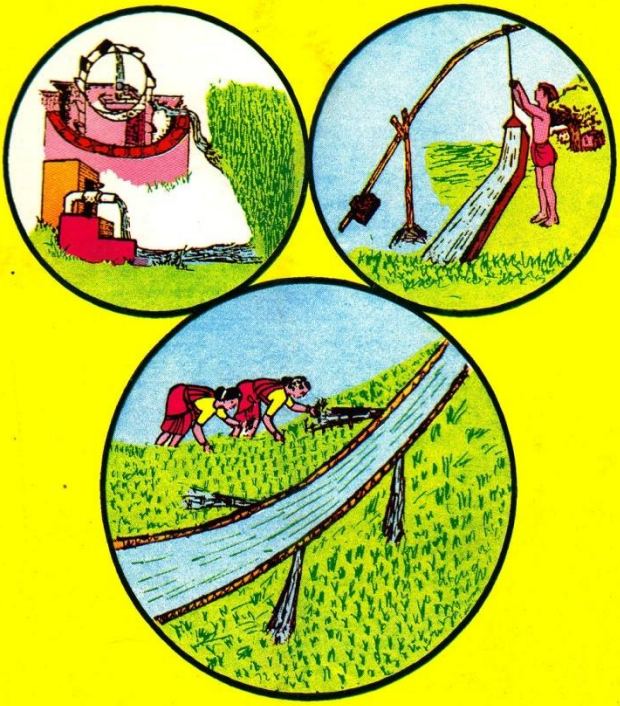
HISTORY OF IRRIGATION IN BIHAR

(Ancient, British & Upto Pre-Plan Period)



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(Ancient, British & upto Pre-Plan Period)

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2nd Edition (March 1997)

Published by:
Water & Land Management Institute, Phulwarisharif, Patna

Printed by:
Engineers Land, Rajendra Nagar, Patna, Ph.: 651996

To,

Sri Jagadanand

Ho'n Minister WRD & Tourism

whose inspiration gave me impetus
to
write this history.

CONTENTS

ACKNOWLEDGEMENTS

I am grateful to Mr. V.S.Dubey, former Commissioner and Secretary, and Mr. Deepak Gupta, Secretary, Water Resources Department, Government of Bihar, for consenting to publish this volume.

I owe a special debt of gratitude to Mr Amal Dasgupta, Ex-Engineer-in-Chief, Water Resources Department,who inspite of his own busy schedule took extra pains in going through the manuscript and made valuable suggestions to enhance its credibility.

I wish to express my deep sense of gratitude to Mr. I.N. Sinha, Ex-Engineer-in-Chief-cum- Additional Commissioner-cum-Special Secretary, Water Resources Department for his invaluable guidance and wise advices. Without his kind support and encouragement this work would not have been possible.

I pay tribute to Mr S.K.Sinha, Ex-Engineer-in-Chief, Water Resources Department, who remains a constant source of inspiration for me and whose encouragement helped in bringing out this book.

I express my warm gratitude to Mr G.P.Shahi, Member, Second Bihar Irrigation Commission and Mr. Baldauji Shrivastava, Retired Chief Engineer, Water Resources Department for their keen interest in this book and valuable suggestions.

I would like to add a special word of thanks to Mr. Arvind Kumar Sinha, Director, WALMI, who skilfully managed to get the manuscript typed on computer in a short time and printed this volume using DTP departmentally, utilising the infrastructure available in WALMI. In this endeavour he was ably assisted by the officers of the Computer Cell, specially Sarvasri Sheel Bhadra Sinha, Systems Manager, Jitendra Kumar Singh, System Analyst, Sunil Kumar Singh, Programmer, Anil Kumar, Assistant Engineers.

Thanks must go to all my colleagues and staff for the help and co-operation rendered by them, specially to Mr Suresh Prasad Mallick and Mr. A. K. Gupta, Steno-typists for taking extra strain in typing the manuscript and to my friend Rajiva Ranjan Prasad for proof -reading.

I must not forget the services extended by my daughters Manisha and Mita and affectionately acknowledge their constant care and help at various stages in sketching this history. Also, a word of appreciation to my wife Mira who silently bore with me, while I was burning the proverbial midnight oil.

The various sources as referred to in the Bibliography from which the materials have been drawn and freely used in this book are also gratefully acknowledged.

GAGAN PRASAD

PREFACE

Latest researches in the field of genetic science have made it possible to grow crops with least amount of water by successfully transferring DNA of some tiny creatures which require little water, to the crop. Irrigation, thus, may not be required at all in the decades to come and may remain in the pages of history only, leaving our progeny to read with interest the story of man's extraordinary efforts in harnessing the water resources for irrigation.

Irrigation is being practised in India since the Aryans came to this country. Here in Patliputra (now Patna) which remained the capital of the mighty Mauryan Empire (400 BC) lived Kautilya,who had laid down the principles on rainfall and irrigation in his famous book *Kautilya Arthashastra*. These principles are little known to the common man today.

To trace out the history of irrigation various sources have to be tapped. Written documents are not readily available and the inscriptions are rarely to be found. The old timers are helpful in bringing out the old stories but their memories sometimes fail them as regards exactness of date and sequence of events. Existing structures and works tell their tale themselves but planners and engineers are obliged to alter, reshape, remodel or sometimes remove the old structures in toto to make room for the new ones to meet the increased demand. This has happened in Bihar also where new ambitious projects have replaced the old ones or the old canals have been made the part of new larger system.

The pieces of information in this book have been collected from the archives, record-rooms and reports which are seldom to be found at one place. The old files in the record-room of the Water Resources Department, Government of Bihar were very much helpful in knowing what had actually happened from the planning stage through execution to maintenance and operation of the old irrigation schemes in Bihar especially in the nineteenth and early twentieth century. In this process it was a pleasure to go through the manuscripts of eminent engineers like *C.H. Dickens, W.A. Inglis, F.H. Rundall, H.C. Levinge, R.B.Buckley* and others whose contributions have enriched the science of Hydraulics through centuries. Some of these names and their formulae are relevant even today and are virtually alive on the tongue of every civil engineer.

In Bihar the history of irrigation can be traced long back but one could find the systematic written documents from the early British period only. Sone Canals, Teur Canal, Saran Canals, Dhaka Canal, Triveni Canal and Kharagpur Irrigation Works are some of the earliest mile stones on the path of scientific development of water resources in the State of Bihar. Some of these canals came into existence even when the

science of Hydraulics was groping to frame its fool-proof laws while Structural Engineering was in its infancy and Soil Mechanics still under the soil.

Stories of these and other old irrigation works narrated in this book would evoke reminiscences of the old timers while they may reveal some startling facts before the new generation.

The author hopes that this book of reference will be of immense value and interest to the engineers, research scholars, the common man and those interested in knowing the background of irrigation in Bihar, more so since the subject of irrigation has become so important in contemporary India. However it is humbly admitted in good spirit that in such type of work there always remains some scope for additions and improvements because many things may come above the surface in future with the efforts of researchers and scholars working in this field.

Commendations may be encouraging—they always are. But the author would feel equally favoured if shortcomings are brought to his notice and suggestions made to improve the volume in future.

PATNA

September, 1995 GAGAN PRASAD

PREFACE TO THE SECOND EDITION

This revised edition records the passing of a new comprehensive and consolidated Irrigation Bill, 1996 by the Bihar Legislature incorporating new concepts in the field of irrigation and repealing plethora of old and defunct Irrigation Acts prevailing in the State since 1864. The changes in the irrigation laws after about a century may prove to be a landmark in the annals of irrigation in Bihar.

Two new maps have also been added—the one depicts the location of old irrigation projects constructed before independence and the other shows the numerous major and medium schemes which have since been implemented by our popular governments.

The second edition in the second year itself is encouraging. Hope this treatise, now in its new improved get up, reaches those hands which have really been searching for it.

PATNA

March 31, 1997 GAGAN PRASAD

CHAPTER I

GENERAL

INTRODUCTION

Geographically Bihar is situated between latitudes 21°58'10" N and 27°31'15" N and longitudes 83°19'50" E and 88°17'40" E. The State is bounded on the north by Nepal, on the west by Uttar Pradesh and Madhya Pradesh, on the east by West Bengal and on the south by Orissa.

Bihar is the second largest State of Indian Republic in population and the ninth largest State in area. It covers a geographical area of 1,73,877 sq. km and as ascertained by the Census of 1991 contains 86.. million souls, indicating high density of population as 497 persons per sq. km. Compared to the Republic, the State has to support 10.2 percent of population with only 5.3 percent of the area of the country.

The economy of Bihar is predominantly rural and agricultural. About 87 percent of the people live in villages and most of them are dependent on agriculture. The State has just more than 108 lakh ha of arable land out of which 105.7 lakh ha is gross cropped and 77 lakh ha is net cropped.

Irrigation is at present assured to nearly 32 lakh ha of land. The intensity of irrigation is of the order of 134 percent. Considering the total water resources, the ultimate irrigation potential likely to develop in the State may be around 123 lakh ha out of which 66 lakh ha could be realised through major and medium projects and 57 lakh ha through minor irrigation schemes. 27 major and 163 medium schemes have been completed by the Water Resources Department of the State to utilise the surface water potential of the river basins in the State. Thereby a potential of 27.15 lakh ha has already been created. However, upto pre-plan period the irrigation potential created was just over 4 lakh ha.

The State consists of two distinct physical units—the alluvial plains of Indo-Gangetic basin and plateau area of Chotanagpur and Santhal Parganas. The river Ganga flowing from west to east divides the plain into two parts. The area between the India-Nepal boarder and the river Ganga is known as North Bihar while the plains south of Ganga is known as South Bihar. Thus Bihar can physiographically

be divided into three natural regions—North Bihar, South Bihar and Chotanagpur and Santhal Parganas plateau which abounds in hills, mountains and forests. Most of the plateau area have an elevation ranging between 300m to 1200m.

HISTORIC EVOLUTION OF STATE

The history of the glorious heritage of Bihar may be traced back from the earliest prehistoric era when this territory was ruled by a primeval King Manu Vaivasvata, son of the Sun God. One of the nine sons of King Vaivasvata, named Nabhagodishta, settled in the region which is now known as North Bihar. He indeed originated the line of Kings that ultimately established the kingdom Vaishali which is well known as the earliest seat of the Republican Government in the world. Yet another famous Kingdom in this region was that of Videha, which was later known as Mithila. It was founded by Nemi, son of Ikshvaku, the eldest son of Manu. The second King of the dynasty, Mithi Janak, founded the capital of Mithila after his own name.

A perusal of the Vedic literature reveals that the territory of Bihar flourished in the Vedic era as well. In the Rigveda there is specific mention of the Kingdom of Kikata which is a synonym for Magadha. The Atharva Veda contains copious references to the Vratyas, who according to some historians were the pre Aryan inhabitants of Magadh. Rajgriha (modern Rajgir) was the capital of the mighty Magadh empire during Mahabharat era. It was then known as Brihadrathpur so named after the founder king, Brihadrath, who was succeeded by Jarasandha.

In the post Mahabharat period, Bihar was ruled over by successive royal dynasties beginning from Shishunagas (Bimbisar and Ajatshatru belonged to this dynasty) and ending with the Palas; Senas, the Nandas, the Mauryas, the Sungas, the Kanvas and the Guptas, coming in between.

According to *Gargi Sanhita* and the *Vayu Puran*, the capital of Magadh was shifted from Rajgriha to Patliputra in 457 BC by Raja Udyain or Udayabhadra, the son of Ajatshatru, who was the well known contemporary of Gautam Buddha, the founder of Buddhist religion.

According to Buddhist account, when Buddha crossed the Ganges on his last journey form Rajgriha to Vaishali, two ministers of Ajatshatru, the king of Magadh, were engaged in building a fort at the village Patli near the confluence of the river Ganga and Sone, strategically an important place to check the Wajjians of Vaishali with whom they often fought for supremacy. It is said that at that time Buddha predicted that this fort would become a great city. The prediction came true. After this Patliputra remained the capital of several mighty empires for a long period. Some of the empires with Patliputra as capital extended even up to Afganishtan in the west and Bengal in the east, Himalayas in the north and Bindhyas in the south.

The ancient kingdom of Magadh which comprised the southern portion of Bihar, now included in the districts of Patna, Gaya and Shahabad has its own unique history. It was an important centre of activities of Gautam Buddha and Mahavir. "Buddhism" and "Jainism" both the world famous great religions propagated by the above two protagonists secured royal patronage in Magadh. In fact the State of Bihar derives its name from the "Buddha Vihars" that came to be established in this part of the country in the years following the advent of Gautam, the Buddha.

From the sixth century BC to the fifth century AD the kingdom of Magadh was a throbbing centre of India's political life. During that period Megasthnese had come as ambassador of Seleucus Nicator, the Governor appointed by Alexander, to the court of Chandragupta in Patliputra about 300 BC. He has noted that Palibothra (Patliputra) the capital city of India on the confluence of the two great rivers Erannoboas (Sone) and Ganga was ten thousand stadia(1149 miles) east of Indus. The length of the city was 80 stadia (9 miles) and breadth 15 stadia (1.7 miles). It was surrounded by a ditch 30 cubits (50 feet) deep. The famous Chinese traveler Fa-Hien who came to Bihar in the year 399 AD has recorded glowing accounts of the magnificent cities of the kingdom and the people.

Hiuen-Tsang the Chinese pilgrim, who visited India in between 630 to 644 AD writes that by that time Magadh had become the subject to Harsh Vardhan, the great king of Kanauj. Patliputra no longer remained the premier city of Northern India and its place was taken by Kanauj. Magadh was then bounded on the north by the Ganges, on the west by Varanasi, on the east by Hiranya Parvat or Monghyr and on the south by Kirana Savarna or Singhbhum. He further informs that the old city, called originally Kusumapura, had been deserted for a long time and was in ruins. Since then the city slowly seems to have fallen into a state of decay.

During the medieval period there were many upheavals and Bihar could not remain peaceful. There were mighty struggles between the Afghans and the Mughals. Sher Shah, the Afghan ruler, made Bihar once again the nerve centre of North Indian politics. In 1541, he transferred the capital of Bihar from Bihar-Sharif to Patna. The great Mughal king Akbar invaded Bihar in 1574. He fought hard against the Afghans and the Hindu chieftains of Bihar and annexed large portions of South Bihar. Ultimately the Mughal rule was extended to Chotanagpur, then called Kukradesh or Jharkhand during the regime of Jahangir.

With the approval of the then Moghul king, the English established a factory at Patna on a permanent footing in 1657. The Dutch had, however, come to settle here a few years earlier. Later the French also settled down here around 1720. Lord Clive, the originator of British Raj in India came to Patna along with Mir Jafar in 1757 after winning the decisive battle of Plassey.

The battle of Plassey made the British virtual masters of Bengal and Bihar. Orissa was annexed in the year 1803. These States were kept directly under the rule

of Governor General of the East India Company. After the Revolt of 1857, the English East India Company was ended and the Government of India was taken over by the Crown. The Board of Control and the Court of Directors were abolished and their places were taken by the Secretary of State for India and the Indian Council. In 1859 the Governor General ceased to have any direct connection with Government of the Presidency of Fort William (comprising Assam, Bengal, Bihar and Orissa) which was then for the first time, placed under a Lieutenant - Governor. Assam was later separated from this Lt. Governorship. However the States of Bihar and Orissa were kept unified with Bengal and were ruled together by the Lt. Governor keeping his seat in Calcutta. On 12th of December 1911 the British Government decided to separate Bihar and Orissa from Bengal and on April 12,1912 they were separated as one unit. Twenty-four years after, in April 1936 Orissa was also separated and thus the State of Bihar as an entity was established. There were however, some minor changes during the fifties at the time of re-organisation of States and Bihar finally came into its present form.

CLIMATE AND RAINFALL

The climate of Bihar may be described to be tropical. The year could be divided into three seasons -- the winter from November to February, the summer from March to May and the rainy season from June to October, characterised by considerable variation in the rainfall, temperature and humidity.

Much of the behaviour of the weather and the climate in this zone is the direct result of the changes in air pressure and movement of air currents from the Indian Ocean across the Bay of Bengal and from the Arabian sea. During the months, from November to May, dry weather prevails. The rainfall during these months is generally little. Some winter rains occur during January and February (nearly 50 mm) due to extra-tropical disturbances but they are very scanty.

South west monsoon, which extends from mid June to mid October is mainly responsible for most of the rainfall. In normal years monsoon arrives in third week of June and the heaviest rainfalls occur in July and August. After middle of September the monsoon currents begin to weaken off. The State also receives some of the heaviest rainfalls due to the cyclonic storms and depressions which move inland from the Bay of Bengal during the monsoon and even during post monsoon months. However, if the westerly winds are stronger, the storms coming inland from the Bay of Bengal recede eastward and rainfall is deficient. The rainy season comes to an end generally in mid October. The *Hathia* rain which comes in the last week of September and first week of October is very beneficial for rice crop as well as for preparation of land for *Rabi* sowing.

The rainy days in a year are generally above fifty. The rainfall during the rainy season accounts for over eighty-five to ninety percent of the total annual rainfall which is of the order of 1280 mm. But the average rainfall figure does not

give accurate picture. The rainfall varies considerably from region to region and also in time. The rainfall decreases generally from east to west, and the Ganga and its neighbouring areas receive least rain while the southern plateau and the northern borders receive higher rainfall. Similarly the time distribution of rainfall is also remarkable. The general trend of monsoon precipitation has been described above but there may be three important variations from the normal in the monsoon rains. Firstly, the beginning of the rains may be delayed considerably over the whole or a large part of the State, secondly there may be prolonged break or breaks lasting over the greater part of July and/or August and thirdly the rains may end considerably earlier than usual. Consequences of the third variation are occasionally very serious and the success of the *Kharif* crop largely depends on this rain especially the *Hathia* rain.

In the extreme cases some of the areas of the State may experience even twenty-five to thirty percent of the total annual rainfall only in twenty four hours, causing rivers to overflow and inundate areas bringing immense miseries to the people whereas at some other time there may be a gap of over a month between two showers. This type of erratic behaviour of rainfall had in the past been the cause of calamitous droughts and famines viz. 1867, 1874, 1886-87, 1896-97, 1908 and 1966-67.

TEMPERATURE

Bihar suffers from extremes of temperature. Winter is quite cold and at some places the temperature may fall below 2 degree Celsius. January is the coldest month of the year. Similarly the heat during the summer is intense. The hilly areas of Chotanagpur plateau and Gaya are among the hottest regions of India. May and June are usually the hottest months when mean maximum temperature varies between 35 and 40 degree Celsius.

WIND

During the hot weather period in Bihar from March to May there is continuous increase in heat and decrease in pressure which results in occasional dust storms of moderate to violent intensities ranging between 60 km to 120 km per hour. From June to September, eastern and south-eastern wind starts blowing with onset of monsoon. During early winter, wind generally blows from east to west but in December and January, direction of wind is from north and north-west which ultimately brings down the temperature in the State.

SOIL

As stated earlier the State of Bihar is divided into three physiographic regions (i) the alluvial plains north of the river Ganga receiving sediments from the river originating in the Himalayas (ii) the alluvial plains south of the river Ganges which receive sediments from the rivers originating in the Chotanagpur plateau and (iii) the Chotanagpur plateau. The topography, the parent materials, the geology, age and covering vegetations of these three regions differ appreciably alongwith the difference in climate, especially variation in temperature and moisture regime etc. These differences have resulted in the formation of many soil types in the State which differ not only regionwise but within the region itself.

A large number of soil series have been recognised in the State and they have been grouped in twenty-three Broad Soil Association Groups. Of these seven are located in North Bihar, six in South Bihar and ten in the Chotanagpur plateau. The North Bihar terai area and the adjoining plains of Kosi and Mahananda are characterised by mostly Recent Alluvium—noncalcarious and non saline type soils. Rice and Jute are the main crops grown in this area along with *Rabi* crops, with the help of canal irrigation. The plains lying between this region and Ganga are calcareous young Alluvium type, and are very fertile. They are very favourable for crops like paddy, wheat, maize and barley as also for cash crops like sugarcane, chilies, tobacco and castor.

South Bihar soils are mostly old alluvium type. Paddy is the main crop but wherever irrigation is available wheat, sugarcane, maize, onion etc. are grown. The areas along the right bank of Ganga which have Tal Land type soils are very fertile but as the soil becomes hard and dry in summer and remains submerged during rains, only one crop during *Rabi* period is grown but with very good yield.

The plateau area of Chotanagpur has ten different types of soil. While the hill and forest soils are generally gravelly or stony and are covered with forests of various types. The red, yellow, light grey catenary soils are found in the districts of Santhal Parganas, South Bhagalpur, South Monghyr, Hazaribag, Dhanbad, Ranchi and Singhbhum, which are fertile soils. Other areas having yellow and reddish yellow or grayish yellow catenary soils in the coal belts or reddish brown in the iron ore regions are not fertile. Some upland grey heavy soils found in Palamau district derived from basic and ultra basic rock are fertile and grow maize and gram even under non-irrigated condition.

THE RIVERS OF BIHAR

Bihar is one of the few States of the country which has been endowed by nature with abundance of water resources. Ganga flowing from west to east and dividing the plains in two distinct parts, receives most of the rivers of State on both its banks—the north Bihar rivers falling on its left bank and the south Bihar rivers on the right bank.

Gandak, Burhi Gandak, Bagmati, Kamla, Kosi and Mahananda are the main rivers of North Bihar. Most of these rivers have their origin in Himalayan region. They pass through Nepal before debauching into the plains of Bihar and finally discharge into Ganga. Some of these rivers e.g. the Kosi and Gandak rise in the Greater Himalayas and have considerable portion of their catchments in the glacial region. They carry enormous amount of silt. Both these rivers have been marked by numerous changes in their courses during historical times. Total catchment area of all the rivers of north Bihar (excluding Ghaghara) before entering the State is about 1,19,430 sq. km and the same within the State is 42,336 sq. km. Total annual runoff of all the rivers of north Bihar are estimated to be nearly 1,28,478 Million Cubic Meter (1042 lakh acre ft).

South Bihar is mainly drained by the river Sone in the west and by other tributaries of Ganga among which are Karmanasa, Poon-poon, Harohar, Kiul, Badua and Chandan. These rivers carry about 27,850 Million Cubic Meter (226 lakh acre ft) of water annually.

Gumani, Ajay, Damodar, South Koel, Sankh are the main rivers of Chotanagpur and Santhal Parganas. The total annual run off of all these rivers is of the order of 22,970 Million Cubic Meter (186 lakh acre-feet).

In addition to this the Ganga main stem within Bihar and their sub-basins contribute nearly 91,365 Million Cubic Meter (740 lakh acre feet). Thus total surface water in Bihar considering contributions of catcment areas draining through the State is about 270,665 Million Cubic Meter (2194 lakh acre feet).

Although such large quantities of water flow through the State, most of the flow is available in the form of floods during the four monsoon months which can partially be utilized. During the remaining eight months, the available flow is such that it cannot meet the full demand of the State.

The details of available surface water on 75 % dependability, of each river basin of the State along with their catchment area can be seen on Table 1.1 (*source Second Irrigation Commission, Bihar*).

Table 1.1

BASINWISE CATCHMENT AREA AND ANNUAL SURFACE WATER AVAILABILITY

(ON 75% DEPENDABILITY)

Basin No.	Name of Basin	State/Countries Covered	Catchment Area in Sq. Km	75 % dependable annual water available.	
				MCM	MAF
1	Ghaghra	Nepal, UP & Bihar	127950.00	68854.70	55.80
2	Gandak	Nepal, UP & Bihar	40797.70	51824.00	42.02
3	Burhi Gandak	Nepal, Bihar	12021.37	4040.00	3.28
4	Bagmati	Nepal, Bihar	14383.85	7265.30	5.89
5	Kamla	Nepal, Bihar	7231.67	3249.40	2.63
6	Kosi	Nepal, China &	74025.20	52219.00	42.33
7	Mahananda	Nepal, Bangaladesh, W.B and Bihar	13307.80	9880.30	8.01
8	Karamnasa	UP, Bihar	7792.10	1424.10	1.14
9	Sone	UP, MP & Bihar	70227.50	17935.00	14.54
10	Punpun	Bihar	9025.75	2253.50	1.83
11	Kiul - Harohar	Bihar	17223.50	4010.30	3.25
12	Badua- Belhernna	Bihar	2215.00	736.80	0.60
13	Bilasi- Chandan - Chir	Bihar	4093.00	1491.10	1.21
14	Ganga including stems	Bihar	16900.00	91365.70	74.07
15	Gumani	Bihar	2271.90	840.60	0.68
16	Mayurakshi & other adjoinig streams	Bihar, WB	5712.20	2287.80	1.85
16A	Small Streams draining outside the State	Orissa, WB & Bihar	1684.70	632.4 0	0.51
17	Ajay	WB, Bihar	6170.00	1238.70	1.00
18	Sankh	MP, Orissa & Bihar	5346.40	2053.80	1.66
19	South Koel	Orissa, Bihar	10988.50	4182.30	3.39
20	Damodar & Barakar	WB, Bihar	16934.00	5800.00	4.71
21	Subernarekha	WB, Orissa & Bihar	15747.50	5930.00	4.81

CHAPTER II

ANCIENT PERIOD

INTRODUCTION

Bihar has always remained a predominantly agricultural State. Even today, in this age of technological and industrial advancement, more than eighty percent of the population depends directly on agriculture and allied activities for their livelihood. The condition which might have been prevailing here, several centuries back, can well be imagined in this background.

Agriculture without any irrigation, in this part of country where rainfall pattern is not dependable, is unthinkable. But when a vast tract of fertile land, made steadily richer by the silt of rivers flowing through the area was available to the meager population living there, they would not have cared to bring water to their fields from elsewhere for irrigating their land for better crop or for more yield. Under normal rainfed condition the land produced much more than what was needed. Obviously there was no incentive for increased production and so no efforts were made to adopt scientific methods for increased productivity.

However, in the natural process, the population went on multiplying and the growing pressure on land gradually made them realise the importance of water for increased production from their fields. They began to watch the natural phenomena producing rain closely, especially the onset of monsoon, its duration, the periods in which it produced incessant rain and more closely its occasional failure, which had started becoming cause of distress.

VEDIC PERIOD

They believed in the beginning that *Raingod Indra* sent clouds every year to quench the thirst of their land and if the rain failed, they thought that *God Indra* was angry with them. To please the *God Indra*, who gave them rain, they used to perform *Yajna* (sacrifice) which definitely had effect on the causation of rainfall, though little is now known about the ingredients and the methods they used in those *Yajnas* to bring the clouds and cause them to rain. The *Rishis* (learned sages) who had acquired the technique were a bit fussy in imparting the knowledge to the next generation for want of so called true and able disciples and gradually the technique went into oblivion.

But grand-mothers have been telling stories to their grandchildren from generations that occasional anger of *God Indra* causes distress. As per their belief, usually this was associated with the sins committed by the people and sometimes even by the king. These sins might presumably be attributed to the ecological disturbances created by the deforestation and denudation in the process of expanding their towns and villages and to the occasional wars waged by the kings to extend their territorial boundaries. They took the rain granted, and when it failed they thought it was the result of their wrong deeds. To get out of this unfavourable situation they performed sacrifices. The famous story of King Janak of Mithila (northern part of Bihar) as mentioned in the great epic *Ramayan* tilling his land himself after failure of rain as a part of austerity measure is known to all. This incident gave birth to Sita who was later married to Rama. Such stories have metaphorical meaning.

In fact while performing *Yajnas*, the *Rishis* used to throw some substances in fire. These substances, called *Havishya*, combining together at higher temperature produced compounds which rose with smoke to the sky to attract rain clouds and create an atmosphere which could produce rain.

There seems to be some logic behind it. Latest developments in the field of Hydrometeorology could only confirm these phenomena. Of late, the Russian scientists have been experimenting this by injecting several hygroscopic particles viz. silver iodide, oxides of nitrogen or droplets of sulphuric acid etceteras in the cloud mass through jet planes to actuate condensation to cause rain. Similarly in the reverse process the mechanical efficiency of the clouds could be disturbed by injecting unwarranted extra nuclei into the atmosphere and thus disperse the clouds.

Invoking water from the heavens had been an Israeli specialty too. Their epic narrates the story of Elizah the prophet who had put the prophet of Ba'al to shame and brought rain down from the blue sky to end a famine. Even today in Israel water is a scarce commodity and is used very sparingly in order to make the most of the country's meager water resources. To meet the growing demand of water every effort is now made to enhance its quantity. Through the Rainfall Augmentation Division of the country, a dedicated team of scientists and technical personnel have been conducting experiments for the last three decades for enhancement of rainfall by cloud seeding and have been successful in increasing the country's rainfall by more than 15 per cent. Now it has become a routine affair. The Division operates two seeding planes, flying in turn under careful radar-radio co-ordination. The planes are equipped with burners attached beneath the wings for spreading the silver iodide crystals in the clouds. In addition to the airborne silver iodide burners, the Division operates a networks of more than sixty on-the-ground burners placed at strategic locations, in order to obtain better coverage of the cloud formation. An interesting part of the operation is that the operators of ground burners are volunteers, usually farmers, who receive instructions by telephone on when to start up or stop the burners.

Emphasis on Yajna

Here in Bihar lived Rishi Yagyavalkya at Janakpur in Mithila and Rishi Vishwamitra at Buxar in Shahabad who along with other sages contributed much to the advancement of knowledge in the field of hydrology and agronomy. Rishi Vishwamitra was one among the numerous learned sages who had composed the verses and hymns of Vedas. It is interesting to note that in some of the verses they had tried to encompass a wider domain of Hydrometeorology and various aspects of water management. They had not only clearly defined the phenomenon of rain but all the facets of hydrologic cycle involving total earth system, the most important concept on which the modern science of hydrology is founded. No wonder they knew how to help formation of clouds, maximise the moisture content, cause condensation on particular type of nuclei and create atmosphere to produce desired rain. That is why they emphasised the importance of *Yajnas* for rain, agriculture and air or environment and their inter-relationship.

कृषिश्च में यज्ञेन कल्पंताम,
वृष्टिश्च में यज्ञेन कल्पंताम। यजुर्वेद 18 - 9
मारूतश्च में यज्ञेन कल्पंताम ॥ यजुर्वेद 18-17

Importance of *Yajna* for rain can vividly be marked in the following *shlokas* of *Bhagvad Gita*:

अन्नाद्भवन्ति भूतानि पर्जन्यादन्नसंभवः।
यज्ञाद्भवति पर्जन्यो यज्ञः कर्मसमुद्भवः ॥ 4 ॥ अध्याय - 3

Indra's contribution in Water Resources Development

Indra, the king of Devas was a favourite god of Aryans. He was a thoroughly war like god. The hymns in the Vedic literature refer to his various battles with the *Asuras* and *Dasyus*, the local people who refused to give away their lands for the construction of canals or channel. He often performed miraculous deeds for the development of water resources for the benefit of the people. The battle of Indra with Vritra is referred to in many hymns. Vritra was a demon in the form of a serpent or dragon who kept the waters enclosed or imprisoned in a mountain. Indra wanted to release the waters after giving battle to the demon and he eventually killed him and thereafter released the waters which flowed in a rapid stream over the corps of Vritra. The meaning behind this story can easily be understood. In fact Indra made the

water enclosed in the mountain available to the people by breaking the natural barrier symbolised as a demon in the story. Our Vedic literature is studded with such stories and such brilliant feats of engineering made the king Indra, the hero of the field of water resources development.

In his book "Myths of Middle India" Verrier Elwin has quoted R.E. Enthoven who deeply studied the legends and folklores of the people of Indian subcontinent, associating the rainbow with the bow of Indra, the *Raingod*. The varied beliefs about the rainbow are -- when Indra draws his bow to release the rains from the demons; or when successful in bringing down rain Indra manifests his glory by drawing a bow; or when in the struggle for supremacy between the hot weather and the rainy season, Indra draws his bow to defeat the hot weather. Well, all these sing the glory of Indra the *Raingod*. No wonder that the synonym of rainbow in Hindi is *Indradhanush*.

MAURYAN PERIOD

Patliputra (now Patna), an imperial city played a pivotal role in the history of India. It remained the capital city of India for several centuries, during the Mauryan empire also. Here, in that period lived the famous politician, economist and learned professor Chanakya, the preceptor and Prime Minister of Chandragupta Maurya, who wrote the famous book *Kautilya- Arthashastra*.

From this book it transpires that people had by that time developed the method and instrumental devices for measuring rainfall. This raingauge was known as *Varshaman*. Kautilya has described the methodology of measuring the rain in detail which used the same principle as that of modern hydrology except that weight measure of *drona, pala, karsa* (also used as weight unit in Iran) etc. were then adopted instead of modern linear measurement viz. inch, cm etc. Kautilya used to keep a record of rainfall distribution all over the empire for proper water management. He has mentioned in his *Arthashastra* :

" Sixteen dronas is the amount of rain in dry lands (jungalas), one and a half times that in the wet lands (anoopanam), where sowing are in conformity with the nature of the region (deshwayanam), thirteen dronas and a half in the Maharashtra (asmakas), twentythree dronas in the Avantis and an immense quantity in western countries (aparantanam) and the snowy regions, and as to time, in lands where sowing are made with the help of canals."

Opinions differ today in the interpretation of weight, length and volume measures mentioned in the *Arthashastra*. However, according to *Kautilya's Arthashastra Vol. I to III* edited by Kangle, a *drona* was equal to 128,000 grains by weight, approximately equivalent to a capacity of a little over 500 cubic inch or a little less than a quarter bushel or 2 gallons of water. To be precise, a *drona* was equivalent to the weight of 511 cubic inches of water. In *Arthashastra*, the size of

raingauge is mentioned as 1 *aratni* (equivalent to about 18 inches). If the raingauge was cylindrical its surface area would be 254.5 sq. inches and if of square shape (18"x18"), the surface area would work out to 324 square inches. Thus, 16 *dronas* amount to about 32 inches of rain in a cylindrical raingauge and about 25 inches of rain in a raingauge of square section.

Kautilya also used to keep the track of time distribution of rainfall during the entire monsoon period - *"When one third of the annual rain falls during the first and the last months of the rainy season together, and two third in the intervening two months - the rainfall is considered very even (Sushumarupam)."*

The author has also classified the clouds from agricultural point of view. He says, "Three clouds raining more or less *continuously for seven days (saptahika) each, 80 clouds (astih) of light and intermittent showers and 60 clouds (atapameghanam) producing rain accompanied with sunshine are beneficial for agriculture*". He further adds *"Where it rains distributing wind and sunshine properly and creating three periods for the drying of cowdung cakes (Karisan), there the growth of crops is certain"*.

He could forecast the quantum of rain by watching the movement of astronomical bodies." *Its ascertainment is made from the position, motion and impregnation (Garbhadhan) of Jupiter, from the rise, setting and movements of Venus and from modification in the natural appearance (prakritivaikrtat) of the Sun. From the Sun is known the successful sprouting of seeds, from Jupiter the formation of stalks in the crops, from Venus rain". Garbhadhan* is explained elsewhere as dew in *Margasirsa*, snow in *Pausa*, wind in *Magha*, clouds in *Phalgun*, wind and rain in *Chaitra* and rain with wind and lightning in *Vaisakh*, together with rain on the days of conception viz. the first four days of the *Krishna pasha* of *Vaisakh*. It is to be noted that Brihatsamhita refers to the impregnation of a cloud 195 days prior to its sending down rain.

This goes without saying that all these observations and methods were used for agricultural developments and efficient water management. Kautilya had laid down clear cut rules for the crop planning in order to manage the rainfall - excess or deficient. The celebrated author has enunciated in his Arthashastra - *"In conformity with the rainfall, the Superintendent of Agriculture shall cause crops to be sown requiring either plenty of water or little water"*.

In the zone where rain was usually deficient the Preceptor says *"The king should construct dams, reservoirs etc. filled with water either perennial or drawn from some other source or he may provide with sites, roads, timber and other necessary things to those who construct reservoir on their own accords"*. Kautilya further adds that the king shall exercise his right over ownership with regard to fishing, ferrying and trading of vegetables in reservoirs or lakes.

From Kautilya's Arthashastra it transpires that during the times of famine the king and his subjects took shelter near dams. Aquatic animals in the rivers, canals and dams were protected and fishing was allowed under a license. If privately managed dams were neglected for five years they were taken over by the State. If they were constructed by the public contribution, revenue for five years was remitted, and if only repairs were carried on by public efforts, revenue was remitted for four years.

A rational water pricing system, an important aspect of water management, was also developed by the versatile author. The laws which were framed are mentioned in Arthashastra *"those cultivators who irrigate their lands by manual labour shall pay one fifth of the produce as water rate; those carrying water on shoulders or lifting the water by bullocks shall pay one fourth, and those who irrigate their land by raising water from rivers, lakes, tanks and wells, shall have to pay one-third to one-fourth of the produce."* It is to be noted that this land revenue was the chief source of income of the empire.

However, little is known about the irrigation method really practised during those days.

CHAPTER III

BRITISH PERIOD

EARLY BRITISH PERIOD (Up to 1850)

INTRODUCTION

Before the advent of modern canal irrigation in the Sone area in the middle of nineteenth century, no consolidated effort seems to have been made for harnessing the natural sources of water for irrigating the land in Bihar on a large scale. But the cultivators had developed their own system of irrigation at local level. These systems were tailored to fit their own regional requirements. Both surface and ground water were exploited to the extent the villagers could afford. But they made use of river water or natural drainage to a greater degree because their exploitation was comparatively cheaper and less laborious. However, they had to take recourse to well irrigation when surface water completely dried up and where ground water was available at shallower depth.

IRRIGATION PRACTICE IN NORTH BIHAR

To the north, the land from Nepal *terai* area to the Ganges is very flat. A number of major rivers rising in the lower ranges of the Himalayas or originating from the foothills debouch, into the plains of North Bihar after passing through the territory of Nepal. They carry enormous amount of water. But due to the high discharges in these rivers and their large width, it had been beyond the competency of the villagers to harness these rivers for irrigation purposes on their own, unless the Government or the landlords came to their rescue. However, with the little technical knowledge and limited resources available with them at that time neither the Government nor the landlords could do anything tangible for them in this regard.

Very often these big rivers ravaged the area ruthlessly. Even though the flood water of these rivers inundated the area, devastated their hearths and homes and brought immense miseries to the people, these floods were nonetheless blessings in disguise. Barring the notorious river Kosi, the spill of other rivers helped in land building by depositing beneficial silt over the ground. This silt made the land so fertile that even without irrigation under normal rainfed condition the people could grow a number of crops like rice (both *Bhadai* and *Agahani*), maize, barley and wheat etc. over and above the cash crops like sugar cane, tobacco, opium and indigo. The outturn of *Agahani* (winter) rice was on an average 14 *maunds* per acre (525

kg/acre). Usually after each flood, if the flood receded in time, there was bumper crop. But this was not the case everywhere and every year.

In this region, the monsoonic rain on which the agriculture was then entirely dependent is erratic. The average annual rainfall varies from 100 cms to 150 cms but this figure does not give accurate picture. Its variation both in time and space is remarkable. Often it fails in the most needed period. *Hathia* rains, a must for the survival of *Kharif* crops,usually fails once in four years. In extreme cases a rainfall of 25 cms may be experienced only in 24 hours and sometimes there can be a gap of forty to fifty days between two successive showers.

Obviously the cultivators could not depend entirely on monsoon. They were obliged to keep some arrangements for irrigating their land and this they did by damming temporarily small rivers and rivulets and hill-streams wherever possible or by wells.

Towards the north, in Tirhut, in the erstwhile districts of Muzaffarpur and Darbhanga some small streams coming from Nepal were dammed up every year and water diverted to the adjoining fields flowing freely from one field to the other. No canal or artificial water courses were anywhere constructed. Irrigation from such arrangement did not cover a large area. They were highly localised. The low level earthen dams to divert water were very temporary and were often cut when water was most needed, in order to allow the Nepalese to float their timber down. The rivers like Naya Dhar Kamla, Balan and Tiljuga were also usually embanked. However there were no artificial water-courses in the entire Tirhut district.

Irrigation was likewise carried on from wells during *Rabi* period when surface water dried up, by one of the simple methods described below.

An erect pole locally called *khambha* was stuck in the ground and a bamboo (*dhenki*) balanced on it with a bucket (*dole*) at one end and a weight of mud, dried in the sun, at the other. The water was then raised by leverage.

A small well could cost about Rs. 3/- (1875) and irrigate nearly nine bighas in one season.

Some rich farmers used Persian wheels which were locally known as *rahat*.

In the case of water raised from a hole or ditch, the usual plan was to have *ektha* or *karin* open at one end and suspended from bamboo stand. A man pushed the closed end into the hole full of water then raised it so that the water could run out at the other end and from there guided to where it was wanted. This method involved least labour and was very cheap. Due to its simplicity this was even adopted sometimes for raising water from the temporary river pool to the adjoining field comparatively at higher level.

Another method was for two men to stand, one on each side of a hole full of water and scoop the water up with a bucket made of reeds.

In the district of Champaran (north west portion of Bihar,bordering Nepal and the then North Western Provinces) irrigation was common in some parts while it was rare in other parts. It was carried on more or less on the same line as in Tirhut district mentioned above.

All along the north of the district the small nalas and hill-streams were annually dammed up wherever possible and the surplus water was utilised, by leading channels from the dam to where it was wanted. The *Tharus*, an aboriginal tribe, living in good number in the *terai* area in the north of the district displayed a remarkable aptitude for irrigating their land by this method. They were supposed to be first rate cultivators, taking great pains with their lands and consequently had magnificent crops. These *tharus* used to construct dams of very small height, just to put an obstruction across the hill-streams for storing water and lead the water to their fields through narrow artificial canals called *pynes* which could be several kilometers long. In the next season some parts of these *pynes* could be reutilized but the dams were constructed every year. In certain tracts, however, the water was sometimes cut off by the Nepalis beyond the frontier when it was most wanted in the plains. The *tharus* who are said to have migrated from Rajasthan are simple in habits,contented and averse to litigation. So they never quarreled with the Nepalis for their right of water. The *tharus* were dependent only on the available surface water and rarely utilized other method of irrigation.

There were, however, no canals in the whole of district writes Mr.W.W.Hunter (1877). Wells were not common and tanks were very scarce. The depth of sub-soil water in the well varied from fifteen to twenty feet according to the season. Most of the wells were simple holes dug without any support. Some wells were lined with masonry and others with segmental tiles from four to five feet in diameter. However, wells completely lined with bricks were very rare. The depth of water in the wells rarely exceeded six feet and in the beginning of summer only (April or May) they used to dry up. The Champaran people however, in general, irrigated their cold weather crops. They did not leave the lands fallow and never practiced rotation of crops. Use of manure, for crops other than sugarcane, tobacco, opium and indigo were rare. However the yield of *Aghani* rice in a good year was 12 to 14 *maunds* per acre (450 to 525 kg/acre).

