EMP Report for TWSS Restoration of Capacity of Aruvikkara Reservoir-Desiltation of Aruvikkara Dam, Aruvikkara, Kerala

MCPL/EMD/MIN/2017-18/11/02.....Dec, 2019

Project Proponent

KERALA WATER AUTHORITY, GOVERNMENT OF KERALA

Prepared By

MANTEC CONSULTANTS PVT. LTD.

(QCI/NABET Accredited EIA Consultant at S.No.104 as per list of accredited consultant organizations/Rev.82/Dec 5, 2019 and MoEFCC & NABL approved laboratory)

805, Vishal Bhawan, 95 Nehru Place, New Delhi-110019,

PH. 011-26429294/95/96, **Fax.** 011-26463665/26842531, **e-mail**: mantec@vsnl.com,

Environment Division, D-36, Sector-6, Noida-201 301, U. P.,

Ph. 0120-4215000, 0120-4215807 **Fax.** 0120-4215809,

E-mail: environment@mantecconsultants.com

Website: www.mantecconsultants.com

CONTENTS

List of Tables

LIST OF FIGURES

LIST OF PLATES

UNDERTAKING

This **Report** on **Environmental Management Plan** for TWSS, Restoration of capacity of Aruvikkara Reservoir-Desiltation of Aruvikkara Dam is sole property of the Kerala Water Authority, Government of Kerala.

Kerala Water Authority, Govt. of Kerala, hereby, undertake that the data and information provided in the report are correct and verified.

Authorized Signatory
For,
Kerala Water Authority, Govt. of Kerala
India

DECLARATION OF CONSULTANTS

Declaration by Experts contributing to the EIA Source Improvement of TWSS-Restoration of capacity of Aruvikkara Reservoir-Desiltation of Aruvikkara Dam in Aruvikkara.

I, hereby, certify that I was a part of the EIA EMP team in the following capacity that developed the above EIA.

EIA Coordinator:

Name: Capt.(Retd.) H.K.Sharma

Signature & Date: March 2018

Period of Involvement: November 2017– Present

Contact Information: Mantec Consultants, D-36, Sector-06, Noida-201301

(0120-4215000/804)

Functional Area Experts:

S.No.	Functional Areas	Name of the Experts	Involvement (Period & Task*)	Signature & Date
1.	AP*	Mr. S.B. Sinha	Consultancy provided in functional area of Air Pollution Prevention, Monitoring & Control. (Nov-Dec 2017)	13.3.2018
2.	WP*	Mr. S.B. Sinha	Consultancy provided in functional area of Water Pollution Prevention, Control & Prediction of impacts. (Nov-Dec 2017)	13.3.2018
3.	SHW*	Mr. S.B. Sinha	Consultancy provided in functional area of Solid Waste & Hazardous Waste Management. (Nov-Dec 2017)	13.3.2018
4.	SE*	Mr. Anil Kumar	Consultancy provided in functional area of Socio Economics.((Nov-Dec 2017)	/13.3.2018
		Mr. Mrinal Kumar	Consultancy provided in functional area of Socio Economics.((Nov-Dec 2017)	/13.3.2018
5.	EB*	Dr. Vivek Dwivedi	Consultancy provided in functional area of Ecology & Biodiversity.(Nov-Dec 2017)	13.3.2018
6.	HG*	Mr. R. K. Khanna	Consultancy provided in functional areas of Hydrology, Ground Water & Water Conservation. (Nov-Dec 2017)	13.3.2018

7.	GEO*	Mr. B.M. Sinha	Consultancy provided in functional area of Geology. (Nov-Dec 2017)	13.3.2018
8.	SC*	Dr. Vivek Dwivedi	Consultancy provided in functional area of Soil Conservation. (Nov-Dec 2017)	13.3.2018
9.	AQ*	Mr. S.B. Sinha	Consultancy provided in functional area of Meteorology, Air Quality Modeling & Prediction. (Nov-Dec 2017)	13.3.2018
10.	NV*	Mr. A.S. Brara	Consultancy provided in functional area of Noise study. (Nov-Dec 2017)	13.3.2018
11.	LU*	Mr. Manoj Kumar	Consultancy provided in functional area of Land Use. (Nov-Dec 2017)	/13.3.2018
12.	RH*	Ms Anuradha Sharma	Consultancy provided in functional area of Risk & Hazards. (Nov-Dec 2017)	13.3.2018

Declaration by the Head of the Accredited Consultant Organization

I, **A. S. Brara**, hereby, confirm that the above-mentioned experts prepared the EIA EMP Report of the Source Improvement of TWSS-Restoration of capacity of Aruvikkara Reservoir-Desiltation of Aruvikkara Dam Project. I also confirm that I shall be fully accountable for any mis-leading information mentioned in this statement.

Signature

Name : Mr. A.S. Brara

Designation : CMD

Name of the EIA Consultant Organization: Mantec Consultants Pvt. Ltd., Noida-201301

NABET Certificate No. & Issue date: NABET/EIA/1619/SA 083(Rev 01); 14 Nov, 2019

S.No.	Functional Area Code	Complete name of the Functional Areas
1.	AP	Air Pollution Prevention, Monitoring & Control
2.	WP	Water Pollution Prevention, Control & Prediction of impacts
3.	SHW	Solid Waste & Hazardous Waste Management
4.	SE	Socio-Economics
5.	EB	Ecology & Biodiversity
6.	HG	Hydrology, Ground Water & Water Conservation
7.	GEO	Geology
8.	SC	Soil Conservation
9.	AQ	Meteorology, Air Quality Modeling & Prediction
10.	NV	Noise/Vibration
11.	LU	Land Use
12.	RH	Risk Assessment & Hazard Management

ABBREVIATIONS

AAQM	Ambient Air Quality Monitoring
APHA	American Public Health Association
AWWA	American Water Works Association
BOD	Biochemical Oxygen Demand
CSD	Cutter Suction Dredgers
COD	Chemical Oxygen Demand
CT	Census Town
CSIR	Council of Scientific and Industrial Research
CPCB	Central Pollution Control Board
CWC	Central Water Commission
DPR	Detailed Project Report
DGMS	Directorate General of Mines Safety
dB	Decibel
DMP	Disaster Management Plan
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EC	Environmental Clearance
Ha	Hectare
IC	Incident Controller
IRC	Indian Roads Congress
IUCN	International Union for Conservation of Nature
IBS	Integrated Bathymetric System
KEMDEL	Kerala State Mineral Development Corporation Ltd
KERI	Kerala Engineering Institute
KSPCB	Kerala State Pollution Control Board
KPCB	Kerala Pollution Control Board
KWA	Kerala Water Authority
KLD	Kilo Liter per Day
LoS	Level of Service
MLD	Millions liter per day
MoEF &CC	Ministry of Environment and Forest & Climate Change
MoWR	Ministry of Water Resources
MCM	Million Cubic Meters
MSI	Meteological survey of India
MPN	Most Probable Number

MSL	Mean Sea Level
NABET	National Accreditation Board for Education and Training
NABL	National Accreditation Board for Testing and Calibration Laboratories
NOx	Nitrogen oxides
NH	National Highway
PDS	Public Distribution System
PDCR	Plan, Do, Check & Review
PPE	Personal Protective Equipments
PCU	Passenger Car Unit
PM	Particulate Matter
QoL	Quality of Life
QCI	Quality Council of India
RPM	Respirable Particulate Matter
RQP	Recognized Qualified Person
RDS	Respirable Dust Sampler
SEIAA	State Environmental Impact assessment Authority
SPCB	State Pollution Control Board
SD	Suction Dredgers
SHG	Self-Help Group
SHE	Safety Health and Environmental
SPM	Suspended Particulate Matter
SO2	Sulphur dioxide
TSHD	Trailer Suction Hopper Dredgers
TWSS	Township Water Supply and Sanitation
WTPs	Water Treatment Plants
WPCF	Water Pollution Control Federation

Executive Summary

1. Background

The Aruvikkara Dam in village Aruvikkara is almost 15 Km away from Distt.Trivandrum Kerala state,. It was constructed on Karamana River in year 1928-1933 by Willingdon Water Works.

There are 3 major Water Treatment Plants (WTP) constructed by the Kerala Water Authority near Aruvikkara Dam. As Aruvikkara Dam completed in 1933, the same year Water Supply Scheme in Thiruvananthapuram city was established with an installed capacity of 20 MLD, the source of Water Supply being the Aruvikkara Dam, made across the Karamana river flowing through the southern boundary of the city. The Aruvikkara Dam has been providing piped drinking water to the Trivandrum city.

Since the storage capacity of Aruvikkara is as low as 2 Mm^3, a new dam was constructed at Peppara in the year 1983, 45 kms away from Thiruvananthapuram with a capacity of 70 MCM. Water is let through from the Peppara dam by the river course to Aruvikkara as and when required. The Water Supply system's capacity was going on expanding from 36 MLD in 1962 to 84 MLD in 1972, 108 MLD in 1988 and 194 MLD in 1998, 268 MLD in 2010 meeting the ever-increasing water demand of the ever-expanding city and neighboring Panchayats. Aruvikkara dam is a major source of water supply to the city. The raw water for the treatment plant at Trivandrum is conveyed through 840mm (33") C.I. mains and the treated water from Aruvikkara plant is transmitted through 1200mm (48") C.I. mains (from 72 MLD Plant) and 1500mm (60'') MS mains from 74 MLD plant) and 1200mm (48'') MS mains (from 86 MLD plant).

2. Brief Description of the Proposed Project

The project is planned across river Karamana in Trivandrum District of Kerala. The project is Source Improvement of TWSS-Restoration of capacity of Aruvikkara Reservoir-Desiltation of Aruvikkara Dam in which extraction of sand, silt is envisaged from the water spread area. Due to continuous heavy rainfall & flooding during the recent past years, a large amount of silt material has been deposited on the bed of Karamana River as well as reservoir pockets at Aruvikkara dam site which has reduced capacity of the reservoir, decreased velocity of river flow, caused eutrophication, caused decrease in depth of water, increased vegetation growth, loss of soil, more accumulation of solid waste and has started blocking the inlet doors of Water Treatment Plants (WTPs) near Aruvikkara Dam. Keeping in view the environmental considerations for the ecosystem of the river, it is essential to remove this material from the reservoir.

Therefore, in order to achieve the design capacity of the reservoir, to increase the river flow velocity, to reduce eutrophication, to increase depth of water, to reduce vegetation growth and auto cleansing of solid wastes; it is envisaged to remove deposited material from the existing reservoir in this project.

Basic Detail of the Project

Name of the Project	Source Improvement of TWSS-Restoration of capacity of Aruvikkara Reservoir-Desiltation of Aruvikkara Dam
Type of Project	Desiltation of Waterspread areaWaterspread area as well as reservoir pockets
Location	
River Basin	
(a) Name	Karamana
(b) Originated from	Agastyakoodam
(i) State(s)	Kerala
(ii) Countries (if international river)	N.A.
River/Tributary	Karamana river
a) Length of River	68km
State(s) District(s) Taluka(s) or Tehsils in which following are located	Trivandrum,Kerala
(a) Reservoir	Aruvikkara Dam
(b) Headwork	Aruvikkara Dam
(c) Command Area	Aruvikkara Dam
(d) Power House	N.A.
Name of village near the Head-works	Aruvikkara
Location of Head-works	
(a) Longitude	77°01’0’’E to 77°02’0”E
(b) Latitude	8°34’00”N to 8°35’0”N,
© Lies in Earthquake Zone No.	Zone III
Proposed activity	Desiltation through Dredging

As per direction from Government of Kerala, the Kerala State Mineral Development Corporation Ltd (KEMDEL) has conducted a feasibility study on Desiltation of sediments from Aruvikkara reservoir.

The original capacity of the Aruvikkara reservoir along Karamana river course with the water spread area of 48.00 Ha, which caters to the water supply needs of Thiruvananthapuram city and suburbs at full reservoir level, was 2 million cubic meters (2 MCM). The Kerala Engineering Institute (KERI), Peechi carried out their survey using integrated bathymetric system (IBS) was when the reservoir was full during May, 2009 and found that estimated capacity was only 1137 MCM to due deposition of sediments. The total quantity of sand likely to be recovered from the dredged out material is estimated at 941128 tonnes. The cost of dredging of sand is estimated as Rs 550/-per ton.

The total cost of sand removal from Aruvikkara reservoir will be 941128 tonnes *800 equal to 7529 lakhs or **75.29 Crores**. The total returns of the project would be to the tune of **101.79 Crores**. The study is indicative of the economic viability of the desiltation project.

3.Method of Desiltation

Hydraulic dredgers use a centrifugal pump and pipe system to raise loosened material in suspension to the surface. There are three main types of hydraulic dredger i.e. suction dredgers (SD), cutter suction dredgers (CSD) and trailer suction hopper dredgers (TSHD) out which our project proponent is using cutter suction dredgers (CSD).

4. Scoping of the Project in the Purview of Environment

EIA is the management tool to ensure the sustainable development and it is a process, used to identify the environmental, social, and economic impacts of a project prior to decision-making. It is a decision making tool, which guides the decision makers in taking appropriate decisions for any project. In order to assess the likely impacts arising out of the project, the Environmental Impact Assessment (EIA) study is undertaken, which will be followed by preparation of a Environmental Management Plan (EMP) to minimize those adverse impacts.

As per the Sustainable Sand Mining Management Guidelines 2016, published by MoEF & CC New Delhi, it is clearly mentioned that "*The de-silting of reservoir, dredging for upkeep and maintenance of structures, channels and averting natural disasters will not be treated as mining for the purpose of environmental clearance*." Hence, the project does not require Environmental Clearance.

5. Project Benefits

The project will enable:

1. Restoration of the capacity of Aruvikkara reservoir as pilot project.
2. Extraction of 262500 tons of sand, clay & silt from Water spread area as well as reservoir pockets of Aruvikkara Dam.
3. Improvement in river flow velocity and quality.
4. Prevention of blocking of WTP inlet supply and its function.
5. Availability of minerals for industrial and commercial development of Trivandrum.
6. Removal of Eutrophication from Aruvikkara Reservoir.
7. Increased depth.
8. Prevention of vegetation growth.
9. Self cleansing of solid waste materials.

6. Land Details of the Project

The total water spread area of the project is 48 Ha and the stretch upto the bridge for desiltation of Dam project is 57.86 Ha, however a pilot study for 5.0 Ha is also planned for desiltation. There are 3 Lagoons used for storage of silt/sand/clay.

7. Description of Environment

7.1 Hydrology and Hydro-Geology of the study area

The catchment area of Karamana River is within the Thiruvananthapuram District having an area of 702 Km^2. The Vamanapuram River Basin and Neyyar Basin are situated on the north and the on the South of Karamana basin. The catchment area which lies within Aruvikkara Dam, Thrivandrum is 258.89 Km^2 .The Karamana river flows upto 68km to Arabian Sea in South-west Direction. The average annual steamflow of Karamana River is 836 Mm^3. The Karamana River has 4 major tributaries as Kaviar, Attaiar, and Vaiyapadain & Todiyar.

The Karamana River basin can be broadly classified in two zones as Archean Group Rocks & Quilon & Varkala Beds. The major part of Karamana River mainly consist of Archean Group Rocks. The River flow to south west direction towards Arabian Sea and in this region Quilon & Varkala Bed types of rocks are found as the Waterspread area consists of sand and silt throughout its flow direction.Trivandrum district is very closer to Arabian Coastline, therefore soil is predominantly composed of coastal alluvium, a mixture of clay & sand majority found in the river basin consists of laterite soil.

In the upper reaches of the Karamana river basin, mostly loam type of soil is identified. Loamy soil is yellow or reddish yellow in colour and highly fertile.

In the midland and lowland regions, a thin stretch of river alluvium is found along the river valleys cutting across the extensive laterite soil.

7.2 Rainfall

Study of isohyetal map of of Kerala reveals the isohyet of 2600 mm passes through the centre of the catchment area of the proposed project. Rainfall occurs in the monsoon i.e. from June to October and 90% of the total rainfall occurs during this period. Therefore annual monsoon rainfall monsoon can be safely assumed as 2600 mm. The rainfall data from 1970 to 2004 have been collected for the six rain gauge station falling in the catchment area.

7.3 Geology feature of the district

Geo hydrologically, Trivandrum district is situated in coastline made up of Archean type of rock and Quilon Varkala bed rocks .There are three regions High Land, Mid land & Low land region.

7.4 Description of environment

Environmental data has been collected in relation to restoration of capacity of Aruvikkara Reservior and desiltation of dam for Air, Noise, Water, Soil, Socio-economic and Ecology & Biodiversity. The generation of primary data as well as collection of secondary data and information from the site and surroundings were carried out in Nov 2017.

7.5 Air Environment

Ambient Air quality monitoring reveals that the minimum and maximum concentration of PM $_{10}$ for all 5 monitoring locations was found to be in the range of 30 µg/m^3 at Near KWA Office and 38 µg/m^3 at Near Bhagwati Temple (D/s). The minimum and maximum concentration of $PM_{2.5}$ was 18µg/m^3 and 22µg/m^3. The minimum and maximum concentrations for SO_2 were found 4µg/m^3 and 8µg/m^3. The concentrations for NO_2 were found 10µg/m^3 and 16 µg/m^3 minimum and maximum respectively. The minimum and maximum concentrations for CO were found 0.12mg/m^3 and 0.26mg/m^3.

7.6Water environment

pH varies from to 6.27 to 6.45 in which minimum at Bhagwati Temple (D/S) and maximum at Dam Site. Total Hardness varies from 28 mg/L at Opposite to the Water filling Station (72 MLD) and 31 mg/L at 1 km u/s of the Reservoir. Total Dissolved Solids varies from 39 at Opposite to the Water filling Station (72 MLD)and 46 mg/L at Reservoir (u/s of the dam). Fluoride varies from 0.01 mg/L at Bhagwati Temple (D/S), Opposite to the Water filling Station (72 MLD) and 0.03 mg/L at Dam Site. Chloride varies from 12 mg/L at Opposite to the Water filling Station (72 MLD) and 16 mg/L at Bhagwati Temple (D/S). COD varies from 4 mg/L at Dam Site to 8 mg/L at 1 km u/s of the Reservoir.

7.7 Soil environment

The analysis results show that soil is basic in nature as pH value ranges from 7.18 at Aruvikkara Village and 7.82 at U/S of the Dam. The organic matter found within the study area with minimum 1.02% at Near KWA Office and maximum 1.29 % at Opposite Dam Site (across the bridge). The concentration of Nitrogen, Phosphorus and Potassium were found in good amount in the soil samples.

7.8 Noise environment

The Noise level during day time minimum at Near KWA Office 48.2 Ld and maximum at Aruvikkara village 57.2 Ld. Noise level during night time minimum at Near KWA Office 38.2 Ln and maximum at Aruvikkara village 42.8 Ln.

It was observed that the values obtained were within the prescribed Ambient Noise Quality Standards with respect to Noise indicated no industrial activity in the study area.

7.9 Ecology and Biodiversity of the Study Area

The study area comes under "**Coastal** (West Coast or Malabar Coast)" bio-geographic zone of India (India State of Forest Report, 2015). The reservoir is located on hilly terrain and some parts of study area are plain lands.

According to primary survey conducted in study area and available secondary resources, a total of 53 floral species belonging to 28 plant families with dominance of Arecaceae and Poaceae family were identified and documented. The upper storey consists of *Mangifera indica, Artocarpus hirsutus, Vateria indica, Vitex altissima, Dipterocarpus bourdillonii, Cullenia exarillata, Terminalia bellerica, Terminalia paniculata, Pterocarpus*

marsupium, Albizia odoratissima, Holoptelea parviflora, Lagerstroemia microcarpa, Dalbergia latifolia, Bridelia retusa, Grewia tiliifolia, Mitragyna parviflora, Gluta travancorica etc. The lower storey comprises of species such as *Arenga wightii, Ixora arborea, Atalantia wightii*, while the ground flora consists of *Pogostemon paniculatus, Glycosmis cymosa* etc. Along the margin of streams large formations of *Ochlandra travancoricaand, Ochlandra wightii* were seen. The ground is covered with dense growth of grass like*, Cyrtococcum oxyphyllum, Imperata cylindrica minor, Pennisetum polystachyon* and *Themeda cymbaria* while the climbers include *Salacia chinensis, Adenia hondala* and *Dioscorea bulbifera*.

From the faunal diversity perspectives, a total of 18 mammalian and 43 avian species are found. On account to aquatic life, few common/local fish species with general spectrum of the planktons are observed in water bodies.

7.10 Social economic Environment

According to Census 2011, total population of the study area is approximately 10, 35,899. The gender wise distribution of the above population is 4, 98,159 (48.1 per cent) male and 5, 37,740 (51.9 per cent) female.

Of the total population, 8.9 per cent are children in the age group of 0-6 years. Of the total child population, 50.9 per cent are boys and remaining 49.1 per cent are girl child. The entire population of the study area is distributed into approx. 2,71,191 households and the average household size is 4.

The overall sex ratio has been worked out to 1,079 females per 1,000 males. The sex ratio of population in the age group (0-6) is 965 girls per 1,000 boys.

In the study area, 84.7 per cent of the people are literate. The gender wise distribution of literates is male 49.0 per cent and female 51.0 per cent. The overall literacy rate in the study area has been worked out to 93.0 per cent. The male literacy rate is 95.3 per cent and female literacy rate is 90.9 per cent, creating a gender gap of 4.4 per cent.

8. ANTICIPATED IMPACTS

8.1 Impact on Water Environment

The water quality may get deteriorated during the desiltation work. The samples collected from the study area shows that the turbidity varies from 4 NTU to 6 NTU in the reservoir and TSS from 24 mg/L to 28 mg/L.

Once the dredging operation starts, the concentration of TSS and Turbidity will be increased due to scouring of the settled particles.

There are three WTPs situated near the pilot study area. These are 72 MLD, 74 MLD and 86 MLD WTPs. The 72 MLD WTP inlet door is falling under this pilot study area and its function is will to be directly affected.

- Dredging in the area will be done well above the water table as well as riverbed of Karamana River, therefore, much impact on water regime is not anticipated.

- No waste water will be generated from the dredging activity of dredging of minor minerals as the project only involves lifting of Sand/Silt/Clay Mix from study area. Dredging neither intersect ground water table nor riverbed water level.

Impacts due to dredging activities

Hydraulic dredgers use a centrifugal pump and pipe system to raise loosened material in suspension to the surface. There are three main types of hydraulic dredger, suction dredgers (SD), cutter suction dredgers (CSD) and trailer suction hopper dredgers (TSHD) in which proponent using the cutter suction dredgers (CSD).

Short term Impacts;

- Salinity: At the time of dredging, the observations made at the ebb phase of the tide indicated no appreciable changes in salinity values. The day after dredging, the observations on salinity showed no conspicuous changes – the salinity distribution maintained the same pattern as the days before and during dredging.
- Turbidity: The most commonly observed changes in water quality during dredging are the rapid increase in turbidity. The change of water quality owing to dredging will not leave a permanent impression. The turbidity change was transient and localized.
- Transparency: A trend in the turbidity to gradually attain normalcy in the estuarine regions soon after stoppage of dredging.

Long Term Impacts;

- Desiltation from the Aruvikkara dam location is very beneficial for long term because it provide the construction material for developing the construction work nearest cities or other places.
- Dredging will also useful for clearing, the sediments, silt, rocky material from Riverbed, which were produced by automatically in the monsoon season by increasing the flow rate of river by heavy rainfall.

From the above mentioned points, it is understood that the short term impacts are temporary in nature and self restored after the completion of the activity where as no long-term negative impact are anticipated due to the dredging activity.

8.2 Impact on Soil and Land

During the operation phase, the dredging material will be transported from silted area of the reservoir to the temporary storage sites/lagoon by trucks and loaders. Pumping & Excavation of the stabilized playground will cause soil erosion in that particular area. Also, movements of trucks and other vehicles will cause impact on soil and land along the road and will degrade the area.

8.3 Impacts on Air Environment

Air Pollution will be caused due to fuel combustion in dredging equipments and vehicular movements during operation and transportation of desilted material. Dust

emission is also envisaged during excavation of dry area of the reservoir and vehicular movements. The same will also be caused at the storage and dumping sites.

8.4 Impacts on Noise Environment

The project area is very calm at present, however, during project operation; noise level will be increase due to the mechanical set up for dredging, vehicular movement and activity of laborers.

8.5 Impact on Ecology and Biodiversity

The benefit derived from the creation of manmade reservoir is usually associated with great risks. The impoundment of water in reservoir leads to siltation, which is considered as a threat to the longevity and ecology of the reservoir.

To get rid of the problems caused to aquatic ecosystem by the siltation in reservoir, de-siltation of reservoir is carried out to remove the excess silt accumulated in the reservoir to maintain the quality of water and the aquatic environment. However, the de-siltation work also has some short term or immediate impacts on the aquatic biological environment that are temporary and short-term.

8.6 Impact on Socio-Economic Environment

The socio-economic conditions of the area will be positively affected as the project will generate employment for labour class which will be met by the nearby areas. Apart from the direct employment to the labourers, it will also open various other activities like small tea and snacks shops etc.

In the larger picture when the project is completed, the water and sand availability for drinking and construction purpose respectively will be enhanced. This will eventually improve the overall status of the city.

8.7 Impact on Demographic Composition

Consequent of the proposed project, there will be no significant increase in overall population of the study area as local people will be mainly recruited for employment. The migrants from distant places will be kept bare minimum. Hence, there will be no significant impact on the population composition in the study area. Since there will be no significant change in population, the overall sex ratio will remain more or less same.

8.8 Impact on Employment Opportunities

A positive impact of the project is creation of employment opportunities for the local people. The proposed project may generate employment opportunities first at project implementation stage and subsequently at operational stage. Creation of employment opportunities is a positive impact of the project on socio-economic aspects of people living in the study area.

8.9 Impact on Industrial Development

It is expected that due to the proposed project, the scope for further industrialization in the area will increase. Project will also benefit in meeting the huge demand of

construction material like sand required in building construction and infrastructure works, road material for construction and maintenance of roads/highway in village Aruvikkara of district Trivandrum and nearby cities. Expected increase of industries in the study area may increase employment opportunities for the local people.

8.10 Impact on Agriculture

Since, the proposed project does not need any additional land other than what the project proponent possess, there will be no negative impact on the agricultural yield in the study area due to the proposed project.

From the all above points discussed regarding the impact on the scoio –economic impacts, it is understood that there is no negative impact on socio-economic environment of the study area.

From socio economic point of view, the project will benefit in meeting the huge demand of construction material like sand required in building construction and infrastructure works, road material for construction and maintenance of roads/highway in Aruvikkara, district Trivandrum and nearby cities and due to which local people will get opportunities to enhance their business and sources of income directly or indirectly associated activities of the project.

Another benefit, which the people residing in the study area may get that, is employment opportunities due to the proposed project. Therefore, the occupational pattern of the people in the study area will change making more people engaged in industrial & business activities due to the proposed project.

