No 10.6 Demand & Collection in the State

Year	Demand	Collection	Collection as % of demand	Remark
1986-87	925	383	41.4	Collection cent percent in Punjab & Haryana and more than ninety percent in U.P. followed by Gujrat and Maharashtra.
1987-88	952	415	43.6	
1988-89	960	467	48.6	
1989-90	920	367	39.9	
1990-91	921	417	45.3	
1991-92	956	492	51.5	

Source: Vaidyanathan Committee Report (1992)

The sad picture of water charges falling short of the assessments and huge arrears are also seen in other parts of the country. Demand and collection figures of major and medium projects are given in Table.10.7.

Table 10.7 Demand and Collection Figures of Major and Medium Projects

Name of States	Area	Demand Irrigated	Collection	Collection as % of demand
Bihar	21.49	475	217	45.68
Gujarat	6.98	1110	765	68.92
Haryana	20.23	1179	1298	110.09
Madhya Pradesh	15.97	2792	1264	45.27
Maharashtra	—	1953	1228	62.88
Orissa	13.59	920	367	39.89
Punjab	28.59	1077	1121	102.19
Uttar Pradesh	56.63	6429	6041	93.96
West Bengal	15.58	234	80	34.19

Source: Vaidyanathan Committee Report (1992).

10.4.3 Sustainability of WUA

Large numbers of PPs have been formed. Now it is required to take appropriate measures for strengthening them. Few such steps are: -

(i) Distress sale of agricultural produce should be stopped by creating better marketing network. It is the middlemen who get the lion's share. The farmers and the consumers always suffer.

(ii) On farm Development (OFD) works may be taken up in command areas.

(iii) Farmers should be educated through various training programmes.

(iv) Govt. officials may work closely with farmers with a mindset to extend them help.

(v) Explicit water rights may be given to PPs.

(vi) Farmers should have full freedom of crops to be grown.

(vii) Gradually the farmers association should have rights to fix up water rates and realize them.

This is being followed in European Commission (EC) assisted M.I (Flow) project of Orissa. This gives a greater sense of ownership to the farmers and they do not perceive their water tax payments as having no impact on their systems.

PIM is an important step under taken by Govt. for improving productivity and sustainability of irrigation system. It will result in substantial savings from Govt. exchequer. To establish a new institution in the management of irrigation infrastructure, to change the mindset of farmers and attitude of Govt. officials is a Herculean task. Initially there were lots of hindrances in the implementation of the programme. Certain drawbacks are also noticed. But in this changing scenario, all efforts are being made to achieve the best by adopting a dynamic management system with active participation of beneficiaries / stakeholders. This is truly a 'Win- Win' situation.

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Canal Renovation Works Undertaken by Farmers of WUA

Member of Panipanchayat Guiding the Operation of Gate to Farmers

Chapter XI

FUTURE SCENARIO

11.1 Water Resources Potential - an Appraisal

Fresh water is becoming scarce day-by-day. As the world population (particularly in Asian countries) are alarmingly increasing and with improved living standards; water, the most critical and vital resources for humanity is gradually decreasing. We all know that oceans cover about three fourth of earth's surface. According to the UN estimate total quantity of water on earth is about 1400 million cubic kilometer. This quantity can cover the earth with a layer of 3000m depth. However, only 2.7% of the total water available is freshwater of which 75.2% lies frozen in Polar region and another 22.6% is present as fossil ground water; thus leaving meager 2.2% in rivers, lakes, moisture, soil and vegetation. At any point of time, the atmospheric water content is 0.001 percent and the water that content by all the rivers and lakes is only 0.0132 percent. Thus the distribution of the atmospheric moisture of 0.001 percent on earth's surface causes droughts and flood affecting life on earth.

India has 2.45% of world's land, 4.9% of fresh water resources having 17% of population. From the reported area of 306 million ha for land utilization, the present cultivated area is 142.5 million ha (47%), forest cover 69 million ha. (23%) and 42 million ha (about 14%) is not available for cultivation (as per Ministry of Agriculture & Co-operation, Government of India, 2004). Out of the cultivated area, 40% area is irrigated which produces 55 percent of food grain and rest 60 percent of area is rain fed which produces 45 percent of food grain (Refer WRMSD, 2006 pp20).

Periodically Central Water Commission has been assessing country's water resources. The water resources potential of the country, which occur as a natural runoff in the river is about 1869 Billion Cubic Meter (BCM). It is about four percent of the total river flows of the world. However, due topographical, hydrological and other constraints, only about 690 BCM of available surface water can be utilized in addition to annual replenishable ground water resources of 432 BCM. Thus total utilizable water in the country has been assessed as 1122 BCM. The average annual per capita water availability is estimated to be about 1829 cum in 2001 at national level (vide 11th National Water Convention, New Delhi, pp 25). This will decline to 1342 cum by 2025 AD due to population explosion. At present, irrigation utilizes lion share of about 83% of the water used. With the increase in demand of water for other uses, the share of water used for irrigation may go down to about 73% by 2025 (vide Economic Survey, Government of India, 2001-02 Page194).

In majority of river basins present utilization is significantly high and is in the range of 50 to 95% of utilizable surface water resources excepting river basins like Narmada and Mahanadi where it is relatively low. Though drinking water is the priority of all uses, irrigation is the major consumer of water. Total irrigation potential in the country from surface and ground water sources would be respectively 75.9 million ha and 64 million ha (totalling to 139.9 million ha).

Some water resources statistics of World, India and Orissa are stated as under (vide 46th Technical Session, IEI, Orissa Center, Feb. 2oth, 2005 Pg.53):

a) World Figures:

i)	Annual renewable fresh water	47000 km^3
ii)	Per capita annual availability	8500 cum
iii)	Annual utilized water	3500 km^3
	Agricultural sector 69%	

		Industrial demand 23%	
		Domestic use 08%	
b)	India Figures		
	i)	Annual renewable fresh water	1869 km^3
	ii)	Utilizable fresh water (60% of above)	1122 km^3
	iii)	Per capita annual availability	2200 cum
	iv)	Water utilized for agriculture	83%
c)	Orissa Figures		
	i)	Annual utilisable fresh water Surface water 85.15 km^3 Ground water 20.11 km^3	105.26 km^3
	ii)	Per capita annual availability	3000 cum

It is estimated that the total irrigation potential likely to be developed from various sources in the State are as follows:

a)	Through major and medium projects	39.49 lakh ha
b)	M.I (Flow)	9.70 lakh ha
c)	M.I (Lift)	8.87 lakh ha
d)	Through other minor sources i.e. dug wells, tanks water harvesting structures etc.	0.94 lakh ha
		Total 59.00 lakh ha

(Source: Irrigation in Orissa, 1991, WALMI Pg.27)

11.2 Dr. A.N. Khosla's dream – 'Decade of Destiny'

Dr. A.N.Khosla, an eminent engineer of the country, and the then was Governor of Orissa, delivered a speech at 43rd Annual convention of the Institution of Engineers (India) held at Bangalore on May 19, 1963. He prepared a blue print for the integrated development of the river basins of Orissa known as Orissa's Decade of Destiny (1963-73), the broad sketch of which are discussed here in nutshell.

11.2.1 Orissa and its Problems

"Orissa mirrors the paradox of all backward areas-poverty amidst potential plenty. Orissa has untold wealth of natural resources-land, forest, minerals, a long sea coast; and a population of 17.57 million (which has swelled to 36.80 million as per 2001 census). Yet it is the poorest and most backward State of India (which is even valid today as per the study made by Planning Commission). Any plan for development of these vast natural resources which will help transform poverty into plenty in the State of Orissa may well serve as a model for other similarly situated areas in India and elsewhere in the world".

11.2.2 Flood and Drought

For centuries, the State has been haunted by the twin spectre of flood and drought, and of these the latter has been the most terrible. There is plenty of water during the monsoon and scanty during the dry part of the year, as a result of which the State continues to suffer devastation by floods, and starvation, misery and disease from droughts. There were terrible famines in the 14th, 15th and 16th centuries. People have not forgotten the shock of 'Na-anka famine' of 1865-66 (which has been discussed under sec 2.7.1.1 of the book)

In 1961, heavy flood damage occurred over 3600 sq. miles of area, 6.5 lakh acres of crops were damaged. On relief alone, the expenditure was about Rs.5.77 crores. In 1962, severe drought situation prevailed in most parts of Orissa due to failure of rain when crop loss was more than Rs.60.00 cr. The year of occurrence of flood, drought and cyclone has been given from 1961 to 2002 vide Table 2.9 of the book. Irrigation and flood control are, therefore, two basic minimum needs of the state.

11.2.3 Planning for prosperity

From various angles, one could find that Orissa is the most backward region of the country. The poorer the region, the more urgent is the need for accelerating growth but there is greater difficulty in raising internal resources for investment. The plan provision during five year plans from 1951 onwards are furnished vide Table 11.1.

Table 11.1 Plan Outlay

Sl. No	Plan	Plan outlay (Cr)	Expenditure (Cr.)	State resources (Cr.)	Central Assistance (Cr.)	Total (Cr.)
1	2	3	4	5	6	7
1	First Plan (1951-56)	74.5 (*)	68.1	8.0	60.1	68.1
2	Second plan (1956-61)	100.0 (*)	84.0	18.3	65.7	84.0
3	Third plan (1961-66)	160.0	--	31.3	128.7(**)	160.0
4	Annual plan (1966-69)		34.65			
5	4th plan (1969-74)		60.05	55.92		
6	5th plan (1974-78)		150.55	146.63		
7	Annual plan (1978-80)		134.15	130.10		
8	6th plan (1980-85)	556.00	469.95			
9	7th plan (1985-90)	1284.35	833.90			
10	Annual plan (1990-91)		212.3			
11	Annual plan (1991-92)		245.2			
12	8th plan (1992-97)	3111.5				
13	9th plan (1997-2002)	3388.58	2848.25			
14	10th plan (2002-07)	3991.52	1891.83 (up to 2005-06)			

Source:(*) Includes outlay and expenditure on Hirakud but excludes all centrally sponsored scheme (vide 'Orissa's Decade of Destiny' by Dr.A. N. Khosla-May 19, 1963)

(**) On the basis of over all central assistance available for all states

Sl.No 4 to 12 – For outlay and expenditure figures refer 'Water & Related statistics by CWC,

July 1998 pp 259-266.

Sl.No 13 & 14 – Refer 'Orissa Economic Survey'

Sl.No 5 to 9, Col. 5 - Refer Irrigation in Orissa, WALMI, 1991 Table 6.27, 7.17 and7.18.

Any plan for overall development of this backward but potentially rich State must give priority to the solution of problems arising from flood and drought, besides development of infrastructure. Storing flood waters during monsoon through reservoirs and their regulated release during lean season of the year for irrigation, power generation, flood control, navigation, recreation and maintaining environment and ecology etc.

constitute the core of the plan. A statement showing the Potential created through various categories of projects from Pre-plan period is furnished in Table 11.2.

Table 11.2 Abstract of Potential Created in the State

Sl. No	Category	Latest Estimated cost (Rs. in Cr.)	Expenditure up to 03/2006 (Cr. Rs.)	CCA (000 ha)	Ultimate potential (000 ha)	Potential created up to 03/2006 (000 ha)	Utilization up to 03/2006 (000 ha)
A	Pre-Plan Project						
	Major Projects			170.55			
	Medium projects			13.45			
	Sub-Total	0.00	4.03	184.00	183.12	183.12	183.29
B	Projects completed up to IX Plan						
	Major Projects			263.61			
	Medium projects			188.08			
	ERM Projects			232.29			
	Sub-Total	0.00	816.60	683.98	1017.10	1017.10	963.40
C	Ongoing Projects of X Plan						
	Major Projects	9536.83	4164.36	626.05	1061.61	342.04	234.52
	Medium projects	1257.00	985.53	92.36	132.09	80.43	73.20
	ERM Projects	523.40	520.96	8.38	8.68	8.62	6.73
	Sub-Total	11317.23	5670.85	726.79	1202.38	431.09	314.45
D	New Projects of X Plan						
	Major Projects	617.47	37.51	65.88	62.60	5.88	0.00
	Medium projects	431.63	60.72	25.40	32.45	0.00	0.00
	ERM Projects	123.41	73.20	11.73	11.88	3.93	0.00
	Creek Irr. Project	26.21	6.30	12.65	21.54	0.00	0.00
	Sub-Total	1198.72	117.73	115.66	128.47	9.81	0.00
	Total	12515.95	6669.21	1710.43	2531.07	1641.12	1461.14

11.2.3.1 Plan of May 1945 by Dr. Khosla

In May 1945 Dr. Khosla, the then Chairman of CWI & NC (now Central Water Commission) conceived the first plan for the unified development of Mahanadi basin as an initial step for the overall development of basins of all the rivers of Orissa (now River Basin Planning). It was contemplated to construct three storage dams across Mahanadi at Hirakud, Tikerpara and Naraj for controlling Mahanadi floods and for power generation, irrigation, navigation and pisciculture etc. Work on Hirakud Dam commenced during 1949-50 after detailed survey and investigation and completed in 1957. Proposed Naraj Dam was substituted by a barrage at Mundali for providing irrigation to stage-II delta (in the undivided districts of Puri). Even though foundation stone for Tikerapara Dam was laid by Pt. Nehru in Jan. 1964, the same could not see the light of the day due to submergence of large tracts of land including Sonepur, Boudh and Athmallik towns.

11.2.3.2 Plan of May 1963

This is Dr. Khosla's comprehensive integrated plan which covers the multi-purpose development of the basins of all major and small rivers of the State. It envisages a developmental progrmme under six groups that has been shown in Table 11.3.

Table 11.3 Comprehensive Integrated Plan

Groups	Name of the project	Catchment area (sq.mile)	Submergence area (acres)	Storage MAc.ft.		Area to be irrigated '000Ac.		Power generation in million KWH
				Gross	Live	Kharif	Rabi	
A	Hirakud Dam Project	32750	181000	6.60	4.72	380	220	1120
	Delta Irrigation	--	--	--	--	964	578	
	Machhkund	755	22500	0.79	0.73	--	--	310
	Balimela	1855	44300	3.09	2.30	240	144	1210
B	Tikerpara Dam	48000	600,000	47.0	38.0	--	--	7240
	Gania Barrage	48705	20,000	0.40	0.10	2118	1271	--
C	Indravati	1040	28800	2.35	1.55	350	210	2050
	Upper Kolab	618	45000	1.15	1.08	200	120	693
	Tikra(Brahmani Basin)	512	34000	1.90	1.15	77	46	46
D	Barakot (across Brahmani)	8843	148000	5.95	3.10	637	382	2530
	Lower Kolab	1200	3800	2.91	2.00	200	120	1096
E	Bhimkund (across Baitarani)	2370	80000	3.40	3.00	--	--	2000
F	Burhabalanga Subarnrekha, Khadakhai, Bheden, Ong, Tel, Salki & Bagh	These projects are under investigation (Khadakhai, Salki and Bagh have been completed. Subarnrekha and Ong are under construction)						

All the hydro projects taken together will involve capital expenditure of Rs.927.52 cr. Besides these projects will achieve:

i) Complete flood control
ii) Installation of 8520 MW of hydropower
iii) Irrigation to 82, 57000 ac (33, 41608 ha)
iv) About one thousand miles of navigable canal. Water ways will connect Rourkela steel plant to Paradeep Port and Chilika Lake.
v) Reservoir area of 12, 43800 ac (5, 03366 ha) for pisciculture, recreation and tourism
vi) A potential fresh water protected harbour covering 150 sq.mile (388.6 sqkm) in the western part of Chilika lake with about 36 mile (57.9 km) length of fresh water canal with a perennial discharge of 37750 cusec (1069 cumec).

