IMPACT STUDY OF CHAMRAVATTOM AND KOOTAYI REGULATOR CUM BRIDGES

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PROJECT REPORT

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KERALA, INDIA
2014

DECLARATION

We hereby declare that this project report entitled **"IMPACT STUDY OF CHAMRAVATTOM AND KOOTAYI REGULATOR CUM BRIDGES "** is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

Place: Tavanur,

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CERTIFICATE

Certified that this project report entitled **"IMPACT STUDY OF CHAMRAVATTOM AND KOOTAYI REGULATOR CUM BRIDGES "** is a record of project work done independently by **Jomol T Joseph, Rasmina P and Remya V Mohan** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

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SYMBOLS AND ABBREVIATION

APHA	-	American Public Health association
B	-	Boron
BOD	-	Biological Oxygen Demand
BIS	-	Bureau of Indian Standard
Ca	-	Calcium
Cc	-	Critical damping factor
Cl-	-	Chloride
COND	-	Conductivity
Cu	-	Uniformity coefficient
Cu ft/ s	-	Cubic feet per second
CWRDM	-	Centre for Water Resources Development and Management
D10	-	Grain diameter at 10% passing
D30	-	Grain diameter at 30% passing
D60	-	Grain diameter at 60% passing
EC	-	Electrical Conductivity
EIA	-	Environmental Impact Assessment
DS	-	Down Stream
Fe	-	Iron
Fig	-	Figures
Ft	-	Feet
H+	-	Hydronium ion
Ha	-	Hacters
IIT	-	Indian Institute of Technology
IS	-	Indian standard

KCAET	-	Kelappaji Collage of Agriculture Engineering and Technology
Km	-	Kilo meters
KSRTC	-	Kerala State Road Transport Corporation
KBAs	-	Key Biodiversity Areas
LI	-	Lift Irrigation
m	-	Meter
Mm3	-	Mega meter cube
m3/ s	-	Meter cube per second
mg/ litre	-	Milli gram per litre
mi	-	Miles
Mg	-	Magnesium
MFL	-	Mean Flood Level
MPN	-	Most probable number
MSL	-	Mean sea level
NH	-	National Highway
NO2	-	Nitrite
NO-3	-	Nitrate
NTU	-	Nephlometric Turbidity Unit
P	-	Phosphorus
RCB	-	Regulator Cum Bridge
TB	-	Thanneer Mukkam Barrage
SO42-	-	Sulphate
Sq. m	-	Square meter
Sq. mi.	-	Square miles
US	-	Upstream
USDA	-	United States Department of Agriculture

ºC	-	Degree Celsius
ºF	-	Degree faranheat

INTRODUCTION

CHAPTER I
INTRODUCTION

Uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all of these human uses require fresh water. 70% of Earth's surface is water of which 97.2% is salt water and 2.8% is fresh water. About 1/3 rd of this 2.8% amount of fresh water is only accessible and the remaining is frozen in ice caps.

The utilizable freshwater is found mainly as groundwater, with only a small fraction present above ground or in the air. About 110,000 cubic km of precipitation fall on the world's continents each year, most of which is absorbed by plants and/or evaporated back into the atmosphere, 42,700 cubic km of this precipitation flow through river. 9,000 cubic km of freshwater are readily accessible for human use another 3,500 cubic km are captured and stored in dams and reservoirs.

We currently use about 50% of the world's readily available fresh water (renewable resourse). Surface water is the water in rivers, lakes or fresh water wetlands. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and sub-surface seepage. Sub-surface water, or groundwater, is fresh water located in the pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. If the surface water source is also subject to substantial evaporation, a sub-surface water source may become saline. This situation can occur naturally under endorheic bodies of water, or artificially under irrigated farmland. In coastal areas, human use of a sub-surface water source may cause the direction of seepage to ocean to reverse which can also cause soil salinization. We can increase the input to a sub-surface water source by building reservoirs or detention ponds.

It is estimated that 69% of worldwide water use is for irrigation, with 15-35% of irrigation withdrawals being unsustainable. It takes around 3,000 litres of water, converted from liquid to vapor, to produce enough food to satisfy one person's daily dietary need. This is a considerable amount, when compared to that required for drinking, which is between two and five liters. One of the main water quality problem in coastal areas is due to salt water intrusion. Saltwater intrusion is the movement of saline water into freshwater aquifers, which can lead to contamination of drinking water sources and other consequences. Saltwater intrusion occurs naturally to some degree in most coastal aquifers, owing to the hydraulic connection between groundwater and seawater. Because saltwater has a higher mineral content than freshwater, it is denser and has a higher water pressure. As a result, saltwater can push inland beneath the freshwater. Water extraction drops the level of fresh groundwater, reducing its water pressure and allowing saltwater to flow further inland. Other contributors to saltwater intrusion include navigation channels or agricultural and drainage canals, which provide conduits for saltwater to move inland, and sea level rise. Saltwater intrusion can also be worsened by extreme events like hurricane storm surges.

The fresh groundwater flows from inland areas towards the coast where elevation and groundwater levels are lower. Because saltwater has a higher content of dissolved salts and minerals, it is denser than freshwater, causing it to have higher hydraulic head than freshwater. Hydraulic head refers to the liquid pressure exerted by a water column: a water column with higher hydraulic head will move into a water column with lower hydraulic head, if the columns are connected. The higher pressure and density of saltwater causes it to move into coastal aquifers in a wedge shape under the freshwater. The saltwater and freshwater meet in a transition zone where mixing occurs through dispersion and diffusion.

Groundwater extraction is the primary cause of saltwater intrusion. Under baseline conditions, the inland extent of saltwater is limited by higher pressure exerted by the freshwater column, owing to its higher elevation. Groundwater extraction can lower the level of the freshwater table, reducing the pressure exerted by the freshwater column and allowing the denser saltwater to move inland laterally. Groundwater extraction can also lead to well contamination by causing upwelling, or upcoming, of saltwater from the depths of the aquifer. Under baseline conditions, a saltwater wedge extends inland, underneath the freshwater because of its higher density. Water supply wells located over or near the saltwater wedge can draw the saltwater upward, creating a saltwater cone that might reach and contaminate the well.

Reservoirs are the most important elements of complex water resources development system. They are used for spatial and temporal redistribution of water in quantity and quality and for enhancing the ability of water to generate hydro power. The most important characteristic of reservoir is its potential to cater to multipurpose demand.

The National water policy (1987) suggested that the water resources development projects should be planned and developed as far as possible as multi- objective projects with drinking water supply as top priority followed by irrigation, hydro power etc. The multi-purpose concept in reservoir system is a sound one and its use is increasing day by day due to the following reasons.

(i) Multipurpose projects make the maximum use of a river valley in a unified and a co-ordinated manner.

(ii) In many cases, a mono- purpose reservoir project proves uneconomical and hence, the multipurpose concept has been found necessary in order to provide the much needed economic justification.

In a multipurpose project, the water management would require optimum use of water for various needs at different times. The need for an integrated and comprehensive planning of limited water resources for maximum economic benefits emphasizes the importance of system analysis. Optimization techniques and use of fast digital computers have made it possible to use the system analysis for solving the problems related to resource planning. The second important demand after drinking needs to be met from a reservoir is irrigation. Irrigation consumes a huge quantity of water and quite naturally the major allocation from a reservoir system goes for irrigation. Hence, our aim should be to increase the effectiveness of every drop of water used for irrigation in terms of economy. There lies the importance of crop wise and season wise allocation of the area in the command. Here also, the system analysis techniques play a vital role in optimizing the area allocation for different crops considering various socio-economic constraints.

This project is held in Chamravattom RCB and Thirur RCB. The Chamravattom RCB is across the second longest river, ‘Bharathappuzha’ in Malappuram district of the state Kerala with a length of 209km. the length of bridge will be 978m with a span of 12m having 70 nos of shutters of 12 x 4.50m size. The Thirur RCB is across the river ‘Thirurpuzha’ in Malappuram district of the state Kerala with a length of 48 km.

Construction of regulator cum bridge is a multipurpose project. The main and primary aim this project is to evolve storage sufficiently enough for irrigating gross ayacut area and drinking water supply. Another important aim of this project is effective control of the intrusion of saline water into the upstream side of regulator. Besides, the river when bridged connecting the two adjacent areas, it will improve the communication facilities and also solved the unemployment problems in that area. Barrages or regulator cum bridges use radial or sluice gates to control and raise water levels in their upstream reaches of streams and irrigation canals with mild slopes. These structures are essential for the hydraulic control of these channels to allow the proper feeding of lateral channels or off takes at all range of flow rates. These water control structures can also measure accurately discharge through them which would reduce the need for the construction of separate dedicated flow measurement structures.

The project (RCB) is proposed to stabilize the ayacut maintained by L.I. Scheme in the area that has been commissioned by the State Irrigation Department so far. The capacity of the canal (main and branch) pertaining to all the scheme including their length and other salient details are worked out and attached separately. The capacities of the canals are found quite sufficient and adequate for the purpose and no remodeling is found necessary.

The drinking water supply schemes face acute shortage of water and are in search of additional perennial sources especially during summer, solution to which is also answered better from this scheme. Details of drinking water supply systems and drinking water requirement is appended.

Another important aim of this project is the effective control of the intrusion of saline water into the upstream side of the regulator. The downstream of the river is subjected to tidal and saline intrusion during summer when the river discharge is nil.

The human being has been struggling in order to shape the ecosphere in a manner he wants since the first day. The period in which this struggle was observed most intensively was the period covering the transition from a migrant and primitive hunter society to a resident life and farming. The most deep-seated environmental modification against the nature that had been realized in the history of the human being has started at this time. Even the development and downfall of civilizations are correlated to this interaction between the human being and nature. Barrages have one of the most important roles in utilizing water resources. They were started to construct long years before gaining present information about hydrology and hydromechanics. Barrages have a great deal of positive and negative effects on the environment besides their benefits like controlling stream regimes, consequently preventing floods, obtaining domestic and irrigation water from the stored water and generating energy. Wherever the location of barrage is, its ecological results are the same. The environmental impacts of barrages can be classified according to different criterions as long term and short term impacts, the impacts on the close area and the impacts on the regions where the barrage services, social and unsocial impacts, beneficial and harmful impacts .These effects may be ordered in an intensive and complicated manner like climatic, hydraulic, biologic, social, cultural, archaeological etc. In addition to their very important social and environmental benefits, it is important to minimize the negative effects of dams on the environment regarding sustainable development. The mentioned effects and their solutions have taken into account in the environmental impact assessment concept.

Environmental Impact Assessment (EIA) is a key aspect of many large scale planning applications. It is a technique which is meant to help us understand the potential environmental impacts of major development proposals. Unfortunately as often as not both the process and the outcome of EIA can be complex and confusing leaving local communities unsure as to how a development might affect them.

The material is drawn from regulations, circulars and guidance and is designed to help individuals understand what EIA is and in what circumstances it should be applied. The overall theme of this guide is to encourage local communities to engage in the EIA process. Experts don’t always know best and by ignoring local knowledge their decision may have disastrous consequence for local people living near development sites.

Multipurpose irrigation projects, which are useful in meeting the demand for water in desired times and in regulating stream regimes, have undertaken an important function in the development of civilization. Regulator cum bridges have been constructed in order to prevent floods, to supply drinking and domestic water, to generate energy, for irrigation purposes and for prevention of salt water intrusion. Barrages have a great deal of positive and negative effects on the environment besides their benefits like controlling stream regimes, consequently preventing floods, obtaining domestic and irrigation water from the stored water, prevention of salt water intrusion and generating energy. Barrages hold possibilities of considerable harm for living beings in addition to their advantages such as meeting basic requirements of the society and increasing living standards. Although the effects of water on human life and the development of civilizations are well-known all over the world, it is claimed that the economic benefits expected from the projects designed to utilize water resources could not be gained and also necessary precautions to decrease the environmental, economic and social losses were not taken. Even some studies aiming to block these water supply projects of the developing countries are carried out by some international organizations. Because of this, in the sustainable management of the water, taking into account the economic, social and cultural development and the environmental impacts which came out as a result of the mentioned studies, has gained an increasing importance. Therefore, it is essential that these water resources development studies have a legal background to ensure sustainable development. Plants, animals and people have begun to be damaged from 1960s up today, as a result of uncontrolled extreme population increase, air, water and soil pollution caused by wastes as well as the changes in the ecosystems in parallel. Population increase, technological improvements, the expansions in cities, ways, dams and other engineering studies have disordered the natural balance and the natural body has changed drastically as a consequence of these activities. Meanwhile environment as a subject became popular and has begun to gain importance day by day.

The raising interest against environment cause contradictions between the planners, engineers and some groups in the society who are against all engineering buildings especially barrages. On the other hand, it becomes unavoidable to construct the mentioned plants and buildings to enhance the prosperity of the country by realizing socio-economic and technological developments. Nowadays living cultural, social and environmental values must be taken into consideration in the planning studies which are done based on this new understanding, as well as technical standards and economical values. At this stage, water resources planners have to give more importance to environmental problems in their plans. The planners should be reformist, broad-minded, sufficient in evaluating critical needs. This innovation is necessary for alternatives such as designing less water demand, encouraging solutions which are not structural in flood control, finding better methods to process wastes and purification of waste water. The relations between water pollution, air pollution and solid wastes must be known very well from a broad perspective. There is need to evaluate the real necessity that means the parallelism between the water supplied and the population distribution. Moreover, the importance of water projects in ecological relations and the effects of the projects on water pollution should be known. The most important between these is the evaluation of real necessity. Water projects and acceptable public studies will continue to provide public health and security. Some projects may exchange alternatively. Hydroelectric projects may take the place of insufficient fuel oil. Purposes like hydroelectric, irrigation, flood and recreation spots should be thought all together. Storage pollution changes when better treatment serves more effectively.

In case of a need for a new project arise, the planner has to assess the ecological impacts in and around the stream carefully and he/she has to improve his project in a manner that it will have the least hazardous impacts. Wherever the location of a dam is, its ecological results are the same. The environmental impacts of dams can be classified according to different criterions as long term and short term impacts, the impacts on the close area and the impacts on the regions where the dam services, social and unsocial impacts, beneficial and harmful impacts. The present investigation was undertaken to study the impact of regulator cum bridges.

The specific objectives were;

1. To study the impact of regulator cum bridges on water quality.
2. To study about the impact of Chamravattom regulator cum bridge on soil characteristics.
3. To study about impact of Chamravattom regulator cum bridge on ground water recharge.
4. To study about impact of Chamravattom regulator cum bridge on agriculture sector.
5. To study about the tourism possibilities of Chamravattom bridge.
6. To study the impact of chamravattom regulator cum bridge in transportation.
7. To study the impact of chamravattom regulator cum bridge on ecosystem.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITREATURE

Water is an essential and unique resources that provides life support for plants and animals. For humans, there can be nothing which is more important than water. The phenomenal growth in population during last two decades has resulted in excessive use of water resources in the country. The world population has tripled, but the use of water for human purpose are multiplied six fold. Today about 80 countries comprising of 40% of the population suffer from serious water crisis. According to an estimate, one out of six persons in the developing countries do not have enough drinking water. Leading experts on water resources have been warning that the world is heading towards a water shock which may dwarf the oil crisis. It is, therefore, advisable to have total water planning in a region for allocating water to different sectors for future also. The total and utilizable surface and ground water resources of the region are determined and requirement of water for different uses found out. More often than not total requirements would exceed the availability. In such circumstances water has to be allocated to different sectors after prioritization and optimization. There is no fixed universal mathematical principle by which priorities can be set up in a particular location. The priority to which water should be given would depend upon the local conditions like climate, soil, habits of the people, status of development of agriculture and industries, recreational and tourist requirements etc.