9 Mitigation Measures

9.1 Mitigation Measures for Water Environment

The dredging will impact the water quality severely but temporarily. The impacts are mainly short term disturbance to the reservoir during the dredging activity. However, to reduce the impact on water quality following plan will be adopted:

1. The dredging activity will be carried out in the Pre-Monsoon season i.e. March and April months in Kerala. Hence, impact of dredging will not last more than a month.
2. The desiltation will be done in the phase wise manner. As shown in the Figure 5.2, the desiltation will be started from the rear end Grid 1 to Grid 6. The dredging in this area will not cause suspended material to affect the water quality of the reservoir As Grid 7 will act as a natural barrier. Once this is excavated/dredged, it will restore the capacity of this part without having any impact on the water quality.
3. Grid 7 to Grid 19 will be dredged in the second phase with prior precautions and is done in such a way that the pumping is not being done rainy season. The inlet structures must be surrounded by using Type-II Silt Curtains. Type II Silt Barriers are floating turbidity barriers designed specifically for areas with moving water.

9.2 Mitigation Measures for Soil Environment

- There is no toxic element present in the mineral, which may contaminate the soil.
- Water sprinkling will be adopted to control dust emissions.
- It will be ensured that all transportation vehicles will carry a valid PUC certificate.
- Greenbelt will be developed along the roads and other sites.
- Also, afforestation in the catchment area will be done in consultation with State forest department and locals so that soil erosion can be reduced.

9.3 Mitigation Measures for Air Environment

The concentration of air borne pollutants in the workspace/work zone environment will be monitored regularly. If concentration is higher than threshold limit values are observed, the source of fugitive emissions will be identified and necessary measures will be taken.

- Plantation is recommended on approach roads & nearby vicinity of the project for minimizing dust propagation.
- Proper mitigation measures like water sprinkling will be adopted to control dust emissions.
- It will be ensured that all transportation vehicles will carry a valid PUC certificate.

9.4 Mitigation Measures for Noise Environment

- Regular maintenance of equipments and machineries to keep the noise generation at the reduced/designed level. High noise generating machines will be equipped/fitted with silencers to reduce the noise levels.
- The equipments that need to be placed still like generators will be kept in acoustic enclosures to reduce noise levels. For heavy equipments like rotating or impacting machines noise will be damped by mounting them on anti-vibrations mountings.
- Necessary training/orientation will be provided to the traffic operators/drivers to make them aware of the environmental aspects of the traffic. Loud horns and high speed etc. in the forested/natural areas will be avoided.
- Periodical monitoring of noise will be done.
- Plantation will be taken up along the approach roads and along the periphery of the dredging area to minimizes propagation of noise.

9.5 Mitigation Measures for Biological Environment

- There is no other major impacts is anticipated on the terrestrial ecology other than those which as discussed in the air, water, noise impacts that also affect the flora and fauna and mitigation thereof also suggested in those relevant segments.
- However, there are negative impacts, from the dredging activity in the aquatic environment are anticipated. These are temporary in nature and will only be limited to in the dredging grid/part till the dredging activity. Moreover, in longer term, this will be beneficial for the aquatic environment.
- Since there is no any Schedule-I fishes species found in the reservoir. Hence, here is no need of specific conservation plan.

10. Environment Monitoring Program

Monitoring is important to measure the efficiency of control measures. An environmental impact assessment study is carried over for a specified period of time and the data generated for that specific period cannot bring out all variations induced by the natural or human activities. Therefore, regular monitoring programme of the environmental parameters is essential to take into account the changes in the environmental quality. The objectives of monitoring are to:-

- Verify effectiveness of planning decisions;
- Measure effectiveness of operational procedures;
- Confirm statutory and corporate compliance; and
- Identify unexpected changes.

Monitoring of Various Parameters will include; Slope Failure, Drainage, Blasting Effects, Afforestation, Air Quality Monitoring, Water Quality Monitoring, Noise Quality Monitoring, Occupational Health & Safety

11 Environmental Management Plan

The environmental management plan consists of a set of mitigation, management, monitoring and institutional measures to be taken during implementation and operation of the project, to eliminate adverse environmental impacts or reduce them to acceptable levels. The present environmental management plan addresses, the components of environment, which are likely to be affected by the different operations in a dredging activity.

The Objectives of EMP are:

- Overall conservation of environment.
- Minimization of waste generation and pollution.
- Judicious use of natural resources and water.
- Safety, welfare and good health of the work force and populace.
- Ensure effective operation of all control measures.
- Vigilance against probable disasters and accidents.
- Monitoring of cumulative and long term impacts.
- Ensure effective operation of all control measures.

The important segment of the management Plan will include

- Floating Management Plan
- Greenbelt Development
- Safety during dredging operation
- Disaster Management Plan
- Setting-up of Emergency Infrastructure.

13. Conclusions

The restoration of the reservoir through desiltation is recommended with careful EMP measures for multi-benefits.

CHAPTER 1 : INTRODUCTION

1.1 Preamble

Environmental Impact Assessment (EIA) is the management tool to ensure the sustainable development and it is a process, used to identify the environmental, social, and economic impacts of a project prior to decision-making. It is a decision making tool, which guides the decision makers in taking appropriate decisions for any project. EIA systematically examines both beneficial and adverse consequences of the project and ensures that these impacts are taken into account during the project designing. It also reduces conflicts by promoting community participation, information, decision makers, and helps in developing the base for environmentally sound project. In order to assess the likely impacts arising out of the project, the Environmental Impact Assessment (EIA) study is undertaken, which will be followed by preparation of a Environmental Management Plan (EMP) to minimize those adverse impacts.

As per the Sustainable Sand Mining Management Guidelines 2016, published by MoEF & CC New Delhi, it is clearly mentioned that "***The de-silting of reservoir, dredging for upkeep and maintenance of structures, channels and averting natural disasters will not be treated as mining for the purpose of environmental clearance***." Hence, the project does not require Environmental Clearance. Other statutory requirements for carrying out the desiltation activity are given in **Table 1.1.**

Table 1-1: Statutory Requirements

S.No.	Particulars	Authority/Agency	Roles and Responsibility
1	Mining Plan	RQP	KWA
2	CTE/NOC	Kerala State Pollution Control Board	KWA/Contractor
3	Power Requirement	Kerala State Electricity Board Ltd	KWA/Contractor

1.2 Need of the Project

Kerala is located in Southern part of India on the Malabar Coast at a distance of 600 km from Arabian Sea shoreline. Thrivunanthapuram, capital of Kerala known as "Evergreen City of India". It is situated near the coast therefore it is rich in natural resources especially Tropical moist forests, Subtropical forests with undulating terrains, rivers, dense forests, beaches, and backwaters. Heavy rains are common in Kerala districts. The Karamana river along its course brings huge quantity of material consisting of sand, & silt during every monsoon. This material has to be removed every year in order to channelize the river course and to prevent it from widening.

1.3 Scoping of the Project

The project is planned across river Karamana in Trivandrum District of Kerala. The project is Source Improvement of TWSS-Restoration of capacity of Aruvikkara Reservoir-Desiltation of Aruvikkara Dam in which extraction of sand, silt is envisaged

from the water spread area. Due to continuous heavy rainfall & flooding during the recent past years, a large amount of silt material has been deposited in the bed of Karamana River as well as reservoir pockets at Aruvikkara dam site which has reduced capacity of the reservoir, decreased velocity of river flow, caused eutrophication, caused decrease in depth of water, increased vegetation growth, loss of soil, more accumulation of solid waste and has started blocking the inlet doors of Water Treatment Plants (WTPs) near Aruvikkara Dam. Keeping in view the environmental considerations for the ecosystem of the river, it is essential to remove this material from the reservoir.

Therefore, in order to achieve the design capacity of the reservoir, to increase the river flow velocity, to reduce eutrophication, to increase depth of water, to reduce vegetation growth and auto cleansing of solid wastes; it is envisaged to remove deposited material from the existing reservoir in this project.

1.4 Environmental Sensitivity of the Project

Environmental sensitivity of the project that includes important ecological features and social infrastructures within 15 km radius from the project periphery is given below in **Table 1-2**.

Table 1-2: Environmental Sensitivity (within 15 km study area)

S.No.	Sensitive Ecological Features	Name	Aerial Distance (in km.) from Mine Lease boundary
1.	National Park/Wildlife Sanctuary	None	Nil
2.	Tiger Reserve/Elephant Reserve/Turtle Nesting Ground	None	Nil
3.	Core Zone of Biosphere Reserve	None	Nil
4.	Habitat for migratory birds	None	Nil
5.	Lakes/Reservoir/Dams	Source Improvement of TWSS-Restoration of capacity of Aruvikkara Reservoir-Desiltation of Aruvikkara Dam by removing silt	0 Km
6.	Stream/Rivers	Silted portion of water spread area, which is adjacent to river course as well as in the reservoir pockets.	0 Km
7.	Estuary/Sea	None	Nil
8.	Mangroves	None	Nil

S.No.	Sensitive Ecological Features	Name	Aerial Distance (in km.) from Mine Lease boundary
9.	Mountains/Hills	Project lies in the foothills of Agastyamalai range	10.5 Km
10.	Notified Archaeological sites	None	Nil
11.	Industries/Thermal Power Plants	None	Nil
12.	Defense Installation	Military Area	14.3 Km
13.	Densely populated or built-up area	Trivandrum	15 Km
14.	Hospital	Venad Hospital, Nedumangad District Hospital, Nedumangad RIMS Hospital, Enikkara-Nedumangad Martha Ayurvedic Eye Hospital Military Hospital, Pangode SK Hospital, Thrivandrum Ahalia Foundation Eye Hospital, NH-47	5.4 Km, 7.4 Km 7.1 Km 12.7Km 14.0Km 14.4 Km 14.6 Km
15.	School	Govt.Higher Sec. School, Aruvikkara Abdul Salam Rafi Residential School SNV High School, Thiruvananthapuram St. Thomas School, Thiruvananthapuram	1.4 Km 8.1 Km 10.2 Km 11.3 Km
16.	Important worship place	Aruvikkara Bhagvathy Temple, Edaman Shiva Temple, Aruvikkara. Sree Bhadrakali Temple, Puthulangara. Sree Mutharaman Temple, Kovil	0.75 Km 2.0 Km 5.6 Km 6.8 Km
17.	Important Mosque Place	Azikode Juma Masjid, Azikode Puthukulangara Masjid. Juma Masjid, Thiruvananthapuram Chelayil Muslim Jamaat	3.7 Km 6.6 Km 7.3 Km 13.8 Km

S.No.	Sensitive Ecological Features	Name	Aerial Distance (in km.) from Mine Lease boundary
18.	Important Church Place	St. Thomas Evangelical Church, Parakonam CSI Church, Azikode	2.8 Km 3.7 Km
19.	Institution	Testa Pedagogy Park Govt. Industrial Training Institute, Aryanad	5.4 Km 10.6 Km
20.	Commercial Building	Avenue Centre Shoppe Multi Branded	12.8 Km
21.	Zoological Park/Zoo	Zoological Park, Thiruvananthapuram	14.3 Km
22.	Museum	Kerala State Science & Technology Museum	14.5 Km
23.	Govt. Building	District Collector Office, Thiruvananthapuram	12.4 Km

1.5 Environmental Laws & Order

The Acts, Notifications, Rules and Amendments applicable for setting up a new mining industry or its expansion of an existing mine and for operation of a mine include the following:

- EIA Notification, 2006 under EPA Act, 1986
- The Mines and Mineral (Development and Regulation) Act, 1957
- The Mines Act, 1952
- Mines Rules, 1955
- Mineral Concession Rules, 1960
- Mineral Conservation and Development Rules, 1968
- The Water (Prevention & Control of Pollution) Acts, 1974/Rules, 1975
- The Air (Prevention & Control of Pollution) Acts, 1981/Rules, 1982
- The Environment (Protection) Acts, 1986/Rules, 1986
- Contract Labor (Regulation & Abolition) Act 1970 & Its Central Rule, 1971
- The Central Motor Vehicle Rules, 1989(Under Motor Vehicle Act, 1988)

No major law & order problem is envisaged due to the proposed project. It is expected that the workers will attend to their duties from their residences and return to their homes after the day's work.

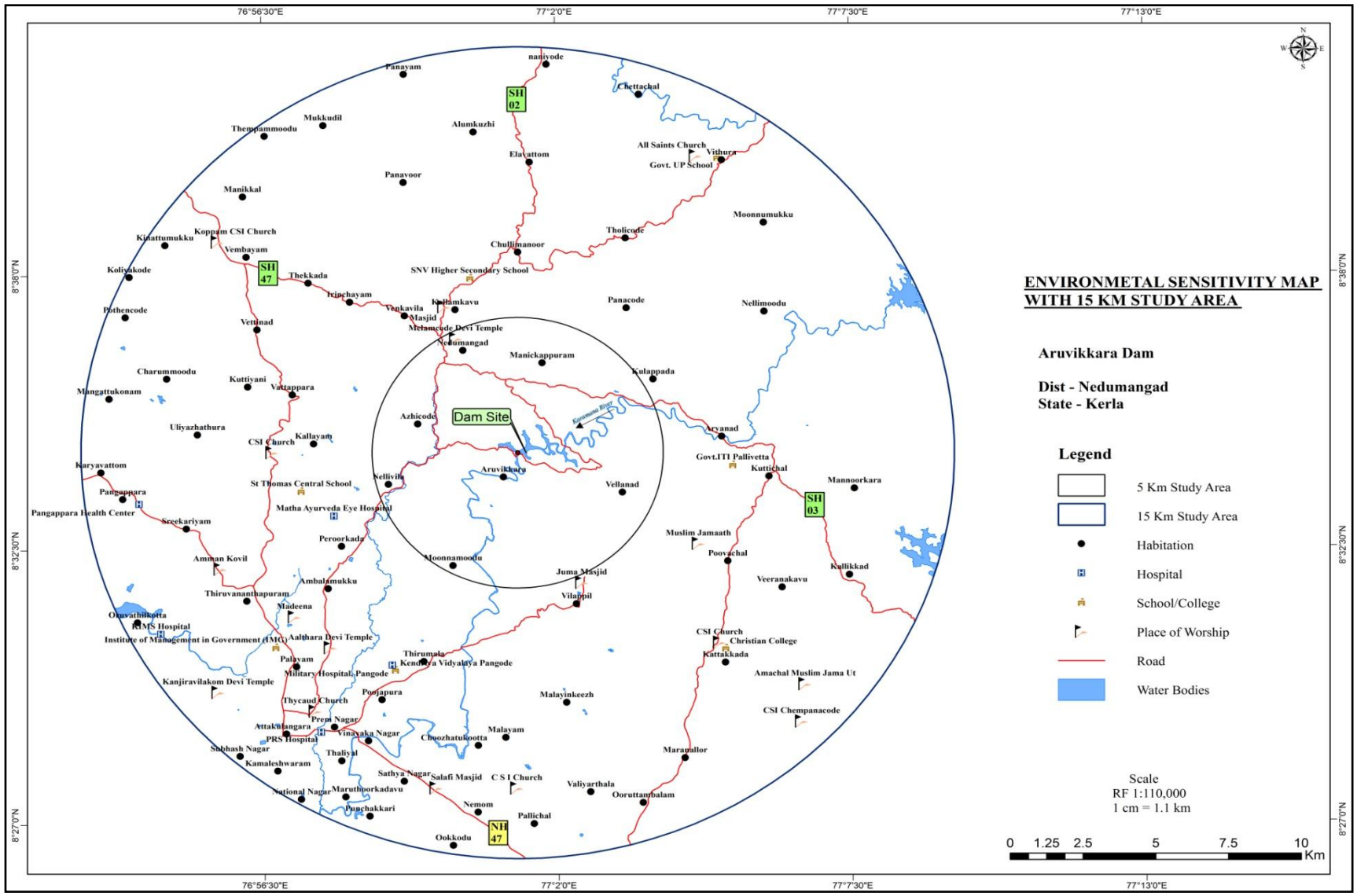


Figure 1-1: Environmental Sensitivity Map

CHAPTER 2 : PROJECT DESCRIPTION

2.1 Project Proponent

Kerala Water Authority was established on 1st April 1984 under the water & wastewater ordinance 1984 by converting the erstwhile public health engineering department to provide for the development and regulation of water supply and wastewater collection and disposal in the state of Kerala and for matters connected therewith. The Kerala Water Supply and Sewage Act, 1986 (Act 14 of 1986) replaced the ordinance. The authority was established by vesting the properties and assets of erstwhile public health engineering department under Section-16 of the act and the assets, rights and the liabilities of the local bodies and Kerala state ruler development board as far as they pertain to the execution of water supply and sewage schemes under Section 18 of the act.

The main function of the authority is preparation, execution, promotion, operation, maintenance and financing of the schemes for supply of water and for the disposal of wastewater. (Source: kwa.kerala.gov.in).

2.2 Brief description of the project

Thiruvananthapuram (formerly known as Trivandrum), the capital city of Kerala state, is located on the west coast of India near the extreme south of the mainland and the southern tip of Kerala state. Referred to as the "Evergreen city of India" by the father of our nation Mahatma Gandhi, the city is characterized by its undulating terrain of low coastal hills and busy commercial alleys. With nearly 10, 00, 000 (ten lakh) inhabitants as per the 2011 Census, it is the largest and most populous city in Kerala. It has an IT hub of the state (Technopark) with over 80% of the state's software exports. The city also houses many central and state government offices and organizations. Apart from being the political nerve center of Kerala, the city is also a major academic hub and houses several educational, science & technology institutions, which makes Thiruvanathapuram the most prominent place in the Kerala state.

The Aruvikkara Dam in village Aruvikkara is almost 15 Km away from Distt. Trivandrum. It was constructed on Karamana River in year 1928-1933 by Willingdon Water Works..

There are 3 major Water Treatment Plants (WTP) constructed by the Kerala Water Authority near Aruvikkara Dam. As Aruvikkara Dam completed in 1933, the same year Water Supply Scheme in Thiruvananthapuram city was established with an installed capacity of 20 MLD, the source of Water Supply being the Aruvikkara Dam, made across the Karamana river flowing through the southern boundary of the city. The Aruvikkara Dam has been providing piped drinking water to the Trivandrum city.

Since the storage capacity of Aruvikkara is as low as 2 MCM, a new dam was constructed at Peppara in the year 1983, 45 kms away from Thiruvananthapuram with a capacity of 70 MCM. Water is let through from the Peppara dam by the river course to Aruvikkara

as and when required. The Water Supply system's capacity was going on expanding from 36 MLD in 1962 to 84 MLD in 1972, 108 MLD in 1988 and 194 MLD in 1998, 268 MLD in 2010 meeting the ever-increasing water demand of the ever-expanding city and neighboring Panchayats. Aruvikkara dam is a major source of water supply to the city. The raw water for the treatment plant at Trivandrum is conveyed through 840mm (33") C.I. mains and the treated water from Aruvikkara plant is transmitted through 1200mm (48") C.I. mains (from 72 MLD Plant) and 1500mm (60'') MS mains from 74 MLD plant) and 1200mm (48'') MS mains (from 86 MLD plant).

2.3 KEMDEL Report

With increasing demands for water storage, loss of capacity in existing reservoirs threatens the sustainability of Water supply, Irrigation and Hydel power. Since the environmental factors impede new projects and the lack of the availability of the areas for new projects Desiltation of the reservoirs would be the best option. It considered that the exploitation of sediments entrapped along the reservoir areas as an alternative source for construction. As per direction from Government of Kerala, the Kerala State Mineral Development Corporation Ltd (KEMDEL) has conducted a Feasibility Study on Desiltation of sediments from Aruvikkara reservoir.

The original capacity of the Aruvikkara reservoir along Karamana river course with the water spread area of 48.00 Ha, which caters to the water supply needs of Thiruvananthapuram city and suburbs at full reservoir level, was 2 million cubic meters (2 MCM). The Kerala Engineering Institute (KERI), Peechi carried out their survey using integrated bathymetric system (IBS) was when the reservoir was full during May, 2009 and found that estimated capacity was only 1137 MCM to due deposition of sediments. The study of satellite imageries pointed out that the land use pattern in the catchment area of Aruvikkara reservoir indicated that the stretch of the river on aimer banks are subjected to disturbances due to the change-of-land-use. Due to conversion to other cultivations and mixed crops and thereby prone for soil erosion. By assuming this rate of sediment deposition as constant, the total sediment accumulation in Aruvikkara reservoir is estimated 1002944 m^3, which is 50.14% of the reservoir capacity, and the reservoir capacity is reduced to 49.865% of the original capacity. The total cost of the desiltation of 1 million cubic meters of sediments by Hydraulic Dredging is arrived tentatively as 5186 lakhs or Rs 51.86 Crore.

The total quantity of sand likely to be recovered from the dredged out material is estimated at 941128 tonnes. The cost of dredging of sand is estimated as Rs 550**/-**per ton.

Besides, the cost of separation of sand from the dredged out sediment from the reservoir is assessed as Rs 250 per ton. Thus, the cost of operation for recovery of sand for construction purpose would be Rs 800/- per ton (550+250). Hence, the total cost of sand from Aruvikkara reservoir will be 941128 tonnes * 800 equal to 7529 lakhs or **75.29 Crores**. Apart from this, the silt and clay fractions in the sediments dredged from the reservoir can be reused in the field of construction, tile and brick industry, for land

filling, reclamation and embankments etc. These would fetch a price assessed as Rs 250/- per ton nearly 30% of the cost of construction sand. Thus, additional revenue of 26.50 Crores will be generated by finding judicious reuse and disposal of the silt and clay fractions recovered from desilted material. The total returns of the project would be to the tune of **101.79 Crores**. The study is indicative of the economic viability of the desiltation project. This will cater to the requirement of sizable portion construction sand in the area and developmental programmes envisaged in Thiruvanathapuram district and nearby areas such as Vizhmjam International Sea Port, Light Metro project, Kazhakuttam NH bypass development etc.

Detailed Project Report (DPR) may be prepared by conducting Feasibility studies on the Proposal. It should include a Dredging operation plan, De-watering plan of the dredged material, enumerating the sequence of dredging operation, effluent pumping, location of the return discharge to the reservoir river downstream of the weir, proposed location of booster pumps if any, location of the silt curtains etc by a competent consultant. The Detailed Project Report consist with separation of dredged material in slurry form to sand, silt and clay may be undertaken pertaining to flow sheet development, process design including material balance and water balance, preliminary equipment selection, engineering package involving equipment specification, pumping system, product stock piling, conceptual design, settling tanks and civil works etc for segregation of the dredged out material.

An EIA study may be followed in tandem by a competent agency in the state for preparation of an Environmental Management Plan for the desiltation project for obtaining Environmental Clearance (EC) from Ministry of Environment and Forest & Climate Change (MoEF&CC)/State Environmental Impact assessment Authority (SEIAA) and State Pollution Control Board (SPCB).

The desiltation of Aruvikkara reservoir will have multifarious benefits.

1) This facilitates to augment the water supply schemes by KWA in the Thiruvananthapuram and suburb area. The original capacity of the Aruvikkara reservoir 2MCM will be restored once the desiltation is completed. The water supply demands for Thiruvananthapuram city and suburbs are around 220 MLD. The storage capacity restored to the region would suffice for pumping of water supply for 10 days to the Trivandrum city.
2) Desiltation of Aruvikkara reservoir will provide a sizable source for the construction sand requirement and will be alternative source for sand from rivers in the state, which been exploited and face severe environmental degradation. The desiltation of Aruvikkara reservoir and recovery of the sand will have the dual benefit of providing alternative source for construction needs of Vizhinjam International Sea port project and Light Metro Thiruvananthnpuram project and Kazhakuttam NH bypass as well. The silt and clay fraction recovered from the sediments can also used in the field of construction and land reclamation and provide a sizable source for the construction sand requirement in the area.

3) Desiltation can improve water quality by reducing the amount of nutrients available from the sediments, thereby reducing nuisance of algae blooms. This can occur through direct removal of nutrient-rich sediments, or by deepening enough the lake to allow thermal stratification to develop and thereby limit nutrient movement from deep-water areas to the upper waters. Dredging in areas of rooted aquatic plants controls their growth through direct removal, also can limit future re-growth if the new water depths are deeper than sunlight can reach.
4) The desiltation of the reservoir and restoration of its storage capacity not only facilitate to augment the water supply demands of Thiruvanathapuram city and suburbs but also help to ward off unexpected flooding of the parts of Thiruvananthapuram city during heavy rains. The present capacity of the reservoir would hardly suffice the 220 MLD requirements for 5 days. This can be doubled *i.e.* 10 to 12 days after desiltation and this would help to prevent unexpected flooding of the parts of Thiruvananthapuram city during continuous heavy rains in the catchment area.
5) The aesthetics will improve and the enhanced scenic beauty can benefit the area and the reservoir banks can be converted to a tourist spot. The spoil areas after completion of the project can be transformed as land for gardening, horticulture; pisiculture etc

Kerala Water Authority (KWA) being a statutory body constituted by the State Government of Kerala has proposed for the collection and disposal of sand & silt (minor mineral) from the reservoir. Due to heavy rainfall & flooding in the state, a large amount of material has been deposited in the riverbed of Kerala. Waterspread area of Aruvikkara Reservoir also faces the same problem of sand & silt deposition, which has reduced their capacity, started blocking of WTP inlet doors which are responsible for supply of drinking water to Distt. Trivandrum. Keeping in view the environmental consideration for the water quality aspects & ecosystem of the river, it is essential to remove this material from the water spread area as well as reservoir pockets. Therefore, in order to channelize the river course, restore capacity of the reservoir, prevention of silt deposition at WTP inlet doors, the-Source Improvement of TWSS-Restoration of capacity of Aruvikkara Reservoir-Desiltation of Aruvikkara Dam, across Karamana River has been proposed.

Project will also benefit in meeting the huge demand of construction material like sand required in building construction and infrastructure works, road material for construction, use of clay/silt in the maintenance of roads/highway; in Aruvikkara, and nearby cities.