METHODS ADOPTED IN SOUTH BIHAR

The people of South Bihar (viz., the then Shahabad, Patna and Gaya districts etc.) were, however, more conscious of irrigation. Perhaps because their fields needed irrigation more than those in North Bihar and more because the features and slope of the country permitted them to adopt a suitable method to utilize surface water

conveniently. So conforming to the old adage that necessity is the mother of invention, they had developed a nice system of irrigation avoiding the expense of raising the water by machinery or animal labour. Their indigenous system was the outcome of the natural conditions and physical configuration of the country and had been evolved to meet the obstacles which they placed in the way of cultivation.

For obtaining the advantage of irrigation for crops by the natural flow of water the people of Shahabad district practiced two methods on large scale as mentioned in the prelude of the Irrigation Project submitted to the British Government by Lt. C.H. Dickens in the year 1853.

One of those methods was to dam across small valleys so as to arrest the surface drainage water of the rains and to cause it to flow out in proper season upon the fields below the dams.

The other method was the conveyance of water in canals from rivers in the hills so as to cause it to flow down upon the plains at a higher level than the land to be irrigated.

The first method was applied to parts of the district having a succession of high and low land at short intervals, which included continuous somewhat steep slopes, and the second to extensive plains lying at the foot of masses of hills in which there were rivers having a considerable supply of water all the year round.

In fact, Lt. Dickens in his first Canal Project (1853) for Shahabad district had proposed a combination of both the above mentioned methods of procuring irrigation by the natural flow of water to suit the case of extensive plains lying at the foot of hills in which there were no rivers having any considerable supply of water in the dry season. By observing the success of prevalent irrigation practice only he had proposed to form reservoirs in the hills to be filled by surface drainage from the rains and to lead the water of these reservoirs by means of canals over the plain country for use during the dry months.

Later while making reconnaissance in Shahabad district, for formulating the Sone Canal Project in 1854, Lt. Dickens came across in some places reservoirs of water for irrigation formed by throwing dams across the small rivers and across *nalas* or hollows on the slope of the hills. The surplus water was allowed to escape round one flank of the dam. He has made specific mention of a large reservoir across the river Kao near Bikramganj. It had a dam nearly three-quarter of a mile (more than a km.) long, 16 feet(4.87m) high in the center, and was said to have been constructed under the orders or with the assistance of the Collector of the district. The river Kao was stated to be dammed in 13 other places, but on a much smaller scale. There were also tanks supplied from channels dug to the larger hill streams viz. Soara, Durgawati etc. so as to be filled when the streams were in flood. All these

reservoirs were used principally for the rice cultivation, and were generally exhausted before they could be used for next crop or at most after the first watering.

As far back as in the year 1811 Dr. Buchanan Hamilton also found such small reservoirs in this portion of the province as well as in the district of Bhagalpur (south east portion on the right bank of Ganges). However, in Shahabad such reservoirs were numerous.

Dr. Buchanan had roamed this part of the country extensively. In his book "Eastern India" while narrating this area, he has mentioned that where the soil was clay, rice came to maturity without assistance but the crop was usually poor and uncertain. Where the soil was light, irrigation was absolutely necessary. To secure a regular supply during the occasional intervals of fair weather that happened during rainy season, and to provide for the want of water later, early recourse had been to both canals from rivers and reservoirs.

The land in the reservoir which in the rainy season was covered with water if the reservoir was small and dried up in time, was usually cultivated for a winter crop like wheat, barley or pulse; but the larger tanks did not admit of this economy. In larger tanks where residual water remained for longer period, fish compensated for the loss of the crop, and defrayed the expenses for upkeep of the reservoir. Dr. Buchanan has mentioned that *"large reservoirs had a bank of a mile (1.6 km) and upwards in length but did not form above one tenth of the whole."*

Canals used to take off from these reservoirs. Many of the canals were several kilometers in length and in the dry season conveyed large quantities of water, often more than what remained in the channel of the river.

Dr. Buchanan states *"The expense, both of making and repairing the canals and the reservoirs, is entirely defrayed by the Zamindars, who appoint proper persons to divide the water among the tenantry."*

During the peak floods these canals and reservoirs could afford a supply by merely allowing the water to flow in the fields through sluices which usually consisted of a hollow *tar* (palm) tree, the end of which was filled with clay, when it was intended that the water should be confined. In the canals the water was raised to the level of each man's sluice by a small temporary dam of earth. Towards the end of the season the water was raised from both reservoirs and canals by mechanical means either by *karin* or basket. The basket suspended by ropes was used when the quantity of remaining water was small, but when the quantity of water was considerable *karin* (an equipment like a canoe) was used if the height to which it was to be raised was small, while the pot raised by a lever was preferred when the height was considerable. The labour involved was only once in raising the water because after the fields next to the reservoirs have been filled, the same water was allowed to flow on others by zgravity without any additional labour.

Dr. Buchanan Hamilton narrates that in some industrious villages, all along the gentle declivities, at some distance from the villages, ditches were dug. These served as reservoirs receiving the water from above and collecting it for the supply to the fields below, during occasional droughts. The fields below were, therefore, usually cultivated with rice, while those between the reservoirs and the villages were cultivated with crops that came to maturity in spring, and did not require so much water as rice did.

He has further added that the landlords who maintained the reservoirs, when kept the reservoirs in tolerable repair, the crops seldom failed and was generally more abundant than could have been expected.

The large reservoirs usually situated at the higher level were locally known as *khazana* or *tal*, smaller ones as *ahar*. An *ahar* was an artificial catchment basin formed by blocking the drainage of the surface water, or even by blocking a small drainage rivulet, and thus locking up the water. These catchment basins were always of a more or less rectangular shape, embankments being raised on three sides of the rectangle, while the fourth side was left open for the drainage water to enter. Owing to the slope of the land in this region, which is from south to north the highest embankment was usually on the north, and this embankment generally ran east and west. From either side of it other embankments projected southwards, diminishing in height as they proceeded, according as the level of the ground rose. In this way a three-sided catchment basin was formed, deepest at the northern side, where there was always some arrangement to let out the water for the purpose of irrigation, at the spot where the drainage of the catchment would naturally issue if there were no embankments.

If the *ahar* was built on a drainage rivulet and thus received the drainage of a larger area than its own, a spillway or weir was provided to pass off surplus water, which might flow to another *ahar* further north. In small *ahars* where the quantity of water banked up was not great, it was generally sufficient to cut a narrow passage through the earthen bank at the deepest spot to draw the water as required. If the volume of water accumulated was large, a half pipe formed out of the trunk of the palm tree and known as *donga* was let into the bank to protect it from excessive erosion; and in case of a very big *ahar* where the depth of water was considerable, a masonry outlet was often built into the bottom of the bank which was called as *bhao* or *bhuari*.

The different parts of an *ahar* also had distinctive names. The bed inside the embankments was *pet* (belly), the bank called *pind*, the side banks being known as *alang* and the main bank at the lowest side of the *ahars* the *peeth* (back).

Usually smaller *ahars* were constructed by the people but *ahars* of large size, the largest irrigating about 1000 acres, were also built.

The system was very complete in itself and provided carefully for a full and economical use of the surface drainage water of the districts. According to the slope of the area the locations of the reservoirs or *tal* were kept above the *ahar* and the *putsar* (irrigated rice-land) below that. The weirs or escape for flood water were on the highest available land and were generally on land belonging to a village above and were connected with drainage channels leading to other *tals* or *ahars* below. The water thus flowed to and from *ahar* to *ahar* and from *putsar* to ahar or *tal* till excess water was absorbed or found its way into the drainage *nala* of the district.

The division of village land into *tal* and cultivable area were clearly defined. Village and individual rights in this system of paddy irrigation were universally recognised and carefully guarded by the people themselves, individual holdings in the *putsar* or paddy area having a right to the *tal* water in proportion to their size. The rights of the tenants to the use of water were duly recorded in the *fard-pashi.*

Often long narrow artificial canals were led off from the rivers or sometimes from the *ahars* also by means of which the water was conveyed to the fields. They were called *pynes.* Writing about the *pynes* of Gaya district in the District Gazetteers (1906), Mr. L.S.S. O'Malley says *"They are led off from a point facing the current of the river, some way upstream above the level of the land they are intended to irrigate; and it is often 2 or 3 miles before the water of the pyne reaches the level of the cultivation. Some are large with many distributaries and some small with few or no distributaries. They are sometimes as much as 10,12 or even 20 miles in length, and some of them irrigate hundreds of villages."*

The large *pynes* that fed a number of distributaries and irrigated many thousand acres were known as *dasiain pynes* i.e. literally *pynes* with 10 branches. The main channels were known as *pynes* and the smaller channels taking off from them were called *bhoklas,* while the smallest channels that led immediately into the field were known as *karhas.* A *pyne* might eventually lead into an *ahar* after it had almost spent itself.

The *pynes* taking off from the rivulets, however, could not irrigate the land situated at higher levels for which the *ahar* had been specially devised.

The *pynes* were constructed by the landlords who were also responsible for their maintenance—a work which required considerable expense, as these pynes quickly silted up, owing to the sandy nature of the river beds, and had to be cleared out every year or two. Ordinary petty maintenance, however, such as the periodical clearance of silt, the repair of small breaches etc. was done by the cultivators themselves under the *goam* system. At the order of the landlord or his local agent or servant, the cultivators had to supply one man per plough to turn out on these occasions and carry out the work. The peasants came in a body, and this was called a *goam.*

Describing further about the pynes of Gaya district O'Malley writes *"The pynes are essentially private canals, and in the case of the more important which serve many villages, each village has its fixed turn of so many days and hours to use the water, these turns being assigned by mutual agreement or ancient custom. This distribution of the right of irrigation by turns (para) is known as "parabandi". In the case of the principal pynes there is a celebrated register of the distribution—the Lal Bahi—prepared by the former owners of the Tekari Raj, and the entries in this book are still accepted as evidence of the rights of the villages specified in it. Disputes, however, frequently occur. One village often tries to get more water than it should, or else when the rainfall is scarce, villages lower down seek to get water before their proper turn; and the disputes sometimes terminate in blows, and occasionally in bloodshed. Quarrels are also common in regard to "bandhs" or "garandis", erected across the pynes or bhoklas to steal or divert the water, thus depriving lands further down of all supply..."*

The system of *ahars* and *pynes* which prevented the water escaping and made it available for cultivation was further supplemented in Gaya district by a method known as *generabandi*. A series of low retaining banks was built across the lines of drainage which was connected by other banks running north and south. The main outer embankment (*gherawa*), which was about 4 feet high, enclosed a considerable area and this was split up by minor embankments called *genera* and within these again were low banks alround the fields. This series of banks, which resembled an enormous chess-board was admirably adapted for retaining the surface water, as not a drop was allowed to flow beyond their limits and the stiff soil was given time to absorb the moisture. This system was known as *generabandi* and was followed generally to irrigate high lands. This was often followed in the irrigated area also, in order to ensure the fullest possible use of all the water available.

Thus the *ahar* and *pyne* system of irrigation formed a most remarkable and ingenious system of artificial irrigation, which was admirably supplemented by the manner in which the water was distributed from field and retained in them by a network of low banks. Irrigation with the *ahar* system was practiced on large scale in Shahabad, Gaya and Patna districts till the construction of Sone Canals (1873) and even afterwards number of them continued. The system was well developed and very extensive in Gaya district where nearly one third of the total irrigation of the district was said to be derived from *pynes* and almost half by *ahars* as stated by Mr. L.S.S. O'Malley in the District Gazetteer of 1906. It was not so elaborate and extensive in Shahabad district but served approximately 1,79,000 acres (72,480 ha) as observed by J.F.W.James in the District Gazetteers (1924).

The *ahar* and *pyne* system in this zone was meant mainly for paddy cultivation. In the cold weather the *ahars* dried up and the *pynes* no longer contained water. Hence *Rabi* crop was not irrigated by them.

The irrigation of *Rabi* crop was for the most part effected by drawing water from wells by means of *moth*. This contrivance required two men and two oxen to work it. It consisted of a large leather bag, which was kept open by a circular rim of iron. It was lowered into the well by means of a stout rope passing over a pulley supported on uprights. To the other end of the rope bullocks were yoked, who raised the water by walking away from the well. One man attended on and drove the bullocks, whilst the other landed and emptied the *moth*.

In some places the weighted lever *latha* was also used which is very simple method of raising water without any use of bullocks and *moth*.

The *latha* was used throughout the State for irrigating the fields. Even today this can be seen in a number of places. The following are its component parts-

(i) *karin* or wooden trough, for holding the water and conveying it to the field to be irrigated.

(ii) *latha* or beam, for raising this trough.

(iii) *ledi* or the dried mud weight at the smaller end of the beam to facilitate the raising of the trough from the reservoir or well in which the water is contained.

(iv) *khunti* or *keel* or peg placed at the end of the beam to prevent the weight from falling off.

(v) *khamba*, the upright post working as fulcrum with two prongs on which the beam rests.

(vi) *barha*, the rope fastening the beam to the trough

(vii) *makaundi*.a small piece of wood which, placed horizontally between the prongs of the khamba supports the beam .

(viii) the *garhai* is fixed to the beam in such a way as to prevent it sliding off the *makaudi*.

A well usually contains more than one *latha* and where practicable should contain four or five, which is the maximum number that can be worked by a single man. According to the common estimate, three men working with two *lathas* can water from one-third to two-thirds of an acre in a day.

In some cases the rope which raises the bucket is attached to a pair of bullocks, who by walking down an incline, raise the water to the required height. A very large kind of well, with steps leading down to the water, called *Baoli* could be found at Biharsharif and in some other parts of Patna district.

The method of the bullocks and *moth* was, however, the most generally employed method for irrigation from wells which were not deep, reaching generally 18 to 28 feet (5.5m to 8.5m) below the surface; on the average 22 feet (6.7m). But the supply of water was in most part of the districts scanty and little more than a foot(30cm) remained in the wells while the *moth* was in use.

To irrigate the crop the water was run through the fields in channels, whence it was sprinkled over the crop with wooden scoops. Due to scarcity, water was not allowed to submerge the whole field plot by plot. However, for opium plenty of water was allowed.

With wells of the average depth the irrigation required two pairs of bullocks (to work and rest by turns) and two men at the well besides a woman or boy in the field to form the channels and sprinkle the water. On an average one *moth* could irrigate about 3/5 of a bigha (3/8 of an acre) in a day.

The greater part of the *Rabi* crop was watered only once or twice in a season, some of them three times (mostly barley twice and wheat three times). Without any other input the unirrigated field could produce only 2 to 6 *maunds* (75 kg to 225 kg) of grain per *bigha* and those irrigated once or twice, could yield from 4 to 8 *maunds* (150 to 300 kg). Land irrigated three times could yield from 7 to 10 *maunds* (262 to 375 kg) per *bigha*.

In some parts, however, in place of *moth*, *rahats* (Persian wheels) were used. In this system a number of buckets tied with an iron chain moved in a vertical plane dipping inside the water of the well one after another in the downward movement and lifting water in the upward movement up to the top of well and emptying in an irrigation channel. The vertical movement of chain and bucket was accomplished by a mechanism actuated by the horizontal movement of two oxen moving round the well or in a circular path little away from the well. This system could lift water from a deep well also and was suited for a well yielding sufficient water.

Irrigation was likewise practiced in almost entire portion of land south of the Ganges. The methods and contrivances used for raising the water were almost the same as mentioned above, their names, however, sometimes differed.

For example in the district of Monghyr, if the water level was not more than two feet below that of the field to be irrigated, the *siuni* was used. This was formed from a piece of very closely woven bamboo matting, about eighteen inches to two feet square, two of whose adjacent corners were brought together and the touching edge

sewn up, so as to produce an article like a flat, shallow scuttle. Two ropes were attached to the wedge shaped end thus formed and one to each of the remaining corners. It was worked by two men, each holding one of the end and one of the corner ropes, who plunged it into the water and bringing it up full, discharged it into the field by a quick raising of the end ropes.

Another contrivance called the *latkuri*, which corresponded to the *donga* of the south western districts was also in use in Monghyr and other south eastern districts. It was made of the hollowed trunk of a palm-tree and was worked by one man who stood on one end in order to depress it into the water. He had merely to withdraw his weight, when a simple lever tilted the trunk up and discharged the water through the other end which rested on the edge of the field. A system of three or four *latkuris* was used for lifting water from a deep tank.

A *jant* was an irrigator and worked in precisely the same way as the one mentioned above, except that, as a large hemispherical vessel of iron or baked earth was substituted for the palm-trunk, the man working it had the extra labour of landing it on the edge of the field and then emptying it in.

For raising water from the wells however the most commonly employed contrivance was *moth* as described above, in the entire south Bihar.

The cultivators, however, preferred use of surface water as they were comparatively cheaper and less laborious. In Monghyr district in Kharagpur area it appears to have been the custom to erect *dhar bandhs* or embankments across small hill streams, in order to intercept their waters for purposes of irrigation. They were formerly constructed at the expense of the Darbhanga estate, by the *jeth rayats* (head men) of the villages within which they lay. As they were made without the necessary careful calculation of the amount of flood water to which they were liable to be exposed, and were constantly being injured, it was proposed in 1873 that a special examination and report should be made on all the embankments and that they should be divided into three classes:-

1. Those likely to prove permanently remunerative, owing to the increased value given to a large area of land by their construction.

2. Those not likely to prove remunerative, but which, having been always maintained at the expense of the estate, could not be abandoned without hardship to the *rayats*, and which could be constructed in a solid manner at an expense not greater than the amount which, at 5 percent would yield the average annual expenditure on repairs.

3. Similar *bandhs* which should be maintained but which could not be constructed within the above limit of expense.

It was also suggested that it might be found desirable to erect *bandhs* at places where they had not existed. The Collector, Monghyr was asked to prepare returns, showing, if possible, the number and the area of the holdings which could be benefited with their rental. He submitted a scheme amounting to £3047 (Rs. 31,000/-) in the year 1875 to benefit 2057 farmers holding 5743 acres of land, the cost of development being Rs. 5/- per acre. This was sanctioned and scheme subsequently implemented.

METHODS ADOPTED IN CHHOTANAGPUR AND SANTHAL PARGANA

In the district of Hazaribagh and Lohardaga two modes of irrigation were in general use --- the *kachcha well* and the *ahar*.

The kachcha well was just a hole dug some 2.5m to 3m deep at a cost of Rs. 5/- (1875). It was reckoned that one such well could irrigate an area of five bighas of land.

To utilize the surface water *ahars* were constructed by throwing small embankment across the upper and narrower end of the trough shaped depression that lay between two ridges of land. It thus formed a reservoir at a higher level from which all land lying below the *ahar* could be irrigated as long as the water could last. Land situated above the embankment and on the brink of the reservoir itself was called *ahar ka dhuba* and could easily be irrigated by a lift. The land immediately below the embankment, known as *ahar ka pinda* was kept moist by the percolation of water through the soil. A good sized *ahar* could hold water all the year round while a small one especially when much used for irrigating cold weather crop dried up by the middle of hot season. The water was led on to the land by *pynes* or small drains taken round the wings of the *ahar* on either side. The embankment itself was cut in the end when the water used to fall too low to be drained off in the *pynes*.

All these *ahars* were constructed by the people on small scale and could irrigate small areas. British Government did not come forward with a comprehensive scheme in the area as any such scheme would have required construction of a number of aqueducts to lead the water over intervening valleys to cater a large area and this was possible with only huge expenditure of capital which could have involved virtually prohibitory rates for the water supplied.

But while the British were concerned for revenue, the people were conscious of irrigation. In consonance with the native ideas in the year 1877-78 the Dhanwar estate (about 40 km east of Koderma) in pargana Kharakdiha had **constructed a small earth dam about a kilometer in length with a maximum height of 44**

feet(13.5m) across a small stream to store water for irrigation. This stream during the rains rose to 8 feet(2.5m) spreading from bank to bank in a width of 50 ft(15m) while in the dry season it dwindled to a mere brook. The catchment area of this stream was about 4 sq. miles (10 sq. km). The dam had submerged an area of nearly one hundred acres (40 ha). Below the dam there was a gentle and unbroken slope of three sq. miles (7.7 sq. km) of land which was irrigated by the reservoir water. The cost involved was about Rs. 30.000/- (1878) and people happily paid water rent to the estate which fetched 15% return on the outlay.

In the district of Singbhum there were no canals or lakes, and the only form of artificial irrigation practice was the construction of embanked reservoirs across the upper ends of the natural depressions, in which rice was grown. Water was thus stored during dry months and was let out upon the crop by drains cut through or round the embankment. But such reservoirs were not many and were found in Saraikela estate and better cultivated parts of the then Dhalbhum pargana. Artificial wells were rare and the natives got even their drinking water either from tanks or from natural springs called *daris* which are found in the low lying lands. These were usually enclosed in a framework of wood to preserve the spring from surface pollution. Almost similar condition prevailed in the Manbhum area though irrigation of some sort was essential to almost every crop as the surface drainage in this zone is rapid and the soil consequently very dry.

Chhotanagpur was then divided in a number of Tributary estates and each tribe had his own method of irrigation. For example, the *Bhuiyas* who were in no way inferior to the other inhabitants of Bihar and had the same means and appliances of agriculture, had learnt the use of manure; but they had no idea of combining together to carry out schemes of artificial irrigation. Each man made his own petty dam to water his fields while the skillful and industrious *Agarias* made the most of their land. They constructed, in concert with their farmer or headman, reservoirs to irrigate large areas and displayed considerable engineering skill. However, none of them is on record to be mentioned specifically.

Irrigation in the Santhal Parganas was also effected, for the most part, by *bundhs* and embankments thrown across the narrow ends of the trough-like land thus creating small reservoirs at a higher level. Land below the embankment growing rice crop could be irrigated by leading the water round the edges of the embankment or by cutting the embankment itself, while the wheat, barley, sugar-cane and poppy crops of the adjacent high lands could be watered by lift. Wells were not used for irrigation and were seldom constructed even to supply drinking water.

LATE BRITISH PERIOD (From 1850 to 1947)

HISTORICAL BACKGROUND

The modern system of irrigation in Bihar began in the middle of the nineteenth century when the British Government thought of providing some protection against the droughts and famines frequently visiting the State. But while doing so, the Government was very particular of the revenue and no irrigation work could be taken up unless it promised good returns. The British by nature are business minded and at that time they were the master of the country, hence while providing protective irrigation, they wanted to make profit out of it.

To guard their interest, the responsibility of planning and execution of irrigation works was assigned to the Military Engineers of the Engineer Crops of the East India Company working under the control of Military Board and subsequently of the Crops of Royal Engineers. In 1854 the Military Board was abolished and the Public Works Department came directly under the control of Government of India. Even so, the engineers on the Civil side continued to be from the Royal Engineers under the direction and control of the Public Works Department of the Government of India. The public works were, however, the responsibility of the Public Works Department of the various provinces under British Raj. The irrigation works in Bihar were controlled by the Public Works Department of the undivided province of Bengal. The headquarter of the Chief Engineer was then at Calcutta. Government of India, however, excercised its control through Inspector General of Irrigation.

In 1921 after the introduction of the first phase of constitutional reforms based on Montague- Chelmsford recommendations, irrigation became a provincial but reserved subject. Although the rigid control previously exercised by the Secretary of State and the Government of India was abolished, the expenditure on irrigation development was not made subject to the vote of provincial legislature. The Administration of irrigation works was reserved to the Governor in Council and was thus under the ultimate control of the Secretary of State for India living in London. Under this arrangement, it was necessary for a provincial Government to obtain approval of the Secretary of State through the Government of India before any irrigation project costing more than 5 million rupees could be sanctioned by the provincial Government.

With the introduction of provincial autonomy in 1937, irrigation became a transferred subject and the provincial Governments were given full powers for development of irrigation works. In Bihar, the Irrigation and the Roads and Building branch of the Public Works Department continued to be administered by the same department till 1948, when these two branches were bifurcated into two different departments, namely, Irrigation and P.W.D (Building and Roads)

Scores of schemes were prepared for providing irrigation in different parts of the State during the last hundred years of British rule. Those which were technically sound and gave impression of profitable undertakings were implemented while others were rejected stating clearly that they were not technically feasible or economically viable, though many of the latter schemes were later successfully executed by our own Government after independence. Some of the irrigation schemes in which the British did not like to invest for obvious reasons were implemented by the local zamindars with the technical know-how and assistance of the British engineers and they worked well. However, there is no denying the fact that the British Government contributed to a large extent to the development of water resources in this part of the country. In fact the British were the first to introduce irrigation in Bihar in scientific and planned manner.

Some of the notable irrigation works in the pre- independence period which later became the land marks in the history of irrigation in Bihar have been narrated in the following chapters.

CHAPTER IV

SONE CANALS

INTRODUCTION

The recorded history of public irrigation through canals in Bihar dates back to the days of East India Company. The premier among the projects was the Sone Canal System and the man behind this magnificent planning was none other than Col. C.H. Dickens, the author of famous Dicken's formula which has been in regular use for nearly one and a quarter century for calculating discharge in the formulation of water resources development projects.

HISTORICAL BACKGROUND

Story begins in the year 1853 when a young Army Engineer Lieutenant Dickens visited the then district of Shahabad in Bihar, under the Lieutenant Governorship of Bengal. He saw the cultivators there, in their fields, labouring hard to lift water from tanks below the surface or wells 10 to 40 feet deep, in order to apply it to their crops. He was moved to see such sheer waste of labour which could be otherwise utilised in a fruitful manner for the development of the country, especially when there was opportunity to plan an excellent irrigation system by utilising the surface water available in large quantity but uselessly flowing to the Ganges.

He was undoubtedly an extraordinary man. Extraordinary, because it was not expected of a young Military officer in the Artillery wing to be so civil, so kind and so alive with the problems of common mass. He possessed an excellent engineering skill and knew how to make the best use of it for orderly marshalling of the water resources for the development of mankind, the art which later made him a popular hero in the field of Irrigation Engineering, if not in the warfield.

DICKEN'S REPORT (1853)

Dickens conceived an idea of irrigating the land in Shahabad by tapping the surface water of various streams in the Kaimore range of hills in the south of the district. His scheme envisaged construction of a series of reservoirs along the foot of the hills to catch the surface drainage from the rains, and to lead the water of these reservoirs by means of canals over the plain country for use during the dry months.

While advocating the feasibility of his scheme, he had explained that such a scheme apart from providing irrigation which was the chief object, would prove to be a means of guarding against the evils of drought, also provide advantage of navigation and to a great extent of protection against floods by arresting the rain-water in the hills through reservoirs. The last but the most interesting advantage he had indicated, which has great relevance even to-day, was that the scheme of canals as an example of practical science applied to such fruitful purposes would go a long way in instructing and educating the general intelligence of the community. In his words "*There is more in a Canal to excite and stimulate the desire of instruction than there is in roads, bridges, or any sort of mere building and though not so striking an example of applied science as a Railway, the application of a Canal being to purposes more interesting to native agriculturists will make it a better example for them.*"

An expenditure of about Rs. 30 lakhs was contemplated for this scheme and it was estimated that the returns would yield a profit from 10 to 19.5%. After consulting Engineer Officers residing in Calcutta, Lieut. Dickens submitted his proposal to the Secretary to Government of Bengal in Calcutta on 25th January 1853, for consideration. The scheme was forwarded to the Governor General of India in council, who sent the same to the Court of Directors in London. The Court of Directors favoured the scheme and deputed him on special duty in Shahabad in the end of 1854 and asked him to submit the scheme in greater detail.

Captain Dickens this time had opportunity to remain in Shahabad till April 1855. Before this visit he had not seen the river Sone and heard no account of it to lead him to look to it as a source from which to divert water into the canals. After conducting surveys and investigations, Captain Dickens found that harnessing the Sone water was better proposition as compared to the construction of numerous reservoirs in the foot hills. On 22nd June 1855 he submitted another report accordingly.

REPORT OF 1855

In his elaborations he had argued that Sone had enough water during the *Rabi* period to cater to the needs of the area adequately, both on the left and right banks of the river. The levels of the area were favourable to receive irrigation from Sone and so the reservoir scheme submitted earlier was of secondary importance. In this report he had stressed the need for making the contemplated canals as navigable channels for carriage of valuable products of the hills viz. forest wood, building stone, lime stone, iron and coal. He had gone to the extent of suggesting even canal solely for navigation to carry the coal and other valuable products of the hills from the Sone Canal near Sasaram to the Ganges between Benares (Varanasi) and Chunar.

The estimate of the cost of the work was raised under the new proposals to nearly 61 lakhs of rupees and it was calculated that the profit would yield a net

return of 11.75% (after completion of only 2/3rds work) to 19% (when fully completed). The Court of Directors carefully examined the whole project and was convinced that the improved system of irrigation would greatly benefit the districts alluded to and that the undertaking might yield an adequate pecuniary return

The Directors were very much impressed with the work of Captain Dickens and bestowed high praises on him. While conveying their feelings, Mr. W. H. Sykes, on behalf of the Court of Directors, wrote to the Governor General of India in Council: *"We desire that you will communicate to Captain Dickens through the proper channel, the high sense which we entertain of his services, and we fully concur in the opinion recorded by you that he is "deserving of the highest praise for the great care and ability with which he has conducted the enquiry upto the present point, for the great amount of field work done, and of valuable local information obtained in so short a time, and with such very little assistance, and for the clear and concise manner in which he has laid before the Government the result of his labours"*

In the end of 1855, Captain Dickens submitted estimates for carrying out a portion of works on the west of the Sone, but the restrictions which were imposed on Public Works expenditure at that time prevented them being sanctioned. However, the Court directed Captain Dickens in December 1855 to proceed with the preparation of detailed surveys and estimates confining himself to the scheme of canals from Sone as per his latest report.

FURTHER INVESTIGATIONS

In June 1856 Captain Dickens again came to Bihar to continue further investigations for the project and this time he proceeded with detailed surveys both on the left and right banks of Sone but before he could do anything substantial he was obliged to break up the establishment and return to Calcutta in March 1857 due to sudden eruption of political disturbances, triggered by an upsurge of anger against the British Rule.

It was a period of turmoil in the country. The nation was not only simmering rather boiling against the foreign rule and was in a full mood to throw off the British yoke. The struggle for freedom had taken a violent turn. The people were out for the blood of the British whom they treated their enemy. Mutiny broke out in the year 1857 rather more seriously in the district of Shahabad under the leadership of Babu Kunwar Singh of Jagdishpur, and further the outbreak of Sepoy regiments at Danapur on 25th July, 1857 had resulted in the flight of most of the mutineers across the Sone into Shahabad. Shahabad thus became the most disturbed district. The British were fleeing for their lives and this resulted into a total standstill of investigation of Sone Canals for nearly four years.

Works could be restarted after this intervention only in December, 1860 when Lieutenant-Col. Dickens was authorised again to visit the districts and devote his whole time to the completion of Project as far as the data collected would allow.

REPORT OF 1861

On the basis of the studies made earlier and with the help of further investigations an elaborate report was submitted by him in 1861 to the Government. The general plan of the project was much the same as proposed in 1855 but with the addition of canals on the east side of the river Sone for the irrigation of the then districts of Gaya and Patna. The main features of the proposal were fanlike spread of water distribution system from 10 to 12 miles (16 to 19 km) below the Head-works all over the area on right and left of the Sone as far as the Karmnasa on the west, Ganges on the north, and the Morhar and Poonpoon on the east, with the provision of four main lines of navigation, to Benares (Varanasi), to the mouth of the Karmnasa, to Arrah and to Patna. He had however, made it clear that construction of all these at the same time were not at all necessary and had left the option open for the Government to proceed in phases. While proposing the method of carrying out the works gradually, he had suggested construction of Patna Canal first and if further outlay could be afforded the Arrah Branch might be undertaken simultaneously or immediately after the Patna Canal. The intention behind this suggestion was that both these canals could start irrigation even before the construction of the anicut across the river Sone.

Another vital change he made in the selection of site for the anicut. In 1855 he was keen only for the area on the left bank of Sone and had suggested Bandoo as the site of anicut, but subsequently, considering the areas on both banks, he had suggested the new site in the neighbourhood of Pathurghatta.

RATES AND COST OF WORKS

The rates for masonry and brick-work in Shahabad had undergone considerable changes due to commencement of Railway works and also due to occurrence of the mutiny.

Table 4.1

ABSTRACTS OF ESTIMATE

Sl No.	Name of Canals	Land	Roads & Fences & Planatation	Excavations	Works of Drainage & Regulation of Supply	Falls	Distributaries	Bridges & Fords	Accomodation for Establishment	Locks	Mills	First Total	Establishme at 121/2 percent	Second Total	30 percent to cover cost of portable rise of prices	Grand
1.	Head Works	4.800	3.800		17,84,546				*1.26.750	1.94.124		21,14,020	2.64.252	23.78.272	6,34,206	30,12,478
2.	Western Main Canal	10.560	7,860	5,73,581	3,55.380	1,14.000	13,000	1.29.000	15.925			12,45,106	1.55.638	14.00,744	3,73,532	17,74 276
3.	Estern Main Canal	9.600	6.600	4.46.709	1,68,295	81.000	13.000	1,34,500	15.300			8.75.004	1 09.375	9.84,379	2,62,501	12.46.880
4.	Arrah Br. & C	49.394	44.852	5,09.813	1,14,250	3,72 000	8.14.800	2.63.674	1,16.600	7.36.400	54,700	30.75.983	3.84.498	34.60 481	9.22.795	43.83.276
5.	Sasaram Br. & c	54.452	54.818	5 84.166	4,37,500	4.09.000	8.49.700	2 66.902	1.19.575	7.28.700	68.600	35.73.413	4.46.677	40.20 090	10.72.024	50.92.114
6.	Patna Br. & c	41.128	41,927	4,11,704	33,000	4.33.000	6.97.700	3.35.697	98.900	7.97.800	47.700	29.37.556	3 67.194	33 04 750	8 81.262	41.86.012
7.	Tikaree Br. & c	25.656	29.599	2,48.748	11.30,700	1,74.000	3.78.500	1,89.386	87.900	10.000	36.400	23.10.889	2.88.855	25.99.744	6.39.268	32.93.012
8.	Navigation Lines	34.839	42.055	4.95.319	6.40.000			2.64.000	65.725	11 72.000	17.600	27.32.038	3.41.503	30 73.541	8.19.611	38.93.152
	Grand Total	2,30.429	2,31.511	32,69.840	46,63.671	16.09.000	27 66.700	15.83.159	6.46.175	36.39.024	2.25.000	1.84.64.009	23 60.992	2.12.25 001	56 59.199	2.66.81 200

Dickens had assumed the average rate of Rs. 15/- per hundred cubic feet for masonry and brick works including pointing or plastering. For earthwork he had taken the rates at Rs. 2/- to Rs 2-8 per thousand cubic feet for ordinary excavation, allowing Rs. 3/- to Rs. 4/- for deep cutting and as much as Rs. 6/- where bailing was required in the foundation of works.

It would be interesting to mention some of the usual wages of the labour then paid by the Government. A beldar was paid 1 Anna 6 Pai per day while an ordinary labour 1 A 3 P, a woman cooli 1 A and a boy only 9 P per day. Dickens had allowed in his estimate 2 Annas for the beldar.

The estimate submitted amounted to Rupees 2,68,81,200/-(the general abstracts of the estimate can be seen in Table 4.1) which was reduced by economies in providing facilities for navigation to Rs. 2,45,00,000/- The net revenue was anticipated to be Rs. 21,41,160/- per annum (Table 4.2) which would have given a return of 8.75% on the outlay.

Table 4.2

Sale of water for irrigation	Rs. 18,42,920
Tolls on navigation	Rs. 2,00,000
Mill rent	Rs. 67,000
Miscellaneous	Rs. 31,240
Total	**Rs. 21,41,160**

PROJECT - A COMMERCIAL ENTERPRISE

The Project was treated a profitable commercial enterprise. After mature deliberation the Government of India decided that the execution of the Sone Canal Project should be left to private enterprises, and it was offered to and accepted by the East India Irrigation and Canal Company on the express understanding that it was to be restricted to the limits assigned to it in Colonel Dickens plans. This company had already undertaken the Orissa and Midnapore Canal works also.

PROPOSAL FOR EXTENSION OF CANALS

But before this scheme was taken up for execution, some sort of discussions went on to widen the scope of the project. Some highly ambitious people who were very much impressed by the scheme, prompted the men at the helm of affairs to extend the canals further beyond the point suggested by Col. Dickens. As a result

Colonel F.H. Rundall, officiating Agent and Manager, East India Irrigation and Canal Company in his letter no. 22 dt. 2nd May, 1865 proposed on behalf of the Company to extend the Sone Canals to Mirzapur on the west and to Monghyr on the east. As per this proposal the course of the western canal was clearly defined skirting the foot of the hills the whole way, passing south of Chainpur and through the rocky pass of Ghate Burganwan. It was to cross the Karmanasa near Kysoa and drop into the Jurgo near Chunar (map of Patna Division 1877)

These proposals were, however, definitely rejected by the Government of India. This was conveyed to the East India Canal Company on 10th of July, 1865, by Col. Dickens.

In his letter dated 13th September, 1867 Mr. H.C. Levinge, Chief Engineer, East India Irrigation and Canal Company while submitting his report and estimate of Sone Canal Project again emphasized the need of extending the canals in the following words "*to provide irrigation for that portion of the District of Shahabad bounded by the Ganges on the north, the Kymore hills on the south, the Karmnasa on the west and the Sone on the east, also to provide irrigation for that portion of Bihar lying between the Sone and Morhar rivers extending as far as the city of Patna; also to provide main lines of navigation from Dehri on Sone to Chunar, Chousa, Buxar, Arrah and Patna with minor branches*".

The old records show that what was suggested was not based on casual surveys only, in fact they had formulated a definitive plan of action. But Government did not accept these proposals and in November, 1867 ordered construction of canals on the lines of original estimate submitted by Col. Dicken in the year 1861.

INTERESTS OF CANAL COMPANY BOUGHT BY GOVT.

In 1868 Government negotiated for the transfer of all the interests of the East India Irrigation and Canal Company to the Government for a sum of Rs. One crore. The said sum was paid by Government to the Company after completion of negotiation. At that time no actual construction work had been commenced on the Sone canals. Simply an expenditure of Rupees Eighty thousand had been incurred on survey and investigation works.

After the transfer of the company was effected, Mr. Leavinge was appointed by the Government as Superintending Engineer of the Sone Circle and Col. Rundall became the Chief Engineer to the Government of Bengal.

COMMENCEMENT OF WORK

The Sone Canals were taken over by the Government on 21st December, 1868 and work was authorised to be taken up on 31st December, 1868. Active

operations were commenced in early 1869 with the construction of an anicut at Dehri-on-Sone.

THE ESTABLISHMENT

Dickens had earmarked 12 1/2 percent in the estimate on establishment for the execution of work. His proposed work force consisted of one Superintending Engineer assisted by two Assistant Engineers (one as Personal Assistant and the other for survey duties) and eight European clerks in the Circle, 5 Executive Engineers each assisted by 3 Assistant Engineers, 12 Overseers and 2 European clerks in the field. Considering the extensive and massive work of the Sone Canals this organisational set up seems to be slender. But the establishment was kept almost on the lines suggested by Dickens. Four working Divisions with headquarters at Dehri, Barun, Arrah, and Buxur and a Western Sone Survey Division were created under the Sone Circle, Dehri for execution of work.

Accommodation for Engineers and subordinates

Dickens had strongly advocated for residential facilities to the officers and staff of the project. Quoting Sir P Cautley, the eminent engineer, who had earned great fame by successfully constructing the prestigious Ganga canal in the then United Provinces (U.P) and whose plans had also been successfully followed in other contemporary projects elsewhere including Bari Doab Canal in Punjab, Dickens stated in his report (1861)- " *In the estimate for this project I have included quarters for the engineers and European subordinates and clerks. In so doing I am supported by the opinion of Sir Proby Cautley; and it seems to me evident that it is in many respects objectionable to have engineers and subordinates engaged in building operations on their own account while employed on Government work.*" He had accordingly made adequate provision for the permanent and some temporary quarters for the officers and staff.

Dickens was equally conscious of providing lodging facilities to the officers while on tour. He proposed to construct first class *Canal Chaukees* (rest houses) affording accommodation for a few days for an engineer with his assistant or subordinate on inspection duty, and some second class accommodation for more temporary visits of the same sort, both also having rooms for stores, for native subordinates, servants and stables. He suggested to locate the first class *chaukees* at every escape sites, almost at a distance of 15 miles (24 km) and second class *chaukees* at every lock and fall or other important work to facilitate frequent inspection.

For proper execution of work, efficient operation and desired upkeep of the system, Sone Canal authorities paid due attention to the proposals of Col. Dickens and followed his suggestion in true spirit.

EXTENSION OF CANAL AGAIN PROPOSED

After taking over charge of Superintending Engineer in Sone Circle Mr. Levinge once again raised the issue of extending the canals up to Monghyr on the east and Mirzapur on the west. His proposal was forwarded to the Government by Col. Rundall, Chief Engineer. The Government of India in letter no. 4811 dated 9th December, 1869 declined to agree to the proposal but demanded a report on this subject. This report was furnished by the Government of Bengal on 14th February 1871 and sent to the Government of India along with the memorandum submitted by Mr. Levinge.

In his memo Mr. Levinge had argued on two lines. He pointed out that *"pynes or small irrigation channels exist in large numbers in the area and command a considerable quantity of land and so afforded obvious proofs that the rainfall but inadequately meets the requirements of the country for water supply and that artificial irrigation is a necessity. Whenever there was deficient rainfall, famine or severe scarcity must ensue, and this has been more than once the case within the last few years"*. He had estimated that if the extensions were carried out, the revenue which would be derived would be as follows:

Table 4.3

Irrigation : 8,80,000 acres of *Rabi* @Rs. 3/ per acre	Rs. 26,40,000/-
Irrigation : 13,05,000 acres of Rice @Rs. 2/ per acre	Rs. 26,10,000/-
Navigation toll for 780 miles of canal,	Rs. 4,00,000/-
Total revenue	Rs. 56,50,000/-
Deduct 2.5% on the cost of works (Rs. 377.5 lakhs) for annual maintenance and repair (-)	Rs. 9,50,000/-
Net revenue	Rs. 47,00,000/-

Thus the net revenue return would have been equivalent to 12.5 per cent on the total expenditure i.e. Rs. 377.5 lakhs. This was endorsed by Colonel Rundall.