Dr. Khosla compared his May 1963 plan for Orissa with TVA of U.S.A. The TVA transformed the entire economy and life of the people living in the Tennessee Valley which was one of the most poverty stricken and backward areas of USA into one of the most prosperous area in power; agriculture and industry etc. and in living standards. He advocated that the plan provides all the features similar to that incorporated in the TVA plan. "It does something more; it will provide irrigation to nearly seven million acres in addition to the present acreage under irrigation. Given the resources, what the TVA has achieved for the Tennessee Valley, the Orissa plan can achieve much more for Orissa and the adjoining states of W.B, Bihar, M.P. and A.P. possibly in a shorter time".

But his ambitious Tikerpara dam with Gania barrage and Bhimkund across river Baitarani could not be implemented even today. The Tikerpara proposal was modified during 1955-56 by lowering the FRL from RL 131 m (430 ft) to RL 99.0 m. But this proposal suffered from the disadvantage of submergence and irrigation as the Athmallik town is situated at RL 80 m. and Boudh at RL 90 m. For irrigation, it was proposed to construct a barrage at Gania with pond level at RL 55.8 m. This necessitated rethinking about Tikerpara; which gave birth to Manibhadra.

11.2.4 Manibhadra Dam Project

The proposal envisaged construction of 2070m length of earth dam with maximum height of 49 m above ground level. It will have six earthen dykes of 2030 m long and a 350 m long main spillway having 16 nos x 15 m x 11 m radial gates. The auxiliary spillway will be 650 m long and two surface Power houses having installed capacity of 960 MW. The project will generate firm power of 297 MW and protect an area of 657432 ha from ravages of flood. The project parameters were fixed on the basis of water availability and minimum submergence.

Due to problem of submergence, it was not possible to provide exclusive storage space for flood moderation above FRL 86.0 m. The highest recorded flood of August, 1982 with a peak of 44750 cumec at delta head Naraj carried a flood volume of 1513 thousand hectare meter. In order to reduce the flood peak to the level of safe carrying capacity of the channels in Mahanadi Delta (i.e., 25, 500 cumec) a storage of 445 th. ham is required. To provide exclusive storage space of 445 th. ham for flood moderation above FRL, would affect Boudh town as the MWL may rise up to RL 93.10 m. Therefore, it was planned to maintain the reservoir at RL 82.30 m during monsoon so that impingement of a flood of August, 1982 magnitude or higher (200 year return period, having routed out flow 25, 500 cumec) will raise the MWL to RL 91.50m and still regulate the peak to 25, 500 cumec at Delta head.

This proposal also met the same fate as that of Tikerpara. Government of Orissa dropped the proposal of dam at Manibhdra mainly on the consideration of large scale submergence due to proposed structure. Moreover, the presence of Felspar deficient Khondolite on the river facing slope of Manibhadra and Subalaya hills, abutment conditions are not favourable. The foundation of the proposed dam was also considered critical as at the final site location, the river bed consisted of a deposit of about 30 m depth of sand below which rock strata was met. The proposal was to provide deep concrete cut off extending into rock. It was apprehended that the dam constructed on sand foundation may suffer from damage due to liquefaction under earthquake forces.

The proposal remained in the cold storage, and the danger of flood continued to haunt the mind of politicians, administrators, engineers and particularly the inhabitants as the coastal belt of the State continued to remain exposed to the danger of flooding. This state of affair still remains unsolved.

11.2.5 Subalaya Barrage

As implementation of both Tikerpara and Manibhadra Dams across Mahanadi were shelved due to large scale submergence and agitation by people, it was thought of constructing a barrage at Subalaya to ameliorate the sufferings of coastal Orissa from floods. In the first project proposal (1964), it was aimed at utilizing fully the available water resources by submerging 1200 villages, three towns and thick forest growth. Submergence and R&R problems became main bottleneck. Even after laying the foundation stone by the Prime Minister, the project could not be implemented.

This gave birth to the second proposal of Manibhadra Dam (1985) by reducing power potential. Though the submergence was considerably reduced to 273 villages, two towns and relatively less forest growth, this proposal was also aborted for similar reasons after the foundation stone for the project was laid by the Chief Minister.

After premature death of above two proposals, another alternative was thought of for flood moderation by dynamic storage with conservation level of RL 54.90 m and MWL of 77.0 m. In case of 100 year maximum flood peak of 49264 cumec (17.4 lakh cusec), the proposed barrage structure will moderate the flood to 24632 cumec (8.7 lakh cusec) at the head of delta. Between the conservation level of RL 54.9 m to MWL of 77.0 m, about 73 villages will remain below the flood level for a period of six and half days. The villages will be protected by embankments with road connections at higher levels. This preliminary proposal based on topo-sheet study also ended in a fiasco as flood control by a barrage structure is an impossible proposition.

It is ridiculous 'to have the cake and eat it too'. To give relief to the people of coastal region, it is necessary to construct another storage reservoir across Mahanadi. Simultaneously, it is also needed that there will no submergence and R&R issues. Both are contradictory. Thus there appears to be no solution to the vexed flood problem of coastal region in the near future.

11.3 Basin Planning

11.3.1 Objective

Basin planning which is a component of State Water Plan is the corner stone for future water resources development of the State. Planning process of a river basin can be described as an orderly procedure to optimize the development of water and related land resources. This would result in investigating the alternatives, programming of potential projects with respect to a set of objectives, taking into account physical and managerial opportunities and limitations.

River basin planning concentrates the planning effort in the natural hydrological unit, the river basin. The basin level approach is based on the broad set of interrelationships amongst the domains of natural phenomena classified into physical, biological and human systems. It offers a framework for bringing out integration in planning consistence with overall economic, social and environmental policies of the state and that of the country.

Primary objectives of river basin plans of the State are as follows: -

i) To prepare long-term perspective plan for the development of Basin's Water Resources.
ii) To develop a comprehensive and integrated approach to the development of water and other natural resources using water, within the constraints of water availability.
iii) To review the management of existing water resources project and incorporate necessary changes on technical and administrative aspect for making the project sustainable.
iv) To identify and set priorities for promoting water resource development projects.
v) To formulate a long term Integrated State Water Plan for water resources development.
vi) To create a data bank for posterity.

This is a continuous process for upgrading the State Water Plan.

11.3.2 Scope of Work

"The study envisages to prepare an integrated state water plan comprising of all the river basin of Orissa so as to estimate the water resources of the State and utilise the available water optimally by encouraging consumptive use of water though judicious multi-sectoral uses to meet the growing demand on this resource with time due to increase in population and their needs. It also emphasizes to maintain the existing environment with diverse ecosystem of the state without compromising with the quality of life sustaining water, ensuring quality drinking water for all. The scope includes study to identify and suggest for implementation of the Water Resources Projects so as to narrow down the gap between developed and the under developed region in food production and to make the river basin self-reliant in meeting the food requirement of its inhabitant as per the suggested standard of nutrition requirement. It will also examine the performance of the existing projects and to suggest the necessary changes, both technical and administrative, to be incorporated, to make the projects sustainable. Optimization and prioritization of future Water Resources Projects are also part of the study."

The Study has been planned to formulate the basin planning of individual river basins in three spiral studies in such a fashion that the 2nd becomes the finer version of the first and the third becomes the final plan of the river basin. Then all these individual basin plans will be integrated into a single plan incorporating necessary inter basin import and export, in the larger interest of the state, honouring the interstate agreements, in the 4th and the final spiral study of Orissa River Basin Planning. The Fourth Spiral Studies would bring forth the desired integrated State Water Plan of Orissa Water Resources and become a guideline for the future Water Resources Development. Rivers of the State and their Basins have been described in nutshell vide Chapter No.III, of the book.

Details of completed and ongoing projects and their benefits have been narrated in Chapter No-VI. The projects contemplated are summarized basin wise in tabular form.

11.4 Future projects (Major & Medium) contemplated

Future projects proposed in various river basins are furnished in Table 11.4 to Table 11.12.

Table 11.4 Baitarani Basin

Sl.No	Name of the Project	C.A (sqkm)	C.C.A (ha)	Irrigation (ha)		Remark
				Kharif	Rabi	
1	Jharpara	855	17500	14525	10150	(*) Bhimkund is one of the most ill-fated projects. A number of alternate proposals have been studied earlier but could not be implemented. Besides irrigation, it would have generated 345 MW of power.
2	Khairi	295	8000	8000	4240	
3	Bandhan	192	4500	4500	2835	
4	Ororai	383	10000	8300	5800	
5	Musal	370	9000	9000	4262	
6	Sita	378	5000	5000	2368	
7	Sim-Kantamuli	231	6000	6000	3333	
8(*)	Bhimukund (Rajnagar)	3418	45000	45000	25000	
9	Anandapur Barrage Project (Integrated)	8570	152000	144650	25000	
	a) Salandi ayacut	--	92000	87930	18180	
	b) Inside basin	--	6200	5681	1922	
	c) Outside basin	--	53800	53800	4898	

Source: - Baitarani Basin plan, 3rd spiral study, OWPO, April 2003, Annex.6.14.

Table 11. 5 Mahanadi Basin

Sl. No	Name of the Project	C.A sqkm	C.C.A (ha)	Irrigation (ha)		Irrigation demand (M cum)	Total demand including evapo.losses(M cum)
				Kharif	Rabi		
1	Jeera	115	4600	4140	1150	43.95	58.33
2	Lower Jonk	458	7500	6825	1275	68.44	--
3	Karandijore	67	2100	1890	525	18.78	24.77
4	Kutulsinga	83	2540	2032	889	23.26	25.48
5	Upper Bheden	311	11000	9900	4180	100.26	127.28
6	Lower Bheden	414	19000	17100	7220	171.63	224.75
7	Lambodara	328	11200	8960	--	89.61	102.81
8	Sankhabagan	279	4650	4185	2093	49.76	61.33
9	Upper Tel Dam	597	13240	10592	5296	162.47	177.66
10	Banjari nallah	240	3400	3060	1394	27.54	39.00
11	Sagada	443	18750	16875	7500	170.18	228.57
12	Upper Indra	337	7200	6480	3096	75.18	83.39
13	Lower Lanth	1131	30000	27000	9000	289.8	357.99
14	Upper Udanti	302	24000	21360	--	172.74	117.87
15	Lower Udanti	672	14000	12600	--	119.58	248.90
16	Khadago	1980	37140	34912	17827	479.66	524.56
17	Surabalijore	381	18000	16200	8100	177.2	213.21
18	Upper Tel barrage	6061	9610	7688	2403	92.76	92.76
19	Lower Tel barrage	1127	61000	54900	18300	551.82	551.82
20	Uttei-Raul	1438	26474	23827	11384	283.31	393.85
Inter Basin Water Transfer							
1	Export to Brahmani – Baitarani	--	84986	76487	--	669.30	669.30
2	Export to Rushikulya	--	71631	50142	--	508.79	508.79

(Source: - Mahanadi Basin Plan, 3rd spiral study, O.W.P.O, Dept. of Water Resources, Govt. of Orissa, Annex.3.1)

Table 11. 6 Budhabalanga Basin

Sl. No	Name of the Project	Name of the river / nallah	C.A sq.Km	C.C.A (ha)	Remark
1	Budhabalanga	Budhabalanga	461	24000	Deokund project is dropped as it comes within Similipal R.F area.
2	Sanjo	Sanjo	111	3800	

Source: - Budhabalanga Basin 3rd spiral study, O.W.P.O, Aug 2004 pp 50-51, and Annex.6.4 to 6.6.

Table 11.7 Indravati Basin

Sl. No	Name of the Project	C.A sq.Km	C.C.A (ha)	Irrigation (ha)		Irrigation demand (M cum)	Total demand (M cum)
				Khariff	Rabi		
1	Lower Bhaskel D.W	1393.2	29440	26496	1178	222.4	222.4
2	Turi D.W	421.0	12000	10800	--	66.3	66.3
3	Guntat D.W	213.1	2800	2520	--	18.7	18.7
4	Gaijori D.W	103.7	2256	2030	--	17.2	17.2
5	Angi D.W	51.8	1200	1080	--	8.7	8.7
6	Belari D.W	158.4	800	720	--	6.3	6.3
7	Bangi D.W	86.4	1600	1440	--	10.6	10.6

(Source: - Basin Planning Report, 3rd spiral study, O.W.P.O, July 2004, Annex.-3.01)

Table 11.8 Brahmani Basin

Sl. no	Name of the Project	C.A (sqkm)	C.C.A (ha)	Irrigation (ha)		Irrigation demand (M cum)	Total demand including evapo.losses (M cum)
				Kharif	Rabi		
1	Singadajore	200.0	2500	2438	--	14.2	14.2
2	Kutungmara	312.3	11000	10560	4235	73.0	88.2
3	Tikira	1048.2	115536	109759	63545	1493.3	1544.0
4	Madalia	80.0	1500	1440	578	21.1	25.6
5	Koel Barrage	170.9	10500	10238	263	54.3	54.3
6	Takua	168.0	3000	2625	--	13.3	13.3
7	Chandrinala	151.0	5000	4800	1925	31.5	36.1
8	Korapani	118.7	6800	6528	2618	42.1	46.7
9	Antasira	150.0	7200	6912	2772	44.0	51.0
10	Suidihi	62.5	2900	2828	73	13.8	15.3
11	Hinjili	155.0	4200	4032	1617	29.9	41.9
12	Mankada	312.0	9350	8976	1216	53.8	66.6
13	Barasuan	78.0	3000	2925	75	15.5	19.1
14	Kuradhi	264.2	2700	2592	--	14.6	14.6
15	Kala Dam	195.0	6440	6182	837	36.6	51.2
16	Champalijore	199.0	3965	3806	1527	25.9	37.3
17	Brahmani (lift)	--	7000	7000	6300	73.6	73.6

(Source: - Brahmani Basin plan, 3rd spiral study, O.W.P.O, Nov.2002, Annex.3.1)

Table 11.9 Kolab Basin

Sl.No	Name of the Project	Name of the river	C.A Sq.km	C.C.A (ha)
1	Lower Kolab Dam	Kolab	4351.2	31984
2	Govindapalli Interated Project a) Dharmagedda	Dharmgedda	161.6	21862
	b) Garia	Garia nallah	114.0	
	c) Jamnadi	Jamnadi	258.5	
3	Prasanpalli Dam		102.9	3644

(Source: - Kolab basin, 3rd spiral study, OWPO, August 2004 pp 18 and Annexure- 6.1, 6.2 and 6.3)

Table 11.10 Vansadhara Basin

Sl. No	Name of the Project	Name of the river / nallah	C.A sqkm	C.C.A (ha)	Remark
1	Sananadi	Sananadi	517	8000	
2	Bhangi	Bhangi	182	2000	
3	Vansadhara	Vansadhara	514	12000	
4	Pedagoda	Pedagoda	345	9000	
5	Dimur	Dimur	360	--	Sl. 5, 6, 7 and 8 for power generation and export to Rushikulya basin.
6	Badjore	Badjore	411	--	
7	Lower Harahangi	Harabhangi	966	--	
8	Nandini	Badjore	145.0	--	

Source: - Vansadhara basin- 3rd spiral study, O.W.P.O, July 2003 pp 22, Annex.6.1 and Irrigation in Orissa (1991) pp 45

N.B:- Pre-feasibility report of Lower Vansadhara Project has been prepared for providing irrigation to 31000 ha and for power generation (vide CE, PPF Report Oct.2006).

Table 11.11 Nagavali Basin

Sl.No	Name of the Project	Name of the river / nallah	C.A sq.Km	C.C.A (ha)	Remark
1	Singari	Barha nadi	194	6000	There are no major or medium projects in side the basin at present.
2	Katipada Barrage	Nagavali	866	10000	
3	Karanipadu	Ghorhanalla	38	1200	
4	Samuja	On a tributary	39	1200	
5	Narayan patana	Jhanjabati	327	10000	
6	Bhosanjhola	On a tributary	27	1000	
7	Sirikana	Sirikana	703	10000	
8	Kumarsahi	Dalkona nallah	195	6000	

Source: - Nagavali basin-3rd spiral study, O.W.P.O, Aug 2004 pp 82-85, Annex.6.1 to 6.8.

