

ENVIRONMENTAL ASSESSMENT REPORT:
VELLAKAYAM MICRO HYDRO ELECTRIC PROJECT (90 kW)

Submitted by

Y. SLEEBACHEN

Charuvila veedu, Chengamanad P.O.,
Kottarakkara-691557
Kollam District, Kerala State

Prepared by



Agriculture and Ecosystem Management Group (AGES)

Pandit's Colony, Kawdiar P.O.,
Thiruvananthapuram-695 003

January 2026

STUDY TEAM

No.	Name and Address	Qualification and Specialization	Experience relevant to the study
1.	S. Mohan Kumar (Principal Investigator and Facilitator) Executive Director, Agriculture and Ecosystem Management Group (AGES), Pandit's Colony, P.O. Kawdiar, Thiruvananthapuram-695 003 <i>(Formerly Specialist, Kerala State Remote Sensing and Environment Centre, Thiruvananthapuram)</i>	M.Sc. (Geology) <i>Geology; Hydrology; Land Use Planning and Remote Sensing; Environmental Management</i>	40 years of experience in Geological exploration, Land use planning, Remote sensing data management; Natural resource assessment; involved/facilitated EIA studies of 5 hydroelectric projects, 5 construction projects and 2 mining projects
2.	Dr. P.K. Shaji (EIA Study Coordinator) Research Director (Hon.), AGES, Thiruvananthapuram <i>(Formerly Principal Scientist and Deputy Director, Environmental Resources Research Centre (ERRC), P.O. Peroorkada, Thiruvananthapuram-695 005)</i>	M.Sc. (Botany), Ph.D. <i>Ecology and Biodiversity; Eco-physiology; Environmental Management</i>	33 years of post-doctoral research experience in Ecology; Coordinated/ participated in 52 EIA studies, including 16 hydro-electric projects, 2 thermal power projects, 6 port/harbour-related projects, 25 building/ area development projects, 3 highway projects, and one mining project.
3.	Dr. T. Shaju (Expert Participant) Consultant, AGES, Thiruvananthapuram <i>(Formerly Principal Scientist, Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram)</i>	M.Sc. (Botany), Ph.D. <i>Plant Systematics, Ecology and Biodiversity; Conservation Biology</i>	32 years of research experience in Plant systematics, Ecology, and Conservation Biology; Participated in 16 EIA studies, including 12 hydro-electric projects, and one mining project.
4.	Dr. Blessan Santhosh George (Expert Participant) Consultant, AGES, Thiruvananthapuram <i>(Research Coordinator, Doctor John's Biotech Centre for Research and Development, Kottarakkara, Kollam District; and Coordinator, Warblers and Waders, Thiruvananthapuram)</i>	M.Sc. (Biotechnology), Ph.D. <i>Biodiversity, Natural history, Molecular Biology</i>	11 years of experience in Bird identification and general Faunal assessment; Coordinated three state department supported bird surveys in 2025; Coordinated more than twenty nature trails and bird-watching trips.

5.	Dr. A. Rajaneesh (Expert Participant) Consultant, AGES, Thiruvananthapuram <i>(Geospatial Expert, GISTech Solutions, Kalathukal-Kachani Road, Karakulam P.O, Thiruvananthapuram-695 564)</i>	M.Sc. (Applied Geology), M.Phil., Ph.D. <i>Geo-Hazards, GIS and Remote Sensing, Geology, Hydro-geology</i>	12 years research and professional experience in Geospatial analysis of Geo-hazards and Water resources. Authored/co-authored 32 research articles.
	Agriculture and Ecosystem Management Group (AGES) Pandit's Colony, Kawdiar P.O. Thiruvananthapuram-695 003 Tel: +91-471-7965293, 9895397559 Email: hello@agesindia.org, info@agesindia.org		

Prefatory Note

Hydropower development is regarded as one of the cleanest and most economical energy harnessing technologies offering the advantage of instantaneous starting and stopping facilities, which makes it particularly suitable for meeting peak load demand. Kerala, with the special attributes of undulating terrain crisscrossed by a network of rivers and rivulets and high rainfall, possesses substantial potential for hydropower development. However, the dependence of major hydropower schemes on forested landscapes of the Western Ghats harbouring significant biodiversity, and high density of population in the midland and lowland regions, often pose a challenge in their planning and implementation. In this context, the emergence of small and micro hydropower projects, which generally involve manageable environmental concerns, is a positive development. The Vellakayam Micro Hydro Electric Project (90 kW), proposed as a run-of-the-river scheme in Kothamangalam thodu, a tributary of Mullarigadu puzha and a sub-tributary of Kaliyar feeding into the Muvattupuzha River, is one such power generation scheme, being developed by Mr. Y. Sleebachen, an independent power producer (IPP).

Considering that the Vellakayam Micro Hydro Electric Project has an installed capacity of less than 25 MW, environmental clearance as per EIA Notification (2006) is not required. However, since the project implementation involves diversion of 0.133 ha (0.329 acre or 32.88 cents) of forestland categorised under Section 9(3) of the Kerala Government Land Assignment Act (1960), obtaining forest clearance under Forest (Conservation) Act (1980) is mandatory. In this context, the project proponent has engaged the Agriculture and Ecosystem Management Group (AGES) to conduct an environmental assessment study with the primary objective of evaluating the project in an environmental perspective and supporting the forest clearance process.

The present document forms the report of the studies carried out by a multidisciplinary team of experts associated with the AGES. The ground data generated through field investigations, along with the analyses conducted, indicate that the impacts on natural and domesticated systems and their components are manageable with the adoption of the recommended conservation and management measures. Based on the facts and figures outlined in this report, the hydropower project merits favourable consideration by the regulatory authorities for implementation.

We are extremely thankful to Mr. Y. Sleebachen for his confidence in entrusting us with this important task, which serves as research backup to the power development scheme, and for his wholehearted cooperation throughout the process. We are also thankful to Mr. Basil George, Senior Executive, Hydro Tech Engineering Consultants, Adimaly for his active participation at various stages of the study.

S. MOHAN KUMAR
Executive Director, AGES

Thiruvananthapuram
12 January 2026

CONTENTS

	<i>Page Number</i>
Prefatory note	
01. Introduction	1
Clean energy for climate resilience and sustainability	1
Hydropower in climate and development pathways	1
Environmental impacts of hydropower projects and their management	3
Importance of micro-hydropower projects	3
Advantages of small and micro hydropower schemes over large-scale hydro-electric projects	4
Kerala's hydropower potential	5
Small hydropower schemes in private sector	5
The Vellakayam Micro Hydro Electric Project	6
Environmental assessment for forest clearance	6
Study objectives	7
Conduct of the EIA study	7
02. Project features	9
Background	9
Project location	9
Project components	9
Period of construction and cost	10
Land requirement	10
03. Baseline environmental characteristics	11
Study area	11
Climate	11
Air quality and noise	12
Land forms: Geomorphology	12
Slope characteristics	13
Geology	13
Seismicity	14
Drainage pattern	14
Land use	15
Terrestrial vegetation	15
• <i>Floral composition and diversity</i>	17
• <i>Endemic plants</i>	18
• <i>IUCN categorised plant species</i>	19
• <i>Invasive weeds</i>	21
Terrestrial and aquatic fauna	23
• <i>Butterflies</i>	24

• <i>Odonates</i>	27
• <i>Fishes</i>	29
• <i>Amphibians</i>	30
• <i>Reptiles</i>	30
• <i>Birds</i>	31
• <i>Mammals</i>	40
Socio-economic settings	41
04. Assessment of environmental impacts	43
Impacts on air environment	44
Impacts on water environment	44
• <i>Change in drainage pattern</i>	44
• <i>Change in surface water quality</i>	44
• <i>Aquatic habitats and downstream flow</i>	45
Impacts on land environment	45
• <i>Seismicity concerns</i>	45
• <i>Slope stability concerns</i>	46
• <i>Land use changes</i>	46
Impacts on biological environment	46
• <i>Impacts on flora</i>	46
• <i>Impacts on terrestrial and aquatic fauna</i>	48
Impacts on socio-economic and cultural environment	49
Assessment cumulative environmental impacts of hydro-electric power projects in Kaliayar river basin	49
05. Environmental management plan	51
Management measures for the pre-construction and construction phases	51
• <i>Establishment of accommodation facility and rest-shed for workers</i>	51
• <i>Facility for disposal of construction debris and other wastes</i>	51
• <i>Control of air quality deterioration and noise pollution</i>	52
• <i>Management of impacts on fauna</i>	52
Management measures for the post-construction phase	52
• <i>Downstream releases</i>	52
• <i>Calculation of ecological flow</i>	53
• <i>Management of aquatic and riparian habitats</i>	53
• <i>Desilting and downstream flow of sediments</i>	54
Compensatory (tree planting) afforestation	54
Net Present Value of Forests (NPV)	56
Environmental monitoring plan for the construction and post-establishment phases	56
Conclusion	56

Appendices

1. Salient features: Vellakayam Micro Hydro Electric Project	57
2. List of flowering plants recorded from the Vellakayam MHEP project area and surroundings	60

List of tables

1. Percentage distribution of slopes in the project area and surroundings	13
2. Land use characteristics of the project area and surroundings	15
3. Endemic plants recorded from the project area and surroundings	18
4. IUCN categorised plant species in the project area and surroundings	19
5. Invasive weeds in the project area and surroundings	21
6. Details of area covered for faunal survey	24
7. List of butterflies recorded from the project area and surroundings	25
8. List of odonates recorded from the project area and surroundings	28
9. List of reptiles recorded from the project area and surroundings	30
10. List of birds recorded from the project area and surroundings	32
11. Species-wise and girth-wise enumeration of trees in the project site	47
12. List of species to be considered in the compensatory planting	54

List of figures

1. Location of the project area in Muvattupuzha river basin
2. Project layout
3. Study area
4. Digital elevation map (DEM) of the project environment
5. Slope distribution map of the project environment
6. Drainage network of the project environment
7. Land-use/land cover map of the project environment
8. Location and catchment area of the Vellakayam and Pattayakudi hydroelectric projects in the Kaliyar river basin

List of photographic plates

1. Project area and surroundings
2. Rock types and slopes of the study area (project environment)
3. Land form and land cover attributes of the study area (project environment)
4. Important trees in the project area and surroundings
5. Notable shrubs, climbers and herbs in the project area and surroundings
6. Faunal elements in the project area and surroundings

01. INTRODUCTION

Clean energy for climate resilience and sustainability

Clean energy plays a pivotal role in climate change mitigation strategies and sustainable development pathways. The burning of fossil fuels for electricity, transport, and industrial activities remains the primary source of greenhouse gas emission, substantially elevating atmospheric carbon dioxide (CO₂) concentration. This has accelerated global warming and triggered a range of environmental repercussions such as extreme weather events, rising sea levels, habitat degradation, and loss of biodiversity. As energy underpins economic growth and social development, transition to clean and renewable energy sources is essential to mitigate these impacts and build a sustainable low-carbon future. Clean and renewable energy thus offers a practical, and long-term solution for reducing emissions, safeguarding ecosystems, and ensuring equitable access to energy while strengthening environmental and economic resilience in a rapidly changing climate.

Energy derived from renewable sources such as solar, wind, geothermal, and hydropower enables electricity generation without significant emissions of carbon dioxide or other greenhouse gases, including methane, nitrous oxide and fluorinated gases. By replacing fossil fuel-based generation, renewable energy systems reduce carbon emission, prevent air quality deterioration, and decrease reliance on non-renewal resources. They also help enhance energy security by diversifying the energy portfolio and utilizing locally available resources. From a developmental perspective, clean energy contributes directly to sustainable development by fostering economic growth, improving social wellbeing, and supporting environmental stewardship. It enhances access to reliable and affordable electricity in rural and remote areas, stimulates green employment, and drives innovations in energy-efficient technologies. Moreover, clean energy systems are integral for climate resilience and adaptation. Decentralised solutions can maintain power supply even during disruptions caused by extreme weather events, while the integration of smart-grid options enhances system flexibility and sustainability of energy systems.

Hydropower in climate and development pathways

Hydropower provides a significant pathway in addressing the dual challenges of climate change mitigation and sustainable development. As a renewable, clean, and proven source of energy, it harnesses the kinetic energy of flowing or falling water to generate electricity without direct greenhouse gas emission. This positions hydropower as a key contributor to reducing dependence on fossil fuels, and lowering global carbon footprints. The major advantages of hydropower include its extensive domestic resource base, the absence of polluting emissions during operation, its ability in many cases to respond rapidly to utility load demands, and its low operating and maintenance costs. Its capacity for instantaneous start-up and shut-down makes it particularly suitable for meeting peak load demands.

In the context of climate change, hydropower enhances the stability of energy systems by providing reliable, low-carbon electricity generation. Especially reservoir-based systems offer storage and operational flexibility, enabling hydropower to balance the inherent variability of other renewable sources such as solar and wind. This balancing function strengthens the resilience and reliability of national power grids, ensuring a consistent supply of energy supply even during fluctuations in intermittent renewable generation. From a sustainable development perspective, hydropower also delivers multiple socio-economic and environmental benefits. It supports energy security, strengthens rural electrification, and promotes economic development by creating local employment and catalysing regional infrastructure augmentation. Moreover, appropriately planned hydropower projects can contribute to integrated water management by providing flood control, irrigation support and enhanced water supply reliability.

However, sustainable hydropower development requires careful environmental and social considerations to minimise ecological disturbance and ensure equitable benefits sharing. When designed and managed responsibly, it becomes a cornerstone of a low-carbon and climate resilient future, linking clean energy generation with broader goals of sustainable development, and environmental governance.

Environmental impacts of hydropower projects and their management

Hydropower projects, although recognised as a clean and renewable source of energy, can create notable environmental consequences, particularly in the case of large dams and reservoir-based schemes. The magnitude and nature of these impacts vary depending on the location, scale, design parameters, and operational practices of the project. A major environmental concern is the alteration of natural river flow regimes. The construction of dams disrupts river continuity, affecting downstream hydrology, sediment transport, and seasonal flow variations. Reservoir impoundments can result in the submergence of vital forests, agricultural lands and human settlements, leading to the loss of terrestrial habitats and biodiversity. Aquatic ecosystems are similarly affected. Changes in flow velocity, water temperature, and dissolved oxygen levels can interfere with fish migration, spawning, and the overall ecological integrity of river systems. Sedimentation is another critical issue, as reservoirs often trap silt and nutrients, reducing downstream soil fertility and diminishing storage capacity of the reservoir over time. In tropical regions, the decomposition of organic matter in inundated areas contribute to the release of greenhouse gases, such as methane and carbon dioxide. Additionally, large hydroelectric projects may cause social and cultural repercussions through displacement of local communities and disruption of traditional livelihoods.

Effective management and mitigation measures are therefore essential to minimise these adverse impacts. The key strategies include maintaining environmental flows to sustain downstream ecosystems, providing fish passage to support upstream and downstream migration, implementing catchment area treatment and afforestation programmes to control soil erosion, and undertaking biodiversity conservation and habitat restoration

initiatives. Regular monitoring of river water quality, sedimentation levels, and ecological indicators is critical to ensuring long-term environmental health and project sustainability. Equally important are equitable resettlement processes and comprehensive livelihood restoration plans for the affected communities. In short, while hydropower remains an important component of renewable energy development, its environmental and social impacts must be carefully managed through sound planning, scientific assessment, and sustainable management strategies. Integrating ecological considerations into all stages of project design, construction and operation is imperative to ensure that hydropower development contributes positively to both clean energy generation and environmental protection, and sustainable development outcomes.

Importance of micro-hydropower projects

Micro hydropower projects, generally producing up to 100 kilowatts (kW) of electricity, constitute a critical component of decentralised and sustainable energy systems. These installations harness the energy of flowing or falling water in small rivers or streams to generate electricity through simple and efficient technology. Owing to their small scale, they typically require limited civil works and cause minimal alteration to natural river systems, rendering them an environmentally benign form of renewable energy. The significance of micro hydroelectric power lies primarily in its potential to provide reliable and affordable electricity to remote and rural areas where conventional grid supply is unavailable or inconsistent. By providing localised and dependable energy source, these projects support rural electrification, enhance living standards, and stimulate economic development through small scale industries, irrigation, and community services.

From an environmental standpoint, micro-hydropower contributes to the reduction of greenhouse gas emissions by replacing conventional fossil-fuel-based energy generation. The run-of-the-river configuration commonly adopted in such systems ensures minimal impacts on aquatic ecosystems and landscape integrity. In addition, these projects are characterised by low operation and maintenance costs and comparatively long operational lifespan, strengthening their economic feasibility. Overall, micro-hydropower projects play a crucial role in advancing clean energy transition and rural development. They embody a sustainable approach that combines energy self-sufficiency, environmental stewardship, and socio-economic benefits, making them an essential element of renewable energy strategies.

Advantages of small and micro hydropower schemes over large-scale hydro-electric projects

Small and micro hydro-electric projects offer several distinct advantages over large-scale hydropower systems, particularly with respect to environmental sustainability, social acceptability, and localised developmental benefits. These systems, typically generating up to 25 megawatts in the case of small hydropower, and up to 100 kilowatts in the case of micro-hydropower, are designed to harness the energy of flowing water without

extensive damming or reservoir formation. As mentioned earlier, the primary advantage of micro and small hydropower projects is their reduced environmental footprint. These installations generally operate on a run-of-the-river basis, thereby avoiding largescale impoundments and significantly minimising alteration to natural river flows, aquatic habitats, and sediment transport. They cause minimal or negligible land submergence and rarely require community relocation, thus preventing the ecological and social disruptions often associated with large dam projects. These systems also offer cost-effectiveness and operational benefits. Their design, construction, and maintenance are relatively simple, involving lower capital investment and shorter installation timeliness. Operation and maintenance activities can be managed locally, enabling community participation and capacity building.

In contrast, the environmental damages caused by large scale hydropower development can be serious. Large dams and reservoirs often submerging extensive areas of forestlands, wetlands, and croplands, can create an assortment of ecological problems. The wildlife habitats altered or destroyed by such reservoirs could be especially valuable. One of the most significant effects of major hydropower development relates to blockage of fishes from moving up and down the river. This affects upstream migration of fishes like salmon for spawning in pristine river waters and downriver movements of their young ones to the ocean. Reservoir impoundments also alter water quality by trapping sediments, disrupting natural thermal regimes, and reducing dissolved oxygen levels. Stratification of water layers can create inhospitable conditions for aquatic life, especially when deeper, colder layers become oxygen-deficient due to limited surface exposure. Much of this degradation arises from the submergence of vegetation and the accumulation of organic material in reservoir sediments.

Large hydropower projects also present serious social challenges. River valleys are typically populated, and reservoir-induced submergence often leads to large-scale displacement of people. Resettlement involves complex tasks, including demarcation of submergence areas, valuation and compensation of affected properties, and identification of sites for resettlement. These processes demand careful planning, appropriate administrative coordination, and timely execution to avoid prolonged human hardship. Additionally, large dams pose safety risks. In regions such as the Himalayas, where several hydroelectric projects are proposed, the combination of geological instability and frequent earthquakes raises concerns about dam safety. The creation of massive reservoirs can exert additional pressure on tectonic plates, potentially exacerbating seismic activity. Beyond natural hazards, dams may also be vulnerable to military attacks or acts of terrorism, given their strategic significance.

Therefore, while large-scale hydropower plays an important role in national energy supply, small and micro hydroelectric projects stand out for their lower environmental impacts, greater social compatibility, cost-effectiveness, and suitability for decentralised energy

generation. These attributes make them particularly valuable in advancing sustainable and inclusive energy development.

Kerala's hydropower potential

Kerala, endowed with an extensive network of rivers, 41 west-flowing and three east-flowing ones, along with numerous rivulets and streams originating from the Western Ghats and crisscrossing the entire land stretch, has tremendous potential for hydropower development. The State receives an average annual rainfall of approximately 3560 mm from the Southwest and Northeast monsoons. The rainfall so obtained flows through the rivers and numerous rivulets to reach the sea or backwaters in less than 48 hours leaving only a fraction of the hydropower potential tapped/utilized currently. Kerala once enjoyed a comfortable position with regard to the availability of power with the commissioning of major hydroelectric projects such as Sabarigiri and Idukki in 1966 and 1976 respectively. The State even recorded surplus power, enhancing bulk export between 1978 to 1982. However, the rising electricity demands coupled with stagnation in capacity addition led to a critical power situation the mid-1980s, marked by frequent load shedding. The context underscored the need for accelerated development of new hydro, thermal, and non-conventional energy projects, complemented by power procurement from Central sector. The State's generation planning framework therefore emphasised a balance portfolio comprising run-of-the-river schemes, augmentation and extension projects, and small to medium hydropower development, together with harnessing non-conventional sources of solar and wind power generation, supported by thermal power imports to reliably meet Kerala's growing energy demands.

Small hydropower schemes in private sector

Small and micro hydropower schemes are recognised as appropriate and environmentally safe renewable energy options capable of supplying reliable and uninterrupted electricity to rural areas while also serving as captive power sources for industrial establishments. It is well established that small and micro hydropower projects require minimal storage, resulting in little or negligible environmental degradation, and are therefore considered among the most eco-friendly approaches of power generation. The topography, slope characteristics, dense drainage networks, adequate runoff, and rich vegetation cover in the upper catchments are the key factors that support the design and development of small hydropower schemes. In this regard, the State of Kerala holds an advantageous position with its undulating topography, extensive monsoon spread over a period of over six months, and a widespread network of rivers and streams.

In view of these advantageous features and towards encouraging private participation in power development, the Government of Kerala has allotted several small and micro hydropower schemes under the *Independent Power Projects* (IPP) framework. The Energy Management Centre (EMC), Thiruvananthapuram, also serving as the regional centre of UNIDO, has been designated as the nodal agency for this initiative. The Vellakayam Micro

Hydroelectric Project (90 kW) is one such scheme identified by the Energy Management Centre (EMC) and subsequently taken up by Mr. Y. Sleebachen, a private entrepreneur, for implementation in Idukki District.

The Vellakayam Micro Hydro Electric Project

The Vellakayam Micro Hydro Electric Project (90 kW), proposed in Vannappuram Village of Idukki District, is based on the surface flow of Kothamangalam thodu (fourth-order stream, joining Mullaringad puzha a sub-tributary of Kaliyar river) in Muvattupuzha river basin. The Government of Kerala allotted the micro hydel scheme to an independent power producer (IPP), Mr. Y. Sleebachen, vide GO (Ms) No. 17/2019/PD dated 03 October 2019 as per Small Hydro Power Policy (2012). The capital investment for the project will be made by the IPP, and the whole responsibility of the project accomplishment including technical requirements, safety, quality control, and implementation monitoring shall be with the project developer. The power generated from the project will be distributed through the network of KSEBL through a power purchase agreement.

The power generation scheme mainly comprises a 2.0 m high conventional diversion weir constructed across the stream at an average river bed level of + 337.45 m; a forebay-cum-desilting tank (23 m X 8 m X 4 m) located on the right bank; a 2.32 m long interconnecting channel; a water conductor system, consisting of an intake structure with a vertical trash rack, and a surface-type penstock pipeline with a total length of 102.5 m including two bifurcation pipes of 8.5 m. The powerhouse (dimension: 14.06 m X 7.03 m), proposed on the right bank will house two turbines, each rated at 45 kW generation capacity. After power generation, water will be discharged back into the stream through a 2.0 m long tailrace channel. Power evacuation is proposed through the existing distribution line, requiring approximately 10 m of additional line extension.

The total land required for the project is 0.133 ha (0.329 acre), located along the stream including the riparian belts. The land forms part of forestland, and is categorised under Section 9(3) of the Kerala Government Land Assignment Act, 1960. The total cost of the project, based on 2017 estimates is INR 164 lakhs; the levelized cost of energy is estimated at INR 6.64 per kWh, with a payback period of approximately 10 years.

Environmental assessment for forest clearance

While major hydroelectric and irrigation projects provide substantial benefits in terms of industrial development, agricultural productivity and improvements in various socio-economic indicators, they are often associated with significant adverse impacts on environmental quality. When the focus of such projects is directed primarily towards delivering benefits to downstream areas, environmental conditions of the project site and its upstream catchment frequently receive insufficient attention. As evidenced in several cases, this imbalance has contributed to rapid deforestation, deterioration of water and soil quality, loss of native plant species, threat to wildlife, increased vulnerability to natural

hazards such as earthquakes, ecosystem imbalances, broader socio-economic and cultural disruptions, among many other undesirable repercussions.

Given that the Vellakayam Micro Hydro Electric Project has a modest installed capacity of 90 kW, it does not require environmental clearance under the Environmental Impact Assessment (EIA) Notification (2006). However, as the project involves diversion of 0.133 ha (0.329 acre or 32.88 cents) of forestland, forest clearance under Forest (Conservation) Act (1980) is mandatory. In this context, the project proponent engaged the Agriculture and Ecosystem Management Group (AGES), Thiruvananthapuram to undertake an environmental assessment study with the primary objective of evaluating the ecological compatibility of the project, assessing the cumulative impacts in the river basin, and developing appropriate management measures to mitigate any potential adverse impacts.

The present study, carried out by a multidisciplinary team of researchers, mainly focused on assessing the existing environmental conditions of the project area and its vicinity, evaluating potential impacts on natural resources and ecological systems, and preparing an Environment Management Plan (EMP). The study was designed as a research backup to the proposed power project and to meet the requirements of the State Forest Department, Govt. of Kerala. While the multidisciplinary assessment aimed to evaluate the ecological compatibility and long-term sustainability of the power scheme, it further emphasised on cumulative assessment of impacts on the watershed, and formulation of appropriate strategies and measures for the protection of natural resources and habitats.

Study objectives

The major objectives of the environmental assessment study of Vellakayam Micro Hydro Electric Project (90 kW) are as follows:

- To describe the power generation scheme in relation to its geographical location and environmental settings.
- To gather basic environmental information on natural resource content and ecological features of the area.
- To identify the major environmental concerns and natural resource issues that need focused consideration and elaboration.
- To describe the concerns in the project/environment context, in consideration of the baseline environmental features and components/actions of the project.
- To assess the impacts of the project and its actions on various components of the environment.
- To discuss options for mitigating adverse impacts, if any, towards shaping the project environmentally compatible and sustainable.