EXTENSION DEFERRED

Though the proposed extensions were proved to be feasible and financially viable by Col. Rundall and Mr. H.C. Levinge, they were not acceded by Sir George Campbell, who by that time had succeeded to the Lieutenant Governor-ship of Bengal. In his letter dated 2nd May, 1871 he rather suggested a considerable contraction of the works as then sanctioned. The extension of the Western Main Canal beyond 22nd mile and of the Eastern Main Canal beyond Poonpoon aqueduct were accordingly stopped on his recommendation. In a letter dated 20th June, 1871 he wrote to the Government of India that Mr. Rundall's anticipation of speedy return for the outlay was too sanguine and were not supported by the experience of similar works in other parts of the country.

Mr. Rundall had by that time joined Government of India as Inspector General of Irrigation. He, in his letter dated 14th July 1871 enquired from the Lt. Governor of Bengal regarding the basis of his thinking. Sir George Campbell in his reply dated 6th September, 1871 argued that *"... the canals of which he has had any experience have not yielded so speedy a return as was expected. Col. Rundall bases his expectation on the estimates for the works taken and reduced to the unit of the acre. Now it seems to the Lt. Governor that we can at present have no reliable calculations of the acres which are to yield a return to the Sone works, because we have no detailed survey of the ground, no detailed information regarding the crops and their necessities, and nothing whatever to enable us to say with any confidence for how much land water will be taken, and what rates the cultivators will pay on a very large area".*

"In the Lt.-Governor's opinion estimates based on the mere geographical area in square miles, and the assumption that the greater part of each square mile will pay high rates for irrigation, are not altogether reliable. They can at best be mere conjectures, and conjectures generally err on the side of being too sanguine. Especially it is a notorious result of canal experience that it takes time to induce the cultivators to abandon their old methods and to consent to pay even moderate irrigation rates".

"There is another ground on which the Lt. Governor entertains some doubts of the sanguine anticipations of revenue from so very large a scheme as that of the Sone Canals, viz., the very radical question whether the necessary water is in the river. Perhaps he may be pardoned for hinting a doubt of this kind on mere lay grounds, because he has witnessed the difficulty experienced at the head of the Bari Dooab Canals, when after the completion of the works the engineers discovered that the water on which they had calculated was not in the river....."

"In the Lt. Governor's opinion, then, the capability of irrigation of every canal designed, in whole or in part, for the winter crop irrigation should so far as that crop is concerned, be estimated at the minimum supply of the driest of seasons".

Giving weightage to Lt. Governor's arguments, the extensions of canals were deferred by Government of India.

The old guards of British business culture might appreciate the views expressed by Sir George Campbell which were guided more by the interest of revenue than the public welfare but his pessimistic approach did great harm to the development of the region as a whole.

However, the works of Sone Canals were proceeding with speed, the Main Canals being reduced as recommended by Sir George Campbell, but in other respects on the general lines indicated by Colonel Dickens and projected by the East India Canal Company.

EXTENSION OF WESTERN MAIN CANAL UPTO CHUNAR AGAIN EMPHASIZED

Work had been progressing as per schedule and strictly following the approved plan but Levinge at the same time had all along been stressing the need for the extension of the canals.

With his relentless efforts and unqualified support of Col. Rundall he was successful in the year 1874 in persuading the Government of Bengal to seek approval of Government of India for the extension of Western Main Canal upto Chunar, if not the Eastern Main Canal which was then in advanced stage of construction.

Government of India was apprised of the feelings of Mr. Levinge but Sir George Campbell while forwarding the memorandum of Levinge had once again expressed his apprehension of short supply of water from Sone.

Government of India was all appreciations for Levinge and in view of the soundness of his proposal forwarded the same to Sir Marquis of Salisbury, Secretary of State for India in London for approval and meanwhile permitted excavation of canal beyond 22nd mile of Western Main Canal to provide relief to the poor people famishing after the famine of 1873.

But Secretary of State for India in his Despatch No. 33 dated 31st March, 1874, did not agree to the proposal and with reference to Sir George Campbell's apprehension of short supply of water said "*... the constructive operation on the Western Main Canal may be limited to what is necessary for the relief of the famishing poor until the capability of the river to supply water to this portion of the canal has been carefully ascertained.*"

In his reply (No. 75, dated the 12th May, 1874) Governor General of India wrote to Sir Marquis of Salisbury that construction on extension of Sone Canal had been stopped, but at the same time tried to convince the Secretary of State that there was enough water in Sone to supply the same to the canals.

While stressing the need of irrigation and benefits of having a navigable canal in this part of the country Governor General of India had said in his Despatch:

"Your Lordship appears to have been influenced by another consideration in giving the orders in the Despatch now under reply. The expensive works on the Western Main Canal from the Sone would, no doubt, be a reason for proceeding with special caution in carrying out that line of canal, were it not for two compensating circumstances. One of these is that this Western Main Canal commands a drier country, where the wells being very deep, water is consequently of greater value, and the risk of failure of the crops from drought greater than in north and eastern portion of the tract. The other circumstance is the value of this particular canal for navigation, for

which it has special advantages. The limestone of the south eastern face of the Kymore hills is the only limestone (other than kunkur) within many hundred miles of the cities of Benares and Allahabad. This canal skirts the base of these hills where the limestone crops out, and will carry it almost direct to Benares. There are also the sandstone and the jungle produce of these hills, and the coal of the Palamou fields beyond. There is, in this case, therefore, a valuable traffic well suited for water carriage, and a favourable line for working it. These two considerations then - the greater dryness of the country, and greater need of water, together with the good prospects of the navigation seem to us to justify the commencement of the Western Main Canal, now that the other line in hand have made sufficient progress, and considering that there is evidence of a disposition to take the water in the country west of the Sone.

So long then as the canal seems on moderate calculation likely to earn a sufficient return on capital outlay, it appears to us the more widely the irrigation is spread, the better."

Arguing on the lines mentioned above Government of India had requested Sir Marquis of Salisbury to remove the restriction placed upon the further progress of Western Main Canal.

But Marquis declined to agree. In his Despatch No. 61 dated 9th July, 1874 he observed *"I am not disposed to question the soundness of the principle, on which you insist, of distributing the waters of the river as widely as may be consistent with giving the canals full work in average seasons; so that, in seasons of scarcity, each portion of the district may get its share, and be able to raise its fair proportion of crops; neither do I imagine it to be at all doubtful that the country which the Western Canal would traverse is greatly in need of irrigation, or that, if capable of being navigated, the canal might be of immense use for traffic. My only fear is that, if the canal were carried out as proposed, enough of water might not remain available for it after the other canals of the system were supplied. On this point grave doubts were entertained by Sir George Campbell; and although it is possible that these may hereafter be discovered to be ill founded, I cannot but think it more prudent before deciding to extend the Western Main Canal, to ascertain by further experiment what quantity of water will be available for its supply."*

Regarding the utility of canal for navigation purpose he asked for precise data—*"I should also like to be more precisely and exactly informed of the data on which you found the expectation that this canal will be profitable for purposes of navigation. I should like to have exact reports, showing what are the minerals, and where situated, which you expect to be carried by the canal; where is the demands for them, and, altogether, what are the grounds for expecting large revenue from navigation."*

Government of Bengal, forwarding this Despatch of Secretary of State (in order No. 733 I dated 12th August, 1874) demanded the desired report in detail from Mr. H. C. Levinge, Superintending Engineer, Sone Circle.

Mr. Levinge in his Memorandum (No. 4365 dated 25th September 1874) which is undoubtedly one of the most important contributions to the literature of the Sone Project, described first in detail the nature of the country from Sasaram to Chunar, through which the Western Main Canal was to be extended and the means which were already existing in the area for the irrigation of the crops. Quoting examples he had elaborated that the existing *ahar* system of irrigation in the area were not effective. In a period of drought the supply failed. Also very commonly the embankments of *ahars* were breached by the torrents pouring from the hills after a violent burst of rain, then, of course, the impounded water escaped and if as was frequently the case, a long spell of dry weather caused the failure of crop. In ordinary years, however, the *ahars* protected the rice crop. For the *Rabi* crops, however, wells were the only means, but they were very deep.

Referring his report, submitted in December 1870, he had further stressed that the canal was a must for protecting rice crop, since rice was the principal food of the people of Shahabad. He wrote *"I have always maintained and still do so, and am more than ever convinced, now that I have had nearly six years' experience of the district, that the greatest demand for water will be for rice, and that it is to the irrigation of that crop the Government must look for the principal source of revenue from the canals".*

He further wrote *"I would again most emphatically repeat that the salvation of the principal food crop of the part of the district under discussion can absolutely be ensured by the construction of this canal".*

Regarding the availability of water in Sone he said *"The volume of water in Sone at the time of year the rice crop requires water is always super abundant, more than enough in fact to irrigate the whole of the districts, commanded by the weir, even if the canals were extended east and west to the utmost limits. This point has never been disputed, and is in fact beyond dispute, and it would be strange indeed if during, or immediately after an Indian rainy season, be it ever so light, a great river like the Sone, draining 30,000 square miles of country, could not supply 10,000 cubic feet per second at least".*

For the *Rabi* crops he agreed that *"Water will be given to the rubbee as far as it is available, and in this case undoubtedly to the extent to which irrigation can be given is dependent on the cold weather supply of the Sone".*

In his assessment of cold weather supply he agreed with Colonel Haig, Chief Engineer who in his note dated 4th July 1873 had estimated that not more than 3000 cubic feet per second should be relied on as the minimum discharge. Col. H. W. Gulliver, Joint Secretary to the Government of Bengal had also agreed to this

estimation. But Col. Rundall, Inspector General of Irrigation considered that 4000 cusec should be calculated on as the average minimum cold weather supply. Levinge, however, quoting the example of 1873, a year of unusual drought and scanty rainfall when the crops had failed, asserted that even with 3000 cusec of water available in Sone nearly 4,30,000 acres of land could be irrigated throughout the cold season, or in round numbers, one quarter of the whole irrigable area from Chunar to the Sone on one side, and the country between the Sone and Poonpoon on the other, or the half of the irrigable area occupied by *Rabi* crops. He suggested that the proportional allotment of the cold weather supply could in that case be arranged to irrigate as follows:

Table 4.4

Description	Area in Acres
Arrah Canal	100,800
Buxar Canal	78,500
Western Main Canal	38,600
Patna Canal	91,400
Extension to Chunar	120,700
Total	430,000

Regarding navigation he had said that the said canal could be used for the carriage of sandstone, firewood, sal poles besides the produce of the area i.e. sugar, grains of all sorts, and indigo (for there were several factories on the line). He also anticipated a large passenger traffic between the cities of Benares and Gaya, going for pilgrimage.

In the end Levinge had concluded *"In a year of scarcity and famine, when the Government is put to enormous expenses in importing and conveying food, the cry of the public is, why are not works of irrigation constructed ? In the course of a year or two, the famine is forgotten, and then the cry is, these costly works of irrigation do not pay, why were they constructed ? If full credit were given to the canals for what they really do perform in a year of drought they might perhaps be more favourably considered".*

On receipt of this reply Col. H. W. Gulliver, Joint Secretary to the Government of Bengal in his Memo no. 898 I dated 5th October 1874 asked for more specific data as desired by Lord Marquis, Secretary of State for India, to prove that the canal would be *"profitable for navigation".*

In his Memo no 944 I dated 14th October 1874, Col. Gulliver further wanted the information regarding the annual outturn of food grains compared with the estimated consumption of the population. An estimate also of the amount of outturn

which was beyond the risk of failure irrespective of the canals; of that which would be protected when the works already sanctioned and in progress were completed, and of the remainder which would be liable to failure was also demanded.

Again in his letter dated 1st February 1875 Colonel Gulliver directed Mr. Levinge to obtain the opinion of the civil authorities as to the advisability of carrying out the extension of the canal as proposed by him.

One can today very well guess the meaning of raising so many queries.

Mr. Levinge furnished all the data desired but enough time had elapsed in collection of the same and in obtaining the opinion of civil authorities. He could send the same to the Government of Bengal in March 1876. Meanwhile the Governor General of India with his Despatch No. 106 P.W. dated (Simla) the 12th October 1875 sent the revised estimate to Lord Marquis, Secretary of State for India for sanction.

A copy of the original Despatch, a valuable document which tells the story of Sone Canals in its entirety is appended (Appendix -IV.1). Also appended (Appendix - IV.2) is the reply of the Secretary of State for India confirming the sanction of the revised estimate.

In his Despatch the Governor General of India had bestowed praise on the officers concerned in the Sone Canal Project, giving *"great credit to Mr. Levinge"* Superintending Engineer, Sone Circle who had steered the project through much difficulty.

Sir Marquis of Salisbury had also joined the Governor General in commending the officer *".... you take the opportunity to bestow high, and doubtless well merited, praises on Colonel Rundall, Mr. Levinge, and other officers concerned in the undertaking, for the rapidity with which it has been prosecuted".*

But it was not gratifying for Mr. Levinge. A dedicated engineer of extra ordinary caliber, as he was, who turned the dream of Dickens into reality, he would not have aspired only for the commendations. He did deserve that sans doubt, but what he had desired all along had not been fulfilled. His consistent and relentless efforts for extending the Western Main Canal upto Chunar or Eastern Main Canal upto Monghyr could not bear any fruit. This was deferred and deferred. The extension of canals were ultimately dropped and thus Levinge remained unrewarded.

It is interesting to note that later in the year 1905 when the renowned engineer, **W. A. Inglis** inspected the Sone Canals in the capacity of Chief Engineer, Bengal, he also expressed his inclination for extending the Eastern Sone Canal beyond Punpun. In his inspection note of 18th December, 1905 (Appendix -IV.3) he writes *"I have had in view for some time the possibility of extension of irrigation on the east of Sone. It seems clear that there is enough water in the river, and that the carrying capacity of the Eastern Main Canal is sufficient to allow of this to a moderate*

extent. The idea of building an aqueduct across the Poonpoon at the present end of the Eastern Main Canal and extending irrigation there is rather fascinating and if the soil is suitable the water would be delivered with only a short lead. I find however, that the local opinion is in favour of extending along the existing distributaries which may no doubt be less expensive. A map should be prepared showing where expansions of irrigation can be obtained in this manner. At the same time the land on the east of the Poonpoon should be reconnoitered. There are advantages which have to be considered, in widening the range of the canal irrigation. On the west of the Sone there is practically no scope for extending irrigation as full supply which can be got into the Western Main Canal is already taken up." (Para 3 of his inspection note)

COMPLETION OF WORK

The Sone canal project was completed in the year 1875. Water was supplied from the canals while they were still under construction on the occasion of the drought in 1873 (Please see enclosed photocopy of Page 56 of the explanation by C. W. Hope, the then Executive Engineer of Dehri Division, (Appendix - IV.4). Water was allowed through breaches in the canals to reach the parched fields. It was then supplied gratuitously and saved many valuable lives by protecting a considerable portion of crops by providing irrigation in nearly 1,59,000 acres. According to the calculations of Col. H. W. Gulliver, the then Joint Secretary to the Government of Bengal in the Public Works Department, Irrigation Branch, these crops were valued at nearly Rs. 50 lakhs. The whole expenditure on the works at that time had hardly amounted to Rs. 80 lakhs.

The supply of water had been given on payment of rates in a regular manner from the year 1876-77 after promulgation of Bengal Irrigation Act 1876. The Arrah Canal was opened for navigation in September 1876, the Patna Canal in December 1878 and the Buxar Canal in August, 1880.

By the end of 19th century all these canals together could carry a maximum discharge of 6,350 cusec and commanded a cultivated area of 13,54,302 acres. About 80 per cent of the irrigation lay in Shahabad district, 11 per cent in Gaya and 9 per cent in Patna.

THE RIVER SONE

Under the name of **"Erannoboas"** the river Sone has been mentioned by Megasthenes as the third river throughout India and inferior to none but the Indus, and the Ganges into which it discharges its waters. **" Erannoboas"** was the Greek form of **"Hiranya-Bahu"** meaning "golden armed", a name taken perhaps from the river's golden sands.

The river Sone is a major tributary, next only to Yamuna, of the river Ganga and meets the latter on its right bank near Patna. Sone rises together with the Narmada and Mahanadi on the elevated plateau of Central India. It originates from the Maikala range of Amarkantak high lands in Bilaspur district of Madhya Pradesh, at latitude 20° 44' N and Longitude 82° 4' E, the location better known as Sone Bhadra and runs 520 km (325 miles) through a high rocky tract, receiving tributaries only from the south. On the north, the drainage area of the river is limited by the steep slopes and precipices of the Kaimur range along which the river flows and the table-land above which drains away towards Ganga.

While flowing in northerly direction, in the mountainous region, it is joined on the left bank by its first principal tributary Johille near Borawala village. The river thereafter meanders up to Sarai where it strikes upon the Kaimur range and meets the river Mahanadi. At this point the river takes an acute angle turn and flows in easterly direction through Madhya Pradesh for a distance of 510 km (319 miles) receiving on its right bank two of its important tributaries Banas and Gopad in the upstream of Kuldah bridge.

The river then runs west to east and enters Uttar Pradesh in Mirzapur district and meets Rihand just upstream of Chopan and then river Gagger below Chopan. It then receives one of its important tributaries Kanhar and this way flowing through a distance of 82 km in U.P. it enters Bihar.

In Bihar it is met by its most important tributary North Koel from southern side. The river thereafter takes a sharp north-east turn and passes Akbarpur, Dehri and Koelwar where the Eastern Railway crosses it on a fine lattice girder bridge (constructed between year 1855 to 1862) and finally falls into the Ganges on its right bank about 32 km upstream of Patna after having flowed through a total length of 839 km.

The chief peculiarity in the Bihar portion of its course is its great width, which is more than 3 km for the greater part of the last 150 km, while opposite Tilothu it actually attains a breadth of 4.5 km. This extensive bed consists entirely of sand, and during eight months of the year contains a stream only a couple of 100m broad. The depth of water, on the average, is under 6m and in its deepest parts hardly exceeds 10m. The strong dry westerly winds which prevail from January to April, and sometimes till June, heap up the sand on many parts of the eastern bank

nearly 4 to 5 m above the level of the country forming a natural embankment for many kilometers.

Another great feature of the river is the paroxysmal violence of its floods. As mentioned above, in the dry season the bed shows an enormous amount of sand with an insignificant stream of water, meandering from bank to bank barely 100 m wide and fordable in many places, but rains make the river suddenly swollen. Sone drains an area of 70,000 sq. km and after a few hours rain on the Central Indian Plateau it bursts in full flood and rushes down so violently as to spill even over its enormous bed, and often causes disastrous inundation. Apart from inundating the vast village areas, the Sone water has several times in the past entered the township of district headquarter Arrah (1864,1867,1869,1870) in the last century. Recent deluge of Patna (1975) has been attributed to the fury of this river only.

The maximum observed discharge of the river is 34,126 cumec (12 lakh cusec) but while designing the diversion works in 1861 the design discharge was adopted as 17.5 lakh cusec (49,560 cumec). The Sone barrage later was designed for 41,350 cumec (14.6 lakh cusec). The minimum dry weather discharge is of the order of 17 cumec (600 cusec) only.

The high discharge in the river are for very short duration, hardly lasting for more than four to five days, when the river rapidly sinks to its normal level. For most part of the year the river gives the look of a desert full of golden coloured sand (from which the name is derived) intermixed with variety of small pebbles some of which are very ornamental. The fineness modulus of the sand is high, nearly 2, and at places more, ideally suited for any good construction work and since no other river in this region provides such grade of good quality coarse sand, Sone sands are used extensively in this region for construction work.

THE DETAILS OF THE PROJECT

DIVERSION HEAD WORKS

In order to divert the Sone water into the Eastern and Western Main Canals, a weir-type structure was proposed by Dickens across the river Sone on the pattern of headworks already constructed in Godavary and Krishna in the then Madras State (Tamilandu). But unlike the headworks at those places he had planned an anicut (he called it dam of very low height) just to raise the water only 6 feet above the summer level. In recommending a structure of lower height he had two main considerations in his mind --- to avoid the risk of aggravating the violence of river over a tall structure in a river like Sone with comparatively greater declivity and to avoid the delay in giving the districts the benefit of water, thus obtaining for the investor an early return for his money.

Lt. Col. Dickens had planned the Canal heads in such a manner that even without constructing the permanent weir he could divert half the supply of water needed to fill the canals with the help of only temporary expedients. He had estimated for such a temporary diversion structure of piles and clay right across the river at a cost of only Rs. 2,24,469/-

In his report he had mentioned an interesting suggestion made by Mr. Bingham, who had had the experience of observing the Sone for many years, that the construction of a permanent dam (anicut) might be avoided altogether, by encouraging the growth of a species of weed which flourishes in patches in the bed of Sone, and occasionally gives rise to the formation of islands. Though Col. Dickens did not share in his anticipation of success from this plan but saw no harm in trying the experiment.

What was eventually constructed was an eight feet high masonry sloping weir with dry stone apron across the river at Dehri-on-Sone about a kilometer upstream of the causeway which then carried the Grand Trunk Road from Barun to Dehri. **This weir was 12,469 feet (3801m) long between the abutments and was the longest undivided structure of its kind in the world at that time.**

At that time in Madras, in case of Krishna and Godavary, the foundation of the masonry consisted single row of blocks or wells which were sunk 6 to 7 feet below the dry weather flow level. Deviating from the Madras' model in block sinking for the foundation of the masonry of anicut, Dickens had proposed a double row of blocks (or wells) sunk 20'(6m) deep, the two rows breaking joints. This he had suggested mainly to increase the supply of water in addition to additional security of the structure, by increasing the creep length of water. He had before him the example of Jamuna Canals where after feeding the canals the river practically looked dry but water appeared again a few kilometers downstream and the quantity was no less than half the discharge of the river (without receiving any affluent in that length) as calculated by Sir P. Cautley (1850).

But from the point of view of economy he had made comparative studies with different size and depth of blocks to be sunk and shown that the cost of structure could be brought down from Rs. 13.8 lakh to Rs. 10.8 lakhs by adopting single line block 10 feet deep in place of two rows of 20 feet depth. Ultimately the foundations of the weir were formed by large hollow blocks of 16 feet (4.87m) by 15 feet (4.57m) and 10 feet (3.05m) deep, with 15 inch (38 cms) walls leaving a space from which sand was excavated by means of Fouracres' excavators (after the name of Executive Engineer, Dehri Workshop). The blocks were thus gradually sunk, an average period of three days being necessary to complete the process for each. On this well foundation two massive masonry walls were built, the upstream wall which was the main wall, was 8 feet (2.44 m) high, the rear one only 5 feet 6 inches (1.67m). The space between the walls as well as the rear apron was filled with rubble stones, the upper surface of which was packed with an inclination of 1 in 12 with massive blocks of stone. On the upstream side the slope was 1:3 and the stones were of

comparatively smaller size. The total cost of the anicut, which was begun in 1869 and completed in 1875, amounted to about 15 lakh of rupees.

UNDER SLUICES

Three sets of under sluices, each containing twenty-two vents of 20'-6" (6.25m), which could be opened and closed as occasions required, were provided to pass the superfluous river water beyond the requirement of irrigation. Out of these three sluices one was kept in the center of the weir and the other two at each end so as to obviate, by their scouring action, the danger of the river silting up at either bank where the Eastern and the Western Canals took off.

The scouring sluices were fitted with gates which could be opened or closed at any state of the river other than high flood. By means of these gates the level of the water in the pool above the weir could be kept at the height required to feed the canals.

Closing and lifting of gates even today sometimes pose problems and at that time, when technology was not so advanced, the possibilities of such problems were even more. It so happened with the sluice-gates of the anicut also. Due to enormous pressure exerted by water, nearly 30 tons on each gate in static condition and 600 tons in dynamic condition, a serious difficulty arose in providing means for opening and shutting the gates. Mr. Fouracres, Executive Engineer, Dehri Work-shop devised a system of shutters, by which the opening and closing were effected almost simultaneously. Each vent or opening was provided with two gates or shutters, the rear one of which had its center of pressure so adjusted that, when the water rose above 8 feet (2.44m), it tumbled over and lay flat on a bed cut out in the stone. At this time the front gate also lay flat on the floor, to which it was secured by pins. The water thus passed through without any obstruction. When it was desired to dam up the water, the pins, which held the front gates were slipped out and the gate started moving upwards. Whenever the water got under, the gate rose almost immediately, and the possibility of coming it up was so fast that it could be fragmented into numerous pieces. To provide against the contingency, each gate was supported by iron tubular backstays, into which piston rods were fitted and which pierced with two or three small holes, through which the water could enter, when the shutter was flat on the floor and the piston at the far end. As the gate rose, the piston entered the cylinder and slowly forced the water out from the small holes already alluded to, so that the enormous pressure on the gate was almost completely neutralized and the gate quietly slipped into a perpendicular position. The water which was behind then ran off and the rear gate was lifted into its first position, a valve in the front gate opened, the water rushed in till it filled the space between and the front gate was once more pushed down and secured as before with insertion of pins.

THE CANALS

Design aspect

While designing the canals, Dickens had to face number of difficulties since Sone canal was the first canal of its kind in this part of the country. He had no definite method before him to assess the requirement of water for the area to be irrigated and no defined criteria to ascertain the discharges of the canals. An alien, he was not well informed with the irrigation needs of different types of crops in this region.

However, he was a keen observer. While surveying and examining the area in detail in the early part of the year 1855, he had very closely watched the people of Shahabad irrigating their *Rabi* crops by lifting water from wells by means of the bullocks and leather bag, locally known as *moth*. He had marked that a *moth* holding about 2.75 cubic feet of water raised water at the rate of 25 times per hour. But this frequency was for a short period. *Moth* when worked for the whole day, could raise only 150 times, and irrigated nearly 3/5 of a bigha (3/8 of an acre). Dickens took this number of lifting liberally as 300 and taking this bulk of water required for 3/8 of an acre for one watering, he estimated that an acre of land would require 800 bags for one watering and 3200 bags for four watering or for a full season's irrigation. But he felt that this estimation was based on an imperfect kind of irrigation practised in Shahabad. The crops in this type of land and dry climate in fact required more water. Hence he resolved to double the quantity of water, that is 6400 bags or 17,600 cubic feet of water to irrigate one acre.

The *Rabi* irrigation in Shahabad then commenced from early November and terminated at the end of February, thus lasting for nearly 120 days. Now one cubic feet of water per second for 120 days makes 1,03,68,000 cubic feet which could irrigate 588 acres on the above mentioned scale. But this supply was to be delivered from the canal and not by bags or buckets. Hence it was necessary to add to it the quantity required to make up for the wastage in passing down the channel, in order to determine the discharge required at the canal head.

No data were then available for ascertaining the losses from evaporation, soakage, leaks, seepage and thefts of water on the Indian Canals. Dicknes was, therefore, obliged to refer to the examples of Italian Canals given in Lt. Colonel Baird Smith's work on Italian Irrigation (1851). This work had mentioned of four canals with their discharges mentioned in parenthesis viz. Caluso (440 cusec), Naviglio Grande (1851 cusec), Muzza (2,652 cusec),Martesina (843 cusec) recording losses 90.65 cusec, 158.25 cusec, 477 cusec and 105 cusec respectively. These losses expressed in percentage were 20.6, 8.6, 18.0 and 12.4 percent.

From that study Dicknes inferred that even in the dry climate of Shahabad, by good management, the losses could be kept under 20 percent. Thus, deducting

this proportion, Dickens argued that each cusec (cubic feet per second) of discharge at the canal head should irrigate 470 acres, something less than ¾ of a square mile.

In practice in the North-West Provinces (now U.P.) it was, however, found that each cusec could not irrigate on the average more than 218 acres of land or a little more than 1/3 of a square mile. Dickens was aware of this. But he expressed disagreement with this and maintained that due to imperfection of the canals the losses were on higher side and that the canal water in North-West Provinces was very wastefully applied by the cultivators. He pointed out that with the view of inducing economy in the use of the canal water contracts for letting the discharge from established openings were entered into on the Western Jamuna Canal, so as to levy the water rent on the quantity of water supplied instead of the area of land irrigated. But to carry out this principle in full it was necessary to have some uniform and accurate system of measuring discharge of water from each outlet. This matter had for some time engaged the attention of Lt. Col Baird Smith who was then (1855) about to establish "Modules" on the pattern of Italian system on the Ganga Canal, and levy water-rent in proportion to the discharge measured by means of these contrivances.

Dickens further quoted the rules specified by Lt. Col Smith for the distribution of water for spring crops which allowed four waterings of 3 inches each, or in all one foot spread over the surface, which gave 43,560 cubic feet per acre in 130 days, whence, making no deduction for losses in the canal, a cusec was considered adequate to water 360 acres of spring crops for the season.

Advancing these arguments and anticipating the success of Lt. Col Smith's module, Dickens concluded that each cusec of water should irrigate at least 320 acres or ½ a square mile. He thus ultimately allowed 45 percent wastage of canal water in his calculations. For assessing requirement of water for gross command area he recommended 2 cusec for every 3 square miles.

Later in his report of 1861 he made larger allowance. In place of 2/3rds of a cusec per square mile he calculated the requirements for irrigation at the rate of 3/4th of a cusec for every square mile of gross area. It is to be mentioned that Sir Proby Cautley allowed 8 cusec for every mile of canal in the North-West Provinces. If the canal be supposed to irrigate 4,5 or 6 miles on each side, this gives respectively 1,4/5ths or 2/3rds of a cusec per square mile of gross command area. Quoting this example Dickens justified his calculations.

Dickens had proposed canals for both irrigation and navigation. While part of the canal was meant for both irrigation and navigation, some part was proposed exclusively for navigation. As per the report submitted by him in the year 1861 the length of Western Main Canal along with its branches for irrigation was 361 miles (225.62 km) and that of Eastern Main Canal with its branches 320 miles (200 km). To this he had added 145 Miles (90.62 km) of canals only for navigation. Thus the total length of the canal system was 826 miles (516.25 km). He calculated the

discharge of Western canals as 1980 cusec (56.1 cumec) and that of Eastern Main Canals 1144 cusec (32.4 cumec), total 3124 cusec (88.5 cumec) of which 600 cusec (17 cumec) was reserved for navigation and 2524 cusec (71.5 cumec) proposed to be consumed in irrigation.

While designing the section of the canals he had provided variable bed slope which was comparatively gentler, much less than what had been usually adopted in Northern Indian Canals. He had in fact adopted a fixed velocity instead of a fixed slope of bed. The slope of the bed was calculated to give the velocity of about 3 feet per second with side slope of 1.5 to 1, and a bed width equal to the depth plus one squared in feet. From these data and the required discharge, the dimensions of the channel were calculated. He had used the formula of Eytelwein as given in Young's Tracts on Hydraulics in the above calculations. The formula was,

$$v = 9 / 10\sqrt{2fd}$$

where,

v = Velocity per second in feet

f = fall of bed per mile in feet.

d = hydraulic mean depth.

For the navigable lines – that is, for the lines of canal where water was required for navigation in excess of what was passing down the canal for irrigation – Dickens allowed in each case 150 cusec. These, with the fall and velocity allowed, had a width of 18 feet 6 inch at bottom and about 28 feet on the water line with a depth of 3.25 feet of water. The dimensions laid down by the French for "Petite Navigation" canal were 33.3 feet wide at the water line and 22 feet at the bed level with depth of water 5 feet. "Patite Navigation" was larger than many English canals. Still Dickens thought that the dimensions he had proposed might not suffice for the traffic likely to be developed on the Sone Canals. Hence he had added in parallel lines, still water canals of 20 feet width at the bottom with 3 feet 6 inches depth of water, to take what would otherwise be upstream traffic of the flowing canals, whenever the latter were less in width than 22 feet on the floor.

CANALS DESIGNED FOR KHARIF

Somehow a wrong notion has been prevailing that Sone Canals were designed for *Rabi* irrigation only. But it is not true.

Dickens had, no doubt, designed the canals for *Rabi* irrigation. But the officers responsible for the construction of canals foresaw that prosperity of the canals would not depend on *Rabi* irrigation only. The views of Mr. Levinge,

Superintending Engineer, Sone Circle regarding this has already been mentioned earlier. Col. Rundall, Chief Engineer had strong conviction that it was from *Kharif* cultivation, not from *Rabi* that the canal returns must be made to yield a profit. He impressed upon the officers then in the top echelon to change their way of thinking and his conviction had moulded the subsequent policy of the department to a great extent.

While the details of canal designs were still being worked out before construction, possibility of supplying water during *Kharif* was examined at the behest of Colonel Rundall. It became vividly perceptible that the alignment of new system of canals would disturb to a great extent the old system of *ahars* and *pynes* through which the cultivators irrigated their *Kharif* crops. It was felt that once their old system of irrigation was destroyed it would be obligatory to supply water regularly during *Kharif* period also and not once in four or five years in the year of scarcity as anticipated by Colonel Dickens. *Kharif* being the principal crop of the area, the cultivators could not be denied water to raise their crops during this period. Another vital question from the point of view of earning revenue was whether the cultivators would take water from the canals and pay for it. Thorough examination showed that there would certainly be such demand, rather the greatest demand for water would be for rice only and the cultivators would willingly pay for the same.

It was ultimately found prudent to design the canal sections for *Kharif* crops which definitely required more water than the *Rabi* cultivation. This decision in fact saved the canal system from serious consequences in future. The entire system could have failed utterly for the inadequate capacity of the canals and also the Government could not earn enough revenue to pay for the interest on the capital and maintain the system.

It was then assessed that 1 cusec of water could irrigate 133 acres of rice and this was taken as the standard for calculating the dimensions of all the canals in Sone Canal System.

MAIN WESTERN CANAL

In the report on the project dated 31st December 1870 it was stated that the Main Western Canal would command for irrigation 2938 square miles of country or 14,69,000 acres allowing 500 acres to a square mile (the remaining 140 acres occupied by villages, topes, tanks etc.). Later in his memorandum submitted on 14th March 1871, forwarding plans for approval and sanction for the extension of Main Western Canal to Karmnasa with estimate amounting to Rs. 22,93,675/- Mr. Levinge, Superintending Engineer, Sone Circle proposed to supply water to the district of Shahabad, situated between the Sone on the east and Karmnasa on the west containing 12,00,000 acres only. He suggested that the remaining 2,69,000 acres to the west of Karmnasa could afterwards be irrigated, either by raising the anicut by 2 feet, thus forcing a greater supply into the canal or by constructing

reservoirs on the upper part of the Karmnasa, where a magnificent site was known to exist, or on the smaller rivers, as proposed originally by Colonel Dickens in his Sone Canal Project.

Thus the M.W.C. from its head to the point where the first branch was to take off was calculated to carry 4511 cusec (127.7 cumec) of water to irrigate 12 lakh acres (4.85 lakh ha.) assuming that only half of the area would require simultaneous irrigation, as explained in the report on the project, that is to say, it was meant to carry sufficient water to irrigate 6.00,000 acres at the same time. This figure 4511 cusec was the required discharge which could be easily derived by dividing the area to be irrigated by 133 acres which was supposed to be duty of 1 cusec of water for *Kharif* irrigation. However after selecting the proper section of canal and using the formulae prevalent at that time the exact figure came a bit less (4342 cusec). With the same adopted section using Manning's formula one can arrive at little bit higher discharge. The canal in its first reach had base width 180 feet(54.9 m), full supply depth 9 feet (2.74 m), side slope 2 to 1, the breadth on the water line 216 feet and the slope of the bed 6 inch per mile (1 in 10560). At 5th mile (8th km) Arrah Canal branched off with 1616 cusec (45.7 cumec)whence the bed width was reduced to 124 feet (37.8 m) and the width at water line to 160 feet (48.78m), other dimensions remaining as before. At 12th mile (19th Km.) Buxar canal and Chausa canal together were to abstract further 1260 cusec (35.7 cumec) thus leaving 1635 cusec (46.3 cumec) in the Main Western Canal. The MWC was to carry this discharge from 12th mile to the lock on the 23rd mile, a short distance above which the Gara Chaubey Branch canal takes off with 620 cusec (17.56 cumec) leaving 1015 cusec(28.75 cumec) in the MWC. The width of the canal at the 12th mile had accordingly been reduced to 100 feet (30.5 m) at the base and slope of bed to 2.5 inches per mile, the depth of water and side slopes remaining as before.

Levinge had submitted his memorandum to extend the canal from 22nd mile to 76th mile for navigation. According to his plan the MWC was proposed to carry 1015 cusec (28.75 cumec),left over after branching off Gara Chaubey Branch Canal, over the proposed weir at the Kudra at 23rd mile after which the width of the canal was to be reduced to 84 feet at the base, 120 feet at water line and bed slope 1 inch per mile, the dimensions determined to be minimum and to be kept the same upto terminus i.e. upto Mirzapur.

Total fall in the country from the Sone at Dehri to the low water of the Ganges at Mirzapur is 123.25 feet. To negotiate this a number of locks were proposed in the canal.

In fact extension beyond 22nd mile had also commenced. Some work were done as a sort of relief measure during the scarcity period of 1874-75 but extension beyond 22nd mile was finally dropped as mentioned earlier.

However, the canal was completed upto 22nd mile as planned. The discharge which were meant to be carried beyond Kudra were subsequently diverted mostly to

Arrah Canal and Buxar Canal. Due to the favourable condition at their off take points and hydraulic efficiency, these canals were able to draw discharges much beyond their designed capacity.

In aligning the MWC the main object was to avoid the heavy cutting, nearly 30 feet (9.15 m) at Dehri and carry the water along the ridge of the area. In its first reach the canal curved round in northerly direction to the offtake point of the Arrah Canal and then took a turn towards west, crossed river Kao over a syphon aqueduct at Maranpur, which is a marvellous engineering work of 25 arches, and finally terminated on the G T Road 3 Kilometers west of Sasaram. The Canal in its full length was unlined. The average cost involved in excavating the canal was Rs. 35,000 per kilometer.

Arrah Canal

The Arrah Canal branches off from the Main Western Canal at the 5th mile and follows the course of the Sone for 30 miles (48 km), when it strikes northwards, running on a natural ridge passes the town of Arrah, and finally after a total course of sixty miles (96 km) it falls into the Gangi Nadi, a local stream falling into the Ganges after traversing a distance of 16 km. It is designed for navigation as well as irrigation.

The difference of elevation between Sone at Dehri and Ganga at the outfall point is 180 feet (54.9m). To overcome this fall thirteen locks were constructed, two of which were double. For the first 24 km from Dehri the Canal had the base width 86 feet (26.2m),at 42nd km the breadth was reduced to 57 feet (17.4m) and at the 52nd km it was further reduced to 47 feet (14.3m), the minimum width considered to be compatible with navigation.

Bihiya Canal, 50 km long and Dumraon Canal 64 km long, are the main branches of Arrah Canal and along with them the Arrah Canal was contemplated originally to command an area of 4,30,000 acres (1.73 lakh ha.) half of which supposed to be under *Rabi* irrigation and the other half under *Kharif*.

Arrah Canal was originally designed for 1616 cusec only, however, as stated earlier it subsequently carried discharge much beyond its designed capacity and irrigated much larger area than anticipated. In fact the control structure in MWC is in the downstream of its offtake point from where the MWC takes a left turn giving advantage to Arrah Canal to draw as much discharge as possible since the latter proceeds almost in the same north direction towards which MWC flows while feeding the Arrah Canal. At this point due to such favourable situation Arrah Canal seems to function as main canal.

Buxar and Chausa Canals

Buxar Canal leaves the MWC at its 12th mile and communicates with the Ganges at Buxar after a course of 45 miles (72 km). As stated earlier it was designed for 715 cusec (20.23 cumec), with base width 47 feet (14.33m), width at F.S.L. 75 feet (22.9m),F.S.D. 7 feet(2.13m) and side slope 2:1. It had in its command the area between the river Kao on the east and Dhanauti on the west. This area needed irrigation then desperately. This canal was also made navigable. The total fall from the bed of the canal at the offtake to the lower sill of the terminal lock was 158.73 ft (48.4m) of which 153.73 ft (46.9m) were negotiated by 12 locks, two of which were double.

Chausa Canal the main branch of Buxar Canal is 40 miles (64 km)long and was designed for 545 cusec (15.42 cumec). Together the two canals originally contemplated a command of 3,09,500 acres (1.25 lakh ha.) half of which were under *Kharif* and half under *Rabi* crops. Buxar Canal also drew much larger discharge later like Arrah Canal and irrigated a large area.

OTHER BRANCHES AND DISTRIBUTARIES

Over and above these branches and some small distributaries viz. Salaya, Sawank, Baraon, Balthri and Khurmabad, Main Western Canal feeds its another important branch, the Gara Chaubey Branch Canal with 620 cusec (17.5 cumec) in its last reach to command an area of 1,65,000 acres (0.66 lakh ha.). Due to the inherent design problem in its control structure at the offtake point this canal was seldom able to draw adequate discharge.

These branches of the Western Canal System have their own distribution system which are spread like fan in the entire area between Sone on the east and Karmanasa on the west, G.T Road on the south and E.R. line on the north running from Arrah to Buxar almost parallel to Ganges.

SYSTEM EASTERN CANAL

Main Eastern Canal

Mr. Levinge and Col Rundall wanted to bring entire area on the right bank of river Sone, even beyond Poonpoon under irrigation by extending the canal as far as Monghyr but as mentioned earlier the Government abruptly stopped the excavation work beyond Poonpoon. The Eastern Canal was thus dug up to Poonpoon for a length of only 8 miles (12.8 km) and was designed to carry 1613 cusec. Thus it became mainly a sort of feeder canal for Patna Canal in addition to providing a little water for Manora distributary directly taking off in its tail reach.

Patna Canal

Four miles (6.4 km) from the Sone at Dehri, Patna Canal branches off from Eastern Main Canal and follows the direction of Sone passing very close to right bank which is apparently the ridge of the command area. After running a distance of 79 miles (126 km) it finally falls into Ganga at Khagaul near Patna, the capital of the State. It was designed to command an area of about 5 lakh acres (2 lakh ha.) which is between Sone and Poonpoon. At the offtake point the bed width of the canal is 134 ft. (40.8m) with F.S.D. 7.5 ft., which reduces gradually reach- wise as the canal advances. The canal was designed for navigation purpose also, hence a minimum obligatory depth of 6 ft. (1.83 m) and a width of 20 feet was provided in the tail reach. The falls were negotiated with the help of navigation lock as in case of Western Canal System. These falls also have been acting as cross-regulators with the help of wooden planks handled manually for irrigation.

OTHER FEATURES

The alignment of each and every canal was very carefully examined. Mr. H. C. Levinge, Superintending Engineer, Sone Circle had personally examined the country and walked over every line laid out. (Appendix IV.5)

In general, while aligning the canals, care was taken to run the canal in such a way that they do not cross the natural drainage channels but where this was not possible syphons were provided to pass the water under the canal unhindered. The most extensive work of this description was the Kao Syphon which carried water of that river (extreme discharge over 8000 cusec) under the M.W.C.