Table 11.12 Rushikulya Basin

Sl. No	Name of the Project	Name of the river / nallah	C.A sqkm	C.C.A (ha)	Remark
1	Pipalapankha (*)	Rushikulya & Adangi nallah	512	Nil	Sl.1 and Sl. 2 were mainly for industrial water supply to the proposed steel plants, which may not materialize.
2	Loharkhandi (**)	Loharkhandi & Bapangi nallah	196	146	
3	Nandini weir	Nandini nallah	136	1600	
4	Chadheiya weir	Chadheiya nallah	30	600	
5	Bont weir	Bont nallah	105	1800	
6	Bhetapali weir	Kharkhari nallah	204	3900	
7	Budanadi weir	Buda nallah	294	3700	

(*) Forest land of about 900 ha. will be submerged.

(**) Submergence of forest land of 231 ha and 246 families in five revenue villages will be affected.

Source: - Rushikulya basin, 3rd spiral study-OWPO December 2001 pp 83 and Annex 6.6 to 6.13.

11.4.1 Subarnrekha Basin

No major and medium projects are contemplated for the basin (vide Basin Planning report, 3rd spiral study, OWPO, August 2004 pp 78-79). Subarnrekha irrigation Project is the only major project under construction which has been discussed in Chapter VI.

11.4.2 Bahuda Basin

There are no potential major or medium projects in the basin in future. Only M.I (flow and lift) projects are contemplated. However extension of existing ayacut of Baghalati is under progress (vide Bahuda basin, 3rd spiral study, OWPO, March 2004 pp 21)

11.5 Interbasin Transfer

11.5.1 Need for Interlinking

Rainfall over the country is primarily orographic associated with tropical depressions originating in the Arabian Sea and Bay of Bengal. The summer monsoon is more than 75% of total precipitations. The uncertainty of rainfall marked by longer dry spells and fluctuations in seasonal and annual is a serious problem, the country experiences. Parts of Haryana, Maharashtra, Andhra Pradesh, Gujarat, Rajasthan, Madhya Pradesh, Karnataka & Tamilnadu are deficient in rainfall and subjected to large scale variations. This results in frequent droughts which cause immense hardship to the population. During summer months, drinking water is not available as the rivers dry up and groundwater level depletes. Due to extreme variations of rainfall when some parts of country faces drought situation and unable to raise even a single crop, the other part receives heavy rainfall creating flood havoc.

This necessitates diversion of surplus water from water rich zones to deficit areas for multi uses, i.e., Irrigated agriculture, drinking & industrial water supply, hydropower generation, navigation, recreation, recharging ground water table & maintaining ecological balance. These coupled with flood control & drought mitigation with regulated environmental flow in the rivers will accelerate economic growth. This practice was also followed in earlier ages.

11.5.2 Practices in Ancient Ages

Our culture, civilisation, heritage, ecology and social conditions are deeply related to rivers basins. All ancient civilisaitons have grown up on the banks of rivers and all great epics written there by sages.

In the Vedas, the earliest sacred books of Aryans, mention has been made about wells, canals and dams. In 'Rigved' four types of water sources are mentioned, viz, waters which come from the sky or rainwater, those which flow in rivers and streams, those which are obtained by digging and those which ooze out of springs (VII.49.2). In 'Yajurveda' also mention is made of canals and dams. They are termed as 'Kulya' and 'Sarasi'. Sarasi denotes a big reservoir of water as well as a lake.

'Atharvaveda' (III.13) gives descriptions of digging canals from the rivers. River is mentioned as a cow and canal as a calf. The ancient historical work mentions, an account of gigantic feat of king Bhagiratha and his engineers of diverting the course of waters of the sacred, Ganga from the altitudes of the Himalayas, towards the present Indo- Gangetic plain, the granary of India.

11.5.3 Proposal for Interlinking

During 1972, U.N. experts visited our country. In their report, they endorsed the concept of National Water Grid. The report stated that "India's national economy in its development and growth will be confronted with the problem of increasing scarcity of water within next thirty years. From basic compilation of water demands and water yields, it becomes evident that by the year 2000 or so, the National Water Grid will be a vital necessity. No time should be lost to start the very complex and difficult investigations today so that plans will be matured and prepared in due time and facilities will become operative when the need will have come". In this context, proposals formulated by Dr. K.L.Rao, Capt. Dastur and others are discussed here in brief.

i) Dr. K.L.Rao's proposal in 1972 envisaged Ganga-Cauvery link of 2640 km. long as its main component involving large scale pumping over 550 m head. This high pumping requires about 5000 to 7000 MW of power & irrigates only four million ha. No flood control benefit was included. Cost at 2002 price level was about Rs.1.50 lakh crores, CWC examined the proposal and found to be economically prohibitive.

ii) Capt. Dastur's proposal of 1977 envisaged construction of two canals i.e. first 4200 km. long Himalayan canal at the foot of Himalayan slope running from river Ravi in the West to Brahmaputra in the east and the second 9300 km. long Garland Canal covering central & southern region, with both the canals integrated to no. of lakes and interconnected with pipe lines at Delhi & Patna. The proposal was examined by experts from CWC, IIT Delhi & Roorkee and from Geological Survey of India and found to be technically infeasible.

iii) After construction of Task Force by Govt. of India, above two proposals along with few more were re-examined by Independent Group of Experts (IGE) comprising Prof. P.B.S Sharma and Prof. Subhas Chander. Other alternative proposals were: -

- National Waterways Project (NWP) – by Sri A.C.Kamraj
- Integrated Water Resource Development & Management Plan for India by Sri. M.D.Pol.
- A Path Breaking Scheme – Ganga Cauvery Multi-Purpose Project by Sri N.M.Joshi.
- Integrated Water Plan – India's Water Bowl - As National Water Grid by Sri. S.Dhawan.

After critical examination the experts concluded that 'all the proposals examined are only at conceptual stage and are not rooted in the basic tenets of the temporal and spatial hydrology of river basins, and as such, are technically unsound, incomplete and hence cannot be pursued within their present form'.

11.5.4 National Perspective Plan (NPP)

Ministry of Irrigation (Now M.O.W.R) and Central Water Commission (CWC) formulated National Perspective Plan for Water Resources Development in 1980 keeping in view the interbasin transfer from surplus to deficit basin or areas to minimize the regional imbalances and optimally utilize available Water Resources.

The broad approach was that existing uses will remain undisturbed, the agreement between the States will be honoured. Transfer of water will be mostly by gravity and where absolutely needed, water will be lifted not exceeding 120m. The plan has two components i.e. Himalayan and Peninsular rivers.

Himalayan Rivers Development proposes construction of storage reservoirs on the tributaries of Ganga and Brahmaputra in India, Nepal & Bhutan. This requires international agreement.

Peninsular rivers Development has four parts:

I) Interlinking of Mahanadi – Godavari – Krishna – Cauvery - Vaigai Rivers and building storages at potential sites.

II) Interlinking of West flowing rivers, north of Bombay and south of Tapi.

III) Interlinking of Ken - Chambal rivers

IV) Diversion of other west flowing rivers towards eastern side.

11.5.5 International Scenario

In other countries one finds numerous examples of inter-basin water transfers. The table No 11.13 shows that the ILR porgramme in general is a successful concept practised all over world to ensure usages of water in an optimal manner.

Table 11.13 ILR in Other Countries

Sl.No	Name of Country	Scheme Completed	
		Nos.	Annual Transfer of water (BCM)
1	Canada	37	268
2	Czech. Republic	6	6
3	India	7	10
4	Germany	2	1
5	Iraq	6	45
6	Pakistan	7	50
7	Australia	1	-
8	Chile	2	3
9	Japan	1	-
10	USA	49	45

11.5.6 Indian Experiences

Long distance interbaisn transfer of water is not a new concept in our county. A bright example is south India's transfer of water of west flowing Periyar to Vaigai system in east. Another successful example is Perambikulam- Aliyar project.

The Periyar Project comprises a 47 m high masonry dam across a gorge on west flowing Periyar with 1.74 km. long tunnel to convey 40.75 cumec water eastwards to Vaigai basin. It provides irrigation to 0.81 lakh ha. with 140 MW power generation. The project was commissioned in 1895.

The Perambikulam-Aliyar is a complex scheme having seven streams, out of which five flowing to west and two to east, have been dammed and their reservoirs connected by tunnels. It irrigates 1.62 lakh ha. in Coimbatore district of Tamilnadu & Chitur area of Kerala with 185 MW power.

The Kurnool – Cuddapah canal is 304 km long having 84.9 cumec capacity extending from Krishna to Pennar basin for irrigating 0.53 lakh ha.

The Telugu Ganga Project carries Krishna waters from Srisailam reservoirs through a channel to Somasila reservoir in Pennar valley. From Somasila, water is taken through 45 km canal to Kandaleru and then to Poondi reservoir in Tamilnadu through another 200 km canal.

Similarly in North India, Inter sub-basin transfers in Indus basin and Rajsthan Canal Project have been successfully implemented. A diversion dam at Pandoh 140 km upstream of Pong Dam on Beas enables diversion of water from Beas to Bhakra reservoir on Sutlej River and generates 165 MW of power. The Beas Sutlej link is 37.25 km long of which 25.45 km is tunnel through difficult rock formations.

The Rajasthan Canal diverts water from Himalayas to the deserts of Rajasthan. The project comprises of a huge multipurpose dam across river Beas at Pong, a barrage at Harike and a grand canal system.

Above projects implemented both in North & South India have not resulted in environmental degradation & no noticeable environmental damages.

11.5.7 Interbasin Transfer in the State

There are two bright examples of interbasin transfer in the state i.e. Upper Indravati Multipurpose Project and Harabhangi project. The former project comprises of four dams across rivers Indravati, Podagad, Kapur & Muran with eight dykes, two link channels and 4 km long tunnel to provide irrigation to more than one lakh ha. in drought prone areas of Kalahandi and generate 600 MW power by transfer of water from Godavari basin to Mahanadi basin. Tail race release from Power House is picked up at Hati barrage from where two canals take off i.e. Left Main Canal and Right Main Canal for irrigation. Kalahandi which was once synonymous with starvation is now self sufficient in food-grain production.

Another is Harabhangi Project in Adva village of Gajapati district. The water is diverted from Vansadhara basin to Rushikulya basin through a water conductor system leading from Harabhangi reservoir into existing natural drainage called river Padma where it is picked up through a weir at Gokulpur to irrigate 9150 ha. in Kharif and 8500 ha in Rabi in Ganjam district. (Refer 11th National Water Convention, New Delhi, 11 May 2005, pp 335-339)

Details of Indravati and Harabhangi Projects have been discussed in Chapter VI.

11.5.8 Study by NWDA

To give a concrete shape to Peninsular and Himalayan Rivers – Development Components of N.P.P for diversion of water, National Water Development Agency (NWDA) was set up in 1982 as an Autonomous Society under MOWR to carry out the water balance & other studies on scientific and realistic basis and prepare Pre-Feasibility & Feasibility Reports for link schemes. Total 30 links have been identified. Himalayan component will have 14 links & Peninsular component with 16 links. The details have been shown in the drawing enclosed. Benefits from Peninsular Component are as follows: -

i) 13 million ha of additional irrigation.
ii) 4000 M.W of hydropower
iii) Drought mitigation to some extent in A.P, Karnataka, Tamilnadu & Madhya Pradesh.
iv) Flood control to certain extent in Mahanadi and Godavari basin.
v) Facilitate inland navigation as the link canals will be 50 to 100m wide & more than 6 m deep.

As there may be delay in concluding agreements with neighboring countries for Himalayan links, emphasis was attributed more on peninsular links.

11.5.8.1 Mahanadi –Godavari Link

In the peninsular link Mahanadi (Manibhadra)–Godavari (Dowlaiswaram) link is a major link, which is critical for Orissa. The details of the scheme based on Pre-feasibility Report of NWDA are as follows.

This link envisages diversion of about 11176 Mcum of water annually from the proposed Manibhadra Dam on river Mahanadi to Godavari to serve the demands of Manibhadra Right Bank Canal, provide irrigation enroute and transfer 6500 Mcum of water to southern Peninsula to meet their deficit requirement. The water conductor system is 932 km. lined canal (including 6.30 km. long tunnel) lying in Orissa and A.P. The capacity of canal is 627 cumecs. The canal would cross major rivers like Rushikulya. Bahuda, Vansdhara, Nagavali, Champawati before joining Godavari at Dowlaiswaram barrage.

The link will irrigate 3.5 lakh ha. in Orissa in the districts of Nayagarh, Khurda, Puri & Ganjam and one lakh ha. in A.P. in Srikakulam, Vijayanagaram and Vishakhapatnam district, utilizing 3854 Mcum of water. It will discharge 6500 Mcum into Godavari after losing 822 M cum in transmission.

Manibhadra Dam Project which was contemplated earlier as an alternative to Tikerpara (vide Sec.11.2.4) could not be implemented due to submergence and R & R problem.

11.5.9 Proposed Inter-Basin Transfer in the State

Under Sec. 11.5 (Mahanadi Basin), it is envisaged to transfer flood water of river Mahanadi to Brahmani and Rushikulya basins. The proposals are virtually in inception stage. After completion of left and right canals off taking from samal Barrage to irrigate more than two lakh ha and for providing industrial water to the mega plants coming up at 'Kalinganagar', there will be scarcity of water for meeting irrigation, industrial, domestic and environmental needs. Through a flood flow canal of about 600cumec capacity, the spill waters of Hirakud dam reservoir is to be transferred to Rengali reservoir in Brahmani basin and to construct another reservoir across Garada nallah enroute where a Power House is also contemplated. The benefits likely to accrue from this link is (i) additional irrigation (ii) power generation (ii) partial flood control (iv) industrial water supply and (v) maintaining minimum environmental flow in Brahmani river.

Besides above, it is proposed to augment flow in river Rushikulya to meet growing demands of irrigation, industry and domestic water supply by transferring waters of Mahanadi either by constructing a barrage at Barmul and / or from proposed Salki hydel project. Above proposals are only at conceptual stage.

11.6 Industrial Water Demand

Annually about 1122 km^3 of fresh water is utilised in our country of which irrigation sector consumes the lion share of 83%, industry 04%, domestic uses 06%, and others 07% . But globally annual utilization of water is about 3500 km^3 of which agriculture, industry and domestic sectors utilize respectively about 69% , 23% & and 08%. Due to increase in population, urbanization and industrialization both industrial and domestic sector will consume more water at the cost of irrigation. As assessed by NCIWRDP, in 1977 water use in industrial sector was of the order of 22 BCM which may increase to almost 4 to 5 times by 2050. The industrial plants in our country consume about 2 to 3.5 times more water per unit production compared to similar plants operating in developed countries (vide 46th Technical Session, Institution of Engineers, Orissa centre Feb.20th, 2005 pp 36-37). Due to rapid stride in Industrialization in the state of Orissa, required provision has been made for the industries likely to come up by 2051 AD during

Basin Planning study. Some new major industries are proposed to be set up in Mahanadi, Brahmani and Baitarani basins which have been indicated below. After few decades, it may so happen that for the industries located nearer to the coast desalination may be preferred to meet their industrial water need.