Conduct of the study

The study was conducted through two field surveys carried out in October 2025 by a multidisciplinary team of experts (geology, hydrology, ecology, floristics, wildlife biology,

and environmental management. The surveys focused on the proposed development sites including the diversion weir, penstock alignment, powerhouse, upstream and downstream stretches of the stream and the surrounding project environment. Analysis of the primary data collected during the field surveys combined with a critical review of authentic secondary information on various environmental aspects, enabled the documentation and description of baseline characteristics of the project and surroundings. By integrating the proposed project components and activities with the existing environmental features, the major environmental concerns were identified (in the project/environment context), and these were further elaborated and analysed for preparation of the present report.

A cumulative assessment of the impacts on the watershed was also carried out with reference to the Kaliyar river basin. In addition, appropriate management measures have been proposed to ensure that the power generation scheme remains environmentally compatible and sustainable.

02. PROJECT DESCRIPTION

Background

The State of Kerala possesses significant potential for the development of mini and micro hydropower projects, primarily owing to its undulating topography, prolonged monsoon extending for over six months, and a well-distributed network of rivers and streams. Recognising these inherent advantages and with the objective of promoting private sector participation in power development, the Government of Kerala has allotted several small and micro hydropower schemes for implementation under Independent Power Producer (IPP) model. The Energy Management Centre (EMC), Thiruvananthapuram, the regional centre of UNIDO, has been designated as the nodal agency to coordinate and facilitate these initiatives. Vellakayam Micro Hydroelectric Project (90 kW) located in Vannappuram Village, Idukki District represents one such scheme identified by the Energy Management Centre and later taken up for implementation by Mr. Y. Sleebachen, a private entrepreneur.

Project location

The Vellakayam Hydro Electric Project, with an installed capacity of 90 kW (2 X 45 kW) is proposed to be established in a perennial fourth-order stream (Kothamangalam thodu) that joins Mullaringadu puzha, one of the tributaries of Kaliyar River and a sub-tributary of Muvattupuzha River. Geographically, the proposed diversion weir site is located at latitude 9° 59' 14.25" N and longitude 76° 50' 32.0" E, at Vellakayam in Vannapuram Village of Thodupuzha Taluk in Idukki District (refer Fig. 01 for project location; also Fig. 02 for project layout). The powerhouse is proposed to be located approximately 130 m downstream of the weir site, with a gross head of about 15 m. The project area falls in the administrative jurisdiction of Thodupuzha Revenue Division, and is accessible by road from Thodupuzha town, located about 33 km away. The nearest railway station is Kaduthuruthy at a distance of about 75 km, while the nearest airport, Cochin International Airport at Nedumbassery, Kochi, is approximately 90 km by road from the proposed development site. The salient features are summarised in Appendix-01 (see also Fig. 02, and Plate-01).

Project components

Diversion weir and forebay tank: A conventional concrete diversion weir of 2.0 m height and 30 m length is proposed at Vellakayam across the third-order perennial stream, at an average riverbed level of + 337.45 m. The weir will have a width of 3.4 m, with an overflow section of 11.2 m length, and non-overflow sections of 2.81 m on the left flank and 13.32 m on the right flank. A forebay-cum-desilting tank measuring 33.7 m X 8.0 m X 4.0 m is proposed on the right bank of the stream, connected to the weir through a concrete lined interconnecting channel 2.32 m long, 1.6m wide and 2 m high. The catchment area proposed to be intercepted for power generation at the weir site is 4.2 km². The full reservoir level (FRL) is designed at + 339.45 m with a submergence length of 39 m.

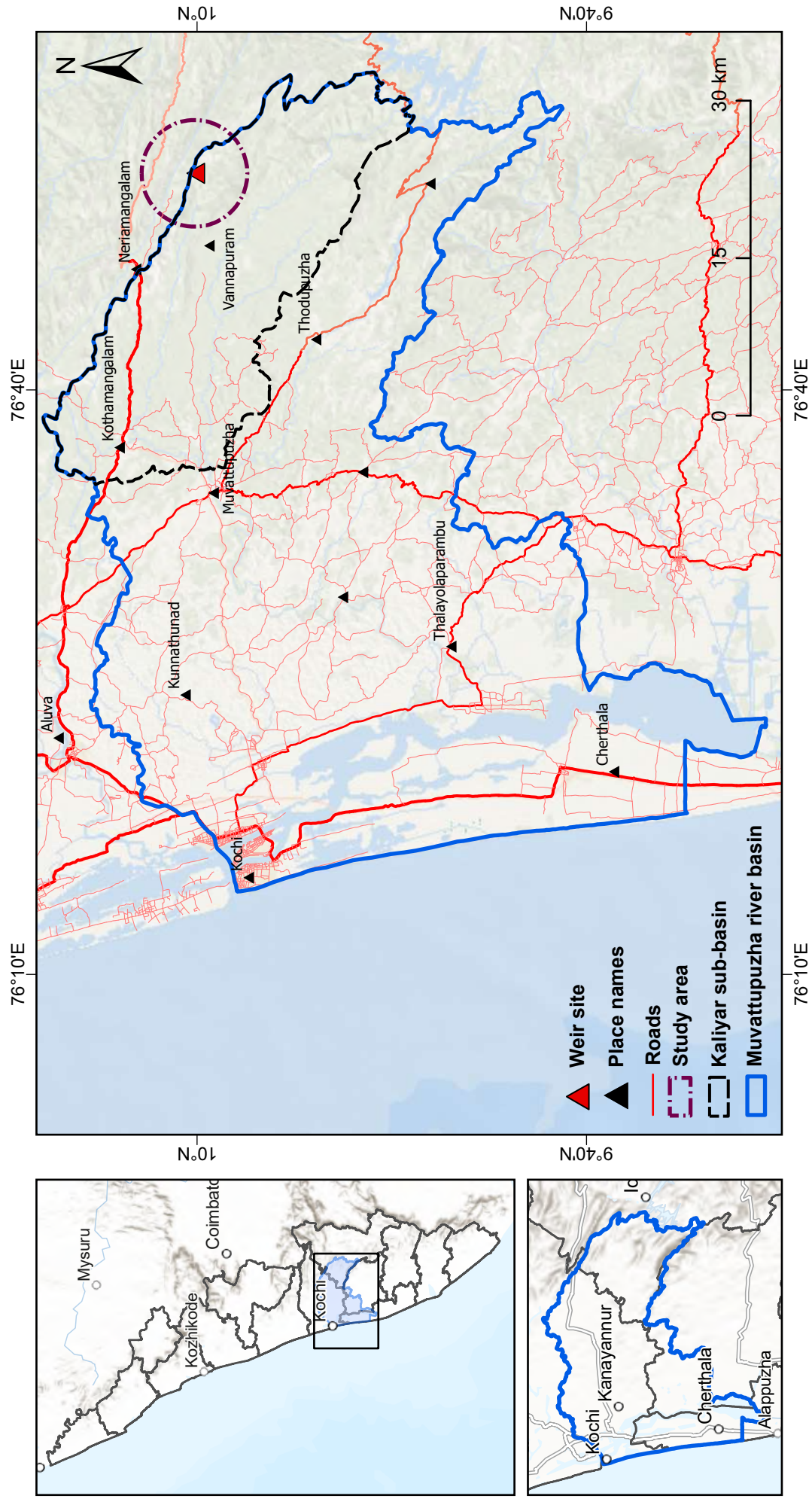


**FIG. 1: VELLAKAYAM MICRO HYDRO ELECTRIC PROJECT
LOCATION OF THE PROJECT AREA IN MUVATTUPUZHA RIVER BASIN**

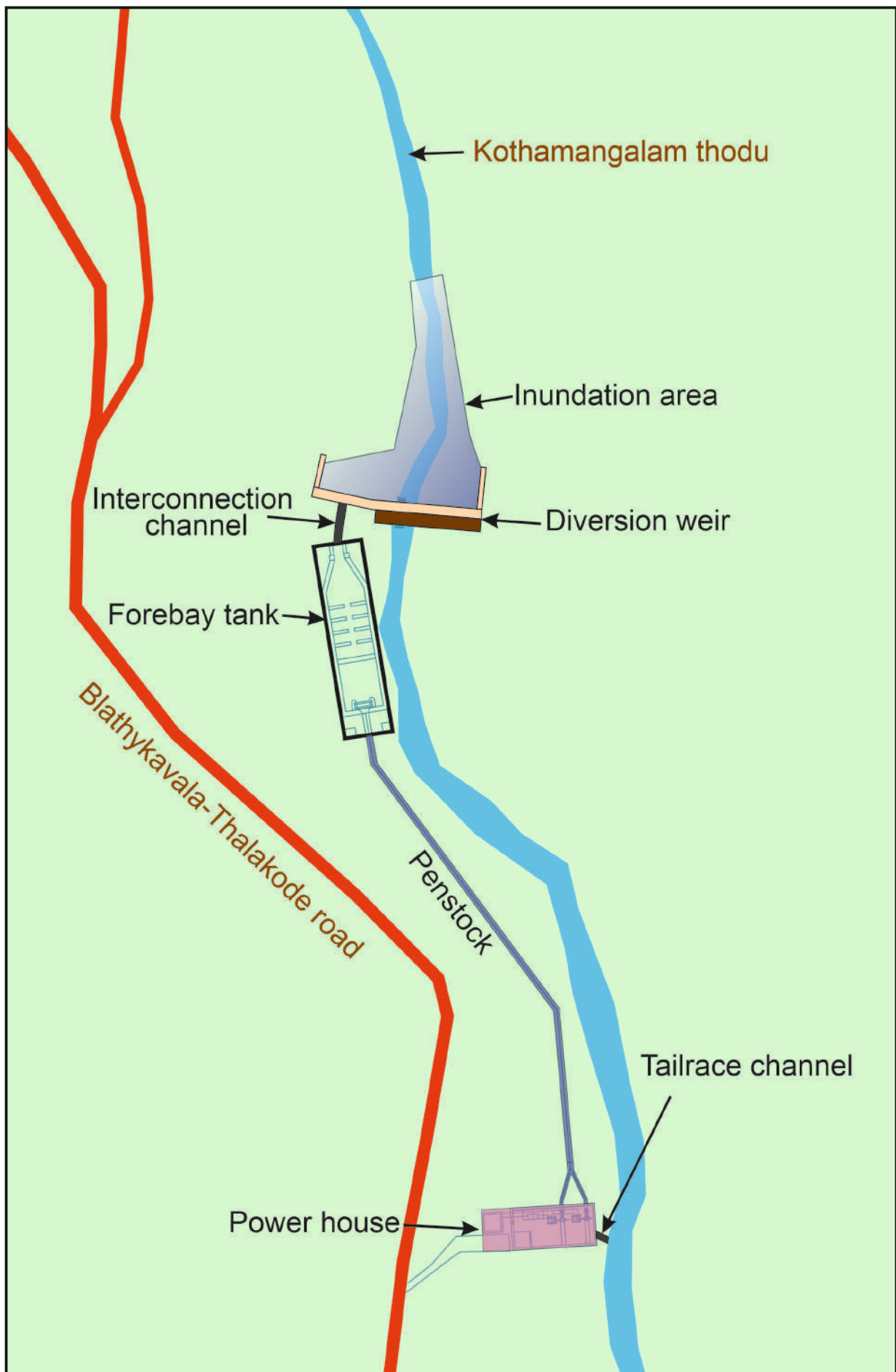


**FIG. 2: VELLAKAYAM MICRO HYDRO ELECTRIC PROJECT
PROJECT LAYOUT**



Plate-01: Project area and surroundings

- A. Weir site; B. Site of forebay tank; C. Powerhouse site; D. Upstream of weir site;
 E. Downstream of tailrace confluence; F. Upstream stretch of Kothamangalam thodu;
 G. Riparian vegetation in the downstream stretch of Kothamangalam thodu;
 H. Mullaringadu puzha; I. Kaliyar river; J. Road leading to the project area

Water conductor system: The water conductor system proposed on the right bank of the stream consists of an intake structure with a vertical trash rack, and a surface-type penstock pipeline with a total length of 102.5 m including two bifurcation pipes of 8.5 m.

Powerhouse: The powerhouse, proposed on the right bank (dimension: 14.06 m X 7.03 m) will house two turbines, each rated at 45 kW generation capacity. After power generation, water will be discharged back into the stream through a 3.0 m long tailrace channel. Power evacuation is proposed through the existing distribution line, requiring approximately 10 m of additional line extension.

Period of construction and cost

The project construction is envisaged to be completed within a period of one year. Total cost of the power project, based on 2017 estimates is INR 164 lakh; the levelized cost of energy is estimated at INR 6.64 per kWh, with a payback period of approximately 10 years.

Land requirement

The total land required for the project is 0.133 ha (0.329 acre), located along the stream, including the riparian belts. The land forms part of forestland, and is categorised under Section 9(3) of the Kerala Government Land Assignment Act, 1960.

03. BASELINE ENVIRONMENTAL CHARACTERISTICS

Analysis of baseline environmental characteristics of the project area and surroundings, based on primary data collected through field investigations and supported by relevant secondary information from authentic sources, is a crucial prerequisite for assessing and predicting the impacts of a development project within a specific geographic context. Both primary and secondary impacts vary significantly depending on the location of the proposed development project. Accordingly, the baseline environmental conditions of the Vellakayam Micro Hydro Electric Project area and its surroundings have been analyzed covering land, water, ecological, biological, and socio-economic components of the project environment. The assessment was based on primary data collection with two field surveys conducted in the month of October 2025, supplemented with secondary data compiled from reliable sources.

Study area

The power development project, based on the surface flow of a third-order stream in the Muvattupuzha river basin, is proposed at geographical location of 09°59'14.25"N latitude and 76°50'32.00"E longitude (Fig. 01). In analysing baseline environmental characteristics, an area encompassing the development zone (including the sites of diversion weir, water conductor system and powerhouse), along with the upstream and downstream reaches, within a radial distance of 5.0 km from the dam-site as the centre, has been considered. The study area, predominantly comprising agri-horticultural fields, human settlements, natural forests and plantations, falls within the limits of 09°56'29.081"N and 10°1.0' 54.93"N latitudes and 76°47'49.29"E and 76°53'18.74"E longitudes, and is covered under Survey of India Topographical Sheet No. 58 C/13 (Fig. 03).

The general characteristics of the study area, including topography, geology, slope, drainage pattern, land use and vegetation cover, were analysed using GIS, supported by random field verification and collation of available secondary data. While detailed field investigations were carried out in the immediate project surroundings (Fig. 02), covering approximately a 1.0 km stretch and 500 m on either side of the stream within which the development site is located, to collect primary information on land features, vegetation composition, biodiversity, endemism and species rarity.

Climate

A tropical humid climate prevails in the project area and surroundings throughout the year. The region lies within a tropical climate setting, with elevations ranging from 41 to 866 m above mean sea level, and the temperature varies from 14°C to 41°C with a mean value of 22°C. The area receives an average annual rainfall of approximately 3677 mm, contributed by the South-west monsoon (June to August) and the North-east monsoon (September to

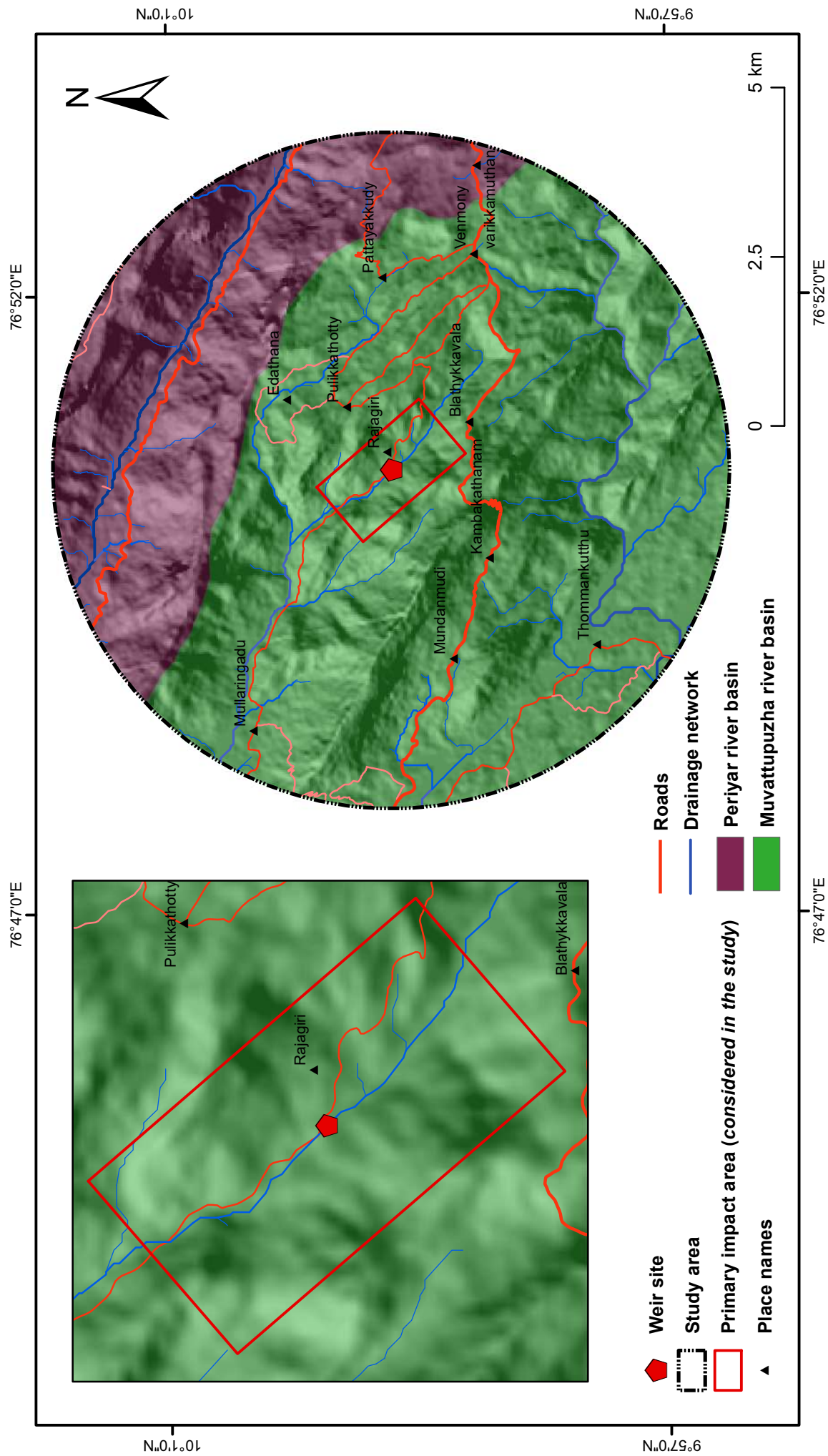
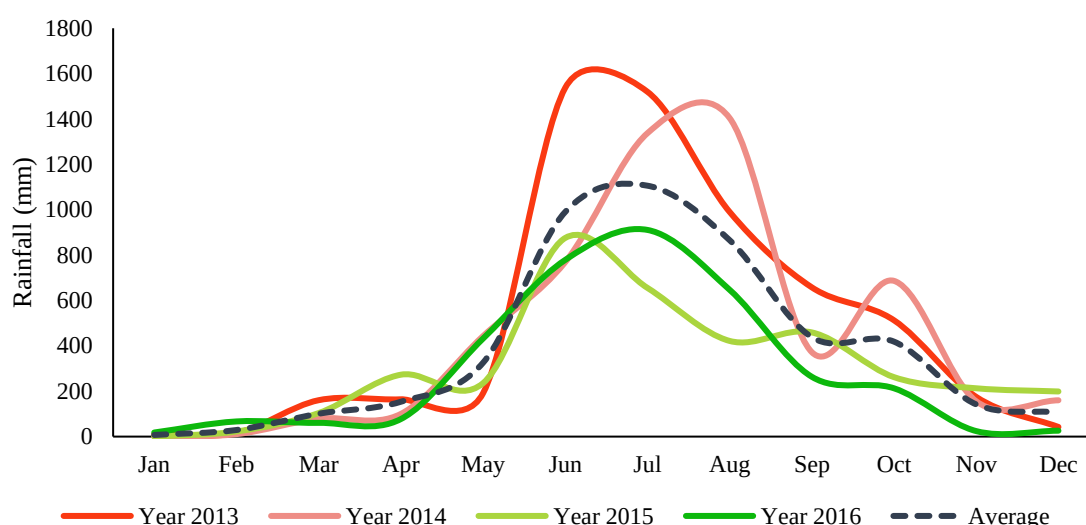


FIG. 3: VELLAKAYAM MICRO HYDRO ELECTRIC PROJECT
STUDY AREA

November). The graphical representation of monthly rainfall trends for the period from 2013 to 2016, shown below, illustrates seasonal variation with peak rainfall during the South-west monsoon.



Air quality and noise

Owing to the comparatively compact land cover, comprising agri-horticultural plantations and forest areas, and the absence of any industrial activity in the vicinity, the ambient air quality of the area is assessed to be in a 'clean' status. Occasional vehicular movement is the only source of noise, apart from routine sounds from the nearby sparsely distributed settlements. Overall, the area maintains a calm and quiet acoustic environment.

Land forms: Geomorphology

Geomorphologically, the area is dominated by moderately dissected structural hills and valleys, with a physiography that is largely structurally controlled. The proposed site of the diversion weir lies within the rugged, rainfall-rich mountainous terrain characterized by steep hill slopes interspersed with numerous ephemeral streams. Most of the hills in the surroundings are structural in origin and are aligned along the regional foliation strike of the rocks. The prominent hills in the vicinity include Kottapara, Meenuliyan para, and Kuthirakuthi hills. Physiographically, the study area and its surroundings fall within the highland hilly region of the Western Ghats (see Fig. 04 for digital elevation model of the study area). The terrain is characterised by steep slopes, pronounced ridges, deep incised valleys, and high drainage density.

The highest point in the study area is at an altitude of 866 m above mean sea level (MSL), located to the northeast of the weir site. The lowest elevation is 41 m above MSL, situated near Kaliyar to the south. The study area comprises four elongated ridges separated by narrow valleys, generally trending in a northwest-southeast (NW-SE). These ridges have elevations ranging from 400 m to 860 m above MSL. The proposed weir site is located between two of these ridges. The catchment area has a maximum elevation of 744 m and

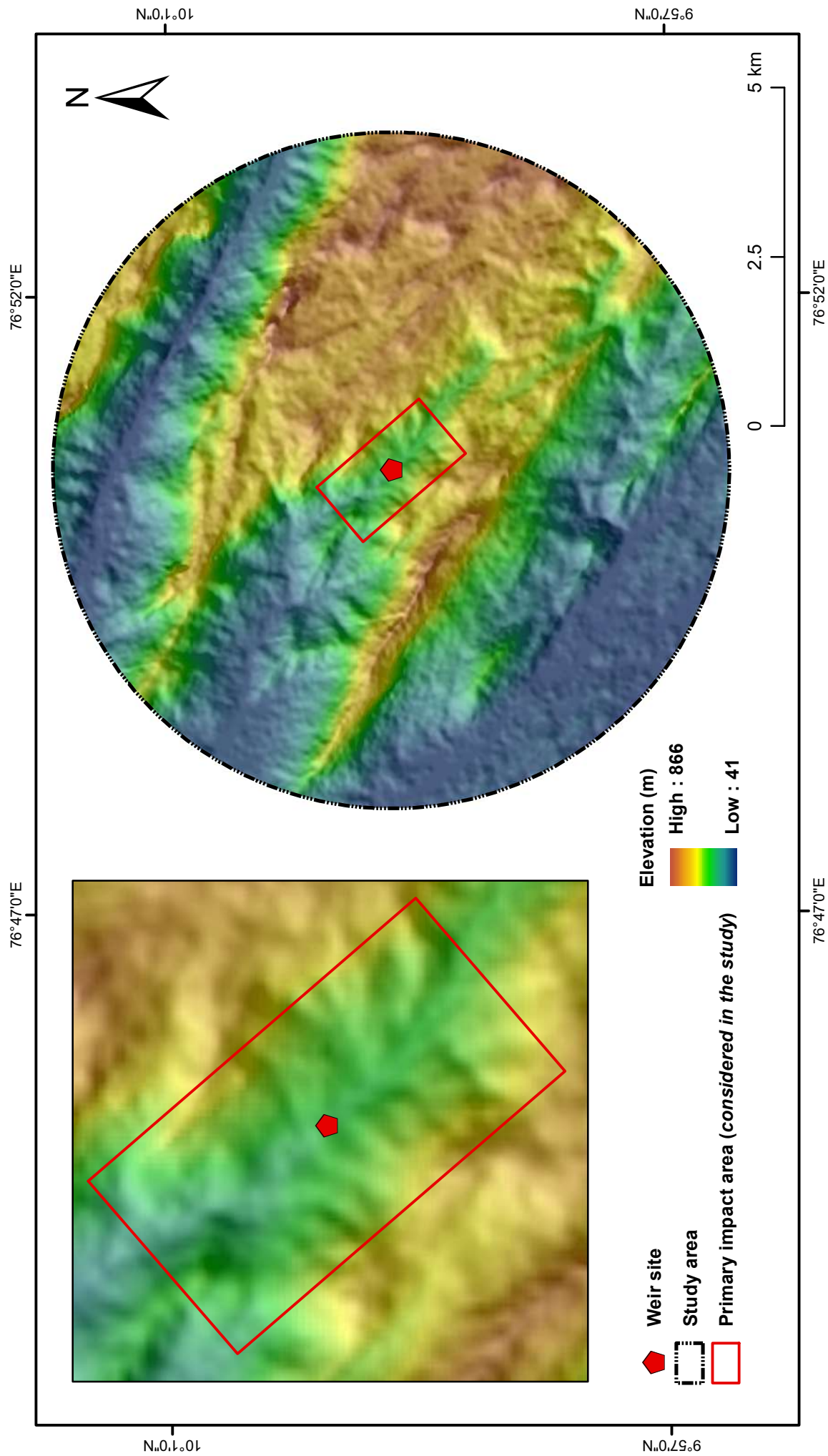


**FIG. 4: VELLAKAYAM MICRO HYDRO ELECTRIC PROJECT
DIGITAL ELEVATION MAP (DEM) OF THE PROJECT ENVIRONMENT**

a minimum 349 m above MSL at the proposed weir location. There is a waterfall in the downstream stretch of Mullaringad thodu. Other notable waterfalls in the study area include Thommankuthu and Anayadikuthu. The rocky outcrop near the weir site mainly consists of weathered and fractured charnockite, exhibiting a spheroidal weathering pattern.