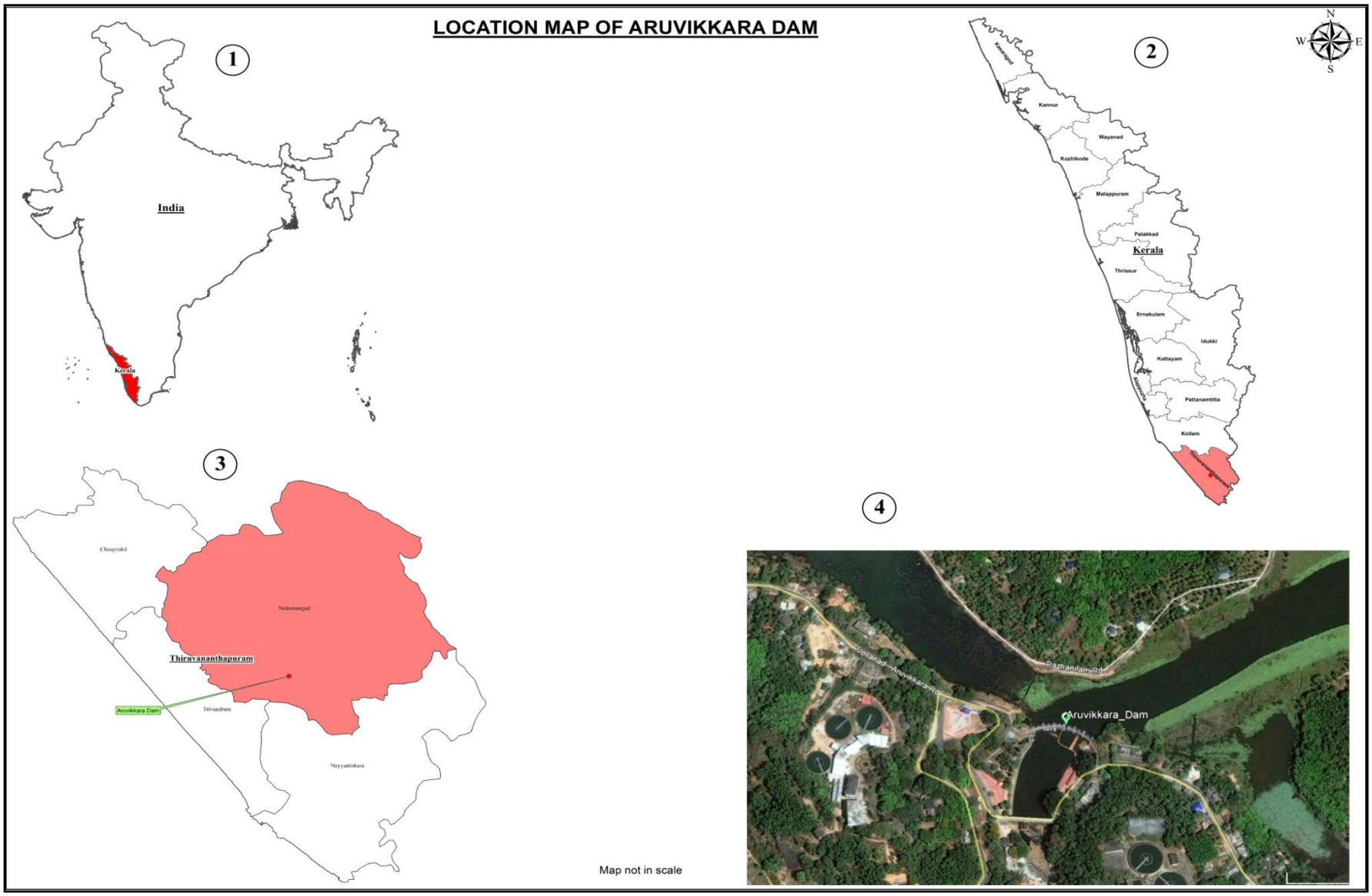


Figure 2-1: Location Map of the Project

The desiltation is proposed on the, Aruvikkara Reservoir near village Aruvikkara, Trivandrum district, Kerala. This 5.0Ha area will be used as pilot project and if got succeed in desiltation process with least impact on the water quality for WTP, it will be implemented on the remaining area of 50.23Ha.

The collection of minor minerals will be carried out from the 9.95% of the total area i.e. approximately 5.0Ha, as a pilot project.

If succeed in desiltation of 5.0 Ha pilot area, desiltation will be implemented on the remaining area of reservoir. The project is envisaged to extract 262500 tonnes of Silt by -Mechanized-Cutter Suction Dredging method in water spread area as well as in reservoir pockets.

2.4 Salient Features of the Proposed Project/Activity

Salient features of the project are given below in the **Table 2.1.**

Table 2-1 : Salient feature of the project

S.N.	Particular	Detail
1.	Name of the Project	Source Improvement of TWSS- Restoration of capacity of Aruvikkara Reservoir-Desiltation of Aruvikkara Dam
2.	Type of Project	Desiltation of Waterspread areaWaterspread area as well as reservoir pockets
3.	Location	
3.1	River Basin	
	(a) Name	Karamana
	(b) Originated from	Agastyakoodam
	(i) State(s)	Kerala
	(ii) Countries (if international river)	N.A.
3.2	River/Tributary	Karamana river
	b) Length of River	68km
3.3	State(s) District(s) Taluka(s) or Tehsils in which following are located	Trivandrum, Kerala
	(a) Reservoir	Aruvikkara Dam
	(b) Headwork	Aruvikkara Dam
	(c) Command Area	Aruvikkara Dam
	(d) Power House	N.A.
3.4	Name of village near the Head-works	Aruvikkara
3.5	Location of Head-works	
	(a) Longitude	77°01'0''E to 77°02'0"E
	(b) Latitude	8°34'00"N to 8°35'0"N,
	(c) Lies in Earthquake Zone No.	Zone III
3.6	Project area reference to	
	(a)Layout plan	
3.7	Access to the project Name Distance from project site	

	(a)Airport	Trivandrum (19.3Km)
	(b)Rail head	Thrivananthapuram Central (17Km)
	(c)Road head	Trivandrum-Changotha (T-C) Road, Trivandrum(11.0Km)
	(d)Road head	NH-47(23.2 Km), NH-66(20.3km)
	(e)Sea Port	Vizhinjam (32.9 Km) (under construction)
4.	International/Inter state aspects of the projects	State aspects are involved
	(a)Catchments area of the basin	258.89 sq.Km (Kerala)
5.	Estimated life of the project (years)	
6.	Desiltation (ha.) (proposed)	48 Ha
	(i) District (s) Benefited (if the district benefited is pre-dominantly tribal or drought prone, it may be so indicated against each district).	Trivandrum
7.	Terrain	Undulating with elevation
	a) Range	100m to 1717m
8.	Waterfalls	Bona & Azhvanthol
9.	Climate	Tropical & Montane Subtropical
10.	Temperature	16 to 35 degree
11.	Wildlife Sanctuary	Neyyar (20 Km), Peppara (43.5 Km)
12.	Forest	Tropical Moist Evergreen
13.	Water supply	
13.1	Domestic	
	(a) Names of towns/villages served	Trivandrum district
	(b) Size of population served	10, 00, 000
	(c) Water demand Availability	268 MLD
14.	Hydrology	
14.1	Catchment area of entire Karamana river	702 sq-Km
14.1.1	Catchment area at upper head work site	258.89 sq Km
14.2	i. Rainfed	Good
	ii. Snow fed	Nil
	iii. Precipitation annual	2600mm
	iv. Steam flow annual	836 MCM
	v. No. of tributaries	4 nos.
	vi. Reservoir	50.23Ha
	vii. Important Rain gauge station	Kovalam, Nedumangad, Trivandrum OBS, Trivandrum Aerodome, Thumba, Vellayani
15.	Temporary Storage Sites/Lagoons	1.19 Ha
16.	Amount of mineral extracted	262500 Tones
17.	Maximum storage	2.00 MCM
18.	Shutter details	6 nos. of 12.08*2.4m straight gate
19.	Water spread area	48.00 Ha

20.	Type of Dam	Gravity masonry Dam
21.	Dam length	83.21m
22.	Top width of Dam	2.13m
23.	Maximum height of dam	19.27m
24.	Bed level	32.62m
25.	Land use	Water body
26.	Minerals of mine	Sand/Silt/Clay Mix (Minor Minerals)
27.	Life of mine	Continuous, being replenished yearly
28	Method of mining	Cutter Suction Dredging
29.	No of working days in a year	300
30.	Water demand for Labor (Drinking and Dust Suppression)	5 KLD
31.	Sources of water	Karamana River
32.	Man power	50
33.	Labor Accommodation and solid waste from labor camp	Labors will come from the local areas and after completing the day, they move to their homes. Therefore, no accommodation is required. Toilet facility with soak pit will be provided for labor use. Therefore, no solid waste management system will required.
34.	Seismic Zone	III

2.5 Method of Desiltation

Hydraulic dredgers use a centrifugal pump and pipe system to raise loosened material in suspension to the surface. There are three main types of hydraulic dredger i.e. suction dredgers (SD), cutter suction dredgers (CSD) and trailer suction hopper dredgers (TSHD) out which our project proponent is using cutter suction dredgers (CSD).

The cutter suction dredger dislodges material with a rotating cutter equipped with cutting teeth. The loosened material is sucked into the suction mouth located in the cutter head by means of centrifugal pump installed on the pontoon or ladder of the dredger. Further transport of the material to the relocation site is achieved by hydraulic transport through a discharge pipeline. Occasionally the material can be pumped into transport barges for further transport (Bray, 2008).

Most cutter suction dredgers do not have an optimal combination of cutting capacity and suction capacity for all types of soil, thus contributing to sediment re suspension (Dearnaley et al 1996; Bray 2008). Also a spill layer (0.25 – 1m) remains in general on the Riverbed after dredging if no special precautions are taken. An additional pass at the same dredging depth can remove this spill layer. The re-suspension caused by the cutter suction dredger can, however, be reduced by the following considerations:

- Cutter speed, swing velocity and suction discharge must be optimised with respect to each other. The continuous improvements in automation, control and the cutter

suction head positioning have afforded considerable economic and environmental advantage.

- A moveable shield around and above a cutter head or suction head reduces the escape of suspended material into the surrounding water column.
- Optimisation of the design of the cutter head with respect to the material being dredged to improve the direction of the material towards the suction intake.
- Use of silt curtains (Dearnaley *et. al.*, 1996).

2.6 Project Benefits

The project will enable:

- Restoration of the capacity of Aruvikkara reservoir as pilot project.
- Extraction of 262500 tons of sand, clay & silt from water spread area as well as reservoir pockets of Aruvikkara Dam.
- Improvement in river flow velocity and quality.
- Prevention of blocking of WTP inlet supply and its function.
- Availability of minerals for industrial and commercial development of Trivandrum.
- Removal of Eutrophication from Aruvikkara Reservoir.
- Increased depth.
- Prevention of vegetation growth.
- Self cleansing of solid waste materials.

2.7 Land Details of the Project

The total water spread area of the project is 48 Ha and the stretch upto the bridge for desiltation of Dam project is 57.86 Ha, however a pilot study for 5.0 Ha is also planned for desiltation. There are 3 Lagoons used for storage of silt/sand/clay. The details of land are given in **Table 2.2** below.

Table 2-2: Land Details

S. No.	Details	Area, Ha
1	Playing ground (a part of the reservoir which got solidified due to silt deposition)	1.6
2	Area b/w Dam and playing ground	6.03
3	Area from the Dam till the bridge	50.23
	Sub Total(A)	**57.86**
4	Lagoon I	0.52
5	Lagoon II	0.44
6	Lagoon III	0.23
	Sub Total(B)	**1.19**
	Total(A+B)	**59.05**

Plate 1: Site Photographs Showing Reservoir Features

Figure 2-2 : Entire Project Layout

Figure 2-3: Area for Desiltation in Pilot Study

CHAPTER 3 : ANALYSIS OF ALTERNATIVES

Any dredging activity cannot be carried out without preparing a mining plan and got it approved by the State Geology department. The mining plan is prepared by Recognized Qualified Person generally known as RQP who is certified by Mines & Geology department. An engineer with five years of experience in a supervisory capacity in the field of mining and with a Recognized Qualified Person (RQP) certificate from a state government is permitted to prepare a mining plan. The mining plan is then submitted to the state government for approval before a company starts work on the ground. The mining plan includes the total reserve, mineable reserve and geological reserve of the mine area. It also covers the method of mining, different plans such as surface plan, section plan, mine closure plan, conceptual plan etc. As the mine plan for this project is available at present, three different methods are adopted to estimate these reserves. which are as follows:

The average depth of the reservoir is 3.5 meters. As the silt deposited area at the very last end near road is completely filled with silt and is used as football ground by villagers, It is assumed that silt depth here as3.5 m. However, it is measured that average water depth at all other locations in the reservoir (pilot study) is 1.0 meter; hence silt deposition is estimated at 2.5 meter depth.

1. The area under the study was mapped on google earth and by using polylines, its area has been estimated and so as the reserves. By using this method, the area for this pilot study is estimated around 5.0Ha.

As per this method total accumulated sediment in the reservoir is calculated approximately 262500 tonnes for 5.0 Ha.

Table 3-1 Estimation of Reserves by Whole Area Estimation

Section	Area (Ha)	Av. Water Depth (m)	Av. Silt level (m)	Av. Total depth (m)	Silt Vol. (cu-m)	Density (g/cm^3)	Density (Kg/m^3)	Silt (Kg)	Silt (Tonns)
Play Ground	1.6	0	3.5	3.5	56000	1.5	1500	84000000	84000
B/W Playground and Dam	3.4	1	2.5	3.5	119000	1.5	1500	178500000	178500
Total	5.0	1	6	7	175000			262500000	262500

2. The area under the pilot study is divided into the grid of 25 m width with varying lengths. Total area is divided into 30 sections and area of each section is calculated assuming them as trapezium.

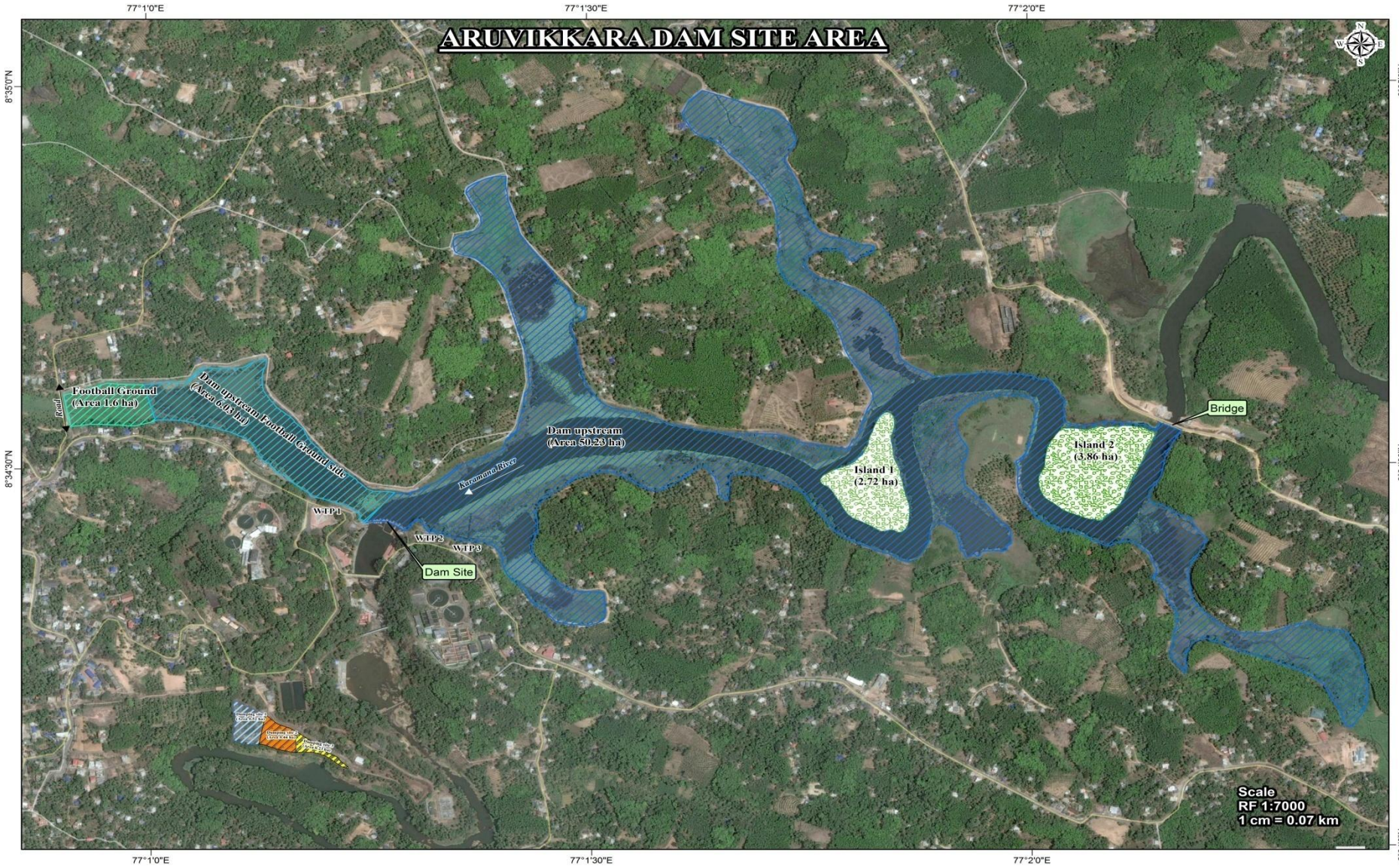


Figure 3-1: Area marked on Google Earth as whole

The area worked out by using this method is 84075 m^2 or 8.41 Ha. The quantities worked out have been given in the **Table 3.2.**

Table 3-2: Estimation of Reserve

Section	Length (m)	Width (m)	Area, (sq-m)	Silt Depth (m)	Volume (cu-m)	Density (kg/cum)	Reserves (kg)	Reserves (Tonnes)
1	95	25	2387.5	3.5	8356.3	1500	12534375	12534.375
2	96	25	2475	3.5	8662.5	1500	12993750	12993.75
3	102	25	2662.5	3.5	9318.8	1500	13978125	13978.125
4	111	25	2775	3.5	9712.5	1500	14568750	14568.75
5	111	25	2800	3.5	9800	1500	14700000	14700
6	113	25	2775	3.5	9712.5	1500	14568750	14568.75
7	109	25	2650	3.5	9275	1500	13912500	13912.5
8	103	25	2500	2.5	6250	1500	9375000	9375
9	97	25	2475	2.5	6187.5	1500	9281250	9281.25
10	101	25	2587.5	2.5	6468.8	1500	9703125	9703.125
11	106	25	3050	2.5	7625	1500	11437500	11437.5
12	138	25	3525	2.5	8812.5	1500	13218750	13218.75
13	144	25	3712.5	2.5	9281.3	1500	13921875	13921.875
14	153	25	4050	2.5	10125	1500	15187500	15187.5
15	171	25	4100	2.5	10250	1500	15375000	15375
16	157	25	3575	2.5	8937.5	1500	13406250	13406.25
17	129	25	3100	2.5	7750	1500	11625000	11625
18	119	25	2862.5	2.5	7156.3	1500	10734375	10734.375
19	110	25	2787.5	2.5	6968.8	1500	10453125	10453.125
20	113	25	2925	2.5	7312.5	1500	10968750	10968.75
21	121	25	2950	2.5	7375	1500	11062500	11062.5
22	115	25	2762.5	2.5	6906.3	1500	10359375	10359.375
23	106	25	2612.5	2.5	6531.3	1500	9796875	9796.875
24	103	25	2587.5	2.5	6468.8	1500	9703125	9703.125
25	104	25	2537.5	2.5	6343.8	1500	9515625	9515.625
26	99	25	2425	2.5	6062.5	1500	9093750	9093.75
27	95	25	2262.5	2.5	5656.3	1500	8484375	8484.375
28	86	25	2037.5	2.5	5093.8	1500	7640625	7640.625
29	77	25	1925	2.5	4812.5	1500	7218750	7218.75
30	77	25	2200	2.5	5500	1500	8250000	8250
					Total		**343068750**	**343068.75**

Figure 3-2: Map showing Grid of 25m width lengthwise

In this method, the area under the pilot study is divided in the grid of 20 m width. Cross section of dredged and excavated reservoir area will be measured separately.

Total dredged area of reservoir is divided into 460 sections and volume of each section is calculated in Table 5.3. Similarly, excavated area is also divided into 140 sections in Table 5.4. The total volume of dredged area is measured as 81800 m^3 where excavated area is calculated 23500m^3. This method estimates total accumulated sediment dredged from reservoir area is calculated as 122700000 Kg or 122700 Tonnes. The total excavated sediment is calculated approximately 35250000 Kg or 35250 Tonnes.

Table 3-3 Estimation of Dredged reservoir area

Section	Area (sq-m)	Width (m)	Volume (cu-m)	Density (kg/cum)	Reserve (kg)	Reserve (Tonnes)
0	130	20	2600	1500	3900000	3900
20	140	20	2800	1500	4200000	4200
40	150	20	3000	1500	4500000	4500
60	170	20	3400	1500	5100000	5100
80	180	20	3600	1500	5400000	5400
100	180	20	3600	1500	5400000	5400
120	170	20	3400	1500	5100000	5100
140	160	20	3200	1500	4800000	4800
160	215	20	4300	1500	6450000	6450
180	195	20	3900	1500	5850000	5850
200	230	20	4600	1500	6900000	6900
220	215	20	4300	1500	6450000	6450
240	230	20	4600	1500	6900000	6900
260	300	20	6000	1500	9000000	9000
280	270	20	5400	1500	8100000	8100
300	300	20	6000	1500	9000000	9000
320	295	20	5900	1500	8850000	8850
340	120	20	2400	1500	3600000	3600
360	90	20	1800	1500	2700000	2700
380	80	20	1600	1500	2400000	2400
400	65	20	1300	1500	1950000	1950
420	55	20	1100	1500	1650000	1650
440	70	20	1400	1500	2100000	2100
460	80	20	1600	1500	2400000	2400
		TOTAL (A)	**81800**	**1500**	**122700000**	**122700**

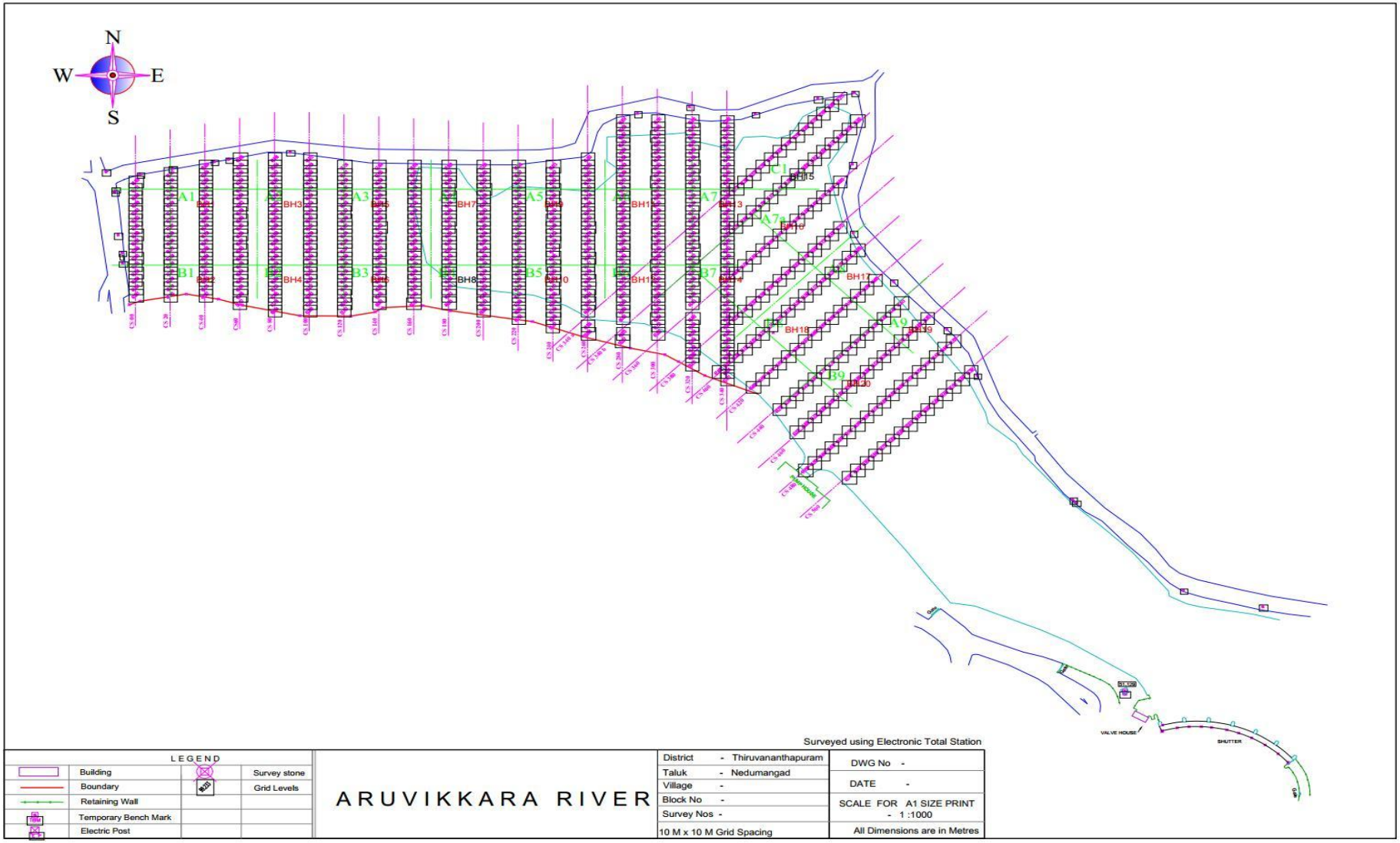


Figure 3-3 Map Showing Grid of 20m Width Cross-Section-Wise

Table 3-4 Estimation of excavated reservoir area

Section	Area (sq-m)	Width (m)	Volume (cu-m)	Density (kg/cum)	Reserve (kg)	Reserve (Tonnes)
0	165	20	3300	1500	4950000	4950
20	170	20	3400	1500	5100000	5100
40	160	20	3200	1500	4800000	4800
60	165	20	3300	1500	4950000	4950
80	170	20	3400	1500	5100000	5100
100	140	20	2800	1500	4200000	4200
120	120	20	2400	1500	3600000	3600
140	85	20	1700	1500	2550000	2550
		Total(B)	**23500**	**1500**	**35250000**	**35250**

By comparing the three methods, it is concluded that the volume of sediment estimated by 20m grid method is more accurate and hence, adopted for this study. The total amount of silt/sand desilted from Water spread area of 5 Ha equivalent to total of excavation & dredging (**A+B**) will be calculated as **1262250000 Kg** or **1262250 Tonne.**

3.1 Kepner 's SeaCurtain-Silt Barrier

Kepner Plastic SeaCurtain/Silt Barriers play important role in the floating management plan of proposed project of Aruvikkara Reservoir. These curtains are used to provide environmental as well as waterway protection during dredging process. They are majorly used to resolve debris control issues. They trap the sediments & sand at the operation zone from polluting the water. All Silt Barriers are designed to provide best combination of performance, handling, flexibility, strength, durability and economy for all debris requirements. They restrict the contamination of wastes therefore, protects the water environment. A variety of Silt Curtains are subject to the requirements and current profiles with respect to types of debris, methods of debris containment, diversion and their removals. The standard lengths of 50 ft (15m) and 100 ft (30m) sections of silt barriers are readily connected to create total barrier systems of any desired length. However, the tensioning, anchoring and terminal constructions are always a custom design to the application requirements.

Silt Barriers are constructed of heavy-duty vinyl, polyurethane, alloy coated and other fabrics. These are resistant to abrasion, UV-rays, extreme weather, hydrocarbons, aquatic life growth and most chemicals. Other features included as flotation, with barrier construction, which will limit sediments -waste dispersion.