A reservoir is created with the purpose of impounding part of the runoff from the catchment upstream by the construction of regulator or dam across a river or stream. Storage is done during the period when the flow is in excess of demand and released during the lean period so as to maintain constant water supply for drinking, irrigation and other uses including power generation, prevention of salt water intrusion. A barrage is a type of dam which consists of a line of large gates that can be opened or closed to control the amount of water passing the dam. The gates are set between flanking piers which are responsible for supporting the water load. They are often used to control and stabilize water flow of rivers for irrigation systems. According to the World Commission on Dams, a key difference between a barrage and a dam is that a dam is built for storing water in a reservoir, which raises the level of water significantly. A barrage is built for diverting water, and is generally built on flat terrain across wide meandering rivers, raising the water level only a few feet. Barrages are larger than head works. Barrages that are commonly used to dam a lagoon or estuary as a method to capture tidal power from tidal inflows are known as tidal barrages. The only difference between a weir and a barrage is of gates that is the flow in barrage is regulated by gates and that in weirs, by its crest height.

2.1 Classification of Regulator Cum Bridges

2.1.1 According to purpose

(i) Regulation of discharge

(ii) Regulation of water slopes (and velocity)

(iii) Measurement of discharge

(iv) Division or diversion of discharge

(v) Change in bed slope

2.1.2 According to location

(i) Head Regulator cum Bridge

(ii) Intermediate Regulator cum Bridge

(iii) Escape Regulator cum Bridge

(iv) Division and Diversion Regulator cum Bridge

2.1.3 According type of construction

(i) Masonry arch regulator

(ii) Mixed type regulator (masonry + RC)

(iii) RC regulator

2.2 Location of Regulator cum Bridges

The site for regulator cum bridges should be selected such that

(i) They are always be located at straight reaches

(ii) They are never located within curves in waterways (either silting or scouring is liable to occur causing destruction of the regulator).

(iii) They are located at diversion; location should be chosen 50-200m DS the point of diversion.

2.3 Advantages of Regulator cum Bridges

(i) Regulator may be fully opened at flood time giving enough water way area to avoid excess heading up.

(ii) Both upstream and downstream water levels are controlled.

(iii) Minimize silting at upstream.

2.4 Main elements of Regulator cum Bridges

The main elements of Regulator cum bridges are:

(i) Water area of vents

(ii) Bridge

(iii) Piers between the regulator vents

(iv) Abutments

(v) Floor

(vi) Gates

2.5 Design of Regulator cum Bridges

2.5.1 Design elements of Regulator cum Bridges

(i) Estimation of design flood

(ii) Hydraulic units

(iii) Width of barrage

(iv) Afflux

(v) Tail water rating curve

(vi) Crest levels

(vii) Discharges through a barrage (free flow conditions)

(viii) Discharge through a barrage (submerged flow conditions)

2.5.2 Design data for Regulator cum Bridges

General

(i) Name of stream

(ii) What arrangements exist for crossing the river at present?

(a) During monsoon

(b) During dry season

(iii) Has earthquake ever occurred in the region of the bridge site? If so, what was its intensity?

(iv) Catchment area in sq.km

(v) Maximum recorded intensity of rainfall in catchment

(vi) Rainfall in centimeters per year in the region

Nature of stream

(i) Is the stream

(a) Alluvial (with erodible banks)

(b) Quasi-alluvial (with more or less fixed bed but erodible banks)

(c) Rigid (with unreadable banks and bed)

(ii) Is the stream

(a) Perennial

(b) Seasonal

(c) If tidal, level of high tide

(d) If tidal, level of low tide

(iii) Are the banks at the proposed site?

(a) Firm and steep

(b) Firm but gently sloping

(c) Erodible and indefinite

(d) Does the stream confine itself within banks or overtop banks in floods

(iv) Nature of stream in the vicinity of the proposed site

(a) Clean bed, straight banks or rifts or deep pools

(b) Widing - some pools and shoals, but clean

2.6 Objectives of Regulator cum Bridges

(i) To evolve sufficient storage for irrigating a gross command area.

(ii) To stabilize the Irrigation potential of the command area.

(iii) To solve the drinking water problems in the area by increasing the water table level in the nearby wells.

(iv)To control effectively the intrusion of saline water towards the upstream side of the regulator.

(v)The river when bridged will be an important link connecting two banks.

(vi) Recurring damages of river bank now being experienced can be prevented as upstream side is proposed to be protected by flood banks.

(vii)To rebuild the environmental conditions of the existing area

2.7 Impacts of Regulator cum Bridges

Prevention of saline water intrusion, increase in ground water table, increase in agricultural production, improved transportation and communication facilities are the main objectives of regulator cum bridges. Even though regulator cum bridge has number of positive impacts, it has got number of negative effects also, especially on the upstream side of it. The study was undertaken for analyzing the impact of regulator cum bridge at Koottayi, Chamravattom in Malappuram District (Kerala, India) with the specific objectives of determining the impact on water quality, ground water fluctuations, agriculture and transportation. The results of the study reveal that Koottayi regulator cum bridge has got many positive impacts including prevention of salt water intrusion and increased fresh water availability. At the same time it adversely affects the quality of water due to the restriction of natural flushing action of the river. It creates stagnant layers of water and also accumulates pollutants in the upstream side of regulator cum bridges. Due to this amount of dissolved oxygen in river water gets reduced. This intrusion adversely affects the aquatic ecosystem.

The results of the study about chamravattom regulator cum bridge shows that it has got more positive impacts than negative impacts. The positive impact of Chamravattom regulator cum of reduction in saline water intrusion, raise in ground water table and increase in the area of production. On the other hand it adversely affect the quality of the water on the downstream side.

2.7.1 Positive impacts on Regulator cum Bridges

A reservoir is created with the purpose of impounding part of the runoff from the catchment upstream by the construction of regulator or dam across a river or stream. Storage is done during the period when the flow is in excess of demand and released during the lean period so as to maintain constant water supply for drinking, irrigation and other uses including power generation, prevention of salt water intrusion.

Kotri Barrage is a barrage on the Indus River near Hyderabad in the Sindh province of Pakistan. The barrage was completed in 1955. Kotri Barrage is used to control water flow in the River Indus for irrigation and flood control purposes. It has a discharge capacity of 875,000 cusecs. It is a gate-controlled weir type barrage with a navigation lock. The barrage has 44 bays, each 60 feet (18 m) wide. The maximum flood level height of Kotri Barrage is 43.1 feet. It feeds Fulleli, Pinyari and Kolari Canals.

The Chao Phraya Dam is a barrage dam located in Sapphaya District, Chainat, Thailand. It regulates the flow of the Chao Phraya River as it passes into lower Central Thailand, distributing water to an area of 11,600 square kilometers (4,500 sq mi) in seventeen provinces as part of the Greater Chao Phraya Irrigation Project. The dam has sixteen 12.5-metre gates, and its construction took place from 1952 to 1957.

The Prakasam Barrage project across the Krishna River connecting Krishna and Guntur districts, Completed in 1957 it helps irrigating 12 lakh (1.2 Million) acres of land. One of the first major irrigation projects of South India, the Prakasam Barrage in Vijayawada was completely successful in its mission. Andhra Pradesh largely owes its rich agriculture to the Prakasam dam as the project facilitated the irrigation of large tracts of farmland. The dam provides views of the lake. It has become a tourist attraction of Vijayawada. . The barrage serves also as a road bridge and spans over a lake.

Kota Barrage is the fourth in the series of Chambal Valley Projects, located about 0.8 km upstream of Kota City in Rajasthan. Water released after power generation at Gandhi Sagar dam, Rana Pratap Sagar dam and Jawahar Sagar Dams, is diverted by Kota Barrage for irrigation in Rajasthan and in Madhya Pradesh through canals on the left and the right sides of the river. The work on this dam was completed in 1960. The total catchment area of Kota Barrage is 27,332 km^2, of which the free catchment area below Jawahar Sagar Dam is just 137 km^2. The live storage is 99 Mm^3. It is an earth fill dam with a concrete spillway. The right and left main canals have a head works discharge capacity of 188 and 42 m^3/sec, respectively. The total length of the main canals, branches and distribution system is about 2,342 km, serving an area of 2,290 km^2 of CCA. 50% of the water intercepted at Kota Barrage has been agreed to be diverted to Madhya Pradesh for irrigation. The Barrage operates 18 gates to control flow of flood and canal water downstream, and serves as bridge between parts of Kota on both side of the river.

Guddu Barrage is a barrage on the Indus River near Kashmore in the Sindh province of Pakistan. The barrage was completed in 1962 at a cost of 474.8 million. Guddu Barrage is used to control water flow in the River Indus for irrigation and flood control purposes. It has a discharge capacity of 1.2 million cubic feet per second (34,000 m^3/s). It is a gate-controlled weir type barrage with a navigation lock. The barrage has 64 bays, each 60 feet (18 m) wide. The maximum flood level height of Guddu Barrage is 26 feet (8 m). It controls irrigation supplies to 2.9 million acres (12,000 km^2) of agricultural land in the Jacobabad, Larkana and Sukkur districts of Sindh province and the Naseerabad district of Balochistan province. It feeds Ghotki Feeder, Begari Feeder, Desert and Pat Feeder canals.

Farakka Barrage is a barrage across the Ganges River, located in the Indian state of West Bengal. Construction was started in 1961 and completed in 1975. The barrage is about 2,240 metres (7,350 ft) long. The barrage was built to divert up to 44,000 cu ft/s (1,200 m^3/s) of water from the Ganges River into the Hooghly River during the dry season, from January to June, in order to flush out the accumulating silt which in the 1950s and 1960s was a problem at the Port of Kolkata (Calcutta) on the Hooghly River. The Hooghly River divides Murshidabad and Malda districts of West Bengal.

The Fitzroy river barrage (Queensland) project was finished in 1970 after four years of construction, to meet the long term water supply needs of Rock Hampton. It holds around 80,000 mega liters of water. It is owned and operated by Fitzroy River Water, which is a commercial business activity of the Rock Hampton Regional Council. There are 18 gates on the barrage that are computer operated to open up one by one when water gets to a certain level, although it would only be in times of flood that all 18 gates would be open. The barrage also incorporates a fish ladder to allow fish to get from the tidal water to the fresh and vice versa.

A large barrage on the Indus river with a series of embankments or flood bunds which, at low water levels, divide the reservoir into five shallow lakes each of up to 250 ha in area. The construction was completed in 1971. Maximum flooding occurs in spring. The depth of the five lakes varies from 0.2m in the dry season to 5.0m at the height of the flood season; the depth of the main river channel varies from 4.6m to 8.8m. PH values range from 6.5 to 7.2.

The Bhimgoda Barrage, also referred to as the Bhimgoda Weir or Bhimgoda Head Works, is a barrage on the Ganges River at Har ki Pauri near Haridwar in Haridwar district, Uttarakhand, India. Built as the head works of the Upper Ganges Canal, an initial barrage was completed by 1854 and replaced twice; the final one completed in 1983. The primary purpose for the barrage is irrigation but it also serves to provide water for hydroelectric power production and control floods. The area behind the barrage is known as the Neel Dhara Bird Sanctuary and is a popular destination for various water birds and tourist.

The Nampho Dam or West Sea Dam, also known as the West Sea Barrage, is a barrage located 15 km west of the special city of Nampho, North Korea. It is a huge, eight-kilometer-long system of dams, three lock chambers, and 36 sluices, allowing the passage of ships up to 50,000 tons. The dam closes the Taedong River off from the Yellow Sea. It was built from 1981 to 1986, with the resources of the whole country directed to this main construction project. The stated goal of the West Sea Dam was:

(i) The raising of the water level in the Taedong River and increased ship traffic.

(ii) The prevention of seawater intrusion into the fresh water, thus solving the water supply problem.

(iii) The irrigation of additional land, enlarging the arable territory of the region.

Joseph et al. (1986) conducted a study on the vembanad kole wetland system and river basin management. The main aim of this study was to find out the water regime changes in the wet land. From this study they found that construction of Thanneermukkom barrage has created number of water quality problems. Thaneermukkom barrage constructed across the Vembanad backwater has succeeded in its primary purpose of preventing salinity intrusion in Kuttanad belt. However, it has created a number of water quality problems such as restricting the flushing action, thereby making upper portion of the Vembanad lagoon into a bowl of agrochemicals and fecal matter, and also accelerating the growth of water hyacinth and other weeds which cause problems to inland navigation. The barrage has adversely affected fishing communities and it is reported that estuarine fisheries have dwindled considerably.

The Viyyam Regulator Cum Bridge is a multipurpose project (1991). The aims of this project are to prevent the salinity intrusion into the kole lands. It also helps irrigation of puncha corps upstream of kole lands by utilizing the storage created by the intervention. It also function as a flood control structure by leading the entire flood discharge of the Viyyam kayal to the Kanjiramukkuriver. In addition to the puncha crop, the impounded salinity-free water can be used for irrigating cash crops viz., coconut, arecanut, pepper etc. as well. The single lane bridge proposed would reduce the distance between Kanhiramukku and Edappal

Ponnani road by 8km. The road bridge connects Ponnani Municipality and Maranchery Grama Panchayath. On completion of the project saline water intrusion into the vast kole lands extending to2430 ha prevented completely. This would help production of paddy considerably as more numbers of farmers would resort to puncha paddy cultivation. Yearly expenditure on constructing temporary bund can be stopped. The impounded storage would recharge the ground water table and the problem of drinking water shortage can be solved to great extent. Also, pumped irrigation from wells for cash/other crops shall be possible as the reservoir created would recharge the wells. Hence in addition to paddy, production of cash crops like coconut, arecanut, pepper etc. Would also increase. Since it is directly connected to sea, this intervention would help to reduce the effects of natural calamities such as Tsunami to some extent. During monsoon, the flood discharge can be regulated effectively through the Kanhiramukku River by preventing irregular flow of flood waters on the downstream side. The single- lane bridge structure would provide road access to thousands of local people. The school- going children would be the main beneficiary. The distance between Kanhiramukku to Ponnani can be reduced by 8 km. the Kanhiramukku river on the downstream side has tremendous potential for tourism development as well.