Slope characteristics

The study area lies within the upland region (100-300 m above MSL) and foothill zone (300-600 m above MSL) of Kerala, and is characterised by an undulating to steep terrain. The slope map is presented in Fig. 05. A percentage analysis was carried out to determine the distribution of area across different slope categories. Accordingly, the study area has been classified into seven slope classes, namely, level to nearly level (0-1%), very gently sloping (1-3%), gently sloping (3-5%), moderately sloping (5-10%), moderately steeply sloping (10-15%), steeply sloping (15-30%) and very steeply sloping (>30%). A major portion of the area falls in the steeply sloping category (41.83%) followed by very steeply sloping (17.64%) and moderately steeply sloping occupying 14.41% (Table-01). The other categories are moderately sloping (14.26%), gently sloping (5.32%), very gently sloping (4.22%), and level to nearly level (2.31%). This distribution indicates the predominantly steep and undulating nature of study area. The low-slope areas are concentrated in the southwestern part of the study area, while higher values are observed along both sides of ridges trending in the northwest-southeast (NW-SE) direction. The steeply sloping units mainly occur along the crests of structural and denudational hills.

Table-01: Percentage distribution of slopes in the project area and surroundings

Sl. No.	Slope category *	Area (%)
1.	Level to nearly level (0-1°)	2.31
2.	Very gently sloping (1-3°)	4.22
3.	Gently sloping (3-5°)	5.32
4.	Moderately sloping (5-10°)	14.26
5.	Moderately steeply sloping (10-15°)	14.41
6.	Steeply sloping (15-30°)	41.83
7.	Very steeply sloping (>30°)	17.64

*Slope value in bracket

Geology

The proposed project area falls within the rugged, rainfall-rich terrain of Idukki district. Located along the midstream reach of Kothamangalam thodu, the site's terrain and geological characteristics are representative of such features in the district. Geological formations exposed in the area include charnockites and a suite of gneissic rocks comprising biotite gneiss, granite gneiss, and hornblende gneiss. Banded iron formation and pyroxene granulite occur as enclaves within biotite gneiss. In the close proximity to the proposed weir site, exposures of weathered charnockite are observed (Plate-02: A),

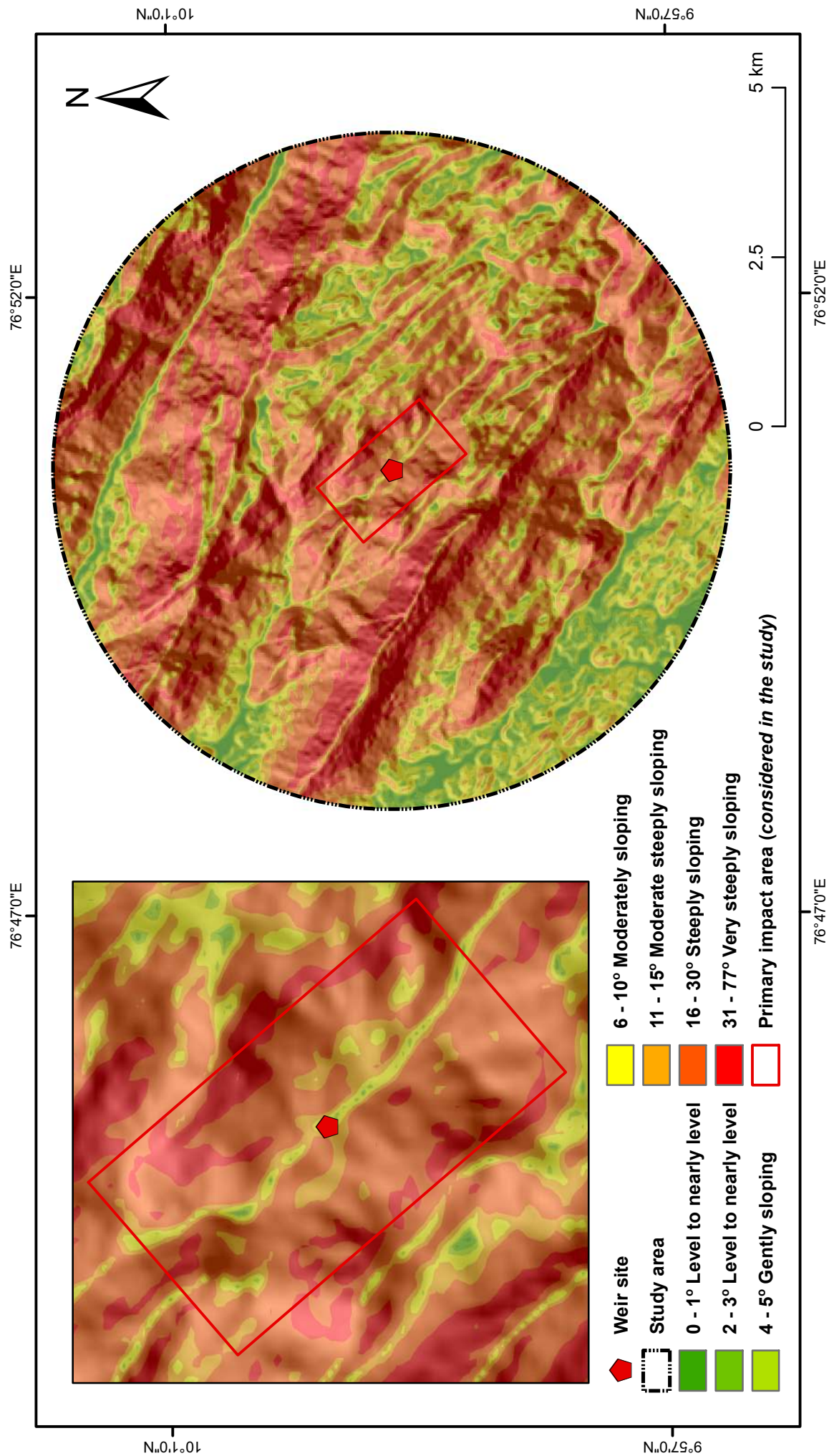
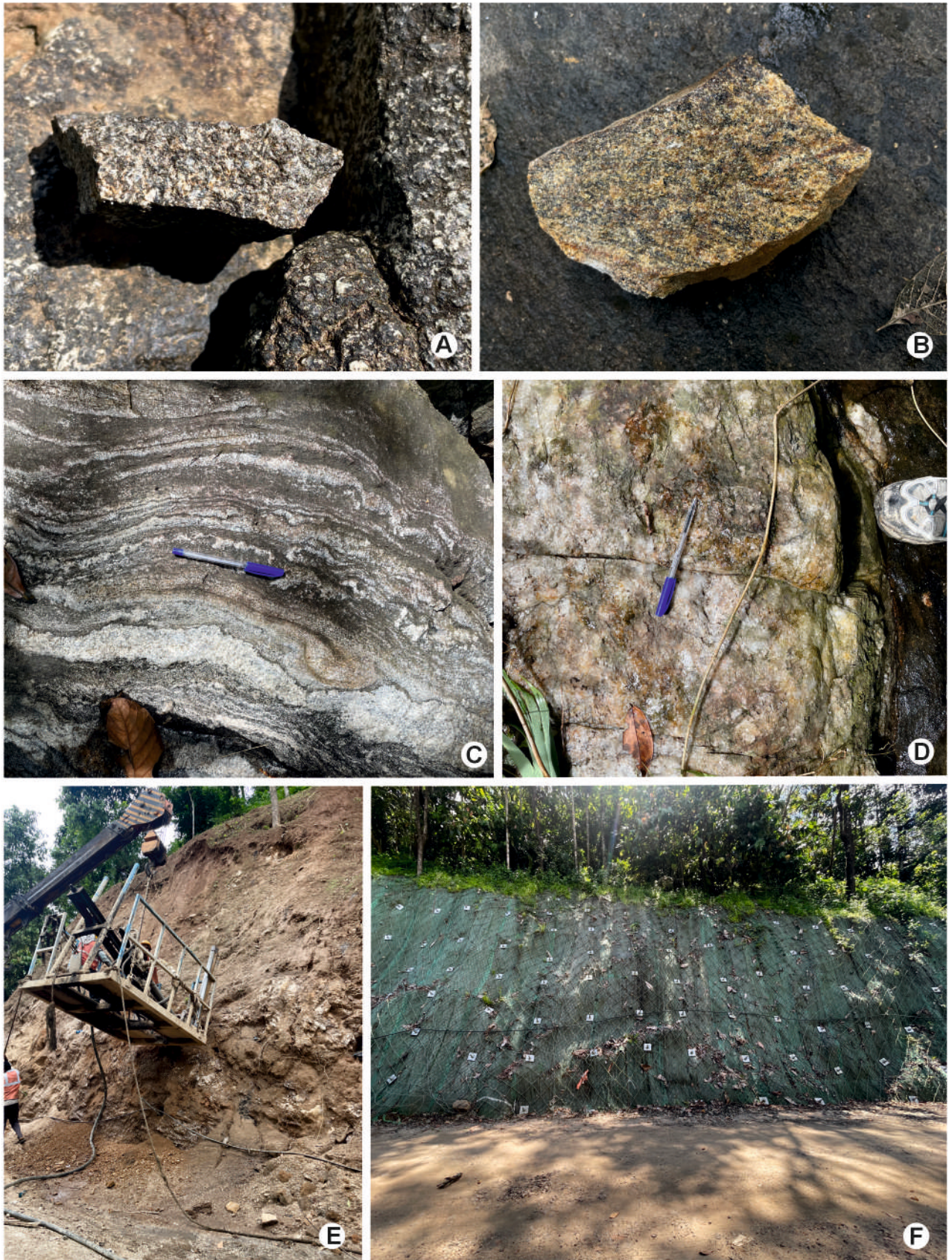


**FIG. 5: VELLAKAYAM MICRO HYDRO ELECTRIC PROJECT
SLOPE DISTRIBUTION MAP OF THE PROJECT ENVIRONMENT**



with the varying degree of weathering across the study area (Plate-02: B). Folded gneisses, indicative of shearing activity during metamorphism are also present (Plate-02: C). In addition, quartz veins and massive quartzite bodies exhibiting fractures have also been identified within the study area (Plate-02: D).

Seismicity

The study area lies within Zone-III as per the Seismic Zoning Map of India prepared by Geological Survey of India, and is therefore considered moderately stable. In the recent past, several low-magnitude earthquakes have been reported in the region, particularly in Idukki and Kottayam districts. The epicentres of these tremors were located within a radius of 10 to 15 km from Kulamavu near Idukki reservoir. Furthermore, the Central Kerala region is regarded as more susceptible to earthquakes of light to moderate intensity.

Landslide prone areas

The Idukki District is prone to landslide due to its unique terrain and slope characteristics, and is marked by highly undulating steep slopes. The soil present on these slopes becomes unstable when saturated with water during monsoons. In certain locations within the study area (covered in 5.0 km radius around the project site), substantial soil thickness is observed, which increases the likelihood of slope failure in such areas; however, such conditions are not observed in the immediate vicinity of the proposed development site (Plate-02: E). At the weir site, only a thin soil cover and few unstable boulders are present, requiring due consideration during project construction. Overall, the study area exhibits varying degrees of land susceptibility corresponding to differences in soil thickness and slope conditions. The local self-government authorities have implemented mitigation measures, such as wire mesh protection and retaining walls, at locations with high soil thickness and instability (Plate-02: F).

Drainage pattern

The proposed weir site is located on a third-order stream, Kothamangalam thodu, which joins the Mullaringad puzha about 1.9 km downstream. Mullaringad puzha subsequently joins Kaliyar River and then flows into the Muvattupuzha River, near Muvattupuzha town. Thereafter, it continues as a single channel up to Vettukattumukku where it branches into two distributaries, namely Murijapuzha and Ithupuzha, along with several rivulets leading to the formation of a fluvial marsh before draining into the Vembanadu Lake. The total stream length in the study area is 465 km, while the catchment area of the Vellakayam project has a stream length of 23.11 km, consisting of 13.22 km of first-order streams, 6.67 km of second-order streams, 1.00 km of third-order streams, and 2.22 km of fourth-order streams. The drainage pattern in the study area is complex displaying a combination of trellis and dendritic patterns, indicating a highly undulating, structurally controlled hilly terrain. Drainage pattern of the study area, including the catchment of Kothamangalam thodu intersecting at the weir site is depicted in Fig. 06.

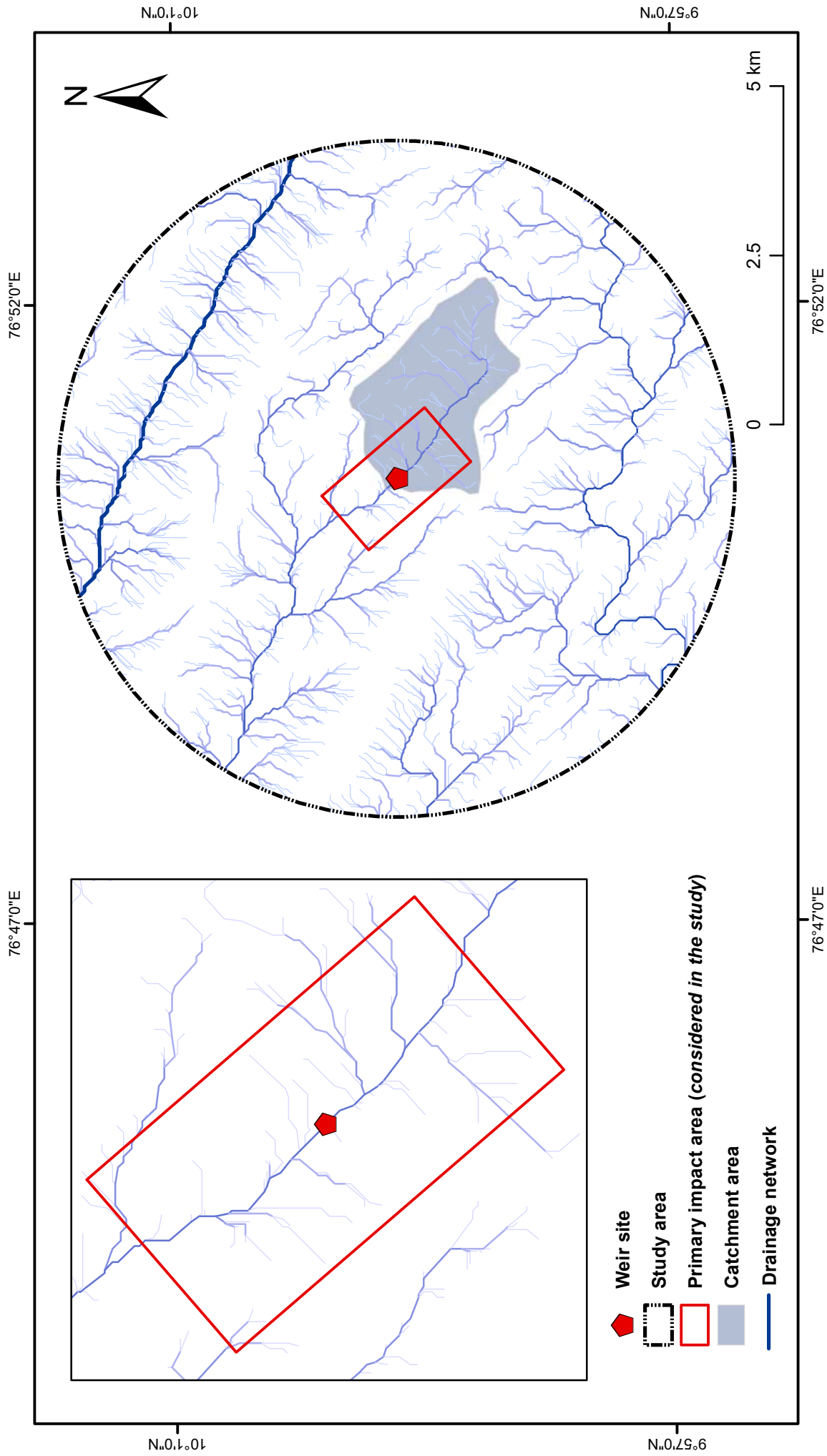


**FIG. 6: VELLAKAYAM MICRO HYDRO ELECTRIC PROJECT
DRAINAGE NETWORK OF THE PROJECT ENVIRONMENT**

Land use

Land use characteristics of the project area and surroundings (study area in 5 km radius), covering an extent of 78.54 km² were analysed using high-resolution remote sensing data (Google Earth) integrated on a GIS platform. The base map of the study area was prepared by digitizing the relevant topographic sheets (Nos. 58 C/13 and 58 B/16). Field surveys were carried out to ground truth and validate the interpretations derived from GIS-based analysis. The assessment was undertaken to classify and quantify various land use/land cover categories from an environmental/ecological impact perspective. The results of the analysis are presented in Table-02.

Table-02: Land use characteristics of the project area and surroundings.

Sl. No.	Particulars	Area		
		(in km ²)	(in ha)	(in %)
1.	Agriculture with sparse settlements	26.34	2633.95	33.54
2.	Agriculture with moderate settlements	23.05	2304.90	29.35
3.	Forests and forest plantations	13.54	1354.39	17.25
4.	Barren (mostly rocky) area	14.21	1421.32	18.10
5.	Township (built-up) area	0.39	38.76	0.49
6.	Waterbodies	1.00	100.23	1.28

The predominant land use category in the study area is agri-horticulture with settlements accounting for about 66% of the total area. The settlement density varies spatially with 33.54% area with sparse, and 29.35% with moderate settlements, indicating different levels of human interventions in the ecosystem. Forests and barren (rocky) land together constitute approximately 35% of the area, and are largely devoid of anthropogenic activity. Majority of the forest area is concentrated in the southern part of the study area, while the barren rocky outcrops are mainly observed in the northern side. In addition, small patches of barren land are scattered throughout the study area. The built-up (township) area accounts for less than 1% of the total area (Fig. 07).

Terrestrial vegetation

Terrestrial vegetation of the study area comprises agri-horticultural plantations, forests, and forest plantations. Major crops of cultivated areas include cocoa, rubber, pineapple, and mixed crops associated with homesteads. The cultivated areas and their peripheral zones are notably infested with alien weeds and several exotic garden escape species. Natural forests of the area are classified as West Coast Tropical Evergreen, West Coast Tropical Semi-evergreen, and Southern Tropical Moist Deciduous forests. Forest plantations are mainly of Teak. The top canopy of the low-level evergreen forests is formed by large trees such as *Artocarpus hirsutus* (Anjili), *Calophyllum polyanthum* (Punnappa), *Mesua ferrea* (Nanku), *Tetrameles nudiflora* (Cheeni), *Canarium strictum* (Kunthirikam), *Bischofia javanica* (Mlachathayan), *Hopea parviflora* (Thampakam), *Vateria indica* (Vellappayin), *Dysoxylum malabaricum* (Vellakil), *Bombax ceiba* (Elavu), *Dipterocarpus*

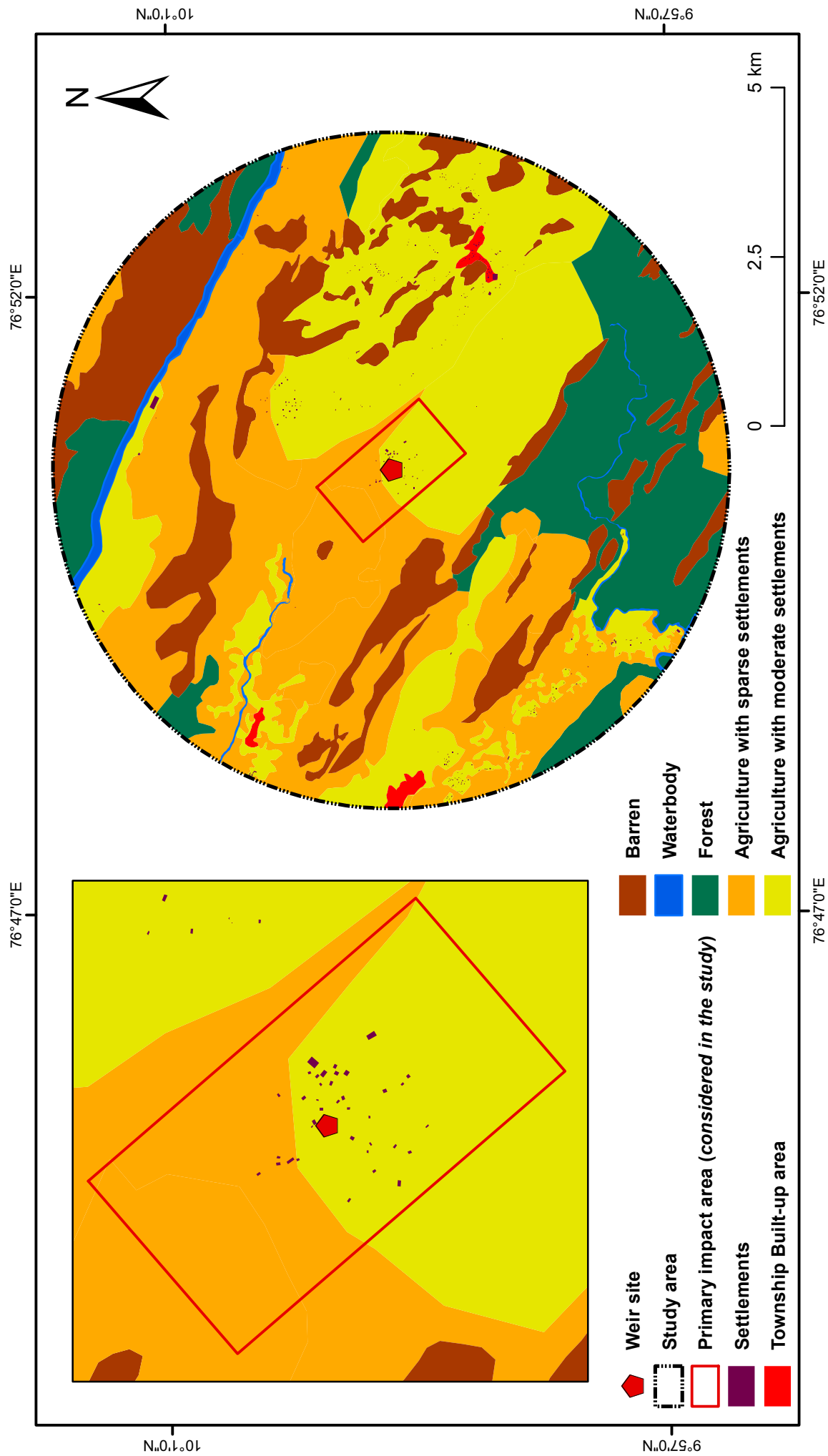


**FIG. 7: VELLAKAYAM MICRO HYDRO ELECTRIC PROJECT
LAND-USE/LAND COVER MAP OF THE PROJECT ENVIRONMENT**



Plate-03: Land form and land cover attributes of the study area (project environment)

A. Mountainous terrain; **B.** Forest; **C.** Cocoa plantation; **D.** Rubber plantation; **E.** Cardamom plantation; **F.** Pineapple cultivation; **G.** Riparian forest; **H.** Rocky areas and forest patches

indicus (Kalpayin), *Lophopetalum wightianum* (Venkotta), and *Mangifera indica* (Mango). The middle storey is mainly of *Persea macrantha* (Ooravu), *Cinnamomum malabattrum* (Vayana), *Dimocarpus longan* (Chempooavam), *Hydnocarpus pentandrus* (Marotti), and *Toona ciliata* (Madhagiri-vembu), among others. The shrub layer includes *Strobilanthes ciliata* (Karinkurinji), *Calamus* spp. (Chooral), and *Glycosmis pentaphylla* (Panal). Some of these forest areas were previously under cardamom cultivation.

The semi-evergreen forests are considered as an intermediary stage between tropical evergreen and moist deciduous forests. This type of forests develops mainly due to biotic interferences and local climatic conditions. The top storey is largely deciduous in nature, whereas the middle and lower storeys are predominantly evergreen. The top storey of trees consists of *Tetrameles nudiflora* (Cheeni), *Artocarpus hirsutus* (Anjili), *Dalbergia latifolia* (Eetti), *Bombax ceiba* (Elavu), *Vateria indica* (Vellappayin), and *Hopea parviflora* (Thampakam), among others. The lower storeys are composed of *Toona ciliata* (Madhagiri-vembu), *Cinnamomum malabattrum* (Vayana), *Spondias pinnata* (Ambazham), *Monoon fragrans* (Nedunar), *Adina cordifolia* (Manjakkadambu), *Tetrapilus dioicus* (Edana), and *Hydnocarpus pentandrus* (Marotti). The shrub layer includes *Helicteres isora* (Idampiri-valampiri), *Strobilanthes ciliata* (Karinkurinji), *Calamus thwaitesii* (Chooral), and *Glycosmis pentaphylla* (Panal). *Acacia caesia* (Incha) and *Dioscorea* spp. are the notable climbers. Natural regeneration is nearly absent due to Cardamom cultivation, grazing and recurring fire incidents.

Moist deciduous forests comprise an intimate mixture of deciduous and evergreen species, with deciduous trees being dominant. The occurrence of bamboos and reeds is very common, and the undergrowth is generally affected by recurring forest fires. The top canopy is composed of *Alstonia scholaris* (Ezilampala), *Bombax ceiba* (Elavu), *Terminalia bellerica* (Thanni), *T. elliptica* (Karimaruthu), *T. paniculata* (Maruthu), and *Stereospermum colais* (Poopathiri). The middle and lower storeys include *Persea macrantha* (Ooravu), *Adina cordifolia* (Manjakkadambu), *Toona ciliata* (Madhagiri-vembu), *Dillenia pentagyna* (Pattippunna), *Lagerstroemia speciosa* (Manimaruthu), *Bridelia retusa* (Mulluvenga), *Xylia xylocarpa* (Irul), *Vitex altissima* (Mayila), and *Cinnamomum malabattrum* (Vayana). Notable shrub species include *Glycosmis pentaphylla* (Panal), *Helicteres isora* (Idampiri-valampiri), and *Catunaregam spinosa* (Malankara). Important climbers are *Calycopteris floribunda* (Pullanji), *Bauhinia phoenicea* (Vallimandaram), *Spatholobus parviflorus* (Athambu-valli), *Acacia caesia* (Incha), and *Calamus thwaitesii* (Chooral). Regeneration is very poor.