The locks were all designed almost on the same plan being 155 feet (47.2m) long and 20 feet (6.1m) wide inside the chamber at the level of the flooring with a lift from 10 to 14 feet (3m to 4.3m). A waste weir was necessarily added to each to maintain a minimum depth of 5 feet (1.52m) on the sill of preceding lock. Cast-iron grooved brackets were fitted to regulate the supply, or, if necessary, to impound the water for navigation. Over each weir and tail-bay a light girder bridge was constructed and in addition to these, bridges were also provided at every 4 to 6 km besides ferries at the more important villages. Terminal works of all the escape channels and of all the canals, except of the chief navigable line were designed as simple falls dropping them to the level of the natural water course into which they were to discharge their surplus water. The chief navigable lines were designed to end each in a double series of locks connecting them with dry season level of Ganga.

DISCHARGES IN THE CANALS AND AREA IRRIGATED

With the passage of time the demand for water went on increasing and so also grew the desire of the British to earn more money from the canals. The canals were stressed to their maximum. Some of the branch canals viz. Arrah Canal and Buxar Canal were forced to draw much more than their original designed capacity.

Subsequently Sone Canal Rules laid down the limit of maximum discharge for each canal viz. Western Main Canal 4000 cusec, Arrah Canal 2250 cusec, Buxar Canal 1600 cusec, and Eastern Main Canal 1600 cusec.

But at times these canals crossed this limit also and irrigated large areas. Table 4.5 shows the discharges of the Sone canals in the month of October when the flow in the river is steady and Table-4.6 shows the area irrigated during *Kharif* season for 21 years right from the first year of operation. Figures of *Rabi* irrigation can be seen in Table-4.8 They give an idea to what extent these canals served the area.

The maximum area ever irrigated by Sone Canals before remodelling was 6,19,033 acres in the year 1920-21. In the five preceding years the average area irrigated was 5,33,193 acres.

Table 4.5

Discharges of the Sone Canals in October

Year	Maximum discharge during any ten day in October in cubicfeet per second		Average discharge during the whole month of October in cubicfeet per second	
	Western Main Canal	Eastern Main Canal	Western Main Canal	Eastern Main Canal
1	2	3	4	5
1885	3,210	1,450	2,806	1;024
1886	1,810	976	1,384	708
1887	3,149	1,371	2,694	983
1888	3,874	1,540	3,687	1,406
1889	3,610	1,526	3,140	1,332
1890	2,573	1,391	2,192	1,143
1891	3,858	1,572	3,647	1,462
1892	3,939	1,575	3,776	1,466
1893	3,300	1,384	2,299	1,068
1894	2,468	1,205	1,935	953
1895	4,009	1,733	3,700	1,649
1896	4,296	1,833	3,967	1,688

Table - 4.6

Area irrigated by the Sone Canals in the Kharif season

Year	Acres
1876	1,923
1877	1,07,087
1878	99,964
1879	38,139
1880	1,31,175
1881	1,18,377
1882	1,24,274
1883	2,15,790
1884	2,49,927
1885	2,25,122
1886	2,07,565
1887	2,20,428
1888	2,38,895
1889	2,30,741
1890	2,11,726
1891	2,48,819
1892	2,74,839
1893	2,80,528
1894	2,58,361
1895	2,61,485
1896	3,12,000

PERFORMANCE EVALUATION

THE BACKGROUND

During the days when Sone Canals were constructed, the science of hydraulics was in its infancy and the technology was trying to balance its steps before marching. The engineers while planning the project and designing the structures were thus tempted to look towards some of the completed projects for their guidance and gaining confidence. But there were not many projects to reckon upon. The few which were in operation in other parts of the country and could serve as beacon light viz. Bari Doab, Ganga and Yamuna Canals in the west and Krishna and Godavary Canals in the south were yet to prove their efficacy. They could not be copied either blindly due to difference in regional condition and the different nature of rivers—their depth, discharge, width and slope, quantity and quality of silt they carried, their different command and catchment characteristics and lastly the need of the command area the canals were supposed to cater.

Mr. Dickens while presenting his plan of Sone Canals had enunciated *"The project is therefore principally for constructing artificial rivers like the canals of Northern India, of Madras Presidency, and of Northern Italy; and only to a comparatively small extent, still-water canals, such as are usual in England".*

As regards outline of the plan and type of structures in canal he said " *The works are in all essential of the same plan as has been successfully carried out by the Madras Engineers on Godavary and Krishna".* But this was for general comparison only. There was marked difference in the design of structures. In some respect they were unique. He himself sketched the difference in these words *"I have deviated from Madras model in block sinking for the foundation of the masonry"* and admitted *"No work of this kind has yet been done in this (Bengal) Presidency".*

The river characteristics had telling influence on the design. He elaborated in his project report *"... Krishna was much deeper than anything have to deal with on the Sone .. Sone much wider.. with more declivity.. with immense filter (porous bed)".* Here was the compulsion for adopting new design. He took lesson from the loss of water in the enormously porous bed of Yamuna at the offtake point of Yamuna Canals where after feeding the canals, nearly half of river discharge disappeared in the bed of the river only to appear again a few kilometers downstream. Being wary in selecting structures like Bari Doab Canals and Ganga Canals, comparing "Petite Navigation" of France with his proposed navigable Sone Canals and explaining the difference between the two he justified the construction of navigable canals stressing the need of the area and most importantly showing the scope of good return for the Government.

But adopting the best models out of the existing projects and suggesting even better proposition he could not convince one and all.

Some persons entertained apprehension about the future of the Sone Canal project. Lt. Governor Sir Campbell belonged to such school. He had great doubts about the success of the canals so he had pruned the project considerably in spite of the high technical skill shown and convincing arguments advanced in the proposals of Mr. Levinge and Colonel Randall for extending the canals up to Mirzapur on the west and Mungher on the east. Some other valuable modifications suggested by Colonel Randall, who seemingly possessed a marvelous foresight were also turned down on some pretext or other.

In the light of above, it would be interesting to see how far the Sone Canals were successful on technological front, to what extent they could fulfill the demand of the command area, what changes they brought after the introduction of irrigation in the area and in which proportion they could quench the insatiable thirst of British treasury.

RAPID CHANGE IN AGRICULTURAL CONDITION

After commissioning the canal system the agricultural condition of the command area was considerably affected, to an extent which the planners had not anticipated at the time of planning. The demand for water had increased unexpectedly and they found it difficult to fulfill their expectations. A radical change had manifested in the cropping pattern.

According to an estimate of Dr. Buchanan Hamilton (writer of "Eastern India") about one half of the cultivated area of the Shahabad district was cultivated with rice in 1811 and Mr. A. P. MacDonnel in his report on food grain supply of Bengal and Bihar (page 6) had estimated in the year 1875 that out of the total 16.9 lakh acres cultivated area of Shahabad, rice covered an area of 8 lakh acres as against 3.60 lakh acres under *Rabi*. Almost the same proportion was estimated by the Engineer-Officers at the time of construction of the Sone Canal works. Both Col. Dickens and Mr. Levinge had considered rice to be the principal crop in the district. But Dickens had devised the project with special reference to the irrigation of the *Rabi* crops. He did not calculate upon the irrigation of the rice crops as a source of income from the Sone Canals, because he assessed that there generally was water enough for their *Kharif* crops from the monsoon as managed by the people by means of their small tanks and in normal years they would not like to take water from canal and pay for it during *Kharif* period.

In fact during those days there were numerous reservoirs locally known as *khazanas* or *ahars* in the area where people used to store the monsoon water and with the help of *pynes* (canals) irrigated their land during *Kharif* period. The system was very efficient and supply of water rarely failed. This may be corroborated by the

fact that while other districts of Bihar experienced severe droughts and famines frequently they were conspicuous by their absence in the Sone area where *Ahar* system was practised. This state of things was recognised by Col. Dickens hence he never thought of providing irrigation during *Kharif* period.

Mr. Levinge and Col. Rundall maintained from the very beginning that the prosperity of the canals would not depend on *Rabi* irrigation as Col. Dickens had thought. In his report dated 2nd May 1865 Col Rundall urged strongly that "*the scheme of irrigation from the Sone should be based with reference not to its cold weather, but to its monsoon supply*". This was however not accepted by the Government at that time. In Government of India Letter (No. 693 C dt. 10th July 1865 paragraph 12) which was drafted by Col. Dickens himself it was mentioned that the canal was reckoned upon as a means of saving the rice crops in bad seasons but the income to be derived from it was left out of account in calculating the revenue of the canal under the belief that the people would not be willing to pay annually for what they would require only during exceptional seasons. This was also the impression of Sir George Campbell, Lt. Governor till early 1871. Hence he was in favour of designing the canal for *Rabi* irrigation as proposed by Col Dickens.

But Col Rundall and Mr. Levinge were not ready to compromise on this score. They continued to hammer their point into the mind of the policy makers and went on reasoning and persuading till they were able to change their concept. **The Sone canal was ultimately designed for *Kharif*.** Thus, Sone Canal owes much for its success to these two stalwarts. Had they not been successful in their mission; Sone Canal would have miserably failed for its inadequate capacity. This could have disastrous effect on the future development of irrigation in this State since Sone Canal was the first venture in this direction, the failure of which would have killed all aspirations of the engineers and planners in the nascent stage only.

After the introduction of canal irrigation the farmers belonging to the command area quickly switched over to paddy cultivation which ultimately developed as most popular *Kharif* crop in the area. *Rabi* lands irrigable from the canals were extensively converted into rice cultivation. Since rice cultivation gave less trouble and could yield a larger profit it was preferred by the cultivators. The character of the cultivation in the command area radically changed and the area of *Rabi* irrigation from the canals proportionately diminished instead of increasing. This belied the assumptions of Col. Dickens. After two years of canal irrigation, in the year 1877-78 the area under *Kharif* and *Rabi* irrigation were reported as 1,07,087 acres and 1,24,812 acres respectively. The corresponding figures of the year 1884-85 were 2,49,927 acres and 81,548 acres. In the following year i.e.; 1885-86 the area under rice cultivation was reported to be 2,25,122 acres and that under *Rabi* only 68,647 acres. Thus the average area of rice under irrigation after a decade of canal irrigation rose to a proportion three times that of *Rabi*.

DISCONTENT

Unfortunately the canal was not able to cover the area anticipated and earn adequate revenue. The duty for *Kharif* rice at the time of planning was assumed as 133 acres per cusec but after actual application of water to the field it was observed to be much less. In the command of Western Main Canal the average duty for *Kharif* rice was found to vary between 65 to 80 acres per cusec and in the command of Eastern Main Canal between 45 to 65 acres only due to varied nature of soil.

It soon became clear that from a financial point of view, the Sone Canals project had not fulfilled the expectations of the project planners and this was enough to irk the British Government. On the other hand, a feeling of irritation had been rankling among the people from the very beginning of the canal irrigation as their old system of irrigation had been destroyed and the canal officers were now collecting the water rate oppressively. This had manifested itself in an agitation against the canal administration. A Committee of Enquiry was appointed in the year 1887 to enquire into the administration of the Sone Canals which submitted its report in the following year.

Some of the findings of the Committee were interesting, a few were startling. A very strange fact which came to the surface was that the old *ahar* system of irrigation working so efficiently before the canal construction was deliberately destroyed. To the officer engaged on the alignment and construction of the works it soon became apparent that it would be impossible to lay out the canals with any prospect of profit, unless the canals themselves were so constructed as to supersede within the area commanded by them the old system of irrigating rice with *ahar* water. It was commonly alleged that the lines of the distributaries were laid down with the very object of destroying the old system. Unofficial declarations were made that the *ahars* were the natural enemies of the canals. Colonel Heywood, the Superintending Engineer of the Sone Canals, wrote to the Government in a demi-official letter in June 1884 that "*The ahars cover the country; they never will disappear; they are in many places adding to them this year, and as long as they exist, the canal officer will find the water withdrawn from his control*".

It was also soon perceived that it was from *Kharif* cultivation and not from *Rabi*, that the canal returns must be made to yield a profit as was the conviction of Col. Rundall. Col. Rundall thought that *ahars* irrigation was trifling, and that the introduction of canal irrigation would come altogether as a blessing to the cultivators. But his successors were not so deceived and when it was known that the *ahar* system prevailed throughout the whole tract of the country, the officers of the department were quick to see that the two system of irrigation could not exist simultaneously on the same lands and that the success of canals could only depend on the extiriction of a system of irrigation in rivalry and competition with their own. "*Consciously or unconsciously the policy of destroying and removing the old bunds have been adopted. The old system of irrigation has been practically extinguished in the portion of the district irrigable by the canals*" observed the Commission appointed

in 1887. The Commission on the basis of evidences recorded during the course of enquiry and inspecting the area itself was fully convinced that **the canals were so constructed to destroy the old ahar system.** Thus the people generally had no other means of irrigation left to them but to apply for canal water.

Some people were not happy with the new canal irrigation. They complained that the outturn of crop with the application of canal water was less than that they formerly got from *Ahar* water. This reduction in produce was more marked in the case of area having Kewal soil (heavy soil) or Kurael lands which were said to be injured by canal water. Some people felt that in the early period of canal irrigation, for two to three years, the Sone water was good for soil but afterwards the yield gradually reduced, on an average from 15 *maunds* (560 kg) per acre to 7 to 10 *maunds* (260 kg to 375 kg) per acre. People said that the canal water did not possess fertilizing qualities.

The Ganges inundations over the *diara* lands to the north of Shahabad were pointed to as being in a high degree beneficial but inundation from the Sone was said to have been always injurious. This however could not be substantiated with any concrete proof rather experimental results conducted by the concerned department indicated the other way. Perhaps it was a sort of prejudice which had been handed down from generation to generation, about which Col. Dickens had mentioned in his project report (1855) *"I must first remark that the people of the district have a prejudice against the use of the Sone water for irrigation, in support of which they refer to the putrifying properties of the water..... but this prejudice appears to have no solid foundation".*

However it was found that canal water definitely had an adverse effect on *Rabi* crops which were previously grown with well water because the *ahars* used to dry up during cold season. The officers of the Irrigation Department were obliged to admit from the evidence of their own experiments that **the produce of *Rabi* lands irrigated by wells exceeded that of similar lands watered by the canals.**

Another serious complaint was regarding the drainage congestion of the area after the construction of canals. It had affected in two ways. Previously the old *ahar* system afforded no permanent obstruction. The water flowed on from *ahar* to *ahar* and from *putsar* (irrigated rice land) to *ahar* or *tal* until the excess water was absorbed or found its way into the drainage *nala* of the district. Now the canal had obstructed this free flow of water into these drainage nalas and this had resulted in many cases into accumulation of excess water and consequently turned a vast stretch of land into water-logged area. Secondly, under the *ahar system* the supply of water available was comparatively scanty; there was no waste and no inundation. Long established custom had created ways and means for the distribution of water which were remarkable for the smoothness with which they worked. Now water supplied by the high level canals and distributaries overflowed the fields far and wide so that large areas which were previously inaccessible to wet cultivation were now flooded, and canal water filled the old *ahars*, the road side cuttings, hollow village

tracks and every one of the ditches wherever they could reach. The seepage from the canals further added to the misery.

This accumulation of water for longer period had not only destroyed crops in the lower reaches, it also caused deterioration in the general health of public. It was said to have brought unhealthiness in the very districts which were in the former times famous in India for their healthiness and freedom from malarial fevers. According to some doctors and health authorities the canal irrigation had brought conditions conducive to spread of diseases like malaria, rheumatism, spleen and the like and general enfeeblement of population so that they were less able to resist cholera when once introduced among them. Death rate was found to be on increase in the irrigated areas.

However these phenomena were not new for Sone area only. Everywhere in India where canals were constructed a similar change had been observed, whether it was Western Yamuna Canal in the west or Godavary and Cauvery in the extreme south, or canals in Orissa in the east. In his recently published book "The Dammed", Fred Pearce has painted even more gloomy picture. He writes "*Where the canals went, and where water logging was worst, mosquitoes gathered, and fever was rife during the years of heaviest floods. Malaria was endemic in India then, as now. But the local sanitary commissioner reported a general and intense level of fever along the tracts of the Ganges and Yamuna Canals, which were very much to blame. Annual death rates among peasants along the canals exceeded one in ten in the worst year, such as 1879. That year, the sanitary commissioner reported that fuel for crematoria had run out and there were no able-bodied people to tend the fields...*". The unhealthiness occasioned by the canals were frequent not only in India but abroad also. It is to be noted that owing to this dampness, in England and in other parts of Europe viz.. Spain, canal irrigation in the immediate vicinity of towns and villages, are prohibited.

SONE CANALS—A GREAT BOON

There might have been reports of some ill effects here and there but on the whole the canal proved to be a great boon for the area. Undoubtedly the wealth of the State had substantially been augmented by the introduction of the canal irrigation. A vast stretch of land both jungle and sandy which was considered formerly waste could be brought under cultivation with satisfactory yield. The portion between Piro and Behea known as the *jungle mahal* is now a fertile rice bowl. Because of the canals many fallow tracts came under cultivation and the cost of land in the area rose several times. A large portion of the command area which were growing only poor quality crops viz. *Maruwa* and *Kurthi* for want of water had turned into rich paddy and *Rabi* field, worth three to four times the former value. The cultivation of valuable crops like sugarcane received a great impetus from canal irrigation, the increase trebled in a decade. The outturn of all the crops irrigated by canal water had in fact greatly increased. This could be corroborated by the fact that the area under

irrigation was steadily increasing every year. Especially the extension of the cultivation of rice on lands formerly devoted to *Rabi* crops only was apparently considered to be an immediate gain to the cultivators because rice was considered to be a surer crop and could yield a better return than *Rabi* when sown in inferior lands.

In addition to irrigation the canal had provided an increased facilities of communication both along the canal themselves and on the service roads made on spoil banks. This was a real benefit in those days of underdeveloped condition and was greatly appreciated. The canals also brought a supply of drinking and bathing water to the people who lived in the neighbourhood of the distributaries such as they never enjoyed before.

Over and above these tangible and intangible benefits the canals had provided in its presence a security against droughts and scarcities. The great value of canal in this respect was conclusively demonstrated in the years 1873 and 1877 during which the scanty rainfall had created a famine like situation and taken a toll of many valuable lives in other parts of the State but the area catered by Sone canals could face the situation boldly and came out without any serious consequences. In fact during the fateful year of 1873 even the canals and distributaries were not yet completed properly but water was supplied, and that too gratuitously. The prospects in the year 1877 were so gloomy that with a view simply to the production of more food it was determined at a certain sacrifice of revenue to reduce the water rate for the rice crop from Rs. 2-8 an acre to Re 1/- and to give water free in Patna Canal where owing to the unfinished state of the distributaries regular assessment was impracticable. These measures led to a considerable demand for water and irrigated *Kharif* rice proved a bumper crop. This also made the canals popular for years to come and prompted the cultivators to grow such *Kharif* rice every year. Similarly the year 1883 was also a year of scanty rainfall, the crops would have failed had the canal not come to their rescue. In 1988-89 distress and scarcity would have been the inevitable result of the total failure of the rains in September and October but for these irrigation works.

1896--An extra-ordinary year in the history of Sone Canals

The *Kharif* season of 1896 was one of extreme pressure on the Sone Canals. This year the historically infamous famine had taken whole of Bengal Presidency in its grip taking toll of lakhs of souls. During this period the contribution of Sone Canal was so great that it not only helped in mitigating the miseries of the people rather filled their silos with bumper crop. It seems worthwhile to narrate the story of this fantastic achievement of Sone Canal in detail to highlight the real importance of canal for the area.

The three most important months for rice crop are August, September and October. The average rainfall in these months in the area commanded by Sone Canals, as determined by observations at a number of stations, is about 23 inches (58 cm). The year 1896 had received less than half i.e. 11" (28 cm) during this period. If the rainfall in the month of July, which also matters though not as much, is also included, the total rainfall during the 4 months was only 19 inches (48 cm) as against 35 inches (89 cm) in the normal years.

The two important periods for the *Kharif* crop are :-

1. the transplanting season, being six weeks from about the 21st July to the end of August, and

2. the first three weeks of October.

In the first period the rainfall in the area is usually about 16 inches (40.6 cm). In the year 1896 it was 9.1 inches (23 cm) only, that also not in the right moment. From the 21st July to the 21st August, which is the busiest time for transplanting, there were only occasional light showers, aggregating less than 3 inches (7.6 cm) of rainfall, which were quite useless for transplanting. It was only in irrigated tracts, and in few places where there were good *ahars* or other means of irrigation that any transplanting could be done. However, in the last week of August there was about 6 inches (15 cm) of rain. On this fall a great deal of transplanting was done.

In the second period i.e. during first three weeks of October there was no rainfall at all.

During the transplanting season the demand for water from Sone Canals was of course, very great. At that time it was not possible, owing to great fluctuations of the river, to pass as much water into the canals as can be passed into them in October, when the river is usually steady. The average discharges passed into the canal in August 1896 were—

Western Main Canal	3,341 cusec
Eastern Main Canal	1,345 cusec

These discharges were about 10 per cent larger than had ever been carried before in August. As happens during the scarcity period, the cultivators in the upper part of the canals showed the tendency to consume the discharge allotted to lower part also. However, with great difficulty, sometimes with application of force also the officers could supply water to transplant all the fields under lease enforcing a rigid system of *tatils*, though people resented against it. The Superintending Engineer, Sone Circle while sending his report to the Chief Engineer that year wrote "*Indeed, if the water this year, from the 21st July to the 21st of August, had been supplied according to what the people wanted, the canals would have had to have been twice the size they are*".

The rainfall during September was less than 2.5 inches (6.35 cm), there was consequently a pretty strong demand for water during the whole month. It is usual for the cultivators to *nigar* their fields, that is, to drain them off in the middle of September, before the *Hathia Nakshtra*. That year it was not done. On the 22nd of September 1896 the rains ceased entirely. In the *Hathia* (26th of September to about 10th October) and during the whole of October, there was no rain at all. The demand for water were again insatiable. Usually the demand slackens after the 15th or 20th October, but that year it had been continuous all through the month. The *Kharif* season ends technically on the 25th October but the canals had to supply water for rice crops upto first week of November and in some part even upto second week.

Special measures were adopted in October to ensure a larger supply of water than usual. The shutters of the weir were specially treated. The Western Main Canal was run at higher levels than had ever been previously recorded. One is thrilled to read the notes written on 6th November 1896 by Mr. R. B. Buckley, the then Superintending Engineer, Sone Circle who faced the situation with remarkable courage and boldness. In his words -

"I found it necessary to be constantly on the spot encouraging larger, and still larger, discharges : all the subordinates feared to exceed what they thought was the limit of safety, and they were right to be cautious: the responsibility fell on myself. No doubt in forcing the canals as I did, there was some risk; but the result was successful, and we have established now the fact that the canals will carry a good deal more than is laid down as their maxima. But of course such discharges need care and intelligent supervision. The maximum laid down (page 85 of the Sone book of rules) for the Arrah Canal is 2,250 cubic feet per second: the actual maximum this year reached 2,650. The maximum defined for the Buxar canal is 1,600, it carried for a time 1,860. The maximum of the Eastern Main Canal is supposed to be 1,600: it took up to 1,850, and, with certain arrangements, would easily take more. The main Western Canal is theoretically limited to 4,000 cubic feet. I forced 4,400 into it. These figures may be useful guides for future years. But let those who run these discharges again remember that they can only be passed under certain circumstances, and when all the staff are well on the alert".

Thus so far the discharges run in the canals, Sone Canals made history that year. But even these discharges were insufficient to please the people. During the end of September and first fifteen days of October, the discharges were limited by the capacity of the canals. After that the discharges of the canals were limited by the amount of water available in the river. The river Sone itself was not copious enough to satisfy the thirsty cultivators. The level of water in the river fell below the crest of the shutters. The gauge-discharge register showed that the discharge in the Sone on 25th October,1896 was only 5,610 cusec as compared to 8542 cusec minimum recorded since observations of the river in October were commenced in 1885. (Table 4.7)

In a year of such extreme pressure one can expect some violence also to occur. It so happened really. Three or four attempts were made to cut the canals—one of these, near the head of the Arrah Canal, would, had it been successful, have stopped the entire supply to Shahabad district for several days. Luckily the cut was detected in time and the escape of water stopped before causing any harm. Two other attempts were successful—one in Dumraon Canal and other in Behea Canal—both breaches deliberately made by villagers. When these attempts on the safety of the canals were known, the Lt. Governor ordered special measures to be adopted to protect the banks. But before these orders were received, the Collector of Shahabad, acting in unison with the Executive Engineer of the Arrah Division, had already adopted vigorous and effective measures which at least carried conviction to the criminals that such acts would not be lightly passed over.

Inspite of all such difficulties the canals irrigated an area, the figure of which broke all previous records. The district wise area for which water-rates were charged was :

Patna District	41,000 acres
Gaya District	40,000 acres
Shahabad District	2,31,000 acres
TOTAL	3,12,000 acres

The *Kharif* crop of 1896, which had been saved by Sone Canals were then worth Rs 150 lakhs which was more than half the cost involved in the entire system of Sone Canals including all charges.

In the year 1873 the rainfall in August, September, October and November was much the same as it had been in 1896. The rice crop failed much as it had done in the year 1896 outside the area commanded by canals. In 1873-74 there was scarcity in Bihar. The Sone Canal was not in operation. In comparing the year of 1896 with 1873-74 it is interesting to see what difference the Canals made in the situation. It is stated in Mr. Finncane's letter of the 3rd November 1896 that in the year 1873-74 the Government had to import 130 lakhs of *maunds* (4.87 lakh tonnes) of grain. In the year 1896, the 3,12,000 acres of crops which were saved by Sone Canals in the *Kharif* season only placed about 60 lakhs of *maunds* of unhusked rice or 40 lakhs of maunds (1.5 lakh tonnes) cleaned rice in the hands of the people. It further helped to produce another 25 lakhs of maunds (0.93 lakh tonnes) of corns by irrigating nearly 2,43,000 acres of *Rabi* crops, thus taken together nearly 50 per cent of what had been imported in the year 1873-74.

It was not without any reason when Mr. P. Nolan, Secretary to the Government of Bengal, Finance Department, in his note dated 10th July, 1888

mentioned that ***the Sone Canals are more useful and popular than those of Orissa and Midnapore.***

Above all Sone Canals had brought a sort of awareness among the inhabitants of the area, a real instruction to the natives as the young master **planner Lt. Dickens had dreamt.**

Table 4.7

Observed Discharge in the river Sone during the months of October and November

YEAR	OCTOBER		NOVEMBER	
	DATE	DISCHARGE in Cuse	DATE	DISCHARGE in Cusec
1	2	3	4	5
1885	21st	13,376	12th	11,801
	30th	12,821	26th	7,904
1886	27th	34,659	19th	18,929
	28th		30th	17,317
1887	30th	16,402	20th	8,954
			28th	8,160
1888	22nd	12,304	1st	10,087
			16th	9,634
1889	22nd	13,132	2nd	13,868
			15th	7,766
1890	29th	14,292	15th	10,177
1891	25th	15,976	1st	12,105
			15th	9,829
1892	24th	9,543	15th	8,275
			30th	6,104
1893	28th	28,832	16th	22,136
			29th	13,914
1894			30th	14,787
1895			17th	6,384
1896	6th	9,627	2nd	4,945
	16th	8,701	16th	3,977
	25th	5,660		
1897			15th	11,391
1898			4th	9,161
			18th	6,763
1899	1st	6,581	9th	3,090
	10th	5,483	19th	3,134
	12th	4,481		
	20th	3,956		
	31st	4,137		
1900			2nd	15,332
			15th	8,806
1901			1st	8,156
			16th	7,216
1902	18th	8,357	2nd	6,968
			16th	6,853
1903			3rd	16,916
			15th	9,969
1904	1st	15,883	1st	16,514
	16th	9,130	16th	7,442
1905	16th	13,557	1st	8,724
			16th	5,763
1906	18th	14,749	1st	13,465

FINANCIAL APPRAISAL

INTRODUCTION

Now a days economic benefit criterion is adopted for sanctioning any irrigation project. Benefit cost ratio is the basis for approval of the projects. But this concept has developed during the recent years and came to be recognised only in the year 1964 when the Central Government accepted the recommendations of the "Committee to Suggest Ways and Means of Improving Financial Returns from Irrigation Projects" headed by Prof. D. R. Gadgil. Prior to that, criterion of direct financial return was rigidly followed for judging the utility of an irrigation project.

During the British days, irrigation works in India were treated as commercial undertakings and only such schemes were sanctioned as could pay for the annual expenses on maintenance and operation and meet the interest charges on the loan raised.

THE FINANCIAL CRITERIA

Till the middle of 19th century very few irrigation projects were executed by the British Government. Therefore maintaining a separate account for the revenue and expenditure of the irrigation works was not felt necessary. The irrigation charges were included in the revenue account. But when a good number of such works were taken up for implementation it became obligatory to maintain a separate account for this purpose which was instituted in the year 1854. This in succession necessitated some defined criteria for investment in irrigation projects. But this was not easy to evolve. Discussions went on for years and after much deliberations the Select Committee of the House of Commons in 1872 stated in clear terms that the financial results of the irrigation works should be the best test of their utility.

The Select Committee also laid down the criteria for financial test. According to this the sum actually spent on any irrigation work was designated as capital cost of the work. Every year the revenue account was to be debited with the simple interest on the capital cost of the works along with the working expenses of the year and credited with direct and indirect receipts. The difference between the credit and debit was called the profit or loss for that year. Criteria evolved provided that the project should be able to yield, after a gestation period of 10 years, a specific rate of return on the sum-at-charge which was capital cost plus the interest on the capital during the gestation period. To satisfy the financial criteria the pricing of water had to be such as to earn at least the prescribed return on capital after meeting other costs.

The financial criterion was followed rigidly in almost all cases. However in stray cases if the project did not fulfill the financial criterion but still considered necessary in the public interest it could be sanctioned as a protective work.

The rate of return varied over the time. For a long period, up to 1919 it was 4%, between 1st April 1919 and 1st August 1921 it was fixed at 5% and thereafter it was raised to 6 percent which continued up to 1st April 1949.

It is to be noted that at the time of independence, irrigation works in the country, as a whole, yielded a net profit of 8% after meeting the cost of maintenance and interest charges.

Even after independence this financial criterion continued but to step up the development of irrigation in independent India the rate was lowered from April, 1949 and fixed at 3.75 percent only. From August 1954 it was raised and fixed at 4.5 percent which continued till 1st April 1960 when it was again raised to 5 percent. From April, 69 it was further raised to 6 ½ percent which continued till economic criteria took its roots.

From 1867 to 1921 i.e. before the Montague Chelmsford Reforms, all major irrigation projects were sanctioned by the Secretary of State and funds were provided by the Government of India from loans raised in London. Works were executed by the Provincial Government and expenditure was treated as an advance made to them from the revenues of India at a rate of interest fixed by the Government of India from time to time. After 1921, however, all productive irrigation projects were financed by State Governments.

FINANCIAL STATUS OF SONE CANALS

In this background let us see how the Sone canals fared on financial front.

The Project report of 1861 had promised a return of 8.75 percent on the outlay. Later in the year 1875, when the canal had already been commissioned, it was estimated that the net profit from the Sone Canals would be Rs. 26,40,536/- or equal to a return of 8.3 percent on the outlay. On 7th May 1878, Major-General Dickens in his evidence before the Select Committee of the House of Commons on East India Public Works stated that the departmental estimate of the percentage of profit from the Sone Canals was about 7 percent. When asked by the Chairman whether the department had seen no reason to think that that was an over estimate, he had replied *"No, I think not. Of course it was new part of the country to begin irrigation in, but otherwise we have no reason to doubt that it will come to that"*.

But for reasons, not anticipated earlier, the Sone Canals had not, from a financial point of view, fulfilled the expectations formed of it.

COMPARISON OF CAPITAL COST

By curtailing the scope of the project, the cost of the project as estimated by Colonel Dickens in 1861 had not been exceeded. But whereas in October 1875 the Government of India anticipated a yearly irrigated area of 10,43,680 acres the average of the five years ending 1900-01 was only 4,63,181 acres. The maximum attained before the end of the 19th century was 5,55,156 acres in 1896-97 which was an exceptional year as described earlier. It went down to 4,49,541 acres in 1911-12. The situation started improving after a decade. From the year 1915-16 to 1919-20 the canals irrigated on an average 5,33,193 acres per year. The figure touched 6,19,033 acres in 1920-21, the maximum area ever irrigated by Sone Canals before remodelling. The culturable area commanded by Sone Canals as envisaged at the time of planning was 13,54,302 acres. Thus the canals on an average watered about one third of this area.

The total capital cost of the Sone Canals upto 31st March 1902 had been Rs. 2,67,62,426/. Taking the figure of average area then irrigated the capital cost of the Sone Canal per acre irrigated worked out to Rs. 58/- as against Rs. 33/- per acre in case of Tribeni Canals which was commissioned in the year 1914, four decades after the completion of Sone Canals. The capital cost per acre irrigated for 7 major irrigation works in Punjab viz. Western Yamuna (1890), Bari Doab (1890), Sirhind (1891), Lower Sohag and Para (1891), Sidhnai (1892), Chenab (1892) and Swat River (1893) on an average worked out to Rs. 21/- per acre only on the basis of their financial results in 1900-01. Capital cost per acre irrigated of contemporary projects in Sindh was at par with that of Punjab and the corresponding figure of the four productive works in U.P (the then United Provinces) viz. Eastern Yamuna Canal (1850), Upper Ganga Canal (1854), Lower Ganga Canal (1878) and Agra Canal (1874) worked out to Rs. 35/- per acre. Obviously the capital cost per acre irrigated in case of Sone Canals was higher as compared to the contemporary projects in other parts of the country. The terrains of the other projects not being much different the higher cost was attributed to the provisions of navigation facilities in Sone Canals.

RECEIPTS AND EXPENDITURE

The supply of water in Sone Canal was given on payment of rates in a regular manner from the year 1876-77. The Table 4.8 shows the gross receipts from all sources and the gross expenditure incurred for each year from 1876-77 to 1886-87. It is clear from this table that the capital outlay at the end of 1886-87 was Rs. 2,49,98,067/-. In addition to this the interest amounted to Rs. 1,22,32,871/-.

Table 4.8

Year	Capital outlay to the end of year in Rs.	Area actually irrigated in Acres		Total revenue of the year	Total expenditure of the Year	Excess revenue over expenditure	Interest	Including Excess expenditure	Interest rate percent on capital
		Kharif	Rabi	Rs.	Rs.	Rs.	Rs.	Rs.	
1876-77	17376842	1923	11341	73180	199590	(-)126410	736667	863077	4.97
1877-78	19068165	107087	124821	101292	252407	(-)151115	819218	970333	5.09
1878-79	20776997	99964	77430	437626	662998	(-)274938	903092	117830	5.67
1879-80	21762786	38139	58005	531588	357297	174291	957145	782854	3.59
1880-81	22581227	131175	47708	478644	472570	6074	997676	991602	4.39
1881-82	23293432	118377	33944	736292	457322	278970	917494	638524	2.74
1882-83	23665975	124274	14920	684677	529841	154836	939188	784352	3.30
1883-84	24256190	215790	109436	603807	514477	89330	958443	869113	3.58
1884-85	24648407	249927	81548	862474	635530	226944	978092	751048	3.05
1885-86	24861348	225122	68647	1062646	584002	478644	991240	412596	1.66
1886-87	24998067	207565	75416	918429	613588	3044871	997188	692317	2.76
						Amount of interest due on 1/4/76	Rs. 2037428		
						Total Interest	Rs.1,22,32,871		

A close look at the table would reveal that during the last four years of the decade when the system had stabilized, the average gross receipts from all sources were nearly Rs. 8.6 lakhs. Average collections were, from water rate Rs. 7.4 lakh, from navigation Rs. 0.50 lakh and rest from miscellaneous receipts like mills, arboriculture and the like.

Average annual expenditure amounted to about 6 lakhs of rupees—an outlay of about Rs. 4 lakhs was annually incurred on maintenance and repairs and on engineering establishments proper, the Revenue management of the Irrigation Department required about Rs. 1.4 lakh and the Navigation Department about Rs. 0.15 lakh, the remaining expenditure was on account of refunds and indirect charges for leave and pension allowance etc.

The receipts at the end of a decade after commissioning the canal exceeded the working expenses by more than 3 lakhs of rupees per annum but the excess expenditure including interest still continued to pose a problem for the British Government since it was considered to be a heavy drain upon the revenue of the country.

To meet the heavy charges of interest, not only from Sone Canals but from all irrigation canals in Bengal it was proposed in 1877 to levy a compulsory cess on all irrigable and protected lands.

This proposal met with strong opposition and was ultimately withdrawn. However it was decided that the charges should be met; not exclusively by particular localities concerned but from general revenue, and under Bengal Act - II of 1877 a provincial public works cess was imposed to enable the Government of Bengal to discharge the contribution levied on it by the Government of India on account of Public Works. This rate was uniform and was charged as half an anna (an anna was one sixteenth of a rupee) in the rupee on the rental in all the districts under the Bengal Government in which the road cess was effective. The interest on Sone Canals was therefore not paid by the districts benefited but these districts contributed in the same proportion as all the districts in Bengal contributed to meet the charge.

The total capital cost of the Sone Canals upto 31st March 1902, as stated earlier, rose to Rs. 2,67,62,426.00. The annual charges for maintenance, revenue management etc. amounted to Rs. 6,04,804.00 taken on the average of the three years ending 31st March 1902. The total annual revenue collected for the same period was Rs. 11,12,278.00 leaving a net revenue of Rs. 5,07,474.00 equivalent to an interest of 1.89 percent on the capital outlay.

It is to be mentioned that a very large sum, Rs. 66,85,606.00 was spent in making the canals first class navigation lines. It was expected that this expenditure would fetch a good return. But unfortunately the navigation receipts had been seriously affected by the opening of the Moghulsarai - Gaya Railway. During the four years ending 1899-1900 they averaged Rs. 87,600.00, but they fell to Rs. 36,507.00

in 1900-01 and to Rs. 23,595.00 in the following year. The average cost of navigation establishment only was Rs. 15,000.00 per annum. There were 218 miles (349 Km) open to navigation and the average rate of tollage was about 2.2 pies per ton mile. The dwindling figures of earnings from navigation were very disappointing since the navigation had shared nearly 25 percent of the capital outlay of Sone Canal.

Thus on the whole for many years the canals were unremunerative. However, from the second decade of 20th century, with good management, the situation started improving. By the end of 1921-22 when the capital outlay amounted to Rs. 2,68,98,109/- the net revenue for the year was Rs. 15,37,513/- yielding a return of 5.72 per cent, but still below the mark of 7 per cent as stated by Major General Dickens in his evidence before the Select Committee of the House of Commons on 7th May 1878.

WATER RATES IN SONE CANALS

Water rates play a great role for the success of an irrigation system and during the days when Sone Canals were commissioned the financial criterion had clearly been laid down. To satisfy this criterion pricing of water had to be such as to earn the prescribed return on capital after meeting other costs.

For 1875-76 water was given at the provisional rates of Rs. 2-8 per acre for *Rabi* and *Kharif* crops with the exception of sugarcane and opium for the irrigation of which Rs. 5 per acre was charged.

These rates were, however, simple contract rates, not having been imposed under the provisions of any Act. Rules under Act III (B.C) of 1876 were passed in August 1876 and the following rates were fixed for three years from the Ist June 1876 to the 1st June 1879.

Table 4.9

Class	Nature of Crop	Flow Irrigation						Lift Irrigation					
		per Bigha			per Acre			per Bigha			per Acre		
		Rs	A.	P.	Rs	A.	P.	Rs	A.	P.	Rs	A.	P.
1	Sugarcane, Tobacco, Indigo, Opium and gardens	3	2	0	5	0	0	2	1	4	3	5	4
2	Rice, Vegetables, Water Nuts, Barley, Cotton & other crops	1	9	0	2	8	0	1	0	8	1	10	8

In October 1878 these rates were modified for areas leased for three years certain, for which the following rates were charged:-

	Per Acre		
	Rs.	A.	P.
Rabi including bhadai	2	4	0
Kharif	1	8	0

The rates for three years leases remained in force up to the 1st of June 1879. The rates for annual leases remained in force up to the 25th June 1881 from which date those shown below were imposed—

Table 4.10

Nature of Crop	Flow Irrigation						Lift Irrigation					
	Per Bigha			Per Acre			Per Bigha			Per Acre		
	Rs	A.	P.	Rs	A.	P.	Rs	A.	P.	Rs	A.	P.
For water supplied between the 25th June of one year & 1st April of following year.												
Annual Lease												
Rice	1	14	0	3	0	0	1	4	0	2	0	0
Bhadai	1	9	0	2	8	0	1	0	8	1	10	8
Rabi	1	9	0	2	8	0	1	0	8	1	10	8
Sugarcane	3	2	0	5	0	0	2	1	4	3	5	4
For water supplied between the 1st April & 25th June of each year for all crops.	2	8	0	4	0	0	1	10	8	2	10	0

Five Year Lease	Per Bigha			Per Acre		
	Rs.	A.	P.	Rs.	A.	P.
For water supplied between the 25th June and 1st April. For all crops	1	4	0	2	0	0

Committee recommends reduction in rate

Government considered these rates to be reasonable but the people by and large felt the rates to be high. In fact the canal irrigation had become unpopular due to various reasons as explained earlier and the people started agitating against the canal administration. A committee was appointed in the year 1887 to examine into the working of the entire system. This committee inter alia suggested to bring the whole area under lease and recommended to bring down the rate from Rs. 1-4 per *bigha* to Re. 1/- only in case of five year leases.

They allowed occasional watering in case of rice for which a charge on volumetric basis could be collected. The price of water sold by volume was calculated on the discharge at the outlet. It was assumed that a discharge of one cubic feet per second for 12 hours will irrigate 4 *bighas* of land liberally with a flooding of 4 inches of water. There are 43,200 seconds in 12 hours and the charge for 43,200 cubic feet of water was fixed up at Rs. 4/- and it was said that smaller amount of water than this could not be sold. This worked out to Re. 1 per *bigha* in place of Rs. 1-14 then charged.