Basin wise present and future demand is furnished in Table 11.13

Table 11.13 Basin wise Industrial Water Requirement

Sl. No	Name of the basin	Demand 2001		Demand 2051		Reference to Annexure of respective basin reports
		Cumec	Mcum	Cumec	Mcum	
1	2	3	4	5	6	7
1	Mahanadi (*)	2.80	88.39	18.40	580.26	Annex.5.27
2	Indravati	0.73	23.0	1.27	40.0	Annex.5.23
3	Brahmani (**)	10.02	315.88	25.00	786.55	Annex.5.27 & Pg.66
4	Kolab	0.65	20.34	1.20	37.90	Annex.3.1
5	Subarnrekha	0.60	18.92	1.34	42.26	Pg.62
6	Baitarani (***)	0.14	4.55	0.32	10.04	Annex.5.32
7	Vansadhara	0.04	1.26	0.13	4.10	Annex.7.12
8	Nagavali	0.07	2.21	0.16	5.05	Annex.7.12
9	Rushikulya	1.54	48.6	3.06	96.4	Annex.5.1 T- 4.5
10	Budhabalnga	0.75	23.6	1.70	53.3	Annex.5.1 (Y)
11	Bahuda	0.14	4.50	0.25	7.70	Pg.49

(*) POSCO, a South Korean firm proposes to establish an integrated steel plant of 12 MTPA near Paradeep Port for which water requirement is 3.50 cumec and IOCL needs 1.0 cumec. These figures have not been included in the demand.

(**) There is going to be an industrial hub at Kalinganagar where TATA, L & T and other industrial houses are proposing mega Projects.

(***) Mittal Steel is going to establish a 12 MTPA steel plant at Patna (Keonjhar) and will meet the requirement from Kanpur reservoir now under construction.

Industrial water allocated in to various industries from river basin of Mahanadi, Brahmani, Baitarani, Kolab and Rushikulya are respectively 26 cumec, 8.15 cumec, 0.76 cumec, 0.194 cumec and 0.155 cumec upto end of June 2007. Some more industrial houses have also applied but these are being examined.

11.7 Conclusion

Projects, likely to be implemented in future for various river basins have been indicated under Section 11.4 basing on topo-sheet studies only. These are not exhaustive as planning is an ongoing process. Due to population explosion, for meeting their food grain demand and providing drinking water, the projects which have not been considered feasible today from techno-economic considerations, may by taken up few decades hence. Some new projects may be added and few from the above list may also be deleted depending on the circumstances prevailing then. In future, B.C. Ratio, I.R.R and E.R.R may not play a vital role for selection and implementation of river valley projects. Focus will be primarily on environmental & ecological considerations, R & R issues and strong political will. Anyway, the situation is not at all grim for the State.

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Chapter XII

PROBLEMS & PROSPECTS

12.1 Environmental Issues

12.1.1 Introduction

Irrigation is the single largest consumptive use of fresh water in the world. It is linked to food production and food security. About 20% of world's agricultural land is irrigated. Irrigated agriculture accounts for nearly 40% of the world's agricultural production. Along with livelihood enhancement, the broader impacts of irrigation projects on rural and regional development are often not quantified. Beyond economic impacts, irrigation schemes also produce a series of indirect or intangible social benefits derived from the multiple use of irrigation water. Project benefits are estimated relying simply on expected crop output and not considering the use of water for horticulture, livestock, fish production and tourism etc. as well as domestic, municipal and industrial water supply.

In terms of generating employment the principal impact of dam projects-aside from the construction jobs -arises from the new productive enterprises allowed by provision of water. As with any indirect economic impact, it is important to consider not just the gross number of jobs created by a project but also whether alternative uses of project resources would have generated similar gains.

When Aswan High Dam (Egypt) was constructed, there was hue and cry regarding environmental, disaster. All manner of dreadful consequences were forecast that spelt the doom of Egypt. A quarter century after commissioning of the dam, the Executive Director of UNEP said, "There is no argument: the dam's contributions to substantially increasing food production and hydropower generation has made an enormous difference to the quality of life of the Egyptian people. And in this particular case the adverse impacts were all anticipated and plans set for addressing them, but international political situations delayed the implementation." Another opinion by Dixon et al in 1990: "The evaluation of the last 21 years since the completion of the high dam at Aswan has found that the project has had a profound impact on Egypt and the Nile. Irrigation, Power and flood control benefits have all been achieved and are large. The dam gave important protection to Egypt during the African drought and in particular, during the critically dry year of 1983. There are some who believe the dam paid for itself in that one year that was almost as bad as 1913." (Dixon, Talbot,Le Moigne, 1990). A joint American-Egyptian team studied over seven years and assessed the positive and negative impacts of the project. The conclusion was unambiguous: "the Aswan High Dam is not an ecological disaster but an economic blessing."

"It is evident that the benefits accrued from large river valley projects are so immense that they substantially outweigh the costs of immediate human and environmental disruptions. On the other hand, long-term adverse effects of not utilising the water resources would be catastrophic, due to recurrence of floods, droughts and the resulting unemployment, which further increases the backwardness in highly populated developing countries; like India. Controversy of the large versus small dams is highly unfortunate. Basic fact remains that medium and small water projects cannot substitute large water storages but can at best complement larger projects. This, too, depends upon the hydrological, geological, topographical, meteorological and regional conditions, which are entirely different in India and developed countries due to our monsoon climate.

It is to be underlined that catchment area treatment and watershed management mainly degraded due to jhoom cultivation, over grazing by unlimited cattles, unscientific farming practices and very large number of hotels at hill slopes are development projects in their own right and should be planned and executed as such independently without putting undue financial burden on river valley projects. At best, treatment of directly draining degraded sub-watersheds along the reservoir rim could be charged to the cost of the reservoir project.

In the planning, implementation and operation of projects preservation of quality of environment and the ecological balance are primary considerations. Adverse impact, if any, on the environment are minimized and off-set by adequate compensatory measures with built-in mechanism for emergency preparedness. The focus by large number of critics, media and environmental activities as it is construed at present, concentrates on what it is not, and then tries to ameliorate the negative impacts. Maximisation of positive environmental impacts should be an equally important consideration. If due care is taken right from initial stages of planning, water resources projects can contribute greatly to enhancement of environmental quality with minimal ill effects.

It is desirable that environmental aspects and the process of planning and operation of water resources projects are rightly taught at different levels of education as well as to the experts of different disciplines. Another important fact remains that participation of people is a must in the management of water. Unlike in other branches of engineering, the people are an integral part of the water management system. The community is to be made not only water conscious, but also to be integrated to participate in the planning and management of such projects and pollution prevention programmes".
(Source: IWRS, Theme Paper on Integrated Water Resources Development and Management, 2002 Pg.51)

12.1.2 Environmental Overview of the State

The State has four physiographic regions with several ecologically significant areas. Those are as follows:

i. Coastal plains-Chilika Lake and Bhitar Kanika estuarine mangrove ecosystem and adjacent coastal beach complex, which are world's main breeding area for the pacific Ridley Sea Turtle.
ii. Northern Plateau–Similipal, which has a large diversity of flora (more than 3000 species) and fauna (including the Similipal National Park and Tiger Reserve).
iii. Central Table land–Gandhamardan Hills complex, which is still unprotected, has a diversity of flora and fauna (including medicinal plant).
iv. Eastern Ghats–Mahendragiri Mountains complex which is a transitional zone between the Himalayan and Indian peninsula ecosystems is not protected as yet.

As regards environmental management in water resource sector, potential pressure may arise if careful planning and mitigating actions are not implemented, through:

a. Extensive changes in regimes due to storage and diversion, redistribution and use of water for irrigation and power generation.
b. Drainage, water logging and salinity problems in command areas particularly in the lower deltaic areas and coastal zones.
c. Conflicting priorities for water allocation (e.g., Rapid industrialization and mining activities).
d. Unnecessary heavy demands for pollution assimilation capacity by mining operation and industries in river like Brahmani and estuarine zone (e.g., Ib river lower reach and Angul, Talcher area of Brahmani.

e. Quality of river water is deteriorating with large number of municipal and industrial effluents being discharged untreated into rivers. Return flows from irrigated areas pollute river water with residual fertilizers, pesticides and herbicides. Necessity for maintaining minimum flow therefore, arise out of need to maintain water quality, river regime, maintenance of river eco-system or other public necessities.
f. Depletion of water level in aquifers due to excessive pumping of the ground water for mining and industry is detrimental to local people using ground water for domestic and irrigation purposes.

Rourkela Steel plant complex upstream of Rengali Reservoir, the mining and industrial development at Talcher and Angul downstream of Samal Barrage, where pollution assimilative capacity will be substantially reduced due to diversion of water for irrigation and industry, are environmental priorities. Further mega industrial complex coming up at Kalingnagar (near Jajpur Road) may aggravate the situation if adequate safeguards are not taken.

12.1.2.1 Environmental assessment of OWRC Project

World Bank financed Orissa water Resources Consolidation Project (OWRCP) for increasing agricultural productivity and improving planning management and development process for the State's Water Resources sector. It was a State wide programme spanning over six years from 1996 to 2002. The largest investment component was scheme completion (54%) followed by SIFT (Systems Improvement and Farmer's Turnover, 24.8%) of base cost. Balance investments were for Institutional Strengthening, (8.8%), R&R (7%), Basin planning and Environmental Action plan (3%), W.R. Research and Agricultural Intensification (2%) and IPDP (0.4%).

Under scheme completion, total 8nos. of projects were included. Those were (i)Rengali Left Canal from RD 0 to 30 km,(ii)Mahanadi-Chitrotpala Island Irrigation Project(MCIIP) (iii) Naraj Barrage as a replacement of century old anicut (like that of Hatinikund Barrage in Haryana)(iv) Badanalla (v) Harabhangi (vi)Hariharjore (vii)Upper Jonk & (viii) Baghua . In SIFT component, 18 nos. of major and medium projects were included for rehabilitation and modernization besides balance works of Ex- NWMP schemes.

While funding for the Naraj Barrage the sectoral Environmental Assessment of World Bank recommended an additional study through an international consultant 'Euroconsult' to assess how the barrage could be managed to safeguard the ecology of Chilika Lake as its fragile brackish water ecosystem was progressively deteriorating due to excessive silt deposition and reduction in salinity. Failure of old dilapidated Naraj weir would have serious flooding in Mahanadi Delta and deleterious impact on Chilika Lake. The new barrage safeguards against this risk and provides capacity for additional environmental enhancement. Accordingly, operational Rules for the new Barrage were formulated by 'Euroconsult.'

12.1.2.2 Positive and Nagative impacts of new Naraj Barrage

12.1.2.2.1 Positive impact

i) "Ensure irrigation water to 206,000 ha of fertile land in delta stage-1 command area of the Mahanadi delta, which is otherwise vulnerable to disruption in any point of time. (in the event of collapse of century old dilapidated anicut)

ii) Providing flood protection and silt reduction loading to 160,000 ha in the delta stage-II area.

iii) Ensuring regulation of floods in the Kuakhai arm to its safe bank full capacity upto a flood of 28,300 cumec in the Mahanadi at Head of delta (i.e. Naraj).

iv) Providing a management tool for the management of Lake Chilika . Upto a flood of 28,300 cumec at the Naraj Barrage the fresh water and the sediment inflow into Lake Chilika can be regulated. The operational rules of the Naraj Barrage have to be developed in such a manner that intelligent operation of the Naraj Barrage will result into the conservation of this unique ecosystem with respect to the salinity gradient and the sediment loading rates. It should be noticed that only around 50% of the fresh water inflow into Lake Chilika comes from the Mahanadi river the rest originates from the small rivers around the lake. Also the salinity gradient is further determined by the drainage cuts directly to the sea and by the width and depth of the mouth of Chilika Lake to the sea.In case the Naraj weir is not replaced by the new Naraj Barrage and the old weir collapses there will be no irrigation water in Delta Stage-I (most of the water will flow through the Kathjori Branch) and there will be extensive long term flooding in the Delta Stage-II area and there will flow too much freshwater and sediment to lake Chilika which will cause the breakdown of the Chilika Lake ecosystem.

v) Providing an alternate communication link from Cuttack to Bhubaneswar state capital and reduce traffic congestion in the National Highway-5."

12.1.2.2.2 Negative impact

"The Naraj Barrage itself has very limited, if any, adverse impacts. The adverse impacts might arise for Lake Chilika, if the operational rules of the Naraj Barrage do not take into account the freshwater needs (positive as well as negative needs) for Lake Chilika (preliminary estimates indicate that Lake Chilika needs are approximately 1,400 million cum/year of total freshwater inflow the Mahanadi river to maintain the salinity gradient as indicated by the Chilika Development Authority; these figures should be refined through a comprehensive monitoring program) An environmental study will be commissioned.executed by an international renown consultant for the development of the operational rules of the Naraj Barrage in conjunction with the existing and planed drainage cuts, in order to achieve the objectives of the Naraj Barrage, as mentioned above."

12.1.2.3 Environmental Impact of few other Major & Medium Irrigation Schemes of OWRCP

Environmental impact of Major & Medium schemes of OWRCP Environmental assessment study was carried out for the projects taken up under OWRCP by M/S Snowy Mountains Engineering Corporation (SMEC) in Mar.1995, the extract of which are as follows: (vide Table 12.1)

Table 12.1 Environmental Impact Assessment of OWRC Projects

Sl no	+ve and -ve impact of the project	Upper Jonk	Hariharajore	Badanala	Harabhangi	Baghua StageII	Mohanadi- Chitrotpola	Rengali Irrigation (upto 30 km)
A	**Positive Impact**							
i	Benefited population & area	53645nos covering 9425ha CCA	29532nos with 9450ha CCA	32364nos with 9800ha CCA	67458nos covering 9650 ha CCA	106249nos covering 8000ha CCA	19542ha CCA will get assured irrigation	53645nos covering 9425ha CCA from the sub-project
ii	Increase in crop Production	Paddy: 16034ton/yr Veg.: 13613ton/yr G.nut:1223 ton/yr	Paddy: 7076ton/yr Veg.: 5600ton/yr G.nut: 3497ton/yr Pulses: 2154ton/yr	Paddy: 15000ton//yr Veg.: 11000ton/y G.nut:2400 ton/yr	Paddy: 16000ton/yr Sugarcane : 22000ton/yr	Paddy: 3000ton/yr Ragi.: 2635ton/yr G.nut: 4000 ton/yr Pulses: 380ton/yr		Paddy: 11000ton/yrVeg. 17000ton/yrS cane: 46000 ton/yr
iii	Net farm Income	Av. farm size1.27ha Rainfed:Rs.4740.00 Irrigated:Rs18060.0	Av. farm size1.74ha Rainfed:Rs.5165.00 Irrigated:Rs25648.00	Av.farmsize2.07ha Rainfed:Rs.7558.00 Irrigated:Rs49102.0	Av.farm size1.7ha Rainfed:Rs.7400.00 Irrigated:Rs42400.0	Av.farm size1.15ha Rainfed:Rs.6005.00 Irrigated:Rs17924.0	Rainfed:Rs.12203.00 Irrigated:Rs31189.0	Av.farm size1.0ha Rainfed:Rs.5189.00 Irrigated:Rs24400.0
iv	Pisciculture etc.	SC & ST population (41%) will be benefited	22% SC & 30% ST population will be benefited	64.44% SC & ST population will be benefited	——	17% SC & ST population (19289no) will be benefited	——	In Barrage pond
v	Other benefits	——	——	——	——	——	——	Drinking water to nearby villages
B	**Negative Impact**							
a	Use of pesticide	IPM for rice to be introduced to counteract pesticide use	IPM for rice to be introduced to counteract pesticide use	IPM for rice to be introduced to counter act pesticide use.	IPM for rice to be introduced to counteract pesticide use	IPM for rice to be introduced to counteract pesticide use	IPM for rice to be introduced to counteract pesticide loading rates	IPM for rice to be introduced to reduce pesticide loading
b	Water borne disseases	Risk of incidence of Malaria	Increased incidence of Malaria	Increased malaria incidence	Risk of incidence of Malaria	Increased incidence of malaria	Risk of incidence of Malaria	Rick of incidence of malaria & water borne disease
c	Intrusion of tribal people for poaching and cutting trees	May increase, which need to be monitored	May increase	May increase	——	——	——	——
d	Submergence of Archeological monuments	A monstry and a temple of Goddess Durga will be submerged & to be persevered	——	——	——	——	——	——
e	Water logging etc.	Not anticipated	——	——	——	——	Water logging is potential –ve impact for which adequate drainage to be provided	Beyond 30 km, the environmental impact on Bhitarkanika to be investigated

For all the projects under WRCP periodic environmental monitoring and management, i.e., catchment treatment and compensatory afforestation programme have been taken up. R &R measures have been implemented as per the policy in vogue. These are also applicable for other projects not covered under World Bank assistance and similar action has been taken. Orissa's Rehabilitation Policy vis-à-vis National Policy is appended vide Annex. I, II and III. Day-by-day, people have become more conscious about ecology and environment. Many NGOs have come forward to save the environment. But 'poverty is worst polluter'. Irrigation is to be considered as poverty alleviation measure which will go a long way in improving socio-economic condition of the people consequently the environment. In this regard relevant extract from IWRS 2002 is quoted here.