The Hathnikund Barrage is a concrete barrage located on the Yamuna River in Yamuna Nagar district of Haryana state, India. It was constructed between October 1996 and June 1999 for the purpose of irrigation. It replaced the Tajewala Barrage 3 km (2 m) downstream which was constructed in 1873 and is now out of service. The barrage diverts water into the Western and Eastern Yamuna Canals. The small reservoir created by the barrage also serves as a wetland for 31 species of water birds. Plans to replace the Tajewala Barrage had been in the works since the early 1970s but an agreement between the governments of Haryana and Himachal Pradesh (which share the water it diverts) was not made until July 1994. The barrage is 360 m (1,181 ft) long and its spillway is composed of ten main floodgates along with five under sluices on its right side and three on its left. The maximum discharge of the barrage is 28,200 m^3/s (995,874 cu ft/s) (1 in 500 year flood).

Nagaragawa Estuary Barrage project is completed in 1997, this project serving as a Prevention of Saline Damage Due to Dredging and Water Resources Development. In the lower reaches of the three Kiso rivers facing Ice Bay, saltwater has been entering under fresh water as if a wedge were inserted and intruding upstream, and the inhabitants have suffered salinization of both river water and ground water used as drinking and agricultural water supplies, and soils on farmlands. The ground subsidence caused by the need to draw on very large amounts of ground water since the mid-1950s led to saltwater intrusion further upstream, aggravating the saline damage. Salinity of ground water in the Nagashima-cho area used to be very high before the Nagaragawa Estuary Barrage went into service. Since the barrage went into service, salinity of waters upstream of the barrage has decreased, and the salinity of ground water in the Nagara river area is on the decline.

The Dakpathar Barrage is a concrete barrage across the Yamuna River adjacent to Dakpathar in Uttarakhand, India. In a run-of-the-river scheme, the barrage serves to divert water into the East Yamuna Canal for hydroelectric power production at the Dhakrani and Dhalipur Power Plants. The barrage is controlled by 25 floodgates and has a length of 516.5 m. The entrance to the canal is directly behind the dam on its left bank. Water discharged from the Dhalipur Power Plant continues along the canal until it reaches the reservoir of the Asan Barrage.

The Asan Barrage is a barrage in the Uttarakhand-Himachal Pradesh border region in Doon Valley, (Dehradun District), northern India, situated at the confluence of the Eastern Yamuna Canal and the Asan River and about 11 km (7 mi) from Dakpathar, and 28 km. northwest of Dehradun. Directly behind the barrage on its eastern flank, water reenters the Eastern Yamuna Canal on the west side of the Yamuna River. At a distance of 4.5 km (3 mi) from the barrage on the canal, water reaches the 30 MW Kulhal Power Plant.

The Goolwa Barrage project consists five barrage structures in the channels linking Lake Alexandrina to the mouth of the River Murray and the Coorong in Australia. They were constructed in order to

(i) Reduce salinity levels in the lower reaches of the River Murray, Lake Alexandrina and Lake Albert and

(ii) To stabilise the river level, for both upstream irrigation and

Prior to the barrages, during periods of low flow tidal effects and the intrusion of seawater were felt up to 250 km upstream from the mouth of the River Murray, approximately as far inland as present-day.

The Tees Barrage is a barrage across the River Tees just upriver of Blue House Point in the borough of Stockton-On-Tees in North East of England and is used to control the flow of the river, preventing flooding and the effects of tidal change. The Tees Barrage comprises a river barrage, road bridge, footbridge, barge lock, fish pass and white water course. The waters above the barrage are permanently held at the level of an average high tide and are used for watersports such as canoeing, jet skiing, dragon boat racing and incorporates a 1 km rowing course. The barrage is accessible by road only from Thorn by-on-Tees as there is very limited road access to the north bank of the Tees.

The Fitzroy River Barrage is a dam type structure built as part of the Camballin Irrigation Scheme in Western Australia. It was a series of collapsible shutters which were designed to collapse when the river level was approximately twelve inches over the shutters. The structure was intended to divert the water in the Fitzroy River to be stored in the Seventeen Mile Dam, by flowing up Uralla Creek, unnaturally in the opposite direction to the natural flow of the creek. The barrage was built by the Public Works Department of Western Australia and was designed to hold 4.58 x 106 cubic metres of water. A small village was erected at the barrage site during the construction phase. Presently there is still the superstructure remaining along with the stilted shed which was used as machinery shed. The Department of Water currently still maintains a small shed on the site for its stream gauging equipment.

The Eider Barrage is located at the mouth of the river Eider near Tonning on Germany’s North Sea coast. Its main purpose is protection from storm surges by the North Seas. It is Germany’s largest coastal protection structure. It was also intended to contribute to economic recovery in the districts of Norderdithmarschen and Eiderstedt. The barrage comprises two separate rows each of five gates. The site was laid out in such a way as to guarantee the level of protection of a double dyke. Between the gates a road runs through, protected by a 236 metres long tunnel. Above the tunnel is a footpath, which offers a good view of the west coast and the river Eider. Also equipped with double gates is a lock incorporated into the barrage for shipping. Including the newly built dyke, the barrage is 4.9 kilometers long, lies 8.5 metres above sea level and 7 metres above the average high tide. Five gates, each 40 metres long, allow the water of the Eider to flow into the North Sea when the tide ebbs, and North Sea water into the Eider when it flows. Nearby is a 75 metres long and 14 metres wide lift lock (*Kammerschleuse*), through which ships pass into the North Sea from the adjacent harbor. Today the barrage is also a tourist attraction as they travel through Eiderstedt with its seaside resorts of Sankt Peter-Ording and Vollerwiek or the resort of Grading. The construction of the barrage resulted in the old Eider estuary becoming the Katinger Watt nature reserve; on the opposite side of the river in 1989 the Dithmarscher

Eider watt was established in order to at least partially compensate for the losses of salt meadows and mudflats caused by the building of the barrage. Many fishing smacks were moved from Tonning to the fishing port by the barrage which was closer to the fishing grounds.

Kavanakallu Regulator cum bridge (RCB) across Chaliyar River in Malappuram Completed Projects District of Kerala (2000). The river Chaliyar is the main source of water to the city of Kozhikode. People residing in a number of nearby Panchayath also depend on this river for irrigation and drinking purposes. Though the river is water rich, the water level depletes during summer and there used to be severe shortage. Besides, there is salt water intrusion which further compounds the problem. Though, there had been the practice of constructing a temporary bund to prevent the entry of saline water, it involved huge recurring expenses every year. Against this backdrop, the Government of Kerala decided to construct a bridge cum regulator at Kavanakallu Chaliyar. This multi-purpose project was started in December 1992. The project was commissioned on 21st November 2000. The reservoir stores about 12 million cubic metres of water and has become a great boon to the people of Kozhikode and Malappuram districts in its adjoining areas in meeting their needs of drinking water and irrigation. About 2000 ha of cash crops could now be directly irrigated. It is also possible to supply adequate drinking water to Kozhikode Corporation Area. Further, salt water intrusion into the Agricultural land on the upstream side of the regulator has been successfully arrested. Besides, the above benefits of irrigation and drinking water supply, the construction of the regulator cum bridge has helped the people of the area in mitigating their transportation difficulties too. The construction of the bridge across the river and the resultant connectivity has helped in bringing about a sea change on this front as well. There is considerable reduction in road distance from places like Nilambur, Manjeri etc. to Mavoor and Kozhikode**.**

Thrithala multipurpose medium irrigation Project (2007) envisages the construction of a regulator cum bridge across Bharathapuzha at Thrithala (Velliyamkallu) in Ottappalam Taluk in Palakkad District. The project is expected to provide irrigation facilities to 1883 ha area in Ottappalam Taluk, provide drinking water facilities to Kunnamkulam, Chavakkadu and Guruvayur Municipalities and 22 Panchayath in the Project area benefiting about 7 lakh people.

By impounding water within the river with flood banks for a quantity of 13.3 Mm3 the ground water for the area will be energized to a comfortable level. No submergence of land is involved due to impounding of water since reservoir is proposed to be retained within the confines of river margin itself by means of Flood bank on either side. Regarding the communication facilities, the RCB will connect the underdeveloped places of Paradur, Pallipuram etc to Thrithala and Kunnamkulam. The distance from Kozhikode to Kunnamkulam and Guruvayoor via Valancherry through this RCB will be reduced by 11 km.

The Severn Barrage refers to a range of ideas for building a barrage from the English coast to the Welsh coast over the Severn tidal estuary. Ideas for damming or barraging the Severn estuary (and Bristol Channel) have existed since the 19th century. The building of such a barrage would be a huge engineering feat, comparable with some of the world's biggest construction projects. Transport links, flood protection, harbor creation, or tidal power generation are the main purposes of this project. In recent decades it is the latter that has grown to be the primary focus for barrage ideas, and the others are now seen as useful side-effects. The Severn Tidal Power Feasibility Study (2008–10), the British government concluded that there was no strategic case for building a barrage but to continue to investigate emerging technologies. The Marina Barrage is a dam in Singapore built at the confluence of five rivers, across the Marina Channel between Marina East and Marina South. It was officially opened on 1 November 2008. It was Singapore's fifteenth reservoir. It provides water storage, flood control and recreation.

Ouseburn Barrage was officially opened in September 2009 and brought a much needed improvement to the area. But it was only up and running for just over a year before work began on refurbishing the nearby Toffee Factory. The aim of the barrage, with its lock and weir, is to prevent the tide going out and exposing the lower reaches of the Ouseburn to mud, silt, debris and odor. It was expected that by impounding the river and keeping the water level at around 2.6 meters, a more attractive waterside environment will be created.

Praveena N, Rakhi J. F and Ajay Gokul A.J (2013) conducted a study on impact study of Koottayi regulator cum bridge (Malappuram district, Kerala) with the specific objectives of determining the impact on water quality, ground water fluctuations, agriculture and transportation. The results of the study reveal that Koottayi regulator cum bridge has got many positive impacts including prevention of salt water intrusion and increased fresh water availability. At the same time it adversely affects the quality of water due to the restriction of natural flushing action of the river. It creates stagnant layers of water and also accumulates pollutants in the upstream side of regulator cum bridges. Due to this amount of dissolved oxygen in river water gets reduced. This intrusion adversely affects the aquatic ecosystem.

2.7.2 Negative impacts of Regulator cum Bridges

The Cardiff Bay Barrage lies across the mouth of Cardiff Bay, Wales between Queen Alexandra Dock and Penarth Head. It was one of the largest civil engineering projects in Europe during construction in the 1990s. Watson proposed building a barrage stretching across the mouth of Cardiff Bay from Cardiff Docks to Penarth which would impound freshwater from the rivers Ely and Taff to create a large freshwater lake - thus providing permanent high-water. By making the area more appealing it was hoped this would attract investment into the docklands. The barrage was consequently seen as central to the regeneration project. In 1987, prior to approval of the construction of the barrage, the Cardiff Bay Development Corporation was established to proceed with redeveloping the docklands - an area comprising one sixth of the entire area of the city of Cardiff. In November 1999 the barrage was completed and the sluice gates closed at high water to retain the seawater from the Bristol Channel within the 500-acre bay. At first major water-quality problems ensued which required the bay to be drained dry overnight and re-filled each day. Eventually oxygenation systems (based on those used at the Swansea Barrage) were installed which improved water quality and allowed the composition of the Bay to become entirely freshwater - the only salt-water ingress being that from the three locks providing access to and from the sea for the proliferating number of boats using Cardiff Bay. The barrage was opened to the public in 2001. Impact on the ecology of the bay, According to two studies published in 2006, the loss of intertidal mudflats has resulted in the numbers and diversity of the birds using Cardiff Bay greatly reducing. Almost all of the Common Shelduck and shorebirds that used the bay when mud was exposed no longer feed there. Initially these birds used nearby sites to feed, but in most cases, this behavior was not sustained, and the birds were unable to settle elsewhere. Common Redshanks displaced from Cardiff Bay settled at the nearby Rhymney estuary, but they exhibited lower body weight, and their annual survival rate declined from 85% to 78% as a result of lower levels of winter survival. The freshwater lake had problem with blue-green algae initially which made it impossible to swim in the water or participate in water sports. These issues have now largely been resolved though some toxic algae remains in some of the dock areas in the Bay. Cardiff Bay has become the first area of freshwater in Wales to be infested with zebra mussels - an alien species to the

UK which multiplies rapidly to the detriment of native marine life. The Cardiff Harbor Authority has decreed that "Personal watercraft" used in Cardiff Bay such as kayaks, canoes and sailing dinghies must be washed down with bleach solution before being taken to any other area of freshwater.

Anitha et al. (1988) conducted a study on integrating wetlands and river basin management in the Vembanad kole wetland system. The aim of this study was to analyze the regulators for the prevention of salt water. The Karanchira lock and the Kottenkottuvalu regulator were constructed to prevent saline water intrusion. The proposed regulators at Koothumakkal and Thamaravalayam and Idiyanchira regulators are expected to control the salinity ingress more effectively. Research shows that intrusion of salt water can be achieved if water flow rates of 11 m2 /sec are maintained. This could be achieved either by diverting water from the Karuvannur river or through better management of current water resources in reservoirs and impoundments.

Banerjee (1999) conducted a study on the Impact of Farakka Barrage on the Human Fabric. The broad objective of the study is to see the impact of the Farakka Barrage resulting into aggravation of flood and riverbank erosion upon the people living in the immediate upstream and downstream area. The problem of rural improvisation and marginalization and response to the situation is observed along with the background history of the barrage, expert’s assessment of the situation and possible solutions.

A joint study conducted by IIT, Chennai and CWRDM, Kozhikode on the environmental aspects of Thanneermukkom barrage and Thottappally spillway proposed the Government to enhance the duration of the shutters of the barrage opened up during December-March, usually when it keeps closed. If approved by the Government, the ingress of saline water upstream Vembanad Lake will take place for more days. This is a long-standing demand of various environmental organizations and activists concerned on the lake. The project will help mending the ecological damages occurred to the region in the past as well as augmenting paddy cultivation. The other main recommendations of the study group: The flood water level of Kuttanad may be reduced by half a metres during rainy season, if the width of the approach canal of Thottappally spillway is increased by 300 metres 10 km upstream from the present 100 metres. The issue of pollution of Vembanad Lake may be reduced if the coffer dam portion of the Thanneermukkom barrage be removed and new gates and shutters fixed. Installing an array of ten sensors 250 m upstream of Thanneermukkom barrage may enable measuring the salinity level of lake water upstream when the shutters are opened. It is estimated that the salinity below 1.5 ppt (parts per thousand) will not damage the cultivation of Kuttanad. The shutters may be regulated to control the salinity below this stipulated measure. Simultaneously, the shutters may be regulated based on the readings taken from the sensors fixed downstream to take note of the salinity there other water sources of Onattukara and Kuttanad.