Occasional watering for *Rabi* and sugarcane was not to be paid for by volume. However the rate for *Rabi* under annual lease was reduced to Re 1 from Rs. 1 and 9 annas per *bigha*. Similarly in case of sugarcane the rate was brought down to Rs. 2-8 from Rs. 3-2 per *bigha*. No reduction was recommended in case of hot weather crops which remained as Rs. 2-8 per *bigha*. These rates were supposed to take effect from 1888-89. While recommending the above reduction in rates the Committee had observed that if there were no special reasons to the contrary, the Government was entitled, and indeed required to impose water rates up to the full limit which the people would consent to pay for use of water. This duty, they opined, was imposed on Government in the interest of the tax-payers at large, at whose expense irrigation works were carried out. **The individuals for whose benefit these works were constructed may fairly be required to pay for them to the full value of the benefit received. It was not just that the cultivators of a tract under canal irrigation should be enriched at the cost of the tax payers in general.** But in case of Sone Canals since the system had impaired the *Ahar* system for which cultivators were not obliged to pay previously, a concession in water-rate was felt necessary at the initial stage. It was also necessary from the point of view of educating the cultivators as to the value of irrigation, they reasoned.

Rates revised

Later the rates were revised in early nineties and the long lease rates were raised to Rs. 2/- per acre.

Subsequently seven years leases were introduced in the area and the rates were revised on 1st April 1897 enhancing the long lease rate from Rs. 2/- to Rs. 2-8 per acre.

In the year 1902 the charges per acre irrigated for water from Sone Canals were as here under :

Table 4.11

	Rs.	A.
7 years lease for all crops between 25th June and 25th of next March	2	8
Kharif season lease between 25th of June to 25th of October	3	8
Rabi season lease between 15th October and 25th of March	2	0
Hot weather lease between 25th March and 25th June	4	8
Ditto ditto per watering	2	0

The last two rates were each increased by 8 annas in 1902.

Irrigation Commission recommends increase in rate

In the year 1903 the First Indian Irrigation Commission felt that the rates charged for Sone Canal water were very low and recommended increase in the water rates.

The area under long lease had been steadily expanding. During the three years ending in March 1896 it averaged 2,71,552 acres but in 1901-02 it amounted to 3,17,318 acres although the rate was increased from Rs. 2/- per acre to Rs. 2-8 per acre from the 1st April 1897. The increase of revenue had been gradual but continuous. It had been approaching its limit, as in the following year these leases were given for only 2,52,393 acres whereas the area for which applications were refused amounted to 1,12,648 acres, or say 44% of the area applied for. The demand for season leases were also approaching to its limit. This was a clear indication that the project would not fail due to slack demand as in case of Orissa where the cultivators failed to appreciated the value of irrigation. In such circumstances the Commission felt that there was no justification for low rates which were then charged.

The interest charges on the Sone Canals to the end of 1901-02 had exceeded the net revenue by Rs. 2,15,44,497/-. During the three years ending March 1902, the average annual of excess of interest charges over net revenue amounted to Rs. 5,26,024/-. It was felt that with this rate these works were likely to impose a constant annual charge of about Rs. 5 lakh on this State. Thus it became imperative to take measures to increase the net revenue by increasing the water rates. The average annual amount of water rates during the same period had been Rs. 10,26,459/- on an area of 4,81,333 acres or an average of Rs. 2.15 per acre.

The Indian Irrigation Commission (1901-03) suggested an increase of 50% in the water rate to cover the interest and working expenditure in future. However, they felt that this increase should not be brought all at once and suggested gradual increase.

The Commission justified the increase from another point of view also. Experiments on the outturn of irrigated and unirrigated crops of rice and wheat had been made for many years in all the Divisions of these canals. Experiments conducted on 409 irrigated and 268 unirrigated rice lands and 170 irrigated and 142 unirrigated wheat land indicated that on application of irrigation the outturn increased as shown in the table below -

Table 4.12

Three years ending	Average value of Annual outturn (Grain and Straw) per acre					
	RICE			WHEAT		
	Irrigated	Unirrigated	Difference	Irrigated	Unirrigated	Difference
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
March, 1986	33	Not Observed	-	36	Not Observed	-
1989	38	24	14	43	38	5
1902	34	23	11	42	32	10

The irrigation increased the value of an acre of rice by Rs. 12 (an average increase of 53 per cent) and that of an acre of wheat by Rs. 7'(an average increase of 21 per cent). Hence the Commission pleaded that there was room for enhancement of water rate.

It may be noted that the water rate at that time, Rs. 2-8 per acre was about 7% of the rice produce per year.

COMPARISON WITH CONTEMPORARY PROJECTS

There were altogether 8 major irrigation works in Punjab by the end of 19th century out of which 7 were commissioned during the period 1890 to 1893. Financial results of these 7 canals in 1901 indicated that these canals on an average yielded a return of 11.2% on their capital cost. During ten years of operation these canals had earned a total gross revenue which exceeded the accumulated working expenses and interest charges by about 50% of the capital cost of the works, Rs. 921 lakhs. They irrigated 43.57 lakh acres of land. The capital cost worked out to Rs. 21/- per acre which was definitely low.

Working expenses during the year amounted to Rs. 43 lakh equivalent to	Rs. 0.99 per acre
Interest charge @ 4% on Rs. 21/-	Rs. 0.84 per acre
Sum of the two works out to	Rs. 1.83 per acre
Gross revenue during the year of study was	Rs. 3.36 per acre
Net profit to the Government during the year	Rs. 1.53 per acre

Thus clear profit was nearly 7 %.

The value of the crop assessed was Rs. 1205 lakh.

Average value of crop per acre = Rs.1205/43.57

= Rs.27.65 per acre.

It is to be noted that the gross revenue collected per year was 12% of the value of the crop.

Similarly in the then United Provinces 4 number of canals viz. Upper Ganga Canal (1854), Lower Ganga Canal (1878) Agra Canal (1874) and Eastern Yamuna Canal (1850) irrigated on an average 22.4 lakh acres of land. The total capital cost was Rs. 786 lakh. These canals yielded an annual net revenue of Rs. 58 lakh during 6 years (1896 to 1901), equivalent to 7.37 percent on their capital cost. Relevant data of above period showed that after meeting interest charges which amounted Rs. 29.3 lakh they left clear profit to the State of Rs. 28.6 lakh per annum. The capital cost in case of these 4 canals worked out to Rs. 35/- per acre.

The Gross revenue annually earned (R. 84.75 lakh) or	Rs. 3.80 per acre
Working expenses average	Rs. 1.20 per acre
Interest charges @ 4% on Rs. 35/-	Rs. 1.40 per acre
Total working expenses & interest	Rs. 2.60 per acre
Net profit to the Government	Rs. 1.20 per acre

The value of the irrigated crop in an average year was estimated at Rs. 800 lakh or Rs. 35.70 per acre. Hence the canal revenue (Rs. 3.80 per acre) was 10.5 percent of the value of the irrigated crop.

Obviously the revenue earned by Sone Canals was on the lower side as compared to these canals and on the whole the financial status was not very sound to please the British.

The water rates were enhanced form time to time and Table 4.13 shows the rates during different period. But revenue collection did never show better result as compared to the expenditure on the system including interest on the capital cost.

It seems that application of the benefit cost ratio criterion in recent years has had certain undesirable effect on the minds of irrigation managers. The requirement that projects should earn a minimum financial return on the capital investment in them has completely been given up. For years the State Government has been charging so little for canal water that they cannot cover even the costs of canal maintenance. Due to financial crunch facing the State sufficient funds as per the norms are not allotted for the operation and maintenance of the canals by the State Government which has to divert funds for this purpose from other sources. This has resulted into fast deterioration of the irrigation system.

The Second Indian Irrigation Commission (1972) expressed anxiety over this trend and had recommended that if the return does not cover working expenses and interest charges on capital, the impact of the project on the irrigation revenues of the State should be examined to see if an upward revision of water rates in the State would be necessary.

The Irrigation Commission (1972) had suggested that the water rate should be related to the gross income from the crop and not to the cost of the project and recommended a rate ranging between 5 percent of the value of the food crops and 12 percent of the cash crops.

The procedures for the cost-benefit analysis of irrigation projects were reviewed in 1983 by a Committee constituted by the Planning Commission, Government of India. This Committee recommended replacing the benefit cost ratio by the internal rate of return (IRR) criterion. World Bank also uses IRR criterion for practically all its economic and financial analyses of projects.

In the benefit-cost ratio, the benefit represents the total gains accruing from a project and the cost represents the expenditure involved in producing them, all in terms of current values. The rate of return deals with a different aspect as it connotes a ratio between the current annual benefit from a project and the capital investment on the project. This is another way of using the incremental net benefits streams or incremental cash flow for measuring the worth of a project. It tries to find the discount rate that makes the net present worth of the incremental net benefit stream or incremental cash flow equal to zero. This discount rate is called the internal rate of return. It is the maximum interest that a project could pay for the resources used if the project is to recover its investments and operating costs and still breaks even. From yet another vantage point, one could ask what interest rate the project would

earn. In other words, what would be the earning of the money invested in the project? This earning rate of a project is the internal rate of return.

The Committee constituted by the Planning Commission suggested that projects should normally earn a minimum IRR of 9 percent to qualify for approval. However, in drought prone hilly areas and in areas where 75 percent dependable flows of the basin had been utilized, a lower minimum IRR of 7 percent was prescribed.

The National Conference of Irrigation and Water Resources Ministers (1986) noted that the prevailing water rates were too low to meet even the operation and maintenance charges and wanted the rates to be increased gradually.

The National Water Policy (1987) laid down by National Water Resources Council had also asserted that water rates should cover the annual maintenance and operation charges and a part of fixed cost.

The Fifth, Sixth, and Seventh Finance Commission suggested that the financial returns should not only cover working expenses but also a specified percentage of interest on the capital investment. The Fifth Commission had recommended a rate of return of 2.5 percent on capital investment while the Sixth and Seventh Finance Commission adopted a lower rate of 1%. The Eighth and Ninth Finance Commission adopted a diluted norm and suggested that the receipts should cover at least cost of maintenance.

Criticizing the water rates in Bihar the World Bank in its reports of 1991 has said that the rates are too low and are indicative of high subsidy. They wanted that such subsidy should be discouraged. They suggested that water rates must be enough to meet at least the operation and maintenance cost.

It is a healthy sign that the Committee on Pricing of Irrigation water constituted by Planning Commission G O I under the Chairmanship of Dr. A. Vaidynathan has advocated in its report (1992) for reintroduction of financial return criterion for the irrigation projects and has recommended that recovery of operation and maintenance cost plus 1% on capital outlay should be reintroduced along with test of viability in terms of social benefits relative to social costs.

In fact for long life and efficient running of the system, conversion of each irrigation system into an independent self financing system seems to be the only answer in the long run.

Had the water rates of Sone Canals been enhanced gradually at justifiable intervals, the system could have been maintained properly and even modernized to meet the present day requirement by its own collection of rates and there would not have been an urgent need to invest a colossal amount so as to seek the help of World Bank or other such agencies for modernization of the canal system. Ironically this amount has to come ultimately from the pockets of those tax payers who are not the direct beneficiaries.

Table 4.13

Sl. No.	Class of Lease (With period of supply	Water Rates per acre irrigation from Sone Canals from 1902 onwards																																	
		1902			1904			1905			1914			31st Aug.1922			1938			25th June 1944			25th Feb.1845			26th Aug.1963			1st Aug.1963		1st July 1966		1973		3rd July 1974		17th Aug.1983	
		Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	Ps.	Rs.	Ps.	Rs.	Ps.	Rs.	Ps.	Rs.	Ps.
1.	Long term from 25th June to 25th Marth	2	8	0	3	0	0	3	0	0	3	8	0	4	8	0	4	2	0	4	8	0	4	8	0	9	0	0	10	0	15	0	20	0	30	0	-	
2.	Kharif Season 25th June to 25th October	3	8	0	4	0	0	4.	0	0	4	8	0	5	5	0	4	10	9	5	0	0	5	0	0	10	0	0	11	0	16	0	21	0	31	50	36	20
3.	Single Kharif Water	2	0	0	2	0	0	2	0	0	2	8	0	2	8	0	2	8	0	2	8	0	2	8	0	5	0	0	6	0	9	0	12	0	18	0	20	70
4.	Rabi Season 26th October to 25th March	2	0	0	2	0	0	2	8	0	2	8	0	3	8	0	3	4	0	3	4	0	3	4	0	5	0	0	6	0	9	0	12	0	18	0	20	70
5.	Hot weather 26th March to 24th June or 25th Feb. to 25th March	4	8	0	4	8	0	4	8	0	5	0	0	7	8	0	-	8	0	7	8	0	9	0	0	18	0	0	19	0	28	0	37	0	55	50	63	80
6.	Ditto single watering	2	0	0	2	0	0	2	0	0	2	8	0	2	8	0	2	8	0	2	8	0	3	0	0	6	0	0	-	0	10	0	13	0	19	50	22	40
7.	Water supplied by Volume during Kharif (for 1 cusec for 12 hours)	4	0	0	4	0	0	4	0	0	4	8	0																									
8.	Water supplied to fill Ahar between 1st November to 25th March.	1	0	0	1	0	0	1	0	0	1	2	0																									

Note : The water rates from the date of commissioning of Sone Canals till 1902 are mentioned in the text.

ASSESSMENT AND COLLECTION OF THE WATER RATE

The administration of Sone Canal was divided into two convenient portions, the first related to assessment and second to the collection of water rates. The first department was managed by the Engineering staff and the second by the Collector of the district.

The Procedure

The procedure adopted for the assessment and collection of water rate just after commissioning of Sone Canal and which later came to be popularly known as Satta system in its modified form from 1891 sequel to the rules framed by the Government under section 99 of Bengal Irrigation Act 1876 was in short as mentioned below.

Under the original section 74 of the Bengal Irrigation Act VII (B.C) of 1876, before water could be supplied to the field, a written application in the prescribed form was required to be presented by every cultivator desiring water, and no person was liable to pay any rate for water supplied to his land with the permission of the canal officer otherwise than on such application.

Applications were received, for one year leases or five year leases as the case may be, by the Engineer-in-charge of the subdivision within which the lands lay. In the case of applications for one year lease, statement of the applicant as to the name of the cultivator and the area to be irrigated was accepted. Thereafter a fresh measurement took place when the crop was ready for the purpose of ascertaining what plots had actually been irrigated. One year leases were granted for particular crops only. In the case of applications for five year leases the lands were measured before the lease was concluded. But cultivators could sow within the area any crop to his own sweet will and irrigate for a period of five years, the lands were measured only once for the entire period of lease. The year began on 25th June and terminated on the 31st March. Hot weather irrigation (April to June) was only supplied under special conditions and on separate applications made for that purpose. When a lease had been granted a permit to use water was given. The accepted application signed by at least 85% of the occupiers together with the permit signed by the authorised canal officer constituted the lease document which was a sort of agreement and was known as Satta.

As soon as permits were issued on lease applications, the sectional canal officer opened the outlets in Government distributaries to release water in the concerned village channel. He carried out the regulation of the supply of water by means of *mates*, *khalasis* and *chokidars* etc. directly subordinate to him.

In the case of lands under five year lease there was no further interference but in case of lands under annual leases a canal staff named *patrol* went round daily within their perspective beats, while irrigation was going on to see how the water was

being taken by the cultivators. They were required to enter the measurement of the irrigated fields and the date of watering in their *sudkar* or primary register of irrigation. They were also bound to report any unauthorised use of water by the cultivator who had not obtained a permit from the department. The *patrols* had to enter in their register everyday the amount of inspection done by them and their reports which they were obliged to submit weekly to the subdivisional officer.

Under the Satta system the *patrol* had to obtain the signature of the *lambardar* on the sudkar in evidence that all the fields in the irrigation blocks had been irrigated satisfactorily. The *lambardars* were appointed by the subdivisional canal officer in consultation with the applicants to represent them jointly or groupwise. The *lambardars* were expected to be fairly literate and having beneficial interest in the land to be irrigated. They used to obtain the signature of the applicants for supply of water, attend and give assistance in measuring land irrigated or to be irrigated, give timely information to the canal officer of the irrigation requirement of the lease block and completion of irrigation, receive from the canal officer and distribute the demand slips (*purchas*) to the persons named therein and performed various other coordinating types of duties for which the canal officer paid them a small percentage of the total water rate assessed as remuneration.

After the irrigation was over, measurement of irrigated area was taken by the *ameens*. At the time of measurement, the patrol was required to be present and to furnish information to the *ameens* regarding the tenants occupying the different plots within the lease. Before the introduction of Satta system, the *patwaris* used to help the *ameens* in this work. On the completion of measurement the patrol was required to take a copy of the *ameens khasra* or the field book. The *patrol* had to sign every page of the *khasra* and certify that no field entered in the sudkar have been omitted. *lambardars* had also to sign *khasra* as representative of the irrigators in acceptance of the measurements. Apart from these, signatures of at least two respectable cultivators were also taken on the *khasra* to ensure correctness as far as possible. The *ameen* had to note down in every case what crop was on the ground and what was the condition of the crop. In case of objection by the cultivators to any of the fields being included in the assessment, the *ameen* had to note these alongwith the reasons in his *khasra* and report the matter to the subdivisional officer. The *ameen's* measurement papers formed the basis of the assessment of the water rate.

Under the S.D.O worked *ziladar*, who was head of revenue section and assisted him in fair assessment of water rate. On the basis of the *khasra* submitted by the *ameens* the *ziladar* prepared the assessment list, called *khatiani* and put up to the canal subdivisional officer.

After necessary check and signature, the Canal Subdivisional Officer submitted these to the Divisional Canal Officer (Executive Engineer) who signed them and forwarded to the canal Deputy Collector for realisation of the water charges. At the same time the copies of the abstract demands or perchas were sent to the

lambardar for distribution to the lessees which was deemed to be the notice of demand of the amount due from such lessees. Anyone dissatisfied with the demand recorded against him could complain to the SDO or Divisional Canal Officer (E.E) within one month from the date of the publication of the khatiani in the village. An appeal could also be filed within 40 days to the Collector.

An officer called Overseer , also designated as Section Officer, was posted under the S.D.O to assist him in regulation and maintenance of canals and supply of water. He was also expected to report cases of unauthorised irrigation. The proper working of the system was dependent essentially on the honesty and efficiency of the patrol, ameen and patwaree etc. They were the pivot on which the entire system hinged. Without them no assessment of water rate was possible. Evidently such extensive powers in the hands of ill-paid subordinates could result in the practice of fraud on an extensive scale. And Sone Canal system reportedly suffered to a large extent due to this. But in spite of all its lapses and demerits, the system worked fairly well for more than a century till 1977-78 when it was abolished by the Government, and had also been successfully followed for assessment and collection of water rate in some of the other projects in the State.

SUBSEQUENT IMPROVEMENTS AND CHANGES IN THE CANAL SYSTEM

During operation of the project certain difficulties such as siltation of under sluices and canals, serious problems in the operation of head works and damage to anicut were encountered from time to time. They had to be rectified but necessarily at the cost of valuable time. Sometimes due to these problems the canals had to be closed even for two weeks or more at a stretch during irrigation period and in case of no rainfall in the command area it caused great inconvenience and discontent among the rate payers who were solely dependent on these canals.

The Government which was responsible for the maintenance of the canals was no doubt conscious of the problems and was keen to see the water running in the canals but for a pretty long time abstained from making vital changes which were needed to operate the system efficiently.

Some minor changes and modifications were, however, made from time to time. A few of them are mentioned below:

During the course of ten to twelve years of operation, due to the ponding effect and consequent siltation, the river bed upstream of weir got raised to the level of weir crest and hence the lower shutters (formerly there was only one shutter of 10 feet height) of head regulator (5 feet height) got buried under rolling sand which continued to find easy access into the canals. In those days a fleet of 20 to 25 dredgers used to be employed in the canals to keep its head clear of sand deposit during *Kharif* season and the average annual cost of this clearance used to be over a

lakh of rupees. The siltation sometimes assumed such a serious proportion that it was feared the works would prove to be a failure. This led to installing of steel shutters in the crest of weir walls, at first of 2 feet (sometimes in 1879-80) and later replacing them by shutters of 2.75 feet height in 1907.

In the year 1886 some of the under sluice piers were overthrown due to slenderness. They were replaced by thicker piers and the number of vents were reduced to twenty at both side sluices. Similarly reducing the number of vents to sixteen in the central sluice portion, provision of a fish ladder was made in the year 1889.

Dehri and Barun under sluice shutters were initially designed to work on wooden *needles* which were subsequently removed and wooden back shutters were provided instead.

In 1910 channel grooves were provided to head regulators for inserting kurries for regulation which continued for decades to come.

The demand of water was steadily increasing but the Main Western Canal was not able to cope up due to insufficient supply. Hence a surface supply inlet consisting of ten vents was constructed in 1895 into the Main Western Canal to augment the discharge. Ten more vents were added to it in 1896. The maximum discharge under favourable conditions through this inlet was 2000 cusec (56.6 cumecs). This provision alongwith provision of higher crest shutters was made to increase the maximum discharge of Main Western Canal to 5000 cusec (142 cumec). However, the maximum recorded discharge at the head in the M.W.C. was 4700 cusec (133 cumecs) only.

The central sluices were entirely closed in 1901-02 since they required too frequent manipulation during flood which was troublesome and dangerous as well. Also it required heavy repairs and so for the economy in maintenance it was considered wise to close them up.

The causeway in G.T. Road in the downstream of weir had influenced the design of weir – a talus with steep slope of 1 in 12 and with no downstream curtain wall at the toe. After abandoning the causeway in 1923 several breaches occurred in this portion. Through these breaches a serious retrogression of levels was taking place and fairly deep parallel channel developed at the toe of talus. These were closed with expensive wire mattresses in 1932 as per recommendation of C.B.I. These measures resulted in considerable improvement in the bed condition below weir.

The approach embankments of E.I.Railway bridge constructed 3 km downstream of diversion headworks, intruded far too inside the river and had caused a channel parallel to weir. For overcoming this difficulty a sand groyne and a leading channel were constructed on Barun side on the recommendation of C.B.I. But they

gave way in the first flood itself. A wire mattress stone groyne about 1000 feet long was then constructed which also did not serve the purpose satisfactorily.

Some serious problems had also arisen in the operation of steel shutters of weir due to their erosion by the salts in water. There was also appreciable leakage passing between and under the shutters which required frequent caulking. These gave a lot of trouble in operation.

Due to the absence of divide wall the position of approach channel on Dehri side kept shifting. Once it eroded the left bank above Dehri lock to an alarming extent and a lot of expenditure had to be incurred on protection works viz. construction of spurs etc.

Due to these problems in operation and heavy expenditure on maintenance the Chief Engineer after inspecting headworks personally in the year 1930 constituted a committee to examine the entire system and suggest ways and means for efficient operation of the system. The Committee submitted its report in January, 1931. A detailed project for remodelling the system was accordingly formulated an year after. This included replacement of scouring sluices with drop shutters, with stone lifting gates and replacement of weir crest shutters of different height with solid cement concrete crest wall, five feet thick and three feet high, and grouting the surface of downstream slope for a width of 30 feet with cement concrete. Administrative approval was accorded to this project in 1933 but Government asked Mr. Betterton to examine again its technical and economic viability and unfortunately after his adverse remarks this remodelling scheme was dropped. Mr. Betterton had not seen the problem as an insurance for continuance of existing irrigational obligations but as a profit making venture for expansion—a typical British business angle of vision.

Later a committee of Messers Hall, Came, Karim and Brown suggested several measures to combat the problems. These were mostly on the lines mentioned above and had encompassed certain modifications in the distribution system also. They had also stressed the need of telecommunication system throughout the canals for improved irrigation and flood warning etc.

These suggestions were sent to the Director, Central Irrigation Research Station, Poona, which kept on corresponding for years. But no decision could be taken. Year after year the papers got mounted up, hands got changed everywhere till the dawn of independence when the decision came in our hands. Coinciding with this, fortunately, Rihand dam was constructed in U.P. which brightened the scope of getting additional supplies from this scheme.

To take advantage of the new developments and to get rid of all those problems in operation, the authorities, whose thoughts were now guided more than anything else by the welfare of the people, ordered to examine the possibility of replacing the anicut by a new barrage. The anicut had become too old and a good

deal of creep had been marked under its shallow well foundation. The failure of Krishna anicut at Vijaywada in Andhra Pradesh due to voids in the structure also raised suspicion in the minds of Bihar engineers that Dehri anicut might give way any time resulting in complete collapse of the existing irrigation system. Subsequently electrical analog tests confirmed the presence of voids in Dehri anicut. Hence detailed investigations were carried out for construction of a new barrage to replace the old anicut and also for remodelling the existing canal system.

Based on these investigations, following changes and modifications were made in Sone Canal system.

(i) Construction of a new barrage at Indrapuri 8 K.M. upstream of old Dehri anicut in 1968.

(ii) Construction of two link canals one each on either bank in 1968 to connect the old canal system with the new barrage.

(iii) Remodelling of the old canal system.

(iv) Construction of two high level canals in 1974, taking off from two Link Canals on either flank named as Sone Western High Level Canal and Sone Eastern High Level Canal to provide irrigation to higher areas which were outside the command of old canal system.

Yet another ambitious project with an estimated cost of Rs. 1600 crores has been formulated for modernisation of Sone Canals. This scheme aims at improving the entire engineering system, mainly lining of main canals and distribution system, modifying the structures, removing all the bottlenecks and difficulties in the system to make it adaptable to meet the irrigation demand of the new high yielding varieties of crops and making the most efficient use of water by improving the water management to such a standard as is expected of a modern efficient project.

Well, one of the oldest irrigation systems can be so adapted to meet the present day need, that itself reflects its glory. The size of the works and their having stood the test of time speak volumes of the ingenuity of the engineers of the time when theories of Hydraulics were in experimental stage and Soil Mechanics was yet to take its shape.

CHAPTER V

TEUR CANAL

INTRODUCTION

Teur Canal is one of the oldest canals in North Bihar. It was constructed during the period when few people in that region had any acquaintance with canal . In fact after commissioning the canal, ironically a controversy arose whether it should be called a "canal". Because under the terms and meaning of Bengal Irrigation Act III of 1876, a "canal", natural or artificial meant for irrigation is a work, the construction, maintenance or improvement of which are financed and controlled by the Government or Government agencies. Teur Canal was originally constructed and owned by an Indian Zamindar of that area and not by the Government. Hence there was hesitation in calling it a "**Canal**".

It was the time when the Sone Canal had just made its debut in South Bihar and was yet to make its impact. Government was not in a mood to invest any further amount in other canals without watching the outcome of Sone Canals, especially the returns on the capital outlay.

The then district of Champaran in North Bihar had immense possibilities for canal irrigation. Rai Bahadur Durga Prasad Singh, the then Zamindar of Madhuban in the jurisdiction of Ghorasahan Police Station, was very conscious of irrigation and with the help of the people of that area had been maintaining a good length of *Pyne* for irrigating their land. Mr. T.F.R. Hewitt, the Collector of Champaran had very keenly been watching the activities of the people of that area in extending irrigation to their land. But since the Government was not in favour of investing any amount in such a project, Mr. Hewitt devised a plan making use of his good office to impress upon the Zamindar of Madhuban to spend for a canal taking off from Teur River. He assured the Zamindar to make available the technical know-how and assistance of the officers of Irrigation Department for the construction of the canal.

HISTORICAL BACKGROUND

Thus in the year 1876 , in pursuance of a project devised by Mr. T.F.R. Hewitt, Collector of Champaran, the Irrigation Department of the Government of Bengal undertook to construct a canal for the irrigation of land in Dooho Sooho Tuppa of the district of Champaran. The Zamindar of Madhuban , Rai Bahadur Durga Prasad Singh , undertook to pay the cost of the undertaking which was originally estimated at Rs. 57,000/- but subsequently raised to Rs. 78,546/- . The

actual expenditure incurred on the construction of the canal was Rs. 72,926 /-. Of this sum Rs. 61,997/- was contributed by the Madhuban Zamindar, Rs. 4048/- by other Zamindars who were benefited by the work and the balance Rs. 6,881/- was paid by the Government, since this was found to be extra cost partially due to the errors on the part of Government engineers.

The work was completed in the year 1879 and the first watering given in 1880 when an area of about 5,000 acres (2023 ha) were irrigated in July and 3200 acres (1295 ha) in September and October, out of total estimated irrigable area of 17,424 acres (7050 ha).

As stated above, the canal was chiefly constructed at the cost of the Madhuban zamindar whose intention, sans doubt, was to secure the crops of his own estate in the first instance and obtain a profit by the sale of water to villages outside his estate. In view of the above, the distribution of water remained in the hands of the Madhuban zamindar. But soon difficulties were foreseen in connection with his retention of the management of the canal. It was apprehended by the officials that the arrangement would lead to rack-renting and that the Zamindar could not legally collect water rates under the then Irrigation Act. In fact, as it seems, the British wanted to take possession of the canal in order to make money. These so called difficulties and apprehensions were the part of preamble of the ultimate game.

PLAN HATCHED TO TAKE OVER THE CANAL

In 1881 two alternative courses, as below, were suggested by Mr. Edger, the then Collector of Champaran for adoption by the Zamindar:

(1) To receive back his contribution and withdraw altogether from the undertaking.

(2) To undertake entire management with a full knowledge of the difficulties to be encountered and reimburse Government the sums expended on maintenance of canal.

The son of the Late Zamindar of Madhuban, Babu Bishun Prakas Narain Singh, declined to relinquish his interest in the canal constructed by his father, considering it a disgrace to do so.

In Bengal Government letter no 829 I dated 22.4.1882 the Lt. Governor approved of the canal being made over to the Zamindar if he reimbursed to the Government the cost of maintenance incurred in 1880-81 . The Zamindar agreed to take over entire management of the canal but stipulated that the Collector should recover the full sums , due from the other Zamindars, for construction and maintenance and further requested that the Irrigation Act might be made applicable to the canal.

Long before the canal was made, irrigation was effected by temporary bunds across the Teur and other rivers in that area. The Zamindar used to collect some water rate for the maintenance of the *pynes*. Now after making fresh investment in Teur Canal, the Zamindar wanted further enhancement in water-rates. In addition the Babu of Madhuban wanted that the Government should also extend cooperation in tackling the problems created by Nepalese who often bunded the Teur river in the upstream in their territory and cut off the supply of water to the Teur Canal.

But the Government of Bengal in their letter no 2089 L dated 6th Nov. 1882 to the Commissioner of Patna, stated that Lt. Governor did not consider himself in a position to recede from the offer made to the Babu and laid down that the Act III (B.C) of 1876 , could not be extended to the canal so long as it remained a private property and made it categorically clear that the Government could not interfere with the action of the Nepalese who were outside the British jurisdiction. Government also stated that the other Zamindars who contributed for the canal must be allowed to retain their interest in the canal and the Babu of Madhuban must accept all risks of future liabilities for claims in the Civil Courts etc. regarding the canal.

GOVERNMENT TAKES OVER THE CANAL

The Babu of Madhuban realized the real intention of the British Government. Sensing the trouble ,he wrote declining to take over the canal on the above terms and then on the recommendation of the Commissioner of Patna, without wasting any time, the Government took over the canal stating the compulsion that since the Zamindar did not accept the terms, it had become obligatory for the Government to do so. A notification to this effect was published in the "Calcutta Gazette " of 7th Nov. 1885 declaring the canal under the Irrigation Act.

The deed of transfer of canal to the Government was drawn by Government solicitor and was signed by the then Madhuban Zamindar Babu Bishun Prakash Narain Singh , son of Late Babu Durga Prasad Singh who really constructed the canal . The terms included that:

(1) The canal be known and recorded as the Bishun Prakash Narain Singh of Madhuban Canal, but for the sake of convenience and brevity called hereafter the Madhuban Canal.

(2) The Zamindar, his heirs would be allowed to draw canal water free of all cost to irrigate 200 bighas of his zirat land.

(3) If the canal be no longer required or maintained as canal it would be reconveyed to the Babu of Madhuban

The Babu of Madhuban solaced himself with the provisions of para (2) of the agreement and the Government stood by its commitment till 1891 . But later during his visit in that year the Lt. Governor pointed out some defects in the system of irrigation from the canal and its management . His note was forwarded to the Superintending Engineer, Sone circle who in his letter no 2323 dt. 3.6.1893 reported that 4,945 acres of *Kharif* crop, 1200 acres of poppy and 500 acres of *Rabi* crops were irrigated in 1892-93 besides 2,664 acres of hot weather crop. For the development of irrigation and future working of canal he made some suggestions which included charging a water rate @ Re 1 per annum for long leases, Rs. 2 for season leases and Re 1 for *Rabi* and poppy. He proposed to construct a distributary 6.5 miles long which would irrigate 5000 acres at a cost of Rs. 20,000/- . He had suggested to acquire the *Raj pyne* for a mile so far as the offtake of the proposed distributary to convert it into a channel suitable to discharge 100 cusecs . He had also proposed to charge the Madhuban Zamindar a sum or Rs. 500 per year or 4 annas per acre for water supplied by Government to his *pyne* sufficient to irrigate 2100 acres. For this he had argued that since the Babu of Madhuban saved the cost of maintenance of headworks he should be happy to pay the water rates .

The Lt. Governor, however, declined to order any further works in connection with the canal since the water rates realized would not be sufficient to pay even the cost of collection.

However, since then the canal remained under the full control of the Government. The Zamindar, who constructed it, lost all authority over it and was later obliged to pay for the water which he originally brought to the field with great effort and money.

DETAILS OF TEUR CANAL

River Teur

Teur is a tributary of river Burhi Gandak and is a navigable river . It has its origin in Nepal and meets river Burhi Gandak about 8 km. north of the district town of Motihari. There is not enough discharge in the river in the dry period but the monsoon discharge may touch 5000 cusec mark.

The Weir

A masonry weir had been constructed over the river Teur near Ekderi Bungalow, 25 km north of Motihari, to divert water into an earthen canal taking off from its right bank. The crest of the weir was kept 6 feet 6 inches above the floor. The weir had a tapering section having a width of 5 feet at the top and 7 feet at the floor level. It was fitted with bracket for 3 feet of boarding. The length of the weir excluding the sluices was 90 feet and that with sluices 119 feet . There were two sluices each having 10 feet opening . The weir was designed for a floor discharge of 5938 cusecs. An amount of Rs. 51,722 was then spent on the construction of this weir.

The Head Sluice

The head sluice had 5 vents of 4'x3' each to discharge in all 178 cusec (5 cumec). A tunnel escape had also been provided with a vent 3 feet wide and with an area 12.5 sq. feet.

Canal

The canal took off from the right bank of the river and was 6 miles and 1060 feet (10 km) long. It was divided into three reaches. The upper reach (first mile) was designed to carry 178 cusec of water. The width of the canal at bed level was 30 feet (9.15 m). The width was reduced to 15 feet to carry 87 cusecs in the second reach (1 to 5 miles) and 6 feet in the tail end. The depth of water was kept 4 feet throughout. A 6 feet masonry fall was provided in the second reach with a width of crest 6 feet. Eight number of wooden bridges were constructed at intervals over the canal to connect the village roads.

At the 2nd mile a *pyne* took off which ran parallel to the canal and this *pyne* fed four other *pynes* . The entire system was designed to irrigate an area or 17,000 acres (7050 ha). An expenditure of Rs. 21,204/- was incurred over the excavation of canal .

EXTENSION OF TEUR CANAL SUGGESTED BY W.A.INGLIS

Mr. W.A. Inglis the then Superintending Engineer, Sone Circle had made a proposal in his letter no 2323 dt. 3rd June 1893 to the Chief Engineer, Bengal for the extension of canal for a further length of 6.5 miles to bring another 9,840 acres under irrigation. He had argued that if even an area of only 5000 acres were catered and a water rate of Re 1 per acre was charged from the beneficiaries, this would fetch a net extra income of Rs 3000/- deducting Rs. 1000/- as maintenance cost of the distributary (@ Rs. 60 per mile) and Rs. 1000/- for assessment and collection of rates. This sum was enough to pay the interest of a capital of Rs. 75,000/- @ 4% whereas construction of extra length of distributary could have required only Rs. 20,000/-. Thus it was profitable proposition. But the Government was doubtful about the collection and so the Lt. Governor in his letter no 1357 I dt. 9th November 1894 rejected the proposal.

THE PRESENT CONDITION

The weir, the canal and the structures were damaged by the earthquake which struck the region in the year 1934, but after necessary repair the canal was again pressed into service and had been catering the irrigation needs of the area till 1973 . After the construction of Chiraiya Distributary of Ghorasahan Branch Canal

of Gandak Canal System which now encompasses the area served by Teur Canal, this canal has become redundant. Teur Canal had the glory of being the first gravity canal in North Bihar constructed by an Indian which served the area without any trouble for about a century till it became the part of a gigantic modern irrigation project viz. Gandak Project.

It was unique in other sense also. **By birth it was denied its name but by adoption it was recognised as "Canal"**

CHAPTER VI

THE KHARAGPUR IRRIGATION WORKS

INTRODUCTION

The British were reluctant to invest in any irrigation project unless they were sure of good pecuniary returns. But a good part of their character was that they prompted the landords and Zamindars to take up such works wherever found feasible, even if not economically viable as per their norms.

During the late sixties of the nineteenth century when Sone Canals were taken up for construction in Shahabad district, irrigation was much talked about in the other districts of the State also. At this time the Kharagpur estate of the Maharaja of Darbhanga in the district of Monghyr had been under the management of the Court of Wards and had the advantage of skilled European supervision. One of the most valuable results of this management was an excellent irrigation scheme which envisaged construction of an earth dam, first of its kind in Bihar , across the river Man, a small tributary of Ganga .

This scheme was planned to irrigate 26,240 *bighas* (16,400 acres) of land which was very much suitable for cultivation of fine rice. It was estimated that with the advent of irrigation the yield would increase abundantly and the cultivators would willingly pay three times the prevalent land rentals which could fetch a return of nearly eight percent on the capital outlay. In addition it was hoped that the irrigation would in future prevent those periodical losses of revenue due to failure of crops which had been occurring nearly quinquennially.

THE RIVER MAN

About two miles south of the town of Kharagpur, the river Man runs through a gorge between two steep hills. This river has its source in the perennial hot springs of Bhimbandh and is never dry. Its bed is formed of sand and shingles, more or less bound together by alluvial silt. This layer is from eight to sixteen feet thick and overlies a stratum of the stiffest clay of varying depth which is again supported on the quartzite and jasper rock which constitutes the predominant formation of the surrounding country. Just at the narrowest point of the gorge, this rock cropped out across the river bed and the British engineers took advantage of this to form a natural foundation to raise a high dam. To the south the gorge widened out into a valley, hemmed in on all sides by low but abrupt hills, an ideal configuration for a reservoir. The catchment area of the river is 36 sq. miles (92 sq. km). The maximum

rainfall recorded in the area, at that time when the scheme was contemplated was 59.42 inches (1500 mm) and the corresponding discharge observed during the same period was 11,067 cusec (314 cumec). The hydrological studies indicated that the largest discharge may be of the order of 19,278 cusec (546 cumec).

COST OF THE PROJECT

Sanction for the irrigation works was obtained from the Government for the expenditure of £24,990 (Rs 2,50,000/-) in April 1870 . Contracts were finalised immediately afterwards but little could be done till the following October. In fact in the very beginning difficulty was faced in arranging the labours. The chord line of the East Indian Railway was then in course of construction through the western parts of the district and had absorbed the greater part of the local labour supply, by offering higher rates of wages than the Kharagpur contractors were willing to pay . Situation could improve only when the engineers of Kharagpur works could get permission to allow higher rates. A good deal of work was done in the winter of 1871-72 when an amount of Rs 92,000/- was spent and it was hoped that the works could be completed by the end of 1873 . However as they progressed, it was found that the amount originally sanctioned could suffice construction of the main dam only and a large extra sum would be required for canal and appurtenant works. New estimates were drawn up and £69,257 (Rs 7,00,000 /-) was ultimately granted for the whole work. Out of this £19,493 (Rs. 2.00 lakhs) was allotted to the main dam and £ 49,764 (Rs. 5.00 Lakhs) to canals and distribution system.

THE DETAILS OF THE PROJECT

THE DAM

The dam was 81 feet (24.7 m) high, measured from the river bed. It was 27 feet wide on the top with side slope 1 in 3 . The maximum length on the top from abutment to abutment was 700 feet (213.4 m) .

The dam was composed throughout of homogeneous red clay rammed in thin layers. A central core wall was built by rubble stone masonry , 3 feet (0.91m) thick at the top and 10 feet (3m) wide at the base, spread out by footings to 26 feet (7.9 M) in the foundation which rested on the solid clay. The front of the slope of dam was protected by a layer of rubble stone about 1 feet thick.

Not many dams had been constructed at that time and the engineers involved in dam construction were afraid of the shingly bed of the river Man, as its porous nature caused fear of considerable seepage below the dam which might result in the entire destruction of the dam. To safeguard this, at first five wells of 11 feet (3.4 m) in diameter and 1.5 feet apart, were sunk in the line of the core wall, through the

shingle bed and the sub-laying clay, down to the rock. It was afterwards resolved to remove entirely the shingle bed and the following technique was adopted.

Thick teak planks, in double rows, six feet apart were driven down through the clay and filled with puddle, the whole way across the river, 13 feet from the line of the core wall on the upstream side. The intermediate shingles between the wall and the teak piles were then removed and the space filled with concrete. Another similar teak pile line was constructed in the line of the foot of the inner slope, 250 feet from the core wall, the whole of the loose materials being again cleaned out down to the solid clay and rock. A portable engine and a Gunne's pump (named after the engineer) were employed to keep the pit free of water. The whole of the work had been very neatly and well executed, the side slopes being carefully dressed and turfed, masonry drains provided for carrying off rain water from the slopes and the roads, and the whole protected by neat wire fencing.

At the time of construction in May 1875 a sudden freshet in the river carried back into the excavation some of the shingles which had been removed causing only temporary delay, no damage was done. The extra cost entailed by this little accident was only Rs. 800/-

The dam was constructed by keeping small gap in the main dam to pass the river water. Finally the gap was filled in the year 1876 when the dam started storing water.

SPILLWAY

A broad crested spillway had been provided by cutting on the south side from the rock, the greatest depth of cutting being 40 feet (12.2 m) . It was 100 feet (30.5 m) long and 340 feet (103.6m) wide on the crest. The rock was solid quartz and free from the adverse effect of water. The hill at this point sloped rapidly on both faces and there was a deep ravine on the outer side communicating with the river by which the water was carried off. The crest of the spillway was 20 feet (6.1 m) below the top of the dam and 23 feet (7m) above the sills of the outlet irrigation sluices.

THE OUTLETS

The northern outlet was cut through clay and rock. On the latter the sluices were founded. The southern outlet was through stiff clay in 30 feet (9.1m) cutting. All these sluices had a cut stone floor and rubble stone apron, extending for 200 feet (61m) . The walls were faced with cut stone and pierced in the case of northern outlet with 3 vents of 4 feet by 3 feet and in the southern outlet with 4 vents of the same size. They were fitted with iron frames and gates, worked from above by powerful screw gearing . Besides the spillway some waste sluices of similar construction had been provided in order to meet the riparian rights of down stream people.