Flotation:

Flexible, cylindrical float sections of closed cell rolled foam are electronically sealed in the boom. Flotation provides reserve buoyancy in excess of 10 times the total weight of the boom per foot.

Ballast/Tension:

Galvanized chain sealed into the skirt and attached to the end connectors assures wave conformance and maintains bottom tension and draft.

3.1.1 Silt Barrier Accessories

Kepner Plastic Silt Curtain/Barriers offer a complete range of stand-alone and product enhancing accessories including the spill containment and recovery supplements described as

Anchor system: this is kepner's original self-burying anchor, drag chain, rode line and buoy system for booms, buoys and small vessel management.
Tow bridle assembly: this system is for a stable two-point tow load (including hd pear link, ht galvanized steel cables, float, ballast and galvanized steel shackles)
Boom repair kit: this equipment package provides the necessary tools and materials for most field service repair requirements (adhesives and cleaners sold/shipped separately)
Tow line assembly: this is a versatile, all-purpose 100 foot length of buoyant, heavy duty polypropylene rope assembly spliced to a galvanized thimble/shackle for linking loads to vessels.
Mirafi" fw402 is composed of high-tenacity monofilament polypropylene yarns, which are woven into a stable network such that the yarns retain their relative position. Mirafi® fw402 is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.

Table 3-5 Mirafi FW402 properties

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Wide Width Tensile Strength	ASTM D 4595	kN/m (lbs/in)	35.0 (200)	24.5 (140)
Grab Tensile Strength	ASTM D 4632	kN (lbs)	1.6 (365)	0.9 (200)
Grab Tensile Elongation	ASTM D 4632	%	24	10
Trapezoid Tear Strength	ASTM D 4533	kN (lbs)	0.5 (115)	0.3 (75)
Mullen Burst Strength	ASTM D 3786	kPa (psi)	3100.0(450)	
Puncture Strength[1]	ASTM D 4833	kN (ibs)	0.4 (90)	
CBR Puncture Strength	ASTM D 6241	kN (Ibs)	3.0 (675)	
Apparent Opening Size (AOS)[2]	ASTM D 4751	mm (U.S. Sieve)	0.425 (40)	
Percent Open Area	COE-02215	%	10	
Permittivity	ASTM D 4491	sec"[1]	2.1	
Permeability	ASTM D 4491	cm/sec	0.14	
Flow Rate	ASTM D 4491	l/min/m^2 (gal/min/ft^2)	5907.3 (145)	
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	90	

Physical Properties	Test Method	Unit	Typical Value
Mass/Unit Area	ASTM D 5261	g/m2 (oz/yd2)	206.8 (6.1)
Thickness	ASTM D 5199	mm (mils)	0.7 (27)
Roll Dimensions (width x length)	—	m (ft)	3.8 (12.5) x 91 (300)
Roll Area	—	m2 (yd2)	348 (417)
Estimated Roll Weight	—	kg (Ibs)	76.6 (169)

Silt Curtain for trapping sediments during dredging

Silt Barrier Accessories

Plate 2: Dredging Technique and Equipments

CHAPTER 4 : DESCRIPTION OF ENVIRONMENT

4.1 Overview

Environment Impact Assessment (EIA) includes the study of various components of environment *viz.,* Physical (soil, air, noise and water), Biological (flora and fauna) and socio-economics of the people under purview of the project. Integration of these parameters gives an overall assessment of positive and negative impacts due to construction of a dam and reservoir project. For overall prediction of impacts, the study area considered was 10 km radius covering all consequential project components viz., dam, reservoir *etc*. for conducting the study of all stated attributes.

4.2 Catchment Area

The catchment area of Karamana River is within the Thiruvananthapuram District having an area of 702 Km^2. The Vamanapuram River Basin and Neyyar Basin are situated on the North and the on the South of Karamana basin. The catchment area which lies in Aruvikkara, Thrivandrum is 258.89 Km^2. The Karamana river flows upto 68km to Arabian Sea. The Karamana River has 4 major tributaries as Kaviar, Attaiar, Vaiyapadain & Todiyar.Some important Rain gauge stations are Kovalam (1), Nedumangad (2), Thrivunanthapuram OBS (3), Thrivunanthapuram Aerodrome (4), Thumba (5) and Vellayani (6) Respectively. Whole of the catchment area mainly consists of high hill slopes to medium hill slopes up to the proposed dam site. It has also been seen that whole of the catchment area is mainly covered with tropical forest, valley and waterspread area with shingles, pebbles and cobbles of different size.

4.3 Topography

The Karamana River situated in southern tip of the Western Ghats and it flows in Thiruvananthapuram along its course during the study area. Karamana river originates from Chemmunjimalai, Agastyarkoodam Mountains located at highest elevation of 1717m to the lowest elevation of riverbed at Aruvikkara Dam is 32 m. The area is consisting with a soil cover of small thickness and having relatively undulating steep terrain. The area has valleys, hillocks with undulating elevation, and tropical forest. The entire Karamana River Basin can broadly be classified into three distinct physiographic zones as given in **Table 4.1.**

Table 4-1: Physiographic Zones

SN	Physiographic Classification	Description
1	High Land Region	Generally situated at the Western Ghats having an altitude of about 76m above the MSL,
2	Mid Land region	Covers a large area with an altitude within 76m and 7.6m MSL This area is highly undulating with wide variation of slope. Geomorphologically this area is comprised of low lateritic up hills and the major land use pattern includes Paddy fields, Coconut and Rubber plantation and Areca nut plantations
3	Low Land Region	Which is a narrow strip of land along the western coast, spraded from the midland region to the river mouth including the delta basin with an altitude less than 7.6m MSL
		*(KSREC – Land Resources of Kerala -200*2)

4.4 Physiography and Geology

The Karamana River traverses from SSE to SW direction at the southern tip of the Western Ghats and its length of 68 km flow in Thiruvananthapuram along its course during the study area. The river originates from Chemmunjimalai, Agastyarkoodam mountain.

As water flows through the river, it also brings down suspended materials and bed load as silt & sand, rolling/sliding along the bed from its fragile catchment. Reservoir acts as a plain sedimentation tank situated at 62m of elevation.

Visual inspection of the suspended material and bed load brought down by the river shows variation in sizes of material from less than 5mm up to more than 20 mm. (KSREC – Land Resources of Kerala -2002)

4.4.1 Drainage

- **Surface water**

Area for desiltation itself is a water spread area of Karamana River, which flows from SE to SW direction (southern tip of western ghat to Arabian Sea). This is the major flowing pattern in study area.

- **Ground water**

The ground water table ranges from 5-10 m below ground level in pre-monsoon and 2-5m bgl during post-monsoon season.

4.5 Climate

As per the general circulation pattern of Peninsular region the state of Kerala experiences two types of Monsoons such as South-West and North-East. The district has a climate that borders between tropical savanna climate and tropical monsoon climate. The Karamana basin experiences both the South-West and North-East Monsoon. The South-West Monsoon sets in June and lasts till August. The North East Monsoon sets in October and continues in the end of November. The average rainfall in the river basin is about 2600 mm. While the South-Western part and the north eastern part of the basin receives about 140 cm and 300 cm respectively. The major parameters that are having direct and indirect influences on the rainfall distribution pattern towards the eastern ward enhancement are such as altitude, slope of the terrain, synoptic variables and configuration of the land. The river basin receives precipitation in all seasons, but around 47% of the annual rainfall occurs based on the dynamics of south-west monsoon. The rainfall is very heavy and October is considering as the rainiest month, (Meteological Survey of India, MSI)

The district has a climate that borders between tropical savanna climate and tropical monsoon climate. In a broad sense, it can be said that the district experience a tropical monsoon climate. The annual variation of mean air temperature at Trivandrum district is from 21^{o}C to 34^{o}C. The humidity is high and rises about 90% during the monsoon season**.**

The average annual rainfall of the district is 2035mm. It is significant that the district gets benefits of both monsoon – southwest monsoon and northeast monsoon. The district is characterized by very high precipitation which is spread over very few wet days and a long dry season (December- May) and a marked gradient from the eastern hilly region to the sea rapidly re-conveying the rainfall back to the sea through short, fast, west flowing rivers. Trivandrum is the first city along the path of southwest monsoon and gets its showers by end of May/beginning of June. The district also gets rain from receding northeast monsoon, which hits the district by October. The southwest monsoon contributes more than the northeast monsoon to the total rainfall in the district. The dry season sets by December in the district. December, January and February are the coldest months while March, April and May are hottest. The normal rainfall of the district is 2001.6 mm. The normal monthly rainfall in mm for the year 2011 is given in Table 4.2 and 4.3.

Table 4-2: Normal Monthly Rainfall – 2011

Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
19	21	33	150	186	329	240	141	161	276	184	63	1803

Table 4-3: Monthly rainfall in Trivandrum district for the period 2006 – 2011

Year	2006	2007	2008	2009	2010	2011
January	19	0	0	5	108	44
February	0	2	25	0	0	71
March	69	4	276	60	73	15
April	100	213	158	45	109	170
May	496	197	90	207	217	80
June	444	349	116	183	237	272
July	437	307	286	204	235	99
August	389	177	181	87	119	83
September	380	279	203	183	114	131
October	430	328	364	119	414	140
November	259	214	195	346	326	242
December	40	12	38	43	188	169
Total	3063	2082	1932	1483	2141	1516
(Source: Thiruvananthapuram CGWB report December, 2013)						

The monthly rainfall data for the period 2007-2011 shows that during 2007 and 2010 rainfall was above normal rainfall. The coastal area receives less rainfall when compared to the eastern region and there is a sharp increase in rainfall from south to north. Even if the district receives both monsoons, a delay or failure of the monsoon often causes drought conditions in the district**.**

4.6 Ground Water Resources

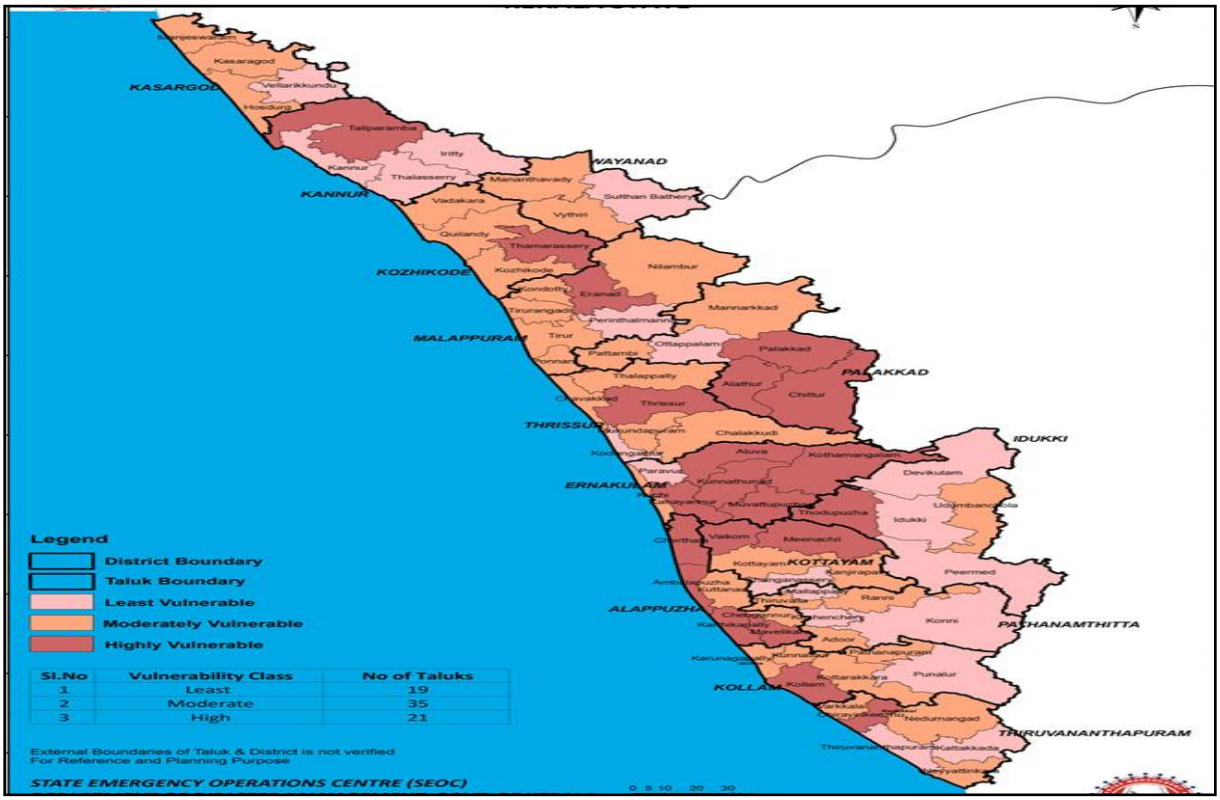
In Trivandrum district groundwater occurs in all the geological formations from Archaean crystallines to recent alluvium under phreatic as wells under semi-confined condition. In weathered crystallines and in shallow sedimentary formations groundwater occurs under phreatic condition while semi-confined condition exists in deep fractured crystalline rocks and laterites. In shallow crystalline formations, groundwater occurs in the highly weathered and fairly deep and interconnected well-

jointed parts. While deep fractures in deeper crystalline rocks form major potential aquifers that may be harnessing water from the semi-consolidated weathered product, laterite, lying over it.

The net groundwater availability of the Trivandrum district is 304.74 MCM whereas the gross groundwater draft of the district is 171.01 MCM, thus keeping a balance of 133.73 MCM for future ground water development assessed based on ground water department, Thrivandrum (March, 2009).

4.7 Seismicity

Trivandrum district falls in seismic moderate damage risk zone-III.



(*Deptt. of Disaster Management, 2002, Kerala*)

Figure 4-1: Seismic Map of Trivandrum District

Plate 3: Sampling and Monitoring Locations

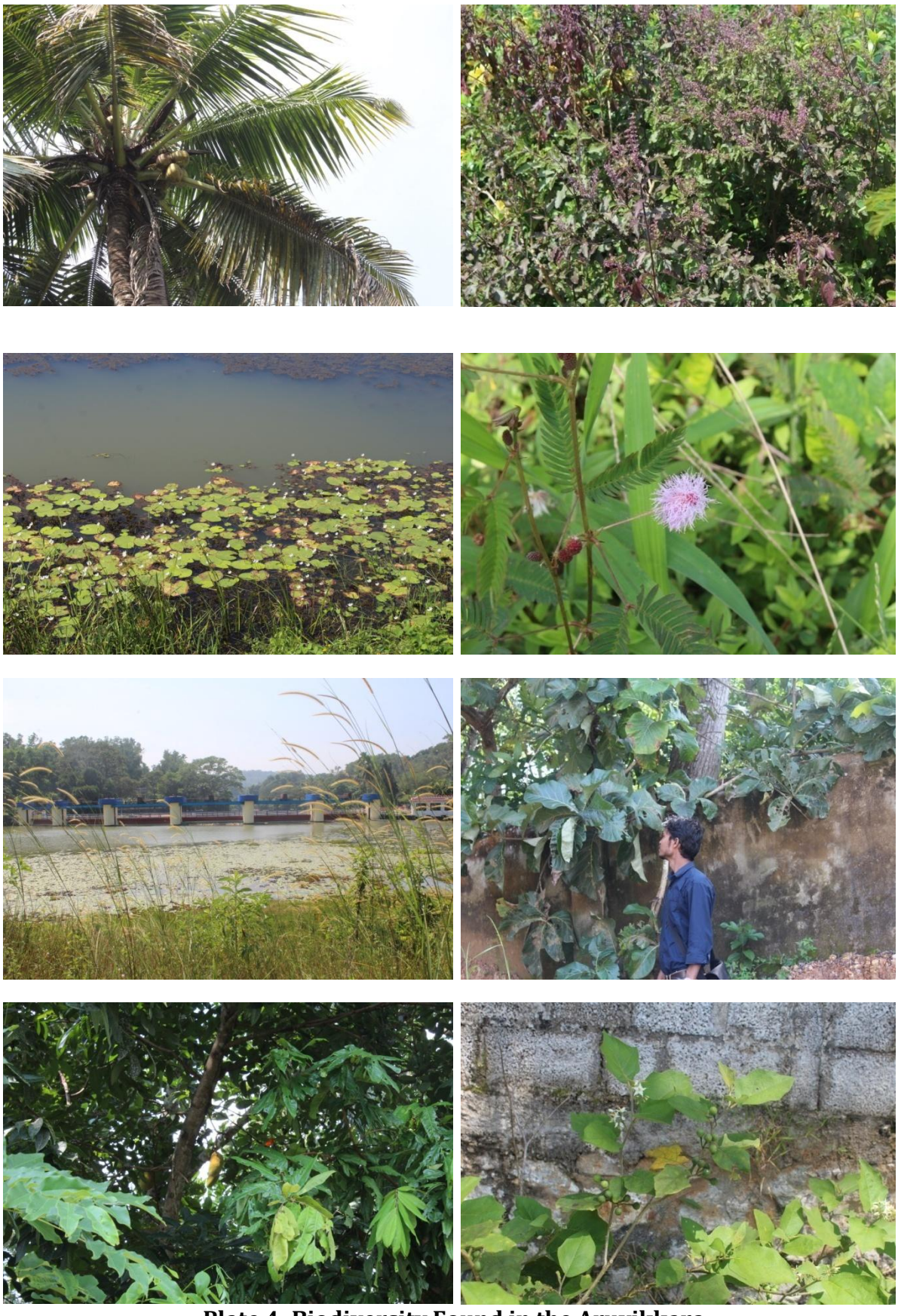


Plate 4: Biodiversity Found in the Aruvikkara

4.8 Baseline Data of Physical Environment

4.8.1 Study Area

Baseline studies on environmental components are generated as per the work order for first 20 days. The report contains baseline data for all environmental components *i.e.* physical, biological and socio-economic components.

The study area includes of the following:

i Area within 10 km. radius of the project area and sites of appurtenant works of main project components (*i.e*. dam and reservoir)

ii Environmental Sensitivity Map for 15km study area of the proposed project.

4.8.2 Land Use/Land cover map of the study area/Reservoir

The land use/land cover details are shown in **Fig. 4-2**.

Table 4-4: Land use/Land Cover Map in the Study Area

S.No	Classes	Area (sq.km)	Area in %
1	Settlement	99.72	31.73
2	Vegetation & Agricultural Land	212.96	67.77
3	Waste Land	0.45	0.14
4	Water Bodies	1.12	0.36
	Total	**314.25**	**100.00**

4.8.3 Soil Quality Assessment

Soil samples from various locations in catchment area and study area were collected. The sample locations have been selected to represent the area characteristics based on geology, land use and floristic pattern. The samples have been collected from five locations for soil quality in project area. The location of the soil samples and results are given in **Table 4.5-4.6**.

Table 4-5 Location of Soil quality monitoring stations

Station Code	Location	Latitude	Longitude	Distance (in Km)
S1	Aruvikkara Village	8°34'14.89"N	77° 0'55.75"E	0.60
S2	Near Bhagwati Temple	8°34'23.54"N	77° 1'11.49"E	0.12
S3	Opposite Dam site (across the bridge)	8°34'22.26"N	77° 1'16.46"E	0.10
S4	U/s of the Dam	8°34'31.32"N	77° 1'21.10"E	0.05
S5	Near KWA office	8°34'21.88"N	77° 1'7.98"E	0.21

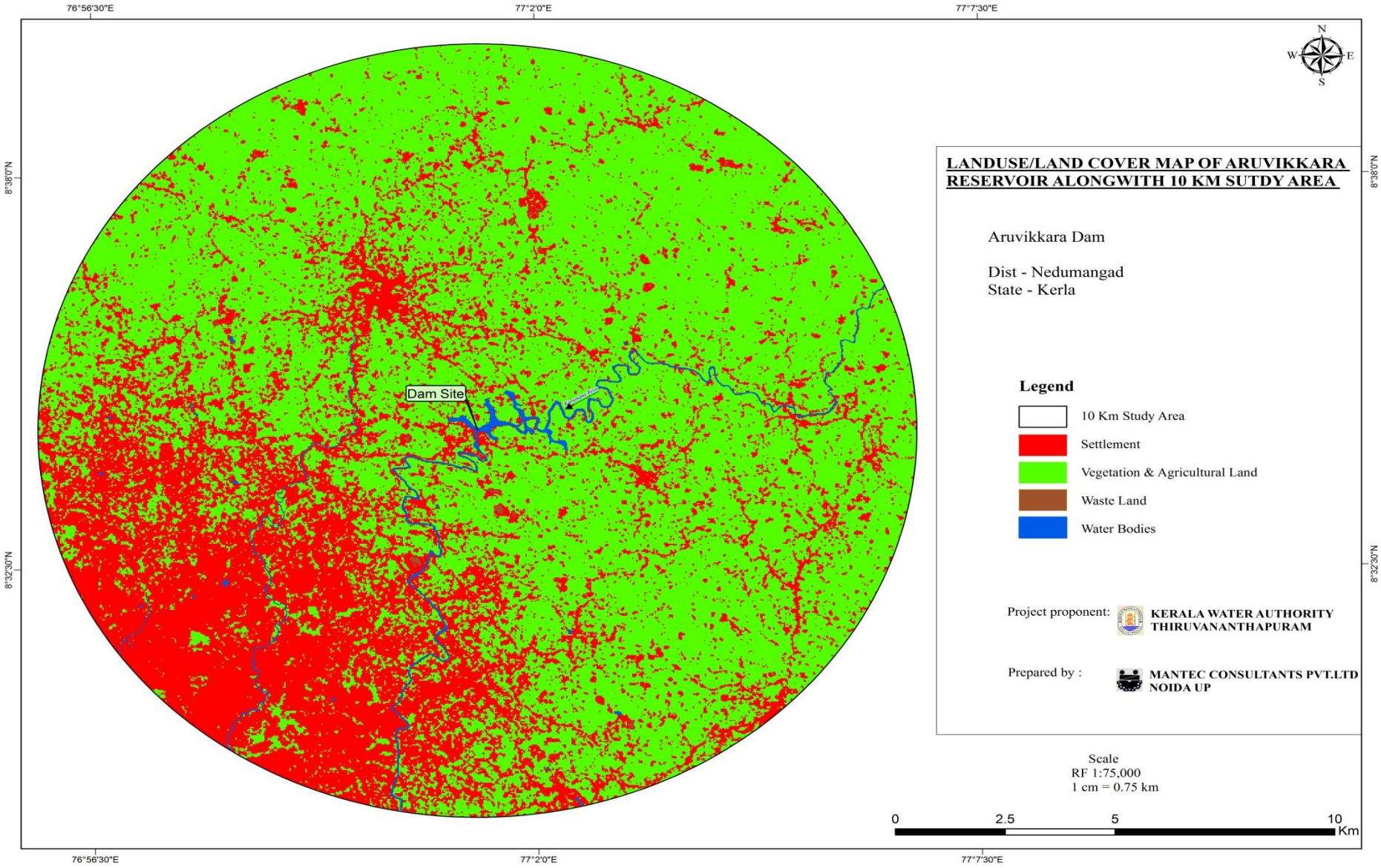


Figure 4-2: Land Use/Land Cover Map

Table 4-6: Soil Quality monitoring result in the Study Area

S.No.	Parameters	Location Units	Location 1	Location 2	Location 3	Location 4	Location 5
			Aruvikkara Village	Near Bhagwati Temple (D/S)	Opposite Dam Site (across the bridge)	U/S of the Dam	Near KWA Office
			Value	Value	Value	Value	Value
1	pH	-	7.18	7.26	7.21	7.82	7.46
2	Bulk Density	gm/cm3	1.26	1.38	1.28	1.32	1.42
3	Conductivity	Micro mhos/cm	186	168	198	204	188
4	Moisture	%	7.8	9.4	8.8	7.6	6.4
5	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
6	Sand	%	48	46	52	49	50
7	Clay	%	16	18	16	15	14
8	Silt	%	36	36	32	36	36
9	Sodium	mg/100gm	2.8	1.8	2.2	2.4	1.9
10	Potassium	mg/100gm	1.1	1.2	0.8	1.4	0.8
11	CEC	meq/100gm	7.52	6.16	6.58	8.24	7.04
12	Nitrogen	mg/100gm	18.2	20.8	24.6	22.4	26.8
13	Phosphorous	mg/100gm	0.78	0.88	0.92	0.82	0.74
14	Organic Matter	%	1.26	1.08	1.29	1.12	1.02
15	Ca	meq/100gm	2.38	2.48	3.24	2.24	2.42
16	Mg	meq/100gm	1.68	1.54	2.18	1.24	1.72
17	SAR	-	0.85	0.55	0.58	0.79	0.57

4.8.4 Air Quality Assessment

The baseline status of the ambient air quality has been assessed through a scientifically designed ambient air quality-monitoring network. The design of monitoring network in the air quality surveillance programme has been based on the following considerations:

- Meteorological conditions on synoptic basis;
- Topography of the study area;
- Representatives of regional background air quality for obtaining baseline status;
- Representatives of likely impact areas.

Ambient Air Quality Monitoring (AAQM) stations were set up at five locations with due consideration to the above mentioned points.

Sampling at each of the five stations was done and on its basis the baseline data of ambient air environment was generated for the parameters mentioned below:

1. Suspended Particulate Matter (SPM)
2. Respirable Particulate Matter (RPM)
3. Sulphur dioxide (SO_2)
4. Nitrogen oxide (NOx)

In regard to the techniques for collection of sample of particulate matter, the "Respirable Dust Sampler Envirotech Model APM 460 BL" was used for air monitoring.

The dust particulate matter was collected on filter paper (size GF/A20.3x25.4 cm) and dust cup and the gaseous pollutants were collected simultaneously by a known volume of air through a number of bubblers of different flow rate through appropriate solution for absorbing different gases. The collected sample was analyzed according to standard method for different pollutants.

Theory of Respirable Dust Sampler (RDS)

The principle involved in Suspended Particulate Matter (SPM) sampling method is that the particles filtered from known volume of an air sample by a suction apparatus are deposited on a filter paper. Generally, the gaseous pollutants in air are made to react with liquid absorbing media at atmospheric temperature and pressure when air is bubbled through the absorbing solution in the impinger. RD sampler measures only the concentration of SPM and Gases in the ambient air.