The Swansea barrage (or the Tawe barrage) project was completed in 1992 creating a new marina at the mouth of the River Tawe extending the leisure boat facilities already being offered by the old South Dock. The barrage structure includes a boat lock, spillway, and fish pass and generator turbine. The turbine serves a dual use: acting as a power generator for the National Grid as well as being used to pump water back into the Tawe river system. The barrage scheme gave rise to a number of environmental concerns. Fish navigation up the river and dissolved oxygen levels were problems that arose after completion. Salt water that came in at high spring tides sank to the bottom and stayed there, reducing oxygen levels. The Environmental Advice Centre was commissioned to undertake an aeration scheme trial in the River Tawe in the summer of 1998. The system was based on a diffuser design and propeller mixer, which proved highly effective at exporting the saltwater from the deep area of the trial site and raising dissolved oxygen concentrations at the bed. Following the success of the trial system a more extensive system was designed for the river for installation in 1999 -2000. The installation comprised a combination of diffusers and a large propeller mixer. The installation will be completed over two years to treat all the problem areas over a 4km long reach of river and ameliorate the poor water quality presented in these areas. Monitoring results from the system installed to date have indicated that aeration has effectively raised the oxygen concentration and assisted in the export of saline water from the system. Other fears that arose with the building of the barrage such as the raising of the water table causing ground subsidence problems in the low-lying areas around the River Tawe. Since completion, no significant subsidence problems have arisen.

CWRDM (1997) conducted studies on quality of water and soils of estuarine agricultural lands. Kattampally River is a tributary of Valapattanam River in North Kerala. A regulator has been constructed during 1967 with thirteen shutters, a lock gate and road over the regulator. This regulator is intended to control flood due to backing up of flood discharge in Valappattanam River and to control salinity intrusion in estuarine paddy cultivated land. However the paddy cultivation in the estuarine paddy cultivated land declined due to many reasons and major part of the land kept as fallow. Subsequently due to normal wear and tear the shutters of the regulator got leaky and salt water intrusion through the leaky shutters used to occur especially during summer months. CWRDM has been asked to study the quality of water and soil in the estuarine agricultural land by Govt. of Kerala during 1997.the study revealed that the water quality in the estuary reached up to sea salinity due to heavy leakage and sea water intrusion through the damaged and leaky regulator shutters. Based on the recommendations of CWRDM, irrigation department Govt. of Kerala repaired and replaced all the shutters of the regulator during 1999. The project was envisaged to study the effectiveness of regulator to control the saline water intrusion into the estuary from downstream side. The objectives of the scheme are

(i) To evaluate the effectiveness of the regulator at Kattampally towards the controlling sea water intrusion into the upstream estuarine reach.

(ii) To evolve a shutter operation criteria for the regulator at Kattampally towards controlling the water levels at upstream side and sea

The conclusion of the study were as follows

(i) The gauge reading at Kolasserinthodu for the period of Nov. 2003 to Dec. 2004 shows that there is flowing the stream except for the month of March and April 2004. The runoff coefficient at this gauging station gives values as 0.46 for June, 0.65 for July and 0.68 for August.

(ii) The gauge reading at Palliparamba and Munderipalam in the Kattampalli estuary shows that there is shortage of water throughout the year with mean monthly maximum of 108m and minimum of 0.20m.

(iii) One day maximum rainfall in the catchment for a return period of 25 years is worked out as 275.55mm the average one day maximum is 124.76mm

(iv) It is observed that before reconditioning and leak proofing of shutters, (before 1999) sea water intrusion in Kattampalli estuary was total to the tune of 40,800 micromhos/cm. After reconditioning and replacement of shutters, salinity has been considerably reduced in the estuary and the maximum observed is 16,990 micromhos, i.e. there is more than 50% reduction in the salinity in the estuary. Further reduction is possible through further leak proofing at the bottom and sides of shutters.

(v) An operation criteria for the regulator has been involved based on duration of shutter opening and depth of water level to be lowered at the upstream side of the estuary.it can be used as a guideline for optimal operation of shutters towards controlling flooding and sea water intrusion in the Kattampalli estuary at the upstream side of the regulator.

The recommendations of the study were as follows

(i) Salinity control measures at Kattampalli estuarine wetlands can be further improved by proofing, reconditioning and periodic leak proofing, reconditioning and perfecting the closing and opening operation of the regulator shutters. During summer season the opening of shutters should be limited to the recession part of tidal cycle. The rating chart developed for this purpose can be used as a guide line towards the optimal shutter operation criteria for regulator at Kattampally.

(ii) The operation of shutters must be perfected and there should be a means to ensure the same especially during summer months. The lock gate operation also has to be minimized for an optimal requirement during summer season. Agricultural development in the upper part of regulator may be taken up after an operational pilot study in small area.

Zaidi et al. (2003) conducted a study on problems in Taunsa barrage. The aim of this study is to find out the problems in Tounsa barrage, their impacts and proposed remedial measures. The major problems are Excessive sedimentation and Excessive retrogression of downstream water levels forcing limitation on head across and creating energy dissipation problems

a. Retrogression of levels on the downstream and resulting problem of jump washout and energy dissipation

b. Subsurface flow problems and separation of foundation alluvium

c. Repeated damages to impact blocks, deflection blocks and skin concrete

d. Excessive sediment entry into DG Khan Canal, silt ejector failure, and consequent feeding problems

e. Fish ladder inefficiency

f. The flared out walls – inefficient drainage

g. Defects in regulation gates & gearings, causing multiple operational hazards

h. General aging effect.

Khaleel (2004) conducted a study on Some Sustainability issues in Kannur. According to him one of the major problem is due to construction of regulator-cum-bridge at Kattampally. The weir-cum-bridge was constructed to check the intrusion of tidal salt water and to retain the fresh water run-off so as to bring more land under double crop. But the kaipad paddy fields of this area naturally need the tidal water to make the soil fertile and cultivable. In short, the weir-cum-bridge rendered about 4000 acres of paddy wetland uncultivable. When the tidal water flow is prevented, the paddy fields, where tonnes of rice were being harvested, become completely barren; yield from coconut palms decrease considerably; availability of different types of fishes including costly prawns, thirutha, crabs, clams, etc. have dwindled; the environment has been chemically and biologically altered. All these have also resulted in labour displacement, loss of food security, conflicts among farmers and poverty. Marginalization of the poor is complete, especially of the ones who earned their income through minor fishery, forcing them to look for construction jobs in Kannur town area. This has affected thousands of people from hundreds of families in nine Panchayath. The affected farmers are demanding lifting the regulator of the bridge.

Nigel (2006) conducted a study on Tidal Barrages and Birds; this paper reviews the main effects that building tidal power barrages would have on the bird populations using Britain’s estuaries. The changes in the tidal prism that would occur after a tidal power barrage is built are discussed in the context of their effect on the ecology of the estuary. Three main issues are discussed; the effect of changes in size and nature of the intertidal areas of the estuary, effects on salt marshes, and the displacement of birds at closure. Recently, tidal stream technologies have been developed which are individually likely to have small effects on birds. However the cumulative effects of large scale tidal stream arrays need to be investigated. Finally, the effects of tidal barrages are put in the context of Britain’s energy policy and the need to reduce greenhouse gas emissions. Should tidal power barrages be considered in the future, there will be a need for strategic assessments to be used to select sites that maximize the energy produced while minimizing the impacts on bird populations.

Balachandran (2008) conducted a study on development of paddy cultivation in the Kattampally project area. A barrage was constructed in 1966 by the Government of Kerala, at the confluence point of Kattampally tributary with 13 operable shutter lock gates and Road Bridge. This project is the first major scheme proposed in the district and was designed as a multipurpose scheme for irrigation, flood control, prevention of salt water intrusion and for navigation and communication. The river is nearly 20kms, long and out of this length the river is affected by the tidal action for a length of about 15 kms. The lower part of the Kattampally area were swampy and water logged and used to experience flood during rainy season and salinity on summer. After construction of barrage the expected result could not be obtained due to various reasons. One of the main problems in area has been the instruction of saline water throughout damaged shutters causing destruction of paddy cultivation and increased salinity of bound water which affects the drinking water also. For the reclamation of paddy cultivation in this area, the following works are to be carried out on a war footing.

(i) All the shutters of the project should be repaired immediately to prevent the intrusion of salt water.

(ii) At present there are only 13 regulators across the river which is insufficient for draining the water completely. It is necessary to construct 5 more regulators across the river to ensure proper drainage of the water.

(iii) Water should be released to the project area as and when required for paddy cultivation from Pazhassi irrigation project canals.

(iv) Drainage channels and bunds should be built along both sides of the Kattampally River with provision to drain water collected during rainy season and for storing it in the downstream area. The stored water should be used during non-rainy seasons.

(v) An operation policy for the Kattampally and Kaipad lands.

(vi) Paddy varieties which are high yielding and which have salt tolerance should be popularized through the conduct of front line demonstrations.

(vii) It should be made mandatory to apply good quality lime at the beginning of the cropping season.

(viii) Survey of the paddy land which can be brought under cultivation should be made. Immediately and those farmers may be exposed to modern rice farming techniques through interactive sessions. All the cultivation operations may be made on a Group farming basis. Such farmers may be registered and given green cards showing the details of the rice and ownership details.

(ix) The land which has been left fallow in the past should be surveyed and an action these areas back to rice farming should be made, if the owners of the land are not willing to take up rice, neighboring "Padasekarasamithis" or "Kudumbasree" units or other self-help groups may be encouraged to take up rice farming in these fallow lands. These farmers/SHGs may be given a onetime grand of Rs.15000 per ha to meet the initial expenditure (to make up the area cultivable).

(x) As a long term plan the entire area of Kaipad lands may divided in to uniform blocks based on land characteristics and channel should be provided in between these blocks (as in Kuttanad and Kole lands). These channels can be used to drain out water to facilitate farming during rainy season and during summer, these can be used for irrigation purpose.

Balachandran and Padma Kumar (2008) conducted a study on the development of paddy cultivation in the Kattampally. According to their study a regulator cum bridge was constructed in 1996 by the government of Kerala, at the confluence point of Kattampally tributary with 13 operable shutter lock gates and Road Bridge. This project is the first major scheme proposed in this district and was designed as a multipurpose scheme for irrigation, flood control, prevention of salt water intrusion and for navigation and communication. Its primary objective had been to double the cropping intensity by conversion of Kaipad cultivation into punja. One of the main purpose of construction of the Regulator Cum Bridge was prevention of entry of salt water into the surrounding cultivable wetland of around 1200 hectare. After the construction of the Regulator Cum Bridge the expected results could not be obtained mainly due to the following reasons.

(i) Excessive floods during the monsoon due to faulty construction and intrusion of saline waters through the shutters causing destruction of paddy cultivation and increased salinity of bound water.

(ii) Hardening of soil and wide spread occurrence of leeches and excessive bushy weed growth.

In the context that land use pattern in the area has also changed considerably during the past 40 years, with mixed trees/crops becoming popular, any suggestion of an absolute return to the old system is impractical. As there is scarcity of labor to work in waste deep waters, for the traditional kaipad cultivation, as in the past, it becomes essential to encourage cultivation of saline tolerant high yielding rice varieties under a controlled water management regime. The necessities division of entire paddy lands into suitable entities/blocks by forming embankments and with reference to topographical characteristics and extend of inundation.

Christina Tang (2009) conducted a study on Water Quality and Cost-Benefit Analysis of Rainwater Harvesting in Kuttanad. One of the main aim of this study is to analyze the quality of drinking and irrigating water. Pollution and unscrupulous urban planning have severely deteriorated the quality and quantity of Kuttanad fresh water supply in recent decades. The fresh water supply is hugely defective mainly due to poor water management and planning. The Thanneermukkom barrage, constructed in 1975, provides an example of poor water management and planning, which was constructed to impede salt water intrusion into Vembanad Lake to allow the growth of a second rice crop in Kuttanad. The barrage has greatly obstructed the waterway and created a stagnant water body which has led to a number of severe environmental problems. These problems include eutrophication, decline in backwater fish yield, siltation, loss of biodiversity and water borne diseases. The barrage caused a shift of salinity gradient towards the north, and an increase in occurrence of fish diseases, and an explosive growth of alien aquatic weeds. The siltation also poses dangers of flash flood to the community, especially during the monsoon seasons. In addition, the obstructed waterways and the continuous fallow of rice fields have created breeding grounds for disease vectors such as mosquitoes and rodent respectively.

Sarker et al. (2011) conducted a study on climate impact assessment on Teesta barrage in Bangladesh. The aim of this study is to find out the change of climatic parameters due to construction of Teesta Barrage Irrigation Project on its catchment area. The Teesta

Barrage Project was implemented to increase the agricultural production in the vast area of northern Bangladesh suffering from acute shortage of water every year. After all, the project has succeeded in increased production of crops; improved lifestyle of rural people and conservation of community resources. Change in climate is noticed in surrounding project area, has some positive and negative impacts on the ecosystem. The major findings of the study can be summarized as below:

(i) There is no significant change of temperature due to implementation of the project, whereas a significant change in rainfall pattern was observed.

(ii) There is a minor change in humidity but remarkable change is observed in evaporation.

(iii) Proper use surface water available in Teesta Barrage catchment area is the best option, which would enable the farmers to use cheaper irrigation water that would also be environment-friendly.

Shiva Prasad et al. (2012) conducted a study on Influence of Saltwater Barrage on Tides, Salinity, and Chlorophyll *a* in Cochin Estuary. Thanneermukkom Barrage (TB) is constructed in the southern arm of Cochin estuary. It prevents salt intrusion upstream and regulates river discharge downstream. Characteristics of the estuary when the barrage is opened and closed are discussed. The analysis showed that the closure of the barrage caused amplification of tides in the immediate vicinity and up to 10 km farther downstream. When the barrage was closed, the northern region of the Thanneermukkom Barrage transformed from an ebb-dominant system into a flood-dominant system. During high discharge periods, the barrage was opened and salinity intrusion was exponentially dependent on river discharge. During the dry period, the reduction in river flow compounded with closure of the barrage resulted in an increased salinity concentration downstream. Whereas oceanic salinity was observed at the ocean-end station, about 13PSU occurred at the river-end station when the barrage was closed. Hydrodynamic control on phytoplankton biomass was also evident. Higher surface chlorophyll *a* Levels were observed at higher salinity during the closed barrage period, and residence time was estimated for 4 days during this period.

Pollution Control Board and Kerala Water Authority (2012) examined reasons for the fish kill in Tirur River. According to Dr. Suresh, a sudden increase of pollutants in the river could be the reason for the fish kill, which was reported in a stretch of more than 12 km from Mangalam to Thalakkalathur. Places such as Pariyapuram, Vettam, Tirur, Pachattiri, and Cheriyamundam were the worst. According to Mr. Mohammed, an environmentalist, who runs an outdoor studio called Noor Lake at Pachattiri, the fish kill was due to the stagnation of polluted water following the construction of a Regulator Cum Bridge at Koottayi. Presence of algae in large amounts in the river made the color of water green. The sudden gush of water after several months could have stirred up the pollutants in the water and caused the harm.

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MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

3.1 Location

The study was conducted in the areas of influence of Chamravattom Regulator cum Bridge and Koottayi Regulator cum Bridge.