12.1.2.4 Impacts of Water Storage Projects

"There are numerous incidental benefits from the construction of large dams and canal systems such as improving environment and health, afforestation, fisheries development, tourism and recreational facilities, development of agro-based industries, network of roads in command areas, development of land and improving general socio-economic standards of the people. It has been established in numerous case studies that significant improvement occurs in the food and nutritional level of the people with higher per capita food availability and diversification of crop production especially cash crops after introduction of irrigation in the area that are quite remunerative to the farmers. New employment opportunities generated by intensification of agricultural and the associated activities further improve the financial condition of the people including landless labourers. As a multiplier effect, large river valley projects tremendously improve the health of rural population by significantly enhancing the education, health care, transport facilities and the lifestyle particularly of women.

Water resource project may submerge forests, reduce downstream flows in rivers and at times lead to bio-diversity. It may noted that the loss of forest area due to submergence is less than five percent of the total forest area lost in the country in the last five decades. Loss of bio-mass through submergence is, far smaller than the biomass generated on account of the irrigation. Notably, it has been observed that a forest far superior to the original, sans the original bio-diversity, comes up after the creation of the reservoir. Adverse effects like water logging and salinity are being prevented through conjunctive use of groundwater, prevention of canal water leakage, reduction of seepage losses from water carrying bodies, implementation of adequate drainage and adoption of efficient irrigation methods along with water conservation.

Reservoir may create new condition for the growth of organism and ultimately as adjustment are made, foster new eco-systems. Varieties of new organism thrive on this new eco-lake system. Additional water made available for the dry period of the year, when the environment tends to be harsh making area inhospitable supports the growth of life around. Water resources projects provide a dependable source of drinking water. People from the irrigated areas enjoy better health and sanitation facilities, thus reducing the incidences of disease. General decline in incidences of diseases has been reported from different irrigation commands. The very availability of water leads to improvement in the level of sanitation. The improved economic status also makes people health conscious and capable of availing requisite health care.

Substantial increase in the numbers of tigers, panthers, elephants and Cheetals have been observed in National Corbett Park with the availability of green fodder and clean water through out the year and improved climatic conditions after construction of the Ramganga Multipurpose Dam Project. It is also observed that rare species of birds flock there, after the reservoir construction. Similar phenomenon of increased count in birds and wildlife has also been observed around the Rihand and Matatila reservoirs, which were previously barren lands. It is worth noting that some of the best tourist places of India like Ukai tourist resort, Periyar wildlife sanctuary, Shalimar Garden, Brindavan Garden , Pinjore and Bagalkot New Township Garden are highly attractive bye products of river valley projects in India.

New water supply facilities sourced from large dams have really improved sanitary conditions, leading to significant improvement in general health conditions. Water resources projects also provide a dependable source for drinking water. People from irrigated areas , in general enjoy better health and sanitation facilities, thus reducing the incidence of disease. Large dams help in conversion of wasteland into agricultural land and making the area greener. Indira Gandhi canal has not only transformed Western Rajasthan into vast green area but also checked the spread of Thar Desert in the adjoining areas of Punjab and Haryana. Bhakra Dam is a shining example, which has changed backward area of erstwhile –undivided Punjab into the granary of India with improved environment. The availability of water from Sardar Sarovar Project will benefit about 1.91 lakh of people residing in 124 villages in arid and drought-prone border areas of Jalore and Barmer Districts of Rajasthan which have been suffering grave hardship on account of scarcity of water, besides checking the advancement of Thar Desert.

Employment benefits of river valley projects have been widely experienced. Apart from employment benefits during construction and maintenance of projects, sizeable recurring on farm employment benefits are generated, because labour use in irrigated farming is more than in un-irrigated farming. Thus, irrigation development in a tract stems out migration of job seekers from that tract to distant centres and also brings a chain of multiplier socio-economic benefits.

India is predominantly an agricultural country, depending on monsoons during the four months of the year. Available monsoon flows are to be used judiciously to cater to various needs for the balance period of the year. This necessarily warrants construction of reservoirs to store surplus flood flows to meet various demands during lean season. Water resource development requires a judicious mix of large, medium or small reservoirs, which are location specific. In fact, the scenario of water resources development in India depicts a discrete combination of all the sizes of projects; based on the integration of techno-economic feasibility and environmental capability along with regional demands. Sustainable management of water resources with due respect to ecological, economic and ethical sustainability blended with technical feasibility requires a holistic and integrated approach involving engineering, socio-economic and environmental aspects in Indian context" (Refer Theme paper of IWRS 2002- PP 4-5).

12.1 Performance Evaluation of Water Resources Projects

12.1.1 Introduction

Large and wide spread programme of implementation of irrigation development taken up during the planned era has also created some problems concerning drainage, lag in potential created and utilized, low irrigation efficiencies etc. The past experience show that though apart of the failure can be attributed to lack of management skill and inter departmental co-ordination at various stages, major part of failure can be attributable to the deficiencies in water delivery system, large losses during conveyance and distribution, inequitable and untimely delivery of water to the fields, poor on-farm development and management, inappropriate methods of field applications etc.

With rise in cost of construction of water resources projects and pressure on land due to increase in population, attention is to be focused towards better water management with a view to find ways and means to raise productivity while minimizing the wastage of scarce water. This necessitates significant improvements in efficiency and flexibility of irrigation system. With lack of flexibility in delivery, the farmers have insufficient freedom in deciding the cropping pattern.

There is no national level assessment of over all efficiencies obtained from surface and ground water. However, in general, the overall efficiencies obtained are in order of 35-40% in surface water and 65-70% in ground water. The low productivity Indian Irrigated agriculture with irrigated yields ranging from around 1.5 to 4.0tonnes per hectare for cereal crops as compared to about 5 tonnes/ha can loosely be attributed to inefficiencies of management and improper operation of irrigation systems.

During the project planning and implementation stage, scope of the project is identified and several targets are fixed. After the implementation of the project, out of the set objectives some are achieved and some are partially achieved due to various reasons. Therefore, after completion of the project, there is always a need of monitoring and evaluation of the project objectives. It is useful for the following reasons:

(i) Impact monitoring and evaluation helps to assess whether the development objectives have been met regarding improved agricultural production,

(ii) It suggests the introduction of mitigating measures towards achieving the goal, which serves as a lesson for future projects.

(iii)Assessment of actual benefits (than anticipated during project formulation) provides justification before making investment in similar projects.

About 22% of the completed irrigation projects, suffer from one or other malady and about nine percent have a lag of more than 50% between the potential created and potential utilized. Although no project ever functions exactly as planned at the designing stage, improving performance of an irrigation system could result in agricultural productivity thereby increasing the socio-economic condition of the farmers. It is also required to know the causes of low performance so that further deterioration of existing systems and improvement in future designing of new systems could be suitably effected.

It is pertinent to discuss regarding following few projects for which evaluation has been made, viz. two major, i.e., World Bank funded O.W.R.C.P. and Hirakud, one medium (Sunei) and two minor, viz, Kusunpur and E.C. aided Projects of the State.

12.2.2. Case Study

12.2.2.1 Impact Monitoring and Evaluation of OWRCP

The study was carried out by Agricultural Finance Corporation Ltd., Bhubaneswar in June 2004 as monitoring & evaluation was explicitly stated as part of loan agreement. OWRCP was a sector investment loan aimed to improve the agricultural productivity and sustainability of States water resources sector, introduce multi-sectoral water planning, integrate farmers in irrigation management and strengthen the States institutional and technical capability in water resource development management and planning. Under physical investments, two different types of projects were considered. One was scheme completion which included completion of eight viable ongoing major and medium irrigation projects. The other was SIFT i.e. rehabilitation and modernization of 25 existing schemes.

After completion of the project period, this study was taken up to assess the current situation with and without DOWR (Department of Water Resources) intervention. In other words, the objective of the present study is to assess the impact of OWRCP regarding agricultural production, water management, income environment and other social conditions like health, education, welfare, access to portable water and poverty alleviation etc.

12.2.2.1.1 Physical and Financial Achievement

Under "Scheme completion", it was contemplated to provide irrigation to 66740 ha along with stabilization of an ayacut of 167000 ha in old Delta system. Rehabilitation of main canal and branches were completed for a length of 256.38 km against programme of 288.54 km (i.e. achievement of 88.9%). Ayacut achieved was 57400 ha. against targeted ayacut of 66740 ha (i.e.,86.09%). Funds available for this component including physical and price contingencies was Rs. 7238.53 million (excluding recurrent cost of about Rs. 1409.5million. Expenditure upto June 2003 was Rs. 6226.77 million (i.e., 86.02% achievement).

Similarly for "SIFT" component it was envisaged to irrigate an area of 266893 ha including 1, 11,317 ha of eight ex-NWMP schemes) against which achievement was 89% i.e. 237539 ha. Expenditure till end of June 2003 was 89.62% i.e. Rs. 2927.81 million.

12.2.2.1.2 Impact Analysis

a) Improved Agricultural Production:

"Agriculture is the major source of earning livelihood of the target group of population. Due to development of irrigation facility sharecropping lease holding activities have increased in the project area. Percentage of sharecroppers, lease holders/renters are more in project area villages than outside project area villages. Price of farmland has increased by 57.74% during the last five years in project areas and by 46.87% in outside project areas. Currently the average value of farmland is Rs.122839/ha in project area and Rs.83107/ha in outside project areas. This clearly reveals that development of irrigation facility due to OWRCP intervention has led to increased agricultural activity in the project areas.

As revealed from the study, paddy is cultivated in kharif season in almost 68% of the CCA of the project areas. In Rabi season, depending on availability of irrigation water in canal, farmers grow paddy. Other principal crops are green gram, black gram, groundnut and vegetables. Paddy in Kharif season and green gram/black gram in Rabi season is the usual cropping system followed in major parts of the project area.

Regarding productivity level, the study reveals that productivity of paddy has increased due to provision of irrigation facility. In case of sample farm households of project area, average yield of Kharif paddy is 2626kg/ha as against1687kg/ha in farm house holds of outside project area. This indicates that in project area yield level of Kharif paddy is 55.66% significantly more than outside project area. Project wise breakup reveals a higher percentage in SIFT sub-projects (72.06%) than the scheme completion sub-projects (50.56%). This may be due to the fact that scheme completion sub-projects are recently completed and the benefits of irrigation facility and improved agricultural production are yet to be fully observed. Similarly, the yield level of Rabi paddy is 119% more in project area than out side the project area. In case of green gram, the yield level is 360% more in project area than outside project area. This study clearly reveals that there is significant increase in yield level of major crops due to project intervention.

Prior to irrigation facility, farmers were mainly depending on rainwater for cultivation purpose. Mono cropping was followed depending on the monsoon. Paddy in Kharif season and green gram/black gram in Rabi season in the residual moisture was the cropping system followed in major parts of the project area. But after the provision of irrigation, farmers are taking double cropping in their farms. After paddy in Kharif season, other crops are being cultivated in Rabi and summer season. As a result cropping intensity has increased. In case of project area the cropping intensity is 114.13 as against only 99.97 in out side project area. Regarding project type analysis, the study reveals that in case of SIFT sub-projects cropping intensity is 34.84% more than the outside project area. On the other hand, in case of scheme completion sub-projects, the cropping intensity is more out side the project area (99.01%) and less in project area (98.66%). But as regards to cropping intensity calculated including the fallow, the scheme completion sub-projects it is 102.05% in project areas and 101.52% in outside project area. The above discussion reveals that significant increase in cropping intensity was recorded only in SIFT sub-projects. No change in cropping intensity was recorded in case of scheme completion sub-projects. This may be due to the fact that increased agricultural activities are yet to be fully geared up in scheme completion sub-projects.

Very less achievement has been made in respect of substitution of conventional paddy crop by high value cash crops in studied OWRCP sub-project areas. The data reveals that intensity of maize, sugarcane, cotton and vegetables etc. in Kharif season is less in project area than outside project area. Improvement has been made in Rabi season in which intensity of gram and vegetable is little higher in project area than out side the project area. In fact, cropping intensity of paddy, a high delta crop is significantly more in project area than out side project area. This clearly reveals that after the provision of irrigation more areas have been brought under paddy cultivation rather than the cash crops like sugar cane, cotton, maize etc. major reason being lack of remunerative market for agricultural produces. Marketing of paddy is also a problem, but major part of total production goes towards the consumption in own family."

(b) Overall Quantifiable Financial Impact of OWRCP

"In the present study, an attempt was made to estimate incremental production of paddy due to OWRCP. The analysed data reveals an incremental production of 1212.7 tons in the entire OWRCP area. Converting to this incremental production to financial terms @ Rs. 4000/ton, incremental income comes to Rs 4848.28 lakh/year. Project wise breakup indicates 88867 tons in case of yearly implemented SIFT sub-projects (Rs 3554.68 lakhs), 8303 tons in early scheme completion project (Rs332.12 lakhs) and 24036 tons in mid scheme completion sub-projects (Rs 961.4 lakhs). Once the projects have stabilized, the production from all OWRCP projects would be substantial. The project has brought positive change in health, education, women empowerment and developing a village level organization to look after irrigation infrastructure."

(c) Poverty Alleviation

"In present study poverty analysis was made following two different procedures, one based on household income and another based on food consumption. The expenditure incurred by a household to meet its domestic consumption is an indicator of economic status of the household. To know the overall economic condition of the family/person not only the income level is to be analysed, it is also extremely essential to find out the expenditure level of the family/person to get a complete picture of the economic status. In rural Orissa, Rs246 as per capita monthly expenditure on food items has been considered as the poverty line to decide the economic status of a family/person (Economic Survey 2002-03). The analysis of the empirical data collected from sample farm households on household expenditure below Rs 246/month on food item, while 73% of outside project area had expenditure below Rs. 246/month. In case the early Scheme Completion and outside project area the percentage was 72 and 75 percent respectively. Similarly based on annual household income, below poverty line is defined by Govt. of Orissa, as those families whose annual income is less than Rs11000. Early SIFT schemes had 45 percent of the cases below poverty level while 75 percent of the outside area were below poverty level. In case of Scheme Completion projects, it was 22 percent and 30 percent respectively."

(d) Sustainability of the project

Another important aspect is poor condition of Watercourses, outlets, channels etc. In fact these assets are not being maintained properly as result irrigation efficiency is getting reduced and ultimately the project output. O&M operations of above mentioned watercourses and outlet etc. are to be carried out by WUAs but very less achievement has been made in this regard.

"Lack of remunerative market for agricultural produce is one of the major problems reported in 43% of project area villages and 27% outside project area villages .Though farmers of 63% project area villages and 54% outside project area villages have access to weekly markets, these markets don't fetch good prices for agricultural produces. The volume of marketable surplus of rice is 20.41% in project areas and 9.28% in outside project areas. Cooperatives do not cater to the agricultural produces and farmers face the problem of market glut and un-remunerative prices for their produce. Under such a situation role of WUAs seems to be most important. Market linkage may be established between WUAs and traders/mill owners to fetch good prices for the farmers and avoid distress sale."