The rocky areas support thickets of grasses at several places chiefly comprising species such as *Ischaemum indicum*, *Arundinella ciliata*, *Chrysopogon hackleii*, *Dimeria lawsonii*, *Themeda cymbaria*, *T. triandra* and *Tripogon bromoides*, followed by dense growth of *Strobilanthes ciliatus* at places. Within the soil-filled depressions, species such as *Sapium insigne* (Kalmaram), *Phyllanthus emblica* (Nelli) and *Catunaregam spinosa* are found.

The weir site, its inundation area, and the upstream and downstream stretches of the Kothamangalam thodu support patches of riparian vegetation, which presently remain

discontinuous and degraded due to agri-horticultural activities, particularly dominated by cocoa plantations. The notable tree species within the riparian belts include *Humboltia vahliana* (Karappongu), *Elaeocarpus tuberculatus* (Bhadraksham), *Madhuca neriifolia* (Attilippa), *Vateria indica* (Vellappayin), *Calophyllum apetalum* (Cherupunna), *Persea macrantha* (Ooravu), *Ochreanauclea missionis* (Attuvanchi), and *Hydnocarpus pentandrus* (Marotti). The shrubs and climbers are represented by *Strobilanthes ciliata* (Karinkurinji), *Bauhinia phoenicea* (Vallimandaram), *Glycosmis pentaphylla* (Panal), *Homonoia riparia* (Puzhavanchi), and thickets *Ochlandra travancorica* (Eetta) along with seedlings of *Humboltia vahliana*, *Vateria indica* and other trees. Infestation by *Mikania micrantha* and several other invasive weeds is noteworthy.

Floral composition and diversity

The floristic composition of the project area and its surroundings (covering an approximate 1.0 km stretch of the stream and extending 500 m on either side within which the development site is located) was closely analysed through the two field explorations conducted during October 2025. The plants were identified and enumerated in the form of a checklist (see Appendix-02). Authentic documents on floral composition and diversity of the region (Gamble, 1915-36; Sreekumar and Nair, 1991), checklists (Nayar *et al*, 2006, 2014; Sasidharan, 2004), and related scientific publications were used for authentication of the present enumeration. The flora comprises of native forest plants with a considerable proportion of deciduous elements and evergreen riparian species, cultivated plants of agri-horticultural fields, plantations and homesteads; and alien weeds occurring in the domesticated and associated wilderness areas. Dominant trees found in the project environment are presented in Plate-04; while notable shrubs, climbers, and herbs in Plate-05. The following forms a brief account of the floral analysis performed during the study.

The flora is characteristically dominated by angiosperms (flowering plants). A total of 155 species of flowering plants (angiosperms) were recorded from the area (Appendix-02). Notable pteridophytes, including ferns and fern allies, comprise *Lycopodium wightianum*, *Selaginella brachystachia*, *Selaginella ciliata*, *Adiantum caudatum*, *Adiantum lunulatum*, *Asplenium formosum*, *Cheilanthes opposita*, *Dryopteris concolor*, *Dryneria quercifolia*, *Marsilea minuta*, *Microsorium punctatum*, *Nephrolepis auriculata*, *Nephrolepis delicatula*, *Pteridium revolutum*, *Pteris confusa*, and *Pyrosia heterophylla*. Gymnosperms occasionally found in the area include *Cycas circinalis* and *Gnetum ula*, which occur the in the wild, while *C. revoluta* is cultivated in the homesteads as an ornamental plant.

The main cultivated crops in the area include rubber, cocoa, cardamom, pineapple, pepper, coconut and areca nut, along with limited cultivation of pulses, vegetables, and tuber crops. In addition, a variety of spices, aromatic plants, fruit plants, medicinal species and ornamental plants are grown in homesteads and agricultural fields. Also, *Alpinia galanga* (Kolichi), commonly known as Thai ginger or Greater galangal, is cultivated commercially. Some of the exotic ornamental plants commonly grown in the home



Plate-04: Important trees in the project area and surroundings

A. *Humboltia vahliana*; **B.** *Tetrameles nudiflora*; **C.** *Elaeocarpus tuberculatus*;
D. *Madhuca neriifolia*; **E.** *Moonoon fragrans*; **F.** *Vateria indica*; **G.** *Hydnocarpus pentandrus*;
H. *Persea macrantha*; **I.** *Mangifera indica*; **J.** *Holigarna grahamii*



Plate-05: Notable shrubs, climbers and herbs in the project area and surroundings

A. *Bauhinia phenicea*; **B.** *Ochlandra travancorica*; **C.** *Strobilanthes ciliatus*;
D. *Helicteres isora*; **E.** *Alpinia galanga* (often cultivated); **F.** *Calamus thwaitesii*;
G. *Curcuma xanthorrhiza*; **H.** *Entada rheedii*; **I.** *Globba ophioglossum*; **J.** *Thottea siliquosa*; **K.** *Barleria longiflora*

gardens have presently become garden escapes spreading into degraded or neglected areas and croplands.

Endemic plants

Some plant species have a restricted distribution, often confined to a particular habitat or geographical region. Such taxa are termed *endemics* and the phenomenon is known as *endemism*. Endemic species are of great interest to phyto-geographers, as certain taxa may be evolutionarily ancient (palaeo-eoendemics), while others are relatively new in origin (neo-endemics), together providing evidence of historical movements of land-masses and evolutionary processes. Endemics impart uniqueness to phytogeographical regions and their component flora. The Western Ghats within the Peninsular India is one of the three biodiversity hotspots in India, owing to its rich floristic composition and high concentration of endemic taxa. In Kerala, Nayar (1997) reported 1,272 endemics out of a total of 3,800 species of flowering plants, constituting 33.47% endemism. Of the 155 flowering plants recorded from the project area and surroundings, 16 species are endemics. The details of these endemic species, along with their distribution, are presented in Table-03.

Table-03: Endemic plants recorded from the project area and surroundings

Sl. No	Botanical name	Family	Common/local name	Distribution
1.	<i>Artocarpus hirsutus</i> Lam	Moraceae	Anjili	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala
2.	<i>Bauhinia phenicea</i> Wight & Arn.	Fabaceae	Valli-mandaram	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala
3.	<i>Barleria longiflora</i> L.f.	Acanthaceae		Peninsular India: Odisha, Gujarat, Maharashtra, Telangana, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala
4.	<i>Calophyllum apetalum</i> Willd.	Clusiaceae	Cheru-punna, Attupunna	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala
5.	<i>Cinnamomum malabathrum</i> (Burm. f.) Blume	Lauraceae	Vayana	Western Ghats: Karnataka, Tamil Nadu, Kerala
6.	<i>Garcinia gummi-gutta</i> (L.) Robs. var. <i>gummi-gutta</i>	Clusiaceae	Kudampuli	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala
7.	<i>Holigarna arnottiana</i> Hook.f.	Anacardiaceae	Charu	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala
8.	<i>Humboldtia vahliana</i> Wight	Fabaceae		Western Ghats: Tamil Nadu, Kerala

9.	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken	Flacourtiaceae	Marotti	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala
10.	<i>Litsea coriacea</i> (Heyne ex Meisn.) Hook.f.	Lauraceae	Maravetti-thali	Western Ghats: Karnataka, Goa, Tamil Nadu, Kerala
11.	<i>Monoon fragrans</i> (Dalz.) B. Xue & R.M.K. Saunders	Annonaceae	Nedunar	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala
12.	<i>Ochlandra travancorica</i> (Bedd.) Benth. ex Gamble	Poaceae	Eetta	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala
13.	<i>Ochrenauclea missionis</i> (Wallich ex G. Don) Ridsd.	Rubiaceae	Attuvanchi	Western Ghats: Karnataka, Tamil Nadu, Kerala
14.	<i>Strobilanthes ciliata</i> Nees	Acanthaceae	Karinkurinji	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala
15.	<i>Terminalia paniculata</i> Roth	Combretaceae	Maruthu	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala
16.	<i>Vateria indica</i> L.	Dipterocarpaceae		Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala)

IUCN categorised plant species

As per IUCN (International Union for Conservation of Nature and Natural Resources) classification, rare species are the ones that are uncommon, but not necessarily at risk of extinction. Out of the 155 species of flowering plants recorded during the survey, 33 species fall under different categories of rarity. Of these, three species, *Canarium strictum* (Karutha-kunthirikkam, Black dammar), *Humboldtia vahliana* (Karappongu), and *Tectona grandis* (Thekku, Teak) are categorised Endangered (EN); six species, *Arenga wightii* (Kattu-thengu), *Calophyllum apetalum* (Cherupunna), *Dalbergia latifolia* (Eetti), *Hydnocarpus pentandrus* (Marotti), *Strobilanthes ciliata* (Karinkurinji), and *Vateria indica* (Vellappayin) are classified as Vulnerable (VU), and two species, *Ensete superbum* (Kalluvazha), and *Litsea coriacea* (Maravettithali) are Near Threatened (NT). The remaining species belong to the Least concern (LC) category (Table-04).

Table-04: IUCN categorised plant species in the project area and surroundings

Sl. No	Botanical name	Family	Common/local name	Distribution
1.	<i>Alstonia scholaris</i> (L.) R. Br.	Apocynaceae	Ezhilampala	Least Concern (LC)
2.	<i>Arenga wightii</i> Griff.	Arecaceae	Kattuthengu	Vulnerable (VU)
3.	<i>Artocarpus hirsutus</i> Lam.	Moraceae	Anjili	Least Concern (LC)

4.	<i>Bauhinia phoenicea</i> Wight & Arn.	Fabaceae	Vallimandaram	Vulnerable (VU)
5.	<i>Bridelia stipularis</i> (L.) Blume	Euphorbiaceae	Cheruka-panachi	Least Concern (LC)
6.	<i>Calophyllum apetalum</i> Willd.	Clusiaceae	Cherupunna, Attupunna	Vulnerable (VU)
7.	<i>Canarium strictum</i> Roxb.	Burseraceae	Kunthirikkam, Black dammar	Endangered (EN)
8.	<i>Cinnamomum malabattrum</i> (Burm. f.) Blume	Lauraceae	Vayana	Least Concern (LC)
9.	<i>Dalbergia latifolia</i> Roxb.	Fabaceae: Papilionaceae	Eetti, Rosewood	Vulnerable (VU)
10.	<i>Ensete superbum</i> (Roxb.) Cheesman.	Musaceae	Kalluvazha	Near Threatened (NT)
11.	<i>Erythrina stricta</i> Roxb.	Fabaceae: Papilionaceae	Murukku	Least Concern (LC)
12.	<i>Garcinia gummi-gutta</i> (L.) Robs., var. <i>gummi-gutta</i>	Clusiaceae	Kodampuli	Least Concern (LC)
13.	<i>Glycosmis pentaphylla</i> (Retz.) DC.	Rutaceae	Panal, Panchi	Least Concern (LC)
14.	<i>Helicteres isora</i> L.	Sterculiaceae	Idampiri-valampiri	Least Concern (LC)
15.	<i>Holigarna arnottiana</i> Hook.f.	Anacardiaceae	Charu	Least Concern (LC)
16.	<i>Holigarna grahamii</i> (Wight) Kurz	Anacardiaceae	Anacharu	Least Concern (LC)
17.	<i>Homonoia riparia</i> Lour.	Euphorbiaceae	Puzhavanchi	Least Concern (LC)
18.	<i>Humboldtia vahliana</i> Wight	Fabaceae	Karappongu	Endangered (EN)
19.	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken	Flacourtiaceae	Marotti	Vulnerable (VU)
20.	<i>Lagenandra ovata</i> (L.) Thw.	Araceae	Karimpola, Andavazha	Least Concern (LC)
21.	<i>Lagerstroemia speciosa</i> (L.) Pers.	Lythraceae	Poomaruthu, Manimaruthu	Least Concern (LC)
22.	<i>Litsea coriacea</i> (Heyne ex Meisn.) Hook.f.	Lauraceae	Maravettithali	Near Threatened (NT)
23.	<i>Lophopetalum wightianum</i> Arn.	Celastraceae	Venkotta	Least Concern (LC)
24.	<i>Madhuca neriifolia</i> (Moon) H.J. Lam	Sapotaceae	Attilippa	Least Concern (LC)
25.	<i>Spatholobus parviflorus</i> (Roxb. ex DC.) Kuntze	Fabaceae: papilionaceae	Athambuvalli	Least Concern (LC)
26.	<i>Stereospermum colais</i>	Bignoniaceae	Pathiri, Pooppathiri	Least Concern (LC)

	(Buch.-Ham. ex Dillw.) Mabb.			
27.	<i>Strobilanthes ciliata</i> Nees	Acanthaceae	Karinkurinji	Vulnerable (VU)
28.	<i>Tectona grandis</i> L.f.	Verbenaceae	Thekku, teak	Endangered (EN)
29.	<i>Terminalia bellerica</i> (Gaertn.) Roxb.	Combretaceae	Thanni	Least Concern (LC)
30.	<i>Terminalia paniculata</i> Roth	Combretaceae	Maruthu	Least Concern (LC)
31.	<i>Tetrameles nudiflora</i> R. Br.	Dasticeae	Cheeni	Least Concern (LC)
32.	<i>Vateria indica</i> L.	Dipterocarpaceae	Vellappayin	Vulnerable (VU)
33.	<i>Vitex altissima</i> L.f.	Verbenaceae	Attumayila	Least Concern (LC)

Invasive weeds

The project area and surroundings support a considerable number of invasive weeds, including both exotic species and few native weeds. Of the 155 species recorded, 47 are invasive weeds occurring in the crop lands, plantations, homesteads and degraded forest areas. Table-05 presents the list of weeds recorded from the area. Many of these are exotic species that were introduced in the past as ornamentals and have since become invasive as garden escapes.

Table-05: Invasive weeds in the project area and surroundings

Sl. No.	Botanical name	Family	Common/local name	Nativity
1.	<i>Acmella radicans</i> (Jacq.) R.K. Jansen.	Asteraceae	Venappacha	Exotic: Native of Tropical America
2.	<i>Aerva lanata</i> (L.) Juss.	Amaranthaceae	Cherula	Native; Tropics and Sub-tropics
3.	<i>Ageratum conyzoides</i> L.	Asteraceae	Muriyan-pacha, Appa	Exotic: Native of Mexico
4.	<i>Ageratum houstonianum</i> Mill.	Asteraceae	Appa, Nai- thulasi	Exotic: Native of Tropical America
5.	<i>Alloteropsis cimicina</i> (L.) Stapf.	Poaceae	Summer grass	Native; Old World Tropics
6.	<i>Alternanthera bettzickiana</i> (Regel) G. Nicholson	Amaranthaceae	Calico plant	Exotic: Native to Tropical America
7.	<i>Alternanthera philoxeroides</i> (Mart.) Grisb.	Amaranthaceae	Alligator weed	Exotic: Native to South America
8.	<i>Alternanthera sessilis</i> (L.) R. Br. ex. DC.	Amaranthaceae	Kozhuppa- cheera	Native; Tropics and Sub-tropics
9.	<i>Axonopus compressus</i> (Sw.) P. Beauv	Poaceae	Kalappullu, Buffalo-grass	Exotic: Native to America

10.	<i>Bidens pilosa</i> L.	Asteraceae	Black-jack	Exotic: Native to America
11.	<i>Blumea laevis</i> (Lour.) Merr.	Asteraceae	Kukkrachedi	Native
12.	<i>Calopogonium mucunoides</i> Desv.	Fabaceae: Papilionaceae	Thottappayar	Exotic: Native to Tropical America
13.	<i>Centrosema molle</i> Benth.	Fabaceae: Papilionaceae	Kattu-payar	Exotic: Native to Tropical America
14.	<i>Chromolaena odorata</i> (L.) King & Robins.	Asteraceae	Communist-pacha	Exotic: Native of tropical and sub-tropical America
15.	<i>Chrysopogon aciculatus</i> (Retz.) Trin.	Poaceae	Snehappullu	Native
16.	<i>Conyza canadensis</i> (L.) Cronq.	Asteraceae	Horse weed	Exotic: Native to North America
17.	<i>Costus pictus</i> D. Don ex Lindl.	Costaceae	Insulin-chedi	Exotic: Native of Mexico
18.	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Asteraceae		Exotic: Tropical Africa and Madagascar
19.	<i>Croton caudatus</i> Geisel	Euphorbiaceae	Umithinikkodi	Native
20.	<i>Croton hirtus</i> L.	Euphorbiaceae		Exotic: Native to South America
21.	<i>Cyperus cephalotes</i> Vahl	Cyperaceae		Native
22.	<i>Cyperus digitatus</i> Roxb.	Cyperaceae	Finger flat-sedge	Native
23.	<i>Cyperus tenuiculmis</i> Boeck.	Cyperaceae		Native
24.	<i>Desmodium scorpiurus</i> (Sw.) Desv.	Fabaceae: Papilionaceae	Beggar's lice	Exotic: Native to Tropical America
25.	<i>Digitaria ciliaris</i> (Retz.) Koeler	Poaceae	Tropical crab-grass	Native
26.	<i>Digitaria radicata</i> (Pers.) Miq.	Poaceae	Trailing crab-grass	Native
27.	<i>Eleutheranthera ruderalis</i> (Sw.) Sch.-Bip.	Asteraceae	Ogiera	Exotic: Native of Tropical America
28.	<i>Eragrostis unioides</i> (Retz.) Nees ex Steud.	Poaceae	Chinese lovegrass	Native
29.	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Kuzhinakhappala	Native
30.	<i>Evolvulus nummularius</i> (L.) L.	Convolvulaceae		Exotic: Native to Brazil
31.	<i>Hyptis capitata</i> Jacq.	Lamiaceae	Knob weed	Exotic: Native of Tropical America

32.	<i>Lantana camara</i> L.	Lamiaceae	Aripoochedi	Exotic: Native of Tropical America
33.	<i>Melinis repens</i> (Willd.) Zizka	Poaceae	Natal grass	Exotic: Native to Africa, Arabian Peninsula
34.	<i>Mesosphaerum suaveolens</i> (L.) Kuntze.	Lamiaceae	Pandi-poochedi	Exotic: Native to America
35.	<i>Miconia crenata</i> (Vahl) Michelang.	Melastomataceae	Soap bush, Clidemia	Exotic: Native to South America
36.	<i>Mikania micrantha</i> Kunth.	Asteraceae	Drritharashtra-pacha	Exotic: Native to South America
37.	<i>Mitracarpus hirtus</i> (L.) DC.	Rubiaceae	Tharavu	Exotic: Native to Tropical America
38.	<i>Oplismenus compositus</i> (L.) P. Beauv	Poaceae	Running mountain grass	Native
39.	<i>Pennisetum polystachyon</i> (L.) Schult.	Poaceae	Mission grass	Exotic: Native of Sub-Saharan Africa; Old world tropics
40.	<i>Pueraria phaseoloides</i> (Roxb.) Benth.	Fabaceae: Papilionaceae	Thottappayar	Native
41.	<i>Pycnus polystachyos</i> (Rottb.) P. Beauv.	Cyperaceae	Bunchy sedge	Native
42.	<i>Setaria barbata</i> (Lam.) Kunth	Poaceae	East Indian bristlegrass	Native
43.	<i>Setaria palmifolia</i> (J. Koenig) Stapf	Poaceae	Eenthappana-pullu, Palm grass	Native
44.	<i>Sida acuta</i> Burm. f.,	Malvaceae	Anakkurunthotti	Native
45.	<i>Stachytarpheta jamaicensis</i> (L.) Vahl.	Lamiaceae	Chiravappalli	Exotic: Native to Tropical America
46.	<i>Stachytarpheta urticifolia</i> (Salisb.) Sims	Lamiaceae	Blue snakeweed	Exotic: native to Caribbean and Northern Brazil
47.	<i>Urochloa ramosa</i> (L.) T.Q. Nguyen	Poaceae	Browntop millet	Native

Terrestrial and aquatic fauna

In assessing the faunal composition and diversity in and around the project area, a 5-km radial zone with the proposed weir site at Vellakkayam as the centre was considered. This zone covers the entire project influence area, including the sites of weir, forebay tank, water conductor system, and powerhouse, as well as the upstream and downstream stretches of the river (stream) system. The broader study area encompasses natural and degraded forests, plantations, agri-horticultural fields, and settlements. However, the immediate surroundings of the proposed dam site across the Kothamangalam thodu at Vellakkayam mainly consists of plantations dominated by rubber and cocoa, mixed-crop

farms, and a narrow strip of riparian vegetation along the stream. The faunal enumeration presented here includes species documented during the present survey, as well as those previously reported from the region, including data from the Forest Department and other authentic sources. Both transect and random survey methods were employed for the enumeration of faunal elements, including butterflies, dragonflies, damselflies, fishes, reptiles, amphibians, birds, and mammals. A total of seven survey routes, comprising both road stretches and transects, were used for the faunal assessment within 5-km radial zone of the proposed dam site (see Table-06 for details of the faunal survey routes).

Table-06: Details of area covered for faunal survey

Sl. No.	Route	Habitat description
1.	Dam site - Vellallu/ Ambazhathinalpady foot bridge (upstream of Kothamangalam thodu, from the dam site)	Riparian vegetation and agri-horticultural fields (mainly rubber, cocoa and mixed plantations)
2.	Dam site - Mullaringad (downstream of Kothamangalam thodu from weir site)	Riparian vegetation and agri-horticultural fields (rubber cocoa, pineapple and mixed plantations) interspersed by homesteads
3.	Vellakkayam - Venmany	Agri-horticultural fields (cocoa, rubber, and mixed plantations) interspersed by homesteads.
4.	Vannapuram-Balthykavala	Agri-horticultural fields (cocoa, rubber, and mixed plantations), interspersed by homesteads, forests and forest plantations.
5.	Venmattom-Kuzhimattom	Agri-horticultural fields (cocoa, rubber, and mixed plantations), interspersed by homesteads and forest plantations.
6.	Neendapara - Thattekani	Forests, forest plantations, rocky areas, agri-horticultural fields and homesteads.
7.	Edathanalkkuthu (falls)-downstream of Mullaringadu thodu	Riparian vegetation and agri-horticultural fields (rubber) and homesteads

Butterflies

A total of 79 species of butterflies representing five families were recorded during the assessment (Table-07). The species were characteristic of both forested and open habitats. The family Nymphalidae showed the highest representation, followed by Lycaenidae, Papilionidae, Pieridae and Hesperidae. Most species were either common or not common in occurrence, with relatively few rare sightings. The assessment recorded five endemic species associated with the Western Ghats, and five species listed under Schedule II of the Wildlife (Protection) Act of 1972, occurring alongside widely distributed and habitat-generalist species (Plate-06).

In the vicinity of dam site, both upstream and downstream stretches support several commonly encountered butterflies. Species such as Emigrant Grass Yellow, Common Crow,



Plate-06: Faunal elements in the project area and surroundings

- A.** Black-tipped Forest Glory (*Vestalis apicalis*); **B.** Common Lineblue (*Prosotas nora*); **C.** Crimson Marsh Glider (*Trithemis aurora*); **D.** Golden tree snake (*Chrysopelea ornata*); **E.** Little cormorant (*Microcarbo niger*); **F.** Red-vented bulbul (*Pycnonotus cafer*); **G.** Stream Ruby (*Heliocypha bisignata*); **H.** Vernal hanging parrot (*Loriculus vernalis*); **I.** Brown-backed red marsh hawk (*Orthetrum chrysis*); **J.** Malabar Torrent Dart (*Euphaea fraseri*); **K.** Orange minivet (*Pericrocotus flammeus*); **L.** Yellow-tailed ashy skimmer (*Potamarcha congener*)

various Sailers, Common Lineblue, Banded Blue Pierrot, Clipper, Great Orange-tip, Chocolate Pansy, Blue Bottle, Blue Mormon, Grey Count, Common Rose and Malabar Rose were observed along stream banks, forest edges and open stretches, where they utilise flowering shrubs/climbers, moist soil patches and sheltered microhabitats. The vegetation supporting these butterflies largely comprises common plants that are widely distributed in the surrounding landscape. These host and nectar plants are not confined to immediate project footprint, and are therefore unlikely to be directly affected by the proposed development. Overall, the distribution of abundance classes, ranging from very common to rare, suggests that the area presently offers a variety of microhabitats and resource conditions capable of supporting a diverse butterfly assemblage.