RIPARIAN RIGHTS

Before commencement of the project an agreement was signed between the Darbhanga court of Wards and Raja Lilanand Sinha who owned the riparian land further down of the river that not more than one third of the average amount of water due to rainfall should be impounded.

As stated above , the crest of the spillway was kept 23 feet above the sills of the sluice. The average area of the reservoir in between the sills of the sluices and crest of spillway was 1.7 sq. miles (4.25 sq. km) . The capacity of the reservoir storage between the sills of the sluices and the crest of the spillway thus worked out to be nearly 1090 million cubic feet, which represented the amount of water to be impounded in one year for the purpose of irrigation. Assuming 60 inches rainfall in a year the total water available in the catchment would not be more than 4516 million cubic feet, if no loss is accounted. This implied that the sluices and the spillway together , if required, must be able to discharge 3426 million cubic feet of water. The means provided were amply sufficient to do this . There were altogether 7 sluices of 4'x 3' . When the water in the reservoir was level with the crest of the spillway, they could discharge 1890 cusec and could clear the year's surplus rainfall over the storage in 21 days . Independently of the sluices, the spillway 100 feet in length had its crest 20' below the crest of the main dam and with a head of 9.8 feet could dispose of the greatest discharge ever registered in excess of storage i.e.; 3426 million cubic feet in less that 4 days.

STORAGE FOR IRRIGATION

For irrigation purposes there was a storage of 1090 million cubic feet or 124620 cubic feet for each acre of the area to be irrigated exclusive of the local rainfall over the area. Col. Rundall had estimated that one cubic yard per hour per acre would be required for *Kharif* crops. Thus the available stored water was assumed to be sufficient for 192 days which is much more than the period required for the growth of the *agahani* rice. Thus this left an ample supply for cold weather and spring cultivation.

THE CANALS

Main canals took off from both the banks . The Northern main canal was 140 chain long and fed Shyampur Canal (130 chain), Rahmatbag Canal (180 chain) and other distributaries. The other two canals Muzafferganj Canal (275 chain) and Ramnakabad canal (132 chain) took off from the southern main canal. Later a new branch canal (190 chain) was also added to the southern system to bring more area under its command.

PRESENT STATUS

During an unprecedented flood in the river in the year 1961, the dam was overtopped and it breached on 2nd October 1961 causing large scale damage on the downstream. A new dam was constructed in its place by the Irrigation Department of Government of Bihar. Since then there has been gradual decrease in the utilization of potential due to siltation of canal and dilapidation of canal embankments. An estimate of Rs 34.17 lakh has recently been prepared for the remodelling of canal system and after the completion of this scheme it is expected that the system should be able to irrigate an area of 13000 acres in its command.

CHAPTER VII

SARAN CANALS

INTRODUCTION

Commissioning of Sone Canals in the year 1873 in south Bihar had cultivated irrigation consciousness among the masses. It had sent a message throughout Bengal Presidency to be deciphered by one and all. Irrigating the vast fertile tract of north Bihar had long been a matter of concern. Hence possibilities were being explored in every corner. At this time when the construction of the canals throughout north Bihar generally was being much discussed, the Lieutenant Governor, Sir Richard Temple after visiting the district of Saran wrote in a minute dated 30th July, 1874 as follows:

"The natural facilities for irrigation possessed by Saran district may be thus described. It is traversed throughout its whole length by channels running from north to south which have been originally connected by Gandak River, but which have in late years been separated from it either by deposits of silt or by the embankments constructed to protect the country from the inundations which formerly caused serious damages to the lands on its banks".

Saran during that period was a very big district. The entire portion of Bihar lying on the right bank of Gandak bounded by Gogra and Ganga on the south and North West Province (now U.P.) on the west was known as Saran. Chapra, Siwan and Gopalganj were the important towns in the district. For administrative control it was under Patna Division. Lieutenant Governor Sir Richard Temple in his minute had mentioned about the streams Jharhi, Daha, Gandaki, Dhanai and Ghanghari etc. which were once the spill channels of Gandak and now were scattered throughout the district from west to east in succession and flowing from north to south along the slope of the country. The first, Jharhi takes its rise in the Gorakhpur district of U.P. and passes through the western portion of Saran until it meets the river Gogra. The next, the Daha, rises within the boarders of old Saran district and passing by the town of Siwan also falls into Gogra. The others viz. Gandaki, Dhanai and Ghanghri also take their rise in the same district, the two former close to the head of Daha and the latter further below about 110 km. above the junction of the Gandak with Ganga. These three last streams join at different points of their courses and fall finally into the Gandak near its mouth.

The Civil Officers were then, all anxious to see an irrigation system introduced into the district by means of these streams and they were all sanguine as regards the benefits derivable. It was proposed to utilise them by renewing their connection with the Gandak and regulating their supply by means of sluices in the

embankment thus converting each stream as separate inundation canal. If this plan were to be adopted, there would have been a series of head works, one for each of the several rivers described above.

In course of a conference at Govindganj during the visit of Lt. Governor, some officers suggested that advantage might be taken of the construction of a weir at Batsura (in U.P.) to turn a supply for these channels into an old branch of the river which passes along the right bank from just above the site chosen for the weir and rejoins the Gandak below the head of the Jharhi and from there to make a cut behind the embankments to supply in succession each of the several streams above described, as its head is reached. This cut would have been only about 50 miles (80 km) in length, and as the greater portion of its supply would be drawn off in the first 15 miles, the cost would not have been large. The Lt. Governor Temple had shown his favour for this plan.

ORIGINAL PROJECT

In 1875 Mr. R.A. Oldham, Executive Engineer prepared plans for a scheme of inundation canals from the Gandak river, for the Saran district. Four of the spill channels from the river, the heads of which had been closed by the marginal flood embankment, were to be utilised by means of sluices. It was proposed to bring the spill channels to a regular section and to provide weirs for regulating the level of water.

The four channels were the Gandaki, Dhanai, Ghanghari and the Kutsar. The first two were to be supplied from the Roopan Chup Sota (Sota being the local term for a side or loop channel of the main stream) and the last two from the main channel lower down.

The Roopan Chup Sota, a flood channel of the Gandak was about 30 miles (48 km) long. It took off from the main stream at a point 12.5 miles (20 km) above that where a cut was proposed to connect it with the Gandaki, and 24 miles (38 km) above the corresponding cut for Dhanai. The Roopan Chup Channel had a width of 150 to 200 ft. (45 m. to 60 m.) and a slope 1 foot per mile, the same as that of the main stream. Its bed was raised at number of places due to silting and it was proposed to bring it to a desired level to serve the purpose. It was proposed to construct a weir across the Roopan Chup Sota immediately below each head channel so as to keep up the water to the requisite supply depth.

OBSERVATIONS OF CHIEF ENGINEER

On 30th November 1875 Col. Haig, Chief Engineer, Bengal while reviewing the scheme observed that there would always be a liability to a certain amount of silting requiring clearance every year. Reckoning 2 to 3 feet deposit occasionally at the head of the channel he suggested extra width to make up for this vertical contraction of the section.

Col. Haig also examined the possibility of closing the head altogether but observed that it was an impossible contingency since the main channel of the river appeared to have reached nearly the easterly limit to its oscillation. However for certainty of supply he had suggested some changes in the location of head of Gandaki and Dhanai.

With respect to the use of the drainage channels as irrigation canals Col. Haig considered that this was feasible without interfering with their function as drainage channels. He observed that if it was necessary for irrigation purpose to raise the water at certain points by dams, the bed of the *nullah* or river immediately below these points should be cut out to such a depth that when the full supply for irrigation was passing down, there should be a free outfall for the drains which must discharge at those points. If that condition was fulfilled and such additional cuts were provided as would be necessary to lead the minor natural drains to these points, there would be no objection to using the *nullah* as irrigation canals, but on the contrary they may be made even more effective as drains than before.

PROPOSAL FOR LARGER SCHEME

While the plans were still under scrutiny in April 1876, Col. Haig gave instruction for preparation of plans for a larger scheme which could cover a portion of Gorakhpur district (in U.P.) also as proposed in Sir Richard Temple's minutes. This would have entailed the construction of a weir at Batsura across the river Gandak to take the supply for Saran district. He even suggested the height of the weir as three feet above the bed level and instructed to design the Main Canal to carry a discharge of 3,000 cft/sec. with a depth of 7 ft. The Main Canal according to this plan was to be formed by the canalization of Bansinala which was proposed to be connected with the river Gandak by a cut of about a mile in length opposite to Butsura. The Gandak floods were to be excluded from this nullah by embankments at any points where they could enter, and by a masonry work across its mouth. This work was to be designed as to act as an escape outlet for the whole discharge of the main canal. From the lower end of the main canal the supply for western part of Saran channel and that for eastern part of Saran by a corresponding cut of greater length into the Gandaki. For west Saran two main supply channels were proposed to be formed by canalization of Jharhee and Daha, the latter being fed by a cut from the former. For east Saran Gandaki, Dhanai, Ghanghri and Kutsar streams were to be canalized to act as supply channels. The canal was to carry enough water for the *Kharif* and *Rabi* irrigation in the tract of Gorakhpur and Saran district of Bihar. All these above four channels were to be connected with one another and with Roopan Chup Sota as well as with the Butsura head for better control.

ANOTHER SCHEME BY MR. OLDHAM

Then in October 1876 another scheme was suggested by Mr. Oldham who proposed to draw a supply from the Gandak at Siswa without any weir across the river.

The head at which the supply was to be taken from the Gandak river was situated near the village Siswa in the Gorakhpur district about 2 miles (3 km.) north of the Saran boundary. It was originally the supply channel of the Gandaki nullah but owing to the encroachments of the river and the construction of the Gandak embankment it was separated for many years. It was proposed to excavate the channels to a depth of 4 feet below low water level, build a sluice near its mouth so as to exclude the flood water and lead the supply along the inside of the Gandak embankment, supplying Daha, Gandaki, Dhanai, Ghangri and Kutsar rivers with 780 cubic ft/sec during the dry season and 2000 cubic feet per second during the rains.

It was proposed to leave the distribution of water from the rivers to the proprietors or cultivators of lands requiring water. Mr. Martin, the then Superintending Engineer wrote *"the irrigation will become established by the cultivators damming up the nullah (river) and leading off pynes therefrom at their own expense in a similar manner to the irrigation at present practiced on the frontier hill streams in Sitamarhi and north Champaran"*.

Col. Haig supported this scheme as one *"upon the whole, better adapted to existing conditions than any other that could be brought forward"*. He was bent upon introducing irrigation in the district even on a limited scale and ascertain by actual trial the results instead of writing, disputing and discussing for a better plan.

APATHY OF GOVERNMENT OF INDIA

There, then ensued correspondence with the Government of India on the question of fund. The Government of India declined to categorise the scheme as "Extra-ordinary which would have allowed the application of loan funds but Government of Bengal pleaded strongly to classify the scheme as "Extra-ordinary" on the ground that the project would not only preserve a dense population from the consequences of the drought which then showed a tendency to recur periodically in that district but also afford a much better prospect of paying interest and working expenses than any of the scheme till then sanctioned, the estimated cost being about Rs. 6.00 lakhs and the irrigable area 1,64,000 acres which was at the rate of Rs. 4 per acre against Rs. 58 on the Sone and Rs. 40 to 50 in Midnapur and Orissa respectively. The Government of India however, were firm and categorically rejected the proposal of Bengal Government. In a letter of 17th July 1878 Col. Brownlow, secretary to the Government of India it was conveyed that as it was understood that

the Lt. Governor of Bengal intended to take the Saran irrigation scheme as Provincial work no order appeared necessary.

In the mean time the local officers had been engaged in negotiating with the Managers and Proprietors of some of the Indigo Concerns which were interested in securing a supply of water, for a guarantee of return sufficient to cover the interest of the outlay of Rs. 6.00 lakhs.

SCHEME MODIFIED

The scheme was then again modified. Col. Haig, Chief Engineer in his letter dated 20th April 1879 wrote that after careful investigation, it was found that it was impracticable to lead the Gandak water into the Jharhi as far as Sonepur from the Roopan Chup Sota head and so that part of the scheme must be dropped. Some more modifications were suggested. Incorporating the suggestions of Mr. Haig a scheme was submitted by Mr. Vertannes which consisted (i) embanking the Sota from end to end so as to completely exclude the Gandak floods, (ii) making a short cut from the head originally proposed for the canal to lead the water into the Sota (iii) damming the Sota about half way down so as to raise the water to a suitable level and (iv) making three cuts from it at proper points to conduct the water into Daha, Gandaki and Dhanai. These cuts were to be furnished with regulating sluices at their heads.

With respect to the Jharhi an inquiry made by Mr. Simon in the autumn of 1878 showed that the conditions were not favourable. The supply which could be reckoned on from the Bansi was small and as the bed of the Jharhi was higher than that of Bansi it would have entailed to deepen the former for some distance. The matter was then allowed to drop.

REVISED PLANS AND ESTIMATES

In 1879 Mr. Vertannes submitted revised plans and estimates prepared by Mr. A.O.Hughes under instructions from Major Haywood. The most important alternation was the omission of the flood banks on the left bank of the Roopan Chup Sota. The Sota therefore, remained open to the flood water. The new scheme was a compromise between the original project of Mr. Oldham in 1877 and the one revised by Mr. Vertannes in the beginning of 1878.

According to this scheme the branch of the Gandak river known locally as Roopan Chup Sota was to be kept open, and *Kharif* supply taken from it through the sluices at the heads of the different natural water courses proposed to be utilised for the irrigation of a portion of the Saran districts. For the *Rabi* supply, it was proposed to excavate the channel from Siswa on the right bank of the Gandak River in Gorakhpur districts to the Roopan Chup Sota at its junction with the Daha feeder cut near an Indigo Factory. The new channel was provided with a head sluice at

Siswa and was to be used for throwing into the Sota, sufficient supply of water taken from the main river at Siswa for the irrigation of *Rabi* crops and also occasionally for the *Kharif* crops, when the Gandak river did not rise high enough to flow into the Sota through its natural heads about two miles (3 km) below Siswa. The water courses proposed to be utilized for irrigation purposes were the same namely Daha, Gandaki, Dhanai and Ghanghari along with Kutsar. The first four were to be connected by means of artificial channel provided with necessary head sluices but the last one, the Kutsar Nala was to be supplied from the Ghanghri feeder cut by the aid of the regulator and supplementary sluice.

DEFECTS IN THE PROJECT

There were however some inherent defects in the project. For raising water level in the Sota for supplying water into the different rivers meant for irrigation, it was obligatory to construct annually an earthen cross dam across the Sota. Another negative point was that in every flood excessive siltation was anticipated in front of the head sluice and in the channel which required annual clearance at excessive cost. Mr. Vertannes pointed out these defects and suggested some measures which included construction of a permanent dam across the Sota below the head sluice of Ghanghari in order to avoid the delay in supply of water and regular expenses of constructing and removing annually an earthen cross dam. Yet another drawback was that there was no provision for distribution of watèr from these rivers to the cultivators. The water was to be lifted for application and this made it expensive.

ESTIMATE SANCTIONED

Chief Engineer, Mr. Levinge in his note did not discuss the points raised by Mr. Vertannes and sanctioned the estimate for Rs. 4,63,800/- for works only. He had however pared down the estimate by excluding the cost of maintenance which he observed to be over estimated.

EXECUTION OF THE PROJECT

The project which was eventually constructed was more or less on the lines mentioned above. Five sluices were constructed in Saran embankments. The first one at Siswa where the Sota takes off from the main river and the other sluices at the heads of Daha, Gandaki, Dhanai and Ghanghri rivers respectively. From Siswa a head cut six miles long was constructed up to the head of Daha. Similarly head cuts of 2.5 miles, 3 miles and 6 miles were constructed to connect the Sota to the heads of the river Gandaki, Dhanai and Ghanghri respectively (Appendix-VII.1).

The execution of the scheme had already been started in 1878, most works completed by 1879 and rest in the following year. The initial cost was borne by the Government on a guarantee of some fixed interest from the Indigo planters who were benefited by the scheme.

OPERATION

During the flood season the channel leading to Siswa sluice was closed with an earthen dam and water was supplied to the above four rivers through their respective sluices when the water level in Sota fell too low to feed these rivers through their own sluices, the cross dam in front of the Siswa sluice was cut and an earthen dam was made across the head of the Sota. All the water in the Sota was then forced through Siswa sluice and down the head cut to the head of Daha river. From this a portion of discharge was also returned to the Sota through the Daha sluice and forced into the other three rivers viz. Gandaki, Dhanai and Ghanghari by making cross dams in the Sota below these sluices.

The floors of the above sluices were kept at about the same level as the bed of the Sota which starting from Siswa to the head of Ghanghri were 224.6,218.92, 214.52,207.31 and 207.93 respectively. The Dhanai, Ghanghri sluices were very close to each other and one cross dam only in the Sota would force water into both of them. For this purpose the floor level of head sluice of Dhanai falling upstream, was kept slightly lower (207.31) than the floor level of Ghanghri sluice (207.93). The channel from Sota to the sluices was embanked so that by making a cross dam in them near the Sota, the flood water could be excluded from the channels. But during the rainy season these channels silted up several feet and this required regular clearance before resuming the supply of water for irrigation.

DIFFICULTIES IN OPERATION AND MAINTENANCE

The Indigo concerns had made an agreement for ten years from October, 1879 for a right to use the water for the purpose of their concerns and to sublet the water at a rate of one rupee per acre to such extent as might be required to work up to the sum guaranteed.

But after some time it was found that the water was of much less value for Indigo whether for cultivation or manufacture than had been anticipated. Distribution of water was also difficult. There were some difficulties in operation and maintenance at head also. The wordings of the agreement was not precise and differences of opinion arose with regard to the liabilities of Government and the guarantors. Owing to these reasons the scheme failed only after eleven years.

NEW AGREEMENT

The Indigo planters did not renew their guarantee after the agreed period. In September, 1890 Col. Mac. Neile, then Chief Engineer and Secretary to the Government in a letter to the Commissioner of Patna showed that for the period of ten years covered by the guarantee, which had lapsed, the annual loss to the Government on the working of Saran Canal had been Rs. 8,000/- no charge being made for the interest on Capital outlay. He suggested some terms for the operation of

canal and in the event of these terms being refused by the guarantors the Saran Canal was to be abandoned. In the above circumstances Mr. Bourdillon, the then Collector of Saran recommended the closure of the Saran canals. But at this time Mr. D.N. Reid, Manager of the Maniara Concern who had taken great pains to distribute the water of the Daha and had spent large sums of money on the work, came forward with a proposal to take up the management of the water on part of the system. This was recommended by the Superintending Engineer, Mr. C.C. Stevens. The arrangement proposed was that Government should maintain the head cut and do what was possible to provide a supply within the annual limit of Rs. 11,000/- which Mr. Reid had agreed to pay. Mr. Reid was to have the sale of water supplied and was to maintain the canals as far as he considered necessary.

The Government of Bengal approved the proposal but held it necessary to make a reference to the Government of India before making any agreement for a term of years. It does not appear, however, that the matter was referred to the Government of India. A difficulty which arose in connection with this arrangement was that under the Bengal Irrigation Act there was no authority to give to a private individual the powers of canal officer as defined in the Act. To solve this tangle Mr. Reid was appointed as Collector of water-rates.

This arrangement continued for another three years and then terminated as it did not work satisfactorily. Then it was decided by the Government to open the individual sluice on payment of adequate sum. Rules were approved by the Government in March 1894 offering terms for each canal in the system. But they remained inoperative and the sluices remained closed.

CLOSURE OF CANALS

In the autumn of 1896 (famine period) there was an urgent need of water and the Commissioner of Patna recommended the sale of water by the Government direct to the individuals. But Mr. Buckley, Superintending Engineer opposed on the ground of revenue. Mr. Bourdillon advanced the argument that in the period of scarcity the Government should be prepared to waive consideration of revenue and should look chiefly to the assistance to be given to the public. This view was accepted and water was released at a nominal cost of twelve annas (75 paise) per Saran Bigha. But the results were disappointing. Only 4,000 acres were irrigated. Actually the canal authorities were not in a condition to supply water properly. The canals had silted up and the source of supply, the Roopan Chup Sota had entirely dried up by the middle of February only.

Hence in 1898, Mr. Toogood, Superintending Engineer, recommended the closure of the canal which the Commissioner, Mr. Bourdillon concurred. Since then the sluices remained closed.

EFFORTS FOR IMPROVEMENTS

In November 1902 the Superintending Engineer was instructed to have a survey made to see if any scheme could be suggested which would make the works more efficient regarded purely as inundation canals. But there was no progress on the way of recommissioning the canal.

In 1903 Government of India attracted the attention of Lt. Governor towards the remarks of the Ist Irrigation Commission regarding Saran Canals in paras 438 - 442 Vol.II. Most important among them was that the Commission had recommended in clear terms that Government should not embark on a larger outlay in that district on the security of being recouped by water rates alone. However on 3rd Feb. 1904, Government of India asked to explore the possibility of reopening the canal.

Chief Engineer had already asked the Superintending Engineer to submit his report after proper investigation. Two separate surveys were made – one in 1902-03 to ascertain what could be done towards improving the existing Saran Canal and the other in 1904-05 to get sufficient information to prepare a project for an anicut across the river Gandak for diverting water in Saran Canals. On the basis of these the Superintending Engineer, Bengal wrote in September 1905 that the only way to improve the condition in Saran Canal was to construct an anicut across Gandak or at any rate across Roopan Chup Sota. But this also required a good amount of fund and the Government was not ready to invest the amount without any guarantee of good return.

CANAL ULTIMATELY CLOSED

Nothing could be done till 1915 and the sluices remained closed. Government then contemplated to abandon the canal entirely retaining the land and banks required for the Saran Protective Embankment only. A few number of Indigo Concerns sent signal to pay some small amount for the maintenance of canals but later they also refused to pay. The result was the closure of canal for all time to come.

POST-INDEPENDENCE EFFORTS

However, after independence, during the drought period of 1950- 51 partial revival of Saran Canal was taken up as a famine relief measure at an estimated cost of about Rs. 3 lakhs. Under this operation desilting and resectioning of Roopan Chup Sota and the head cuts were done wherever found necessary and by making an earthen bund in Hazaria Nala at Bhainsahi water could be forced into the canals and an area of 5,977 acres could be irrigated during *Kharif* in 1951. An area of nearly 1000 acres could also be irrigated during the following year. But this beginning also heralded the end.

It soon became clear that in the absence of permanent diversion structure across the source of supply water could not be assured in the canals at the desired time and Government contemplated to construct such structure for better control over the system—the idea which was mooted by Mr. Vertanees seven decades back at the time of planning the canals. He had already warned against the inherent defects in the scheme and due to those defects only ultimately the system collapsed.

After reconnoitering the area a feasible site at Chanpatti in Uttar Pradesh about 12 Km upstream of Siswa was found for the construction of a weir, no other site downstream in the boundary of Bihar could be found favourable. Detailed surveys were conducted and plans prepared but the scheme could not see the light of the day for want of agreement with U.P. Government. And now very few people know that Saran Canals started catering the irrigation needs of Saran district in North Bihar almost at the same time when Sone Canals were commissioned in South Bihar.

CHAPTER VIII

KAMLA PROJECT

INTRODUCTION

The district of Tirhut, the most easterly of the three northern districts of the then (1874) Patna Division was the largest and the most populous district under the Lieutenant Governor of Bengal. On Ist January 1875 the district was divided into two separate districts - the district of Muzaffarpur which retained the old Civil Station as its headquarter while the subdivisions of Darbhanga, Madhubani and Tajpur were formed into the new district of Darbhanga with its headquarter at Darbhanga which was also the seat of Maharaja Darbhanga.

Not only in the district of Darbhanga, wherein the river Kamla debouched after travelling a long distance in Nepal, but in the entire Tirhut there was then not a single State Irrigation work to combat the serious droughts frequently visiting the area, though the Government used to come with some doles as relief operations at the time of scarcities. Despite the immense possibilities of irrigation works in the district, Government did not undertake one because the authorities at the helm of affairs were not sure of good returns. Thus the only recourse was to have private irrigation. Irrigation was a dire necessity because most of the people depended entirely on land, and rains on which they banked for their cultivation would often fail them at the time of need.

In the year 1873-74 a severe drought hit this region after the infamous famine of 1866 and this scarcity was felt with greater severity in Tirhut than in any other part of Bengal. The people of this region craved desperately for irrigation as a measure to protect their agriculture at the time of deficient rainfall. Government ordered an investigation for a scheme from the river Kamla.

THE KAMLA RIVER

The Kamla (meaning Goddess Lakshmi who gives wealth and prosperity) is one of the two main river systems forming Adhwara group of rivers between the Gandak basin on the west and Kosi basin on the east in North Bihar; the Bagmati being the other main system of this group.

Kamla rises in the Mahabharat range of hills in Nepal at an elevation of 1200 meter (Latitude 27° 15' N and longitude 85° 57' E). During its course in Nepal the Kamla receives a number of tributaries like Chandaha, Thakur and Jiwakhola. After

passing through a gorge above Chanpat it debouches into the *terai* area of Nepal at Chisapani. After flowing for about 50 km in Nepal, the river enters Indian territory in village Bajraha near Jayanagar where there was formerly the famous temple of Shilanath, which was swept away by a change in the course of river during the mid nineteenth century. The river thereafter known as Kamla-Balan proceeds in a south easterly direction till it joins the River Kosi on the border of Darbhanga and Saharsha districts after flowing a distance of 278 km in Bihar.

As is the Hindu belief that Kamla (goddess Lakshmi) cannot remain in one house for long so the river Kamla has also been changing its course too frequently. This behaviour of river may be attributed to the heavy sediment load it carries and vulnerability of the area due to its flat slope and type of soil which is easily erodable. Its abandoned courses are scattered in the entire area. During the period of Runnel's survey (1779) it used to flow west of Jainagar and Madhubani about 3 km east of Darbhanga and ultimately joined river Kareh near village Phuhia. One hundred years later Hunter (1877) sketched Kamla flowing form Jainagar in south-west direction towards Kamtaul. Near Kamtaul it had then recently cut a new channel for itself and carried most of its water to little Bagmati leaving the old bed below Kamtaul quite dry in the hot weather. It crossed Darbhanga - Jainagar road about 3 km north of Darbhanga and the Tar Sarai road at Gorsaghat 6 km from the same place. Then winding past Bahera crossing Hathi-Singhia road at Pipra-ghat it reached low lands and joined the river Tiljuga near Tilkeshwar.

The Kamla-Balan has a total catchment area of 1063 sq. km in Nepal and 3600 sq. km in Bihar. The discharge near Jainagar where it enters Indian territory may vary from 25 cumec during summer to 3900 cumec during floods.

THE KAMLA PROJECT

In the year 1877 a scheme was drawn up by Mr. Armstrong for providing irrigation in the district of Darbhanga by taking off a canal from the river Kamla near Jainagar. The scheme envisaged construction of a main canal 12.5 miles (20 km) long with three distributaries to command an area of 460 sq. miles (1190 sq. km). The cost of the project which was carefully worked out, was estimated at Rs. 10.41 lakh and the area likely to be irrigated as 52,500 acres (21250 ha). As regards availability of water the estimate of the Chief Engineer who prepared the project was that on 15th October about 600 cusec (17 cumec) would be obtainable in the driest years and 900 cusec (25.5 cumec) in ordinary years. It was also established that the river was too large to be dammed up in Nepal at that time. Therefore, there was no reason to apprehend that the supply would ever fail short of requirements. But this scheme was not implemented because it could not then promise to yield favourable results in term of Government revenue.

KING'S CANAL

In the year 1896 there was another famine and in the wake of Government apathy to take up any protective work the cultivators began to think seriously for their own arrangement for irrigating their lands. And this time an Englishman, not the one from the lot of British rulers seeking only high returns, rather a servant of Darbhanga Raj, Mr. R.S. King, Submanager of Rahika came forward with an excellent irrigation scheme on the river Kamla on his own initiative. He did not believe in drawing the plan and brooding over. His mission was simple—saving the crop without bothering for any return on the outlay. And his estimate was also not high, because he was not obliged to pay compensation for land acquired for excavation of canals and appurtenant structures and he was not expected to provide bridges at every village road crossing. His goal was to utilize the available water in seasons of drought by temporary and comparatively inexpensive expedients adapted to the exigencies of the moment.

Under the orders of Maharaja of Darbhanga in may 1897 Mr. King spent about Rs. 10,000/- in channels and temporary small dams, diverting Kamla water to the east (west of present Kamla) into the old channels of the river, from which it could be carried by *Pynes* or village channels into adjacent rice lands. In fact, by excavating four numbers of channels in series, he had simply connected the old abandoned courses of Kamla which the river had left several years back while shifting towards west. This way by digging hardly 10 km of channels he had created a canal nearly 30 km long. It took off from the main river near Narkatia and went up to Chaparia. By constructing this canal he had saved nearly 22000 acres (8900 ha) of rice that year.

Again in May 1901 he added a fresh channel 1.5 miles (2.4 kms) long and in the scanty rains of that year he secured the rice crop of 35,200 acres (14,666 ha) situated in 42 villages. In the November following, he made a temporary dam across the river, turning its whole supply into the dry bed of the Jibach river and secured a good *Rabi* crop at an outlay of Rs. 4,000/-

All these works which were promptly executed to protect the cultivation from the vagaries of monsoon made him popular. People named the canal constructed by him as **King's Canal**.

RECOMMENDATIONS OF FIRST IRRIGATION COMMISSION (INDIA)

But as expected the King's Canal could not provide permanent solution due to its inherent limitations. At this time (1901-03) the Ist Irrigation Commission had already been constituted by the Government of India. The Commission in its report praised Mr. R.S. King for his excellent work on the river Kamla. They had recommended(para 429) that "*a detailed estimate of the Kamla scheme should be*

prepared and if the cost per acre was not greater than Rs. 25/- per acre it should be sanctioned and put in hand as soon as fund can be made available". They also endorsed the recommendations of Mr. R.S. King to locate the western channel i.e. Dhowri Distributory three miles further to the west to make it less liable to injury from floods and to command a greater area. In view of the severe distress to which these densely populated districts of North Bihar were subjected whenever there was a failure of monsoon, the Commission pleaded strongly for a protective scheme like Kamla Canal Project.

But as it seems, Government did not consider the views expressed by the Commission seriously. The scheme did not appear to be a profitable one and hence the officers raised many ifs and buts in its implementation. Some of them including the District Officials had serious doubts whether the cultivators would take the water at all and pay for it. The First Irrigation Commission was of the opinion that the cultivators would take water definitely in the years of drought—such years occurred in 1888-89, 1891-92, 1896-97 and 1901-02. The Commission during their investigation period (1900 to 1902) had observed that the people were willing to take the water. They were of the opinion that the cultivators would be certain to take water at least once every four years, if not every year. But the findings of the Commission were not enough to convince the officers at the helm of affairs. They were not sure of high returns and as such not ready to give green signal for the implementation of the project.

SIBOLD'S SCHEME

There was again a famine in the year 1906 and on the agitation of the people, fresh investigations were ordered for Kamla Canal Project. Mr. C.W. Sibold, an Executive Engineer on special duty was asked to prepare a suitable scheme. Mr. Sibold in 1907 worked out a complete project for irrigating 40,800 acres (16,500 ha.) at a cost of Rs. 15,46,434/- but himself agreed that the project was unsound as an engineering work because there was no suitable site available for head works and unsound financially also because it would cost Rs. 38/- per acre instead of Rs. 25/- per acre, the limit fixed by the Irrigation Commission. Ironically, neither the Maharaja of Darbhanga who owned most of the command area nor the Civil Officers in charge were in favour of the project as per the note of the Chief Engineer.

SUGGESTION OF CHIEF ENGINEER

In July 1913 Mr. C.A. White, the then Chief Engineer wrote to the Chief Secretary that neither by Bagmati nor by Kamla could the British lands be properly commanded unless the weirs were built within Nepal territory. He further stressed that weirs were necessary in both the cases and extensive protective works were also required for satisfactory functioning. If these were incorporated in the project that might raise the initial cost of the Kamla project to the tune of Rs. 30 lakhs. However

an area of 60,000 acres (24,300 ha.) in Nepal and 40,000 acres (16,200 ha.) in Bihar could be irrigated by Kamla Project thus bringing down the cost per acre as Rs. 30/-. He had requested the Chief Secretary to take up the matter at highest level to explore the possibility of constructing the headworks in the upper reach of Kamla in Nepal.

VIEWS OF NEPAL DARBAR

Col. Showers on behalf of the British Government asked Lt. Col. J. Manners Smith, the Resident, Nepal Residency to ascertain the views of Nepal Darbar (Government of Nepal) regarding the scheme. The resident in his letter dt. 24th Nov. 1913 communicated that Nepal Darbar did not show any interest in the Kamla Project, however, they could give green signal to such a project on Bagmati. So the scheme was eventually dropped.

Thus the Kamla project which was conceived as early as in the year 1873 could not see the light of the day till the British ruled this country.

SUBSEQUENT DEVELOPMENTS

After the Independence our own popular Government took up the matter afresh and in 1950 a 10 feet (3.05) wide canal was dug along the old alignment of King's canal which had by then become defunct. But as the main feeder of the canal i.e. the Bachhraj Dhar did not have a perennial source of adequate water supply to the canal so after rainy season the canal became useless. To overcome this difficulty in the year 1957 an inundation canal taking off from the Kamla river north of Jainagar and to join the newly excavated Kamla Canal near Narkatiya bypassing the Bachhraj Dhar was contemplated. This scheme which was planned to irrigate an area of 15000 ha. was completed in the year 1958 at an estimated cost of Rs. 28 lakhs. But on completion, it could not irrigate even ten percent of the area. Thus this inundation canal also could not serve the purpose. This was partly due to absence of control structure in the river and partly due to shifting of course of the river, resulting in an inadequate supply of water in the inundation canal due to huge deposit of silt at the mouth of main canal.

Taking lessons from these failures, finally in the year 1964, "Kamla Canal Extension Scheme" was sanctioned by the Government of Bihar which was an ambitious scheme and envisaged construction of a diversion weir across river Kamla near Jayanagar at a cost of Rs. 27.45 lakhs and linking the previously constructed canals to the weir by providing head regulator and extending the canal system to serve some additional area. The estimates were subsequently revised and ultimately

the weir was constructed in the year 1970 at a cost of Rs. 64 lakhs and the Eastern and Western Canal System in the year 1975-76 with an expenditure of Rs. 145.7 lakh. They were designed to provide irrigation benefits in a gross command area of 66.529 ha. The details of this project already implemented and the Modernisation of Kamla Irrigation Project (1981) would be discussed in the second part of the history describing the projects of post-plan period.

CHAPTER IX

TRIBENI CANAL

INTRODUCTION

The idea of providing irrigation in North Bihar by taking off a canal from the river Gandak was mooted out as far back as 1871. It was intended to irrigate land in the then district of Champaran which formed the extreme north western portion of the State and was situated between lattitudes 26° 16' and 27° 30'N, and longitudes 83° 55' and 85° 21' E. The district covered an area of 3531 sq. miles (9,145 sq. km) and as ascertained by the Census of 1872 it contained a population of 14,40,815 souls.

The district of Champaran was at that time bounded on the north by Nepal, on the east by the district of Tirhut with which the Bagmati river formed a natural boundary for about 35 miles, on the south by Tirhut and Saran district; on the west by the district of Gorakhpur in the North West Province (now U.P.) and Raj Botwal of Nepal, the Gandak river forming a natural boundary from Sattar ghat to Tribeni.

The soil of this region is very fertile and even without irrigation under rainfed condition people of the area were growing paddy, wheat, barley, sugarcane, arhar, maize, kodo, sama, tobacco, and indigo. Without irrigation, however, the yield was poor. In stray patches of land irrigation was carried on from some tanks and wells and by damming up some hill streams. But no consolidated efforts were made for irrigation of land on large scale in scientific manner. There were no canals, and tanks were also scarce.

In natural capabilities, Champaran was richer than the adjoining districts but the general economic condition of the people was not good. If they did not starve, they did not flourish even. The economy was mostly dependent on the agricultural produce which in turn depended on monsoon only.

NECESSITY OF IRRIGATION

The average annual rainfall in the area is of the order of 1270 mm but its annual variation is significant, the extreme being 2017 mm (maximum) and 696 mm (minimum). A study of rainfall pattern reveals that it remains deficient once in every four years. Often the rains fail in the period when they are needed most viz. for sowing and transplantation of paddy or at the time of maturity of crops.

This deceptive behaviour of monsoon was more felt in the past when there was little irrigation facility. Sometimes for two consecutive years the rains failed in such a manner as to cause a general destruction of the crops. The most notable instance was in 1865-66 when there was total failure of the local rainfall. A cheap system of irrigation from the hill nalas was rendered very difficult, if not impossible, by the fact that the Nepalis used the same streams at a higher level for irrigating their own fields. At this critical juncture water became the most precious thing and so the Nepalis would not like to share the hill nala water with the Champaran people at all. No rain for two years and no means of irrigation. The result was disastrous – a severe famine in 1866 which took a toll of 56,000 lives (6 percent on an estimated affected population of 8,50,000). The effect of famine and scarcity was most severe in the north and north eastern parts along the Nepal *terai* area where the principal crop of rice had entirely failed. The district was rendered entirely dependent on external supply. The prices of food grains had sky rocketed – three times the rate they were selling at the beginning of the same year. There was no demand for labour. Distress increased rapidly and grain robberies and incendiary fires became alarmingly common. Government took relief measures belatedly still the total number of deaths was over half a lakh people.

It was all due to destruction of crops caused by utter failure of rain. This disaster gave severe jolt and the Government was compelled to find a permanent solution to face such situation in future effectively. After required investigations a blue print for a system of irrigation – canal in the north of Champaran district was prepared in the year 1871. But some technical difficulties were anticipated in the scheme, especially in traversing the canal over numerous rivers and torrents descending from the hills of Nepal. The available technology at that time was not so efficient to tackle the problem effectively. High cost involved was also a deterrent in the implementation of the project. Hence, inspite of the desire to do something positive, the authorities could not muster as much courage to take up this work due to the said engineering difficulties.

But the nature was not going to extend any concession on its part. In the year 1874, owing to the scarcity and badly distributed rainfall, there was another famine which prompted the engineers to formulate a scheme to take off a canal from Gandak at Tribeni Ghat. The Scheme was submitted to the Government for approval. Discussions went on. But even after long deliberations Government was not inclined to sanction the project. The reason was simple and clearly spelt out—the project did not promise good returns.

Government was dilly dallying but monsoon continued its vagaries, often playing truant for the most needed period. Failure of rains became rather frequent. Famines came one after another, severest in the chain was in 1896, when whole of Bengal (comprising Bihar & Orissa) fell in its cruel clutch. Lakhs of people were its victim. This was enough a dose for the Government to give a serious thought once again towards providing big irrigation canals in North Bihar.

By this time the developments in the field of engineering construction and successful operation of Sone Canal System had generated enough confidence among the engineers to accept this challenge. Sensing the need and urgency of the situation Government deputed Mr. J.H.Toogood, Executive Engineer, immediately after the famine in 1896 to report on the feasibility of constructing a canal in this region. Mr. Toogood submitted his favourable report for taking off an inundation canal from the river Gandak and then the Government gave green signal for the preparation of detailed maps and estimate after creating a new Division for this purpose named as Champaran Canal Survey Division with headquarter at Motihari.

THE RIVER GANDAK

The Gandak River System bounded by the Dhaulagiri peak on the west and Manna and Rasuagarhi peaks on the east has a catchment area of 4188 sq. km in Bihar, 570 sq. km in U.P and 36040 sq. km in Nepal of which about one sixth is above the Himalayan snow- line. This snow-fed perennial river has a minimum discharge of about 283 cumec (10,000 cusec) in the month of April and a peak discharge of 19,822 cumec (7,00,000 cusec) during the flood season. Known as " **Sapt Gandaki**" in Nepal and **"Naraiyani"** or "Gandak" in India, the river passing through the hills and thick forests, debouches into the plains at a place called Tribeni (meaning confluence of three rivers) which derives its name from the fact that two other tributaries, namely Panchnad and Sonaha join the river Gandak there. A few kilometers downstream is the place Bhainsalotan where as per the plan of Mr. Toogood a canal was to take off from the left bank of river Gandak for irrigating the land of Champaran. The proximity of confluence suggested the name of canal as "Tribeni Canal". It is said that near this confluence once lived the famous sage Valmiki, the writer of great Hindu epic *Ramayan*, under whose *ashram* (hermitage) Sita got shelter when she was exiled by her husband Rama, the king of Ayodhya. Bhainsalotan which takes it name from the very large number of bisons inhabiting in its forest has now been renamed as Valmikinagar after the name of sage Valmiki.

From Tribeni, the course of river Gandak up to its confluence with Ganga opposite Patna is 277 km. (173 miles) of which about 19 km, (12 miles) of right bank touches Nepal. Near the 128th Km, the river flows out entirely through the territory of Bihar (the then north western part of Bengal) and finally drains into the river Ganga near Hajipur opposite Patna, the capital of Bihar. This place Hajipur on the left bank of the river Gandak is famous for the battle of *Gaj* (Elephant) and *Grah* (Crocodile) at *Konhara ghat* mentioned in the Hindu mythology and is considered as a sacred place.

TRIBENI CANAL PROJECT

Low Cost

Work on the Tribeni Canal Project was started as a measure of famine relief in 1897 when about one-third of the earth work was executed. Two years later the Bengal Government submitted an estimate, amounting to Rs. 37,91,789/- and received the sanction of the Secretary of State, India in 1901. It was estimated that ten years after completion, the canal would yield a net revenue of Rs. 1,88,500/- equivalent to a return of 5 per cent on the total capital outlay. The project thus promised to yield such favourable results as almost to justify its execution as a productive work. It was, however, decided to treat it as an unusually favourable work of the protective class.

It is strange to note that the project which was not considered to be a productive one in 1875 promised to yield good returns in 1901 when the cost of materials and labour had considerably increased. The answer could be traced in the note dated the 5th April 1911 of Sir John Benton, Inspector General of Irrigation, on Tribeni Canal. After the failure of a number of structures he had observed that the design was not in accordance with safe and sound practice in canal construction. Explaining why the departures were made on the unsafe side he remarked -

(I) The Tribeni Canal was found to be a costly work with rather poor revenue prospects. The estimate of cost was not liberal, and to make it such would probably have barred sanction.

(ii) With unexpected difficulties to face the officer charged with execution kept all designs down to the minimum which appeared to him to be safe. This system of rigid economy resulted in the ordinary margins of safety not being allowed and in assumptions being made which further experience would have shown to be unsafe.