Calculation

RSPM (µg/m3) = (weight of filter paper after sampling – initial weight of filter paper)/volume of air.
SPM (µg/m3) = RSPM + (final weight of cyclonic cup – initial weight of cyclonic cup)/volume of air.
For gaseous pollutants
SO_2 (µg/m^3) = (A – A_0) x 1000 x B x D/V
NO_x (µg/m^3) = (A – A_0) x 1000 x B x D/0.82V
Where,
A = Sample Absorbance, A_0 = Reagent blank Absorbance, and
B = Calibration factor (µg/absorbance)
D = Volume of absorbance solution in impinge during monitoring/volume of absorbing solution taken for analysis.
V = Volume of Air Sample in liters.
Air Quality Results-The results of ambient air quality monitoring at the 5 sampling location have been presented in **Table 4.7** to **Table 4.12.**

Table 4-7 Location of Ambient Air Quality monitoring stations

Station Code	Location	Latitude	Longitude	Distance (in Km)
A1	Aruvikkara Village	8°34'14.89"N	77° 0'55.75"E	0.60
A2	Near Bhagwati Temple	8°34'23.54"N	77° 1'11.49"E	0.12
A3	Opposite Dam site (across the bridge)	8°34'22.26"N	77° 1'16.46"E	0.10
A4	U/s of the Dam	8°34'31.32"N	77° 1'21.10"E	0.05
A5	Near KWA office	8°34'21.88"N	77° 1'7.98"E	0.21

Table 4-8: Ambient air quality monitoring results at Aruvikkara

1	Aruvikkara village					
MONTH	**DATE**	**PM_{10} (µg/m3)**	**$PM_{2.5}$ (µg/m3)**	**SO_2 (µg/m3)**	**NO_2 (µg/m3)**	**CO (µg/m3)**
Nov-17	**07.11.2017**	33	19	4	10	0.24
	10.11.2017	31.5	20	4.5	15	0.14
	14.11.2017	30	18	6.5	12	0.18
	17.11.2017	32	18.5	5	11.5	0.21
	Max	**33.0**	**20.0**	**6.5**	**15.0**	**0.24**
	Min	**30.0**	**18.0**	**4.0**	**10.0**	**0.14**
	Avg	**31.63**	**18.88**	**5.00**	**12.13**	**0.19**
	98 percentile	**32.94**	**19.94**	**6.41**	**14.82**	**0.24**

Table 4-9: Ambient air quality monitoring results Near Bhagwati Temple (D/s)

2	Near Bhagwati Temple (D/s)					
MONTH	**DATE**	**PM_{10} (µg/m3)**	**$PM_{2.5}$ (µg/m3)**	**SO_2 (µg/m3)**	**NO_2 (µg/m3)**	**CO (µg/m3)**
Nov-17	**07.11.2017**	38	22	5.5	14	0.26
	10.11.2017	34.5	20	6	13.5	0.12
	14.11.2017	35	20.5	7	16	0.24
	17.11.2017	36.5	21	6.5	15.5	0.14
	Max	**38.0**	**22.0**	**7.0**	**16.0**	**0.26**
	Min	**34.5**	**20.0**	**5.5**	**13.5**	**0.12**
	Avg	**36.00**	**20.88**	**6.25**	**14.75**	**0.19**
	98 percentile	**37.91**	**21.94**	**6.97**	**15.97**	**0.26**

Table 4-10: Ambient air quality monitoring results Opposite to the Dam Site

3	Opposite Dam Site (across the bridge)					
MONTH	**DATE**	**PM_{10} (µg/m3)**	**$PM_{2.5}$ (µg/m3)**	**SO_2 (µg/m3)**	**NO_2 (µg/m3)**	**CO (µg/m3)**
Nov-17	**08.11.2017**	33	18.5	6.5	15	0.26
	11.11.2017	34	20	7	16	0.18
	15.11.2017	30.5	18	6	14.5	0.24
	18.11.2017	32.5	19.5	6.5	13	0.12
	Max	**34.0**	**20.0**	**7.0**	**16.0**	**0.26**
	Min	**30.5**	**18.0**	**6.0**	**13.0**	**0.12**
	Avg	**32.50**	**19.00**	**6.50**	**14.63**	**0.20**
	98 percentile	**33.94**	**19.97**	**6.97**	**15.94**	**0.26**

Table 4-11: Ambient air quality monitoring results U/S of the Dam Site

4	U/s of the Dam					
MONTH	**DATE**	**PM_{10} (µg/m3)**	**$PM_{2.5}$ (µg/m3)**	**SO_2 (µg/m3)**	**NO_2 (µg/m3)**	**CO (µg/m3)**
Nov-17	**08.11.2017**	32	18	5.5	13	0.26
	11.11.2017	34	20	7	15	0.18
	15.11.2017	33.5	19.5	6.5	11.5	0.24
	18.11.2017	36	21	4.5	14	0.16
	Max	**36.0**	**21.0**	**7.0**	**15.0**	**0.26**
	Min	**32.0**	**18.0**	**4.5**	**11.5**	**0.16**
	Avg	**33.88**	**19.63**	**5.88**	**13.38**	**0.21**
	98 percentile	**35.88**	**20.94**	**6.97**	**14.94**	**0.26**

Table 4-12: Ambient air quality monitoring results Near KWA Office

5	Near KWA Office					
MONTH	**DATE**	**PM_{10} (µg/m3)**	**$PM_{2.5}$ (µg/m3)**	**SO_2 (µg/m3)**	**NO_2 (µg/m3)**	**CO (µg/m3)**
Nov-17	**09.11.2017**	31.5	18.5	5	11	0.18
	12.11.2017	33	19.5	6.5	13.5	0.23
	16.11.2017	30	18	7	12	0.19
	19.11.2017	32.5	19	8	10.5	0.25
	Max	**33.0**	**19.5**	**8.0**	**13.5**	**0.25**
	Min	**30.0**	**18.0**	**4.5**	**10.5**	**0.18**
	Avrg	**31.75**	**18.75**	**6.50**	**11.75**	**0.21**
	98 percentile	**32.97**	**19.47**	**7.94**	**13.41**	**0.25**

4.8.5 Noise Quality Assessment

Noise is a very important parameter for the environment. With progress in industrial growth, the level of noise has been increasing continuously. Noise has been further accelerated by introduction of the diesel engine, jet engine, high-tech machineries and increasing road traffic. Noise is considered to be one of the dimensions of pollution, which leads to degradation of the environment and also poses health and communication hazards to living beings. A preliminary reconnaissance survey has been undertaken to identify the major noise generating sources in the area. Noise at different generating sources has been identified based on the activities in the village area and traffic. The noise monitoring has been conducted for determination of ambient noise levels in the study area, for that purpose five locations were selected, which are listed in **Table 4.13**.

Table 4-13: Location of Noise Quality monitoring stations

Station	Location	Latitude	Longitude	Distance (Km)
N1	Aruvikkara Village	8°34'14.89"N	77° 0'55.75"E	0.60
N2	Near Bhagwati Temple	8°34'23.54"N	77° 1'11.49"E	0.12
N3	Opposite Dam site (across the bridge)	8°34'22.26"N	77° 1'16.46"E	0.10
N4	U/s of the Dam	8°34'31.32"N	77° 1'21.10"E	0.05
N5	Near KWA office	8°34'21.88"N	77° 1'7.98"E	0.21

Noise Level Measurement

The noise level was measured for six locations by using sound level meter RS 232 (digital instrument). It consists of the following major section:-

i. The Sensor or Microphone

The sensor is a high precision electrode condenser microphone, which must be protected from physical abuse, dirt, oil, water or ingress of any other such substance.

ii. The Control Panel

The control panel comprises of Recorder for recording the maximum and minimum level of sound range selector, auto and manual reset switches, hold on max and min level.

iii. The Range Selector

These switches can be used for selecting the relevant range of the sound level.

Procedure

The calibrated and charged sound level meter is adjusted for slow time response. The sound level was measured at different sites and the maximum and the minimum level of sound was recorded for the particular site and then average was calculated to arrive at the final readings. Readings were taken in each division of north; south, east and west around each source and at various distances and the maximum and the minimum for particular hours were recorded.

Results for Ambient Noise Levels

Results for Ambient Noise Levels are given in the **Table 4.14.**

Table 4-14 : Results for Ambient Noise Levels

Sr. No.	Noise Location	DOS	Standards of Noise Level			Noise Level db(A)	
			Category of Area	Day dB (A)	Night dB (A)	Day (Ld)	Night (Ln)
1	Aruvikkara village	07.11.2017	Commercial	65	55	57.2	42.8
2	Near Bhagwati Temple (D/s)	11.11.2017	Residential	55	45	53.4	41.6
3	Opposite Dam Site (across the bridge)	12.11.2017	Residential	55	45	51.2	39.4
4	U/s of the Dam	14.11.2017	Residential	55	45	50.4	41.8
5	Near KWA Office	18.11.2017	Residential	55	45	48.2	38.2

4.8.6 Water Quality Assessment

The quality of water is vital concern for mankind since it is directly linked with the human welfare. Water quality characteristics of aquatic environment arise from multitude of physical, chemical and biological interactions. The water bodies are continuously subjected to dynamic state of changes with respect to their geo-chemical characteristics. The dynamic balance in aquatic ecosystem is upset by human activities, resulting in pollution which is obvious by bad taste of drinking water, offensive odor, unchecked growth of aquatic weeds, and decrease in number of fish, oil and grease floating on water bodies. These disturb the normal uses of water for public water supply, industry, agriculture etc. Samples of surface water and ground water were collected within the study area along the project site. To assess the water quality of the area samples were tested for physico-chemical parameters. Total five sites were selected for water sampling. The selection of sites was done considering the location of different project components, junctions of streams, river course, spots of high water velocity and some of the slow flowing water pools. The details of water sampling locations are presented in **Table 4.15**.

Table 4-15: Location of Water Quality Monitoring Stations

Station Code	Location	Latitude	Longitude	Distance (in Km)
W1	Aruvikkara Village	8°34'14.89"N	77° 0'55.75"E	0.60
W2	Near Bhagwati Temple	8°34'23.54"N	77° 1'11.49"E	0.12
W3	Opposite Dam site (across the bridge)	8°34'22.26"N	77° 1'16.46"E	0.10
W4	U/s of the Dam	8°34'31.32"N	77° 1'21.10"E	0.05
W5	Near KWA office	8°34'21.88"N	77° 1'7.98"E	0.21

General survey of the Karamana river upstream and downstream of dam site and other streams joining up to the site was conducted. Selection of spots for water sampling and collection of aquatic organisms was done. Distribution and population density of macro-zoo benthos in the Aruvikkara reservoir was determined. Periodical monitoring of physical, chemical and biological characteristics of river water was done.

Estimation of coliform (MPN) and *E. coli* organisms in river water was done. Importance of water quality on existing aquatic fauna in rivers was determined.

The sampling was carried out for as per the work order. The limnological parameters were recorded mainly following the standard methods described by Welch (1948), CSIR (1974). Mackereth, *et al.* (1978) and APHA, AWWA, WPCF (1995).

Results of the Water Analysis

Results of the water analysis of the samples taken from the study area have been given in the **Table 4.16**. pH varies from to 6.27 to 6.45 in which minimum at Bhagwati Temple (D/S) and maximum at Dam Site. Total Hardness varies from 28 mg/L at Opposite to the Water filling Station (72 MLD) and 31 mg/L at 1 km u/s of the Reservoir. Total Dissolved Solids varies from 39 at Opposite to the Water filling Station (72 MLD)and 46 mg/L at Reservoir (u/s of the dam). Fluoride varies from 0.01 mg/L at Bhagwati Temple (D/S), Opposite to the Water filling Station (72 MLD) and 0.03 mg/L at Dam Site. Chloride varies from 12 mg/L at Opposite to the Water filling Station (72 MLD) and 16 mg/L at Bhagwati Temple (D/S). COD varies from 4 mg/L at Dam Site to 8 mg/L at 1 km u/s of the Reservoir.

Table 4-16 : Results of Water Samples

Sl. No.	Parametera	Units of Measurements	Opposite to the Water filling Station (72 MLD)	Dam Site	Reservoir (u/s of the dam)	Bhagwati Temple (D/S)	1 km u/s of the Reservoir
			Nov-17	Nov-17	Nov-17	Nov-17	Nov-17
1	Colour	Hazen Units	<5	<5	<5	<5	<5
2	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
3	Taste	-	Not Done*	Not Done*	Not Done*	Not Done*	Not Done*
4	Turbidity	NTU	4	5	5	5	6
5	pH	-	6.32	6.45	6.38	6.27	6.35
6	Temperature	°C	26	25	27	26	26
7	Conductivity	µmhos/cm	60	63	71	63	65
8	Alkalinity as $CaCO_3$	mg/l	16	15	18	13	18
9	Total Dissolved Solids	mg/l	39	41	46	41	42
10	Total Suspended Solids	mg/l	28	26	25	24	25
11	Total Hardness as $CaCO_3$	mg/l	28	30	28	30	31
12	Calcium as $CaCO_3$	mg/l	16	20	17	18	21
13	Magnesium as $CaCO_3$	mg/l	12	10	11	12	10
14	Chloride as Cl	mg/l	12	14	15	16	13
15	Phosphate as PO_4	mg/l	0.02	0.01	0.03	0.04	0.01
16	Nitrate as NO_3	mg/l	2.40	1.50	1.60	1.10	1.40
17	Sulphate as SO_4	mg/l	0.2	0.3	0.1	0.2	0.3
18	Fluoride as F	mg/l	0.01	0.03	0.02	0.01	0.02
19	Phenolic Compound	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001

20	Copper as Cu	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
21	Cadmium	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
22	Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
23	Selenium as Se	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
24	Total Arsenic as As	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
25	Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
26	Zinc as Zn, Max	mg/l	0.1	0.09	0.12	0.11	0.09
27	Chromium as Cr^{+6}	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
28	Aluminium as Al	mg/l	<0.03	<0.03	<0.03	<0.03	<0.03
29	Manganese as Mn	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02
30	Boron as B	mg/l	0.08	0.10	0.09	0.60	0.07
31	Iron as Fe	mg/l	0.09	0.10	0.11	0.09	0.12
32	Sodium as Na	mg/l	2	2	4	2	2
33	Potassium as K	mg/l	1	1	2	1	1
34	Dissolved Oxygen	mg/l	6.9	7.4	7.1	6.9	6.7
35	BOD	mg/l	<2	<2	<2	<2	<2
36	COD	mg/l	5	4	5	6	8
37	Total Coliform	MPN/100ml	1120	1100	1420	1251	1247
38	Faecal Coliform	MPN/100ml	840	780	880	810	680

4.9 Biological Environment

The assessment of biological environment was undertaken to assess the existing conditions of flora and fauna (terrestrial and aquatic) in and around the reservoir. The terrestrial biological environment is mainly represented by flora (herbs, shrubs, trees etc.) and fauna (mammals, birds, reptiles etc.) and the aquatic biological environment is represented by phytoplankton, zooplankton, benthic invertebrates, fishes etc. These biotic components not only interacts within them but also with the abiotic components i.e. physical and chemical components (air, water, soil etc.) of the environment. They are the indicators of climatic factors of the area because of their strong relationships with their surroundings. Hence, any change in the surrounding environmental conditions may alter the species composition of these biological communities. Therefore, the present study was carried out to assess the likely impacts due to proposed activities.

The ecology and biodiversity study of the area has been conducted in order to understand the existing status of the flora and fauna (terrestrial and aquatic) and the existing anthropogenic stresses on the prevailing ecosystem to generate baseline information for preparation of Environment Impact Assessment (EIA) report for the project and to evolve mitigation measures for the possible impacts, if any on biological environment.

4.9.1 Methodology Adopted for the Survey

Flora: Extensive field survey was carried out in the study area for assessment of flora. An inventory of floral species has been prepared which were found during the survey. Plants were identified and listed with the help of the local residents and the available literatures from forest department and other secondary resources.

Fauna: Mammals were recorded through direct sighting in the area during the survey. Nocturnal animals were listed through indirect reporting like sign survey, pellets observation etc. Birds were identified through sighting. Secondary resources from forest department were also studied and the local residents were enquired to confirm the presence of faunal species in the study area.

4.9.2 Floral Diversity of Study Area

The study of floral diversity was carried out to assess the available plant resources and obtaining a broad representation of the existing floristic variations in the study area. The study area comes under "**Coastal** (West Coast or Malabar Coast)" bio-geographic zone of India (India State of Forest Report, 2015). The reservoir is located on hilly terrain and some parts of study area are plain lands. The climate is moderately hot and humid with moderate rainfall received during both the Southwest and Northeast monsoons.

These features endowed the state with rich biodiversity. The Vegetation of the area could be classified into following types:

- Southern hilltop tropical evergreen forests
- West coast tropical evergreen forest

- West coast tropical semi evergreen forest
- Moist bamboo brakes
- Southern secondary moist mixed deciduous forest
- Riparian forest
- Grasslands
- Southern subtropical hill forest

The upper storey consists of *Mangifera indica, Artocarpus hirsutus, Vateria indica, Vitex altissima, Dipterocarpus bourdillonii, Cullenia exarillata, Terminalia bellerica, Terminalia paniculata, Pterocarpus marsupium, Albizia odoratissima, Holoptelea parviflora, Lagerstroemia microcarpa, Dalbergia latifolia, Bridelia retusa, Grewia tiliifolia, Mitragyna parviflora, Gluta travancorica* etc.

The lower storey comprises of species such as *Arenga wightii, Ixora arborea, Atalantia wightii*, while the ground floor consists of *Pogostemon paniculatus, Glycosmis cymosa* etc. Along the margin of streams large formations of *Ochlandra travancoricaand, Ochlandra wightii* were seen.

The ground is covered with dense growth of grass like, *Cyrtococcum oxyphyllum, Imperata cylindrica minor, Pennisetum polystachyon* and *Themeda cymbaria* while the climbers include *Salacia chinensis, Adenia hondala* and *Dioscorea bulbifera*. Shrubs and herbs like, *Acrotrema arnottianum, Artabotrys zeylanicus, Crotalaria albida, Desmodium heterocarpon, Tamilnadia uliginosa, Curcuma aromatica, Zingiber zerumbet, Carex beccans* etc. were also seen in some areas.

According to primary survey conducted in study area and available secondary resources, a total of 53 floral species belonging to 28 plant families with dominance of Arecaceae and Poaceae family were identified and documented. The analysis of the floral diversity is presented in table and also represented through pie chart. Details of all plant species, their family, common name and habit is given in **Table 4.17 to 4.20.**

Table 4-17 : Analysis of the flora of the study Area

S. No.	Plant Type	Number of Species
1	Trees	28
2	Shrubs	11
3	Herbs, Grasses & Climbers	14
	Total	**53**

Table 4-18: Flora of the study Area

S. No.	Scientific Name	Common Name	Family
1	*Albizia odoratissima*	Black Siris	Mimosaceae
2	*Albizia lebbeck*	Siris	Mimosaceae
3	*Annona squamosa*	Sharifa	Annonaceae
4	*Anogeissus latifolia*	Nakam	Combretaceae
5	*Artocarpus hirsutus*	Anjili	Moraceae
6	*Borassus flabellifer*	Taad	Arecaceae
7	*Bridelia retusa*	Mulkaini	Phyllanthaceae
8	*Cullenia exarillata*	Karayni	Malvaceae
9	*Cocos nucifera*	Tennai/Nariyal	Arecaceae
10	*Dalbergia latifolia*	Kala Sheesham	Fabaceae
11	*Dipterocarpus bourdillonii*	Garjan	Dipterocarpaceae
12	*Grewia tiliifolia*	Unnam	Tiliaceae
13	*Gluta travancorica*	Thodappa	Anacardiaceae
14	*Holoptelea parviflora*	Aaval	Ulmaceae
15	*Lagerstroemia microcarpa*	Venthekku	Lythraceae
16	*Mangifera indica*	Aam, Maa	Anacardiaceae
17	*Mitragyna parviflora*	Kaim	Rubiaceae
18	*Moringa oleifera*	Senjana	Moraceae
19	*Murraya koenigii*	Kari Patta	Rutaceae
20	*Phoenix sylvestris*	Khajur	Arecaceae
21	*Pterocarpus marsupium*	Venga	Fabaceae
22	*Santalum album*	Chandan	Santalaceae
23	*Tamarindus indica*	Imli	Caesalpiniaceae
24	*Terminalia bellerica*	Bahera	Combretaceae
25	*Terminalia paniculata*	Pumarutu	Combretaceae
26	*Terminalia arjuna*	Arjun	Combretaceae
27	*Vateria indica*	Baine	Dipterocarpaceae
28	*Vitex altissima*	Mylellu	Verbanaceae

Table 4-19: Shrubs found in the Study Area

S. No.	Scientific Name	Common Name	Family
1	*Arenga wightii*	Alathil	Arecaceae
2	*Ixora arborea*	Soochimulla	Rubiaceae
3	*Atalantia wightii*	Nilgiri atalantia	Rutaceae
4	*Cinnamomum verum*	Elavangam	Lauraceae
5	*Baccaurea courtallensis*	Mootippuli	Phyllanthaceae
6	*Hydnocarpus alpine*	Malmurutti	Achariaceae
7	*Acrotrema arnottianum*	Arnott's Acrotrema	Dilleniaceae
8	*Artabotrys zeylanicus*	Ceylon Green Champa	Annonaceae
9	*Crotalaria albida*	Chunchuni	Fabaceae
10	*Desmodium heterocarpon*	Asian Tick Trefoil	Fabaceae
11	*Tamilnadia uliginosa*	Pindichakka	Rubiaceae

Table 4-20: Herbs, Grasses and Climbers in the Study Area

S. No.	Scientific Name	Common Name	Family
1	*Pogostemon paniculatus*	Manam-podam	Lamiaceae
2	*Glycosmis cymosa*	Kuttippanal	Rutaceae
3	*Ochlandra travancorica*	Bamboo	Poaceae
4	*Ochlandra wightii*	Eera	Poaceae
5	*Curcuma aromatica*	Kattumanna	Zingiberaceae
6	*Zingiber zerumbet*	Kathu-insi-kua	Zingiberaceae
7	*Carex baccans*	Crimson Seeded Sedge	Cyperaceae
8	*Adenia hondala*	Mutukk	Passifloraceae
9	*Dioscorea bulbifera*	Zimikand	Dioscoreaceae
10	*Cyrtococcum oxyphyllum*	Grass	Poaceae
11	*Imperata cylindrica*	Cogon Grass	Poaceae
12	*Pennisetum polystachyon*	Fountain Grass	Poaceae
13	*Themeda cymbaria*	Kangaroo Grass	Poaceae
14	*Salacia chinensis*	Chourondi	Celastraceae

Dalbergia latifolia

Terminalia arjuna

Tamarindus indica

Borassus flabellifer

Plate 5: Photographs of floral species found in study area

Albizia odoratissima

Artocarpus hirsutus

Murraya koenigii

Mangifera indica

Themeda cymbaria

Pennisetum polystachyon

Plate 6: Photographs of floral species found in study area

Pogostemon paniculatus

Zingiber zerumbet

Dioscorea bulbifera

Crotalaria albida

Arenga wightii

Artabotrys zeylanicus

Plate 7: Photographs of floral species found in study area

4.9.3 Analysis of Faunal Diversity

The study area mainly comprises of low hills and valleys adjoining the Western Ghats having both human habitation and forest areas. This supports presence of diverse faunal species including wild animals and domestic animals. Domestic animals were seen commonly in the area and presence of wild fauna species were confirmed from local residents and also with the help of secondary literature from forest department and other sources.

Avifauna was distributed throughout the study area and easily sighted. They include both terrestrial as well as aquatic species. A large numbers of fish-eating birds such as cormorants, pelicans, storks, herons, egrets etc have been recorded from the marsh. The other species of birds were Little Grebe, Little Cormorant, Indian Pond Heron, Cattle Egret, Little Egret, Spot Billed Duck, Bulbuls, Kingfisher, Coppersmith Barbet and Drongo etc.

A list of faunal species, their common name, IUCN and status and their schedule as per Wildlife (Protection) Act, 1972 is given below in **Table 4.21 & 4.22.**

Table 4-21: Faunal Species present in the Study Area

S. No.	Scientific Name	Common Name	IUCN Status	Schedule as per WPA, 1972
1	*Canis lupus familiaris*	Dog	-	IV
2	*Capra aegagrus hircus*	Domestic Goat	-	-
3	*Felis chaus*	Jungle Cat	Least Concern	II
4	*Herpestes edwardsii*	Mongoose	Least Concern	II
5	*Funambulus pennanti*	Palm Squirrel	Least Concern	IV
6	*Lepus nigricollis*	Hare	Least Concern	IV
7	*Macaca mulatta*	Rhesus macaque	Least Concern	II
8	*Presbytis entellus*	Gray Langur	Least Concern	II
9	*Sus scrofa cristatus*	Wild Boar	Least Concern	III
10	*Felis domesticus*	Domestic Cat	-	IV
11	*Bubalus bubalis*	Buffalo	-	IV
12	*Bos taurus*	Cow	-	IV
13	*Naja naja*	Cobra	-	II
14	*Ptyas mucosus*	Rat Snake	-	II
15	*Bungarus caeruleus*	Common Krait	-	IV
16	*Eryx johni*	John's Earth Boa	-	IV
17	*Dryophis nasuta*	Common Green Whip Snake	-	IV
18	*Calotes versicolor*	Garden Lizard	-	-

Funambulus pennanti

Naja naja

Bungarus caeruleus

Bubalus bubalis

Sus scrofa cristatus

Felis chaus

Plate 8: Photographs of Faunal species at the study area

Table 4-22: Avifauna present in the Study Area

S. No.	Scientific Name	Common Name	Schedule as per WPA, 1972	IUCN Status
1	*Acridotheres ginginianus*	Bank Myna	IV	Least Concern
2	*Acridotheres tristis*	Common Myna	IV	Least Concern
3	*Anastomus oscitans*	Asian Open bill Stork	IV	Least Concern
4	*Anas poecilorhyncha*	Indian Spot Billed Duck	IV	Least Concern
5	*Anas platyrhynchos domesticus*	Domestic Duck	IV	Least Concern
6	*Ardea alba*	Large Egret	IV	Least Concern
7	*Ardea cinerea*	Grey Heron	IV	Least Concern
8	*Ardea purpurea*	Purple Heron	IV	Least Concern
9	*Ardeola grayii*	Pond Heron or paddy Bird	IV	Least Concern
10	*Bubulcus ibis*	Cattle Egret	IV	Least Concern
11	*Butorides virescens*	Little Green Heron	IV	Least Concern
12	*Calidris alpina*	Dunlin	IV	Least Concern
13	*Calidris minuta*	Little Stint	IV	Least Concern
14	*Calidris minutilla*	Least Sandpiper	IV	Least Concern
15	*Calidris subminuta*	Long-toed Stint	IV	Least Concern
16	*Columba livia*	Rock Pigeon	IV	Least Concern
17	*Copsychus saularis*	Magpie Robin	IV	Least Concern
18	*Corvus splendens*	House Crow	V	Least Concern
19	*Charadrius alexandrinus*	Kentish Plover	IV	Least Concern
20	*Dicrurus leucophaeus*	Ashy Drongo	IV	Least Concern
21	*Dicrurus macrocercus*	Black Drongo	IV	Least Concern
22	*Dromas ardeola*	Crab Plovers	IV	Least Concern
23	*Egretta garzetta*	Little Egret	IV	Least Concern
24	*Francolinus pondicerianus*	Grey Francolin	IV	Least Concern
25	*Fulica atra*	Common Coot	IV	Least Concern
26	*Halcyon smyrnensis*	White-breasted Kingfisher	IV	Least Concern
27	*Limicola falcinellus*	Broad billed Sandpiper	IV	Least Concern
28	*Merops orientalis*	Green Bee-Eater	IV	Least Concern
29	*Microcarbo niger*	Little Cormorant	IV	Least Concern
30	*Mycteria leucocephala*	Painted Stork	IV	Near Threatened
31	*Pavo cristatus*	Indian Peafowl	I	Least Concern
32	*Phalacrocorax carbo*	Great Cormorant	IV	Least Concern
33	*Phalaropus lobatus*	Red-necked phalarope	IV	Least Concern
34	*Pseudibis papillosa*	Indian Black Ibis	IV	Least Concern
35	*Psilopogon haemacephalus*	Coppersmith Barbet	IV	Least Concern
36	*Psittacula krameri*	Rose-ringed Parakeet	IV	Least Concern
37	*Pycnonotus cafer*	Red Vented Bulbul	IV	Least Concern
38	*Sternula albifrons*	Little Tern	IV	Least Concern
39	*Streptopelia senegalensis*	Dove	IV	Least Concern
40	*Tachybaptus ruficollis*	Little Grebe	IV	Least Concern
41	*Terpsiphone paradisi*	Paradise Flycatcher	IV	Least Concern
42	*Thalasseus bengalensis*	Lesser Crested Tern	IV	Least Concern
43	*Upupa epops*	Hoopoe	IV	Least Concern

Pavo cristatus

Streptopelia senegalensis

Acridotheres ginginianus

Limicola falcinellus

Phalaropus lobatus

Thalasseus bengalensis

Plate 9 : Photographs of Avifauna in the study area

4.9.4 Aquatic Ecology

The study area includes the Aruvikkara reservoir, upstream and downstream of Karamana River. The survey was carried out for assessment of aquatic flora and fauna and fisheries. The aquatic biological organisms are the best indicators of the quality of water bodies. The presence or absence of certain organisms indicates the health of an aquatic environment and various physico-chemical characteristics of water such as pH, conductivity, nutrients, BOD etc.