Table-07: List of butterflies recorded from the project area and surroundings

Sl. No.	Common Name	Scientific Name	Abundance	Remarks [#]
Swallowtails, Family: Papilionidae				
1.	Southern Birdwing	<i>Troides minos</i>	NC	En-WG & SI, LC, Sch-II
2.	Southern Blue Bottle	<i>Graphium teredon</i>	C	En-SI, NE
3.	Common Jay	<i>Graphium doson</i>	NC	
4.	Tailed Jay	<i>Graphium agamemnon</i>	NC	En-WGS, LC
5.	Malabar Rose	<i>Pachliopta pandiyana</i>	C	En-WG, LC
6.	Common Rose	<i>Pachliopta aristolochiae</i>	NC	LC
7.	Crimson Rose	<i>Pachliopta hector</i>	NC	LC, Sch-II
8.	Common Mormon	<i>Papilio polytes</i>	NC	
9.	Blue Mormon	<i>Papilio polymnestor</i>	C	
10.	Lime Butterfly	<i>Papilio demoleus</i>	NC	
11.	Malabar Raven	<i>Papilio dravidarum</i>	R	En-WG
12.	Red Helen	<i>Papilio helenus</i>	NC	
Whites and Yellows, Family: Pieridae				
13.	Common Emigrant	<i>Catopsilia pomona</i>	C	
14.	Mottled Emigrant	<i>Catopsilia pyranthe</i>	R	
15.	Common Grass Yellow	<i>Eurema hecabe</i>	C	
16.	Three-spot Grass Yellow	<i>Eurema blanda</i>	C	
17.	Common Jezebel	<i>Delias eucharis</i>	NC	
8.	Psyche	<i>Leptosia nina</i>	C	
19.	Pioneer	<i>Belenois aurota</i>	R	LC
20.	Common Albatross	<i>Appias albina</i>	NC	
21.	Chocolate Albatross	<i>Appias lyncida</i>	NC	
22.	Common Wanderer	<i>Pareronia hippia</i>	NC	

23.	Great Orange-tip	<i>Hebomoia glaucippe</i>	NC	
Blues and Coppers, Family: Lycaenidae				
24.	Common Pierrot	<i>Castalius rosimon</i>	C	
25.	Angled Pierrot	<i>Caleta decidia</i>	NC	
26.	Banded Blue Pierrot	<i>Discolampa ethion</i>	C	
27.	Red Pierrot	<i>Talicauda nyseus</i>	NC	
28.	Tiny Grass Blue	<i>Zizula hylax</i>	NC	
29.	Oriental Grass Jewel	<i>Freyeria putli</i>	C	
30.	Quaker	<i>Neopithecops zalmora</i>	C	
31.	Common Hedge Blue	<i>Acytolepis puspa</i>	NC	
32.	Plains Cupid	<i>Chilades pandava</i>	C	
33.	Gram Blue	<i>Euchrysops cnejus</i>	C	
34.	Pea Blue	<i>Lampides boeticus</i>	NC	Sch-II
35.	Dark Cerulean	<i>Jamides bochus</i>	C	
36.	Common Cerulean	<i>Jamides celeno</i>	VC	
37.	Metallic Cerulean	<i>Jamides alecto</i>	NC	
38.	Common Lineblue	<i>Prosotas nora</i>	NC	
39.	Yamfly	<i>Loxura atymnus</i>	NC	
40.	Common Silverline	<i>Cigaritis vulcanus</i>	NC	
41.	Common Imperial	<i>Cheritra freja</i>	NC	
Brush-footed Butterflies Family: Nymphalidae				
42.	Common Evening Brown	<i>Melanitis leda</i>	C	
43.	Dark Evening Brown	<i>Melanitis phedima</i>	NC	
44.	Common Bushbrown	<i>Mycalesis perseus</i>	C	
45.	Common Palmfly	<i>Elymnias hypermnestra</i>	NC	
46.	Common Treebrown	<i>Lethe rohria</i>	NC	
47.	Glad-eye Bushbrown	<i>Mycalesis patnia</i>	NC	
48.	Glassy Tiger	<i>Parantica aglea</i>	NC	
49.	Blue Tiger	<i>Tirumala limniace</i>	C	
50.	Dark Blue Tiger	<i>Tirumala septentrionis</i>	NC	
51.	Double-branded Crow	<i>Euploea sylvester coreta</i>	NC	
52.	Common Crow	<i>Euploea core</i>	C	
53.	Common Fivering	<i>Ypthima baldus</i>	C	
54.	Common Fourring	<i>Ypthima hubneri</i>	C	
55.	Tawny Coster	<i>Acraea violae</i>	C	

56.	Cruiser	<i>Vindula erota</i>	NC	
57.	Rustic	<i>Cupha erymanthis</i>	C	
58.	Commander	<i>Moduza procris</i>	NC	
59.	Tamil Yeoman	<i>Cirrochroa thais</i>	C	
60.	Common Lascar	<i>Pantoporia hordonia</i>	C	
61.	Common Sailer	<i>Neptis hylas</i>	C	
62.	Chestnut-streaked Sailer	<i>Neptis jumbah</i>	R	
63.	Grey Count	<i>Cynitia lepidea</i>	NC	Sch-II
64.	Common Baron	<i>Euthalia aconthea</i>	NC	
65.	Lemon Pansy	<i>Junonia lemonias</i>	NC	
66.	Chocolate Pansy	<i>Junonia iphita</i>	C	
67.	Grey Pansy	<i>Junonia atlites</i>	C	
68.	Great Eggfly	<i>Hypolimnas bolina</i>	C	
69.	Danaid Eggfly	<i>Hypolimnas misippus</i>	C	Sch-II
Skippers Hesperiidae				
70.	Brown Awl	<i>Badamia exclamationis</i>	NC	
71.	Water Snow Flat	<i>Tagiades litigiosa</i>	C	
72.	Chestnut Bob	<i>Iambrix salsala</i>	C	
73.	Coon	<i>Psolos fuligo</i>	NC	
74.	Indian Palm Bob	<i>Suastus gremius</i>	NC	
75.	Restricted Demon	<i>Notocrypta curvifascia</i>	NC	
76.	Rice Swift	<i>Borbo cinnara</i>	NC	
77.	Conjoined Swift	<i>Pelopidas conjuncta</i>	NC	
78.	Blank Swift	<i>Caltoris kumara</i>	NC	
79.	Indian Dartlet	<i>Oriens goloides</i>	C	
#	Species abundance as R : Rare, NC : Not common, C : Common, and VC : Very common; IUCN Red List status as LC : Least concern; Endemicity as En-WG : Western Ghats endemic, En-WGS : Western Ghats and South India; and Indian Wildlife Protection Act Schedules as Sch-I , and Sch-II			

Odonates

A total of 41 species of odonates were recorded from the study area, representing both dragonflies (Anisoptera) and damselflies (Zygoptera) (Table-08). These species belong to several families including Libellulidae, Coenagrionidae, Calopterygidae, Chlorocyphidae, Platynemididae, Euphaeidae, Lestidae and Synthemistidae. The majority of the species are categorized as Least Concern (LC) under the IUCN Red List, with one species, Clear-winged Forest Glory, recorded as Near Threatened (NT). Commonly observed species include skimmers such as the Ground Skimmer (*Diplacodes trivialis*), Green Marsh Hawk (*Orthetrum sabina*), Pied Paddy Skimmer (*Neurothemis tullia*), and Crimson Marsh Glider

(*Trithemis aurora*). Stream-associated damselflies such as Stream Glory (*Neurobasis chinensis*), Stream Ruby (*Heliocypha bisignata*) and Yellow Bush Dart (*Copera marginipes*) are also regularly encountered along shaded channels (Plate-06).

Field observations indicated that odonate activity varied with water availability along the main stream and associated pools. Dragonflies were found more abundant in open sunlit stretches, while damselflies were concentrated along shaded sections with overhanging vegetation. The species recorded are typical of lowland streams and associated freshwater habitats in the region. Notable observations along the main stream included Black-tipped Forest Glory, Stream Ruby, Brown-backed Red Marsh Hawk, Malabar Torrent Dart, and Yellow-tailed Ashy Skimmer. These species were mainly recorded near the confluence of Kothamangalam thodu with a feeder stream located downstream of the dam site, where flowing water and vegetated margins provided suitable microhabitats.

Table-08: List of odonates recorded from the project area and surroundings

Sl. No.	Common Name	Scientific Name	Family	IUCN Status*
1.	Trumpet Tail	<i>Acisoma panorpoides</i>	Libellulidae	LC
2.	Scarlet Marsh Hawk	<i>Aethriamanta brevipennis</i>	Libellulidae	LC
3.	Rufous-backed Marsh Hawk	<i>Brachydiplax chalybea</i>	Libellulidae	LC
4.	Ditch Jewel	<i>Brachythemis contaminata</i>	Libellulidae	LC
5.	Granite Ghost	<i>Bradinopyga geminata</i>	Libellulidae	LC
6.	Ground Skimmer	<i>Diplacodes trivialis</i>	Libellulidae	LC
7.	Asiatic Blood Tail	<i>Lathrecista asiatica</i>	Libellulidae	LC
8.	Fulvous Forest Skimmer	<i>Neurothemis fulvia</i>	Libellulidae	LC
9.	Pied Paddy Skimmer	<i>Neurothemis tullia</i>	Libellulidae	LC
10.	Stellate River Hawk	<i>Onychothemis testacea</i>	Libellulidae	LC
11.	Brown-backed Red Marsh Hawk	<i>Orthetrum chrysis</i>	Libellulidae	LC
12.	Green Marsh Hawk	<i>Orthetrum sabina</i>	Libellulidae	LC
13.	Marsh Skimmer	<i>Orthetrum luzonicum</i>	Libellulidae	LC
14.	Crimson-tailed Marsh Hawk	<i>Orthetrum prunosum</i>	Libellulidae	LC
15.	Small Skimmer	<i>Orthetrum taeniolatum</i>	Libellulidae	LC
16.	Yellow-tailed Ashy Skimmer	<i>Potamarcha congener</i>	Libellulidae	LC
17.	Common Picture Wing	<i>Rhyothemis variegata</i>	Libellulidae	LC
18.	Voyaging Glider	<i>Tramea limbata</i>	Libellulidae	LC
19.	Crimson Marsh Glider	<i>Trithemis aurora</i>	Libellulidae	LC

20.	Black Stream Glider	<i>Trithemis festiva</i>	Libellulidae	LC
21.	Long-legged Marsh Glider	<i>Trithemis pallidinervis</i>	Libellulidae	LC
22.	Macromidia (Donald's)	<i>Macromidia donaldi</i>	Synthemistidae	LC
23.	Stream Ruby	<i>Helioocypha bisignata</i>	Chlorocyphidae	LC
24.	River Heliodor	<i>Libellago lineata</i>	Chlorocyphidae	LC
25.	Stream Glory	<i>Neurobasis chinensis</i>	Calopterygidae	LC
26.	Black-tipped Forest Glory	<i>Vestalis apicalis</i>	Calopterygidae	LC
27.	Clear-winged Forest Glory	<i>Vestalis gracilis</i>	Calopterygidae	NT
28.	White Dartlet	<i>Agriocnemis pieris</i>	Coenagrionidae	LC
29.	Pygmy Dartlet	<i>Agriocnemis pygmaea</i>	Coenagrionidae	LC
30.	Orange-tailed Marsh Dart	<i>Ceriagrion cerinorubellum</i>	Coenagrionidae	LC
31.	Coromandel Marsh Dart	<i>Ceriagrion coromandelianum</i>	Coenagrionidae	LC
32.	Rusty Marsh Dart	<i>Ceriagrion olivaceum</i>	Coenagrionidae	LC
33.	Golden Dartlet	<i>Ischnura rubilio</i>	Coenagrionidae	LC
34.	Common Bluetail	<i>Ischnura senegalensis</i>	Coenagrionidae	LC
35.	Yellow-striped Blue Dart	<i>Pseudagrion indicum</i>	Coenagrionidae	LC
36.	Blue Grass Dart	<i>Pseudagrion microcephalum</i>	Coenagrionidae	LC
37.	Saffron-faced Blue Dart	<i>Pseudagrion rubriceps</i>	Coenagrionidae	LC
38.	Black Torrent Dart	<i>Dysphaea ethela</i>	Euphaeidae	LC
39.	Sapphire-eyed Spreadwing	<i>Lestes praemorsus</i>	Lestidae	LC
40.	Yellow Bush Dart	<i>Copera marginipes</i>	Platycnemididae	LC
41.	Red-striped Black Bamboo Tail	<i>Prodasineura verticalis</i>	Platycnemididae	LC
*IUCN Red List status as NT : Near Threatened, and LC : Least Concern				

Fishes

Only a few fish species were recorded in the stream and associated waterbodies around the proposed weir site, including *Garra mullya* (locally known as Kallemutti), *Gambusia affinis* (Manathukanni) and *Devario* sp. (Ozhukkilatti). These species are commonly found in shallow flowing sections and small pools with submerged stones and aquatic vegetation. No migratory species were recorded from this stretch of the Kothamangalam thodu during the survey. Spawning grounds or fish breeding habitats were not evident in the project-

influenced stream stretch or its vicinity. Further, no fishing activity or evidence of fish harvesting were observed during the survey.

Amphibians

A total of 13 species of amphibians were recorded from the study area. The assemblage included caecilians, toads, pond frogs, tree frogs and a number of stream-associated taxa. The amphibians comprised common and widely distributed species such as the Common Toad (*Bufo melanostictus*), Cricket Frog (*Fejervarya limnocharis*), Green Frog (*Euphlyctis hexadactyla*) and Skipper Frog (*Euphlyctis cyanophlyctis*), along with forest and stream-associated forms including the Bronzed Frog (*Rana temporalis*) and Bicoloured Frog (*Rana curtipis*). Tree frogs were represented by species such as the Sharp-nosed Frog (*Philautus nasutus*) and Yellow-bellied Bush Frog (*Philautus flaviventris*), as well as a Common Tree Frog observed in shrubbery and small vegetation close to temporary water pools. These taxa typically occur in shaded environments where canopy cover, leaf litter and moisture levels are present. Overall, the amphibian assemblage reflects a mixture of aquatic, semi-aquatic and terrestrial forms, indicative of habitat heterogeneity and the presence of both standing water and shaded forest conditions.

Reptiles

A total of 19 species of reptiles were recorded from the study area, representing lizards, skinks, monitor lizards, colubrid snakes, and pit vipers (Table-09). The majority of the recorded reptiles are widespread and commonly encountered species such as the House Gecko (*Hemidactylus flaviviridis*), Brook's Gecko (*Hemidactylus brooki*), Garden Lizard (*Calotes versicolor*) and Common Skink (*Mabuya carinata*). These species were observed in a range of habitats, including forest edges, plantation areas, and human-influenced settings.

Forest-associated species such as the Forest Calotes (*Calotes rouxi*) and arboreal lizards like the Flying Lizard (*Draco dussumeri*) were recorded in shaded vegetation patches, while rock-dwelling geckos were encountered among boulders and exposed rock surfaces. Snakes were represented by generalist species including the Rat Snake (*Ptyas mucosus*), Checkered Keelback (*Xenochrophis piscator*) and Common Green Whip Snake (*Ahaetulla nasuta*), which were observed in areas with adequate ground cover and access to water.

Table-09: List of reptiles recorded from the project area and surroundings

Sl. No.	Common Name	Scientific Name	IUCN Status*
1.	House gecko	<i>Hemidactylus flaviviridis</i>	LC
3.	Rock gecko	<i>Hemidactylus maculatus</i>	LC
4.	Flying lizard	<i>Draco dussumeri</i>	LC
5.	Garden lizard	<i>Calotes versicolor</i>	LC
6.	Forest calotes	<i>Calotes rouxi</i>	LC
7.	Green calotes	<i>Calotes calotes</i>	LC

8.	Monitor lizard	<i>Varanus bengalensis</i>	NT
9.	Common skink	<i>Mabuya carinata</i>	LC
10.	Little skink	<i>Mabuya macularia</i>	LC
11.	Rat snake	<i>Ptyas mucosus</i>	LC
12.	Common kukri	<i>Oligodon arnensis</i>	LC
13.	Common Indian bronzeback	<i>Dendrelaphis tristis</i>	LC
14.	Buff striped keelback	<i>Amphiesma stolatum</i>	LC
15.	Checkered keelback	<i>Xenochrophis piscator</i>	LC
16.	Common green whip snake	<i>Ahaetulla nasuta</i>	LC
17.	Indian cobra	<i>Naja naja</i>	LC
18.	Malabar rock pit viper	<i>Trimeresurus malabaricus</i>	LC
19.	Golden tree snake	<i>Chrysopelea ornata</i>	LC
*	IUCN Red List status as NT : Near Threatened, and LC : Least Concern		

Birds

The list of birds compiled for this study is primarily based on field observations made during the present survey, supplemented by verified records available for the wider region. Additional information was incorporated from State Forest Department records (Kerala Forest Department, 2016) and those generated using the Mapping Your Neighbourhood Avifauna (MYNA) data exploration tool (myna.stateofindiabirds.in). MYNA is part of the State of India's Birds partnership initiative, and is based on observations contributed by citizen scientists to eBird India, which is managed by the Cornell Lab of Ornithology and Bird Count India (SolB, 2023).

A total of 138 bird species representing 50 families were recorded from the study area, indicating considerable avian diversity. Of these, 20 species are identified as migrants. The list (Table-10) also includes one Vulnerable species and four Near Threatened species, based on current conservation assessments, along with 14 species endemic to the Western Ghats and Western Ghats–Sri Lanka biogeographic regions. In addition, 16 species fall under Schedule I of the Wildlife (Protection) Act, 1972. Several of the bird species recorded in the study area are categorised as *not common*. However, no *very rare* species have been reported either during the present survey or in the existing regional documentation. The highest number of species was contributed by families such as Accipitridae (eagles and kites), Muscicapidae (Old World flycatchers), Strigidae (owls), Picidae (woodpeckers), Pycnonotidae (bulbuls), Sturnidae (starlings), Columbidae (pigeons and doves), and Apodidae (swifts), indicating their broad representation in the study area. The highest avian diversity was observed in and around the Thommankuthu region, located at the southern end of the 5-km radial zone defined for this study. This area supports a mosaic of habitats that favour a wide range of bird species.

The bird diversity at the weir site was assessed by traversing approximately 1 km upstream and 1 km downstream along the Kothamangalam stream, following designated transects. Bird observations were made within an estimated 200-m zone on either side of the stream banks, representing the immediate habitat likely to be affected by the project-related impacts. The bird species in the project zone consists predominantly of common and widely distributed species. The birds observed in the study area include Little Cormorant *Microcarbo niger*, White-throated Kingfisher *Halcyon smyrnensis*, Vernal Hanging Parrot *Loriculus vernalis*, White-browed Wagtail *Motacilla maderaspatensis*, Common Tailorbird *Orthotomus sutorius*, long range migrant Asian Brown Flycatcher *Muscicapa dauurica*, endemic Nilgiri Flowerpecker *Dicaeum neilgherrense*, Red-whiskered Bulbul *Pycnonotus jocosus*, Little Spiderhunter *Arachnothera longirostra*, Hill Myna *Gracula religiosa*, Orange Minivet *Pericrocotus flammeus*, Pale-billed Flowerpecker *Dicaeum erythrorhynchos*, and Racket-tailed Drongo *Dicrurus paradiseus*. These species are typically found in rural and semi-natural landscapes throughout Kerala along the Western Ghats. Additionally, the weir site does not contain any unique habitat features that would be critical for the listed bird species. The habitat types present in the proposed site are also available in the immediate surroundings, both upstream and downstream of the stream, suggesting that the avifauna dependent on these habitats is unlikely to be significantly affected by the project.

Table-10: List of Birds Recorded from the project area and surroundings

Sl. No.	Common Name	Scientific Name	Family	Abundance*	Remarks#
	Junglefowl, Quail, and allies				
1.	Red Spurfowl	<i>Galloperdix spadicea</i>		NC	LC, En-MI, Sch-II
2.	Grey Junglefowl	<i>Gallus sonneratii</i>		C	LC, En-MI, Sch-I
	Pigeons and Doves				
3.	Rock Pigeon	<i>Columba livia</i>	Columbidae	C	LC, N, NS
4.	Spotted Dove	<i>Spilopelia chinensis</i>		C	LC, N, Sch-II
5.	Asian Emerald Dove	<i>Chalcophaps indica</i>		C	LC, N, Sch-II
6.	Grey-fronted Green-Pigeon	<i>Treron affinis</i>		NC, LM	LC, En-WG, Sch-II
7.	Green Imperial-Pigeon	<i>Ducula aenea</i>		NC	NT, N, Sch-II
	Cuckoos				
8.	Greater Coucal	<i>Centropus sinensis</i>	Cuculidae	VC	LC, N, Sch-II
9.	Asian Koel	<i>Eudynamys</i>		C, LM	LC, N,

		<i>scolopaceus</i>			Sch-II
10.	Fork-tailed Drongo-Cuckoo	<i>Surniculus dicruroides</i>		NC, LM	LC, En-IS, Sch-II
11.	Common Hawk-Cuckoo	<i>Hierococcyx varius</i>		NC, LM	LC, En-IS, Sch-II
	Nightjars				
12.	Jerdon's Nightjar	<i>Caprimulgus atripennis</i>	Caprimulgidae	NC	LC, En-IS, NA, Sch-II
13.	Jungle Nightjar	<i>Caprimulgus indicus</i>			LC, En-IS, NA, Sch-II
	Swifts				
14.	Brown-backed Needletail	<i>Hirundapus giganteus</i>	Apodidae	NC	LC, N, Sch-II
15.	Indian Swiftlet	<i>Aerodramus unicolor</i>		NC	LC, En-IS, Sch-I
16.	Alpine swift	<i>Tachymarpis melba</i>		NC, M	LC, N, Sch-II
17.	Little Swift	<i>Apus affinis</i>		C	LC, N, Sch-II
18.	Asian Palm Swift	<i>Cypsiurus balasiensis</i>		NC	LC, N, Sch-II
	Treeswifts				
19.	Crested Treeswift	<i>Hemiprocne coronata</i>	Hemiprocnidae	NC	LC, N, Sch-I
	Rails, Gallinules (Swaphens etc.) and Coots				
20.	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	Rallidae	NC	LC, N, Sch-II
	Cormorants and Anhingas				
21.	Oriental Darter	<i>Anhinga melanogaster</i>	Anhingidae	NC	LC, N, Sch-II
22.	Little Cormorant	<i>Microcarbo niger</i>	Phalacrocoracidae	C	LC, N, Sch-II
	Herons, Ibis, Egrets, Bitterns, and allies				
23.	Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	Ardeidae	NC	LC, N, Sch-II
24.	Little Egret	<i>Egretta garzetta</i>		NC	
25.	Indian Pond-Heron	<i>Ardeola grayii</i>		C	LC, N, Sch-II
26.	Eastern Cattle-Egret	<i>Ardea coromanda</i>		C	LC, N, Sch-II
	Hawks, Eagles and allies				
27.	Black-winged	<i>Elanus caeruleus</i>	Accipitridae	NC, LM	LC, N,

	Kite				Sch-II
28.	Oriental Honey-buzzard	<i>Pernis ptilorhynchus</i>		C, LM	LC, N, Sch-II
29.	Crested Serpent-Eagle	<i>Spilornis cheela</i>		C, LM	LC, N, Sch-I
30.	Changeable Hawk-Eagle	<i>Nisaetus cirrhatus</i>		C	LC, N, Sch-I
31.	Rufous-bellied Eagle	<i>Lophotriorchis kienerii</i>		NC	NT, N, Sch-I
32.	Black Eagle	<i>Ictinaetus malaiensis</i>		NC	LC, N, Sch-I
33.	Booted Eagle	<i>Hieraaetus pennatus</i>		NC, M, LM	LC, N, Sch-I
34.	Crested Goshawk	<i>Lophospiza trivirgata</i>		NC	LC, N, Sch-I
35.	Shikra	<i>Tachyspiza badia</i>		C	LC, N, Sch-I
36.	Black Kite	<i>Milvus migrans</i>		C	LC, N, Sch-II
37.	Brahminy Kite	<i>Haliastur indus</i>		C	LC, N, Sch-I
	Owls				
38.	Indian Scops-Owl	<i>Otus bakkamoena</i>		NC	LC, En-IS, Sch-II
39.	Jungle Owlet	<i>Glaucidium radiatum</i>		C, LM	LC, En-IS, Sch-II
40.	Spotted Owlet	<i>Athene brama</i>	Strigidae	NC	LC, N, Sch-II
41.	Brown Fish-Owl	<i>Ketupa zeylonensis</i>		NC	LC, N, Sch-I
42.	Brown Boobook	<i>Ninox scutulata</i>		C, LM	LC, N, Sch-II
	Trogons				
43.	Malabar Trogon	<i>Harpactes fasciatus</i>	Trogonidae	C	LC, En-IS, Sch-II
	Hornbills				
44.	Malabar Grey Hornbill	<i>Ocyrceros griseus</i>	Bucerotidae	C	V, N, Sch-I
	Bee-eaters				
45.	Asian Green Bee-eater	<i>Merops orientalis</i>		C	LC, N, Sch-II
46.	Blue-tailed Bee-eater	<i>Merops philippinus</i>	Meropidae	NC	LC, N, Sch-II
47.	Chestnut-headed Bee-	<i>Merops leschenaulti</i>		C, LM	LC, N, Sch-II

	eater				
	Kingfishers				
48.	Common Kingfisher	Alcedo atthis	Alcedinidae	NC	LC, N, Sch-II
49.	Stork-billed Kingfisher	Pelargopsis capensis		NC	LC, N, Sch-II
50.	White-throated Kingfisher	Halcyon smyrnensis		C	LC, N, Sch-II
	Rollers				
51.	Indian Roller	Coracias benghalensis	Coraciidae	NC	NT, N, Sch-II
	Asian Barbets				
52.	Malabar Barbet	Psilopogon malabaricus	Megalaaimidae	C	LC, En-WG, Sch-II
53.	Coppersmith Barbet	Psilopogon haemacephalus		NC	LC, N, Sch-II
54.	White-cheeked Barbet	Psilopogon viridis		VC	LC, En-MI, Sch-II
	Woodpeckers				
55.	Heart-spotted Woodpecker	Hemicircus canente	Picidae	NC	LC, N, Sch-I
56.	Brown-capped Pygmy Woodpecker	Yungipicus nanus		NC	LC, En-MI, Sch-II
57.	Malabar Flameback	Chrysocolaptes socialis		C	NR, En-WG, NA, Sch-II
58.	Black-rumped Flameback	Dinopium benghalense		C	LC, En-IS, Sch-II
59.	Common Flameback	Dinopium javanense		NC	LC, N, Sch-II
60.	Rufous Woodpecker	Micropternus brachyurus		NC	LC, N, Sch-II
	Old World Parrots				
61.	Rose-ringed Parakeet	Psittacula krameri	Psittaculidae	C	LC, N, Sch-II
62.	Plum-headed Parakeet	Psittacula cyanocephala		C	LC, En-IS, Sch-II
63.	Malabar Parakeet	Psittacula columboides		NC	LC, En-WG, Sch-II
64.	Vernal Hanging-	Loriculus vernalis		VC	LC, N, Sch-II