3.1.1 Chamravattom Regulator Cum Bridge

The Project Regulator cum bridge at Chamravattom across Bharathapuzha envisages the construction of Regulator cum bridge across Bharathapuzha at a place locally known as chamravattom with the following specifications,

- Top level of the shutter at +6.00m with no flood banks.
- Water can be stored upto +4.00 m.
- Length of bridge is 978m with a span of 12m having 70 nos of shutters of 12×4.50m size.
- The ayacut area achieved will be 4344 ha.
- The total cost will be 96.00 crores.

The project is about 6 km upstream of the confluence point of the river and sea. The latitude and longitude of the site are 10º 51' North and 75º 57’ East. The project site is in the Ponnani and Tirur taluks of Malappuram district.

The project is proposed to stabilize the ayacut area maintained by L.I.Scheme in the area that have been commissioned by the State Irrigation Department so far. Project is also aimed for the formation of additional sluices, extending canals, replacement of motors and pumps,improvements to the existing canals, shifting of pump house etc. The drinking water supply schemes face acute shortage of water during the summer, solution to which is also answered better from this scheme. Another important aim of this project is the effective control of the intrusion of saline water into the upstream side of the regulator.Besides, the river when bridged will be an important link connecting the coastal towns of Ponnani and

Tirur and thereby reducing the disthance 20km by road.This also reduces the distances between Ernakulam and Calicut and thereby contributes very much to the development of the coastal towns.

Plate 1.Chamravattom Regulator cum Bridge

3.1.1.2 General Climatic Conditions

Kerela state has mainly two seasons namely summer and mansoon seasons. The south west monsoon (starting from June and extending up to the middle of October) and the north east monsoon (starting from the middle of October and extending up to November) are prevalent in the catchments and ayacut area of the project. At an average, the south west monsoon provides 65% and north east monsoon 30% of the annual precipitation. The remaining 5% occurs as the non seasonal showers. As the temperature of the area rarely exceeds 35 ºC, neither an extreme hot nor cold is felt in the locality. The area receives sufficiently heavy down pours averaging to about 2800mm.

3.1.1.3 Topography and Geology of the Area

As far as the catchment area is concerned, the average altitude varies from 1964 m in the east to 1m in the west. The gross catchment area is 6186 sq.km.The distance of the river from the site to the sea is 209km.

The project area falls in the low land or sea board.The long and narrow strech of sandy sea board is low and is several parts is liable to be flooded during mansoon.The soil of the project area is classified as sandy loam.The project area and most of the command area is made up of recent deposits.Recent depositions consists of alluvial,marine and latchstrine deposits.

3.1.1.4 Population

The area is well inhabited particularly along the coastal regions. The entire area is thickly populated.The intensity of population in Ponnani and Tirur taluks is 1070 per sq.km. Kozhikode city is the nearest municipal corporation and Ponnani town is the nearest municipality.

Agriculture is the main occupation of the people,51% of the inhabitants depending on it.Paddy is the main crop cultivated in the area, with coconut,arecanut,banana,tapioca and pepper occupying the second position.The people are well concious about the irrigation,artificial manure,pesticides and high yielding varieties of seeds and modern technologies in agriculture.

3.1.1.5 Physical Features

Geographical disposition

Bharathapuzha river, the second longest river of the state takes its origin at an elevation of + 1964 m above M.S.L. from Anamalai hills and flows through the districts of Coimbatore, Palakkad, Malappuram and Thrissur and joins the Arabian sea near the Ponnani town, where it is known as Ponnanipuzha. Its four main tributaries are

(i) Gayatripuzha

(ii) Kannadi river or Chitturpuzha or Amaravathy

(iii) Kalpathypuzha and

(iv) Thuthapuzha.

The Bharathapuzha is also known as 'Nila'.Thirunavaya is on the right bank of proposed barrage.

Topography of the basin reservoir command area

The topography of the reservoir is fairly even without many undulations. No canal system is envisaged in the project as the ayacut area is to be fed by lift irrigations already in existence.

Areas traversed by the river

The river originates from Anamalai hills and on the way it flows through the districts (in Tamil Nadu State) Palakkad, Malappuram, and Thrissur Districts in Kerala State.

Distribution of catchments

The length of the river is 209 kms with a catchment area of 6186 km2. The area of basin is spread over 11 taluks from western guts to the Arabian sea.

Hydrology

Bharathapuzha has to enjoy the catchment spreading to about 200 km of its length, behind the river gauge station at Kuttippuram. The impact of rainfall at the intermediate catchment may have rightly caused to a register runoff at the river gauge station relieved upon for computation of inflow even though the area comprised with in the rain gauge station at Pattambi. Did not get .our for irrigating the third crop by the irrigation scheme, major , medium, minor existing in the Bharathapuzha basin in the upstream side is naturally to cause inflow at the lower reaches of the river. The riparian release of water to the river during the drought period of January, February and March from the irrigation system existing at the upstream side to meet the demands of riots, can also inflate the inflow in the river at the purposed river gauge station located much lower down in the river basin.

Maximum discharge at regulator site

The maximum flood level at the regulator site in 1924 which is the highest ever occurred, was assessed locally and the maximum discharge was calculated and found to be 3 lakhs cusecs (8496 cusecs). This value tallies with the maximum discharges of 2, 32,895 cusecs.

Design features

The construction of a Regulator cum Bridge at Chamravattam in Bharathapuzha to stabilize the irrigation facility in Tirur and Ponnani taluks and to have better communication facilities.

Head works

The regulator cum bridge site is 6 kms upstream of the river mouth. The nearest municipal town is Ponnani which is 6 km away from the site. There are well maintained roads to the site from Ponnani and Tirur. Calicut is 72 kms away from the site. The site is in plains. The slope of the river at site is 1 in 2890 or 0.0035.

Geology and foundation

Hard rock has been met with at depth of 18.75 m to 42.20 m and foundation is pile

Site of Regulator cum Bridge

A site 6 km upstream of river mouth was found most suitable. Hence the average the average bed level of the river is + 1.5m. and bank level is average + 4.5 m.

Layout of Regulator cum Bridge

The regulator consists of 70 spans of 12 m width. Height of the shutter is 4 m. the top level of road is 9.35 m. the carriage way of the bridge is 7.50 m excluding foot path of 1.50 m on either side. All vents are controlled by lift shutters. So no navigation is anticipated no lock arrangements are proposed.

Design of flood

The maximum flood discharge observed in 1961 is 3, 00,000 cusecs. Although the flood levels during 1961 have not exceeded the historic flood of 1924, the former must be considered as an abnormal one as reservoir schemes have come into existence since 1924 increasing the flood observing capacity. Chamravattom is only a regulator and hence only a moderate estimation of flood is seen necessary.

Free board

This being a regulator no permanent reservoir is maintained. The bridge is kept at a level of 9.35 m and will give enough free board to the MFL of 5.50 m of 1961 flood.

River diversion arrangements

The construction is proposed to be taken up during summer months. No heavy flow is

anticipated in the river. Hence the diversion is proposed with ring buds with sand filled gunny bags and providing a puddle core of clay.

Barrage

The barrage will be closed only by the end of monsoon. No sedimentation problem is anticipated as the regulator will be opened by the end of May. There is no head regulator or canals.

The F.R.L is +4.00 m

Storage = storage capacity worked out to be 14.20Mm3

Effect of on sub soil water table

No adverse effect on sub soil water table is possible. The storage will help to avoid salt water intrusion.

Area of submergence

The reservoir at its FRL will be 868 ha.

Collection of data

The various data required including the details of the project location, evaporation, rainfall, stage levels at Kuttipuram and Thrithala, survey details of the site, water demand etc were collected.

(a) **Meteorological data**

i) The rainfall, gauge discharge data for 12 years starting from 2001 to 2012 were collected from the Regional Agricultural Research Station, Pattambi .

(ii) River inflow data

ii) The river flow stage levels for Kuttipuram and Thrithala were collected for the same period from the Irrigation Department.

iii) RCB details

iv) The details about the RCB, command area map, site survey to find water spread area, the design maps and the cropping pattern proposed by the Irrigation department were collected from the Project office at Chamravattom.

3.1.2 Koottayi Regulator Cum Bridge

Tirur River begins in the Tirur taluk village of Athvanad in the Malappuram district of the state of Kerala in south India and flows south-west to Thiruvnavaya and then north-west to Elamkulam where it turns south-west, joining the Bharathapuzha River which flows into the Arabian Sea near the coastal town of Ponnani. It is known for its beautiful mangroves and its many varieties of fishes and birds. This river is navigable and forms part of west coast water transport system. Its length is 48 km . A view of the Koottayi Regulator cum Bridge is shown in plate 2.

Total span	:	16 m
+Clear span	:	6.1 m
Clear road width	:	4.27
Top level of road	:	+ 7.010 m
M FL	:	+ 1.89
Top level of shutter	:	+1.525 m
Ground level	:	+ 1.2 m (Mangalam)
		+ 1.3 m (Koottati)
Retention level	:	+ 1.3 m
Low tide level	:	+ 0.49 m
Still level	:	-1.20 m
Width of apron	:	21.35 m
Thickness of pier	:	1.22 m
Size of shutter	:	6.1 m * 2.89 m
Ayacut benefited	:	2450 acre
Discharge of river	:	270 m3/s

Plate 2.Kootayi Regulator cum Bridge

Construction of a lock-cum-regulator-cum-bridge at Koottayi across Tirur Ponnanipuzha in Malappuram District were awarded in 1979 and 1981 respectively, the department was forced to terminate the contract in December 1981 and June 1984 after completing 14 out of the 25 spans, The original proposal was for construction of 24 spans and a lock chamber. Out of the above 24 spans, 14 spans were completed. The work was held up due to various technical reasons .The fixing of shutters for the completed spans could not be arranged due to various factors. The above work was proposed twenty years back and at that time no other projects were executed and water was not stored in the upstream portions of Bharathapuzha. Later a number of projects such as Chulliyar, Meenkara, Pothundy, Kanjirappuzha, Mangalam etc were executed in addition to the major project, Malampuzha.

Hence the discharge of water in the river basin has been considerably reduced. Moreover the Koottayi regulator was designed considering the flood of 1924, which was the peak flood. Since 1924 no such flood had occurred and even if such a flood could occur the above mentioned projects could absorb a major portion of the flood. Hence after considering all the above facts the Chief Engineer, Irrigation and Administration and Chief Engineer IDRB jointly decided to reduce 4 spans from the original proposal of 24 spans.

3.2 Methodology

Soil and water analysis were conducted for understanding the effect of RCB on soil characteristic and water quality.Water depth measurements are taken from a number of open wells located at the upstream and downstream side of the RCB in periodic intervals to understand the RCB effect on ground water table. Details of increase in area of cultivation,increase in irrigated area are collected from krishibhavans of respective gramapanchayath. Details of maintanance and replacement of pump sets are collected from pump houses.

3.2.1 Water Quality

Upstream of Kootayi regulator cum bridge was visited on 11 June 2013 and 9 December 2013.Four sampling sites were chosen in Tirur puzha upstream, they are Thazhepalam, Mangatteri,Pachutteri,Vettumcheri. At each site, water samples were collected in bottles. The different quality parameters tested in laboratory.

Upstream side of the Chamravattam regulator cum bridge was visited on 3 January 2014 and 5 sampling sites were chosen in Bharathapuzha upstream, they are chamravattam, Nariparamb, Athalur, Tavanur and Kuttippuram.At each site Water samples are collected and tested in laboratory.

3.2.1.1 Electrical Conductivity

The collected water samples from selected sites on the upstream to the regulator cum bridges are subjected to electrical conductivity test.The test is done by using the Water Analyser.

(i) Press COND key, if calibration data is proper then display shows step (ii) othervise display shows for few seconds.

CALIBRATION REQD

and returns to Main Title.

(ii)

CELL CONST: ,X XXX
┘

Press ENTER KEY display shows

PUT SAMPLE/DIP *CELL
SAMPLE NO : 01* ┘

Sample ID number is automatically incremented by one. Enter sample ID number if required. Dip cell and PT100 in the sample ssolution.Press ENTER. After showing the blinking ‘WAIT’ for few seconds ,if PT 100 is good then shows steps (iii) otherwise display asks

TEMP OF SAMPLE/STD)
TEMP ^{o}C = 25.0
┘

Enter temperature of sample if other than 25. Press ENTER. After showing blinking "'WAIT… '" for few seconds the display shows the final reading. Press ESC display returns the the Main Title, or Press ENTER to display results.

3.2.1.2 pH Measurement.

By pressing ESC key repeatedly to get Main Title on the display

(i) Press pH key, if calibration data is proper then display shows step (ii) otherwise display shows for a few seconds

CALIBRATION REQD

and returtrs to Main Title.

(ii)

PUT SAMPLE/DIP *CELL SAMPLE NO : 01 ┘

Sample ID number is automatically incremented by one. Enter sample ID NO, if required. Dip electrode and PT100 in sample solution. Press ENTER. ,after showing blinking "WAIT..." for few seconds, if PT 100 is good then shows steps (iii).

(iii)

TEMP ^{o}C pH XXX XXX PRINT/ ┘

Press PRINT key for printing the reading. Press READ key to observe change in reading for same sample. Press ENTER key for analysing next sample. Press ESC key display shows.

PRESS ESC TO EXIT
˩

Press ESC display returns to the Main Title, or Press ENTER to display results.

Plate 3 . Water Analyser

3.2.1.3 Other Quality Parameters.

Other quality parameter such as chloride, sulphate, calcium, magnesium, iron, nitrate, nitrite, phosphate, total coliform and E.coli were determined in the water quality laboratory of CWRDM, Kozhikode.

3.2.2 Soil Characteristics.

3.2.2.1 Particle Size Distribution

The grain size distributions of soil from the selected samples were done by sieving. Here dry sieve analysis was carried out using: 4.75mm, 2mm, 1mm, 600, 425, 300, 212, 150 and 75 micron IS sieves. Sieving is done using sieve shaker. Weight of soil retained in each sieves were taken. Graduation curve was plotted with particle size and cumulative percentage finer. The samples were collected from the following sites.

i. Chamravattom

ii. Nariparamb

iii. Athalur

iv. Tavanur

v. Kuttippuram

The percentage of soil retained on each sieve was calculated on the basis of the total mass of soil sample taken and from this result percentage passing through each sieve was calculated. A soil sample may be either well graded or poorly graded. A soil is said to be well graded when it has good representation of particles of all sizes. On the other hand a soil is said to be poorly graded if it has most of the particle of about the same size; in the latter case it is known as uniformity graded soil.

For coarse grained soil, certain particle sizes such as D10, D30 and D60 are important .The D10 represents a size' in mm such that 10% of the particles finer than this size. Similarly, the soil particles finer than D60 size are 60% of the total mass of the sample. The size D10 is sometimes called the effective size or effective diameter. The uniformity coefficient Cu is a measure of particle size range and is given by the ratio of D60 and D10 sizes:

$$Cu = D60/D10$$

For a uniformity graded soil, Cu is nearly unity. Cu must be greater than 4 for gravels and 6 for sands. The coefficient of curvature, Cc is a shape parameter also shows the gradation of soil and is calculated using the following equation:

$$Cc = (D30)^2 / (D60*D10)$$

Where, D60 is the grain diameter at 60% passing, D30 is the grain diameter at 30% passing, and D10 is the grain diameter at 10% passing.