Aquatic Flora

The aquatic plants were found in reservoir and nearby river banks. The commonly found macrophytes were *Eichhornia crassipes*, *Potamogeton spp., Salvinia molesta* and *Typha latifolia.* Other recorded plants were *Hydrilla verticillata*, *Nelumbo lutea, Ipomoea aquatica*, *Neptunia oleracea* etc.

Aquatic Insects

Aquatic insects are significant in many ways such as processing organic matter and transporting energy along food chain. Aquatic insects are present in some quantity in almost every type of habitat and many are habitat specialists so they are good indicators. Because of their differential responses to stimuli in their aquatic habitat and determining the quality of that environment, aquatic insects are used for monitoring the health of aquatic environments. At the larval stage, they constitute the principal nutritive fauna of fish.

The study recorded the presence of insects from 6 orders (Odonata, Hemiptera, Coleoptera, Ephemeroptera, Diptera and Trichoptera). The insects reported in reservoir were as follows:

Table 4-23: Insects found in the Study Area

Order	Species	Order	Species
Odonata	*Ischnura*	**Ephemeroptera**	*Caenis*
	Urothemis		*Ephemerella*
	Epitheca		*Baetis*
Hemiptera	*Paraplea*		*Epeorus*
	Microvelia	**Trichoptera**	*Polycentropus*
	Nanotrephes		*Leptocerus*
Coleoptera	*Amphiops*	**Diptera**	*Chironomus*
	Hydroporus		*Sepedon*
	Limnichus		

Many aquatic insects are very sensitive to changes in levels of pollutants in the water and are therefore used as indicators of the ecological well-being of the aquatic ecosystem. Therefore, they should be preserved as they play a significant role in maintaining the health of the ecosystems by being part of the food chain, cleaning up the system as scavengers and contributing immensely to decomposition of dead organic matter. Their decrease will therefore result in the disruption of critical ecosystem services.

Phytoplankton

Phytoplanktons are the primary producers of an aquatic ecosystem and help in maintaining DO of a water body. If there is any increase or decrease in number of phytoplankton, it ultimately affects the whole aquatic ecosystem. The phytoplanktons observed in study area were *Microcystis, Oscillatoria, Nitzschia, Navicula* and *Pediastrum.*

Zooplankton

Zooplankton provides feed to the larger animals present in the water body. These consist mainly of *Nauplii*, *Daphnia* and *Cyclops*. The other zooplanktons observed in study area were *Colurella obtusa, Chlamydomonas minor & Amoeba* etc*.*

The zooplanktons found in water bodies of the study area are given in **Table 4.24.**

Table 4-24: Zooplanktons found in the Study Area

S. No.	Rotifers	Protozoa	Cladocera	Copepoda
1	*Ascomorpha saltans*	*Amoeba proteus*	*Bosmina longirostris*	*Cyclops sp.*
2	*Brachionus bidentata*	*Chlamydomonas minor*	*Chydorus sphaericus*	*Eucyclops agilis*
3	*Colurella obtusa*	*Volvox aureus*	*Daphnia laevis*	*Nauplii*
4	*Epiphanes senta*	*Euglena acus*	*Leydigia acanthocercoides*	
5	*Horella brahmi*	*Paramecium*	*Moina brachiata*	

4.9.5 Fisheries in Study Area

Fishes are an important resource for humans, especially for food. Fisheries have very important economic activity and are a flourishing sector with varied resources and potentials. The fish diversity is correlated with biological and various physico -chemical parameters that regulate the productivity and distribution of different species of fishes. The fish population is abundant and majority of the fishes are exploited for human consumption. Fishes have been regarded as an effective biological indicator of environmental quality and anthropogenic activities in aquatic ecosystem. Fishes have been identified as suitable for biological assessment due to its easy identification and economic value. The anthropogenic activities had caused a rapid decline in the population of fishes. The decline in the availability of fish will affect the livelihood of a

large sector of the economically backward population of the country. The knowledge of correct exploitation, regulation and management of fishing is the first approach to the health of the lacustrine system. Proper conservation methods and prevention of pollution can increase the number of food fish and cultivable fishes in the reservoir.

For the purpose of the study, attempts were made to collect, classify and identify fish of the reservoir. The major fish abundance was noticed in the family Cyprinidae. The fishes found in the reservoir were as follows:

Table 4-25: Fishes Reported in Study Area

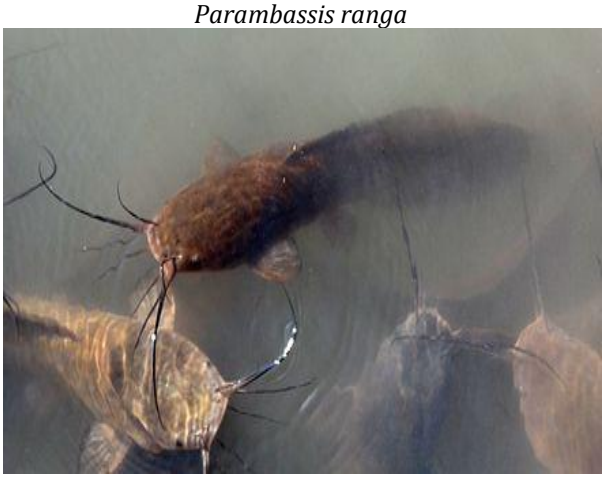
S. No.	Scientific Name	Family	Common Name	IUCN Status
1	*Anguilla bengalensis*	Anguillidae	Indian Mottled Eel	Near Threatened
2	*Parambassis thomassi*	Ambassidae	Western Ghat Glassy Perchlet	Least Concern
3	*Parambassis ranga*	Ambassidae	Indian Glassy Fish	Least Concern
4	*Oreochromis mossambicus*	Cichlidae	Mozambique Tilapia	Near Threatened
5	*Etroplus maculatus*	Cichlidae	Orange Chromide	Least Concern
6	*Nandus nandus*	Nandidae	Gangetic Leaffish	Least Concern
7	*Lepidocephalus thermalis*	Cobitidae	Spiny Loach	Least Concern
8	*Barilius bakeri*	Cyprinidae	Malabar Baril	Least Concern
9	*Garra mullya*	Cyprinidae	Garra Mullya	Least Concern
10	*Puntius dorsalis*	Cyprinidae	Long-Snouted Barb	Least Concern
11	*Puntius mahecola*	Cyprinidae	Mahecola Barb	-
12	*Puntius punctatus*	Cyprinidae	Dotted Sawfin Barb	Least Concern
13	*Puntius parrah*	Cyprinidae	Parrah Barb	Least Concern
14	*Liza tade*	Mugilidae	Tade Mullet	-
15	*Channa marulius*	Channidae	Bullseye Snakehead	Least Concern
16	*Channa striata*	Channidae	Snakehead Murrel	Least Concern
17	*Mystus malabaricus*	Bagridae	Striped Dwarf Catfish	Near Threatened
18	*Mystus gulio*	Bagridae	Long Whiskers Catfish	Least Concern
19	*Clarias dussumieri*	Clariidae	Valencienne's Clarid	Near Threatened
20	*Wallago attu*	Siluridae	Helicopter Catfish	Near Threatened

Anguilla bengalensis

Parambassis thomassi

Parambassis ranga

Oreochromis mossambicus



Clarias dussumieri

Wallago attu

Mystus malabaricus

Channa striata

Plate 10: Photographs of fish species in the study area

4.10 Socio-economic Environment

Socio-Economic Impact Assessment (SEIA) refers to systematic analysis of various social and economic characteristics of human being living in a given geographical area. The geographical area called as Study Area or Impact Area. It is carried out simultaneously with Environment Impact Assessment (EIA). The prime objective of SEIA is to identify and evaluate potential socio-economic and cultural impacts of a proposed development project on the lives and conditions of people, their families and their communities. If the potential impacts are significant and adverse, SEIA assist the developers and other stakeholders to reduce, remove or prevent these impacts from happening. SEIA is a multidisciplinary, using theories and methods from Sociology, Statistics, Economics, History, Psychology, Geography and Anthropology. It is pre-requisite before the project is put into implementation. The study area consists of the core area where the proposed project is expected to come up and a buffer area encircling the project area with a radius of prescribed kilometers from the periphery of the core area. For every new project Socio-Economic Impact Assessment is mandatory. It is also mandatory for existing projects in case of expansion, modernization and change in product mix. The Socio-Economic Impact Assessment focuses the effect of the project on social and economic well-being of the community. Under SEIA, it is examined how a developmental project changes the lives of local residents. The outcome of the study relies on both quantitative and qualitative measure of impacts. The impacts are evaluated in terms of changes in community demographics, housing, employment, wage income, consumption pattern, market effects, public services, retail business, quality of life and artistic qualities of the community. Qualitative assessment of community perceptions about development is an important measure of development impacts, without which no assessment is complete. Hence, due importance is given on qualitative assessment of community perceptions. Further, assessing proposed developments in socio-economic context help the community leaders and local people identify potential social equity issues, evaluate the adequacy of social services and determine whether the project has adverse effects on overall social well-being or not.

The objectives of Socio-Economic Impact Assessment of the project are as follows:

a) To collect baseline data of the study area.
b) To comprehend socio-economic status of the people living in the study area.
c) To assess probable impact of the project on social and economic aspects in the study area.
d) To measure the impact of the project on quality of life of the people living in the study area.
e) To ensure sustainability of positive impact.
f) To suggest mitigation measures and agency responsible for taking action in case of adverse impact.

4.10.1 Methodology adopted for Socio-economic Survey

For Socioeconomic Impact Assessment of the proposed project we recourse to systematic analysis of various socioeconomic characteristics, both in terms of quality and quantity. Accordingly, both qualitative and quantitative data was collected through primary and secondary sources.

For collection of primary data a sample survey was conducted in the rural areas as well as in selected wards of urban area of the study area. In each selected village and municipal ward a specified number of representative households were selected scientifically for collection of information through face to face interviews with the household head or any responsible member of the family. For collection of secondary data we approached the Census of India for published data/information, visited state and district portal and referred to administrative records of the state and district administration. The qualitative data deals with description; they can be observed but not measured. Hence, codes were extensively used during collection of qualitative data. They were decoded after data processing to facilitate data analysis and report writing.

Sample Design

Both in the rural and urban area Two Stage Sampling Design were adopted. In the rural areas, the first stage units are census villages and the second stage units are households in the selected villages. In the urban areas, the first stage unit was municipal ward and the ultimate stage units were households in the selected municipal wards.

Respondents

The head of the selected household of either sex was the respondent for collection of information through face-to-face interview.

Survey Instruments

The following Schedules/Questionnaires were developed for collection of Primary Data through the sample survey:

- Questionnaire- 1: Village/Town Particulars
- Questionnaire- 2: Household Particulars.

Each Schedule/Questionnaire is divided into several blocks and there are both open-ended and closed-ended questions. Provision was made in the Household Schedule/Questionnaire to gather information on perception of the Households regarding the project.

4.10.2 Description of the socio-economic status of the study area

Detail of the habitation of the Study Area

The study area is spread over in Thrivunanthapuram district of Kerala. The study area defines a circle of radius 10 km from the centre of the project site. The project site is situated at village Aruvikkara in the sub-district of Nedumangad. In the study area, there are about 55 identified habitations, which are distributed in rural & urban areas.

The project village is equipped with basic amenities required for livelihood. The people of the project village have the sources of drinking water from Tap, Covered & Uncovered Well, Hand Pump, Tube Well, River/Canal and Tank etc. The project village is well connected with Black Topped (Pucca), Gravel (Kachcha) and Footpath roads and various road transportation services like Public & Private Bus services, Auto & Taxi services. There are numerous educational institutions like Govt. Pre-primary Schools, Govt. & Pvt. Primary Schools, Govt. & Pvt. Middle Schools, Govt. Secondary Schools, Govt. Polytechnic Institute, Pvt. Vocational Training Institute/ITI etc. For the benefit of health issues, the project village has a Primary Health Centre, Maternity & Child Welfare Centre, Family Welfare Centre, Non-government Medical Facilities & Shops and Veterinary Hospital.

Malayalam is the mother language of the native people residing in the study area. There are many languages spoken in Kerala, though the official language of Kerala is Malayalam. This language belongs to the Dravidian group of languages. Almost 90% people of Kerala speak Malayalam. There are five main regional dialects of Malayalam. Other common languages that are spoken in Kerala are English and Tamil. These Kerala languages are often interspersed with words from Sanskrit, Latin, Urdu, etc. due to foreign influence.

Almost everyone in Kerala can converse in English, since education is given much importance there.

Hinduism is the most widely professed religion in Kerala, with significant Muslim and Christian communities. Kerala has a reputation of being, communally, one of the most religiously diverse states in India. According to 2011 Census of India figures, 54.73% of Kerala's population are Hindus, 26.56% are Muslims, 18.38% are Christians, and the remaining 0.32% follows other religions or no religion.

Various tribal people in Kerala have retained the religious beliefs of their ancestors. Hindus constitute the majority in all districts except Malappuram, where they are outnumbered by Muslims. As of 2015, Hindus, Muslims, Christians and others account for 42.87%, 41.45%, 15.42% and 0.26% of the total childbirths in the state, respectively. Consequently, Kerala's religious landscape is set to diversify further in the future.

The Economy of the study area consists mostly of agriculture, and floriculture. Pepper, ginger, and rice cultivation plays a vital in the economy. "Kerala Pepper" is famous worldwide for its rich aroma, and taste. The study area is surrounded by Coffee, pepper and medicinal plant estates. Pisciculture (fish farming) and Tourism is also an important part of the economy.

List of Rural/Urban areas (Census Town-CT) identified in the study area are given in **Table 4-26** below.

Table 4-26: List of Villages/Census Towns in the Study Area

S. No.	Name of Villages/Towns	S. No.	Name of Villages/Towns
01	Aruvikkara	**29**	Moozhy
02	Perumkulam	**30**	Kuttiyani
03	Vellanad	**31**	Kallayam
04	Aryanad	**32**	Kattakkode
05	Pangode	**33**	Vanchuvam
06	Tholicode	**34**	Mottakavu
07	Anad	**35**	Vettampalli
08	Theakada	**36**	Thannimoodu
09	Uzhamalackal	**37**	Manickappuram
10	Perumkadavila	**38**	Cheriyakonni
11	Chenkal	**39**	Aruviyode
12	Pangode	**40**	Poovachal
13	Kurupuzha	**41**	Kuttichal
14	Perumkadavila	**42**	Pezhummoodu
15	Elamba-Mudakkal	**43**	Killy
16	Irumpa	**44**	Mundela
17	Chullimanoor	**45**	Peyad
18	Koraliyodu	**46**	Pottayil
19	Venkavila	**47**	Kollamkavu
20	Vattappara (CT)	**48**	Sasthamangalam
21	Vilappil (CT)	**49**	Mayuram
22	Kudappanakkunnu (CT)	**50**	Muttada
23	Vattappara (CT)	**51**	Keraladityapuram
24	Malayinkeezhu (CT)	**52**	Kunnapuzha
25	Venganoor (CT)	**53**	Edapazhanji
26	Thirumala	**54**	Vellayambalam
27	Oolampara	**55**	Nanthancodu
28	Kusavarkal		

Demographic particulars/population details:

The detailed demographic population of the study area is given in the **Table 4-27** as below.

Table 4-27: Demographic particulars/population details of Study Area

S. No.	Description	Number	Percentage to Respective Total
1	**Total Population**	**10, 35, 899**	**100.0**
	Male	4, 98, 159	48.1
	Female	5, 37, 740	51.9
	Sex Ratio	**1, 079**	
2	**Population (0-6 age group)**	**92, 532**	**100.0**
	Male	47, 091	50.9
	Female	45, 441	49.1
	Sex Ratio	**965**	
3	**Population of Scheduled Caste Community**	**97, 838**	**100.0**
	Male	46, 513	47.5
	Female	51, 325	52.5
	Sex Ratio	**1, 103**	
4	**Population of Scheduled Tribe Community**	**18, 795**	**100.0**
	Male	8, 692	46.2
	Female	10, 103	53.8
	Sex Ratio	**1, 162**	
5	**Population of General Community (including**	**9, 19, 266**	**100.0**

	OBC)		
	Male	4, 42, 954	48.2
	Female	4, 76, 312	51.8
	Sex Ratio	**1, 075**	
6	**Total No. of Households**	**2, 71, 191**	
	Average Household Size	4	
7	**Total Literates**	**8, 77, 654**	**100.0**
	Male	4, 30, 009	49.0
	Female	4, 47, 645	51.0
	Overall Literacy Rate	**93.0**	
	Male	95.3	
	Female	90.9	
	Gender Gap in Literacy Rate	4.4	
8	**Total Workers**	**3, 96, 663**	**100.0**
	Male	2, 82, 067	71.1
	Female	1, 14, 596	28.9
	Gender Gap in Work Participation Rate	42.2	
9	**Main Workers**	**2, 90, 094**	**100.0**
	Male	2, 26, 219	78.0
	Female	63, 875	22.0
	Gender Gap in Work Participation Rate	56.0	
10	**Marginal Workers**	**1, 06, 569**	**100.0**
	Male	55, 848	52.4
	Female	50, 721	47.6
	Gender Gap in Work Participation Rate	4.8	
11	**Household Industrial Workers**	**9, 005**	**100.0**
	Male	5, 752	63.9
	Female	3, 253	36.1
12	**Agricultural Workers**	**55, 987**	**100.0**
	Male	44, 089	78.7
	Female	11, 898	21.3
13	**Cultivators**	**15, 706**	**100.0**
	Male	12, 467	79.4
	Female	3, 239	20.6
14	**Agricultural Labour**	**40, 281**	**100.0**
	Male	31, 622	78.5
	Female	8, 659	21.5
15	**'Other Workers'**	**3, 31, 671**	**100.0**
	Male	2, 32, 226	70.0
	Female	99, 445	30.0
			Source: Census, 2011

Population Composition

According to Census 2011, total population of the study area is approximately 10, 35, 899. The gender wise distribution of the above population is 4, 98, 159 (48.1 per cent) male and 5, 37, 740 (51.9 per cent) female.

Of the total population, 8.9 per cent are children in the age group of 0-6 years. Of the total child population, 50.9 per cent are boys and remaining 49.1 per cent are girl child.

Household and Household Size

The entire population of the study area is distributed into approx. 2, 71, 191 households and the average household size is 4.

Social Communities

Of the total population 9.4 per cent population belongs to Schedule Caste Community. Only 1.8 per cent population belongs to Schedule Tribes and approx. 88.7 per cent of the total population belongs to General Category including that of 'Other Backward Caste'.

Sex Ratio

The overall sex ratio has been worked out to 1, 079 females per 1, 000 males. The sex ratio of population in the age group (0-6) is 965 girls per 1, 000 boys.

The sex ratio among Scheduled Caste population has been worked out to 1, 103 females per 1, 000 males whereas among the Scheduled Tribe population the same has been worked outs to 1, 162 females per 1, 000 males.

Among the population of General Category (including OBC), the sex ratio has been worked out to 1, 075 females per 1, 000 males.

Literates, Literacy Rate and Gender Gap in Literacy Rate

In the study area, 84.7 per cent of the people are literate. The gender wise distribution of literates is male 49.0 per cent and female 51.0 per cent. The overall literacy rate in the study area has been worked out to 93.0 per cent. The male literacy rate is 95.3 per cent and female literacy rate is 90.9 per cent, creating a gender gap of 4.4 per cent.

Workers and Work Participation Rate

In the study area, the total workers are 3, 96, 663 which is 38.3 per cent of the total population. Of the total workers, 71.1 per cent are males and the remaining 28.9 per cent are females. In absolute term, the total number of male workers is 2, 82, 067 and that of female is 1, 14, 596. The gender gap in work participation rate is 42.2 per cent.

Further, of the total workers 73.1 per cent are main workers and the remaining 26.9 per cent are marginal workers.

Further of the total main workers 78.0 per cent are male and the remaining 22.0 per cent are female. In case of marginal workers, 52.4 per cent are male and 47.6 per cent are female.

The workers are further divided into Agricultural Workers, Household Industrial Workers and 'Other Workers'. Their share in the total workers is 14.1 per cent, 2.3 per cent and 83.6 per cent respectively.

Of the people working in agricultural sector, 28.1 per cent are Cultivators who possess cultivable land and the remaining 71.9 per cent are Agricultural Labour, who does not possess land but work in the land owned by big farmers as wage earners or sharecropper.

Basic amenities

The detailed availability of basic amenities at the study area given in **Table 4.-28.**

Table 4-28: Basic Amenities Available in the Study Area

EDUCATION		
Educational Institutions	**Type of Institute**	**Number**
	Pre-primary School (Govt. & Pvt.)	25
	Primary School (Govt. & Pvt.)	173
	Middle School (Govt. & Pvt.)	83
	Secondary School (Govt. & Pvt.)	43
	Senior Secondary School (Govt. & Pvt.)	31
	School for Disabled (Pvt.)	07
	Art & Science College (Govt.)	02
	Engineering College (Pvt.)	02
	Management Institutes (Pvt.)	01
	Polytechnic Institute (Govt. & Pvt.)	03
	Vocational Training School/ITI (Govt. & Pvt.)	07
HEALTH		
Health Facilities	**Types of Health Facilities**	**Number**
	Ayurvedic Hospital	03
	Allopathic Dispensary	39
	Veterinary Hospital	18
	Mobile Health Clinic	01
	Non-govt. Medical Facilities (Charitable)	10
	Community Health Centre	06
	Maternity & Child Welfare Centre	13
	TB Clinic	02
	ASHA	49
	Family Welfare Centre	09
	Primary Health Centre	06
	Primary Health Sub-Centre	25
	Medical Shops	136
WATER		
Drinking Water	**Means of Drinking Water**	**No. of Habitations where the facility available**
	Tap	53
	Hand Pump	55
	Tube Well	55
	Tank	54
	Well (Covered & Uncovered)	49
	Spring	09
	River/Canal	14
ELECTRICITY		
Electricity Supply	**Types of Power Supply**	**No. of Habitations where the facility available**
	Power for Domestic Uses	55
	Power for Agriculture Uses	55
	Power for Commercial or Industrial Uses	55
ROAD		
Approach Road	**Types of Approach Road**	**No. of Habitations where the**

		facility available
	Black Topped (Paved/Pucca) Road	55
	Gravel (Mud/Kachcha) Road	55
	Footpath Road	55
TRANSPORTATION		
Road Transportation	**Types of Services**	**No. of Habitations where the facility available**
	Public & Private Bus Services	55
	Auto & Taxi Services	55
BANKING		
Banks & ATM	**Types of Banking**	**No. of Habitations where the facility available**
	Commercial Bank	19
	Cooperative Bank	49
	Agricultural Credit Societies	11
	ATM	31
		(Source: Census 2011)

Other Amenities available: Internet Cafe, Public Telephone Booths, Private Courier Facility, Self-Help Group (SHG, Public Distribution System (PDS) Shops, Nutritional Centre/Anganwadi, Agricultural Marketing Society, Sports Fields, Sports Club/Recreational Centre, Cinema/Video Hall, Public Library & Reading Room etc.

4.11 Traffic Study

Traffic remains the concealed component of the impact analysis of any new development project. Therefore, the impact of certain projects on traffic and transportation is too far reaching to be subsumed under a generalized EIA study. Traffic Analysis is a study carried out to predict the magnitude and effects that a proposed project, generates on the existing transportation network. Traffic analysis can also be used to evaluate whether the proposed project is appropriate and what type of transportation facility improvements would be necessary.

The three main types of automobile vehicles being used in the country are Passenger cars powered by four strokes gasoline engines. Whereas, some (like auto-rickshaws) are powered mostly by small two stroke engines and diesel engines.

Data Analysis

The traffic study were carried out for SH-02 and SH-03 for 24 hours, which is near to the proposed site and is a medium for transportation of desililted material from dumping site to market.

Table 4-29: Detail of Total Mineral Transportation and Dispatched Ratio

Name of Highway	Direction		Dispatched Ratio in Percentage
	Up	Down	
SH-02	Thiruvananthpuram road	Nedumangad-Shorlacode Road	50*
SH-03	Nedumangad-Shorlacode Road	Vellanad-Nedumangad Road	50*
Total Minerals transported through State Highways			
**50% minor minerals will transfered through SH-02 and *50% minor minerals will transfered through SH-03*			

Existing traffic scenario

The Level of Service (LOS) and the capacity of the Roadway segments computed is based on the Indian Roads Congress (IRC) standards sourced from Guidelines for Capacity of Rural Roads in Plain Areas IRC 64-1990. Following table provides the LOS standards adopted based on the volume to capacity (V/C) ratios at the intersections and its performance.