	Parrot				
	Pittas				
65.	Indian Pitta	<i>Pitta brachyura</i>	Pittidae	NC, M	LC, N, Sch-II
	Cuckooshrikes				
66.	Small Minivet	<i>Pericrocotus cinnamomeus</i>	Campephagidae	NC	LC, N, Sch-I
67.	Orange Minivet	<i>Pericrocotus flammeus</i>		C	LC, En-IS, Sch-II
68.	Indian Cuckooshrike	<i>Coracina macei</i>		NC	LC, N, Sch-II
	Old World Orioles				
69.	Indian Golden Oriole	<i>Oriolus kundoo</i>	Oriolidae	C, M	LC, N, Sch-II
70.	Black-naped Oriole	<i>Oriolus chinensis</i>		NC, M	LC, N, Sch-II
71.	Black-hooded Oriole	<i>Oriolus xanthornus</i>		C	LC, N, Sch-II
	Woodswallows				
72.	Ashy Woodswallow	<i>Artamus fuscus</i>	Artamidae	C, LM	LC, N, Sch-II
	Woodshrikes and allies				
73.	Malabar Woodshrike	<i>Tephrodornis sylvicola</i>	Vangidae	NC	LC, En-WG, Sch-II
74.	Bar-winged Flycatcher-shrike	<i>Hemipus picatus</i>		NC	LC, N, Sch-II
	loras				
75.	Common lora	<i>Aegithina tiphia</i>	Aegithinidae	C	LC, N, Sch-II
	Drongos				
76.	Black Drongo	<i>Dicrurus macrocercus</i>	Dicruridae	C	LC, N, Sch-II
77.	Ashy Drongo	<i>Dicrurus leucophaeus</i>		C, M	LC, N, Sch-II
78.	Bronzed Drongo	<i>Dicrurus aeneus</i>		C	LC, N, Sch-II
79.	Greater Racket-tailed Drongo	<i>Dicrurus paradiseus</i>		VC	LC, N, Sch-II
	Monarch Flycatchers				
80.	Black-naped Monarch	<i>Hypothymis azurea</i>	Monarchidae	NC	LC, N, Sch-II
81.	Indian Paradise-	<i>Terpsiphone paradisi</i>		C, M	LC, N, Sch-II

	Flycatcher				
	Shrikes				
82.	Brown Shrike	Lanius cristatus	Laniidae	C, M	LC, N, Sch-II
	Crows, Treepies, and allies				
83.	Rufous Treepie	Dendrocitta vagabunda	Corvidae	C	LC, N, Sch-II
84.	White-bellied Treepie	Dendrocitta leucogastra		NC	LC, En-WG, Sch-II
85.	House Crow	Corvus splendens		C	LC, N, NP
86.	Large-billed Crow	Corvus macrorhynchos		C	LC, N, Sch-II
	Tits				
87.	Asian Tit	Parus cinereus	Paridae	NC, LM	LC, N, Sch-II
	Prinias, Cisticolas and allies				
88.	Common Tailorbird	Orthotomus sutorius	Cisticolidae	C	LC, N, Sch-II
89.	Grey-breasted Prinia	Prinia hodgsonii		NC	LC, N, Sch-II
90.	Ashy Prinia	Prinia socialis		C	LC, En-IS, Sch-II
91.	Plain Prinia	Prinia inornata		C	LC, N, Sch-II
	Reed Warblers and allies				
92.	Blyth's Reed Warbler	Acrocephalus dumetorum	Acrocephalidae	C, M	LC, N, Sch-II
93.	Clamorous Reed Warbler	Acrocephalus stentoreus		NC	LC, N, Sch-II
	Martins and Swallows				
94.	Barn Swallow	Hirundo rustica	Hirundinidae	NC, M	LC, N, Sch-II
95.	Eastern Red-rumped Swallow	Cecropis daurica		NC, M	LC, N, Sch-II
	Bulbuls				
96.	Yellow-browed Bulbul	Acritillas indica	Pycnonotidae	C	LC, En-WGS, Sch-II
97.	Grey-headed Bulbul	Microtarsus priocephalus		NC	NT, En-WG, Sch-II
98.	Flame-throated Bulbul	Rubigula gularis		NC	LC, En-WG, Sch-II

99.	Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>		C, LM	LC, N, Sch-II
100.	Red-vented Bulbul	<i>Pycnonotus cafer</i>		NC	LC, N, Sch-II
Leaf Warblers					
101.	Green Warbler	<i>Phylloscopus nitidus</i>	Phylloscopidae	C, M	LC, N, Sch-II
102.	Greenish Warbler	<i>Phylloscopus trochiloides</i>		C, M	LC, N, Sch-II
103.	Large-billed Leaf Warbler	<i>Phylloscopus magnirostris</i>		C, M	LC, N, Sch-II
White-eyes, Yuhinas and allies					
104.	Indian White-eye	<i>Zosterops palpebrosus</i>	Zosteropidae	NC	LC, N, Sch-II
Tree-Babblers, Scimitar-Babblers					
105.	Dark-fronted Babbler	<i>Dumetia atriceps</i>	Timaliidae	NC	LC, En-WGS, Sch-II
106.	Indian Scimitar-Babbler	<i>Pomatorhinus horsfieldii</i>		NC	LC, En-MI, Sch-II
Ground Babblers					
107.	Puff-throated Babbler	<i>Pellorneum ruficeps</i>	Pellorneidae	C	LC, N, Sch-II
Laughingthrushes and allies					
108.	Brown-cheeked Fulvetta	<i>Alcippe poioicephala</i>	Leiothrichidae	NC	LC, N, Sch-II
109.	Rufous Babbler	<i>Argya subrufa</i>		NC	LC, N, Sch-II
110.	Jungle Babbler	<i>Argya striata</i>		C	LC, En-IS, Sch-II
111.	Yellow-billed Babbler	<i>Argya affinis</i>		C	LC, En-IS, Sch-II
Nuthatches					
112.	Velvet-fronted Nuthatch	<i>Sitta frontalis</i>	Sittidae	C	LC, N, Sch-II
Starlings					
113.	Southern Hill Myna	<i>Gracula indica</i>	Sturnidae	VC	LC, En-WGS, Sch-I
114.	Chestnut-tailed Starling	<i>Sturnia malabarica</i>		NC, M, LM(?)	LC, N, Sch-II

115.	Malabar Starling	<i>Sturnia blythii</i>		C	LC, En-WG, Sch-II
116.	Common Myna	<i>Acridotheres tristis</i>		C	LC, N, Sch-II
117.	Jungle Myna	<i>Acridotheres fuscus</i>		C	LC, N, Sch-II
	Thrushes and allies				
118.	Orange-headed Thrush	<i>Geokichla citrina</i>	Turdidae	NC, LM	LC, N, Sch-II
	Old World Flycatchers				
119.	Asian Brown Flycatcher	<i>Muscicapa dauurica</i>	Muscicapidae	C, M, LM	LC, N, Sch-II
120.	Brown-breasted Flycatcher	<i>Muscicapa muttui</i>		C, M	LC, N, Sch-II
121.	Oriental Magpie-Robin	<i>Copsychus saularis</i>		C, LM	LC, N, Sch-II
122.	Blue-throated Flycatcher	<i>Cyornis rubeculoides</i>		NC, M	LC, N, Sch-II
123.	Tickell's Blue Flycatcher	<i>Cyornis tickelliae</i>		NC	LC, En-IS, Sch-II
124.	Indian Blue Robin	<i>Larvivora brunnea</i>		NC, M	LC, N, Sch-II
125.	Malabar Whistling-Thrush	<i>Myophonus horsfieldii</i>		C, LM	LC, En-MI, Sch-II
	Flowerpeckers				
126.	Pale-billed Flowerpecker	<i>Dicaeum erythrorhynchos</i>	Dicaeidae	C	LC, En-IS, Sch-II
127.	Nilgiri Flowerpecker	<i>Dicaeum concolor</i>		C	LC, En-WG, Sch-II
	Sunbirds and Spiderhunters				
128.	Purple-rumped Sunbird	<i>Leptocoma zeylonica</i>	Nectariniidae	C	LC, En-IS, Sch-II
129.	Crimson-backed Sunbird	<i>Leptocoma minima</i>		C	LC, En-WG, Sch-II
130.	Purple Sunbird	<i>Cinnyris asiaticus</i>		NC	LC, N, Sch-II
131.	Loten's Sunbird	<i>Cinnyris lotenius</i>		C	LC, En-IS, Sch-II
132.	Little Spiderhunter	<i>Arachnothera longirostra</i>		C	LC, N, Sch-II
	Fairy-bluebirds				

133.	Asian Fairy-bluebird	<i>Irena puella</i>	Irenidae	NC	LC, N, Sch-II
	Leafbirds				
134.	Golden-fronted Leafbird	<i>Chloropsisaurifrons</i>	Chloropseidae	NC	LC, N, Sch-II
	Munias and allies				
135.	Black-throated Munia	<i>Lonchurakelaarti</i>	Estrildidae	NC	LC, En-IS, Sch-II
136.	White-rumped Munia	Lonchura striata		NC	LC, N, Sch-II
	Wagtails and Pipits				
137.	Grey Wagtail	<i>Motacilla cinerea</i>	Motacillidae	NC, M	LC, N, Sch-II
138.	White-browed Wagtail	<i>Motacilla maderaspatensis</i>		NC	LC, En-IS, Sch-II
	TOTAL		Families = 50	Migrants = 20	V = 1; NT = 4; En-WG/ WGS = 14 Sch I = 16
* #	Species abundance as R : Rare; NC : Not common; C : Common; VC : Very common; Migration status as LM : Local migrant; M : Migrant; IUCN Red List status as LC : Least concern; NT : Near threatened; V : Vulnerable; NR : Not recognized; Endemicity as En-WG : Western Ghats endemic; En-WGS : Western Ghats and Sri Lanka endemic; En-MI : Mainland India endemic; En-IS : Indian Subcontinent endemic; and Indian Wildlife Protection Act Schedules as Sch-I , Sch-II , NS -not scheduled				

Mammals

A total of twenty mammal species were recorded from the study area during the present survey. The assemblage included carnivores, small mammals, bats, primates and large herbivores. Frequently observed species included Bonnet Macaque (*Macaca radiata*), Jungle Cat (*Felis chaus*), Small Indian Civet (*Viverricula indica*), and Common Mongoose (*Herpestes edwardsi* group), which were seen around forest edges, while arboreal species such as Giant Squirrel (*Ratufa indica*) are encountered in areas with tall trees, while smaller squirrels were observed in mixed vegetation and plantations.

Large herbivores, including Asiatic Elephant (*Elephas maximus*), Gaur (*Bos gaurus*), Sambar (*Cervus unicolor*), Barking Deer (*Muntiacus muntjak*) and Wild Boar (*Sus scrofa*) are also recorded in forested tracts and along movement paths within the study area (in 5

km radius with the weir site as centre). The presence of species representing multiple trophic levels and activity patterns reflects a mosaic of habitats within the study area.

Socio-economic settings

The proposed project area falls in Vannappuram Grama Panchayat in Vannappuram Village of Thodupuzha Taluk in Idukki District of Kerala State. Vannappuram Panchayat, with an area of 63.28 km², is predominantly rural, and its socio-economic structure are largely dependent on agriculture and allied activities. This reflects a typical highland agrarian landscape of Idukki, with plantations, homesteads and mixed cropping systems forming the backbone of local economy.

As per the Census of India, 2011, Vannappuram village recorded a total population of 28,905 people living in 7,325 households. A later estimate for the Grama Panchayat in 2020 indicated a population of approximately 27,168, suggesting a marginal decline or administrative re-alignment in population figures over the years. Over the last century, population of Idukki District increased nearly twenty-threefold. Census records indicate that the decadal population growth rose sharply from 40.6% in 1941-51 to 67.57% in 1951-61. The sudden surge was mainly due to large-scale migration associated with 'Grow More Food campaign' of the 1950s. Following this rapid increase, the growth rate gradually declined, and during 2001-11 the district recorded a population decrease of 1.8%. The 2011 census enumerated 14,547 males and 14,358 females in Vannappuram Panchayat, resulting in a sex ratio of 987 females per 1000 males. This ratio is marginally lower than the overall Kerala State average, which is known for a comparatively favourable gender balance,

Idukki district recorded an overall literacy rate of about 92.2% in 2011, and Vannappuram Grama Panchayat follows a similar trend with a literacy rate estimated at around 92%. This reflects a relatively high level of educational attainment, consistent with Kerala State's reputation for strong human development indicators. The principal livelihood base of the Panchayat is formed by agriculture. A considerable section of the population is engaged in agriculture-related activities, with a notable proportion of women participating in marginal as well as main work categories.

The Vannappuram region enjoys favourable agro-climatic conditions, suitable for cocoa and rubber plantations, other food crops and spices. Farming is primarily characterised by small and marginal holdings, with nearly 95% of landholdings in Idukki district being below two hectares. Major crops cultivated in and around Vannappuram include cocoa, rubber, pineapple, coconut, areca nut, plantain and coffee, in addition to tubers, few vegetables, and spices such as pepper, cardamom, ginger, and turmeric. Plantation agriculture and mixed cropping systems dominate the local land use pattern. Animal husbandry, goat rearing, and poultry are commonly practiced as supplementary income-generation activities. These are often integrated with agricultural operations and play a vital role in household economy.

The industrial base in the Panchayat and the district remains limited due to constraints of land availability and terrain. Micro, Small, and Medium Enterprises (MSMEs) are few in number, and most such activities revolve around agro-based processing, especially spice processing units, including and small-scale value-addition ventures.

Healthcare and educational facilities form an important part of the social infrastructure of the Panchayat. The district development strategies emphasise strengthening access to public health and education, particularly for rural and economically weaker sections. Medical services are available with Allopathic, Ayurvedic and Homeopathic systems, apart from local/traditional healthcare practices, ensuring a diverse healthcare framework.

The Panchayat, like several parts of Idukki district, has significant presence of Scheduled Castes (SC) and Scheduled Tribes (ST). Communities such as Mala-Arayans, Mannans and Uralis represent the weaker social groups in the region, requiring focused interventions due to socio-economic vulnerabilities.

04. ASSESSMENT ENVIRONMENTAL IMPACTS

Any development project inevitably involves a certain degree of environmental damage. The larger the activity, the greater its potential impact; particularly large projects can cause disturbances that may exceed ecosystem's assimilative capacity and disrupt its ecological balance. Hydropower development projects, in particular, raise specific environmental concerns, mainly related to changes in the land use and river flow patterns. These impacts vary substantially across different geographic settings, and each hydropower project has its own distinct characteristics. The construction of dam, water conveyance system and powerhouse, as well as the creation of impounding reservoir, can trigger certain physical, ecological, biological and social changes. Therefore, it is essential to identify and analyse potential environmental impacts at an early stage of project planning so that appropriate measures can be taken to avoid, minimise, mitigate or compensate for such adverse effects.

The major impacts resulting from the implementation of hydroelectric projects are felt across land, air, water, ecological, socio-economic and aesthetic environments. These impacts arise due to modification of the local environmental conditions, including land submergence, changes in land use, loss of biodiversity, alteration or degradation of wildlife habitats, changes in hydrological regimes such as river flow characteristics and ground water table, and displacement of people. Such effects may be intended or unintended, direct or indirect, and may be either positive and negative. Accordingly, these anticipated consequences can be effectively assessed through project-specific and location-specific studies conducted in a holistic manner. In this context, *assessment* refers to systematic analysis and evaluation of impacts on ecosystems and socio-economic systems. *Analysis* involves the *objective* task of identification of potential impacts, through characterisation of the baseline environmental conditions, and prediction of likely changes resulting from the proposed actions. *Evaluation*, on the other hand, is a *subjective* or normative process that incorporates human values and priorities to determine the significance of effects for affected communities and stakeholders.

In the present environmental impact study of the proposed Vellakayam Micro Hydro Electric Project, an integrated assessment approach has been followed, with emphasis on identification and evaluation of impacts on both physical and ecological environments. To identify potential environmental impacts and concerns, and to subsequently evaluate them in the project-environment context, both checklist and matrix techniques have been employed. The outcome/results of the integrated impact assessment are presented concisely below, in terms of impacts on air, water, land, ecological, and biological systems. For convenience, the concerns and impacts associated with various environmental components during the construction and operation phases are discussed together as they

are considered in a holistic manner to capture the full scope of interactive and cumulative effects.

Impacts on air environment

Construction activities such as vehicular movement associated with transportation of materials, earthworks, and clearing of debris from the site would cause short term changes in local air quality due to emission of dust and suspended particulates. Although these impacts are temporary and confined to the construction phase, they may affect the peripheral areas, pose health risks to workers, and impair stream water quality through settling of particulate matter, if not appropriately controlled. Periodic water sprinkling at construction sites can reduce dust generation to a considerable extent. Operation of machinery and associated power generation using fossil fuels would also contribute to air pollution through emission of smoke and gases including oxides of sulphur and nitrogen, and unburned hydrocarbons. The activities would further lead to increased noise levels. However, as these impacts are temporary, they are considered less significant. The use of fuel-efficient or electrically powered machinery with lower noise output and negligible emissions can effectively control the short-term impacts of air and noise pollution.

Impacts on water environment

The general concerns related to the implementation of hydropower projects on water environment include anticipated changes in drainage pattern, downstream flow, surface water quality arising from earthworks, construction of weir, formation of reservoir, and dumping of construction debris in the river banks.

Change in drainage pattern

As the Vellakayam Micro Hydro Electric Project is envisaged as run-of-the scheme in a moderately steep terrain, modification of natural drainages is expected to be minimal. Construction of the weir across Kothamangalam thodu is unlikely to cause any significant change in stream morphology or the drainage system, as the resulting submergence is limited to a water column height of 2.0 m from the bed level near the weir. Moreover, the project is designed for seasonal power generation, with operations confined to periods of adequate water availability. The weir construction will lead to temporary water stagnation in 0.0468 ha along a stretch of approximately 39 m of the stream. Upstream of the weir, two second order streams and one first order stream join Kothamangalam thodu from the right bank, while one second order and one first order streams join from left bank within a distance of about 100 m from the proposed weir site.

Change in surface water quality

Earthworks, construction of project components such as the weir, forebay tank and powerhouse, and improper disposal of construction debris in the fringe areas of the stream may cause deterioration of water quality during the construction phase. Clearing of vegetation and removal of loose soil from the construction sites of the weir, forebay

tank and powerhouse constitute major pre-construction activities. If the removed material and debris are indiscriminately dumped into the stream or along its banks, deterioration of water quality may occur, with increased levels of suspended solids and other pollutants. This may adversely affect the aquatic life, including fishes, as well as the downstream communities who depend on surface water for daily use. However, by promptly collecting cleared debris and spoils soon after their generation and disposing them systematically, the impacts can be minimised to a large extent.

Aquatic habitats and downstream flow

Formation of reservoirs generally results in an alteration of the aquatic environment in the inundation area from *lotic* (flowing) to *lentic* (stagnant) state. This change can lead to variation in water quality parameters, such as increased temperature, nutrient levels, total suspended solids, biological oxygen demand (BOD) and acidity. Prolonged stagnation would also cause lowering of dissolved oxygen, increased salinity, and deterioration of water quality. However, the proposed Vellakayam project is a run-of-the river scheme with a small impoundment of only about 39 m of stream length, and therefore such impacts are ruled out, as continuous flow and regular replenishment of water will prevent stagnation-related effects. Approximately, 125 m of the stream reach between the weir and the tailrace confluence will be affected during operation phase of the project, if adequate provision for minimum downstream release is not provided. This necessitates maintenance of an ecological flow to the tune of average lean flow in the dry season.

Impacts on land environment

The major impacts anticipated on the land environment due to hydropower development include possible changes in terrain features, land use pattern, and seismicity arising from the establishment of various project components, as well as the dumping of muck/spoils from the construction sites in vulnerable areas. However, being a micro-level scheme, the proposed Vellakkayam project does not involve large strictures, or extensive submergence to cause significant impacts on the land characteristics.

Seismicity concerns

The project area falls in a seismically stable zone (Zone-III as per Geological Survey of India's classification). No active structural features capable inducing significant tremors have been identified in the area. Seismic records indicate that the region has not experienced earthquakes exceeding a magnitude of 3.8 on the Richter scale. Hence the likelihood of seismic impacts is considered negligible. The possibility of reservoir-induced seismicity (RIS) is also insignificant, as the proposed project involves only a low volume of impoundment. The small size of the reservoir and its limited submergence (0.0468 ha) further rule out the chances of reservoir-induced seismicity (RIS). Moreover, no active geological structures are observed within the submergence area, which additionally reduces the risk of reservoir-induced seismicity. Events such as landslides which may cause shock or damage to the weir are therefore considered unlikely.

Slope stability concerns

As indicated earlier, the project is proposed in a moderately steep terrain. There are no unstable slopes within the primary influence zone of the project that could lead to significant failure. However, since loose soil layers are found at certain locations in the surrounding areas, such zones need to be stabilised as a precautionary measure by constructing retaining walls or gabion bunds, with the small boulders safely removed and utilised for construction where feasible. The project-induced landslide risk is minimal as it does not involve formation of a sizeable reservoir. Nevertheless, appropriate mitigation measures, such as providing proper retaining structures along the road adjoining the development area need to be implemented to avoid stability issues.

Land use changes

Land use changes are expected to be minimal, as the total extent of development area is only 0.133 ha, and all the project components will be constructed within this footprint. The site currently supports a degraded but narrow strip of riparian vegetation, closely bordered by agri-horticultural plantations of cocoa and mixed crops. The discontinuous line of riparian trees and bushes houses few remnants of riparian trees such as *Humboltia vahliana* (Karappongu), *Elaeocarpus tuberculatus* (Bhadraksham), *Madhuca neriifolia* (Attilippa), *Vateria indica* (Vellappayin), *Calophyllum apetalum* (Cherupunna), and *Persea macrantha* (Ooravu), along with a few shrubs including *Strobilanthes ciliata* (Karinkurinji), *Bauhinia phoenicea* (Vallimandaram), *Glycosmis pentaphylla* (Panal), *Homonoia riparia* (Puzhavanchi), and thickets *Ochlandra travancorica* (Eetta). Several invasive weeds such as *Mikania micrantha* are well established in the area, together with a few garden escapes, primary colonisers and nomadic species, indicating high degree of disturbance.

Impacts on biological environment

The anticipated impacts of the proposed hydropower project on ecological and biological environment with respect to flora, habitats and ecosystems, species assemblages, richness and diversity, endemism and rarity, are discussed below.

Impacts on flora

The project is proposed in an area under intensive agri-horticultural use interspersed with sparse human settlements. The riparian vegetation along Kothamangalam thodu including the proposed project stretch and its upstream and downstream reaches is discontinuous and highly vulnerable due to its close proximity to plantations, and also invasion by several weeds, notably *Mikania micrantha* (Dhritharashtra-pacha). These weeds along with other exotic garden escape species have colonised in the sunlit gaps along the stream. The invasion by primary colonisers and nomadic species such as *Trema orientalis* (Amathali), *Macaranga peltata* (Vatta), and *Mallotus philippensis* (Thavatta) is particularly noteworthy.

Nevertheless, remnants of native riparian trees and shrubs persist in the area. The tree species recorded include *Humboltia vahliana* (Karappongu), *Elaeocarpus tuberculatus* (Bhadraksham), *Madhuca neriifolia* (Attilippa), *Vateria indica* (Vellappayin), *Calophyllum*

apetalum (Cherupunna), *Persea macrantha* (Ooravu), *Litsea coriacea* (Maravettithali) and *Ochrenauclea missionis* (Attuvanchi). Shrubs include *Strobilanthes ciliata* (Karinkurinji), *Glycosmis pentaphylla* (Panal), *Bauhinia phoenicea* (Vallimandaram), *Homonoia riparia* (Puzhavanchi), and *Ochlandra travancorica* (Eetta). Among these, *Calophyllum apetalum*, *Humboltia vahliana*, *Vateria indica*, *Ochrenauclea missionis*, *Litsea coriacea*, *Ochlandra travancorica* and *Bauhinia phoenicea*, are endemic to the Western Ghats. As per the IUCN Red List, *Humboltia vahliana* is classified as Endangered; while *Calophyllum apetalum*, *Bauhinia phoenicea*, *Ochrenauclea missionis*, *Strobilanthes ciliata* and *Vateria indica* are listed as Vulnerable. Notably, *Humboltia vahliana* shows relatively wider distribution and good regeneration in the area. Although these species are present in the upstream and downstream contiguous stretch of the proposed weir, all practical efforts would be made to avoid disturbance to these peripheral riparian zones during construction. These conservation significant species may also be included in the compensatory tree planting, subject to identification of suitable land in the vicinity of the project area. Further, population restoration of these riparian species in the project influenced stretch and its upstream and downstream areas may be considered, in consultation with the Forest Department, as an environmental commitment of the project proponent. This will help stabilise the stream banks, as these native tree species are deep-rooted and support soil microflora, thereby improving soil structure and fertility.

Enumeration of trees in the proposed project development site is presented in Table-11. This includes a total of 13 trees, under 10 species. Of these, *Artocarpus hirsutus* (Anjili), *Ochrenauclea missionis* (Attuvanchi), *Calophyllum apetalum* (Attupunna), *Litsea coriacea* (Maravettithali), and *Vateria indica* (Vellappayin) are endemic to the Western Ghats. As per the IUCN Red List, *Tectona grandis* (Thekku, Teak) is Endangered, and *Calophyllum apetalum*, *Ochrenauclea missionis*, and *Vateria indica* are Vulnerable. These trees are fairly well distributed in the forest systems within the study area and in different parts of the Western Ghats. Teak is commonly cultivated in forest plantations and homesteads, while *Artocarpus hisutus* (Anjili) occurs naturally in homesteads, forests, and other wilderness areas.

Table-11: Species-wise and girth-wise enumeration of trees in the project site

Sl. No.	Scientific name	Local/common name	Girth (GBH) (cm)	Bole height (m)
1.	<i>Artocarpus hirsutus</i> Lam	Anjili, Wild jack	121	6.0
2.	<i>Artocarpus hirsutus</i> Lam	Anjili, Wild jack	93	7.0
3.	<i>Artocarpus hirsutus</i> Lam	Anjili, Wild jack	69	4.0
4.	<i>Artocarpus hirsutus</i> Lam	Anjili, Wild jack	120	20.0
5.	<i>Calophyllum apetalum</i> Willd.	Attu-punna	80	6.0
6.	<i>Litsea coriacea</i> (Heyne ex Meisn.) Hook.f.	Maravettithali	80	8.0
7.	<i>Macaranga peltata</i>	Vatta	90	10.0

8.	<i>Mangifera indica</i> L.	Mavu, Mango	83	5.0
9.	<i>Monoon fragrans</i> (Dalz.) B. Xue & R.M.K. Saunders	Nedunar	72	4.0
10.	<i>Ochrenauclea missionis</i> (Wallich ex G. Don) Ridsd.	Attuvanchi	145	4.0
11.	<i>Tectona grandis</i> L.f.	Thekku, Teak	77	4.0
12.	<i>Tetrameles nudiflora</i> R. Br.	Cheeni	102	5.0
13.	<i>Vateria indica</i> L.	Vellappayin, White dammar	275	20.0

Impacts on terrestrial and aquatic fauna

The proposed project is located in a landscape, predominantly comprising plantations with small patches wild growths and a narrow riparian strip along the stream. The plantations in the vicinity consisting mixed crops and scattered tree cover, provide canopy continuity, shade, ground vegetation and habitat edges that support various faunal groups. The area does not represent an intact forest system but rather a modified habitat mosaic. Faunal observations in 5 km radial zone of the proposed site indicate the presence of butterflies, odonates, amphibians, reptiles, birds and small mammals, each associated with specific microhabitats. Odonates and butterflies were recorded along flowing reaches of the stream, shallow margins and vegetated banks, while amphibians were observed around seepage zones, shaded understorey and small pools.