Soil gradation is a classification of a coarse-grained soil that ranks the soil based on the different particle sizes contained in the soil. Soil gradation is an important aspect of soil mechanics and geotechnical engineering because it is an indicator of other engineering properties such as compressibility, shear strength, and hydraulic conductivity. In a design, the gradation of the in situ or on site soil often controls the design and ground water drainage of the site. A poorly graded soil will have better drainage than a well graded soil. Soil is graded as either well graded or poorly graded. Poorly graded soils are further divided into uniformly-graded or gap-graded soils. Soil gradation is a classification of the particle size distribution of a soil. Coarse-grained soils, mainly gravels or sands, are graded as either well graded or poorly graded. Poorly graded soils are further divided into uniformly-graded or gap-graded soils.

Plate 4 . Sieve apparatus

3.2.2.2 pH Measurements

Soil samples collected from five selected sites of the upstream of Chamravattom Regulator Cum Bridge and these samples were kept in shade for drying. Dried samples passed through 2 mm IS sieve, 10 gm of soil sample is selected from this for the test sample preparation. 10 gm soil sample was mixed with 25 ml of distilled water in a beaker, stirred well and kept it for 30 minutes. 7 pH and 4 pH buffer solution were used for the calibration of pH meter. After calibration the pH meter readings were taken by dipping the electrode in the sample and digital scale read is noted.

Plate 5. pH Meter

3.2.2.3 Electrical Conductivity

The sample preparation was same as that of sample prepared for pH determination. The conductivity meter was first calibrated using standard NaCl solution. The units were calibrated by adjusting the value on the meter to read the value of constants. This was done by using either increase or decrease button on the meter or using a small tool. The conductivity meter readings were taken by dipping the conductivity probe in to the sample and the digital scale read is noted. Its important to ensure that any air bubbles are removed from the probe. To do this the probe was gently tapped on the sides of the graduates. The readings on the meter were then allowed to stabilize and the value is recorded.

Plate 6 . Conductivity meter

3.3 Ground Water Recharge

Ground water related environmental issues such as declining of water levels and consequent quality deterioration due to salinity intrusion from the cost and the river course during the summer periods is a serious environmental problems in the downstream reaches of Bharathapuzha. The proposed structure across Bharathapuzha at chamravattom will have a very positive impact on ground water regime since it will solve the ground water related environmental issues in the surrounding blocks to a large extent.

In case of confined aquifer, water table depth will be in line with the water level of the open wells. So to measure the recharge in ground water, water level readings are taken from selected 8 open wells located on the upstream and downstream side of the Chamravattom RCB. Measurements are taken repeatedly throughout 2 months when RCB was in closed state.

3.4 Survey

To understand the effect of RCB on area of cultivation, productivity, and maintenance of pump houses, a visit was made RCB at Chamravattom. And we interacted with local people in those sites and collected information about water quality, crop yield, ground water table, salt water intrusion and socio-economic status.

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

This chapter describes the findings of the study conducted on 'Impact of Regulator Cum Bridges' regarding water quality, ground water recharge, salt water intrusion, soil characteristics, transportation, agriculture, ecosystem and socio economic status.

4.1 Water Quality

Water quality test was done to have an insight about the quality of impounding water on the upstream of regulator cum bridges. Water samples from the Koottayi regulator cum bridge collected on 11 June 2013 while all the shutters of the Koottayi regulator cum bridge were closed, and 9 December 2013 while shutters were opened and water samples from Chamravattom regulator cum bridge collected on 3 January 2014 while shutters were closed.

4.1.1 Electrical conductivity

EC values of water samples obtained are shown in tables

Table4.1Electrical conductivityofwater samples from koottayi while shutters were closed

Sl.no.	**SITE**	**EC(µmhos/cm)**
1	Thazhepalam	232
2	Mangatteri	138
3	Pachutteri	663
4	Vettamchery	398

Table 4.2 Electrical conductivity of water samples from koottayi while shutters were opened

SI.no	SITE	EC(µmhos/cm)
1	Thazhepalam	1670
2	Mangatteri	1836
3	Pachutteri	2047
4	Vettamchery	1908

Table 4.3 Electrical conductivity of water samples from Chamravattom while shutters were closed

SI.no	SITE	EC(µmhos/cm)
1	Chamravattom	217
2	Nariparamb	150
3	Athalur	168
4	Tavanur	154
5	Kuttippuram	146

Desired limit of EC of river water is 50 to1500 µmhos/cm. The result shows that EC of water samples at various sites, both from upstream of Koottayi RCB and Chamravattom RCB are in desired range.

From the survey report of downstream reach of RCB, the main problem faced by the people is insufficient drinking water due to salt water intrusion. This indicates that salt water intrusion is successfully prevented by the RCB in the upstream. So that more fresh water is available for irrigation and drinking in the upstream, hence the RCB successfully prevent the salt water intrusion.

4.1.2 pH

pH values of water samples obtained are shown in tables

Table 4.4 pH of water samples from koottayi while shutters were closed

SI.no	SITE	pH
1	Thazhepalam	6.58
2	Mangatteri	6.46
3	Pachutteri	6.60
4	Vettumchery	6.76

Table 4.5 pH of water samples from koottayi while shutters were opened

SI.no	SITE	pH
1	Thazhepalam	8.26
2	Mangatteri	8.59
3	Pachutteri	9.21
4	Vettumchery	`8.65

Table 4.6 pH of water samples from Chamravattom while shutters were closed

SI.no	SITE	PH
1	Chamravattom	6.77
2	Nariparamb	7.63
3	Athalur	7.34
4	Tavanur	7.37
5	Kuttipuram	7.46

Desired limit of pH of river water is between 6.50-8.50. The result shows that pH of water samples at various sites, both from upstream of Koottayi RCB and Chamravattom RCB are in desired range.

4.1.3 Other Quality Parameters

The other water quality parameters of the collected samples are shown in table 4.7.

SI.no	Parameters	1	2	3	4	Desired limit as per BIS
1	Color,Hazen	1.0	1.0	0.50	8.0	8.0
2	Turbidity,NTU	4.20	4.90	2.20	20.0	1.0
3	Total Dissolved Solids, mg/l	1150.0	7790.0	3530.0	2040.0	500.0
4	Total Hardness,mg/l	300.0	1640.0	680.0	380.0	200.0
5	Total Alkalinity,mg/l	108.96	136.2	54.48	108.96	200.0
6	Chloride,mg/l	708.4	265.0	1133.44	566.76	250.0
7	Sulphate,mg/l	169.44	2651.44	373.44	229.92	200.0
8	Calcium,mgl	24.0	152.0	72.0	48.0	75.0
9	Mangnesium,mg/l	58.32	306.18	121.5	63.18	30.0
10	Iron,mg/l	0.31	0.19	0.29	0.15	0.30
11	Total Coliforms, MPN/100ml	4800	1800	3200	4400	Shall not be dectectable in any 100ml sample
12	E.Coli,MPN/100ml	Present	Present	Present	Present	Shall not be dectectable in any 100ml sample

Legend: Sample 1 :Thazhepalam, Sample 2 :Mangatteri, Sample 3:Pachutteri, Sample 4: Vettumchery.

Water quality analysis of the samples revealed that most of the sample have amount of Total Alkalinity, sulphate, calcium, iron concentration much lower than the desired limit.But the Total Coliforms, E.Coli count,Chloride,Sulphate,Magnesium,Total Dissolved Solids and Turbidity are much larger than desired value, indicating that water is highly polluted. And also among the all 4 samples, water sample from Mangatteri is highly chemically polluted,Which has high amound of sulphate,Calcium,Magnesium in the water sample. Total Hardness of this sample is 7790 while the desired limit is 500. This effect may due to the presence of one cement manufacturing on the Tirur river bank and its drainage outlet opens to the Tirur river.

But samples from Thazhepalam and Vettumchery is biologically polluted by the presence of high amount of Total Coliforms and E.Coli in the water sample.Since these places are very nearer to the Tirur town,this biological pollution may due to discharge of Municipal drainage pipelines to the river.

Total Coliforms represents a heterogeneous group, which include bacteria of fecal and non-fecal origin, whereas E. coli, or sometimes referred to as fecal Coliforms, is specifically from humans and warm-blooded animals. The level of E. coli counts in water is primarily used to indicate the possible presence of bacterial pathogens that can cause diseases in humans such as gastroenteritis, cholera, typhoid fever and dysentery if ingested. The Total Coliform counts were high for all samples taken, however, the high E. coli counts for all sites, particularly for Thazhepalam and Vettumchery, is indicative of wash-off of faecal matter from the catchment. The main threat to the health of the local populace, drawing water for drinking is this bacterial contamination. The high concentration of E.coli and total coliforms may due to stagnant layers of impounding water in the upstream of regulator cum bridge. A stagnant layer of water is due to the closing of shutters. It will prevent the natural flushing action of river.

4.2 Soil Characteristics

4.2.1 Particle Size Distribution

The result of the mechanical analysis are plotted to get particle size distribution curve with the percentage finer as the ordinate and particle diameter as the abscissa, the diameter being plotted on a logarithmic scale. The particle size distribution curve gives an idea about the type and gradation of soil. A soil sample may be either well graded or poorly graded. A soil is said to be well graded when it has good representation of particles of all sizes. On the other hand a soil is said to be poorly graded if it has most of the particle of about the same size. The particle size distribution curves are shown in Fig. 4.1 to 4.5.All the soil samples have Cu ≤ 2 are u& 1 < Cc< 3, which indicates that samples are well, graded gravels. Soil gradation is very important to geotechnical engineering. It is an indicator of other engineering properties such as compressibility, shear strength, and hydraulic conductivity. A poorly graded soil has better drainage than a well graded soil because there are more void spaces in a poorly graded soil. A well graded soil is able to be compacted more than a poorly graded soil. Particle size distribution by sieve analysis is shown in Appendix I.