Table 4-30: Level of Services (LoS) Standards

V/C	LOS	Performance
0.0-0.2	A	Excellent
0.2-0.4	B	Very Good
0.4-0.6	C	Good/Average/Fair
0.6-0.8	D	Poor
0.8-1.0	E	Very Poor

Table 4-31: Traffic Calculation

S. No.	Type of Vehicle	Vehicle Distribution/ day for SH-02	Vehicle Distribution/ day for SH-03	PCU	No. of Vehicles in PCU/day for	No. of Vehicles in PCU/day for	Vehicles in PCU/hr for SH-02	Vehicles in PCU/hr for SH-03
1	Cars	98	101	1	98	101	4	5
2	Buses	26	30	3	78	90	3	4
3	Trucks	55	60	3	165	180	7	8
4	Tractors/Trailors	31	35	1.5	46.5	52.5	2	3
5	Two Wheelers	250	230	0.5	125	115	5	5
6	Three Wheelers	115	130	1	115	130	5	6
Total		**575**	**586**		**627.5**	**668.5**	**26**	**31**

Table 4-32: Existing Traffic Scenario

Type of Road	Existing Volume (PCU/day)	Capacity in (PCU/day)	V/C Ratio	LOS
SH-02	**627.5**	2000	0.31	B
SH-03	**637**	2000	0.32	B

Table 4-33: Passenger Car Unit (PCU) Calculation

During Extraction Operation	
Total extraction capacity	262500 Tons
No. of working days	300
Extraction and Transportation of material	875 MT/day
Working hours per day	8 hour
Truck Capacity	20 Tons
Frequency of trucks deployed/day (8 x 6 trips/day x 2 up/down)	96
Increase in PCU/day(= 96*3)	288
Frequency of trucks deployed/hr	36
Increase in PCU/hr (=36*3)	108

Table 4-34: Modified Traffic Scenario

Road	**Increased PCU's-National Highway**	**Volume (V)**	**Capacity (C)**	**Modified V/C Ratio**	**LOS**
SH-02	108	627.5 + 108=735.5	2000	0.36	B
SH-03	108	668.5 + 108= 776.5	2000	0.38	B

Interpretation

- Out of the total traffic vehicles, 2 wheelers are very high followed by light and medium vehicles. The movement of two wheelers and light vehicles are largely found in daytime.
- The difference of heavy vehicle movement, both day and night time was very marginal. The density of heavy vehicles was comparatively low. The LOS study shows that the existing traffic scenario is "Very good" and the free flow of vehicles are observed during the study period.
- Due to the desilting project, the traffic density will increase as the entire mineral will be transported through the SH-02 and SH-03 under study and the value of LOS would remain same i.e. Very good.

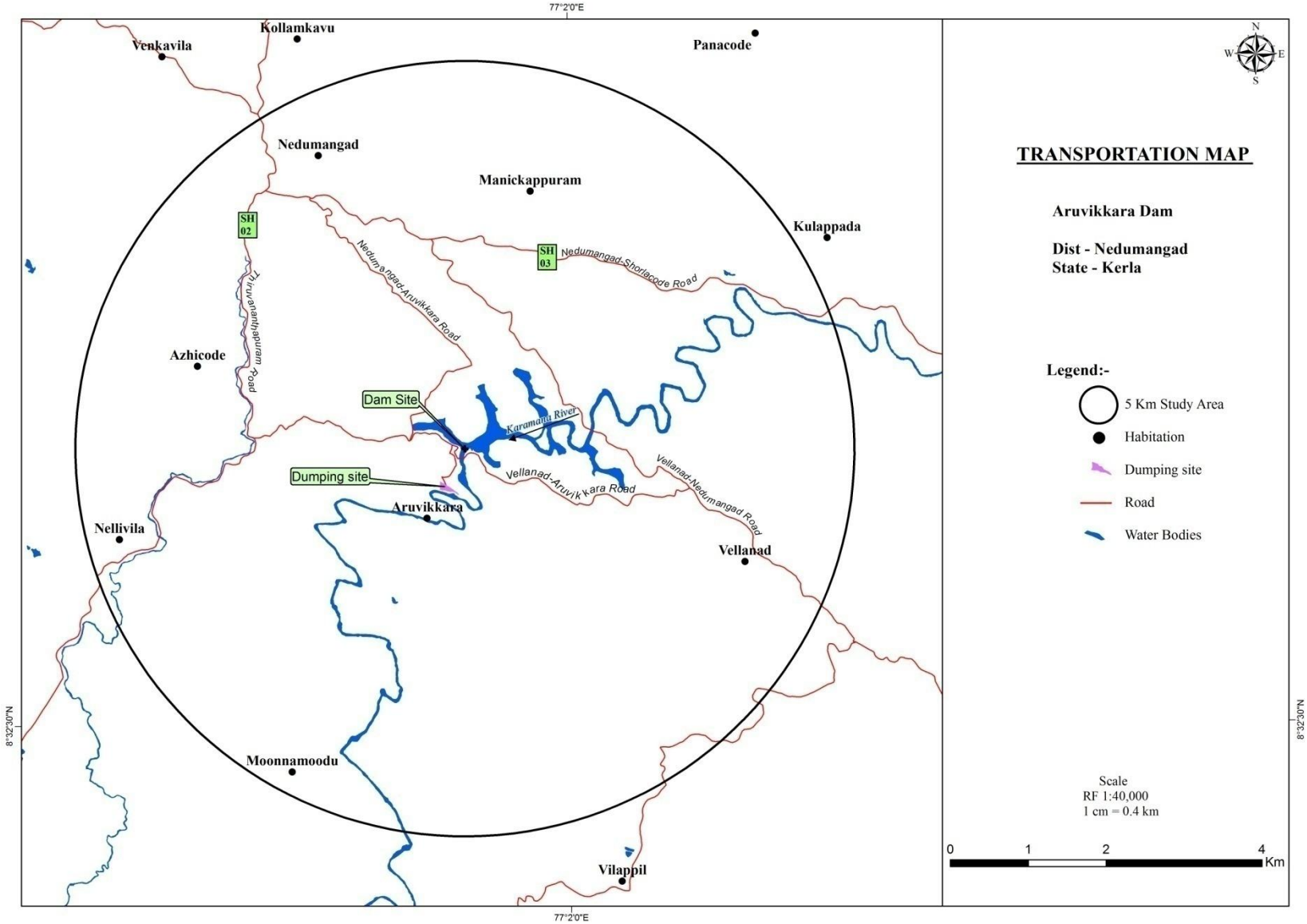


Figure 4-3: Transportation Map

CHAPTER 5 : ADDITIONAL STUDIES

5.1 Hydrology and Hydro-Geology

The catchment area of Karamana River is within the Thiruvananthapuram District having an area of 702 Km^2. The Vamanapuram River Basin and Neyyar Basin are situated on the north and the on the South of Karamana basin. The catchment area which lies within Aruvikkara Dam, Thiruvananthapuram is 258.89 Km^2.The Karamana river flows upto 68km to Arabian Sea in South-west Direction. The average annual stream flow of Karamana River is 836 MCM. The Karamana River has 4 major tributaries as Kaviar, Attaiar, and Vaiyapadain & Todiyar.

The Karamana River basin can be broadly classified into two zones as Archean Group Rocks & Quilon & Varkala Beds. The major part of Karamana River mainly consists of Archean Group Rocks. The River flow to south west direction towards Arabian Sea and in this region Quilon & Varkala Bed types of rocks are found as the Waterspread area consists of sand and silt throughout its flow direction. Trivandrum district is very closer to Arabian Coastline, therefore soil is predominantly composed of coastal alluvium, a mixture of clay & sand majorily found in the river basin consists of laterite soil.

In the upper reaches of the Karamana river basin, mostly loam type of soil is identified. Loamy soil is yellow or reddish yellow in colour and highly fertile.

In the midland and lowland regions, a thin stretch of river alluvium is found along the river valleys cutting across the extensive laterite soil.

Rainfall: Study of isohyetal map of Kerala reveals the isohyet of 2600 mm passes through the centre of the catchment area of the proposed project. Rainfall occurs in the monsoon i.e. from June to October and 90% of the total rainfall occurs during this period. Therefore, annual monsoon rainfall during monsoon can be safely assumed as 2600 mm. The rainfall data from 1970 to 2004 have been collected from the six rain gauge stations falling in the catchment area.

Karamana river is being Gauged at Trivandrum OBS, Aruvikkara village by Trivandrum Division, of CWC gauge site is situated upstream of the proposed dam site and is about 12.5 Km away from the proposed dam site.

5.2 Geological features of the district

Hydro-geologically, Trivandrum district is situated at coastal line made up of Archean type of rock and Quilon Varkala bed rocks. There are three regions High Land, Mid land & Low land region as shown in **Table 5.1.**

Table 5-1 Three types of Hydro-geologically regions found in the Study Area

High Land Region	Generally situated at the Western Ghats having an altitude of about 76m above the MSL,
Mid Land region	Covers a large area with an altitude within 76m and 7.6m MSL This area is highly undulating with wide variation of slope. Geomorphologically this area is comprised of low lateritic up hills and the major land use pattern includes Paddy fields, Coconut and Rubber plantation and Areca nut plantations
Low Land Region	Which is a narrow strip of land along the western coast, spreaded from the midland region to the river mouth including the delta basin with an altitude less than 7.6m MSL
	(KSREC- Land Use Board 2002)

5.3 Soil Classification of the basin:

1. Laterite Soil: This is the most abundant type of soil in this basin. This was formed as the product of weathering of Gneiss and Granite rocks developed under humid tropical conditions. The laterization process which has been catalyzed by the action of heavy rain fall preceded by high temperature in this region.

2. Costal Alluvium Soil: This has been formed by the deposition action of marine deposits. Sand fractions are dominant in this type. The water table is high in this region and the soil is highly acidic in nature.

3. Forest Loam Soil: These type of soils are generally found in the eastern parts of the basin. These types are originated by the action of weathering of crystalline rock under forest cover. The color of this soil varies from dark reddish brown to black in colour with loam to silky loam texture. They are shallow to deep and are well drained. Their nitrogen content is high in this type and it is acidic also. The important crops cultivated in these soils are rubber, tea, cardamom etc.

4. Red Loam Soil: These types of soil can be seen in isolated patches in foothills and hillocks along with laterite. The red colour is due to the presence of iron oxide. The soil is being highly porous and is not fertile.

5. River Alluvium Soil: These types are generally visible also like isolated patches in foothills and hillocks being associated with laterite. The red colour is due to the presence of iron oxide. The soil is being highly porous and is not fertile.

CHAPTER 6 : ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

6.1 Anticipated Impacts

The project once implemented will have its impacts on various environmental parameters. In order to give a clear picture of the impacts, a matrix is prepared for qualitative assessment of the impacts as given in the **Table 6.1** below.

Table 6-1: Impact Matrix

S. No	Project intervention	Soil & land	Geology	Hydrology	Water Quality	Air Quality	Noise Quality	Flora/Fauna	Socio-economic
1	Dredging Activity	√		√	√		√	√	√
2	Storage of Silt	√			√	√		√	
3	Transportation	√				√	√	√	√
4	Operation and maintenance of equipments	√			√	√	√	√	√

Hereafter, the impacts of the project activity are discussed in different domains of the environment, whereas, in the next part, the mitigation thereof will be discussed.

6.1.1 Impact on Water Environment

The water quality may get deteriorated during the desiltation work. The samples collected from the study area shows that the turbidity varies from 4 NTU to 6 NTU in the reservoir and TSS from 24 mg/L to 28 mg/L.

Once the dredging operation starts, the concentration of TSS and Turbidity will be increased due to scouring of the settled particles.

There are three WTPs situated near the pilot study area. These are 72 MLD, 74 MLD and 86 MLD WTPs. The 72 MLD WTP inlet door is falling under this pilot study area and its function is will to be directly affected.

- Dredging in the area will be done well above the water table as well as riverbed of Karamana River, therefore, much impact on water regime is not anticipated.
- No waste water will be generated from the dredging activity of dredging of minor minerals as the project only involves lifting of Sand/Silt/Clay Mix from study area. Dredging neither intersect ground water table nor riverbed water level.

6.2 Impacts due to dredging activities

Hydraulic dredgers use a centrifugal pump and pipe system to raise loosened material in suspension to the surface. There are three main types of hydraulic dredger, suction

dredgers (SD), cutter suction dredgers (CSD) and trailer suction hopper dredgers (TSHD) in which proponent using the cutter suction dredgers (CSD).

Short term Impacts;

- Salinity: At the time of dredging, the observations made at the ebb phase of the tide indicated no appreciable changes in salinity values. The day after dredging, the observations on salinity showed no conspicuous changes – the salinity distribution maintained the same pattern as the days before and during dredging.
- Turbidity: The most commonly observed changes in water quality during dredging are the rapid increase in turbidity. The change of water quality owing to dredging will not leave a permanent impression. The turbidity change was transient and localized.
- Transparency: A trend in the turbidity to gradually attain normalcy in the estuarine regions soon after stoppage of dredging.

Long Term Impacts;

- Desiltation from the Aruvikkara dam location is very beneficial for long term because it provide the construction material for developing the construction work nearest cities or other places.
- Dredging will also useful for clearing, the sediments, silt, rocky material from Riverbed, which were produced by automatically in the monsoon season by increasing the flow rate of river by heavy rainfall.

From the above mentioned points, it is understood that the short term impacts are temporary in nature and self restored after the completion of the activity where as no long-term negative impact are anticipated due to the dredging activity.

6.2.1 Impact on Soil and Land

During the operation phase, the dredging material will be transported from silted area of the reservoir to the temporary storage sites/lagoon by trucks and loaders. Pumping & Excavation of the stabilized playground will cause soil erosion in that particular area. Also, movements of trucks and other vehicles will cause impact on soil and land along the road and will degrade the area.

6.2.2 Impacts on Air Environment

Air Pollution will be caused due to fuel combustion in dredging equipments and vehicular movements during operation and transportation of desilted material. Dust emission is also envisaged during excavation of dry area of the reservoir and vehicular movements. The same will also be caused at the storage and dumping sites.

6.2.3 Impacts on Noise Environment

The project area is very calm at present, however, during project operation; noise level will be increase due to the mechanical set up for dredging, vehicular movement and activity of laborers.

6.2.4 Impact on Ecology and Biodiversity

The benefit derived from the creation of manmade reservoir is usually associated with great risks. The impoundment of water in reservoir leads to siltation, which is considered as a threat to the longevity and ecology of the reservoir. The siltation adversely affects the aquatic biological environment, which is as follows:

a. Besides decreasing reservoir capacity, large-scale siltation decreases the bottom surface area, which has pronounced effects on the reservoir biota and its distribution.

b. Turbidity caused by suspended silt can significantly reduce photosynthesis in reservoirs, which leads to decrease in O_2 content in water. This photosynthetic reduction has widespread effects on higher trophic levels of the food chain.

c. Silt deposits typically form deep fine-grained mud containing only a few macroscopic organisms such as Chironomids, Nematodes and Oligochaetes. Thus decreases the diversity of organisms. Fine suspended particles reduce the number of habitats, which can support benthic organisms and tend to decrease the diversity of the benthic fauna in reservoirs.

d. The siltation also hide/cover the spawning and resting habitat of fishes in the reservoir.

To get rid of the problems caused to aquatic ecosystem by the siltation in reservoir, de-siltation of reservoir is carried out to remove the excess silt accumulated in the reservoir to maintain the quality of water and the aquatic environment. However, the de-siltation work also has some short term or immediate impacts on the aquatic biological environment, which are as follows:

1. The de-siltation process may cause short term disturbance to aquatic life by destabilizing the sub-stratum at the bottom of reservoir. The excavation works may alter the sediment type *i.e.* substratum, or habitat of many benthic organisms which may force the aquatic species to migrate some other place.

2. The de-siltation process causes more turbidity in water which decreases the light penetration to the bottom of reservoir and this affects the photosynthetic activity and the growth of phytoplankton and zooplankton.

3. The extraction of slurry/sediments from bottom of reservoir, which is habitat to the invertebrates will get disturbed. The invertebrates will shift their habitat and thus, the ecology of the reservoir may get affected.

4. Slurry immediately sucked out and limited scouring, may affect the water column and the organisms residing in it. The greatest potential for impact is expected on benthic or epi-benthic organisms because these organisms are in close contact with deposited sediment for long periods of time.

5. The de-siltation process may destroy potential spawning beds in the shallow littoral zone of the reservoir, which may affect their breeding, and then reduction in their

population. Also, the fishes will be unable to find suitable breeding conditions in the littoral zone of the reservoir.

6.2.5 Impact on Socio-Economic Environment

The socio-economic conditions of the area will be positively affected as the project will generate employment for labour class which will be met by the nearby areas. Apart from the direct employment to the labourers, it will also open various other activities like small tea and snacks shops etc.

In the larger picture when the project is completed, the water and sand availability for drinking and construction purpose respectively will be enhanced. This will eventually improve the overall status of the city.

Impact on Demographic Composition

Consequent of the proposed project, there will be no significant increase in overall population of the study area as local people will be mainly recruited for employment. The migrants from distant places will be kept bare minimum. Hence, there will be no significant impact on the population composition in the study area. Since there will be no significant change in population, the overall sex ratio will remain more or less same.

Impact on Employment Opportunities

A positive impact of the project is creation of employment opportunities for the local people. The proposed project may generate employment opportunities first at project implementation stage and subsequently at operational stage. Creation of employment opportunities is a positive impact of the project on socio-economic aspects of people living in the study area.

Impact on Industrial Development

It is expected that due to the proposed project, the scope for further industrialization in the area will increase. Project will also benefit in meeting the huge demand of construction material like sand required in building construction and infrastructure works, road material for construction and maintenance of roads/highway in village Aruvikkara of district Trivandrum and nearby cities. Expected increase of industries in the study area may increase employment opportunities for the local people.

Impact on Agriculture

Since, the proposed project does not need any additional land other than what the project proponent possess, there will be no negative impact on the agricultural yield in the study area due to the proposed project.

From the all above points discussed regarding the impact on the scoio –economic impacts, it is understood that there is no negative impact on socio-economic environment of the study area.

From socio economic point of view, the project will benefit in meeting the huge demand of construction material like sand required in building construction and infrastructure works, road material for construction and maintenance of roads/highway in

Aruvikkara, district Trivandrum and nearby cities and due to which local people will get opportunities to enhance their business and sources of income directly or indirectly associated activities of the project.

Another benefit, which the people residing in the study area may get that, is employment opportunities due to the proposed project. Therefore, the occupational pattern of the people in the study area will change making more people engaged in industrial & business activities due to the proposed project.

6.3 Mitigation Measures

6.3.1 Mitigation Measures for Water Environment

The dredging will impact the water quality severely but temporarily. The impacts are mainly short term disturbance to the reservoir during the dredging activity. However, to reduce the impact on water quality following plan will be adopted:

1. The dredging activity will be carried out in the Pre-Monsoon season i.e. March and April months in Kerala. Hence, impact of dredging will not last more than a month.
2. The desiltation will be done in the phase wise manner. As shown in the Figure 5.2, the desiltation will be started from the rear end Grid 1 to Grid 6. The dredging in this area will not cause suspended material to affect the water quality of the reservoir As Grid 7 will act as a natural barrier. Once this is excavated/dredged, it will restore the capacity of this part without having any impact on the water quality.
3. Grid 7 to Grid 19 will be dredged in the second phase with prior precautions and is done in such a way that the pumping is not being done rainy season. The inlet structures must be surrounded by using Type-II Silt Curtains. Type II Silt Barriers are floating turbidity barriers designed specifically for areas with moving water.

6.3.2 Mitigation Measures for Soil Environment

- There is no toxic element present in the mineral, which may contaminate the soil.
- Water sprinkling will be adopted to control dust emissions.
- It will be ensured that all transportation vehicles will carry a valid PUC certificate.
- Greenbelt will be developed along the roads and other sites.
- Also, afforestation in the catchment area will be done in consultation with State forest department and locals so that soil erosion can be reduced.

6.3.3 Mitigation Measures for Air Environment

The concentration of air borne pollutants in the workspace/work zone environment will be monitored regularly. If concentration is higher than threshold limit values are observed, the source of fugitive emissions will be identified and necessary measures will be taken.

- Plantation is recommended on approach roads & nearby vicinity of the project for minimizing dust propagation.
- Proper mitigation measures like water sprinkling will be adopted to control dust emissions.
- It will be ensured that all transportation vehicles will carry a valid PUC certificate.

Table 6-2: Mitigation Measures for Air Environment

Action	Parameters for Monitoring	Timing
All equipments are operated within specified design parameters.	Random checks of equipment logs/manuals	During site clearing
Vehicle trips to be minimized to the extent possible. All trucks which are carrying dry material must be covered with Tarpaulin sheets to reduce the fugitive emissions.	Vehicle logs/Increase the capacity of vehicle	During site clearing, transportation of minerals
Regular water spraying shall be done	Quantity of water requirement shall be monitored	During site clearing, transporta-tion etc.
Ambient air quality within the premises of the proposed storage site to be monitored.	The ambient air quality will conform to the standards for PM_{10}, SO_2 and NO_2	As per KPCB requirement.

6.3.4 Mitigation Measures for Noise Environment

The measures to control noise will be as follows:

- Regular maintenance of equipments and machineries to keep the noise generation at the reduced/designed level. High noise generating machines will be equipped/fitted with silencers to reduce the noise levels.
- The equipments that need to be placed still like generators will be kept in acoustic enclosures to reduce noise levels. For heavy equipments like rotating or impacting machines noise will be damped by mounting them on anti-vibrations mountings.
- Necessary training/orientation will be provided to the traffic operators/drivers to make them aware of the environmental aspects of the traffic. Loud horns and high speed *etc*. in the forested/natural areas will be avoided.
- Periodical monitoring of noise will be done.
- Plantation will be taken up along the approach roads and along the periphery of the dredging area to minimizes propagation of noise.

6.3.5 Mitigation Measures for Biological Environment

- There is no other major impacts is anticipated on the terrestrial ecology other than those which as discussed in the air, water, noise impacts that also affect the flora and fauna and mitigation thereof also suggested in those relevant segments.
- However, there are negative impacts, from the dredging activity in the aquatic environment are anticipated. These are temporary in nature and will only be limited to in the dredging grid/part till the dredging activity. Moreover, in longer term, this will be beneficial for the aquatic environment.
- Since there is no any Schedule-I fishes species found in the reservoir. Hence, here is no need of specific conservation plan.

Table 6-3: Mitigation Measures Against Each Impact

Project Stage	Project Activities	Potential Environmental Impacts	Proposed Mitigation Measure	Long term Impacts
Operation Phase	Sewage generation and disposal from Labor camps/Site toilets	Water pollution	• Sewage is to be treated in septic tank followed by soak pit.· Monitoring of water related diseases	Labor will come from local areas and Sewage generation would not be in large quantity.
Operation Phase	Cutter Suction Dredging operation, Vehicle movement	Noise generation	• Noise monitoring shall be carried out as per the monitoring plan	Noise will be generated only at the time of desiltation process and due to vehicle movement at the time of transportation.
Operation Phase	Turbidity	Water transparency can change for a short time period.	• After desilting process, the particles will take some time to settle down and thus the turbidity will come down automatically.	Turbidity is not a long term impact.
Operation Phase	Waste generation	Land contamination	• Solid wastes generated shall be collected and disposed in designated pit.	No waste material would be left behind after segregated minor mineral is distributed to the vendors
Operation Phase	Greenbelt development	Improving the vegetation surrounding the river bed and haul road of the area	• The growth vegetation is to be checked through monitoring the survival rate	Greenbelt development would improve the air quality along with strength of soil.
Operation Phase	Provision of infrastructural facilities to the proposed project	As labor is coming from local areas, therefore no infrastructure facilities will be required.	• NA	NA
Operation Phase	Movement of vehicles	Air emissions	• Vehicles engaged in operational activities shall be maintained properly • Pollution under control certificate shall be maintained for all the vehicles of project.	Movement of vehicles will have short term impact on environment.
Operation Phase	Desilted material	Material will be collected in slurry form and stored in a particular place for distributing the minor minerals.	• Material will be directly loaded in distribution trucks and lay down in particular place for distributing the minor minerals.	Desilted material is very useful for development of nearby areas in construction and the same shall be directly sent to the dealers for selling to these areas.

CHAPTER 7 : ENVIRONMENTAL MANAGEMENT PLAN

7.1 General

The environmental management plan consists of a set of mitigation, management, monitoring and institutional measures to be taken during implementation and operation of the project, to eliminate adverse environmental impacts or reduce them to acceptable levels. The present environmental management plan addresses, the components of environment, which are likely to be affected by the different operations in a dredging activity.

The Objectives of EMP are:

- Overall conservation of environment.
- Minimization of waste generation and pollution.
- Judicious use of natural resources and water.
- Safety, welfare and good health of the work force and populace.
- Ensure effective operation of all control measures.
- Vigilance against probable disasters and accidents.
- Monitoring of cumulative and long term impacts.
- Ensure effective operation of all control measures.

7.2 Environment Management System

Proper environmental management plan is proposed for Desiltation of the reservoir project to mitigate the impact during the dredging operations.

- No labour camps will be established near the reservoir rim.
- No cooking, or burning of woods will be allowed in the nearby area.
- Prior to commencement of dredging, a short awareness program will be conducted for labours to make them aware about way of working and various precautions to be taken while at work. Such program will be repeated occasionally.
- In the event of some causality or injury to any worker occurs, proper treatment will be given.
- It will be ensured that noise produced due to vehicles movement while carrying the dredged material is within the permissible noise level.
- No piling of Waterspread area Material will be done in adjoining area.
- If wild animals are noticed crossing the project area, they will not be disturbed or chased away, instead the labours will move away from their path

7.3 Dredging Management Plan

Extraction of silt deposited in water spread area of Aruvikkara Reservoir dredged by a Mechanized Method. The salient features of the operation plan for dredging of water spread area are as given below:

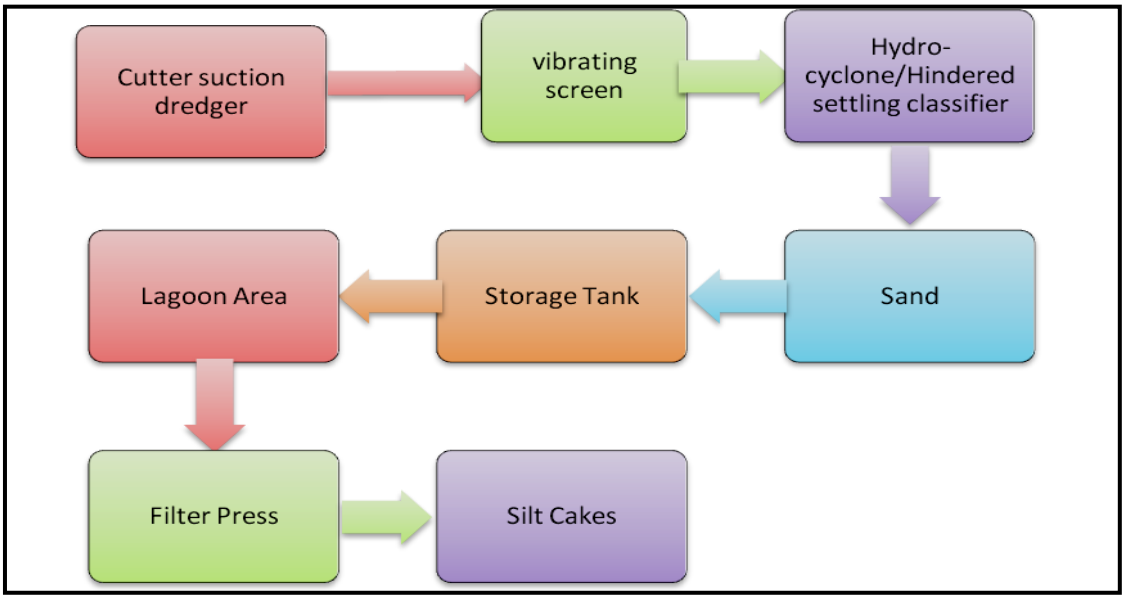


Figure 7-1 Dredging Operation Plan

1. The rate of removal of silt from the water spread area will be 50 cubic meter per hour.
2. At the site, the Cutter Suction Dredger will be installed and it starts pumping of silt material section wise. The rate of sludge, pumped by dredger will be 350 cubic meter per hour.
3. The silt passed through a 5 mm Vibrating Screen for removal of debris, vegetation and coarser particles submerged in water spread area.
4. After removal of coarse particles, the screened slurry will be passed through a Hydro-Cyclones/Hindered Settling Classifiers of suitable size for separation of sand.
5. The sand separated (approximate percentage by volume can be taken as 50% of the silt removed) will be stacked for measurement and auction. The sand separation will be carried out in the open area land portion available at the dredging portion.
6. The resulting slurry stored in a small storage tank, will be continuously pumped to the sludge Lagoon Area at the downstream side of the reservoir.
7. The slurry will be deposited for 24 hours in a plain sedimentation Lagoons.
8. The water after sedimentation will be released to the nearby river after necessary water treatment process to limit the turbidity to 6 NTU.
9. The sludge resulting from the plain sedimentation will be de-watered using a battery of Filter Press to produce silt cakes of moisture content 25% or so.
10. The filtered water by the Filter Presser will be released to the river after necessary water treatment.
11. The silt cakes will be stored in the lagoon area and will be sold to the empanelled buyers.