The confluence downstream of the project site, where the Kothamangalam thodu meets another feeder stream, is observed to support stream-associated fauna, predominantly odonates, that rely on shaded banks, clear water and depth variation. Riparian vegetation in this area provides suitable perching and breeding sites. The damp areas along the stream margins also support butterflies providing for mud puddling. These faunal groups are not confined to the project footprint but occur in similar habitats throughout the surrounding landscape. Their distribution is influenced primarily by vegetation continuity, water availability, substrate heterogeneity, and microclimatic conditions, rather than by the presence of extensive, undisturbed forest tracts.

A few fish species were observed in shallow flowing sections and small pools of the stream. No fishing activities or evidence of fish harvesting were recorded. The fishes observed are non-migratory and capable of short-range movements within perennial channels. Their persistence is linked to flow continuity and water quality. Additionally, the project area and its peripheral zone are not located within any established movement corridor for elephants or other large mammals, and regular passage of such species is not evident. Consequently, impacts on large-scale animal movement, migration or forage access are not anticipated.

The most probable impacts of the project are localised and temporary, arising during construction. These include removal of vegetation near the stream bank, disturbance from

machinery, noise, and temporary alteration of microhabitats. Such disturbances may influence short-term use of stream margins, plantation edges and shaded areas by insects, amphibians, reptiles, birds and small mammals. Formation of a small upstream waterbody will not create a physical barrier and is unlikely to restrict terrestrial movement, given its limited area and shallow character. Under stable flow conditions, the small impoundment may even serve as an additional water source for fauna during dry periods. Post-construction impacts are likely to remain minimal provided that riparian vegetation and downstream flow are maintained. Overall, the assemblage recorded during the study reflects a habitat that can continue to support existing fauna under modified conditions, with impacts expected to be limited to the immediate construction zone and reversible with proper management.

Impacts on socio-economic and cultural environment

As the project implementation does not involve loss of arable land, residential areas, or other properties, socio-economic impacts are expected to be minimal. On the contrary, the project is anticipated to benefit the local community through improved power availability, and the potential expansion of agriculture-based small-scale industries, along with opportunities for hydel and educational tourism. The project execution will not affect the livelihood options or economic activities of the local population. In fact, it is expected to enhance employment prospects and support economic development. Furthermore, the proposed project will not adversely affect any sites of cultural, religious, aesthetic or of archaeological significance.

Assessment of cumulative environmental impacts of hydro-electric power projects in Kaliyar river basin

The Vellakayam Micro Electric Project (90 KW) is proposed in Kothamangalam thodu, a third order tributary of Mullaringad puzha, which in turn is a tributary of Kaliyar river before joining the Muvattupuzha river. Within the river basin of Mullaringad puzha, another micro hydropower scheme, the Pattayakudy Micro Hydro Electric Project with an installed capacity of (100 kW) is also proposed by the same proponent utilising the stream flow of Mullaringad thodu, at Pattayakudy. The two streams merge at Mullaringad before flowing into the Kaliyar river. Fig. 08 shows the locations and catchment areas intersected by both projects. The Kaliyar river has a total catchment area of 586.63 km², of which the Vellakayam and Pattayakudy catchments cover 4.65 km² (0.79%) and 4.69 km² (0.80%) respectively, together accounting for only 1.59% (9.34 km²) of the Kaliyar basin. Terrain features, land use patterns and other environmental characteristics are similar across the two sites, with no significant forest cover except for the riparian vegetation belts, which remain degraded due to agricultural and other human activities.

Since both hydropower projects are designed as run-of-the-river schemes, and together involve only 1.59% of the catchment area with no diversion of surface flow, their combined impact on surface water availability is expected to be minimal. Given the absence of

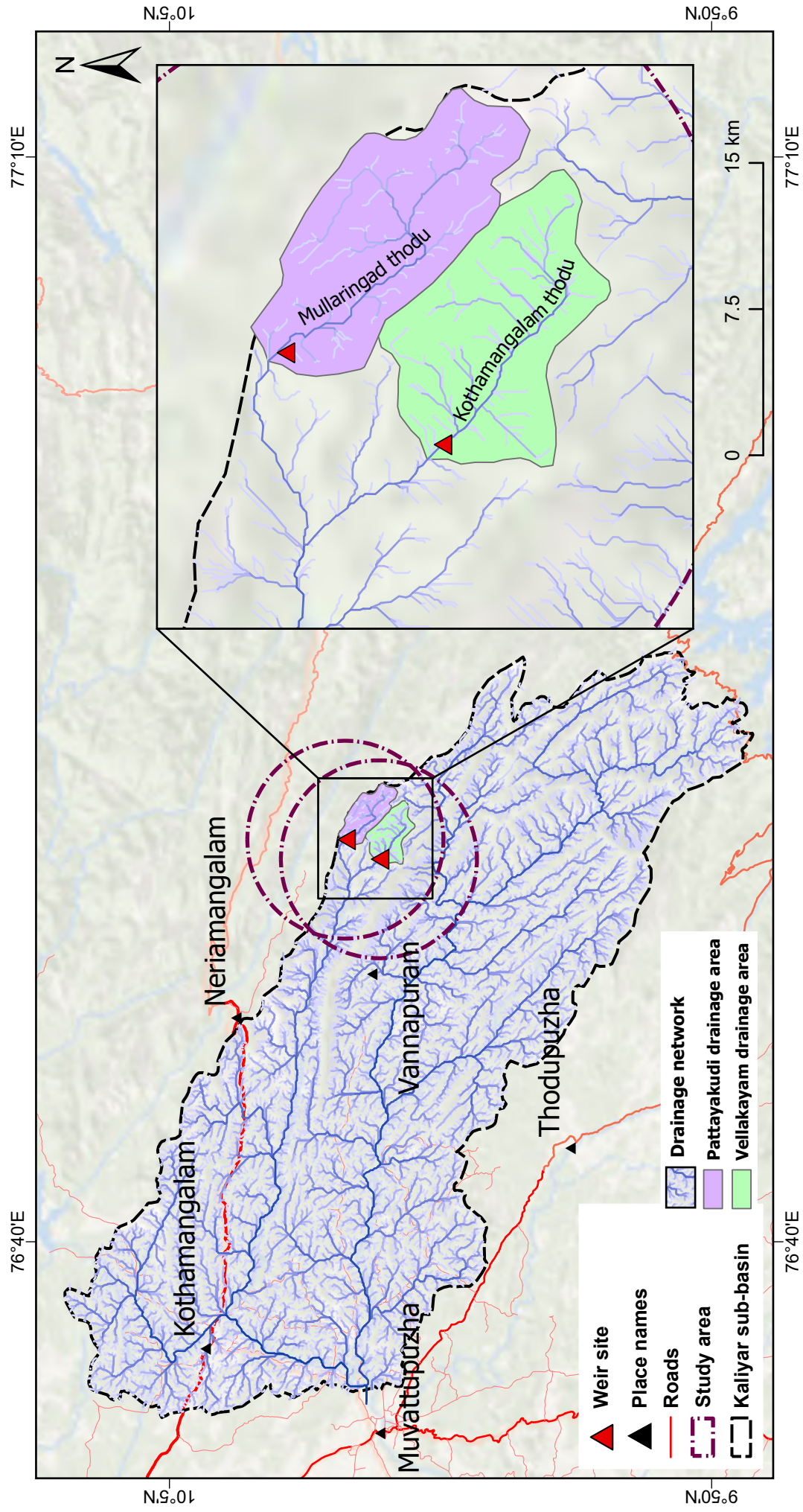


FIG. 8: VELLAKAYAM MICRO HYDRO ELECTRIC PROJECT

LOCATION AND CATCHMENT AREA OF THE VELLAKAYAM AND PATTAYAKUDI HYDRO ELECTRIC PROJECTS IN THE KALIYAR RIVER BASIN

natural forest cover in the catchments and the negligible submergence and land use modification, the cumulative environmental impacts are also expected to be minor. Impacts on flora and fauna are also less significant and expected to be limited to the immediate construction zone and are largely reversible with appropriate management. Additionally, both projects are located in moderately steep terrain without unstable slopes, further reducing concerns related to slope stability. As water used for power generation is released back into the river system, the overall water budget remains unaffected.

05. ENVIRONMENTAL MANAGEMENT PLAN

Environmental Management Plan (EMP) is designed to mitigate the anticipated adverse impacts of a development project and to ensure sustained quality of the environment. In general, the EMP outlines all aspects of project planning, construction and operation that are relevant to environmental resources and processes. It translates the recommended mitigation and monitoring measures into specific actions that are to be implemented by the project proponent. Environmental management involves identification of mitigation and compensation measures for all significant impacts. In the present EMP, due regard is given to environmental protection throughout the entire project. To achieve this, a set of recommendations have been made to ensure that the proponent maintains adequate control over the project activities, minimises the extent of impacts during execution, restores areas affected by construction, and prevents long-term ecological degradation. The programmes and measures for sound environmental management during the pre-construction, construction and operation phases of the proposed project are summarised below.

Management measures for pre-construction and construction phases

Establishment of accommodation facility and rest-shed for workers

A significant number of the workforce is expected to comprise labourers from other parts of Kerala as well as migrant workers from other states. To ensure effective and timely execution of the project, it is essential to provide accommodation facility for skilled and semi-skilled workers, technical personnel, and supervisory staff. While organizing such facilities, utmost care must be taken to minimize any negative impacts on the river/stream systems, as well as natural habitats or other wilderness areas. It is therefore proposed that accommodation facilities be arranged in rented buildings equipped with adequate power supply, water availability, sanitation facility, and waste disposal arrangements. Also, a temporary rest-shed with proper sanitation facilities shall be provided at the construction site for the use of workers and technical personnel associated with the project construction. Adequately treated and filtered drinking water shall be provided at the construction site for all workers.

Facility for disposal of construction debris and other wastes

Debris generated during earthworks, vegetation clearing, and removal of loose soil from the sites of the weir, forebay tank and powerhouse, and other wastes generated during construction must not be dumped into the stream or along its banks, in order to prevent deterioration of water quality. It is essential that all cleared debris and spoils be collected promptly soon after generation and disposed of in a systematic and environment-friendly manner. The use of single-use plastic carry bags and other disposable plastic materials shall be strictly avoided.

Control of air quality deterioration and noise pollution

Temporary air contamination and noise pollution are expected during the construction phase due to earthworks, operation of heavy machinery, transport of materials, stone crushing, and the use of cement and sand. To minimize long-distance transportation and associated emissions, the project proponent proposes to source rock materials, ready-mix concrete and steel from the nearby quarries, commercial units, and authorised dealers. The spread of suspended particulates during construction can be effectively controlled through intermittent sprinkling of water. It is also important to use only good quality, fuel-efficient machinery, which cause minimum emission and noise, thereby reducing impact on the surrounding environment.

Management of impacts on fauna

Minimising impacts on fauna during construction requires maintaining habitat features that support the existing life forms. All construction activities should be confined to designated work areas, and vegetation removal must be restricted to what is strictly necessary for civil works. Unnecessary clearing of riparian vegetation, understory shrubs or canopy trees should be avoided. Stream flow downstream of the weir should be maintained throughout the year, as continuous water availability is essential for aquatic insects, amphibians and fishes. Provision of ecological flow will help maintain shallow margins, shaded pools and riffle sections, and thereby preventing desiccation of the downstream channel.

To reduce sedimentation and to protect aquatic habitats, slope stabilisation and silt control measures should be applied near excavated areas. Excavated material, and construction debris should not be allowed to enter the stream. Retaining ground cover, leaf litter, fallen logs and pebbles will preserve microhabitats used by reptiles and amphibians for shelter and thermoregulation. Plantation areas adjoining the development site should remain undisturbed except for access routes, as these provide canopy connection and foraging grounds for birds, butterflies and arboreal fauna.

Management measures for the post-construction phase

Downstream releases

As stated earlier, the project implementation will result in reduced flow in 124 m long downstream stretch of the stream, between diversion weir and the tail race confluence point. The stream joins Mullaringad puzha 1.9 km downstream of the weir; therefore, the stretch directly affected by flow reduction is confined to this 124 m long segment. A reduction in stream flow, particularly during the lean months, will adversely affect aquatic and riparian habitats in this stretch, if not adequately managed through downstream releases. To address this, it is recommended that a minimum average flow 0.5 m³/s, equivalent to 20% of the present dry weather flow during the summer months, be released from the weir to ensure that downstream aquatic and riparian habitats are not affected. The calculation of ecological flow is summarised below.

Calculation of ecological flow

Ecological flow (E-flow) refers to the minimum quantity of water that must be released downstream of the weir to maintain the ecological balance of the river system. The flow is essential for maintaining aquatic habitats, and sediment transport, while preserving the ecological health of downstream river or stream stretch. As per guidelines by the Ministry of Environment, Forests and Climate Change (MoEFCC, 2018) and the Central Water Commission (CWC), a minimum of 20% of the average flow during the leanest months should be released as ecological flow. The ecological flow for the present project has been estimated using the hydrological method based on lean-season average flow data. The mean annual or lean-season flow (QMAF) for Kothamangalam thodu is considered as 2.5 m³/s. Accordingly, 20% of the lean season flow has been adopted for determining the required E-flow.

The ecological flow is calculated using the following formula:

$$Q_{eco} = P \times QMAF$$

Where, Q_{eco} = Ecological flow (m³/s); P = Minimum percentage of flow (0.2); and $QMAF$ = Mean annual flow or average lean season flow (m³/s).

Given,

$$QMAF = 2.5 \text{ m}^3/\text{s}, Q_{eco} = 0.2 \times 2.5 = 0.5 \text{ m}^3/\text{s}$$

the minimum ecological flow required downstream is 0.5 m³/s.

Sluice gate capacity verification

The discharge capacity of the sluice opening is determined using the standard orifice discharge formula:

$$Q = C_v \times B \times H^{3/2}$$

Where, Q = Discharge through sluice (m³/s); C_v = Coefficient of discharge (1.75 coefficient from CWC Manual for rectangular notch; B = Width of opening (m); and H = Height of opening (m)

Given, $B = 1.0 \text{ m}$, $H = 2.0 \text{ m}$,

$$\text{then } Q = 1.75 \times 1 \times 2^{3/2} = 4.94 \text{ m}^3/\text{s}$$

Thus, the minimum ecological flow required to be released downstream is 0.5 m³/s, while the capacity of the sluice gate is 4.94 m³/s.

Management of aquatic and riparian habitats

Since no fishing activity is currently practiced in the stream, this condition should be maintained by avoiding any encouragement of harvesting or baiting. If intake structures are used, may be fitted with screens to minimise entrapment of fishes. After construction, disturbed surfaces should be restored either through natural regeneration or by planting native species to re-establish shade, bank stability and habitat complexity.

Seasonal monitoring, especially during monsoon and post-monsoon periods, when faunal activity peaks, should be undertaken, to track stream flow, bank stability, vegetation

recovery and presence of representative faunal groups. If localised declines or changes in habitat use are detected, management actions such as selective planting, erosion control or adjustment of flow release should be implemented. By retaining riparian vegetation, ensuring ecological flow, limiting disturbance, restoring ground cover and conducting periodic monitoring, the micro-dam project can be executed and operated with minimal long-term ecological disruption, while allowing butterflies, odonates, amphibians, reptiles, birds and small mammals to continue utilising the area.

Desilting and downstream flow of sediments

During operation, silt deposition occurs in the inundation area, predominantly near the weir. In small hydropower projects, the normal sediment (silt) removal practice is to keep the sluice gate open during the lean season. With the onset of the monsoon, the initial flows carry a high concentration of silt and sediments that would normally be transported downstream by the river flow. This silt-laden flow is therefore allowed to pass through the sluice gate. Once the water becomes relatively clear, the sluice gate is closed and the flow is diverted through the overflow section of the weir. This operation will be carried out periodically, typically on a monthly basis, as maintaining adequate water flow and optimal water quality is essential for efficient power generation under the scheme. The practice will also facilitates downstream sediment transport, which is critical for sustaining aquatic and amphibious habitats.

Compensatory (tree planting) afforestation

The project requires 0.133 ha (0.329 acre) of land located along the stream, including the riparian belts, which is classified as forest land, under Section 9(3) of Kerala Government Land Assignment Act, 1960. Accordingly, compensatory tree planting is recommended in 0.133 ha of land identified by the Forest Department, involving native species. A list species (provisional) for compensatory planting is provided in Table-12. These include the conservation significant species found in the riparian belts near the project site, with the objective of population enhancement of such species. However, the component species shall be finalised in consultation with the Forest Department in consideration of the land characteristics of the selected site.

Table-12: List of species to be considered in the compensatory planting

Sl. No.	Scientific name	Family	Vernacular name
1.	<i>Artocarpus hirsutus</i>	Moracea	Anjili
2.	<i>Bauhinia malabarica</i>	Caesalpiniaceae	Arapuli
3.	<i>Bauhinia phoenicea</i>	Fabaceae	Vallimandaram
4.	<i>Briedelia retusa</i>	Euphorbiaceae	Mulluvenga
5.	<i>Buchanania lanzan</i>	Anacardiaceae	Moongapezhu
6.	<i>Butea monosperma</i>	Fabaceae	Chamatha
7.	<i>Calophyllum apetalum</i>	Clusiaceae	Cherupunna
8.	<i>Canarium strictum</i>	Burseraceae	Kunthirikkam

9.	<i>Carallia brachiata</i>	Rhizophoraceae	Vallabham
10.	<i>Cinnamomum malabattrum</i>	Lauraceae	Vayana
11.	<i>Dalbergia latifloila</i>	Fabaceae	Eetti
12.	<i>Dimocarpus longan</i>	Sapindaceae	Chempoovam
13.	<i>Diospyros bourdillonii</i>	Ebenaceae	Karimaram
14.	<i>Dysoxylum malabaricum</i>	Meliaceae	Vellakil
15.	<i>Elaeocarpus serratus</i>	Elaeocarpaceae	Kara
16.	<i>Flacourtia montna</i>	Flacourtiaceae	Charalpazham
17.	<i>Garcinia gummi-gutta</i>	Clusiaceae	Pinampuli
18.	<i>Hopea parviflora</i>	Dipterocarpaceae	Kambakam
19.	<i>Hopea ponga</i>	Dipterocarpaceae	Naikambakam
20.	<i>Humboldtia vahliana</i>	Caesalpiniaceae	Karappongu
21.	<i>Hydnocarpus alpina</i>	Hippocrataceae	Kattumarotti
22.	<i>Hydnocarpus pentandrus</i>	Flacourtiaceae	Marotti
23.	<i>Lagerstroemia microcarpa</i>	Lythraceae	Venmizhavu
24.	<i>Litsea coriacea</i>	Lauraceae	Maravettithali
25.	<i>Madhuca neriifolia</i>	Sapotaceae	Attilippa
26.	<i>Mangifera indica</i>	Anacardiaceae	Mavu
27.	<i>Mesua ferrea ssp. ferrea</i>	Clusiaceae	Nagachempakam
28.	<i>Ochlandra travancorica</i>	Poaceae	Eetta, Eera
29.	<i>Ochrenauclea missionis</i>	Rubiaceae	Attuvanchi
30.	<i>Olea dioica</i>	Oleaceae	Edana
31.	<i>Stereospermum colais</i>	Bignoniaceae	Poopathiri
32.	<i>Syzygium cumini</i>	Myrtaceae	Njaval
33.	<i>Terminalia arjuna</i>	Combretaceae	Neermaruthu
34.	<i>Terminalia bellirica</i>	Combretaceae	Thanni
35.	<i>Terminalia crenulata</i>	Combretaceae	Thenpavu
36.	<i>Terminalia paniculata</i>	Combretaceae	Maruthi
37.	<i>Tetrameles nudiflora</i>	Datisceae	Cheeni
38.	<i>Vateria indica</i>	Dipterocarpaceae	Vellappayin
39.	<i>Vitex altissima</i>	Verbenaceae	Mayila
40.	<i>Xylia xylocarpa</i>	Mimosaceae	Irul

The approximate cost for implementing the compensatory planting, including land cost and maintenance for 10 years is estimated at INR 20,00,000. This amount or the cost approved by the State Forest Department, shall be transferred to the ad-hoc State Compensatory Afforestation Fund Management and Planning Authority (State CAMPA) account. If non-forest land is identified for compensatory planting, the area shall be transferred and mutated in favour of the State Forest Department and subsequently declared as reserved or protected forest under the relevant sections of the Forest Acts.

Net Present Value of Forests (NPV)

The Net Present Value of Forests (NPV) is the fund to be realized from the user agency (project proponent) to compensate for the consequential loss of environmental benefits (soil protection, maintenance of wildlife habitats, microclimate and ecological balance) that could have accrued from the forestland, had it not been diverted for non-forestry purpose. These amounts are intended to be made use of for getting back the benefits in the long run which are lost due to diversion of the forestland. This is in addition to the funds for compensatory afforestation. Though technical judgment would be primarily applied in determining the losses, the Forest (Conservation) Act (1980) has given a thumb rule, for assessment of environmental value of one hectare of fully forest (density: 1.0) would be taken as INR 126,74,000 (Rupees 126.74 lakhs) to accrue over a period of 50 years. A project which requires deforestation is considered to give a positive cost-benefit ratio, if the monetary return from the project is more than the environmental value. The above figure of assumed environmental value will change proportionately, if there is an increase in the bank rate. The current rate of net present value (NPV) fixed by the Government of India is INR 11,16,9000 (Rupees 11.69 lakhs) per hectare for Class-I open forests as MoEFCC File No. 5-3/2011-FC Vol-1 dated 06 January 2022. The 0.133 ha of forestland to be diverted is mainly occupied by a dissected riparian vegetation and associated trees having a crown density of about 50% to 60%. Consequently, considering an average value of 55%, the NPV to be remitted to the State CAMPA account works out to INR 81,708.55 (0.133 ha x 11.17 lakhs x 0.55 = INR 0. 8170855 lakhs).

Environment monitoring plan for the construction and operation phases

Periodic monitoring of environmental status/quality is essential for ensuring sustainability of any water-related project. Regular/periodic assessment of environmental indicators helps identify potential issues and enables timely implementation of effective remedial measures. The baseline data on the existing environment generated by the present study can serve as reference for future evaluation of environmental quality. The environmental monitoring programme may focus on the following areas:

- changes in landscape, habitats and ecosystems
- changes in vegetation, including species composition and diversity
- changes in faunal composition, including seasonal movements and migration
- variation in water quality, particularly within the reservoir and downstream areas
- fluctuations in aquatic life forms, especially fishes
- changes in agricultural and industrial activities in the surrounding areas
- socio-economic and cultural changes

Conclusion

Based on the assessment, it can be concluded that the project can be showcased as model for sustainable development. In lights of the facts and figures outlined in this report, the project merits favourable consideration by the regulatory authorities for implementation.

Salient features: VELLAKAYAM MICRO HYDRO ELECTRIC PROJECT

I. General information

Proponent:

Y. Sleebachen, Charuvila veedu, P.O. Chengamanad, Kottarakkara-691557
Kollam District, Kerala State

Status:

Independent Power Producer

Project type:

Run-of-the river scheme

Category:

Micro Hydro Electric Project (90 kW)

Operation:

The capital investment for the project will be made by the Independent Power Producer (IPP), and the project proponent shall be responsible for overall execution of the project, including technical compliance, safety assurance, quality control, and implementation monitoring. The power generated from the project will be distributed through Kerala State Electricity Board Limited (KSEBL) network through a power purchase agreement.

Period of implementation

One year

Project cost:

The total cost of the project is estimated at INR 164 lakhs based on 2017 estimates, while the levelized cost of energy is INR 6.64 per kWh in the first year, with an approximate payback period of approximately 10 years.