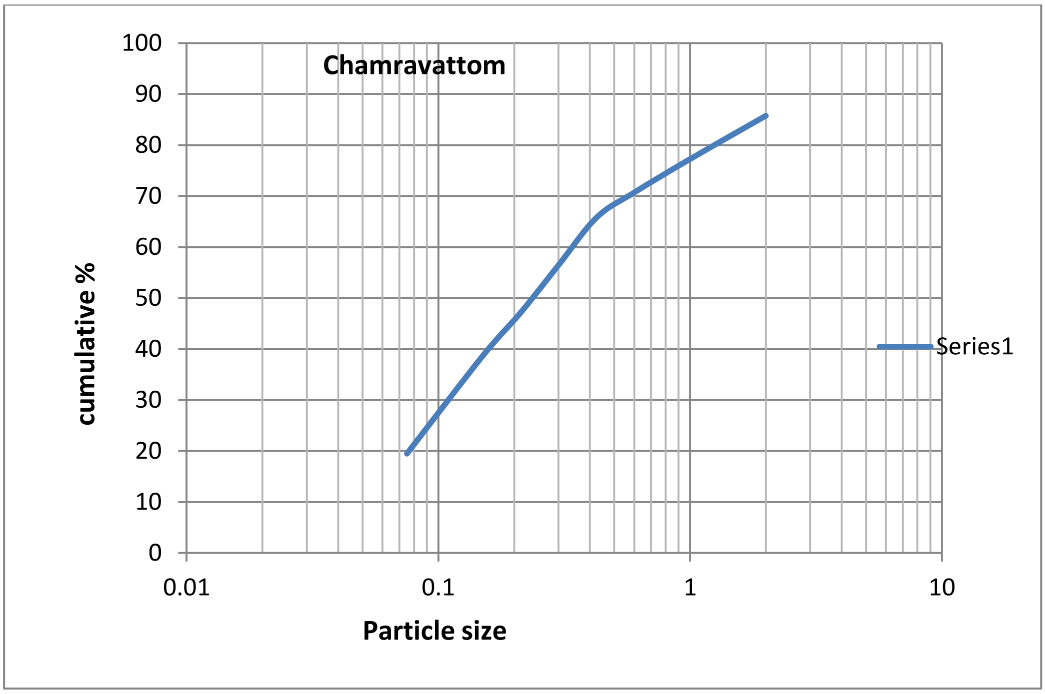

Fig . 4.1 Particle size distribution of soil from Chamravattom

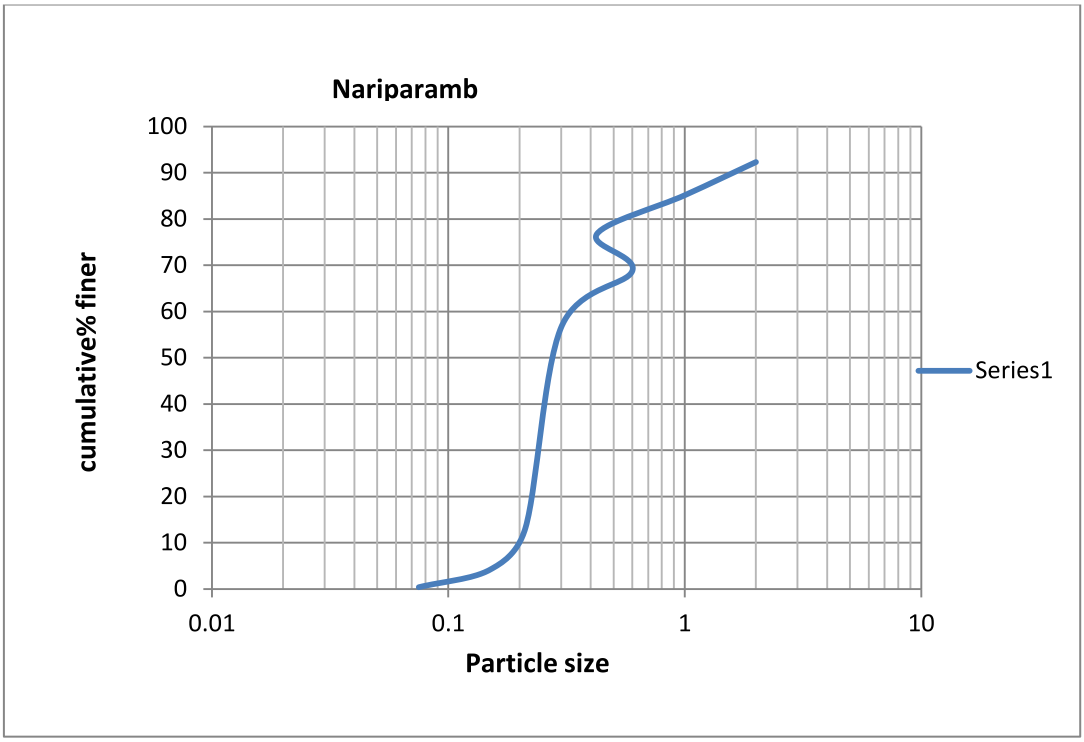

Fig . 4.2 Particle size distribution of soil from Nariparamb

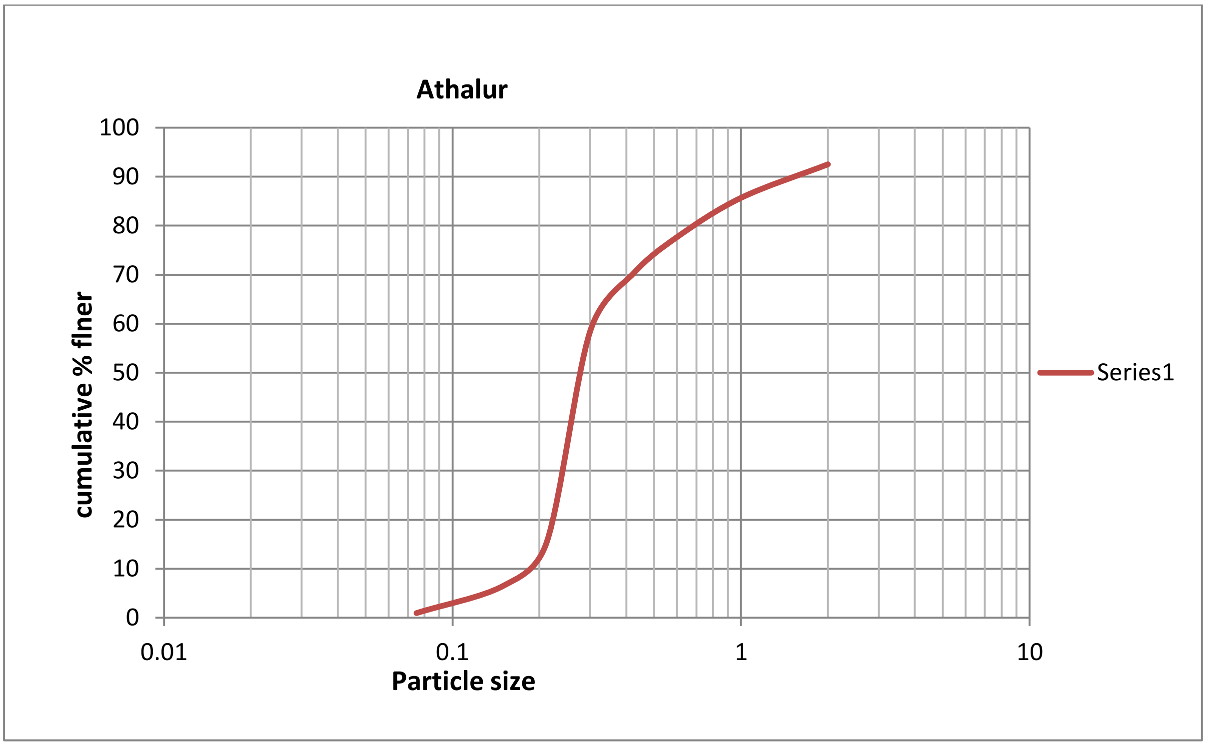

Fig . 4.3 Particle size distribution of soil from Athalur

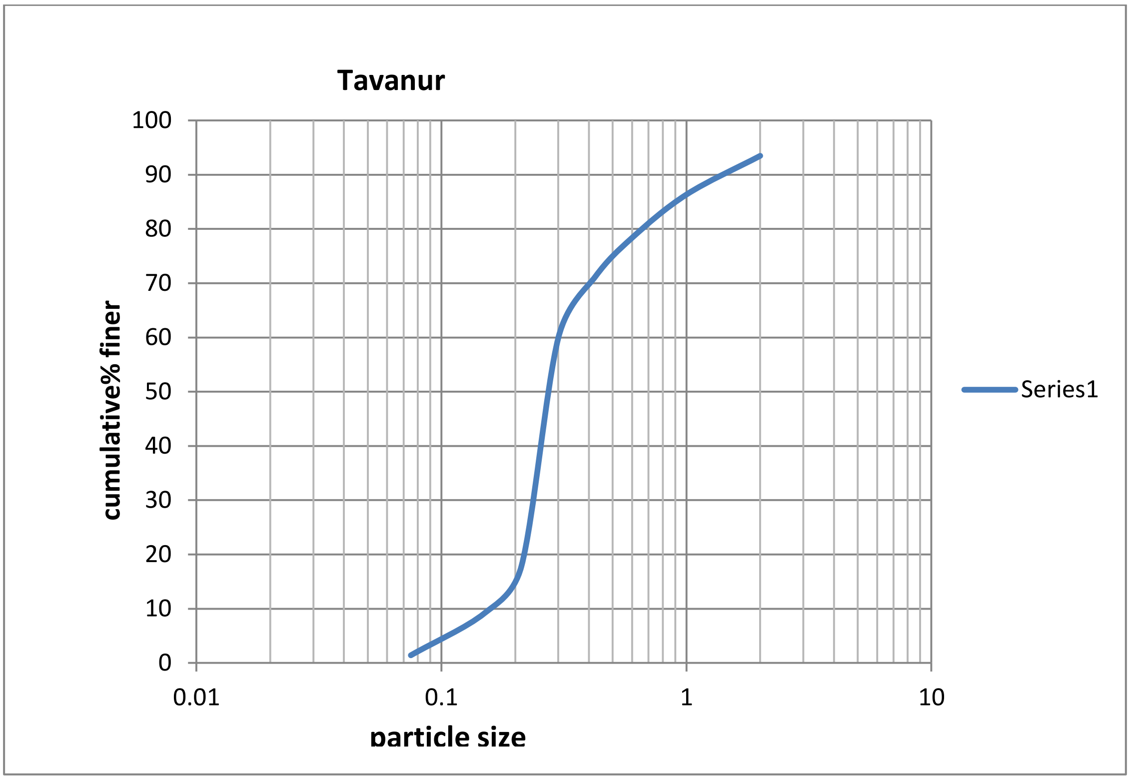

Fig . 4.4 Particle size distribution of soil from Tavanur

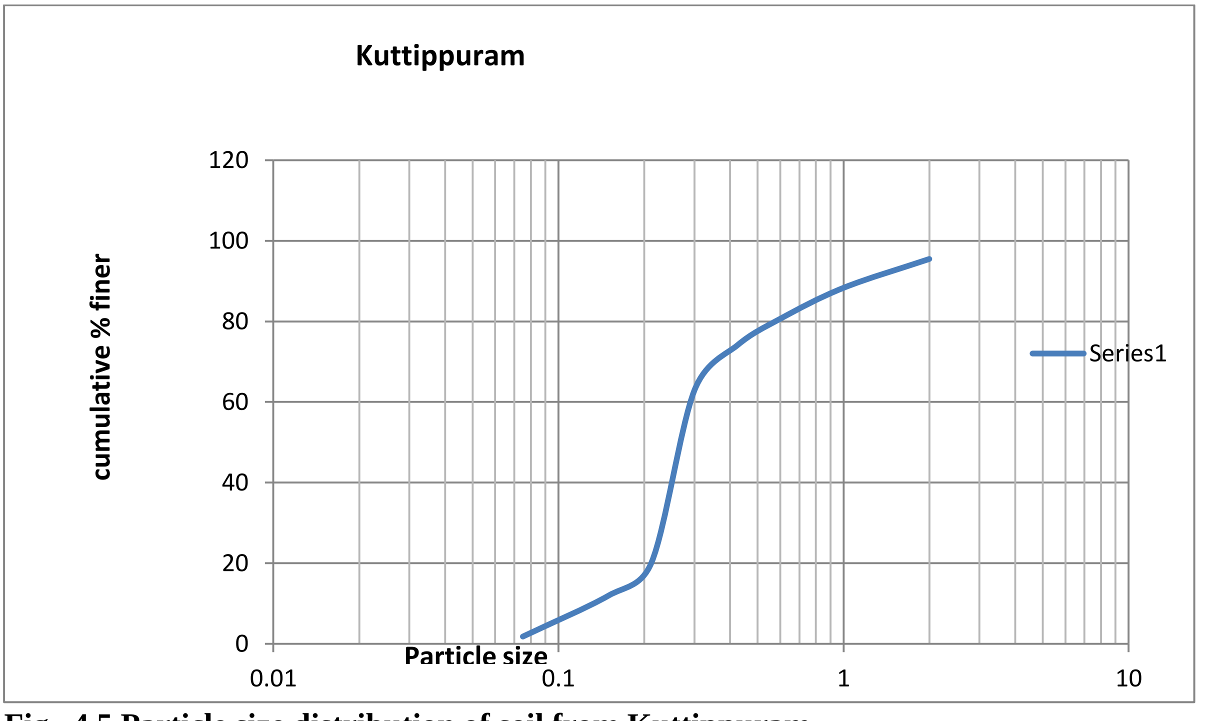

Fig . 4.5 Particle size distribution of soil from Kuttippuram

The Cu and Cc values of the soil samples are shown in table 4.8.

Table 4.8 Cu and Cc of different samples

SI.no	SITE	Cc	Cu
1	Nariparamb	2	0.97
2	Athalur	2	0.97
3	Tavanur	2	0.97
4	Kuttippuram	1.413	1.419

4.2.2 pH

Soil pH is considered a master variable in soils as it controls many chemical processes that take place. It specifically affects plant nutrient availability by controlling the chemical forms of the nutrient. Desirable limits of pH range different soils are shown in Appendix II. pH values of the soil samples are shown in Table 4.7.

4.2.3 Electrical Conductivity

Soil electrical conductivity is a property of soil that is determined by standardized measures of soil conductance by the distance and cross sectional area through which a current travels. The movement of electrons through bulk soil is complex. Electrons may travel through soil water in macrospores, along the surfaces of soil minerals (i.e. exchangeable ions), and through alternating layers of particles and solution. Therefore, multiple factors contribute to soil EC variability, including factors that affect the amount and connectivity of soil water (e.g. bulk density, structure, water potential, precipitation, timing of measurement), soil aggregation (e.g. cementing agents such as clay and organic matter, soil structure), electrolytes in soil water (e.g. salinity, exchangeable ions, soil water content, soil temperature), and the conductivity of the mineral phase (e.g. types and quantity of minerals, degree of isomorphic substitution, exchangeable ions.

EC test result of samples revealed that the EC of soils range from 0-2 ds/m. According to USDA classification the soils falls under class A group of salinity range between 0 and 0.13 g/100g of soil. EC of different soil group and salinity range are shown in Appendix III.

Table 4.9 EC and pH values of samples

SI.no	SITE	pH	EC(µmho/cm)
1	Chamravattom	6.97	0.154
2	Nariparamb	8.21	0.180
3	Athalur	8.16	0.165
4	Tavanur	6.42	0.176
5	Kuttippuram	7.53	0.163

4.3 Ground Water Recharge

Results of surveys conducted in the upstream and downstream sides of Chamravattom RCB reveals that ground water table is raised during closing of shutters on the upstream side and quality of well water is improved alot and salinity intrusion is prevented effectively. So the drinking water shortage during the summer , is solved effectively on the upstream side. But on the downstream side water taste become salty and become yellow in colour and there is no change in the water level. Results of the survey this tabulated as shown below,

Table 4.10 Water level Readings

Date	SITE	Well no	Water level(m)	Remarks
26/4/13	Chamravattom(US)	1	3.02	Before establishing the RCB the water level was below 4.40m.Now watertable get raised
26/4/13	Chamravattom(DS)	2	2.11	Salt water, yellowish in colour
26/4/13	Nariparamb(US)	3	1.60	Before establishing RCB water level was below 2.80m
26/4/13	Athalur	4	3.0	No water was in the well before RCB establishment during this season
18/5/13	Chamravattom(US)	1	2.20	Water level get raised by 82 cm
18/5/13	Chamravattom(DS)	2	2.11	No change
18/5/13	Nariparamb(US)	3	1.0	Water level get raised by 60cm and cleared in appearance.
18/5/13	Athalur(US)	4	2.0	Water level increased by 1m
25/5/13	Oottippadi(DS)	5	6.56	No change in water level before and after construction but water gets cleaned.
25/5/13	Ooottippadi(DS)	6	2.80	No change in the water level, salty taste of the water is reduced after RCB construction
25/5/13	Murayilppadi(US)	7	4.0	No water was in the well before RCB establishment during this season
25/5/13	Murayilppadi(US)	8	2.60	Water level is raised.

4.4 Agriculture

Results of surveys conducted at the upstream of Chamravattom RCB reveals that 10% of people depend on river water for irrigation. Survey was mainly conducted on Purathur pachayat,Thruprangod panchayat and Mangalam panchayat. Details are collected from panchayat Krishibhavans and by interacting with farmers. Results of this survey is given below,

Table 4.11 Basic Datas of Panchayats

Name of panchayat	**Panchayat area(km^2)**	**Net irrigated area(ha)**	**Total cultivating area (ha)**	**Cultivating area under different crops(ha)**			**Increase in cultivating area(ha)**	**Canal irrigation (ha)**	**Well irrigation (ha)**	**By other (ha)**
				crop	*Before RCB*	*After RCB*				
Thruprangod	20.67	1110	1837	paddy	489	492	20-40	160	400	550
				Vegetables	43	50				
				banana	66	70				
				Coconut	1175	1180				
				arecanut	28	30				
Purathur	19.15	1960	1480	paddy	55	65	10-20	190	900	870
				Vegetables	12	15				
				banana	25	27				
				Arecanut	9	11				
				coconut	1145	1150				

Table 4.12 Details of irrigation schemes

SI.no	Name of the Scheme	Panchayat	Present Ayacut area	Status of working
1	Thirunavaya 1st stage	Talakkad	201.58	Functionig properly
2	Thirunavaya 2nd stage	Talakkad	323.88	Functionig properly
3	Chekuthankund	Truprangod	1112.36	Functionig properly
4	Kamukku	Truprangod	44.03	Functionig properly
5	Tavanur	Tavanur	338.58	Functionig properly
6	Pothannur	Tavanur	388.03	Functionig properly
7	Trikkanapuram	Tavanur	241.46	Functionig properly
8	Madirassery	Tavanur	88.26	Functionig properly

Table 4.13 Details of Pumping Station

SI.no	Schemes	No of pumps	HP	Suction(cm)	Delivery(cm)	Remarks
1	Chekuthankund	8	70	40.64	35.56	RB
2	Kamukku	2	50	30.48	25.4	RB
3	Thirunavaya 1	2	110	40.46	40.64	RB
4	Thirunavaya 2	3	50	35.56	35.56	RB
5	Pothannur	3	50	35.56	25.4	LB
6	Tavanur	2	90	30.48	25.4	LB
7	Thrikkannapuram	3	40	25.4	30.48	LB
8	Madirassery	2	40	30.48	30.48	LB

RB: Tirur side LB: Ponnani side

Plate 7. Pumping at Athalur pump house

4.5 Transportation

The main advantage of Chamravattom Bridge is reducing of the duration of Kozhikode to Kochi route by approximately 40 kilometers, Tirur and Ponnani by 20 kilometres and reduces the distance between Ponnani and Malappuram by 10 kilometers. The bridge has also helped to reduce the traffic congestion at Edappal, Valanchery and Kottakal towns. The bridge helps to start KSRTC service on this route to various places. This also brought important and prominent cities of Cochin and Calicut, the seats of commerce and trade in this state, nearer and negotiates as a bypass to the otherwise busy highways touching the coastal towns of Parappanangadi, Tanur, Tirur and Ponnani contributing indirectly towards their social and economic development.