(iii) When the original estimate was prepared the Bengal Irrigation officers had not the advantage of past experience in the preparation of project estimated for large canals, nor had any of them been engaged on the execution of important works for nearly quarter of a century.

Diversion Structure Avoided

Work of this size must have necessitated construction of weir type structure in the river bed to divert water into the canal as was the practice even in those days in the eastern part of Bengal and in Punjab but in case of Tribeni Canal no such arrangement was provided to head up the river water and divert it. It was planned and constructed like inundation canal fed by the rise of water level in the river and

its Head Regulator was located at about 700 meter (2300 ft) upstream of the present Gandak Barrage through which required discharge was regulated to pass directly from the river Gandak. The construction of weir type structure was definitely avoided by the planners to bring the cost of the project down within attractive limit.

Dispute Over Site of Head Regulator

The site selected for the canal offtake was described by the then canal authorities as an "excellent one" an opinion that even the then Inspector General of Irrigation relying on the very limited data available at that time had endorsed. But during the construction period itself the river Gandak showed signs of shoaling up in front of the head regulator and it was felt that unless some proper measures were taken the shoaling up of the river bed might render it imperative to change the position of the head regulator at great expense. Mr. L.M.Jacob, Secretary to the Government of India, Public Works Department later in his letter dated 29th September 1908 addressed to the Secretary to the Government of Bengal, Irrigation Department had regretted in view of the consideration, that what had happened could have been foreseen, had observation data been systematically collected from the start. He made reference to the third paragraph of the note dated 29th February 1908 of the Executive Engineer in which he had stated that deep water existed in 1902 at the offtake site and that the record flood of 1903 caused the shingle deposit and that in his opinion the shoaling was likely to increase. The Chief Engineer, however, in his note of 22nd June 1908 recorded that the shoal had not much altered since 1903. In 1904, when the Local Government recommended sanction to a revised estimate for about Rs. 51 lakhs, the great shoal blocking the canal supply undoubtedly existed, but no reference was made to the possibility that the canal head might from this cause become inoperative without the adoption of some special measures involving heavy expenditure, nor was any provision made for expenditure on that account.

In fact the left bank channel on which reliance was placed was apparently a dying one; it was said that it had been the same for the last twenty years, but more complete information would have probably given reasons for doubting this conclusion. However, the river had deserted the site necessitating recourse to some training works to feed the canal. A lot of discussions went on for the remedial measures to be adopted. The Executive Engineer, the Superintending Engineer and the Chief Engineer all differed in opinion. Finally on the advice of Mr. J. Benton, Inspector General of Irrigation a wire sausage divide of about 640m (2100 ft) length was put up about 180m(600 feet) away from the Head Regulator to obviate shingles being swept into the river channel along the left bank which fed the canal. Later on regular feeding channel 160 feet (48.8m) wide was excavated connecting the main river with the canal head. This worked well and subsequently the wire sausage divide was extended further upstream for a length of 762 m (2500 feet) from the canal offtake while sloping it in towards the left bank of the river. In the year 1911 it was again extended further 750 feet (228m) upstream and 200 feet (61m) downstream as directed by Mr. T. Butler, Chief Engineer. The wire sausage was formed of 4 B.W.G.

Galvaniz8ed wire, woven on the spot to 4" mesh bent into a trapezoidal section, 4 feet at top and with a slope 1:1 and filled with boulders from the river bed.

It was however felt that the ideal site of the Head Regulator would have been 490m (1600 feet) further upstream of the selected offtake site since the set of river afforded promise of the deep stream continuing to hug the left bank as far as up to that point (Inspection note of Mr. J.Benton, Inspector General of Irrigation dated 23rd March 1907).

EXECUTION OF THE PROJECT

The Tribeni canal, offtaking from left bank of Gandak was aligned in an easterly direction on a falling contour across numerous rivers and drainage channels having their origin on the southern slopes of the Himalayas. The length of the canal in the original project was kept 61 miles (97.6 KM) up to Thetharia river.

As stated in the preceding pages in 1896-97 there was severe famine in Champaran and due to pressing need the canal was hurriedly aligned in order that excavation of the channel might be utilized as a famine relief work. About one-third of the work on the Main Canal was executed in 1897 but no part of the channel was fully completed. The work progressed in the difficult terrain with slow paces.

The work on the Head Regulator was commenced in the year 1905 and completed in the year 1907.

The first 30 miles of the canal having been completed water was admitted through the head sluice for the first time at 8'O clock on 7th June 1909 (See copy of the telegram, Appendices-IX.1 and IX.2). The irrigation started formally in 1910 but the project was finally completed in the year 1914 with 61.25 miles (98 km) of main canal 185 miles (298 km) of distributaries and 6 syphons, 18 aqueducts, 8 L.D. syphons and 18 road bridges.

The alignment of the main canal was taken along suitable contour to command as much area as possible. The project envisaged to command on area of about 427 sq. miles (1100 sq. km) or 2.73 lakh acres approximately in the then Champaran district. The channel of the canal was designed to carry 1708 cusec(48.4 cumec) which was supposed to be sufficient to irrigate 200 acres of rice per sq. mile in the command area. The chief masonry works were proposed to be designed to pass a further discharge of 468 cusec (13.3 cumec) on the supposition that the canal might be extended in future to command an area of 117 sq. miles beyond the 61st mile up to the Telari river. The First Indian Irrigation Commission of 1901-03 had recommended in paragraph 420 of their report that the canal should be extended up to the Telari river and in the letter No. 1459 dated the 4th December 1902, from the Secretary, Indian Irrigation Commission, to the Secretary to the Government of India, Revenue and Agriculture department, it was suggested that the canal should be

made large enough to carry a supply for the irrigation of the land between the Telari and Bakea rivers. This required a further supply of 550 cusec (15.6 cumec). Hence the structures in the canal were finally designed for a discharge of 2726 cusec (77.2 cumec). Sufficient berms were allowed in the canal for future expansion.

Advantage of these provisions was afterwards taken in the extension of the Tribeni Canal and the section of the canal was later widened to take a discharge of 2725 cusec. Incorporating all these works, the total cost of the project rose to Rs. 75.27,302.00 (2nd revised estimate sanctioned on 5th January 1912).

BREACHES IN THE CANAL

The canal has been working satisfactorily since its construction. Major damages however, took place in the years 1928,1954 and 1955.

In the year 1928, due to unprecedented excessive rain, intensity being 635 mm (25") of rainfall in 24 hours in the area, as many as 32 breaches were caused in the canal necessitating about 33 lakh cft of earth work and later construction of an extra syphon in 47th mile (75th km) of canal in the year 1930.

In the year 1954, the river Gandak reached maximum H.F.L. of 368.4 on 28th July and the hilly torrents crossing Tribeni Canal also rose simultaneously in spate breaching the canal at 18 places. They were however filled up quickly and canal allowed to run. Subsequently in the month of October (1954) the left wall of Majhawa aqueduct in its 18th mile collapsed. This was a crucial period from the point of view of irrigation but by putting gunny bags the canal was allowed to run and irrigation carried on. In the month of March 1955 the damaged left wall was reconstructed.

Similarly in the year 1955 also, the canal breached at 9 places due to heavy rains and another aqueduct at Sikti in 30th mile collapsed. These were set right and irrigation was carried on with least interruption.

EXPANSION OF TRIBENI CANAL

After the 2nd World war, acute shortage of food necessitated the State (Bihar) to devise ways and means for improving food position. Some short range schemes were taken up in order to give some relief immediately. Under this programme Tribeni Canal Expansion scheme was also taken up at an estimated cost of Rs. 29.77 lakh in June 1950 for giving an additional benefit to about 11330 ha. (28,000 acres) of land. Under this scheme the main canal was desilted in about 78 km length, a number of spill vents were added to some of the syphons and a number of distributaries extended and new distributary Khuti Musan was constructed.

Desilting of the main canal was taken up in December 1950 and completed by middle of April 1951 involving 444 lakh cubicfeet (12.57 lakh cubic meter) of earth work. The leading channel had also badly silted up which necessitated removal of about 4 lakh cubicfeet of boulders.

EXTENSION OF CANAL

A scheme for extension of the main Tribeni Canal was also taken up in 1954 at an estimated cost of Rs. 112.9 lakh. In this 2nd phase of construction which was completed in 1957 the Tribeni Canal was extended further 51.2 km up to river Pasaha. After this extension the Gross Command Area of the canal finally increased to 3.76 lakh acres (1.52 lakh ha), bounded by river Sikarahana on south and south west, the canal itself on north and north west and river Pasaha on east.

During its operation the maximum annual irrigation figures achieved are -

Kharif crop	1,70,000 Acres (68,800 ha)
Rabi crop	40,000 Acres (16,190 ha)
Hot weather crop	40,000 Acres (16,190 ha)

HEAD REGULATOR ABANDONED

Tribeni Canal system ultimately merged in the distribution system of Gandak Project which started to function in the year 1968 after completion of Gandak Barrage at Valmikinagar (Bhainsalotan) across river Gandak. Tribeni Canal became one of the branches of Tirhut Main Canal (Left Main Canal) with which it was linked at its 9.5 R.D. through a link canal, 850m long in the year 1968-69 and the Head Regulator of Tribeni Canal constructed in the first phase (1905-07) was finally abandoned.

The old Head Regulator of Tribeni Canal is now closed but water still flows in the Canal and tells the story of extraordinary feat of its planners.

SUBSEQUENT DEVELOPMENTS

Due to various reasons, the irrigation figures of Tribeni Canal gradually started diminishing. A good number of natural drainages coming from the *terai* area cross the canal and they being flashy in nature and having comparatively steep slope, attack the left bank of canal at their sweet will. Unfortunately the waterway provided for these natural drainages were not sufficient and the specification adopted

at the time of construction of canal especially in the first phase from 0 to 99 K.M. were not adequate from the point of view of present day know how. As stated earlier the factors of safety adopted were in narrow margin. As a result the left bank of canal often breached allowing flood water to enter into the canal. The structures made in lime mortar. as was the practice during those days, did not sustain the flood bravely. They had become old also and in their aging process some of them started collapsing. All these combined together started telling upon the efficiency of the canal and it started deteriorating as the days passed by. The canal system did not work properly and its operation became gradually difficult. In most of the distribution system irrigation suffered for want of water at the time of peak demand.

REMODELLING AND MODERNISATION OF CANAL

In order to improve the functioning of canal and to further increase its irrigation potential by 40,000 acres (16,188 ha) a scheme for Remodelling and Modernisation of Tribeni Canal was prepared in late seventies. The scheme was sanctioned and the execution of the modernisation project was started in the year 1980-81 but had to be closed in March 1985 with the closure of Gandak Phase-I. During this period nearly 60 percent remodelling and modernisation could be completed and rest remained incomplete. So the purpose with which the scheme was started could not be fulfilled. Meanwhile an unprecedented flood in the year 1986 washed away Korena aqueduct at R.D. 293,85 of Tribeni Canal and badly damaged many other structures affecting the canal system. Due to the collapse of Korena aqueduct the system below 293 R.D. became defunct and this reduced the irrigation potential of the system by nearly 1 lakh acres (40,470 ha). The structure was, however, repaired in the year 1993 and irrigation was restored. To complete the remaining works of Remodelling and Modernisation of Tribeni Canal would require an amount of 62 crores as per the estimate submitted in the year 1990 for approval of the Government.

These hurdles would continue to come and would be tackled also. Tribeni Canal has the glory of successfully irrigating a vast stretch of land in North Bihar for the last one century and it would continue to do so for many more decades to come.

CHAPTER X

DHAKA CANAL

INTRODUCTION

Almost simultaneously with Triveni Canal and due to the same compelling reasons the project for Dhaka Canal was drawn up to irrigate another area in the district of Champaran, not far away from the Command of Triveni Canal. But it was comparatively much smaller project.

The famine of 1896-97 suggested the necessity of this canal. Mr.Buckley, Superintending Engineering, Gandak Circle, Muzaffarpur forwarded a report to the Government with a proposal to take out a canal from the river Lalbakeya, a tributary of Bagmati river.

During 1897 a Project was prepared by Mr. Butler, Executive Engineer on the lines of Mr. Buckley's report. The work was commenced in anticipation of the sanction of the detailed estimated, to afford relief to the famine stricken people and in this process nearly 45,00,000 cubic feet of earth work was completed chiefly in the first 8 miles of the Seeraha Branch of Dhaka Canal.

THE RIVER LALBAKEYA

The river Lalbakeya emerges out of the inner valley of Nepal hills and after entering India it flows north to south for nearly 22.5 km in the plains of Bihar before finally meeting the river Bagmati river near village Khoripaker. It is a hill stream type river, rises quickly after heavy rain but goes practically dry during summer. The runoff during October has been observed to be around 300 cusec in a normal year. The discharge available during *Rabi* period varies between 50 to 100 cusec. Its right bank is fairly high land and there is a marginal bank all along its length in the Indian territory but the left bank frequently spills over when the river is in high spate. The maximum discharge anticipated is of the order of 45,000 cusec (1275 cumec).

THE ORIGINAL PROJECT

Mr. Butler's original Project was contemplated to irrigate 15,000 acres under *Kharif* and 5,000 acres under *Rabi* on the supposition that a minimum 300 cusec of water would be available during October.

The cost of the Project was estimated at Rs. 3,45,734/-. The system was to consist of an anicut across the river Lalbakeya and a Main Canal, 3.25 miles (5.2 km.) long with two Branch Canals—Seeraha Branch 13.75 miles (22 km) long to cater 40 sq. miles and Patahi Branch 13.33 miles (21.3 km) long to irrigate 30 sq. miles.

This project was criticised favourably by the civil department but on 20th October, 1899, Mr. Green, Executive Engineer found that supply of the Lalbakeya had run down to 80 cusec instead of 300 cusec as assumed by Butler. Accordingly the project was returned for revision on 20th Nov. 1899.

REVISED PROJECT

Mr. Butler submitted to the Superintending Engineer on 8th March, 1900, a revised report and estimate amounting to Rs. 2,60,241/- assuming an average October supply of 170 cusec. The area to be irrigated was reduced from 15,000 acres to 8,500 acres under *Kharif* while the area under *Rabi* irrigation was kept the same as 5,000 acres. However the section and masonary of the canal were designed to take 300 cusec at the head so that the canal could be extended, if subsequently more water could be obtained from the Bagmati river or elsewhere. Seeraha and Patahi Branches were both stopped at their eleventh mile stones. This estimate was modified by the Chief Engineer and increased to Rs. 2,93,145/-. It was sanctioned by the Government of India (No. 32 C.W.I) on 9th January 1901.

EXECUTION OF WORK

The work was recommenced on the canal in March 1901, the Champaran Division being formed in February, 1901 to carry on this work and the Triveni Canal together.

By the end of working season of 1904 the entire earth work of Main Canal and the two Branch Canals along with Raghopur distributary had already been completed and that of other nine distributaries was in progress. All masonary works of the Head works, Main Canals and two Branch Canals except fitting shutters on the Lalbakeya anicut and the cross drainage syphons under the Main Canal on the 3rd mile were also completed.

PROBLEMS

Some problems were encountered while Lalbakeya's anicut was under execution. It was considerably damaged by floods of 1902. The weir wall had only been finished to a height of 2'6" instead of 3 feet and the masonary was green when the flood came. The work was made good but next year (1903) again the flood recurred and caused immense destruction.

So it was thought wise to cut down the weir to the river bed level and place shutters on this floor only. But due to these extra works the cost of the Project increased considerably and this necessitated revision of estimate. Mr. C.A. White, the then Superintending Engineer, Gandak Circle, submitted a revised estimate amounting to Rs. 6,09,191/- for approval on 27th October 1904 which was sanctioned by Government of India (vide no. 664 I) on 20th May, 1905.

The river had to be cross bunded to carry out the repairs to the anicut, so the water available in the river was diverted into the canals and distributed free for the irrigation of sugarcane, indigo and china etc. The water was much appreciated and the demand was far in excess of the supply.

OPENING OF CANAL

The canal was opened on 16th March, 1904 and the average discharge observed at the head were 18.2 cusec, 14.5 cusec and 33.5 cusec during the month of March, April and May, 1904 respectively.

WATER WELCOMED

The water had created great enthusiasm among the cultivators and it was clear to the officials that on completion of the contemplated canal system the demand of canal water would increase . While the demand for water for indigo was to remain constant the same for surgarcane irrigation etc. was expected to increase considerably. There was not enough water in the river during the lean months and the only method of overcoming the difficulty of meeting the demand was to obtain a supplementary supply from other source such as the Bagmati river or to introduce system of filling tanks and conserving the supply for use during the months of April and May. This could be done in the month of January and February before the supply ran down. No specific decision could be taken in this regard but provision in the canal was made to carry extra discharge available from other sources in future

Water rates were collected on the pattern of Sone Canals. But till 1904 the water was supplied gratuitously.

EXISTING PROJECT

The weir constructed across the river Lalbakeya at Goabari (26°43' North, 85°12' East) in Dhaka Police station, to divert water into the canal is 248 ft. (76.6 m). It can withstand a discharge of 45,000 cusec (1275 cumec).It has 12 vents of 16 ft. (4.87 m) each and an escape vent of 5' (1.52 m). Shutters are provided to close these vents in order to hoard up water for supplying the same to the canal. The canal head regulator consists of 5 numbers of vents of 5' x 4' -6" each with chain and pulley system.

The main Dhaka Canal 25 feet (7.62 m) wide runs for a length of 5.2 km (3.25 miles). For the tail end two branches viz. Patahi and Seeraha 21 km each takes off to distribute the water in an area of 18,130 ha. (44,800 acres) or 70 sq. miles. The system was planned to irrigate 6070 ha. (15,000 acres) under *Kharif* and 2025 ha. (5,000 acres) under *Rabi* period. Obviously there is no Hot Weather irrigation because at that time there is little water in river. The entire work was completed in the year 1908 with an actual expenditure of Rs. 6 lakhs.

NEED FOR MODERNISATION

There is now considerable increase in demand of water in the area with the advent of new varieties of crops and this old system is not able to cope with this increased demand. Most of the structures of the canal system were damaged during the 1934 earthquake and so the canal is now not able to carry even as much water for which is was designed. Hence it has now been contemplated to modernize the entire system including replacement of the old weir with a modern barrage, provision of new Head Regulator with silt excluding device and extension and lining of Canal. The proposed remodelling project is aimed at increasing the overall efficiency of the canal system as well as to increase the irrigation potential from the present 12,696 ha. (70% of 18,130 ha., G.C.A) to 18,633 hectare. This has become easier as it has been decided to augment the discharge of Dhaka Canal by diverting 125 cusec (3.25 cumec) from Ghorasahan Branch Canal of Gandak Canal System to meet the increased demand in the command of Dhaka Canal. One can to-day only appreciate the foresight of the original designers who a century back kept provision for extra discharge into the Dhaka Canal expecting diversion from other sources.

CHAPTER XI

SMALL IRRIGATION SCHEMES IN CHOTANAGPUR

INTRODUCTION

Chotanagpur is of a totally different character from that of Bihar plains. Geologically it is of gneiss formation and consists of broken hilly country. The annual rainfall of Chotanagpur generally exceeds 1270 mm and even in the driest year it is not less than 900 mm. Failure of crops, therefore, can hardly be attributed to want of rainfall, but to its not falling at the required time, as in other parts of the State. In this undulating tract, with its copious rainfall, naturally there must be numerous small streams, the waters of which could be dammed and diverted into tanks and utilized to save the crops at critical time. There were many thousand *ahars* and *bundhs* as mentioned in chapter-III but they were neither scientifically laid out nor properly maintained. Till the end of nineteenth century there was not a single irrigation project constructed by the Government. The real difficulty connected with the construction of protective work by the State was that Government was not able to secure any return on its expenditure in the form of an occupiers' rate, as was levied on large irrigation schemes.

The matter was investigated for the first time by Captain Smith in the year 1869 who opined that it was not desirable to attempt any large irrigation projects in that area but small schemes might be undertaken with advantage in selected localities. The small area of land under cultivation was looked on as an insuperable objection to a large scheme.

In 1874, Mr. Stoney, Executive Engineer made reconnaissance of the area and suggested three small irrigation schemes. In June 1876 the Board of Revenue gave green signal for detailed investigation and preparation of estimates for the above schemes and also others if found feasible.

In the year 1877 Major J.M.Heywood, Superintending Engineer, Sone Circle forwarded (vide his letter No. 2017 dt. 16th June 1877) to the Chief Engineer, Bengal Irrigation Branch, plans and estimates for five different schemes for irrigating the tracts of Palamu and Lohardaga viz. Nadaura, Peeri, Sadabah, Pakraha and Dhawadih. (Photocopy of the tabular statement submitted in 1877 can be seen on Appendix XI.1)

NADAURA SCHEME

This scheme contemplated construction of a weir across the river Nadaura with necessary head sluices and distributary channels at a cost of Rs. 58,735/-. Nadaura is a tributary of river Amanat which falls into river Koel.

The site of the weir was selected near village Seoti. The proposed weir was 100 feet(30.5m) long, 4 feet thick and 5 feet high with an apron of rubble stone having a slope of 1 in 12 on the downstream side and also protected by a casing of rubble stone in front.

The other works comprised head sluices having 3 vents of 3 feet each and nearly 15 miles long distribution system. To negotiate the slope of the area a number of falls were provided. In addition 2 inlets and an outlet combined with a syphon aqueduct were also provided.

The floor of the head sluice was designed 6 inches above the river bed and the level of water in the main canal was proposed to be kept 6 inch below the crest of the weir in order to obtain a required head of 1 foot if there was any flow in the river. In September the discharge in the river did not fall below 100 cusec but towards October the water dried up entirely. This required construction of some tanks to store water in the month of July and August. Some other details are mentioned below:-

Area to be irrigated	5,375 acres
Discharge required	53.7 cusec
Catchment area of the basin	8 sq. miles
High flood discharge	4580 cusec
Length of channels	14.75 miles
Total Cost	Rs. 58,735.00
Cost per acre of irrigable area	Rs. 10.92

PEERI SCHEME

The scheme contemplated construction of a weir across the river Peeri, a tributary of Amanat which itself is a tributary of river Koel. The particulars are given below:-

Area to be irrigated	19,000 acres
Discharge required	190 cusec
Discharge available during Kharif	200 cusec
Catchment area of the basin	Not Known
Length of distribution system	26.75 miles
Total Cost	Rs. 1,29,038.00
Cost per acre of irrigable area	Rs. 6.79

SADABAH SCHEME

The project consisted of a weir across the river Sadabah with head sluices and distributaries. Sadabah is a tributary of river Koel.

Area to be irrigated	12,000 acres
	+9,700 acres
Discharge required	217 cusec
Discharge available during Nov. & Dec.	200 cusec
Catchment area of the basin	22 sq. miles
Length of distribution system	14.5 miles
High Flood discharge	14,435 cusec
Total Cost	Rs. 61,579.00
Cost per acre of irrigable area	Rs. 5.13

PAKRAHA SCHEME

This involved construction of a reservoir extending over 50 acres and calculated to contain 13,276,050 cubic feet of water. The reservoir could hold sufficient water to irrigate 341 acres.

Area to be irrigated	2,950 acres
Catchment area	600 acres
Area of reservoir	50 acres
Length of distributaries	7 miles
High flood discharge	1,386 cusec
Total Cost	Rs. 33,424.00
Cost per acre of irrigable area	Rs. 11.33

DHAWADIH SCHEME

The project was similar to the Pakraha Scheme and it also envisaged construction of a reservoir. The reservoir could contain 9,801,000 cubic feet of water which was only sufficient for 252 acres.

Area to be irrigated	1,250 acres
Catchment area	125 acres
Area of reservoir	37.50 acres
Length of distributaries	3 miles
High flood discharge	275 cusec
Total Cost	Rs. 16,378.00
Cost per acre of irrigable area	Rs. 13.10

Out of the above five schemes, three were for irrigation from diverted rivers and two from reservoirs. The latter two reservoir schemes were rejected by the Chief Engineer as being expensive and of the former two schemes, Peeri and Sadabah were considered worthy of attention, the cost per acre of irrigable area being Rs. 6.79 and Rs. 5.13 respectively as compared to Rs. 58/- per acre in case of Sone, a comparatively much larger project. The results of these investigations were laid before the Lt. Governor by Col. Haig, Joint Secretary on the 7th September 1877 and Lt. Governor remarked that he would not take up the works except on the condition—

" I) that they would be unquestionably profitable.

ii) that the people wish for and are willing to pay for them; and

iii) that the cost of construction can be covered by a rate so low that the people can pay it without difficulty."

Neither the Commissioner of Chotanagpur to whom it was referred, could assure for desired returns nor the technical officers could offer any guarantee for keeping the cost of construction within the limit of Rs. 5/- to Rs. 6/- per acre.

Correspondences went on till the end of 19th Century. In 1903 the first Indian Irrigation Commission examined all the five schemes afresh and recommended the construction of only one work tentatively as an experiment which at the worst was not likely to prove very costly. On this recommendation only Nadaura irrigation project in Palamu Khas Mahal estate was sanctioned on 24th October 1904.

The above story clearly reveals why irrigation projects could not be implemented extensively inspite of the immense possibilities for irrigation in the country and available technical skill of the engineering personnel.

Yet another examples were the Karo and the Korurbar projects in the then Palamu district.

KARO PROJECT

This scheme proposed to build a weir across the river Karo about 30 miles (48 km) south west of Ranchi, a tract which suffered severely from famine both in 1897 and 1900, and from its right end to construct a canal commanding a gross area of over 200 sq. miles (520 sq. km). A minimum discharge of 200 cusec, in the month of October and November, was available in the river.

KORURBAR PROJECT

On 10th of March 1879 a note was issued from the Chief Engineer on a proposed small irrigation scheme in the Palamu district for improvement of the tract between the river Korurbar and Haree distributary of the river Sone. Korurbar is a small affluent of the river Sone, and falls in Sone about 20 miles above Dehri.

The irrigation of the above area was proposed to be derived from the river Korurbar by constructing a weir across the river at a place called Putra Khurd and situated about 24 miles (38.4 km) above the junction of Korurbar and Sone. Old irrigation channels were scattered in the entire area, supplied direct from the river. The planners of the new scheme looked forward to take advantage of these channels which were running from one *ahar* to other *ahar*. The people of the area were expected to pay gladly for an assured water supply and had readily agreed to provide land, free of cost, for construction of the headworks and distribution channels.

Maximum discharge observed in the river was 11,253 cusec which corresponds with rise of 14 feet above summer level. The area to be irrigated was 49 sq. miles (31,360 acres).

The minimum discharge in the river in the month of October varied from 40 cft/sec to 260 cft/sec. This necessitated storage of water in the *ahars* to meet the demand. There were some 24 *ahars* and tanks in the area having total capacity of holding 15 to 16 million cubic foot of water. Still there was shortfall and to store the water it was proposed to construct a small reservoir near Putra Khurd and extend the system of *ahars*. The total cost involved in the entire project was Rs. 2,38,000/- only and the annual maintenance assessed to be only Rs. 15,000/-

Mr. H.C.Levinge, Joint Secretary to Government of Bengal conveyed to Mr. I.J.K. Hevitt, Commissioner of Chotanagpur on 16.1.1880 from Calcutta that he was not in favour of the project. The reasons in his words—*"The catchment basin of the River Korurbar is only 18 sq. miles. Now any prolonged break in the rains could not fail to render this river nearly dry, just at the time water would be most wanted. As, from the smallness of the catchment basin and area to be watered it is certain that the drought would equally affect both..... Taking supply of water in river to be only 40 cft/sec, even doubling it, this would not irrigate more than 4000 bighas.*

Irrigation dependent on River only for supply cannot possibly be successful unless the catchment basin of the River is very large compared with the country to be watered and in this instance it is the reverse.

I hold very strongly to the opinion that in such cases as the Korurbar, reservoirs are indispensable. I feel I should not be so justified in recommending the Government to expend so much on the project unless they can be made at reasonable cost."

CHAPTER XII

IRRIGATION ACTS IN BIHAR

INTRODUCTION

By the time Sone Canals were commissioned in Bengal Presidency, a number of irrigation canals had already come up in northern and southern part of India, and for their efficient operation, different Acts had been promulgated by the British Government to suit the regional requirements.

Hence, before proceeding to describe the Irrigation Acts in Bihar, it would be proper to trace out briefly the history of these Irrigation Acts in different parts of India in general to understand and appreciate the need for fresh legislation for irrigation in this part of the country.

The earliest legislation was in the North West Provinces (now U.P.) in the shape of Act XII of 1845. This was of very simple nature. It empowered the Lt. Governor to make rules for the supply of water and for the levy of water rates. It provided that sums due for the water supplied under such rules might be recovered as if they were arrears of land revenue.

After two decades, in 1865, another Act came into force in the Madras Presidency which was later amended by Act V of 1900. Madras law was unique in as much as it treated the charge for water rather as a cess or tax, on the lines of the land tax, than as a matter of purchase and sale. In other parts of India water was either sold on an agreement or a charge was made when it was voluntarily accepted or used. In Madras, on the contrary, the special provisions in the amendment gave the Government legal right to charge for the water it might supply even if the use was involuntary.

Owing to various reasons including the physical, social and climatic condition it was felt that any law on the lines of Madras Act would not be easily acceptable to the people living in Bengal Presidency. Hence Government began to consider another Act suitable for this part of the country.

The first Act dealing with Irrigation in Bengal was passed in 1864, at a time when works on an extensive scale had been commenced by the East India Irrigation and Canal Company. This Act which came to be known as The Bengal Canal Act (1864), was of simple nature and gave power to the Lt. Governor to make rules for the sale of water and for the recovery of the rates as if they were rent.

After nine years Bengal Embankment Act (1873) was promulgated. Most of the sections of this Act were later repealed by Bengal Embankment Act 1882.

In the year 1873 the "Northern India Canal and Drainage Act" was passed in the Governor-General's council. It had force in the then Punjab, United Province and in the Central Provinces. In the preamble of this Act it was said - *"Whereas throughout the territories to which the Act extends, the Government is entitled to use and control for public purposes the water of all rivers and streams flowing in natural channel, and of all lakes and other natural collections of still water".*

It was provided in the body of the Act (section 8) that compensation may be awarded when the use of water stops or diminishes the supply to any private channels or works. The Northern India Act provided for channels of two classes: the larger called "canals" which were made and maintained by Government and the smaller termed as "watercourses" which were private property.

The main principle observed in conducting the sale of water in Northern India was that of acceptance or use of water i.e. the water was made available to the cultivator who used it or not as he liked and a charge was made in accordance with the use. This was the marked difference between the Madras Act and the Northern India Canal Act.

ACTS APPLICABLE IN BIHAR

BENGAL IRRIGATION ACT, 1876

After the construction of Sone Canals in Bihar certain difficulties were encountered on the front of operation of canal and collection of water-rate. As the existing Acts were found inadequate for the conditions prevailing in Bihar framing of new rules became obligatory. Consequently a bill was introduced in the Legislative Council on the 20th March 1875 and was referred to a Select Committee which consisted of Mr. Dampier, Babu Kristodas Pal and Mr. Schalch. The report of the Select Committee was issued on 14th June 1875 and was considered at the Council meeting on 4th December 1875. In this meeting much stress was laid on the "written contract" for supply of water. Later after much deliberation the bill was passed in the meeting of the Council on 11th December 1875 and it took effect in those districts in the provinces which were on the 29th March 1876 subjects to the Lt. Governor of Bengal. This came to be known as Bengal Irrigation Act 1876.

This was a much more elaborate Act which followed, to a certain extent, the lines of the Northern India Act. It empowered the Lt. Governor to apply and use the water of any natural stream or lake, the intention to do so being duly notified and the compensation being payable for interference with the existing rights or interest.

In respect to private channels the Bengal Act provides for the right of passage in much the same way as the Northern India Act. There is however, a marked difference. Under the Bengal Act, when land has to be taken for a Private channel, it is dealt with as though it were required for public purposes, that is there is forced sale and the land becomes the property of the owner of the channel, subject, however, to certain restrictions as to the purposes for which it may be used. Northern India Act provided for a right of occupation only.

In respect to the sale of water the Bengal Act was more clear and liberal. It required that there shall, in all cases, be a written contract or agreement, expressed in the form of an individual application and permit, before water is supplied. There was no provision to authorise the acceptance or use of water in the absence of a written agreement such as there was in the Northern India Act. On the contrary it was provided under original section 74 (later substituted by Act 16 of 1982) that

" *No person shall be liable to pay any rate or due whatever on account of water supplied to his land with the permission of the canal officer, otherwise than on such application nor shall water be supplied otherwise than on such application*".

Thus a distinct written agreement or contract was required between buyer and seller and if the seller should supply water without such an agreement he was prohibited from making any charge for it. In Madras no such agreement was required. No option was kept to the cess-payer as to acceptance of water, and a rate or cess was levied for beneficial irrigation whether voluntary or involuntary.

Under the Bengal Irrigation Act 1876, the entire cost of a project was to be borne by the Government. The execution of canals in the nineteenth century, and the construction, maintenance and operation of a number of canal system in Bihar even today are being done under this Act. The Tribeni Canals were also constructed and are being maintained with the help of the Powers vested under this Act. After independence in 1947 more and more projects e.g., the Kosi, the Gandak, the Badua and the Chandan etc. have been executed under the provisions of this Act.

There is no mention of financial return on the capital investment on schemes executed under this Act. Under original section 74 of this Act, every cultivator who required water for irrigation was obliged to apply to the Canal S.D.O. and the latter being satisfied with the arrangements and capacity of the canal to supply water, was required to issue permits. The cultivator got the water for irrigation thereafter. The original section 78 of the Act (later substitued by Act 16 of 1982) laid down how charge for supply of water was to be levied and reads as follows :-

"The rates to be charged for canal water supplied for the purposes of irrigation shall be determined by the State Government and all persons accepting the water shall pay for it accordingly".

Under the rules framed under this Act, the procedure to be followed to arrive at the water rates has not been laid down. The procedure for assessment and collection of water rates was laid down in the following rules framed by the Government :-

(1) Sone, Champaran, Saran, and Kamla Canal Irrigation Rules, 1931.

(2) The Sakri Canal Irrigation Rules, 1952.

In the former, there is provision for the following types of leases :-

(a) Long term leases

(b) *Kharif* season lease

(c) *Rabi* season lease

(d) Hot weather season lease

(e) Single watering during the *Kharif* season

(f) One or more watering during the hot weather season; and

(g) Water required for the tank.

In the latter, there is provision only for:-

(a) *Kharif* season lease; and

(b) *Rabi* single watering.

The Sakri Canal rules have since been canceled and the Sone, Champaran, Saran and Kamla Canal Irrigation Rules, 1931 have been renamed as the Bihar Canal Irrigation Rules.

BIHAR PRIVATE IRRIGATION WORKS ACT, 1922

A large number of irrigation schemes, the maintenance of which was the responsibility of the Landlords or any other persons or agency have been executed under Bihar Private Irrigation Works Act, 1922. All expenditure in execution of such schemes have been borne initially by the State Government. On completion of the

construction, the Collector after making the prescribed inquiry and giving notice, apportioned the cost incurred therein to such person or persons, whether landlords or tenants, in such proportions as seemed to him to be fair and equitable. Under some programmes initiated by the Government from time to time certain percentage of the cost of works was realised and balance was borne by the State Government. In certain circumstances, if necessary, even the whole or part of the amount payable by the beneficiaries was remitted. No assessment of water rate was done in respect of such works. The work after completion was handed over to the beneficiaries for maintenance and operation.

BIHAR PUBLIC IRRIGATION AND DRAINAGE WORKS ACT, 1947

Just before independence, this Act named as Bihar Public Irrigation and Drainage Works Act, 1947 came into force. There are provisions in this Act to execute works relating to irrigation, drainage and flood protection. Quite a large number of irrigation schemes have been notified and executed under this Act. The provisions on financial returns from these schemes are contained in section 23,24 and 25 of this Act. Under section 23, the Government may recover the entire expense incurred in connection with such work with interest at the rate of 4 percent per annum or such other rate not exceeding 5 percent per annum, from the persons having interest in the land benefited by such work. Under section 24 of this Act, the State Government has been empowered to recover the cost of maintenance already incurred and the amount calculated to be sufficient to cover the future cost of maintenance from persons having an interest in the land benefited by such works. Under section 25 of this Act, the State Government has been given the option to levy cess for recovery of the interest at the rate of 4 percent per annum or such other rates not exceeding 5 percent per annum on the expenditure incurred in connection with the work and the annual cost of maintenance instead of recovering the cost as provided under section 23 and 24 referred as above.

According to the original intention, a portion of the capital cost of the schemes executed under this Act was to be realised instead of realising or levying water rates. According to the provision in the Act, full description of the lands benefited have to be published after survey and recovery made thereafter by the Collector of the district. It has, however, not been possible so far for the Government, either to realise the cost from the beneficiaries or even to fix the percentage of realisation for even a single scheme. In 1966, the State Government finally decided to realise water rates in such schemes and passed an amending Act making water rates leviable, instead of capital cost being recoverable.

BIHAR LIFT IRRIGATION ACT, 1956

The execution, maintenance and operation of lift irrigation works in Bihar are done under the provisions of this Act. The provisions of this Act are similar to those of the Bengal Irrigation Act. There is a provision under section 24 of this Act to charge water rates for irrigation done which reads:-

"The rates to be charged for supply of water from a lift irrigation work for the purposes of irrigation shall be determined by the State Government and all persons accepting the water shall pay for it accordingly".

OTHER ACTS AND RULES

Subsequently two more acts viz The Bihar Irrigation and Flood Protection (Betterment Contribution) Act, 1959 and The Bihar Irrigation Field Channel Act, 1956 were promulgated

Based on the above mentioned Acts, several Rules have also been framed viz Drainage Rules, Embankment Rules, Navigation Rules and as mentioned earlier, Bihar Canal rules. Apart from these, several ordinances have also been issued from time to time for making amendments in the Acts.

Many of these Acts have now become redundant as they have lost their relevance in the present circumstances. Moreover, plethora of various Acts and rules are creating confusion and in fact adversly affecting the process of providing smooth irrigation services in the State. However, this is not the case with Bihar only. Various other States have also been facing more or less the same problem.

The Second Indian Irrigation Commission (1972) had studied the laws relating to irrigation prevalent in various States and concluded that there was a multiplicity of State statutes covering various aspects of irrigation management and adminstration. The Commission recommended that the laws relating to irrigation should be unified and simplified.

MODEL IRRIGATION BILL

In pursuance of the recommendations made by the Irrigation Commission, the erstwhile Ministry of irrigation and Power, Government of India had requested the Indian Law Institute to carry out a study of the existing Irrigation Acts and suggest a model legislation on the broad lines indicated by the Irrigation Commission for the guidance of the States. Accordingly, the Indian Law Institute, after studying the existing Laws in depth, prepared a draft of "Model Canal Irrigation and Drainage Bill." The Ministry, consequently set up a Committee of experts from various States to examine the provisions of the Bill and suggest modifications, if any, before it could

serve as a model to the States for enacting suitable legislation. This Committee submitted the final draft Model Irrigation Bill in February 1976, which was circulated to the States by the Union Government suggesting enactment of a comprehensive and consolidated Irrigation Act on similar lines with additions and alterations considered necessary to meet the specific needs and situations of individual State.

NEW IRRIGATION ACT

The Second Bihar State Irrigation Commission (1994), after in depth study of the existing Acts and also the provisions of Model Irrigation Bill (1976) prepared a Draft Irrigation Bill, consolidating all the prevailing Acts in the State with necessary alteration and additions to meet the new challenges in providing flood control, drainage and scientific modern irrigation services to the State and other related matters.

State Water Resources Department after carefully examining and making suitable modifications in the provisions of the draft, redrafted it as the Bihar Irrigation Bill, 1996 which was later vetted by State Law Department. Advice of the Advocate General Bihar was also obtained and the bill was concurred by the Council of Ministers, Bihar, in its meeting on 4th March 1996.

The Government introduced this bill in the State Legislative Assembly on 24th July 1996, and the same was finally passed by the Houses on 30th July 1996.

The Bihar Irrigation Act, 1996 has repealed the following Acts :

1. Bengal Canal Act, 1864 (V of 1864)
2. Bengal Embankment Act, 1873 (VI of 1873)
3. Bengal Irrigation Act, 1876 (III of 1876)
4. Bengal Drainage Act, 1880 (VI of 1880)
5. Bengal Embankment Act, 1882 (I of 1882)
6. Bihar Private Irrigation Works Act, 1922 (V of 1992)
7. Bihar Public Irrigation & Drainage Works Act, 1947 (X of 1947)
8. Bihar Lift Irrigation Act, 1956 (XVI of 1956)
9. Bihar Irrigation Field Channel Act, 1965 (XVII of 1965)

Some of the salient features of the new Act, 1976 are as follows :

(i) The rights of the Government over the water resources of the State have been defined in clear terms. (Section 3 and 4)

(ii) To minimize the financial and managerial problems in maintenance and operation of irrigational infrastructure, the concept of Water Users Association has been introcuced. In this bill provision has been made to make it possible for the Government to hand over the smaller and subsidiary canals to a person, a group of persons or to Water Users Associations formed by the beneficiaries for maintenance and operation and to make them virtual "Owners" of the subsidiary system. (Section - 46)

(iii) Nearly three hundred out dated and impracticable sections of the existing laws have been deleted.

(iv) Concept and provision for on-farm-development have been introduced. (Section - 47)

(v) Power of the State for enforcement of cropping pattern in **'assured irrigable command'** according to suitability of climate, soil and availability of water has been introduced. (Section-58)

(vi) Provision for formation of Water Committees for management and supply of water from small irrigation works have been made. (Section-59 to 61)

(vii) Right of State Government for compulsory requisition of labour and material in times of emergency have been defined (Chapter-XIV)

(viii) Levy of water rates and betterment contribution have been introduced (Chapter XI & XII)

(ix) Punishment for pollution of water of irrigation works has been provided. (Section - 82 (e))

This historical event, eliminating British legacy in the domain of Irrigation Laws and introducing new Act with modern concepts in the field of irrigation, is definitely a remarkable achievent of the present Government in the State.

Based on the new Act (1996) the State Water Resources Department is now in the process of framing fresh rules for smooth functioning of irrigation practice in Bihar.

NO ACT YET FOR VOLUMETRIC MEASUREMENT

It is to be noted that sale of water by measure or volume is not specifically provided for in any of the Acts mentioned above including the Bombay Presidency Act which was promulgated in 1879. But from this it may not be inferred that nobody ever thought of it while framing these laws. As long ago as 1851 Captain Baird-Smith of the Bengal Engineers (later Colonel) after a long observation of the system of supplying water from unregulated outlets and watching helplessly the wastage of water, had advocated for introducing to India the Italian system of sale of water by volume.