7.4 Standard Operating Procedure

Sedimentation of storage reservoirs is the process of accumulation of silt due to the obstruction created by the dam. This causes reduction in the storage capacity of the reservoir. The progressive loss of capacity due to sediment accumulation results in reduced benefits and may even cause operational problems in the reservoir projects. Desiltation of reservoirs will help to restore the original designed capacity of the reservoirs. The desilted sediment can be separated into usable components like sand and clay, which can be utilized for construction purposes and brick/tile industries respectively. This will provide a solution to the scarcity of sand in 'the State. Thus the desiltation of reservoirs will help in storage capacity restoration as well as in earning sizeable revenue to the State by way of sale of separated components.

The desiltation of reservoirs will be carried out by using pneumatic de-silting pumps (**Cutter suction dredger**). The sediments will be removed by suction method using de-silting pumps and transported through pipelines to the processing yard for separation and the debris (plastic, glass *etc*) shall be disposed strictly adhering to the safety, conditions stipulated by the Department and without polluting the environment in any manner. The pipeline system shall be the own responsibility of the Proponent. The de-silted sediment in slurry form shall be separated into usable components such as boulder, gravel, sand, clay, silt, organic matter etc by using suitable sediment separators (wet method).

No harmful chemicals/flocculation agents will be added during the separation phase. Separation of components is to be done in such a manner that the properties of the separated materials are strictly in accordance with the market requirements and IS specifications for construction materials.

Reservoir de-siltation process including the following phases:

Phase I: Removal of sediment material from the reservoir
Phase 2: Transportation to separation plant/stacking yard
Phase 3: Separation and washing of cobble, pebble, sand, clay, and other Materials
Phase 4: Sand and clay packing and debris disposal
The de-silted sediment in slurry form will separated into usable components by **wet method.**
The process of pumping the entire materials from reservoirs directly to the separating & packing plants through pipelines have minimum environmental and social disturbance. The Proponent will maintain any damages to road, gates, fence, side protection works etc. due to any of the above processes.

The program for desiltation will be completed within a total period of 24 months based on the quantity of sediments to be removed (Below 2MCM - 12 months, 2MCM to 5MCM - 24 months, 5MCM to 10MCM - 36 months, above 10MCM - 60 months). The process of desiltation is showing on **Fig 7-2.**

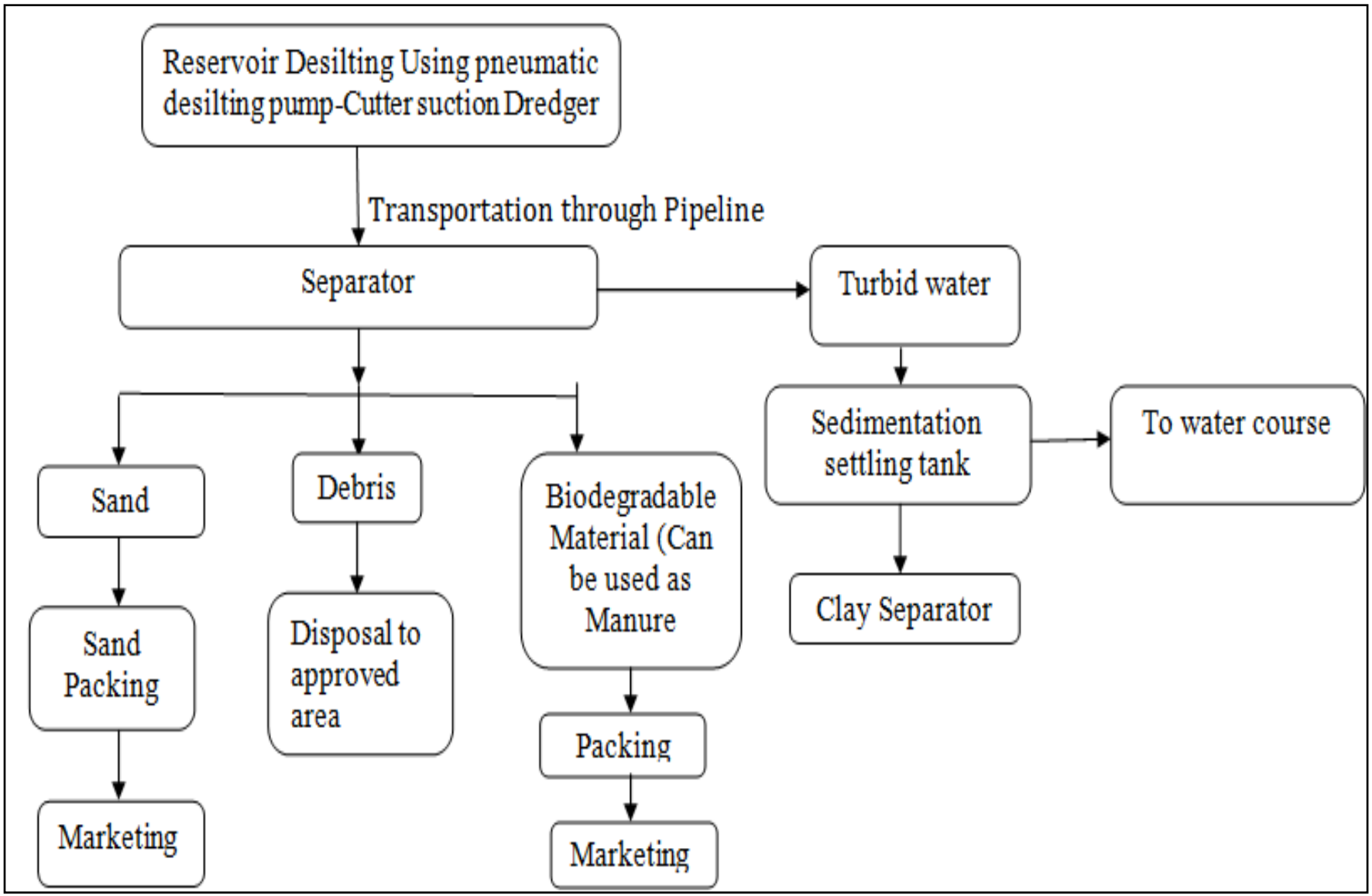


Figure 7-2: Reservoir Desiltation Process

7.5 Floating Management Plan

As per the project, floating management plan must be developed at the proposed area of 5.0 Ha. Kepner's Silt Curtains will be used to control mixing of sediments and debris in the water spread area. Kepner's Silt barriers are installed during the dredging operation. The Silt Curtains restrict spreading of wastes into a limited area. The total cost of floating management by Kepner's Plastic Silt Curtains will be estimated as Rs. 3, 18, 500.

7.6 Greenbelt Development

As per the MoEF&CC, 33% of the project area must be developed for greenbelt purpose. Since the proposed project is a reservoir, the greenbelt can be planned to the nearby area i.e. along the haul road, open area. This will be done in consultation with State Forest Department. Only native species can be planted in this scheme. Total 19.08 Ha of the reservoir area will be developed under this scheme. The cost of green belt development will be Rs. 50, 000 per annum.

7.7 Safety during dredging operation

As soon as the dredging operation starts, the area must be confined with red signals/flags and sign boards. Public must be informed through announcement etc. DGMS has given necessary guidelines for the safety and surveillance against these occupational hazards wise prevention measures. Initial & periodical examination will be conducted. FORM-O is prescribed as Medical examination for every employee as per Rules- 1955. Details of tests are given in the form so that in case any dust/emission related diseases test need to be conducted more frequently as the examination authority deems necessary, the same can be done without any delay.

Normal sanitary facilities will be provided in the nearby area. The management will carry out periodic health check up of workers.

Occupational hazards involved are related to dust pollution, noise pollution and injuries from moving machineries & equipment and fall in to the reservoir. All necessary first aid and medical facilities will be provided to the workers. The site will be well equipped with proper fire protection and firefighting equipment. All operators and mechanics will be trained to handle fire-fighting equipments. Further all the necessary protective equipments such as helmets, safety goggles, earplugs, earmuffs, etc. will be provided to persons working at site as per Mines Rules, 1955. A DMP has been prepared for the Desiltation of Aruvikkara reservoir in this regard.

7.7.1 Disaster Management Plan

The Disaster Management Plan (DMP) is a guide, giving general considerations, directions, and procedures for handling emergencies likely to arise from planned operations.

Structure

The Disaster Management Plan (DMP) is supposed to be a dynamic, changing, document focusing on continual improvement of emergency response planning and arrangements. A structure working on a Plan, Do, Check & Review (PDCR) cycle has been therefore suggested. Another advantage of doing this is to have a system that is in synchronicity with commonly used Health and Safety systems, ISO 14001 and OHSAS 18001.

Policy

The Safety Health and Environmental (SHE) policy should be existing & accessible to all at site and to other stakeholders. The policy should be framed considering legislative compliance, stakeholder involvement, continual improvement, and management by objectives.

Planning

Identification & Prevention of Possible Emergency Situations

Possible emergency situations can broadly be classified into drowning, vehicle collision, and inundation. Additional emergencies can be developed based on audit or other procedures prior to commencement of operations.

Emergency Prevention

Some of the ways of preventing emergencies are as follows:

- Preparation of a Preventive Maintenance Schedule Programme and also covering maintenance schedules for all critical equipments and instruments as per recommendations of the manufacturer's user manuals.
- Importantly, it is of great importance to collect and analyze information pertaining to minor incidents and accidents at the site, as well as for recording near-misses or emergencies that were averted. This information gives an indication of how likely or unlikely it is for the site to face actual emergency and what shall be further action to prevent them from occurring.
- Establishment of an ongoing training and evaluation programme, incorporating the development of capabilities amongst employees about potential emergencies and ways and means of identifying and averting the same. Most emergencies do not occur without some incidence or an abnormal situation. So there is always sometime of few seconds to few minutes to arrest an incident of abnormal situation from turning into an emergency. This is the role of the in-charge who is the incident controller (IC) along with his team.

Emergency Plan Objectives

Specific objectives of the Emergency Response Plan are to be clearly listed with regards to the responses desired for successful management of the possible emergency situations. Suggested objectives could include:

- To define and assess emergencies, including risk and environmental impact assessment.
- To control and contain incidents.
- To safeguard employees.
- To minimize damage to property or/and the environment.
- To inform employees, the general public and the authority on the hazards/risks assessed.
- Safeguard provided residual risk if any and the role to be played by them in the event of emergency.
- To inform authorities like Safety and Fire Department and Mutual Aid Centers to come up for help.
- For effective rescue and treatment of casualties and to count the injured.
- To identify and list fatal accidents if any.
- To secure the safe rehabilitation of affected areas and to restore normally.
- To provide authoritative information to the news media.
- To preserve records, equipments etc. and to organize investigation into the cause of the emergency and preventive measures to stop its recurrence.
- To ensure safety of staff and patients and resume work.
- To work out a plan with all provisions to handle emergencies and to provide for emergency.
- Preparedness and the periodical rehearsal of the plan.

Setting-up of Emergency Infrastructure

To enable the key persons to implement the DMP, the following infrastructure will be required to be set up:

ASSEMBLY POINTS

In case of emergency, the site needs to be evacuated immediately. On evacuation, people will go to pre-assigned assembly points. The charge will be taken by shift in charge, in his absence person deployed by In-charge/Executive Engineer/Contractor will be in charge of respective assembly points, and will supervise Assembly and Head Count. A Board indicating the Assembly Point having relevant information is placed at point for guidance.

Liaison with State Authorities

Government authorities, local hospital, police fire services, taluka, district collector will be kept informed about the occurrence and development of any incident by the In-charge/Executive Engineer/Contractor and procure necessary help and guidance from these authorities.

TASK FORCE OF ESSENTIAL STAFF

A task force of essential trained staff is made available to get work done by the Executive Engineer. Task Force personnel shall be trained to perform tasks as mentioned above.

Emergency Control Center

Site In-charge office will act as Emergency Control Center and provided with required communication facilities. The Control Center is situated in an area of minimum risk and close to the road to allow for ready access by a vehicle if other systems fail or extra communication facilities are needed to be set up. The Emergency control center should consist of following items:

- External telephones
- Internal telephones
- E-Mail facilities
- Emergency plan
- Stationeries
- Torches and emergency lights
- Ropes and Life Jackets

I. Fire Fighting

Person noticing the fire shall immediately raise alarm and ask the nearest person to inform In-charge. Portable Fire Extinguisher shall be used in an attempt to extinguish the fire, by the person at site. In-charge shall assess the severity of fire and if likely to be severe shall take following steps:

- Call fire tenders and mobile trailer pump from nearby fire department.
- Call for assembly of all persons at assembly points
- Arrange for turning "OFF" main switch of electricity supply

II. Emergency Preparedness for Electrical Shock

- Source of power should be put off immediately in case of any electrical shock.
- Injured person should be shifted to safe place.
- Persons engaged in rescuing operation should use all Personal Protective Equipments (PPE) and take appropriate precaution while removing the injured persons.
- Trained persons are engaged to give first-aid treatment to injured persons.
- In case of major injury the injured is shifted to the Dispensary/Hospital.
- In case of electrical fire, only CO2 type Fire Extinguisher is used.
- Accident report in prescribed form is sent to appropriate authority in case of reportable injury.
- All the persons engaged to carry out this operation should be equipped with appropriate PPEs like safety shoes, helmets, dust masks etc.

III. Drowning

- Every worker who is working at site and involves in dredging activity must be wearing the life jackets. Also, person must be trained to work in quick sand conditions. Enough sets of long strong ropes must be kept at the sites to rescue someone who is trapped in the quick sand.

- Minimum one motor boat and one paddle boat should be kept at site during dredging operation in order to help the trapped/drowned persons.

IV. Natural Disasters

✓ **EARTHQUAKE**

- When earthquake hits, all persons shall be encouraged to run out in the open areas designated as Assembly Points.
- All the electrical supply should be disconnected by the electrical department.
- All key personnel shall reach site immediately and carry out designated responsibilities
- Steps detailed in Emergency preparedness are to be carried out.
- As soon as earthquake tremor stops – Incharge shall:
    - Check all areas to ensure that fire is doused.
    - Check all areas for persons trapped inside.
    - Search and Rescue Operation shall be launched with help of Workers, if there is obvious damage to building.

✓ **FLOOD**

- As soon as the water level starts rising up, a siren must be wailed to make the workers aware of the matter.
- All the dredging activity must be stopped immediately. Workers shall be encouraged to evacuate the site.
- All the equipments should be removed and power supply must be cut.

V. Treatment of Affected Persons

- Injured/Affected persons shall be provided suitable first-aid treatment and sent to Doctors/Empanelled hospitals for further treatment depending on injury.
- Patients requiring further treatment shall be sent in Ambulances to Hospitals in Thiruvanathapuram.
- Patients suffering from minor problems shall be discharged and sent home after preliminary treatment.

VI. Post Emergency Activities

- *Medical checkup**:*** Medical checkup of affected persons if any and suitable medical aid shall be provided.
- *Collection of Records:* Exact information shall be collected regarding cause of Emergency and remedial measures suggested preventing recurrence.
- *Inquiry:* Detailed inquiry shall be carried out to find out cause, which will be in the form of fact-finding and recommendations made to suitable authority.
- *Insurance Claims (if any):* Insurance claims for damage due to consequences of emergency shall be filed.

VII. Training

Regular training of all concerned personnel will be conducted to enable the Staff to face any type of Emergency be it Natural Disasters, Fire in Equipment, any drowning at site.

Table 7-1: Control and Action Plan of the Incidents

S. No	Causes	Control	Procedure	Responsible Person (Designation)
1	Heavy floods or rainfall	Opening of dam Gates	Siren Wailing for Workers and Downstream users. Stopping of desiltation activity. Confinement of the desiltation Area by making sign boards.	Site In-charge/Manager
2	Poor Cabling/Earthling To Rotating Equipments	Periodic servicing of electrical instruments. Periodic Inspection/Audit of Electrical equipments – cables and accessories Non Compliance to SOP.	Section VII – Works of Licensees of Indian Electricity Rules 2003	Electrical In charge
3	Head on collision between vehicle and another vehicle (due to poor visibility or incompetent drivers)	Haul road should be sprinkled Regularly. Driving at night shall be avoided. Driver should be RTO licensed holder for driving vehicle.	Sprinkling of water in haul road as per Reg. 124MMR 1961 and appointment of RTO licensed drivers	Site In-charge/Manager
	Poor vehicle maintenance	Periodic servicing of vehicle, Brakes and steering apparatus should be in good condition. Headlight and tail light of the vehicle should be in good condition	Procedure for Maintenance of Vehicles under Reg. 176 of MMR -1961	Site In-charge/Manager
4	Poor machinery Maintenance	Periodic servicing of machineries. Periodic Inspection/Audit of Machineries and Structures Non Compliance to SOP.	Procedure laid under Section 174 Chapter XVI – Machinery and Plant of MMR 1961	Site In-charge/Manager

CHAPTER 8 : ENVIRONMENT MONITORING PROGRAM

Regular monitoring of environmental parameters is of immense importance to assess the status of environment during project operation. With the knowledge of baseline conditions, the monitoring programme will serve as an indicator for any deterioration in environmental conditions due to operation of the project, which will enable to take suitable mitigatory steps in time to safeguard the environment.

Monitoring is important to measure the efficiency of control measures. An environmental impact assessment study is carried over for a specified period of time and the data generated for that specific period cannot bring out all variations induced by the natural or human activities. Therefore, regular monitoring programme of the environmental parameters is essential to take into account the changes in the environmental quality. The objectives of monitoring are to:-

- Verify effectiveness of planning decisions;
- Measure effectiveness of operational procedures;
- Confirm statutory and corporate compliance; and
- Identify unexpected changes.

Monitoring will confirm that emissions are within the prescribed limits. This will take the form of direct measurement and recording of quantitative information, such as quantity and concentrations of discharges, emissions and wastes for measurement against corporate or statutory standards, consent limits or targets. It may also require measurement of ambient environmental quality from the vicinity of a site using ecological/biological, physical and chemical indicators. Monitoring may include socioeconomic interaction, through local liaison activities or even assessment of complaints.

The preventive approach by management may also require monitoring of process inputs, for example, type and method used, resource consumption, equipment and pollution control performance etc. Monitoring will also be required to meet compliance with statutory and corporate requirements. Finally, monitoring results will provide the basis for auditing.

8.1 Monitoring Area

The site is considered as core zone and the area lying within 10Km radius from the mine site is considered as buffer zone.

8.2 Environmental Monitoring Schedule

Post project monitoring will be carried out as per conditions stipulated in Environmental Clearance Letter issued by SEIAA, Kerala, Consent issued by SPCB Kerala as well as according to CPCB guidelines.

Details of the proposed environmental monitoring schedule, which will be undertaken for various environmental components, are detailed below in **Table-8.1**.

Table 8-1: Proposed Environmental Monitoring Programme

S. No.	Activity	Schedule
Air Pollution Monitoring		
1.	Ambient air monitoring of parameters specified by CPCB in their air consents from time to time in the nearby area	Once in every season except monsoon
Water Quality Monitoring		
2.	Monitoring of Ground Water sample as per IS: 10500	Once in every season
3.	Monitoring of Surface Water sample as per IS: 2296	Once in every season
Noise Quality Monitoring		
4.	Noise in the ambient atmosphere near the desiltation area	Once in every season
Greenbelt Maintenance		
5.	Monitoring schedule for Greenbelt development as per approved mining plan	Once in a year
Soil Quality Monitoring		
6.	Soil quality analysis from the samples collected from the site and nearby area	Twice in a year on the basis of 6 months interval as specified by KPCB

8.3 Monitoring of Various Parameters

Slope Failure

The proposed removal of sand and silt from the reservoir will be done by Mechanized - Cutter suction dredging method up-to the depth of 3.0m from the ground level. There will be no slope formation as the excavated pits will get replenished during monsoon. Hence, there will be no slope failure.

Drainage

Local workers will be deployed for the project. Therefore no concrete based sewerage system will be constructed. Domestic sewage generated shall be disposed into the septic tanks followed by soak pits. No domestic waste water will be disposed into the river body or near area. Regular checking will be carried out to find any blockage due to silting or accumulation of loose materials. The drains will also be checked for any damage in lining/stone pitching etc.

Blasting Effects

The proposed project is for dredging of silt and sand which will opt for an open cast manual method. Hence blasting is not required.

Afforestation

Whole of the area is within the reservoir, therefore there is no possibility of any plantation within the area. As it is a government land, KWA in consultation with gram panchayat shall make an arrangement for consenting to raise plantation in the catchment area and raise plantation of local species. Yearly monitoring will be done to ensure the afforestation scheme implementation.

Air Quality Monitoring

Ambient air quality should be monitored both upwind & downwind directions along with adequate meteorological measurement for proper interpretation of data of PM_{10},

SO_2 and NO_X. The number of monitoring stations, air pollutants and frequency of monitoring will be decided as per the CPCB guidelines in 2009. Meteorological stations will be monitored for wind direction and speed, rainfall, temperature & humidity and evaporation.

Water Quality Monitoring

Monitoring of surface run-off and ground infiltration in the study area will be done once in every season except monsoon. Quality of surface water samples will be analyzed for all the parameters as per IS-10500 and IS-2296 respectively.

Also, the area itself has three WTPs and hence a routine regular monitoring of water samples of the reservoir is done.

Noise Quality Monitoring

Noise level monitoring will be done at the work zone to assess the occupational noise exposure levels. Noise levels will also be monitored at the noise generating sources like mineral handling arrangements, vehicle movements and also nearby villages for studying the impact due to higher noise levels for taking necessary control measures at the source.

Occupational Health & Safety

Health check-up for the workers will be conducted at regular intervals till the dredging operation is over. The health camps status will be monitored and the information will be furnished to the approving authority. Project proponent will also coordinate with general public, regulatory authorities, local administration to appraise environmental performance of the mine.

8.4 Reporting Schedule of Monitoring Data

The frequency of reporting of monitored data will be on six monthly basis to the KSPCB and to Regional Office of MoEF&CC, New Delhi. Compliance report will be submitted twice in a year for 6 months interval. The Environmental statement will be prepared for the entire year of operations and will be regularly submitted to regulatory authorities.

8.5 Environmental Monitoring Budget

Table 8-2 Environmental Monitoring Budget

Parameter	Samples	Cost per Sample, INR	Frequency		Total cost for Six Monthly Compliance Report Submission, INR
Air	4	5000	2	per week except monsoon	720000
Water	4	7000	1	per season except Monsoon	56000
Soil	4	4000	1	per half yearly	16000
Noise	4	3000	1	per season except Monsoon	24000
Greenbelt			1	Once in a year	50000
				Total	8, 66, 000
			For Five Years, Total		**43, 30, 000**

CHAPTER 9 : PROJECT BENEFITS

The desiltation of Aruvikkara reservoir will be of multifarious benefits.

1. As the population of Thiruvananthapuram is increasing day by day so as the water demands of the city. The reservoir at Aruvikkara was constructed in 1933 and the silt carried by Karmana River has filled up most of the area of the reservoir. The project is to desilt the reservoir and restore the capacity of Aruvikkara Reservoir so that water damand of the Thiruvanathapuram city and nearby villages can be met in the lean season.
2. The Kerala State is known as one of the beautiful states of India as the state. In order to conserve the nature, the Kerala State has a very strict mining policy to mine the reserves. This is affecting the availability of sand for construction purpose in the capital itself.
3. Once the design capacity is achieved by dredging the silted area, it will provide sufficient depth for aquatic flora and fauna mainly fishes to flourish which is one of the tourist attractions of Aruvikkara reservoir.
4. The proposed project of dredging at Aruvikkara decreases the process of eutrophication in waterspread area as well as reservoir pockets. As eutrophication induces vegetation growth due to more accumulation of nutrients and sediments. Therefore, extraction of these sediments including sand & silt from this area will slow down the growth of plants respectively.
5. The proposed project of extraction of water spread area of Aruvikkara Reservoir helps in cleansing of solid waste that are deposited in the reservoir. Due to cleansing of solid waste from water spread area of reservoir, the quality of water will be improved as well.

CHAPTER 10 : CONCLUSIONS

- The MoWR is drafting a policy framework for Sediment Management in Rivers and Water Bodies.
- In this study it is observed that the quantity of sediments needed to be removed from reservoir is usually very high.
- Eroded areas in the nearby forest must be identified in consultation with forest department and afforestation should be done to stop the silt flow in the reservoir *i.e.* watershed treatment.
- Also, area in the u/s section should be identified for this activity as river also brings sediment with it. This desiltation activity will help in restoring the capacity of reservoir and also helps in providing sand for the commercial purpose.
- Desiltation can improve water quality by reducing the amount of nutrients available from the sediments, thereby reducing nuisance algae blooms. This can occur through direct removal of nutrient-rich sediments, or by deepening the lake enough to allow thermal stratification to develop and thereby limit nutrient movement from deep-water areas to the upper waters.
- Dredging in areas of rooted aquatic plants controls their growth through direct removal, also can limit future re-growth if the new water depths are deeper than sunlight can reach.
- The restoration of the reservoir will flourish growth of fisheries, which is a tourist attraction for the locals.