Plate 8.Transportation

4.6 Tourism Possibility of Chamravattom Bridge

Peoples have been coming to Chamravattom Bridge to see the largest bridge in Kerala. Tourism department has built variety projects in the back of this bridge. They have planned to make Chamravattom as the window of tourism in Malappuram by bringing variety tourism projects along Ponnani shore to Kuttipuram up to 100 crore. There is a chance to make tourism project by relating 500 years old Ponnani Juma Masjid, Thirunavaya NavaMukunda temple, Triprangod temple, Alathiyoor Hanuman Kavu etc and Beeyam Kayal, Tirur Thunjan Parambu, Kanoli Kanal, Nila Park, Padinjarekkara tourism Park.

Tourism department have planned to start boating by utilizing the water availability in Nila and planned to build Nila heritage village. Heritage will consist of Museum, Art gallery, Sports complex and convention centre. Whatever happens in projects one thing is sure that the Chamravattom Bridge will open a lot of job possibility for nearby people.

Plate 9. Tourism plan of Chamravattom

4.7 Ecosystem

Bharathapuzha comprise one of the 16 catchments in the southern Western Ghats that has the highest species richness and endemism of freshwater taxa including fish, mollusc and odonates . It is also one of the five catchments along with Periyar, Pamba, Manimala and Chaliyar that qualify as potential freshwater ‘Key Biodiversity Areas’ (KBAs) . In spite of this, Bharathapuzha is one of the most degraded and threatened river systems in the region.

At the beginning, the decomposing organisms cause an increase in the nutrient substances in water in a short period of time. Therefore, BOD (Biological Oxygen Demand) value of water rises. An anaerobic decomposition media is performed with the help of the stationary layers along the reservoir depth. This results in a dark coloured river smelling badly. Afterwards, an enormous increase in phytoplankton fed by the increased amount of nutrients is observed. Besides the plants covering the water surface as large green-dark coloured bodies, macro flora grows up on water surface. These events can be harmful both for the live of the river, and also for the people fishing. The regulator cum bridge is a real obstacle for the animals swimming from one end of the river to the other end. The existence of the regulator means death for the fish species.

Eutrophication has resulted in the abundance of filamentous algae and weeds in the lower reaches of the river, particularly from Chamravattom to Purakkad. Such large scale pollution not only degrades the habitat but also causes endocrine disruptions and several other physiological imbalances in fish including breeding failure which could ultimately lead to their extinction.

SUMMERY

CHAPTER V

SUMMARY AND CONCLUSIONS

The availability of water is decreasing with increase in its demand. Water is considered as a major input for agricultural production. With such decrease in availability the increasing demand can be met only through scientific management of water resources. Water resource projects involving reservoirs are very expensive and interlinked with many social issues. Regulator cum bridge is gated structures which restricts the natural flow of river water and impound the water behind it. Primary objectives of construction of RCB are increasing the fresh water availability, ground water recharge and increasing area of production. Even though regulator cum bridges has many positive impacts, it has got some negative impacts also.

Koottayi regulator cum bridge also got many positive impact including prevent ion of salt water intrusion (from EC measurements). At the same time it adversely affects the quality of water due to the restriction of natural flushing action of the river. It creates stagnant layers of water and also accumulates pollutants in the upstream side of RCB. Due to this amount of dissolved oxygen in river water gets reduced. This intrusion adversely affects the aquatic ecosystem.

The following conclusions are obtained from the present study.

I. River Water analysis in the upstream side of RCB, shows that EC values range from 50 to 1500 μmhos/cm. EC is the measure salinity of the water; which is in the desired limit. This shows that salinity intrusion in the upstream side of the RCB is successfully prevented. But in downstream side of RCB, the adverse effect of salt water intrusion is more prominent.

II. Water quality analysis of the samples revealed that most of the sample have amount of Total Alkalinity, sulphate, calcium, iron concentration much lower than the desired limit. But the Total Coliforms, E.Coli count, Chloride, Sulphate, Magnesium, Total Dissolved Solids and Turbidity are much larger than desired value, indicating that water is highly polluted. From this it is evident that the water is more polluted due to the restriction of natural flushing out of the river and due to dumping of sewages to the river. This leads to smelling and colour change of water in Tirur River.

III. By the analysis and comparison of pH of Kootayi and Chamravattom water samples revealed that, pH values are ranges from 6.77-7.46 while shutters are closed, which lies between the desirable limits.While shutters are opened, pH values are more that of the river water desirable limits.

IV. Particle size analysis and particle size distribution curves were prepared and gradation of soil was determined by using Cu and Cc values. All soil samples have Cu ≤ 4 and Cc< 3, which indicates that soils are well graded soils. Well graded soils have drainage property lower than poorly graded soils and are liable to be compacted more than a poorly graded soil.

V. Results of EC analysis shows, EC value range is 0.154 to 0.18µmho/cm of soil, which indicates that soil salinity is very low.

VI. From the result of soil pH analysis, it was seen that Tavanur has a pH value of 6.42 , which indicates that soil sample is slightly acidic. Soil samples from chamravattom has pH of 6.97 is neutral in nature. Samples from Kuttippuram have pH value of 7.53 which is slightly alkaline in nature. Samples from Nariparamb and Athalur are moderately alkaline.

VII. Results of surveys conducted in the upstream and downstream sides of Chamravattom RCB reveals that ground water table is raised upto 80cm during closing of shutters, on the upstream side and quality of well water is improved alot and salinity intrusion is prevented effectively. So the drinking water shortage during the summer , is solved effectively on the upstream side.

VIII. In Chamravattom region especially in the Purathoor and Thruprangodu panchayaths area of production is increased about 20% by implementing the RCB in Chamravattom. And these Panchayaths implementing new agro-projects like “SEED VILLAGE”, converting pasture lands to cultivating lands and paddy cultivation throught 3 seasons by forming clusters of farmers. It will improve the socio-economic status of farmers.

IX. Nowadays there are 8 irrigation schemes working properly under Chamravattom project.

X. There are 8 pumping stations working properly for 8 hrs , and conveying water by Canals, to Ponnani side and Tirur side. This will result in water table rise in open wells.So the drinking water shortage during the summer , is solved effectively on the upstream side.

XI. The main advantage of Chamravattom Bridge is reducing of the duration of Kozhikode to Kochi route by approximately 40 kilometers, Tirur and Ponnani by 20 kilometres and reduces the distance between Ponnani and Malappuram by 10 kilometers. The bridge has also helped to reduce the traffic congestion at Edappal, Valanchery and Kottakal towns.

XII. Tourism department has built variety projects in the back of this bridge. They have planned to make Chamravattom as the window of tourism in Malappuram by bringing variety tourism projects along Ponnani shore to Kuttipuram up to 100 crore.

XIII. The problem like smelling and colour change of water in the upstream sides of the Chamravattom and Kootayi RCBs is seen reported through media.

XIV. It seems the issue of leakage of water beneath the bridge due to sand mining from Bharathapuzha, it may cause the acute shortage of drinking water in the region and it also to affect the cultivation of thousands of acres of farm lands in the district in future, if the maintanace is not done properly.

XV. A thorough EIA of the Regulator cum Bridges are to be conducted to assess the negative impacts on the upstream side and appropriate corrective / remedial measures are to be taken to over cum these negative impacts.

XVI. Finally, there is a need for increased education and awareness programs to improve the conservation needs and profile of the Bharathapuzha River system. Since information on the river and its ecology is lacking, students and teachers from local schools and colleges within the river basin can be employed for data collection, monitoring and eco-restoration activities.

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APPENDIX I

Particle size distribution by sieve analysis

NARIPARAMB						
SL.NO	**IS Sieve**	**Particle size**	**Mass retained**	**% retained**	**Cumulative % retained**	**Cumulative % finer (N)**
1	2mm	2	30.5	7.68	7.68	92.32
2	1mm	1	28.5	7.17	14.85	85.15
3	600µ	0.6	33.5	8.43	23.28	76.72
4	425µ	0.425	31.5	7.93	31.21	68.79
5	300µ	0.3	48.5	12.22	43.43	56.57
6	212µ	0.212	172	43.33	86.76	13.24
7	150µ	0.15	36	9.06	95.82	4.18
8	75µ	0.75	15	3.78	99.6	0.4
9	Receiver		1.5	0.38	99.98	0.02

CHAMRAVATTOM						
SL.NO	**IS Sieve**	**Particle size**	**Mass retained**	**% retained**	**Cumulative % retained**	**Cumulative % finer (N)**
1	**2mm**	**2**	**56.5**	**14.26**	**14.26**	**72.26**
2	**1mm**	**1**	**33.6**	**8.48**	**22.74**	**70.7**
3	**600µ**	**0.6**	**26**	**6.56**	**29.3**	**65.78**
4	**425µ**	**0.425**	**19.5**	**4.92**	**34.22**	**65.78**
5	**300µ**	**0.3**	**37**	**9.34**	**43.56**	**56.44**
6	**212µ**	**0.212**	**37**	**9.34**	**52.9**	**47.1**
7	**150µ**	**0.15**	**33.5**	**8.45**	**61.35**	**38.65**
8	**75µ**	**0.75**	**76**	**19.18**	**80.53**	**19.47**
9	**Receiver**		**27**	**6.82**	**87.35**	**12.65**

KUTTIPURAM						
SL.NO	**IS Sieve**	**Particle size**	**Mass retained**	**% retained**	**Cumulative % retained**	**Cumulative % finer (N)**
1	**2mm**	**2**	**18**	**4.52**	**4.52**	**95.48**
2	**1mm**	**1**	**28.5**	**7.16**	**11.68**	**88.32**
3	**600µ**	**0.6**	**30.5**	**7.67**	**19.35**	**80.65**
4	**425µ**	**0.425**	**26**	**6.54**	**25.89**	**74.11**
5	**300µ**	**0.3**	**44.5**	**11.19**	**37.08**	**62.92**
6	**212µ**	**0.212**	**170**	**42.77**	**79.85**	**20.15**
7	**150µ**	**0.15**	**32.5**	**8.17**	**88.02**	**11.98**
8	**75µ**	**0.75**	**40**	**10.18**	**98.2**	**1.8**
9	**Receiver**		**7**	**1.76**	**99.96**	**0.04**

ATHALUR						
SL.NO	**IS Sieve**	**Particle size**	**Mass retained**	**% retained**	**Cumulative % retained**	**Cumulative % finer (N)**
1	**2mm**	**2**	**29.5**	**7.68**	**7.68**	**92.53**
2	**1mm**	**1**	**27**	**6.84**	**14.31**	**85.69**
3	**600µ**	**0.6**	**31.6**	**8.01**	**22.32**	**77.68**
4	**425µ**	**0.425**	**29**	**7.35**	**29.67**	**70.33**
5	**300µ**	**0.3**	**46.8**	**11.86**	**41.53**	**58.47**
6	**212µ**	**0.212**	**170**	**43.10**	**84.63**	**15.37**
7	**150µ**	**0.15**	**35**	**8.87**	**93.5**	**6.5**
8	**75µ**	**0.75**	**22**	**5.57**	**99.07**	**0.93**
9	**Receiver**		**3.5**	**0.88**	**99.95**	**0.05**

TAVANUR						
SL.NO	**IS Sieve**	**Particle size**	**Mass retained**	**% retained**	**Cumulative % retained**	**Cumulative % finer (N)**
1	**2mm**	**2**	**26**	**6.51**	**6.51**	**93.49**
2	**1mm**	**1**	**28.5**	**7.14**	**13.65**	**86.35**
3	**600µ**	**0.6**	**31.8**	**7.97**	**21.62**	**78.38**
4	**425µ**	**0.425**	**28.5**	**7.14**	**23.76**	**71.24**
5	**300µ**	**0.3**	**45**	**11.28**	**40.04**	**59.96**
6	**212µ**	**0.212**	**168**	**42.12**	**82.16**	**17.84**
7	**150µ**	**0.15**	**34.5**	**8.65**	**90.81**	**9.19**
8	**75µ**	**0.75**	**31**	**7.77**	**90.81**	**1.42**
9	**Receiver**		**5.5**	**1.37**	**99.95**	**0.05**

APPENDIX II

Classification of soil pH ranges

The United States Department of Agriculture Natural Resources Conservation Service, formerly Soil Conservation Service classifies soil pH ranges as follows.

Denomination	pH range
Ultra acid	< 3.5
Very strong acid	4.5–5.0
Strong acid	5.1–5.5
Moderate acid	5.6–6.0
Slight acid	6.1–6.5
Neutral	6.6–7.3
Slightly alkaline	7 .4–7.8
Slightly alkaline	7.4–7.8
Moderately alkaline	7.9–8.4
Strongly alkaline	8.5–9.0

APPENDIX III

Classification of soil based on the electrical conductivity of soil

USDA class	Conductivity range(ds/m)	Salt in soil (g/100g)
A	**0-2**	**0-0.13**
B	**2-4**	**0.13-0.26**
C	**4-8**	**0.26-0.51**
D	**8-16**	**0.51-1.02**

ABSTRACT

ABSTRACT

Water scarcity is an alarming problem that we face now-a-days. Even though we have abundant sources of water, good quality water is not available when needed. Here comes the relevance of water conservation structures. Allocation of water in case of multi-purpose projects among various competing needs such as drinking water, irrigation, industrial demands, downstream release etc. is a matter of great concern. Hence reservoirs must be subjected to thorough analysis to see that each drop of water impounded is utilized in the best possible manner. So a study was undertaken for analyzing the impact of Regulator cum Bridges at Chamravattom and Kootayi in Malappuram. The study conducted at Chamravattom with the specific objectives of determining the impacts of RCB on water quality, soil characteristics, ground water recharge, agriculture sector, tourism possibilities, transportation and ecosystem. And the study conducted at Kootayi with the specific objective of determining the impact of RCB on water quality.

Chamravattom regulator cum Bridge have number of positive impacts in terms of prevention of saline intrusion, increase in ground water table, improved irrigation facilities, increase in area of production, better socio-economic status, improved transportation and communication facilities and also promising future in tourism. Chamravattom Bridge has provided some disadvantage along with advantage. The main disadvantage comes under the narrow roads on this route. The benefit of reduction of duration actually gets to people only after the development of the route. And also water near to Chamravattom Bridge has a foul smell after closing the shutters, which is also reported in the case of Kootayi RCB. The results of the present study reveals that a thorough EIA of the RCB’ s are to be conducted to assess the negative impacts on the upstream side and appropriate corrective / remedial measures are to be taken to over cum the negative impacts. Finally, there is a need for increased education and awareness programs to improve the conservation needs and profile of the Bharathapuzha River system.