II. Project location

Geographical coordinates (weir site):

<i>Latitude:</i>	09° 59' 14.25" N
<i>Longitude:</i>	76° 50' 32.00" E
District:	Idukki
Taluk:	Thodupzha
Village	Vannappuram
Panchayat:	Vannappuram Grama Panchayat
River/stream:	Kothamangalam thodu, a sub-tributary of Kaliyar
River basin:	Muvattupuzha

III. Hydrology

Catchment area:	4.2 km ²
Annual average rainfall:	4063 mm
Annual runoff yield:	0.6623 Mm ³
Head (gross):	15 m
Head (net):	13 m
Discharge utilized:	1.7 cumecs

IV. Project components

Diversion weir

Type:	Straight gravity (PCC)
Bed level:	337.45 m above MSL
Deepest foundation level:	336.45 m above MSL
Top elevation:	339.45 m above MSL
Max. height (overflow section):	2.0 m
Min. height (non-overflow section):	3.2 m
Width:	3.4 m
Length (overflow section):	11.2 m
Length of non-overflow section	
• <i>Left flank:</i>	2.81 m
• <i>Right flank:</i>	13.32 m

Forebay cum desilting tank (concrete lined)

Dimension:	33.7 m X 8 m X 4 m
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Interconnecting channel

Length:	2.32 m
Cross section:	1.6 m wide and 2.5 m high (concrete lined)
Bed slope:	1 in 1000

Water conductor system

Intake and Trash rack

Location:	Foreshore of weir pondage
Type of Intake:	River intake channel of 1600 mm diameter
Controls:	One service gate (Vertical lift type)
Trash rack:	Vertical Type

Penstock Pipe

Type:	Mild steel (Surface type)
Number of pipes:	One
Total length:	102.5 m

Design velocity:	2,6 m/sec
Bifurcation pipes:	2 Nos. (8.5 m long)

Powerhouse

Location:	On the right bank of the stream
Type:	Open
Overall dimension:	14.06 m X 7.03 m
Generator floor level:	323.88 m above MSL

Electro mechanical equipment

Turbine

Type of turbine:	PAT (Pump as a turbine)
Number of units:	Two
Output:	45 kW each
Rated speed:	1000 rpm

Generator

Type:	Induction
RPM:	1000 / 1500 rpm
Frequency:	50 Hz
Power Factor:	0.85

APPENDIX-02

List of flowering plants recorded from the Vellakayam MHEP project area and surroundings

Sl. No.	Scientific name of species	Family	Common/Vernacular name	Habit	Distribution
1.	<i>Acacia caesia</i> (L.) Willd.	Fabaceae: Mimosaceae	Incha	Climber	India, Sri Lanka, Malayan Archipelago
2.	<i>Acmella radicans</i> (Jacq.) R.K. Jansen.	Asteraceae	Venappacha	Herb	Exotic: Native to Tropical America
3.	<i>Aerva lanata</i> (L.) Juss.	Amaranthaceae	Cherula	Herb	Tropics and Subtropics
4.	<i>Ageratum conyzoides</i> L.	Asteraceae	Muriyan-pacha, Appa	Herb	Exotic: Native to Mexico; naturalised in the Tropics and Subtropics
5.	<i>Ageratum houstonianum</i> Mill.	Asteraceae	Appa, Nai-thulasi	Herb	Exotic: Native to Tropical America; naturalised in Tropical Asia
6.	<i>Albizia odoratissima</i> (L.f.) Benth.	Fabaceae: Mimosaceae	Pulivaka	Tree	India, Sri Lanka, Bangladesh, Bhutan, Myanmar, Malaysia, Thailand, Vietnam, Laos
7.	<i>Allophylus cobbe</i> (L.) Raeusch.	Sapindaceae	Mukkannan-pezhhu	Shrub	India, Sri Lanka, Myanmar, Malaysia, North Australia
8.	<i>Alloterris cimicina</i> (L.) Stapf	Poaceae	Summer grass	Herb	India, Sri Lanka, Old World Tropics
9.	<i>Alpinia galanga</i> (L.) Willd.	Zingiberaceae	Kolinchi	Herb	India, Myanmar, China, Laos, Cambodia, Vietnam, Thailand, Malesia, Borneo, Vietnam, Philippines
10.	<i>Alstonia scholaris</i> (L.) R. Br.	Apocynaceae	Ezhilampala	Tree	India, Sri Lanka, Myanmar, China, Southeast Asia, Africa, Australia
11.	<i>Alternanthera bettzickiana</i> (Regel) G. Nicholson	Amaranthaceae	Calico plant	Herb	Exotic: Native to Tropical America; naturalised in Asia
12.	<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	Amaranthaceae	Alligator weed	Herb	Exotic: Native to South America; established in Indo-Malaysia and Australia

13.	<i>Alternanthera sessilis</i> (L.) R. Br. ex. DC.	Amaranthaceae	Kozhuppa-cheera	Herb	India, Sri Lanka, Tropics and Subtropics
14.	<i>Anacardium occidentale</i> L.	Anacardiaceae	Kasumavu	Tree	Exotic: Native to Tropical South America
15.	<i>Ananas comosus</i>	Bromeliaceae	Pineapple	Herb	Exotic: Native to Tropical South America
16.	<i>Areca catechu</i> L.	Arecaceae	Kamuku, Areca-nut	Tree	Exotic: Native to Philippines
17.	<i>Arenga wightii</i> Griff.	Arecaceae	Kattuthengu	Tree	Endemic to India (Western Ghats)
18.	<i>Artocarpus altalis</i> (Parkinson) Fosberg	Moraceae	Seema-chakka, Bread-fruit tree	Tree	Exotic: Native to Polynesia
19.	<i>Artocarpus heterophyllus</i> Lam.	Moraceae	Plavu, Jack-fruit tree	Tree	India, Sri Lanka, South East Asia
20.	<i>Artocarpus hirsutus</i> Lam	Moraceae	Anjili, Wild jack	Tree	Endemic to India (Western Ghats)
21.	<i>Axonopus compressus</i> (Sw.) P. Beauv	Poaceae	Kalappullu, Buffalo-grass	Herb	Exotic: Native to America
22.	<i>Barleria longiflora</i> L.f.	Acanthaceae	Long flower bush-violet	Shrub	Endemic to India (Peninsular India)
23.	<i>Bauhinia phoenicea</i> Wight & Arn.	Fabaceae: Caesalpinaceae	Vallimandaram	Climbing shrub	Endemic to India (Western Ghats)
24.	<i>Bidens pilosa</i> L.	Asteraceae	Black-jack	Herb	Exotic: Native to America
25.	<i>Biophytum reinwardtii</i> (Zucc.) Klotzsch.	Oxalidaceae	Mukkutti	Herb	India, China, Malaysia, Java, New Guinea
26.	<i>Blumea laevis</i> (Lour.) Merr.	Asteraceae		Shrub	Indo-Malesia
27.	<i>Boerhavia erecta</i> L.	Nyctaginaceae	Thazhuthama	Herb	Exotic: Native to Africa, China, Malaysia, America
28.	<i>Bridelia stipularis</i> (L.) Blume	Euphorbiaceae	Cheruka-panachi	Climbing shrub	India including Andaman Islands, Sri Lanka, South China, Myanmar, Africa, Philippines, Indonesia,

29.	<i>Calamus thwaitesii</i> Becc.	Areaceae	Valiya-chooral	Climbing shrub	India, Sri Lanka
30.	<i>Calophyllum apetalum</i> Willd.	Clusiaceae	Cherupunna, Attupunna	Tree	Endemic to India (Western Ghats)
31.	<i>Calopogonium mucunoides</i> Desv.	Fabaceae: Papilionaceae	Thottappayar	Climber	Exotic: Native to Tropical America
32.	<i>Canarium strictum</i> Roxb.	Burseraceae	Kunthirikkam, Black dammar	Tree	India, Myanmar, Thailand, China
33.	<i>Carica papaya</i> L.	Caricaceae	Papaya, Omakka	Tree	Exotic: Native to Tropical America
34.	<i>Caryota urens</i> L	Areaceae	Choondappana, Aanappana	Tree	India, Sri Lanka, Myanmar, Nepal, Malaysia, Singapore
35.	<i>Centrosema molle</i> Benth.	Fabaceae: Papilionaceae	Kattu-payar	Climber	Exotic: Native to Tropical America
36.	<i>Chromolaena odorata</i> (L.) King & Robins.	Asteraceae	Communist-pacha	Shrub	Exotic: Native to tropical and sub-tropical America; naturalised in Tropical Asia and Africa
37.	<i>Chrysopogon aciculatus</i> (Retz.) Trin.	Poaceae	Snehappullu	Herb	India, Sri Lanka, Myanmar, Nepal, China, Cambodia, Japan, Vietnam, Thailand, Malesia, Laos, Vietnam, Polynesia, Philippines, Australia
38.	<i>Cinnamomum malabatrum</i> (Burm. f.) Blume	Lauraceae	Vayana	Tree	Endemic to India (Western Ghats)
39.	<i>Cocos nucifera</i> L.	Areaceae	Thengu, Coconut tree	Tree	Exotic: Native to Central Indo-Pacific; nearly cosmopolitan
40.	<i>Coffea arabica</i> L.	Rubiaceae	Kappi, Coffee	Small tree	Exotic: Native to South Ethiopia and Yemen
41.	<i>Colocasia esculenta</i> (L.) Schott	Araceae	Madantha, Chembu	Herb	Pantropic

42.	<i>Commelina benghalensis</i> L.	Commelinaceae	Kanavazha	Herb	India, Sri Lanka, Tropical an Temperate Asia, Africa
43.	<i>Conyza canadensis</i> (L.) Cronq.	Asteraceae		Herb	Exotic: Native to North America
44.	<i>Corypha umbraculifera</i> L.	Areaceae	Kodappana	Tree	India, Sri Lanka
45.	<i>Costus pictus</i> D. Don ex Lindl.	Costaceae	Insulin-chedi	Herb	Exotic: Native of Mexico, introduced and cultivated
46.	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Asteraceae		Herb	Exotic: Tropical Africa and Madagascar; naturalised from Tropical Asia to Australia
47.	<i>Croton caudatus</i> Geisel	Euphorbiaceae	Umithinikkodi	Shrub	India, Sri Lanka, South East Asia, China
48.	<i>Croton hirtus</i> L.	Euphorbiaceae		Herb	Exotic: Native to Mexico, South America
49.	<i>Curculigo trichocarpa</i> (Wight) Bennet & Raizada	Liliaceae	Nilappana	Herb	India, Sri Lanka
50.	<i>Curcuma longa</i> L.	Zingiberaceae	Manjal, Turmeric	Herb	India, South Asia, Southeast Asia, Thailand
51.	<i>Curcuma zanthorrhiza</i> Roxb.	Zingiberaceae	Kattu-koova	Herb	Exotic: native to Indonesia
52.	<i>Cymbopogon citratus</i> (DC.) Stapf	Poaceae	Inchippullu, Lemon-grass	Herb	India, Tropical Asia
53.	<i>Cyperus cephalotes</i> Vahl	Cyperaceae		Herb	India, Sri Lanka, China, Malesia Myanmar, Thailand, Cambodia, Australia
54.	<i>Cyperus digitatus</i> Roxb.	Cyperaceae	Finger flat-sedge	Herb	India, Sri Lanka, Pantropics
55.	<i>Cyperus rotundus</i> L.	Cyperaceae	Muthanga	Herb	India, Sri Lanka, Cosmopolitan
56.	<i>Cyperus tenuiculmis</i> Boeck.	Cyperaceae		Herb	India, Sri Lanka, Old World Tropics
57.	<i>Dalbergia latifolia</i> Roxb.	Fabaceae: Papilionaceae	Eetti, Rosewood	Tree	India, Nepal, Pakistan, Laos, Cambodia, Vietnam, Malaysia
58.	<i>Desmodium scorpiurus</i> (Sw.) Desv.	Fabaceae: Papilionaceae	Beggar's lice	Shrub	Exotic: Native to Tropical America
59.	<i>Digitaria ciliaris</i> (Retz.) Koeler	Poaceae	Tropical crab-grass	Herb	India, Sri Lanka, Pantropics

60.	<i>Digitaria radicata</i> (Pers.) Miq.	Poaceae	Trailing crab-grass	Herb	India, Tropical Asia, Chania, Africa, Pacific Islands
61.	<i>Dimocarpus longan</i> Lour.	Sapinaceae	Chempoovam, Pasakkotta	Tree	India, Sri Lanka, China, Malesia Myanmar, Thailand, Cambodia, Taiwan, Borneo, Malayan Archipelago
62.	<i>Elaeocarpus tuberculatus</i> Roxb.	Elaeocarpaceae	Bhadraksham	Tree	India, Malaysia
63.	<i>Elettaria cardamomum</i> (L.) Maton	Zingiberaceae	Elam, Cardamom	Herb	India, Sri Lanka
64.	<i>Eleutheranthera ruderalis</i> (Sw.) Sch.-Bip.	Asteraceae	Ogiera	Herb	Native of Tropical America; established in Asia
65.	<i>Ensete superbum</i> (Roxb.) Cheesman.	Musaceae	Kalluvazha	Herb	Endemic to India (Peninsular India)
66.	<i>Entada rheedii</i> Spreng	Fabaceae: Mimosaceae	Parandavalli	Climber	India, Sri Lanka, Australia, Tropical South Africa, Tropical Asia
67.	<i>Eragrostis uniolooides</i> (Retz.) Nees ex Steud.	Poaceae	Chinese lovegrass	Herb	India, Sri Lanka, Nepal, South East Asia, Africa
68.	<i>Erythrina stricta</i> Roxb.	Fabaceae: Papilionaceae	Murukku	Tree	India, Bhutan, Nepal, Bangladesh, China, Tibet, Myanmar, Laos, Cambodia, Thailand Vietnam
69.	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Kuzhinakhappala	Herb	India, Sri Lanka, Pantropics
70.	<i>Evolvulus nummularius</i> (L.) L.	Convolvulaceae		Herb	Exotic: Native to Brazil
71.	<i>Ficus benghalensis</i> L.	Moraceae	Peral, Banyaan tree	Tree	India, Sri Lanka, Pakistan
72.	<i>Ficus exasperata</i> Vahl	Moraceae	Therakam	Tree	India, Sri Lanka, South West Asia, Tropical Africa
73.	<i>Ficus hispida</i> L.f.	Moraceae	Erumanakku	Tree	India, Sri Lanka. China, Australia. Malayan archipelago

74.	<i>Ficus racemosa</i> L.	Moraceae	Athi, Country fig	Tree	India, Sri Lanka, Pakistan, Nepal, Bangladesh, Myanmar, Laos, Malaysia, Indonesia
75.	<i>Ficus religiosa</i> L.	Moraceae	Arayal, Peepal	Tree	India, Sri Lanka, Pakistan, China, Vietnam, Thailand
76.	<i>Garcinia gummi-gutta</i> (L.) Robs., var. <i>gummi-gutta</i>	Clusiaceae	Kudampuli, Malabar gamboge	Tree	Endemic to India (Western Ghats)
77.	<i>Garcinia mangostana</i> L.	Clusiaceae	Mangosteen	Tree	Exotic: Native to Malaysia
78.	<i>Globba sessiliflora</i> Sim.	Zingiberaceae	Stalkless swan flower	Herb	India, Myanmar, Thailand
79.	<i>Glycosmis pentaphylla</i> (Retz.) DC.	Rutaceae	Panal, Panchi	Shrub	India, Sri Lanka, China, Myanmar, Malaysian Archipelago, Australia
80.	<i>Helicteres isora</i> L.	Sterculiaceae	Idampiri-valampiri	Shrub	India, Sri Lanka, Bhutan, Nepal, Bangladesh, Pakistan, China, Malesia Myanmar, Java
81.	<i>Heterotis rotundifolia</i> (Sm.) Jacq.-Fél.	Melastomataceae	Pink rose, Pink-lady	Shrub	Exotic: Native to Africa
82.	<i>Hevea brasiliensis</i> Muel.-Arg.	Euphorbiaceae	Rubber tree	Tree	Exotic: Native to Amazon basin
83.	<i>Hibiscus tiliaceus</i> L.	Malvaceae	Talippauthi	Tree	Exotic: Native of Tropical Asia, South America, Africa
84.	<i>Holigarna arnottiana</i> Hook.f.	Anacardiaceae	Charu	Tree	Endemic to India (Western Ghats)
85.	<i>Holigarna grahamii</i> (Wight) Kurz	Anacardiaceae	Anacharu, Valiya charu	Tree	India, Myanmar
86.	<i>Homonoia riparia</i> Lour.	Euphorbiaceae	Puzhavanchi	Shrub	India, Sri Lanka, Southeast Asia
87.	<i>Humboldtia vahliana</i> Wight	Fabaceae: Caesalpinhiaceae	Karapongu	Tree	Endemic to India (Western Ghats)
88.	<i>Hydnocarpus pentandrus</i> (Buch.-Ham.) Oken	Flacourtiaceae	Marotti	Tree	Endemic to India (Western Ghats)
89.	<i>Hyptis capitata</i> Jacq.	Lamiaceae	Knob weed	Herb	Exotic: Native of Tropical America; naturalised in India and Malaysia
90.	<i>Impatiens flaccida</i> Arn.	Balsaminaceae		Herb	India, Sri Lanka, Java

91.	<i>Indianthus virgatus</i> (Roxb.) Suksathan & Borchs.	Marantaceae	Malankoova, Kattukuppa	Shrub	India, Sri Lanka
92.	<i>Lagenandra ovata</i> (L.) Thw.	Araceae	Karimpola, Andavazha	Herb	India, Sri Lanka
93.	<i>Lagerstroemia speciosa</i> (L.) Pers.	Lythraceae	Poomaruthu, Manimaruthu	Tree	India, Sri Lanka, Pakistan, Myanmar, China, Malaysia, Indonesia, New Guinea
94.	<i>Lantana camara</i> L.	Lamiaceae	Aripoochedi	Shrub	Exotic: Native of Tropical America; naturalised in Tropics and Subtropics
95.	<i>Litsea coriacea</i> (Heyne ex Meisn.) Hook.f.	Lauraceae	Maravettithali	Tree	Endemic to India (Western Ghats)
96.	<i>Lophopetalum wightianum</i> Arn.	Celastraceae	Venkotta	Tree	India, Bangladesh, Myanmar, Indonesia, Malaysia
97.	<i>Macaranga peltata</i> Roxb. Muell.	Euphorbiaceae	Vatta	Tree	India, Sri Lanka, Thailand
98.	<i>Madhuca nerifolia</i> (Moon) H.J. Lam	Sapotaceae	Attilippa	Tree	India, Sri Lanka
99.	<i>Mallotus philippensis</i> (Lam.) Muell.-Arg.	Euphorbiaceae	Sindooramaram, Thavatta	Tree	India, Sri Lanka, Myanmar, China, Malaysia, Taiwan, Australia
100.	<i>Mangifera indica</i> L.	Anacardiaceae	Mavu, Mango	Tree	India, Sri Lanka, Myanmar, Laos, Cambodia, Vietnam, Thailand, Malesia
101.	<i>Manihot carthaginensis</i> ssp. <i>glaziovii</i>	Euporbiaceae	Kattu-rubber	Small tree	Exotic: Native to Brazil
102.	<i>Manihot esculenta</i> Crantz	Euporbiaceae	Maracheeni, Cassava	Shrub	Exotic: Native to Brazil
103.	<i>Melinis repens</i> (Willd.) Zizka	Poaceae	Natal grass	Herb	Exotic: Native to Africa, Arabian Peninsula
104.	<i>Memeceylon umbellatum</i> Burm.f.	Melastomataceae	Kalayam, Kasavu	Small tree	India, Sri Lanka
105.	<i>Mesosphaerum suaveolens</i> (L.) Kuntze,	Lamiaceae	Pandi-poochedi	Herb	Exotic: Native to America

106.	<i>Miconia crenata</i> (Vahl) Michelang.	Melastomataceae	Soap bush, Clidemia	Shrub	Exotic: native to South America; invasive in tropical regions
107.	<i>Mikania micrantha</i> Kunth,	Asteraceae	Drritharashtra-pacha	Climber	Exotic: Native to Central and South America; Pantropics
108.	<i>Mimosa pudica</i> L.	Fabaceae: Mimosaceae	Thottavadi	Herb	Exotic: Native to Tropical America; Pantropics
109.	<i>Mitracarpus hirtus</i> (L.) DC.	Rubiaceae	Tharavu	Herb	Exotic: Native to Tropical America
110	<i>Monoon fragrans</i> (Dalz.) B. Xue & R.M.K. Saunders	Annonaceae	Nedunar	Tree	Endemic to India (Western Ghats)
111.	<i>Musa paradisiaca</i> L.	Musaceae	Vazha, Plantain	Herb	India, Asia
112.	<i>Myristica fragrans</i> Houtt.	Myristicaceae	Jathi, Nutmeg	Tree	Exotic: Native to Maluku Islands
113.	<i>Nephelium lappaceum</i> L.	Sapindaceae	Rabutan	Tree	Exotic: Native to Southeast Asia
114.	<i>Ochlandra travancorica</i> (Bedd.) Benth. ex Gamble	Poaceae	Eetta, Eera	Shrub	Endemic to India (Western Ghats)
115.	<i>Ochreanauclea missionis</i> (Wallich ex G. Don) Ridsd.	Rubiaceae	Attuvanchi	Tree	Endemic to India (Western Ghats)
116.	<i>Oplismenus compositus</i> (L.) P. Beauv	Poaceae	Running mountain grass	Herb	India, Sri Lanka, Pantropics
117.	<i>Oroxylum indicum</i> (L.) Benth. ex Kurz	Bignoniaceae	Azhantha	Tree	India, Bhutan, China, Malaysia
118.	<i>Pandanus furcatus</i> Roxb.	Pandanaceae	Kaitha	Shrub	India, Sri Lanka, Myanmar, Bangladesh, Bhutan, Thailand, Laos
119.	<i>Pennisetum polystachyon</i> (L.) Schult.	Poaceae	Mission grass	Herb	Exotic: Native of Sub-Saharan Africa; Old World Tropics
120.	<i>Persea macrantha</i> (Nees) Kosterm.	Lauraceae	Ooravu	Tree	India, Sri Lanka
121.	<i>Pholidota imbricata</i> Hook.	Orchiaceae	Pannamaravazha	Herb	India, Sri Lanka, Tropical & Subtropical Asia, pacific islands

122.	<i>Piper nigrum</i> L.	Piperaceae	Kurumulaku, Pepper	Climber	India, Sri Lanka
123.	<i>Pongamia pinnata</i> (L.) Perre	Fabaceae: Papilionaceae	Ungu, Pongu	Tree	India, Sri Lanka, Bangladesh, Myanmar, Pakistan, Malaysia, Australia
124.	<i>Pothos scandens</i> L.	Araceae	Paruvakkodi	Climber	India, Sri Lanka, Bangladesh, Myanmar, China, Malaysia, Indonesia, Seychelles
125.	<i>Pueraria phaseoloides</i> (Roxb.) Benth.	Fabaceae: Papilionaceae	Thottappayar	Climber	India, Sri Lanka, Bangladesh, Bhutan, Myanmar, China, Thailand, Taiwan
126.	<i>Pycreus polystachyos</i> (Rottb.) P. Beauv.	Cyperaceae	Bunchy sedge	Herb	India, Sri Lanka, Cosmopolitan
127.	<i>Scleria lithosperma</i> (L.) Sw.	Cyperaceae	Nakkupullu	Herb	India, Sri Lanka, Tropics an Subtropics
128.	<i>Setaria barbata</i> (Lam.) Kunth	Poaceae	East Indian bristlegass	Herb	India, Sri Lanka, Myanmar, Bangladesh, Philippines, Indonesia, Africa
129.	<i>Setaria palmifolia</i> (J. Koenig) Stapf	Poaceae	Eenthappana-pullu, Palm grass	Herb	India, Sri Lanka, Old World Tropics
130.	<i>Sida acuta</i> Burm. f.,	Malvaceae	Anakkurunthotti	Shrub	India, Sri Lanka, Pantropics
131.	<i>Sida cordifolia</i> L.	Malvaceae	Kurunthotti	Herb	India, Sri Lanka, Pangtropics
132.	<i>Smilax zeylanica</i> L.	Liliaceae	Kareelanchi	Climber	India, Sri Lanka, Myanmar, Nepal, Malaysia
133.	<i>Spatholobus parviflorus</i> (Roxb. ex DC.) Kuntze	Fabaceae: papilionaceae	Athambuvali	Climber	India, Sri Lanka, Nepal, Bhutan, Myanmar, Thailand, Indonesia
134.	<i>Sphagnetocola calendulacea</i> (L.) Pruski	Asteraceae	Manja-kayyonni	Herb	India, China, Indonesia, Japan, Myanmar, Bangladesh, Sri Lanka, Philippines
135.	<i>Spondias pinnata</i> (L.f.) Kurz.	Anacardiaceae	Ambazham	Tree	India, Sri Lanka, Tropical Asia
136.	<i>Stachytarpheta jamaicensis</i> (L.) Vahl,	Lamiaceae	Chiravappalli	Shrub	Exotic: Native to Tropical America; naturalised in tropical Africa to Asia and Australia
137.	<i>Stachytarpheta urticifolia</i> (Salisb.) Sims	Lamiaceae	Blue snakeweed	Shrub	Pantropics
138.	<i>Stereospermum colais</i> (Buch.-Ham. ex Dillw.) Mabb.	Bignoniaceae	Pathiri, Poopathiri	Tree	India, Sri Lanka, Myanmar, Bhutan, Bangladesh

139.	<i>Strobilanthes ciliata</i> Nees	Acanthaceae	Karinkurinji	Shrub	India: Western Ghats (Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala)
140.	<i>Tectona grandis</i> L.f.	Verbenaceae	Thekku, Teak	Tree	India, Sri Lanka, Myanmar, Malesia
141.	<i>Terminalia bellerica</i> (Gaertn.) Roxb.	Combretaceae	Thanni	Tree	India, South and Southeast Asia
142.	<i>Terminalia paniculata</i> Roth	Combretaceae	Maruthu	Tree	Endemic to India (Peninsular region)
143.	<i>Tetrameles nudiflora</i> R. Br.	Dasticeae	Cheeni, Pontham cheeni	Tree	India, Sri Lanka, Old World Tropics
144.	<i>Tetrapilus dioicus</i> (Roxb.) L.A.S. Johnson	Oleaceae	Edana	Tree	India, Nepal, Bangladesh, Myanmar
145.	<i>Themeda triandra</i> Forssk.	Poaceae	Kangaroo grass	Herb	India, Sri Lanka, Myanmar, Laos, Cambodia, Vietnam, Thailand, Malesia, Bhutan, Vietnam, Polynesia, Philippines, Indonesia, Australia, Tropical Africa
146.	<i>Theobroma cacao</i> L.	Sterculiaceae	Cocoa	Small tree	Exotic: Native to South America; cultivated in Tropical regions
147.	<i>Thottea siliquosa</i> (Lam.) Ding Hou	Aristolochiaceae	Alpam		India, Sri Lanka
148.	<i>Trema orientale</i> (L.) Blume	Ulmaceae	Amathali	Tree	India, Sri Lanka, Myanmar, Laos, Cambodia, Vietnam, Thailand, Malesia, Vietnam, Polynesia, Philippines, Indonesia, Australia, Tropical Africa
149.	<i>Urochloa ramosa</i> (L.) T.Q. Nguyen	Poaceae	Browntop millet	Herb	India, Sri Lanka, Myanmar, Laos, Cambodia, Vietnam, Thailand, Malesia, Vietnam, Australia, Africa
151.	<i>Vanda testacea</i> (Lindl.) Rchb.f.	Orchiaceae	Maravazha	Herb	India, Sri Lanka, Nepal, Myanmar
152.	<i>Vateria indica</i> L.	Dipterocarpaceae	Vellappayin, White dammar	Tree	Endemic India (Western Ghats)

153.	<i>Vitex altissima</i> L.f.	Verbenaceae	Attumayila	Tree	India, Sri Lanka, Bangladesh, Laos, Cambodia, Vietnam, Malaysia
154.	<i>Zingiber officinale</i> Roscoe	Zingiberaceae	Inchi, Ginger	Herb	India, China, Southeast Asia, South Africa, Caribbean Islands
155.	<i>Zingiber zerumbet</i> (L.) J.E. Smith	Zingiberaceae	Kattinchi	Herb	India, Sri Lanka, Myanmar, Laos, Cambodia, Vietnam, Thailand, Malesia, Vietnam