(Source: Impact Monitoring and evaluation of OWRCP, June, 2004 by Agricultural Finance Corporation Ltd., Bhubaneswar PP 94, 106,107, & 115).

12.2.2.2 Hirakud Multipurpose Project

Hirakud Multipurpose project across river Mahanadi was constructed 15km upstream of Sambalpur town during April 1948 to January 1957 for Irrigation, flood control and power generation. Partial irrigation was given during 1956. Baragarh main canal and Sasan Main canal off-take on right and left respectively to command ayacut of 1.59 lakh ha in Kharif and 1.08lakh ha in Rabi. The powerhouse is located at the toe of the power dam on the right flank with revised capacity of 331.50MW.

Performance evaluation of Hirakud project command area was carried out using satellite Remote Sensing Technique (April 2004). The conclusions of the study are reproduced here.

"Analysis of satellite data for the three Rabi seasons of 1992-93, 1994-95 and 2001-02 indicate increase in total crop area with more than 95% under Paddy crop. The crop area is consistently lower than the Rabi program in Sason and Sambalpur subdivisions.

Steady increase in area irrigated per unit of water is observed as a result of increase in crop area as well as reduction in irrigation supply. Sason Main Canal has consistently low water utilization. Steady decrease in area irrigated per unit of water is observed in Huma Tail distributary, Bhimtikra distributary and Retamunda branch commands.

Variability in paddy transplantation period is observed across the command with early transplanted paddy concentrated in Attabira and Larasara sections and late transplanted paddy concentrated in Bhimtikra and Upper Huma sections. The harvesting pattern of paddy crop cutting experiments confirms the above observations. As a result of these differences in transplantation period, the irrigation water demand is varying spatially and temporally across the command area. The transplantation variability information obtained from satellite data, which is available by mid-March, provides scope for accurate estimation of irrigation demand. Usefulness of this information in canal operations can be taken up as a pilot study in near future.

The paddy crop condition in parts of Atabira and Godobhaga Canal commands is observed to be constantly good and crop condition is poor in parts of Rampur, Barapali and Sasan subdivisions.

The performances of NWMP/WRCP distributaries show a mixed trend. A steady performance is observed in Parmanpur distributary while performance of Bargarh distributary is fluctuating. Resam distributary shows significant increase in crop area and water utilization. The performance of Bhimtikra distributary command shows a declining trend.

About 592 ha of the command area is suffering from surface water logging, which is scattered and distributed all over the command. The soils of the command area are either in saturated condition or wet for most of the time due to cyclic paddy crop cultivation in both the seasons. This results in lack of sufficient time for drying of soils, which raises salts to the surface.

12.2.2.3 Performance of Sunei Irrigation Project.

Sunei Irrigation project has been constructed across Sunei River, a tributary of river Budhabalanga in the district of Mayurbhanja at Lat. 21° 27-0" N and Long 86° 28' 0"E having gross command area of 9000 ha and cultivable command area of 7200 ha. Year of commencement and completion of the project was respectively 1976 and 1992 .The project comprises of 2277 m long compacted earth fill dam 80m long chute spillway with an objective of providing irrigation facilities to one of the most drought prone areas of Mayurbhanja having predominantly tribal population.

To assess the impact of implementation of Sunei Irrigation Project, Central Water Commission financed the proposal and entrusted to WALMI, Orissa for conducting the study during Oct.2001. The study reveals that within the framework of traditional methods of distribution and application of water, the Sunei canal system has led to improvements in farm practices and production over time. The overall socio-economic condition has improved. There has been significant improvement in levels of living of all the section of society.

The conclusion and suggestions of the study are as follows:

12.2.2.3.1 Conclusion and Suggestion by WALMI

The notable direct impact of canal irrigation has been on farm practices and production. There are changes in cropping pattern and cropping intensity. The input structure has changed in favour of purchased inputs. Some of the operations have been mechanized. There have been improvements in the overall socio-economic environment. With agricultural activity having become market oriented; the rural economy has been monetized. There has been significant improvement in the socio-economic infrastructure facilities. The agriculture sector's capacity to absorb labour has increased. It was observed that workers have shifted from other rural activities to agricultural activities to increase the rural labour force. Thus dependence of the rural working population on agriculture has increased. The wage rate of agricultural labour has increased over time and there is also improvement in working conditions. The land price has increased by ten times since the operation of canal. With development, everyone has gained though some more than others. The examination of important indicators suggests significant improvement in levels of living of all sections of the society. Overall, the impact of canal irrigation on fauna and flora has been favourable.

There has been an overall positive impact on health of population and public hygiene. There has been decrease in certain water-borne diseases due to the availability of safe drinking water after the operation of canal. However, health hazards due to careless use of pesticides may become a serious problem if the local population remains oblivious of them for long. Some urgent measures need to be taken to educate the population. Number of cases of respiratory infection in Kaptipada Primary Health care Centre has been noted, probably due to rapid urbanization in this area.

Some specific observations are shown in Table 12.2.

Table 12. 2 Specific Observations on Project Benefits

Sl.No.	Items	Pre-Project	Post Project Projection as per Project Report	Present Achievement
1	Yield	1.5 Tonne/ha	4 Tonnes/ha	2.8 Tonnes/ha
2	Land value	Rs.15314/ha	-	Rs.112879/ha
3	Cultivators	11%	-	40%
4	Drinking water	Scarce	-	Easily available

Suggestions for further improvements of benefits

The project needs following measures for furthering its beneficial impacts.

i. The beneficiary farmers should be involved in all activities of the project by formulation of Water Users associations (Pani Panchayat).

- Increase in productivity can be achieved per unit of water.
- Equity of water distribution between Head, Middle & Tail end can be effectively managed.
- Timeliness, adequacy, assured water supply can be achieved.
- The improved seeds, fertilizers, agricultural implementation can be made available through W.U.A.
- Pani Panchayat can generate marketing facilities for farm produce.

ii. Agriculture Deptt. may consider more demonstration activities and training of the farmers for better and efficient use of agricultural inputs.

iii. System Improvement: The distribution system has deteriorated due to improper & lack of timely maintenance of canal system for want of adequate O&M funding. In order to achieve full envisaged benefit of the project, it is suggested to improve the present conveyance system & restore the original design section.

iv. Dam Safety Measures: As the Head works of the project were completed since 1982 regular inspection for safety of dam is suggested every year during pre monsoon & post monsoon periods. Accordingly the project authorities should take up necessary safety measures.

v. Health Concern: The concerned Departments should identify health problem in the command area to keep watch on Health hazards that are likely to develop due to canal operation and impounding of the reservoir.

vi. Eco-tourism: The project is contiguously situated by Similipal Tiger Reserve and Kuldiha & Hadagard sanctuaries. The presence of the reserve forest and the incidence of reservoirs have mutually benefited for the preservation of eco-friendly regime of the area. The Tiger reserve forest is already a tourist attraction. Combined with the Sunei Irrigation reservoir, development of a plan of eco-tourism may be considered for the area.

(Source: Performance Evaluation of Sunei Irrigation Project by WALMI ,Orissa, October ,2001 Pp 104-106)

12.2.2.4 Post Evaluation of Kusunpur M.I.P

Post evaluation of Kusunpur Project was carried out by M/s Infratech Construction and Consultancy, Cuttack in March 1996.This is a reservoir scheme comprising a homogeneous earthfill dam of 815.5m length and un-gated 76.2m length ogee spillway to command 890ha in Kharif and 139ha in Rabi. The project was completed during 1984.

Overall condition of the earth dam and the spillway were satisfactory except the HR gate. But the distribution system was ill maintained. The major physical deficiencies are as follows:

i. Bed of the canal has been silted. Bed width does not conform to the design section,. Canal banks have been eroded.

ii. Structures have been out flanked. Some canal structures of both left and right main canals have either failed or on the verge of collapse.

iii. CR gates are damaged. In most of the outlets, there are no gates. Thus water flows through out the irrigation period. Only control is exercised through the HR gates. In the process valuable water is is being wasted and designed ayacut is not achieved.

During 1988, the earth dam has been raised by 0.60m without modifying the spillway structure. The project was designed to provide class III irrigation, i.e., 18" (457mm) of water annually.

Following cropping pattern was adopted.

Kharif:	Early paddy (65%)-	578.5ha
	Medium Padddy(35%)	311.5ha
Rabi:	Dalua (Hyv) Paddy (10%)	89.0ha
	Pulses... (5.6%)	50.0ha

Certified ayacut during the Kharif is 559ha and Rabi nil, (vide CE, No.3244 dt.09.02.95). For the year 1992-93 and 93-94, the reservoir working table was studied which shows that for the above cropping pattern, there is no dearth of water, both for kharif and Rabi. Water depth of 818mm (32") and 790mm (31") could have been provided during kharif for 92-93 and 93-94, respectively. Thus the project could have been classified as Class I Irrigation Project instead of class III as contemplated in the project planning. Further, there is water for supplying 1265mm (50") depth to89 ha of Dalua (Rabi) Paddy and 172mm (6.8") of water to 50 ha of pulses. This indicates clearly under utilization of potential created.

Crop cutting data was collected from Agriculture Department, which shows increase in the yield under project period. The same is furnished in Table 12.3.

Table 12.3 Incremental Production in Post Project Period

Sl. No	Variety(Local/ Hyv)	Yield (Kg/ha)		% of Increase
		Pre Project	Post Project	
1.	Kharif			
(a)	Paddy (local)	800	2300	187.5
(b)	Paddy (Hyv)	----	2900	
2.	Rabi			
(a)	Paddy (Hyv)	---	3500	---
(b)	Pulses	450	1000	122

Source: Post evaluation of Kusunpur MIP(March 1996) Pp 17.

12.2.2.5 Post evaluation of crop yield in Ramiala, Talasara & Kuanria Medium Irrigation Projects

Table 12.4 compares the yield rate of various crops during Pre & post project period of above mentioned three projects (Refer 'Workshop on Integrated Development of Irrigated Agriculture' East zone, 21-22 April 1994 Pg. 53)

Table 12.4 Yield Rate of Crops in Pre & Post Project Scenario

Crop	Yield rate (tons / ha)						Average yield of 3 Projects		
	Pre Project Period			Post Project Period			Pre	Post	% increase
	Ramiala	Kuanuria	Talasara	Ramiala	Kuanuria	Talasara			
Kharif paddy (local)	1.33	1.28	1.20	1.75	1.67	2.01	1.27	1.80	41.7
Paddy (HYV)	1.92	1.52	1.50	2.58	2.43	2.90	1.65	2.64	60.0
Total pady	1.63	1.40	1.35	2.17	2.05	2.46	1.46	2.23	52.7
Maize	0.8	N.A	--	1.00	N.A	--	0.80	1.00	25.0
Millet (Raji)	0.45	0.43	--	1.10	0.97	--	0.44	1.03	134.0
G.Nut	0.85	0.82	0.83	1.00	1.00	0.83	1.00	--	--
Pulses	0.42	0.41	0.50	0.63	0.54	0.60	0.41	0.59	43.9
Rabi Dalua paddy	1.65	1.72	1.81	2.78	2.63	2.90	1.73	2.77	60.1
Wheat	1.81	1.76	1.91	1.92	1.93	2.10	1.83	1.98	8.2
G.Nut	1.12	0.95	--	1.49	2.50	1.00	1.04	1.66	59.6
Mustard	0.30	0.30	--	0.52	0.40	0.40	0.30	0.44	46.7
Til	0.40	0.38	--	0.52	0.51	--	0.39	0.52	33.3
Pulses	0.48	0.30	0.40	0.69	0.50	0.62	0.39	0.60	53.8

Crop yield has been higher for all crops varying between 8% to 134% during post project period but remains far below the national average due to want of application of other inputs and inefficient water management.

12.3 Rehabilitation and Resettlement

State did not have any unified R & R policy for the oustees of irrigation project. For the first major project Hirakud, policy followed was to pay full compensation for the lands and properties acquired. The displaced persons were free to resettle in Govt. sponsored colonies. Reclaimed lands were provided to them at a subsidized rate of Rs.213.0 per acre without any limit. Cost of reclamation was Rs.500.0 per acre. In the colonies, amenities such as school, roads, community houses, well and tanks etc. were constructed entirely by Govt. (vide Irrigation in Orissa, by A.K.Dalua, Dec. 1991Pg.161).

Due to agitation by submerged area people, for Rengali Dam, the policy adopted was better than that of Hirakud. Two main improvements were as follows; i.e., (a) lands for resettlement in Govt. sponsored colonies were provided free of salami. Displaced land less families were also entitled for this benefit, (b) displaced persons who wanted to make their own arrangements instead of land allotted to them by Govt., were free to do so and were given rehabilitation, assistance in form of cash which were amended several times. Again the policy has been revised during 2006 (vide Orissa Gazette No 21392-R.Reh.149/06 –R & DM Dt.06-06-2007. In the present scenario, the R & R of the Project affected persons should be taken up first before commencement of the headworks.

12.4 Organisation for Development of Irrigation, Drainage and Flood Control

Orissa became a separate province on 1st April 1936. Feudatory States merged with the province during 1949 after the country gained independence on 15th August 1947. Prior to that during British rule canal irrigation in Mahanadi Delta (Stage-I) and Rushikulya Canal system were taken up which were major contribution in the field of Water Resources Development, (vide chapter-V of this book). Construction of these works was done by British Engineers. In Feudatory States some irrigation Development (Refer Chapter IV) had also taken place in a small scale in which both Indian and British engineers were associated.

Before independence, the development works were looked upon by one Chief Engineer posted in Bengal. But after 1947, one Chief Engineer under the administrative control of Works Development looked after entire development works of the State. During 1958, C.E (Irrigation) post was created for the first time to look after irrigation works and flood management.

In 1962, the Works Department was bifurcated into two Administrative Department, i.e., Works Department and Irrigation & Power Department. Under I & P Dept. there was one C.E to look after overall development of irrigation and F.C and two Addl. C.E., i.e., one to look after works and the other Design. Besides one post of C.E, Rural Engineering Organisation (R.E.O.) was also created under R.D. Department (1962) for construction & maintenance of (i) Rural roads (ii) Public Health Centers (P.H.C.), Revenue buildings under Tahasils and Blocks and (iii) Minor irrigation projects.

Under I & P Department new posts were created, abolished or redeployed. This is a continuous process and will go on in this fashion. In 1967, post of Addl. C.E, Design was abolished but during 1972-73, one Addl. C.E post was created for Rengali and Bhimkund Projects. In 1978, Orissa Construction Corporation was established to take up construction works of major, medium irrigation projects including bridges, and headed by Managing Director in the rank of Chief Engineer. With commencement of works of Balimela Dam Project, one post of Addl. C.E was created.

During 1980-81, R.E.O. was bifurcated into (i) Minor Irrigation and (ii) Rural Roads Organasation. Minor Irrigation (M.I) came under R.D. Department from March 1990 and finally to W.R. Department since 1996.

In 1982, the post of Chief Engineer was upgraded to Engineer-in-Chief (E.I.C.) and Addl. C.Es to Chief Engineer. Subsequently, C.Es for Upper Indravati Project, Mahanadi & Birupa Barrage Project, Rengali Irrigation Project and Design were created in between 1983 to 1988.

During 1990, Power portion was separated from I & P Dept. leaving exclusively Irrigation. In the same year C.E.s for WALMI, Potteru Irrigation, Planning and another for Upper Indravati Irrigation were created. Another post of E.I.C. for Planning and Design was created in 1993.

Govt. of Orissa availed World Bank loan for completion of incomplete major & medium Projects and for system improvement, which is known as Orissa Water Resources Consolidation Project (OWRCP). As per Bank's guide line there was restructuring of Irrigation Department, which was renamed as Dept. of Water Resources (DOWR). The overall objectives of re-organisation were as follows:

- Broaden DOWR's responsibilities to include technical responsibility for basin planning and created a State Water Resources Board for multi-sectoral decisions regarding water planning and allocation.
- Create functionally specialized line units for each key functional responsibility of new DOWR.