He wrote in his valuable work on Italian Irrigation:-

"After 10 year's observation of the practical working of the plan of issuing water from unregulated outlets, on the basis of special service, or area irrigated, I have come to the conclusion that it is the most unsatisfactory of all methods whether reference be had to the true interest of the State, or those of the agricultural community. Its maintenance is justifiable only when physical circumstances offer inseparable obstacles to the use of any other plan".

One wonders what a sound judgment and remarkable foresight he had. He was most desirous of introducing to India the Italian system of sale of water by volume. Ironically even today, due to several reasons, we are not able to follow the system suggested by Capt. Baird-Smith one and a half century ago to save the precious water. Though no such Act seems to be in the offing, the possibility of one such cannot be ruled out. Of late wise people have started thinking seriously in this direction. It had been suggested that cultivators should form societies at the outlet level to purchase water by volume and to take up for themselves the detailed distribution in the outlet command.

Creation and Utilization of Irrigation Potential up to preplan period (as per record available in WRD, Government of Bihar)

Sl.	Name of project.	Irrigation Potential (in 1000 ha)
1.	Sone Canals	346.6
2.	Teur Canal	1.8
3.	Dhaka Canal	7.0
4.	Tribeni Canal	48.2
	Total:	403.6

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Sone Canal Modernisation Project (1988) by WAPCOS

APPENDICES

Appendix - IV.1

Despatch from the Government of India in the Public Works Department, Irrigation Branch, to the Right Hon'ble the Secretary of State for India,-(No.106P.-W., dated Simla, the 12th October 1875.)

MY LORD MARQUIS,

Referring to our despatch (Public Works) No. 72I of 13th June 1871, we have the honour to forward herewith copies of papers relating to the revised estimates for the Sone Canal, from which Your Lordship will perceive that we have accorded our provisional sanction to revised estimates aggregating Rs. 3,14,70,449, or excluding charges involving no cash outlay Rs. 2,71,03,615. We trust that Her Majesty's Government will approve our proceedings and concur in the praise bestowed by us on the officers concerned in this great undertaking.

2. We have reviewed the revised estimates in detail in our Secretary's letter No. dated, to the Government of Bengal, of which a copy accompanies, and we should here dwell upon a few only of the most prominent matters.

3. The full estimates for the Sone Canal have been as follows :-

	£
Colonel Dicken's estimate of 1861	2,688,120
" Rundall's " of 1871	3,755,000
" Haig's " of 1873	2,709,757
The present estimate	3,147,045

The estimates for 1871 were approved by the Duke of Argyll in despatch No. 42 of 29th June 1871, though no formal sanction was given to the actual amount or to the extent of the works it represented.

4. Subsequently (despatch No. 60 of 22nd August 1871) Her Majesty's Government confirmed the sanction given by us to the estimates for a portion of the works. These estimates were for £ 889,677. The revised estimates now sent up for the same works aggregate £ 820,651. This is a close agreement but certain deductions have to be made for works struck out or reduced in the modifications of this project made after 1871 and leading up to Colonel Haig's estimate of 1873. These

reduce the sanctioned original estimates to £ 831,797 and make the excess £ 61,854. But still this is a good result, for works of so much difficulty and magnitude, and which are so far advanced that the revised estimate is now very safe. We think that Mr. Levinge and his staff deserve great credit.

Additional sanctions for subsidiary works have meanwhile been given, and the outlay up to 1st May last is now reported to be Rs. 1,28,27,471.

5. The scope of the general scheme has however been more than once altered.

The first project mentioned in paragraph 3 embraced the country between the Poon-Poon (with a small tract up to the Morhur) on the east and the Kurumnassa on the west (i.e., the country along the south bank of the Ganges, from Patna to Buxar) with a navigable line to the Ganges near Chunar. Colonel Rundall's scheme, approved and in part sanctioned in 1871, as already mentioned, embraced the country along the south bank of the Ganges, from Barh to Chunar. Colonel Haig's scheme reduced it again to somewhat smaller dimensions than the original project, taking only from the Poon-Poon to the Koodra. The present estimate is based on Colonel Haig's project. The increase in the amount above Colonel Haig's estimate provides larger dimensions to the Western Main Canal in view to extension, adding to the cost 5 ½ lakhs. This is the only material difference in the cost of works. The remaining difference of 38 ½ lakhs is due to the percentage charges under establishment, tools and plant, pensions, &c., as explained to Your Lordship in our late despatch on the estimates of large projects (No. 24 of 11th March 1875).

No provision is included in these estimates for the extension of the Main Western Canal referred to in Your Lordship's despatch No. 33 dated 31st March 1874.

6. In considering the previous and present calculations of the cost of the project, it will be most convenient now to compare that of 1861 with the estimate now submitted, omitting the larger project of 1871. A supplementary estimate has been prepared bringing the project to the same area, omitting the small tract east of the Poon-Poon, as in original estimate.

	Rs
This being added,, the whole amounts to	3,87,84.928
But of this the provision for establishment and other charges is	1,46,44,134
Leaving for works	2,44,40,794
The estimate for works in 1861* was	2,45,20,208

	Rs.
* Works	2,45,20,208
Establishment	23,60,992
Total	2,68,81,260

The character of the project has however been considerably changed since 1861. The head works are placed 18 miles lower down the river, which affords a saving, and there is moreover the saving of the irrigation of the small tract east of the Poon- Poon; **while the size of the channels is larger to give more irrigation for the rice crops during the monsoon**, which leads to a considerable excess. Again the original estimate provided for 30 percent increase of prices. This the result shows to have been justified, since the rate for plain masonry has risen from Rs. 15 to Rs. 20 and 24 per 100 cubic feet, and that for ordinary excavation from Rs. 2 to Rs. 2 ½ per 1,000 cubic feet. Still it is satisfactory to find that the gross estimated cost of the outlay incurred directly on the works has not risen, but that the rise is due mainly to those causes of more complete accounting explained in our second despatch No. 24P.W dated 11th March 1875 of excesses estimates.

7. The details of the difference are given in the table below :-

	1861	1875
	Rs.	Rs.
Works	2,45,20,208	2,41,40,794
Maintenance till in use		3,59,013
Establishment	23,60,992	61,63,979
Tools and Plant		28,70,372
Interest		34,98,976
Value of claims for pensions and leave		15,40,994
Capitalization of land revenue		2,10,800
Total	2,68,81,200	3,87,84,928

N.B.- At the time the original estimate was framed tools and plant were included in the rates for work. To this extent therefore it may be said there is a rise in the estimates for works. Establishment was taken at the rate then usual of 12 ½ percent; this percentage was not calculated on the rise of 30 percent, in prices, as should have been done. **Establishment is now taken at 25 percent**. The other heads of charges were not then thought of.

8. As regards the remunerative character of this scheme, it is to be noted that the estimated profits in 1861 were taken at Rs. 21,41,160, being 7.9 percent on the capital of 268 ¾ lakhs.

As shown in paragraph 18 of our letter to the Government of Bengal, the probable ultimate net revenue on the scheme, restricted to the area of Colonel Haig's project, may now be taken at Rs. 26,20,350 equivalent to 8.3 percent on an outlay of 314 ¾ lakhs. Even if it be assumed that the estimate of maintenance is rated too low and that it will amount to as much as 3 percent of the capital, there will still be a profit of 6.8 per cent. If however only the actual cash outlay of Rs. 3,45,34,093 (including establishment, tools and plant) be taken, omitting the book charges, which were not fixed when the original calculations were made, the profits work out to 7.7 percent.

If the project should hereafter be extended to the Kurumnassa, as has been contemplated, without increasing the capacities of the channels beyond what is projected in the smaller scheme, then the probable additional cost will be

	Rs. 78,14,479
to which we add total cost	Rs. 3,14,70,449
of that now submitted, then the total cost as far as Chunar will be	Rs. 3,87,84,928
The additional gross income on the extension may be taken at	Rs. 2,83,160
Deducting maintenance on 62,720 acres at 12 anna per acre	Rs. 47,010
there remains a net return of	Rs. 1,86,120
Adding on the net profit on the restricted scheme of	Rs. 26,20,350
there results a total net revenue of	Rs. 28,06,650

which will be equivalent to about 7 1/4 percent on the entire outlay.

9. It is true nevertheless that, if the cash outlay be charged with compound interest at 4 ½ percent, and if the revenue grow on faster than that of the Ganges Canal did, the interest will swallow up all the profits and the project will never pay. But if on the other hand it be calculated that the canal (which is to be opened in the current year) works at a loss (as in the forecast) till 1870-80, that in the next year it begins to make net earnings in a small way, and goes on increasing on the average at ½ percent per annum (the Ganges Canal rate of increase was 1/3), then the project will eventually not only repay the interest but also recoup the capital. So greatly does a small increase in the rate of growth of the irrigation affect the success of these projects.

10. Bearing however in mind its indirect advantage, the benefit it will afford to the people, and its use in famine, and further that according to our forecast the country can afford the outlay, there seems to be no reason to regret that the work was undertaken.

11. In the autumn of 1873 the canal in its incomplete state saved 159,000 acres of crops, valued according to Colonel Gulliver's calculation at nearly £500,000. The whole expenditure on the works at that time had hardly amounted to £800,000. These figures will give some idea of the advantages derived from such works in time of scarcity.

12. With these remarks we recommend the revised estimate for Your Lordship's sanction.

Documents accompanying.

1. From Government of Bengal, Public Works Department, Irrigation Branch, No. 1391, dated 8th February 1875, and enclosures.

2. To Government of Bengal, No. 3761, dated 12th October 1875.

Appendix - IV.2

From the Right Hon'ble the Secretary of State for India, to His Excellency the Right Hon'ble the Governor General of India in Council,-(No.1, dated India Office, London, the 6th January 1876.)

MY LORD,

I have had before me in Council your Excellency's letter No. 106 of the 12th October last, submitting revised estimates for the Sone Canal of an aggregate amount of £31,47,044. This total exceeds by £4,58,921 that of Colonel Dicken's original estimate of 1861, and is also greater by £4,37,288 than that of the one prepared by Colonel Haig in 1871; but the difference in both cases is explained to be partly due to the introduction into the later calculations in accordance with the present mode of keeping accounts of various charges which previously had either no place, or much smaller place, in the estimates for individual projects. The remaining difference appears to be entirely attributable to rise in rates and prices, and to the enlargement of or additions to the original project.

2. In comparing the earlier estimates with the one last submitted, you speak of the former as "singularly true guides to the real cost of the works," in as much as their amount has been exceeded by only 10 percent, and you take the opportunity to bestow high, and doubtless well merited, praises on Colonel Rundall, Mr. Levinge, and other officers concerned in the undertaking, for the rapidity with which it has been prosecuted. The excess above referred to is to be understood as exclusive of what are termed "book charges" in contradistinction to the actual money expenditure necessitated by the work, since the inclusion of these would apparently raise the excess to nearly 17 percent. Irrespectively, too, of these later charges, several large items are entered which did not appear in former estimates of this character, and as to which, though they doubtless are contingent on the execution of the canal, it may be a question whether they should be included in the capital outlay on which the returns are to be reckoned. Among such items may be observed one of about £5,00,000 for the field surveys of the area to be irrigated.

3. With reference to the revised estimate of probable income, I share your Excellency's conviction that there is no reason to regret that the work has been undertaken. That indirectly at least, if not directly, it is sure to pay, may be inferred from the figures entered in the 11th paragraph of your letter, and which, as you justly represent, suggest a very encouraging "idea of the advantages derivable from

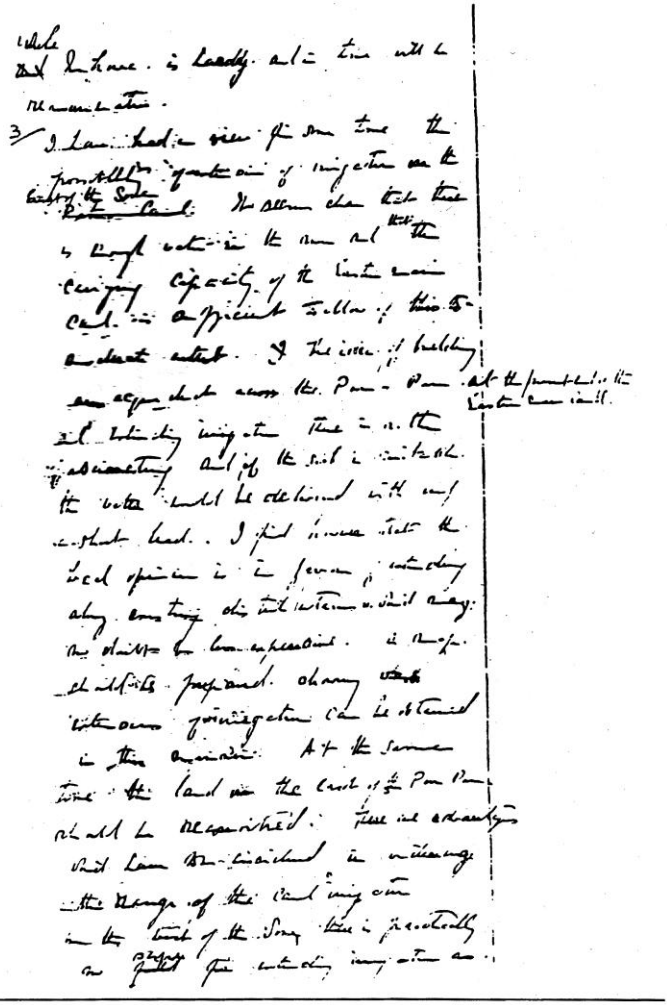
4. The provisional sanction given by your Excellency to the revised estimates submitted with the letter under acknowledgment is confirmed.

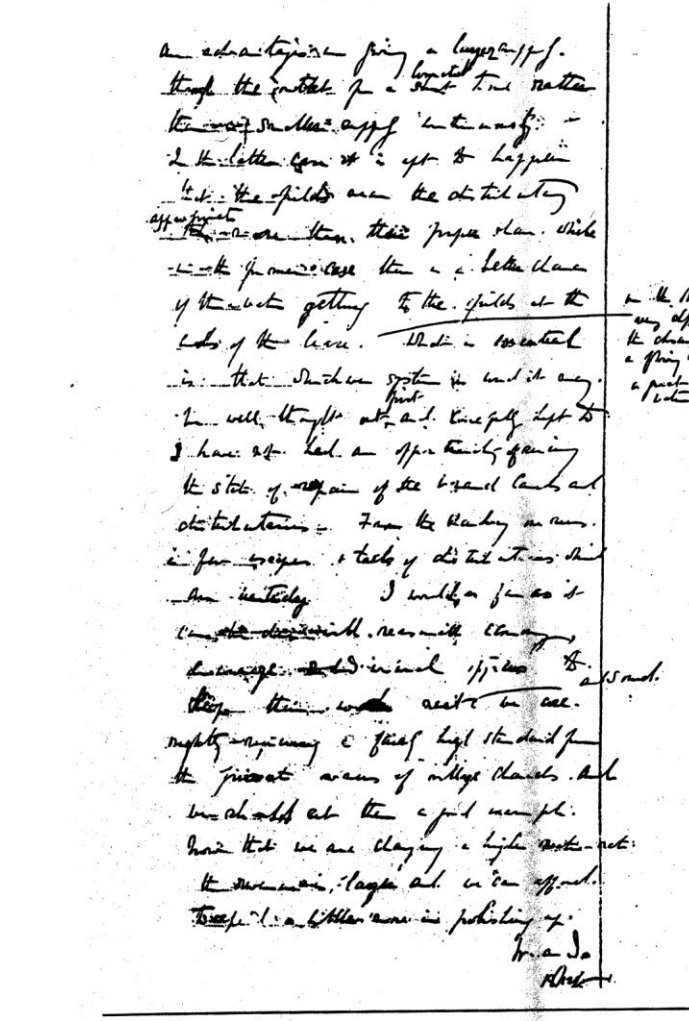
5. The statistical data which, at my suggestion, have been called for to allow of its being decided whether an extension of the Main Western Branch of the Canal is desirable have, I observe, not as yet been fully collected.

Appendix -IV.3

Inspection note of W. A. Inglis, Chief Engineer, Bengal dt. 18.12.1905

(Paragraph : 3) I have had in view for some time the possibility of extension of irrigation on the east of Sone. It seems clear that there is enough water in the river, and that the carrying capacity of the Eastern Main Canal is sufficient to allow of this to a moderate extent. The idea of building an aqueduct across the Poonpoon at the present end of the Eastern Main Canal and extending irrigation there is rather fascinating and if the soil is suitable the water could be delivered with only short lead. I find however, that the local opinion is in favour of extending along the existing distributaries which may no doubt be less expensive. A map should be prepared showing where expansions of irrigation can be obtained in this manner. At the same time the land on the east of the Poonpoon should be reconnoitered. There are advantages which have to be considered, in widening the range of the canal irrigation. On the west of the Sone there is practically no scope for extending irrigation as the full supply which can be got into the Western Main Canal is already taken up.

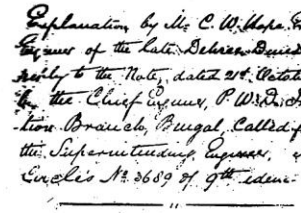




Appendix- IV.4

Explanation by Mr. C. W. Hope, Executive Engineer of the late Dehri Division in reply to the note dated 21st October 1875 by the Chief Engineer, P.W.D. Irrigation Branch, Bengal called for in the Superintending Engineer, Sone Circle's No. 3689 of 9th idem.

(Page :1) Colonel Haig states that in consequence of a demiofficial communication received on the 13th October 1875 from Colonel Staddard, the acting Superintending Engineer, he left Calcutta that night to ascertain by personal inquiry how matters really were as regards the failure of the supply of water for Irrigation from the Arrah and Patna Canals and that he arrived at Dehari on the 16th idem. He narrates what he saw and found, and describes the measures, which were being carried out at Dehari to release the supply of water and .....



Appendix-IV.4

Explanation by Mr. C. W. Hope, Executive Engineer of the late Dehri Division in reply to the note dated 21st October 1875 by the Chief Engineer, P.W.D. , Irrigation Branch, Bengal, called for in the Superintending Engineer, Sone Circle's No. 3689 of 9th idem.

(Page : 56) ..... have received instruction to give all the water that might be demanded. I regret that he did not warn me of what was required in order that I might have made timely preparations. I had never been told, either by him or by Mr. Levinge that it was my duty to have beams ready for closing the sluices for irrigation in September and there was no new timber from which beams long enough and strong enough could have been picked—In 1873, when the scarcity threatened and Mr. Levinge offered to give water from the unfinished works, I was in charge of the Dehari Division. The weir was only 5ft. high, and the supply was all given in the first instance by rubble stone dams thrown across the Sluice, and by a rubble dam on the weir afterwards. The piers were then scarcely begun and beams could not have been used. I believe beams and sleepers were used for closing the sluices.....

have received instructions to give all the water that might be demanded. I regret that he did not warn me of what was required in order that I might have made timely preparations. I had never been told, either by them or by Mr Lennige, that it was my duty to have beams ready for closing the sluices for irrigation in September. And there was no more timber in Delree from which beams long enough and strong enough could have been picked. In 1873, when the scarcity threatened, and Mr Lennige offered to give water from the unfinished works, I was in charge of the Delree Division. The weir was only 5 ft high, and the supply was all given in the first instance by rubble dams thrown across the sluices, and by a rubble dam on the weir afterwards. The piers were then scarcely begun, and beams could not have been used. I believe beams and sleepers were cut for closing the

sluice beams, closing beams have been in use

no proper timber in Delree.

water given 1873 by rubble dams.

Appendix-IV.5

Memorandum from, COLONEL H.W.GULLIVER, R.E., Officiating Chief Engineer,, Bengal, Irrigation Branch, to the Superintending Engineer, Sone Circle,- (No. 237C.-E., dated the 16th March 1875.)

Returns the estimates* with plans for the Paligunge Distributary, Patna Canal, for re-consideration. The Chief Engineer has marked in pencil on the contoured map what appears to him to be grave errors in the alignment of this and the other distributaries of the Patna Canal.

*Regular No. 77 R.G. of 1874-75 No. 18 of 1875, No. 43 of 1874, No. 21 of 1874 (52 in number)

2. Superintending Engineer must remember that it is of the utmost importance that these distributaries should be as nearly as possible on the very highest point of the ridges, as otherwise they not only intercept drainages, but make the construction of the village water-courses more difficult.

3. The Ameerpoora and Lallgunge branches do not appear to be necessary, as they only extend to a distance which can be reached by the ordinary, village water-courses.

4. Chief Engineer takes this opportunity of pointing out that it is not advisable to carry out any of these small sub-distributaries in the first instance until the spread of irrigation shows the necessity for them.

5. In the index map for the Government of India, proposed distributaries of which estimates have not been submitted, should be shown in dotted blue lines; sanctioned distributaries in thin blue lines.

6. The one of which the estimate accompanies the map is a red line.

No. 10. From H.C. Levinge. Esq., c.z. Superintending Engineer,. Sone Circle, to the Chief Engineer, Bengal, Irrigation Branch,- (No. 1019, dated Arrah, the 24th March 1875.)

Sir

I have the honor to acknowledge the receipt of your No. 237 of the 10th instant, returning the plans and estimates of the Paligunge distributary of the Patna Canal and commenting on the alignment of the other distributaries.

2. I am well aware of the importance of keeping the distributaries on the very highest points of all the ridges, and have invariably insisted on this being done.

3. I have very carefully examined the alterations made in pencil on the map, and with the exception of the No. 1 distributary from the Eastern Main Canal, Munora, am satisfied from personal knowledge of the ground that no advantage will be gained by making any change . I beg to remind you that one whole season was lost in consequence of these lines having been wrongly laid out by the Executive Engineer of the Eastern Sone Survey Division, and that afterwards I myself personally examined the country and walked over every line as now laid out.

It would certainly appear from the contour map that the alterations made by you are advisable; but I must explain that the cross lines of levels were taken at one mile apart, and that they do not show all the ridges and hollows in detail, but these are very unmistakeable on the ground.

5. As regards the Paligunge line, I beg to explain that during the famine time the land was marked out; 7 miles or so have been taken up and paid for, and earthwork commenced. The expenditure on this is now treated as objectionable by the Controller, and it is desirable that sanction should be obtained. I would not urge this if I was not satisfied that no improvement can be made by altering the alignment.

Appendix-IX.1

Govt. of (190) Bengal

Note Regarding opening of Tribeni Canal

dated 9th June 1909

Department : Irrigation

Branch : Irrigation

File 2C/6 of 09

No. 88 ©

Issue no. 470 T/I

Date of issue 9th June 09.

To,

India, P.W.D.

Sir,

I am directed to report that the first 30 miles of the Tribeni Canal having been completed water was admitted through the Head sluice for the first time on the 7th instant.

sd/- Illegible

9.6

(Secretary)

Govt. of (190) Bengal.

73 Progs. for June 1907 No. 338

To India P. W. D.

Enclosures :

Maps or plans :

Spare copies :

Summer :

Department 9

Branch 9

File $\frac{75}{6}$ / 09

Number 580

Issue number 470 T/I

Date of issue 9th June 09

9. JUN. 1909

Reminders issued :—

A.

B.

C.

Sir,

I am directed to report that the first 30 miles of the Tribeni Canal having been completed water was admitted through the Head-Sluice for the first time on the 7th instant.

I have &c.

Secy.

Appendix-IX.2

Telegram sent by Lt. Governor on 9th June 1909

Govt. of (190) Bengal

dated 9th June 1909 No. 337

Department : Irrigation

Branch : Irrigation

File 2C/6 of 09

No. 88 ©

Issue no. 470 T/I

Date of issue 9th June 1909.

From Bengal Works

Darjeeling

To,

Gandak Construction

Muzaffarpur

Lieutenant Governor is pleased to hear that Tribeni canal has been successfully opened.

sd/- Illegible

9.6

(Secretary)

Govt of [190] Bengal

Department	S
Branch	I
File	S.C. 6 of 09
Number	58 (C)
Issue number	669 719
Date of despatch	9th June 1909

B Progs. for June 1909 No. 337

TELEGRAM

Subject

DESPATCHED 9 JUN 1909

From Bengal Writs

To Gauhati Commissioner Assam

Cipher Secret

C. G. is pleased to hear that Tribeni Canal has been successfully opened

9/6/09

File 11/6/09

Photocopy of the tabular statement submitted by Maj. J.M. Heywood, S.E (1877)

Palamau District

Irrigation Project

Tabular Statement Shewing the acreage & mileage rates on the irrigable area. –

Name of Project	Total Estimated Cost	Area to be commanded in Acres	Rate per Acre	Length of Channels in miles	Rate per mile	Remarks
	Rs.		Rs.		Rs.	
Nardewra Project	58735	5375	10.92	14.75	3952	
Sahraha "	33424	2950 a	11.18	6.75	4952	
Khanadih "	16378	1250	13.10	3.00	5459	The total Estimated Cost
Suddanah "	61579	12000 b	5.13	14.5	4247	includes Headworks, Tools
Pare "	129035	21700	5.94	26.75	4824	& Plant Superintendence
Total	299152	43275	6.90	65.75	4550	& Buildings.

a. Supply of water insufficient to irrigate more than 1000 acres.

× b. Exclusive of 9500 acres South of the Durgabati river which would probably cost Rs. 57000 for irrigation works if the scheme were extended.

J.M. Heywood Major
Ex. Eng.
16/6/77

Major
Supt. Engineer ... Circle

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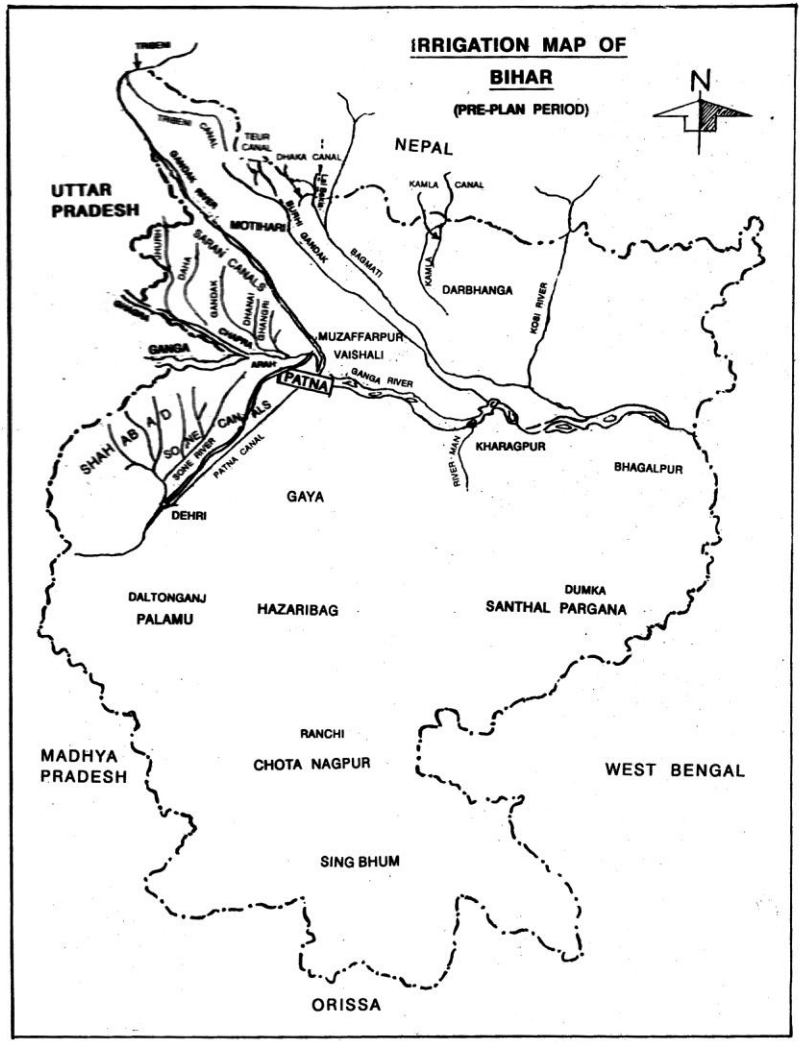
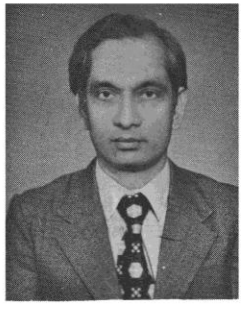
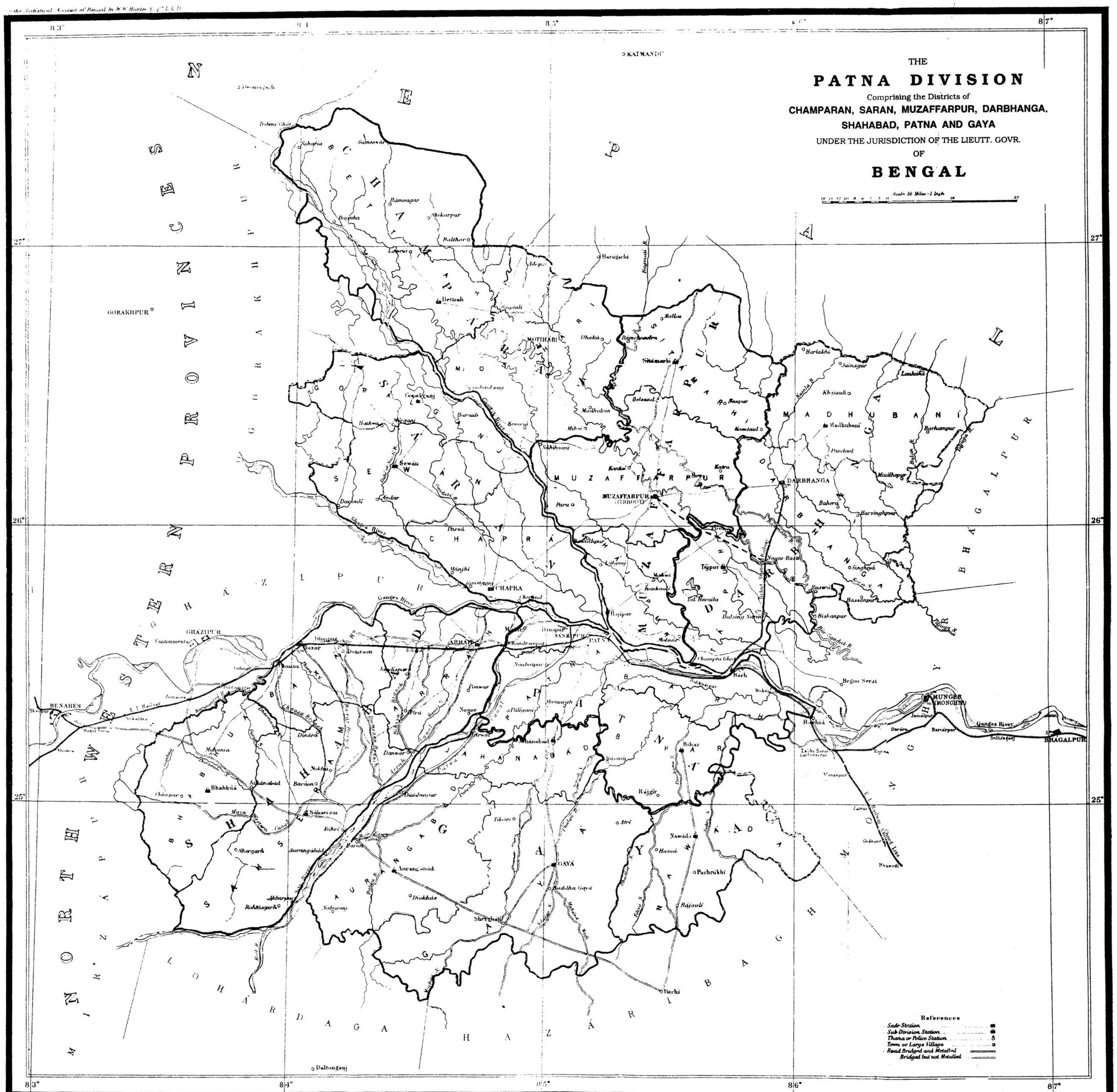

IRRIGATION MAP OF
BIHAR
(PRE-PLAN PERIOD)
N
NEPAL
UTTAR PRADESH
TRIBENI
TRIBENI CANAL
TEUR CANAL
CHAKA CANAL
GANDAK RIVER
BURHI GANDAK
BAGMATI
KAMLA CANAL
KAMLA
DARBHANGA
KOSI RIVER
MOTIHARI
SARAN CANALS
DAHA
GANDAK
DHANAI
CHAMPA
MUZAFFARPUR
VAISHALI
GANGA
PATNA
GANGA RIVER
SHAHABAD CANALS
SONE
SONE RIVER
PATNA CANAL
RIVER MAN
KHARAGPUR
BHAGALPUR
DEHRI
GAYA
DALTONGANJ
PALAMU
HAZARIBAG
DUMKA
SANTHAL PARGANA
RANCHI
CHOTA NAGPUR
MADHYA PRADESH
WEST BENGAL
SING BHUM
ORISSA



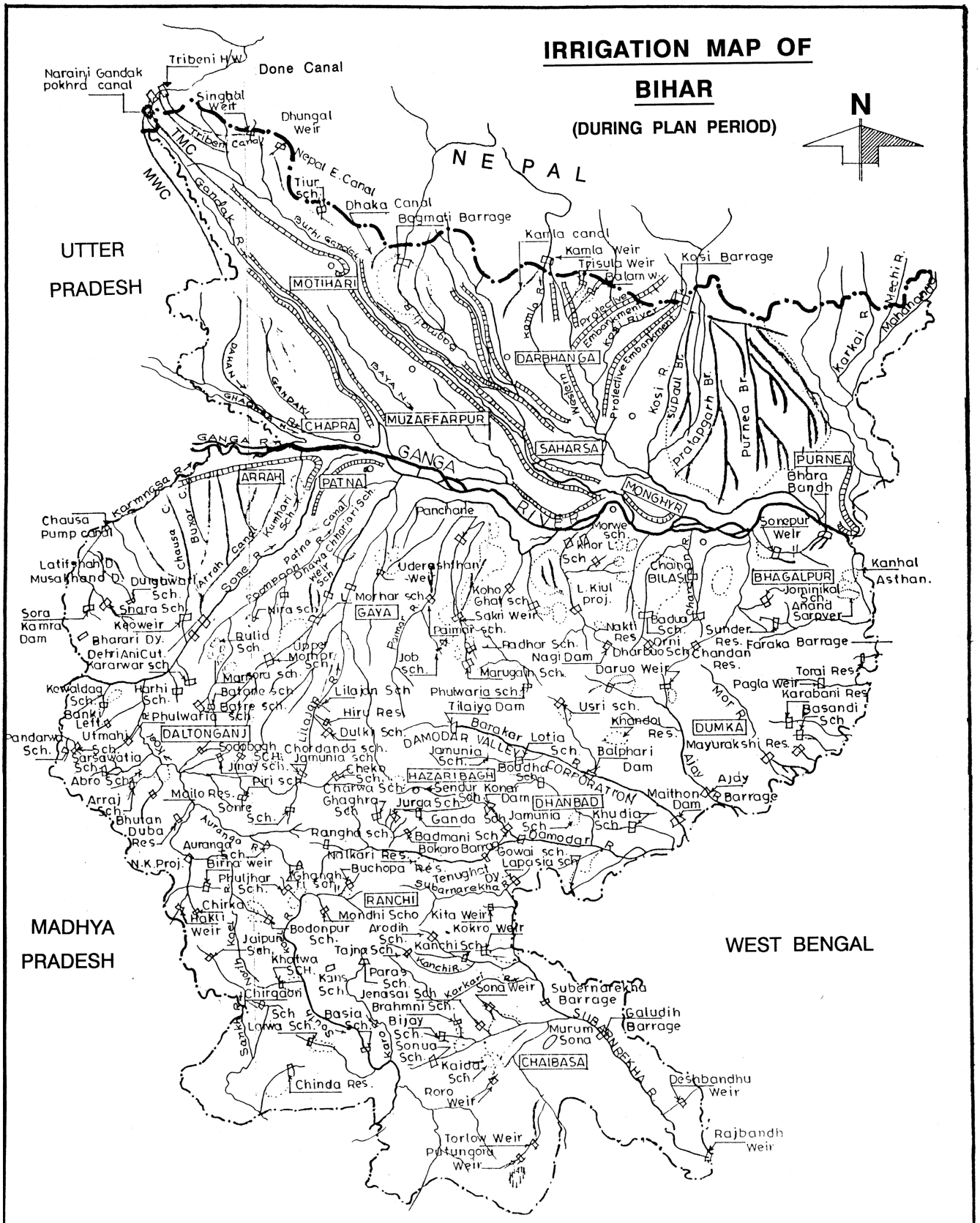
Gagan Prasad (born on 22.12.1942)

a Superintending Engineer in WRD, Bihar, is at present head of State Hydrology Cell. After graduating in Civil Engg. from MIT, Muzaffarpur, he obtained M.E. degree from University of Roorkee with specialisation in Earth Dams. Did higher study in Hydrological Engg. from Delft University (Netherlands) alongwith continental study tour of Europe (England, Germany, France, Switzerland, Austria, Holland, Belgium, Luxemburg, Italy, Greece etc.). Worked as expert in the capacity of *Ingénieur d' Etat* for 4 years in Hydraulic Ministry of Govt. of Algeria. Closely associated with Second Bihar Irrigation Commission (1992-94), helped in preparation of its report including evaluation of surface water yield of all the river basins of Bihar and drafting of new consolidated Irrigation Act for the State. Attended several national and international Seminars and Symposia and published many scientific papers. Regularly delivering lectures in Engg. institutions. A voracious reader with a penchant for exploring the fundamentals and thereby unfolding the process of development of knowledge. A polyglot, fluent in French, regularly contributing in reputed national journals and periodicals and participating in electronic media.

He made a dent on national scene as a member of the Technical Expert Committee constituted to give its opinion on the dispute between Andhra Pradesh and Karnataka over *Almatti Dam* in Krishna basin. Also member, International Commission on Large Dams and Fellow, Institution of Engineers (India), he is associated with several such learned societies.



Published under the direction of Colonel H. L. Thuillier C.S.I., F.R.S., Surveyor General of India.
Surveyor General's Office, Calcutta.


IRRIGATION MAP OF
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N
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UTTER
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MADHYA
PRADESH
WEST BENGAL
ORISSA
Tribeni H/W
Done Canal
Narainj Gandak
pokhrd canal
Singhal
Weir
Dhungal
Weir
Tribeni canal
TMC
MWC
Gandak R.
Nepal E.Canal
Tiur
Sch.
Dhaka Canal
Bagmati Barrage
Burhi Gandak
Kamla canal
Kamla Weir
Trisula Weir
Palamw.
Kosi Barrage
Kamla R.
Protective Embankment
Kosi River
Karkai R.
Mechi R.
Mahananda
MOTIHARI
DARBHANGA
Kosi R.
Supaul Br.
Pratapgarh Br.
Purnea Br.
Eastern
BAYA N
DAHAN
GHAGRA R.
GANDAK
CHAPRA
MUZAFFARPUR
SAHARSA
PURNEA
Bhara
Bandh
GANGA
RIVER
Karmnasa R.
ARRAH
PATNA
MONGHYR
Chausa
Pump canal
Chausa
Buxar C.
Arrah Canal
Sone R.
Kumhari Sch.
Patna R. Canal
Dhadwa R. Canal
Chhariori Sch.
Panchane
Morwe
sch.
Khor L.
Sch
Sonepur
Weir
Kanhal
Asthan.
Latifshah D.
Musakhand D.
Dungawari
Sch.
Sora
Kamra
Dam
Shara Sch.
Kaoweir
Bharari Dy.
Dehri Ani Cut.
Kararwar sch
Nira sch.
GAYA
Morhar sch
Koho
Ghat sch
Sakri Weir
Udergshthan
Weir
L. Kiul
proj.
Chanan
BILASI
BHAGALPUR
Jominikal
Sch.
Anand
Sarover
Bulid
Sch.
Upper
Mothor
Sch.
Paimar
Paimar sch.
Job
Sch.
Radhar Sch.
Nagi Dam
Nakti
Res.
Badua
Sch.
Orni
Sunder
Res.
Faraka Barrage
Dharbuo Sch
Chandan
Res.
Daruo Weir
Marsora sch.
Barone sch
Lilajan Sch
Phulwaria sch.
Tilaiya Dam
Usri sch.
Torai Res.
Pagla Weir
Karabani Res
Basandi
Sch.
Kewaldag
Sch.
Harhi
Sch.
Batre sch.
Banki
Left
Utmahi
Sch.
Phulwaria Sch.
DALTONGANJ
Hiru Res.
Dulki Sch.
DAMODAR VALLEY
CORPORATION
Barakar
Lotia
Sch.
Jamunia
Sch.
Khandol
Res.
DUMKA
Mayurakshi Res.
Pandarwa
Sch.
Sarsawatia
Sch.
Soobagh
Sch.
Chordanda sch.
Jamunia sch.
Balphari
Dam
Ajay
Jhay sch.
Chekb
Sch.
HAZARIBAGH
Boddha
Sch.
Abro Sch.
Piri sch
Charwa Sch.
Sendur Koner
Dam
Ajay
Barrage
Arraj
Sch.
Mailo Res.
Sone
Sch.
Ghaghra
Sch
Jurga Sch.
DHANBAD
Maithon
Dam
Bhutan
Duba
Res.
Auranga R.
Ganda Sch
Jamunia
Sch
Khudia
Sch.
Rangha sch.
Badmani Sch
Damodar R.
Auranga
Sch.
Bokaro Barrage
Gowai sch.
Lapasia sch
N.K.Proj.
Birna weir
Nalkari Res.
Buchopa Res.
Tenughat Dy.
Subarnarekha
Phuljhar
Sch.
Kohangh
Sch.
RANCHI
Chirka
Hakti
Weir
Mondhi Scho
Kita Weir
Kokro Weir
Bodonpur
Sch.
Arodih
Sch.
Kanchi Sch
Kanchir.
Jaipur
Sch.
Tajna Sch.
Khatwa
SCH.
Kans
Sch
Para
Sch.
Sona Weir
Subernarekha
Barrage
Chirgaon
Sch
Jenasai Sch
Brahmni Sch.
Basia
Sch.
Bijay
Sch.
Sonua
Sch.
Murum
Sona
Galudih
Barrage
Lowa Sch.
CHAIBASA
Kaida
Sch.
Chinda Res.
Roro
Weir
Deshbandhu
Weir
Torlow Weir
Putungora
Weir
Rajbandh
Weir