- Create specialised corporate management and personal management & training.
- Decentralise management along river basin lines including substantial transfer of decision making to field managers.
- Create Institutional capability for implementing water sector related R & R and environmental management.

Restructured organisation of DOWR during OWRCP period and the present organisation scenario are shown in **Fig 12.1 and 12.2,** respectively.

12.5 Constraints

12.5.1 Poor Infrastructure

During 1994, the World Bank rightly pointed out, "the adequacy of infrastructure helps to determine one country's success and another's failure- in diversifying production, expanding trade, coping with population growth, reducing poverty or improving environmental conditions." In modern society, infrastructure plays a decisive role in determining the overall productivity and development of a country's economy, as well as quality of life of its citizens.

Irrigation is considered as one of the most important infrastructures. It is also critical and vital input required for agricultural production as irrigation facility enables the farmers to use other yield enhancing inputs like HYV seeds and chemical fertilizer etc. Irrigation facility in Orissa is relatively less when compared to many other states vide (Table 12.4.) even though abundant water resources available. Therefore, there is urgent necessity to extend irrigation facility to un-irrigated areas, which has been discussed in Chapter XI.

Table 12.4 Comparative Yield of Food Grain inVarious States

Sl No.	State	% of net area irrigated to net area sown (2000-01)	Fertilizer use per unit of gross cropped area kg / ha (2002-03)	Yield rate of rice qntl/ha (2002-03)	Yield rate of food grain(qtl./ha)2002-03	% of share of food grain production to all India (2002-03)	Length of road per 1000sq.km of area (in km) 1998-99	Railway length in km per 1000sqkm of area 2001-02
1.	Orissa	33.16	39.00	15.11	7.06	2.04	1447	14.90
2	Andhra Pradesh	40.74	128.44	30.09	16.94	6.12	653	18.94
3.	Bihar	48.74	87.15	15.16	14.93	5.90	950	36.41
4	Madhya Pradesh	28.20	36.44	10.03	9.48	5.59	663	15.76
5	West Bengal	43.45	122.23	25.04	23.74	8.91	893	41.48
6	Uttar Pradesh	72.76	126.51	21.87	20.29	20.85	1185	29.14
7	Gujarat	31.55	77.76	18.91	11.27	2.08	476	27.09
8	Haryana	83.89	152.79	27.49	31.00	7.08	653	35.01
9	Punjab	84.47	174.99	36.94	38.32	13.49	1282	41.74
10	Maharashtra	16.78	73.80	18.50	8.46	6.21	1241	17.74
11	Rajasthan	30.93	10.33	16.53	8.75	4.32	412	17.22

Source: Economic Survey (2005-06), Govt. of Orissa Annex-21.2

ORISSA W.R.C.P ORGANISATION STRUCTURE OF DOWR

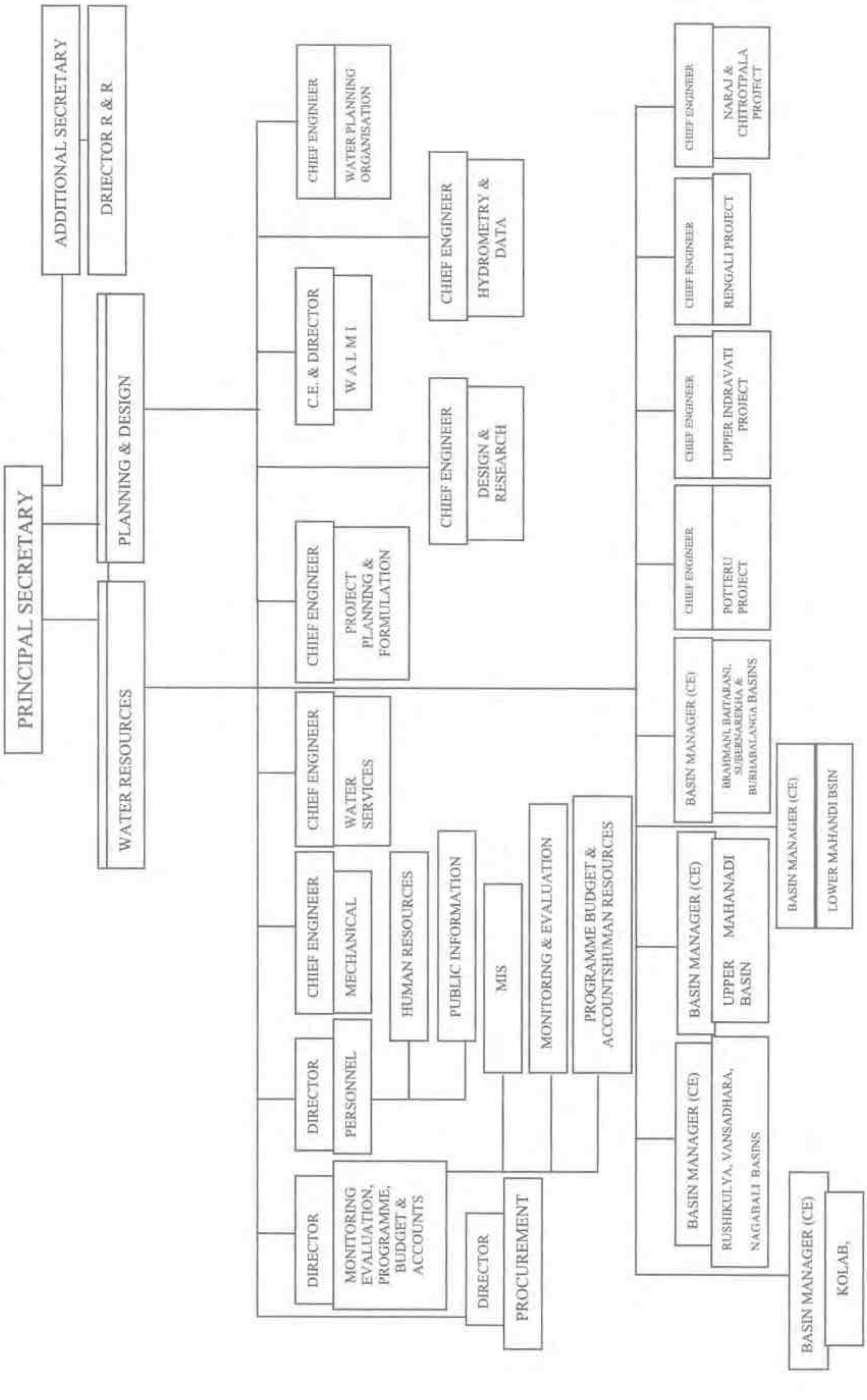

Fig 12.1

PRESENT ORGANISATION STRUCTURE OF DOWR

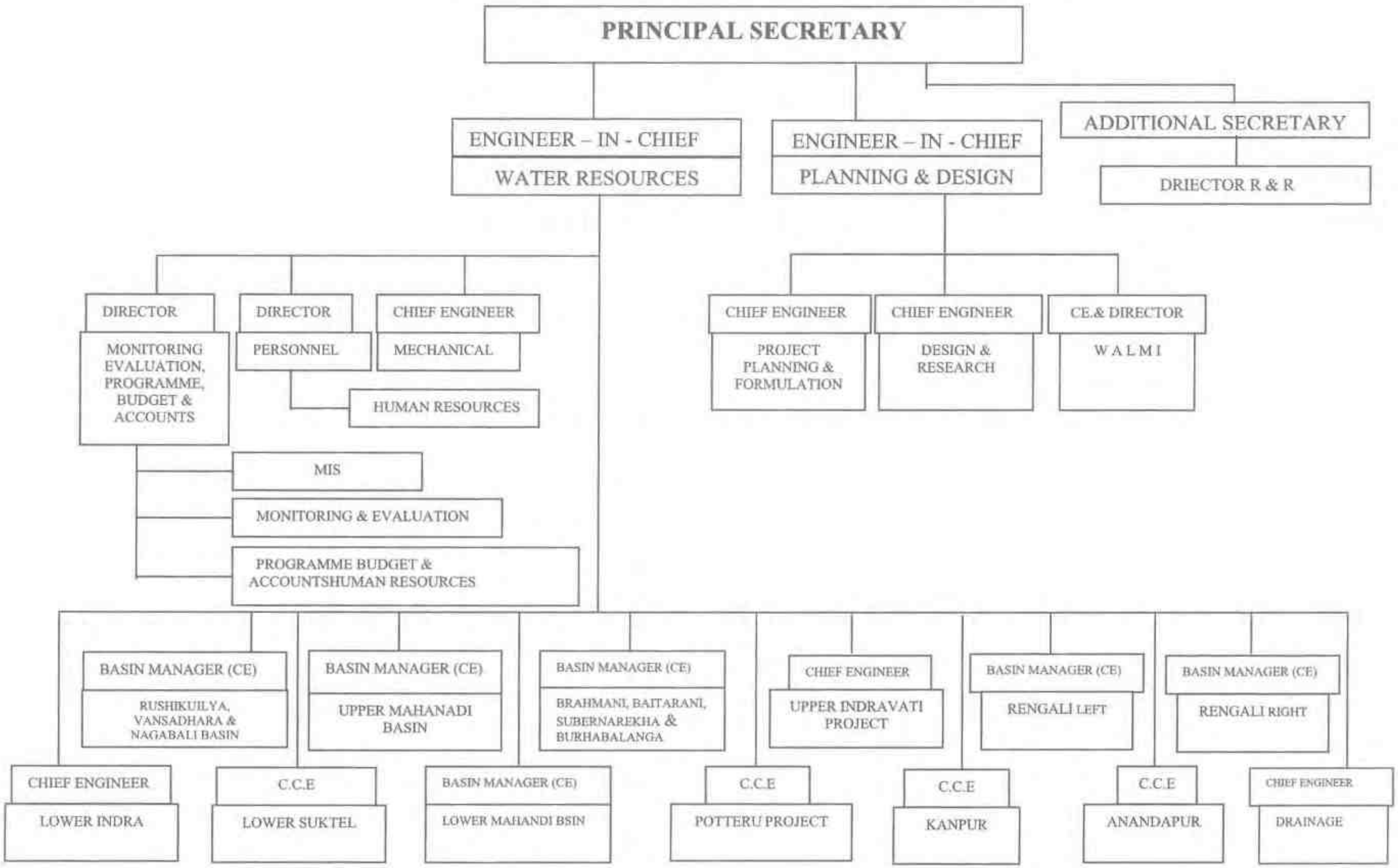

Fig 12.2

12.5.2 Performance in Agriculture

Orissa's Geographical area is almost 4.74% of India and its population as per 2001 census is 3.57% of country's population. The state is rich in mineral resources and has abundant water resources. It can be seen from the Table 12.4 that States contribution to Country's food grain basket is meager 2.04%

Table 12.5 shows state and region-wise analysis of levels of yield and compound growth rate that average value of crop yield is highest in the southern part of India followed by N-W region, Eastern and Central region. For the triennium ending 1992-95, the average value of the yield is highest for Kerala and then in descending order are Tamilnadu, Punjab and Haryana.

Table 12.5 States and Region–wise Average Yield & Compound Growth Rates of Crops (At 1990-93 constant prices)

Sl no	States/ Regions	Average Value of yields (Rs / ha)				Annual compound growth rate (%)			
		1962-65	1970-73	1980-83	1992-95	1970-73 over 1962-65	1980–83 over 1970-73	1992-95 over 1980-83	1992-95 over 1962-65
1	Orissa	4114.37	4072.70	4374.84	5979.16	-0.13	0.72	2.64	1.25
2	Assam	5727.97	6241.20	6906.69	8196.82	1.08	1.02	1.44	1.20
3	Bihar	3679.55	4009.73	4048.56	5678.08	1.08	0.10	2.86	1.46
4	West Bengal	5074.57	5614.56	5943.81	9958.45	1.27	0.57	4.39	2.27
I	**Eastern Region**	**4338.30**	**4671.31**	**4944.00**	**7318.50**	**0.93**	**0.57**	**3.32**	**1.76**
5	Haryana	3927.21	5090.01	6229.13	10128.73	3.30	2.04	4.13	3.21
6	Himachal Pradesh	3048.15	3733.76	3917.69	5195.63	2.57	0.48	2.38	1.79
7	Jammu & Kashmir	2986.95	4481.40	5758.75	5567.01	5.20	2.54	-0.28	2.10
8	Punjab	5395.62	7476.29	9707.65	13597.22	4.16	2.65	2.85	3.13
9	Uttar Pradesh	3970.10	4589.98	5805.13	8656.20	1.83	2.38	3.39	2.63
II	**North-west Region**	**4092.75**	**5024.54**	**6422.63**	**9582.50**	**2.60**	**2.49**	**3.39**	**2.88**
10	Gujarat	3673.01	4326.57	5693.43	7460.09	2.07	2.78	2.28	2.39
11	Madhya Pradesh	2603.49	2835.86	3069.65	4773.12	1.07	0.80	3.75	2.04
12	Maharastra	2898.61	2343.57	3794.68	5176.94	-2.62	4.94	2.62	1.95
13	Rajasthan	1740.45	2217.10	2334.77	3715.22	3.07	0.52	3.95	2.56
III	**Central Region**	**2653.78**	**2763.12**	**3464.09**	**4943.84**	**0.51**	**2.29**	**3.01**	**2.10**
14	Andhra Pradesh	4064.96	4363.05	6276.23	9390.64	0.89	3.70	3.41	2.83
15	Karnataka	3207.56	4267.23	4989.92	6969.70	3.63	1.58	2.82	2.62
16	Kerala	11375.65	12957.56	12333.85	15625.96	1.64	-0.49	1.99	1.06
17	Tamil Nadu	6689.49	7899.75	8756.47	14073.94	2.10	1.03	4.03	2.51
IV	**Southern Region**	**4873.34**	**5872.68**	**6848.20**	**9990.63**	**2.36**	**1.55**	**3.20**	**2.42**
	All-India	**3738.19**	**4256.79**	**5090.42**	**7388.05**	**1.64**	**1.80**	**3.15**	**2.30**
	C.V (%)	**56.86**	**58.19**	**48.12**	**46.30**	**91.34**	**85.20**	**39.05**	**29.26**

Note: 1. Average yield = (value of output of 43 crops/area under 43 crops)

(Source: Calculated from Govt. of India, Area and production of principal crops in India(various issues), Ministry of Agriculture, New Delhi, Bhalla, G.S. ed Gurmail Singh,(2001) Indian Agriculture: Four Decades of Development, New Delhi: Sage, Pg,24-25, Orissa Development Report, Planning Commission, 2002 Pg. 109).

For Orissa, the average value of yield was only Rs.5979.00/ha, whereas it was Rs.15626/ha for Kerala. As regards annual compound growth rate of yield over the period 1962-92, it is computed to be the highest for N-W region followed by Southern, Central and Eastern region. A State-wise comparison reveals that the percentage annual compound growth rate is the highest for Haryana (i.e., 3.2%) followed by Punjab and AP. In Orissa, it is only 1.3 against all India average of 2.3%.

Orissa's economy is characterized by high level poverty caused by unemployment and underemployment. But the recent phenomenon is growing joblessness amongst the educated mass. This necessitates for appropriate investment to create employment opportunities. But being an agrarian economy, it is important that the State needs to emphasize on agriculture, irrigation, flood control, drainage improvement and agro-based industries to reduce the burden of unemployment in vast unorganized sector both as short term and long term measures. Table 12.6 shows the percentage share of sectoral allocation of plan outlay on agriculture. (Refer: Orissa Development report 2002 Pp 133)

Table12.6 Percentage Share of Sectoral Allocation of Plan outlay on Agriculture

Sl no	Development Sector	Percentage of Share								
		4th Plan (1969-74)	5th Plan (1974-78)	Two Annual plans (1978-80)	6th plan (1980-85)	7th Plan (1985-90)	Two Annual plans (1990-92)	8th Plan (1992-97)	9th Plan (1997-2002)	10th Plan (2002-07)
					Orissa					
1	Agriculture & Allied Services	18.65	14.89	22.01	6.01	7.02		7.49	3.75	4.2
2	Rural Development	16.16	15.67	13.59	9.02	7.45		4.05	5.61	4.7
3	Irrigation and flood Control	45.70*	57.28*	51.01*	31.33	25.78		30.79	22.59	21.0
4	Others	19.49	12.16	13.39	53.64	59.75		57.67	68.05	70.1
5	Total	100	100	100	100	100		100	100	100
					India					
1	Agriculture & Allied Services	14.7	12.3	16.4	5.8	5.8#	5.85#	5.2	4.9	
2	Rural Development	1.5**	1.5**	2.1**	5.5	7.0#	6.75#	7.9	8.7	
3	Irrigation and flood Control	8.6	9.8	10.6	12.5	7.6#	6.65#	7.5	6.5	
4	Others	75.2	76.4	70.9	76.2	79.6#	80.75#	79.4	79.9	
5	Total	100	100	100	100	100	100	100	100	

* Included power Sector also

* *Figures represent Village and SSIs also

Figures are actual instead of outlays

Source: Govt. of Orissa, Economic Survey (Various Issues), Govt. of India, Economic Survey, 2000-2001

12.5.3 Reasons for Low Productivity

12.5.3.1 Low Application of Critical Inputs

Orissa is one of the most agriculturally backward states of India. Agricultural productivity in Orissa is quite low due to traditional farming practices, low use of yield stimulating inputs like HYV seeds, chemical fertilizers, organics manure; uneconomic size of operational holding, incidence of high tenancy, low capital formation and investment in agriculture, inadequate rural infrastructure and services and inappropriate policy environment .An inter–state comparison of yield and input use reveals that in the agriculturally progressive states like Punjab, Haryana and A.P. the use of chemical fertilizer is significantly higher in comparison to Orissa (Table 12.7). The application of fertilizer per hectare in case of Orissa in the year 2002 was only 39.0 kg/ha, whereas in Punjab, Haryana and A.P. it was nearly175kg, 153kg and 128kg, respectively. Also, percentage of gross cropped area irrigated was markedly higher in agriculturally advanced states like Punjab(84 percent) Haryana (84percent) and A.P. (41 percent).Thus the low application of two important yield enhancing inputs like irrigation and fertilizer are considered to be the most immediate and important determining factors responsible for low agricultural productivity in Orissa. Yield rate of different crops in the State along with other States for 2002 -03 is given in the Table 12.7.

Table 12. 7 State wise Yield Rate of Various Crops

States	Yield rate of different crops (kg / ha)												
	Rice	Wheat	Jowar	Bajra	Maize	Gram	Arhar	G.nut	Must ard	Cotton	Jute & Mesta	S. Cane	Potato
West Bengal	2463	2189			1996	781			805		2396	65708	19761
Uttar Pradesh	1836	2596	881	1277	1101	893	910	662	895			59292	22962
Andhra Pradesh	2621		926	711	2825	979	347	558		230	1360	65756	
Punjab	3510	4200			2039				909	410		60325	20576
Tamil Nadu	3350		962	1348	1677		636	1784		305		105778	17756
Bihar	1386	1903			1682	964	1064		642		1217	24593	9826
Orissa	**759**	**1359**	**520**	**484**	**1123**	**619**	**643**	**1194**	**275**	**287**	**819**	**60150**	**9937**
Assam	1471	1129							497		1765	36353	7813
Karnataka	1938	648	735	459	2164	538	471	648		159		84361	3078
Chhatisgarh	702					615							
Haryana	2724	4053	195	893		745			1147	340		44444	19000
Maharashtra	1213	1295	808	741	2004	564	733	1041		158	324	61795	
Jharkhand	1430	1625			1799		1511						
Gujarat	1241	1966	780	965	1706	503	630	539	1072	175		69351	21788
Madhya pradesh	620	1392	946	758	1765	720	643	635	687	118		39545	12269
Kerala	2230												
All India	**1804**	**2618**	**769**	**610**	**1642**	**728**	**653**	**733**	**866**	**193**	**1968**	**64562**	**17321**

Source: Orissa Agricultural Statistics (2004-2005), Directorate of Agriculture& food production Pp. 34

12.5.3.2 Crop diversification

Crop diversification in agriculture aims at promoting high valued crops, which are less water intensive, and more labour intensive. Further promotion of rural agro-based industries should be particularly emphasized for higher growth with greater absorption of unskilled and semiskilled labourers. Production of high value crops and products in the State is given in Table 12.8, which do not meet its own requirement. Therefore fruit, fish, flower, vegetables and pulses etc. are imported from other States.

Table 12.8 Production of High Value Crops of the State (Million tonne)

Year	Sugar cane	Cotton('ooo bales)	Fruits	Vegetables	Milk	Egg (million)	Fish
2000-01	2.10	65	1.28	8.09	0.87	730	2.59
2001-02	1.89	55	1.36	7.39	0.93	858	2.82
2002-03	1.51	50	1.54	7.10	0.94	909	2.89
2003-04	1.81	88	1.26	7.19	0.99	931	3.07
2004-05	2.32	111	1.40	7.96	1.28	1215	3.15

Recently due to increase in demand for flowers, floriculture is being encouraged. Table 12.9 presents the area and production of different floricultural crops during 2003-4 & 2004-05. This is, no doubt, a good beginning.

Table 12.9 Area & Production of Floricultural Crops

Year	Marigold		Rose		Gladioli		Tuberose	
	Area (ha)	Production (Qntl)	Area (ha)	Production (Qntl)	Area (ha)	Production (Qntl)	Area (ha)	Production (Qntl)
2003-04	194.64	14581	41.62	92.19	11.37	1136800	33.62	540
2004-05	221.05	16599	46.14	98.63	12.07	1205960	34.92	555

Source: Economic survey 2005-06, Government of Orissa, Pp 4/10

In the State food grains account for a major proportion of gross cropped area (vide chapter II, Table 2.19) i.e. about 90 percent. Only ten percent of the gross cropped area are under cash crops, which include oil seeds, fibre crops, plantation crops and vegetables. Instead of diversification in cropping pattern i.e. cultivating remunerative cash crops, farmers mainly grow only rice for domestic consumption but not for the sale in the market. Subsistence farming is pervasive. This is due to the reason that agriculture is not commercialized. It can also be seen from Table No.2.20 that cropping intensity is low (i.e. varying between 135 to 152%).

Crop diversification methods like crop rotation, mixed cropping and double cropping have been found successful in many situations. The major advantages of these types of diversification include reduced erosion, improved soil fertility, increased yield, reduction in need for nitrogen fertilizer in the case of legumes, and reduced risk of crop failure. Diversity of crop varieties can enhance the stability of yield and result in water saving. These can be achieved through efficient agricultural extension services, which will improve the overall economic condition of the farmers in the State.

12.5.3.3 Distribution of Operational Holdings

The size-wise distribution of operational holdings given in Table 12.10 shows that during 1991-92, eighty-four percent of farm operators belonged to marginal farmer and small farmer categories i.e., cultivating less than two ha of land. Though they constitute 84% of operational holdings, they cultivate on 52% of area where as large farmers having more than four ha constituting about four percent operate on 20% of area. This indicates skewed distribution of land. Again, the holdings are scattered and fragmented.

Table 12.10 Distribution of Operational Holdings

Size of operational holdings (ha)	% of operational holdings				% of operational area			
	1961 -62	1971 -72	1981 -82	1991 -92	1961 -62	1971 -72	1981 -82	1991-92
Less than 1.01	39.42	54.52	54.45	59.99	6.97	18.60	17.02	22.09
1.01-2.00	22.92	25.78	26.11	24.34	12.51	27.32	26.48	30.16
2.01-4.00	19.65	13.90	14.08	12.02	20.73	27.06	26.16	27.87
4.01-10.00	13.66	5.25	4.63	3.36	31.04	21.56	17.84	16.20
Above 10.00	4.35	0.55	0.73	0.29	28.75	5.46	12.50	3.68
All sizes	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Orissa Development Report, Planning Commission, Govt. of India (2002) Pp125 and N.S.S. Reports.

During 1990-91, the operational land holding in the State was only 1.34ha where as in Punjab and Haryana it was respectively 3.61ha and 2.43ha. While the number of marginal and small holdings are more or less the same with all India figure, the operational area under marginal and small holdings in the State is much higher i.e. 47% against country figure of 32%.Besides smaller land holdings, the farmers of Orissa are extremely poor and resource less. That is why; they are unable to invest in costly inputs like HYV seeds, chemical fertilizer, mechanized farm implements and pump sets etc. Even when they avail loan from the banks and money lenders for procurement of various inputs, there is high risk in production. In addition to lack of infrastructures like inadequate storage godowns, cold storage, transport and marketing facilities. Thus resource less farmers of the State are not in a position to adopt cultivation of high yielding varieties of crops with modern practices of production.

12.5.3.4 State Agriculture Policy

Agricultural policy of the State must take into account the population growth and their food requirement. In 1901, Orissa population was 103 lakhs, which has now become 368 lakhs (as per 2001 census). This may swell to about 425 lakhs in 2021 Projected future agricultural requirement is furnished in Table 12.11.

Table 12.11 Existing Status and Future Agricultural Requirements

Sl no	Item	Existing Status		Future Requirements		
		1995-96	1998-99	2001-02	2011-12	2020-21
A. Production (lakh tonnes)						
1.	Rice	62.26	53.90	83.08	98.88	115.24
2.	Total Cereals	67.29	57.67	90.30	107.48	125.25
3.	Total Pulses	11.94	6.10	7.00	8.59	10.26
4.	Total edible oil seeds	8.55	4.54	10.67	14.55	18.80
5.	Vegetables	64.57	39.97	16.38	26.81	38.45
6.	Fish and Meat	2.89	--	4.56	6.64	10.71
B. Others						
7.	Yield Rate of Rice	1375	1212	1760	1988	2148
8.	(i) Area under rice	45.29	44.47	47.20	49.80	53.63
	(ii) Area under major Pulses (Green gram, Black gram, Arhar)	15.45	--	18.45	21.32	24.85
	(iii) Area under major oil seeds (Ground nut, Mustard, Seasum and Niger)	10.77	--	12.42	14.75	17.68
9.	Fertilizer use					
	(i) compound growth rate (CGR)	14.7	--	17.5	7	3.6
	(ii) Nutrient Use (kg/ha)	35	46	66.5	134	191
10.	Seed Requirement (Tonnes)					
	(i) Rice	19998	---	44,249	46,690	50,288
	(ii) Total pulses	874	--	4,221	7,874	12,156
	(iii) Total oil seeds	6,721	--	6,602	15,006	28,402
11.	Total crop loan and Investment Credit (Crores Rs.)	--	--	2100.16	5906.82	11614.54

Source: Mitra G.N. (2000), Vision 2021 for progressive Agriculture in Orissa, Yojana, Vol. 44

The main objectives of State Agricultural policy (1996) are as follows:

- To extend irrigation facilities to 50% of CCA through completion of incomplete irrigation projects and promotion of individual and group enterprise.
- To enhance the status of agriculture from subsistence one to profitable & commercial venture.
- To make agriculture main route for poverty eradication.
- To adopt integrated programmes for problem soil, such as waterlogged areas, areas with soil erosion, dry and rain-fed areas, areas under shifting cultivation, waste land, saline and alkaline soil etc.
- To establish agro-based industries and food processing industries.
- To be self sufficient in the production of fruits, flowers, vegetables, potato, onion, milk, egg, fish and meat.
- To increase areas under tea, coffee, rubber, cashew and other plantation crops.
- To promote private enterprise in marketing of agricultural products and to reorient agriculture towards export.

The policy is under revision keeping the National Agricultural Policy in view.

For achieving the desired level food production keeping in mind the dietary requirement, it is needed to raise GCA and cropping intensity, which in turn, depends on increasing irrigation potential and other infrastructures.

12.6 Research Activities

Research activities in the field of irrigation, drainage and flood control have to keep pace with latest technological development and have to be accelerated with the expansion of the development programme. At central level, research activities are carried out by Central Water and Power Research Station (CWPRS) at Pune, Central Soil and Material Research Station (CSMRS) at New Delhi, National Institute of Hydrology (NIH) at Roorkee and State level irrigation institutes. Besides infrastructure facilities are available at the National Institutes viz. IITs, NITs, Water Technology Centre, CGWB and some of the leading Agricultural Universities.

National Conference of Irrigation and Water Resources Ministers of States and U.T.s held in July 1986 recommended an allocation of one percent of the capital investment earmarked for Research so that research facilities could be expanded to find out technically sound and economic designs for water resources structures.

The major research activities of CWPRS, Pune include model testing, basic research and evaluation of economic designs for ensuring safety and operational efficiency of river valley projects. CSMRS conducts basic and applied research and provides advice in the field of geo-mechanics and constructions services to both Central and State Govts.

WALMIs under State Govts. and Water Resources Center in some Universities undertake action research on the live systems and adoptive trials on the farmer's field for improved water management.

In Orissa, fundamental and applied research in water resources sector should emphasize particularly on water management, water logging, river training works, coastal protection, economic design and new methodology for faster construction.

12.7 Concluding Remarks

Keeping in view the importance of agriculture in creating employment, generating income, ensuring self-sufficiency in food production, the allocation for agriculture and irrigation in the total plan outlay need to be enhanced. Emphasis should be laid on providing appropriate rural infrastructures and services. Irrigation facilities are to be extended to uplands covering dry land and rain-fed areas giving priorities for completing the ongoing schemes. Ground water development should be encouraged (as ground water exploitation is relatively low in the State) by providing subsidized credit for construction of wells and tube wells, and also for purchase of diesel or electric pump sets. Other infrastructures like rural road, transport, power supply, marketing and storage facilities need to be improved. Agricultural credit may be extended to the small and marginal farmers in time and as per their requirement. For better recovery of crop loans, group lending may be encouraged. Effective extension services must be provided to the farmers. Agricultural inputs like quality seeds; chemical fertilizer and pesticides may be made available to the farmers in time and as per their requirement at reasonable prices. It is most important that all the inputs should be supplied to the farmers under one roof and through single window, so that transportation costs would be minimized. Farmers are to be motivated to undertake joint farming and to form water user groups (Pani Panchayats) for efficient, equitable and sustainable management of irrigation system and watershed. Micro-financing through formation of self-help groups may be given due importance. The coverage of crop insurance needs to be extended.

A stanza written by a Tamil poet is relevant here whose English translation reads as follows:

"Let not rain fall; Let the seas and the rivers dry up; Let there be famine every where; Let not each do his respective duty in the world; Even if all these adverse circumstances happen at the same time, only if the peasants do their duty, water their crops from wells by means of a semi mechanical device the crops will grow and there will be no hunger in the land".

As the agriculture is at the threshold of commercialization after liberalization and globalization, there is immediate need to shift from routine cultivation of paddy (monoculture) to newer cropping system to meet the ever increasing demand of pulses, oil seeds, fodder, fiber, fuel, spices, vegetables, medicinal and other commercial crops, and make agriculture an attractive and profitable business for which irrigation will play a vital and crucial role.

With an iron will and pragmatic approach of engineers, scientists, administrators and politicians, it is definitely possible to increase the agricultural growth to about 4.5% as envisaged in all India target for the Eleventh Plan (2007-12). This will not only reduce poverty but will bring smiles in the faces of millions. Lastly:

"Sarve Bhavantu Sukhino
Sarve Santu Niramayah
Sarve Vadrani Pashyantu
Ma Kaschit Dukhabhagbhavet"

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