Additional Principal Chief Conservator of Forests & Nodal Officer F(C), Act

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FC1-749/2019 **Date: .09.2025**

To

The Principal Secretary,
Forest & Wildlife Department,
Govt. Secretariat, Thiruvananthapuram.

Sir,

Sub:- Forest & Wildlife Department – Proposal for diversion of 0.9354 ha of forest land under section 2 of Forest (Conservation) Act, 1980 in Nilambur (North) Division for Valanthode Small Hydro Electric Project Scheme in favour of Kerala State Electricity Board Ltd. - regarding.

Ref:-
1. Ministry of Environment, Forest & Climate Change Letter No. F.No.4-KLB1318/2021-BAN/099 dated 30.11.2021.
2. Letter No. VLTN/SHEP/DB-14/2016-17/16 dated 07.11.2024 of KSEBL.

Kind attention is invited to the subject cited above. As directed by Integrated Regional Office, Bangalore vide letter under reference (1), the User Agency has conducted a scientific study through M/s CISSA (Centre for Innovation in Science & Social Action) on the impact of the proposal on the biodiversity of the proposed site. The KSEB (User Agency) has submitted the study report vide reference (2) and Chief Conservator of Forests (Eastern Circle) Palakkad has recommended the proposal as no significant threats or vulnerabilities have been identified. The project is recommended for approval on the condition that the User Agency agrees to implement the mitigation measures outlined in the scientific report. Copy of the scientific report is submitted herewith for kind perusal and onward submission to Regional Empowered Committee for consideration for implementing the above project.

Yours faithfully

Enclosure: Study Report by M/s CISSA

09/09/25

Additional Principal Chief Conservator of Forests & Nodal Officer F(C) Act

A STUDY ON THE STATUS OF BIODIVERSITY AND STRUCTURAL STABILITY OF PROPOSED VALANTHODE SMALL HYDRO ELECTRIC PROJECT

FINAL TECHNICAL REPORT

SUBMITTED TO

THE KERALA STATE ELECTRICTIY BOARD LIMITED

CENTRE FOR INNOVATION IN SCIENCE AND SOCIAL ACTION

VELLAYAMBALAM, THIRUVANANTHAPURAM

MARCH 2024

RESEARCH TEAM

Project Coordinator	Dr A G Pandurangan, Advisor, Environment and Biodiversity, CISSA
Joint Coordinator	Dr P N Krishnnan, Director, Ecology and Biodiversity, CISSA
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Terrestrial and Aquatic Fauna including Wildlife	i. Dr. M Balakrishnan, Former Professor, University of Kerala
	ii. Dr. S Anil Kumar, Former Researcher, University of Kerala.
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Project Personnel	i. M. Pradeepkumar, Administration, CISSA
	ii. Manu Prasad M J, Designer, CISSA
	iii. Akhila A. S., Reprographic Assistant, CISSA

Foreword

Energy is a critical component of a Nations's economic development. The progress of a country lies in the sustainable production and supply of energy economically to the people and other users for scientific, industrial and agricultural output. Energy can be produced in different ways by using coal, natural gas, nuclear, solar, thermal, hydel schemes etc. Among all these, hydel projects provide clean source of energy in the long run when compared to others. Kerala is endowed with lot of water potential and hence the State Government and Kerala State Electricity Board Ltd., had implemented several hydel projects to meet energy requirements. Valanthode is one such a scheme to be implemented after assessing the biodiversity wealth for safeguarding the environment by engaging CISSA's expertise.

I am glad to present the final technical report which is an outcome of the field investigation on the status of biodiversity and structural stability of the proposed Valanthode Small Hydroelectric Project. The project is located in the river Kurumanpuzha, a sub-basin of the river Chaliyar at Valanthode, Nilmbur Taluk of Malappuram district. The information contained in this report is based on original data generated through field exploration and analysis thereon. The institute takes full responsibility of the data generated, interpretations, conclusions and the probable impacts contained in this report.

I congratulate the entire study team, especially Dr A. G Pandurangan, Scientific Advisor and Dr P.N.Krishnan, Director (Ecology & Biodiversity), for co-ordination, meticulous planning, execution and bringing out the report in time. The team CISSA congratulate all the Subject-expert, officials of KSEB Ltd, State Forest Department, Local Self Government officials, other Stake holders who are all assisted in one or the other way to complete the study in a professional way to give equal weightage for Environment, Biodiversity and Development.

Thiruvananthapuram
15.03.2024

Dr. Sureshkumar .C
General Secretary, CISSA

Prefatory Note

Energy is vital for economic and social development. Among the various technologies available for power production, hydroelectric generation is perhaps the cleanest, cheapest and even the most traditional method, making best use of a renewable natural resources, which involves less pollution to the environment. The areas of concern with respect to hydel power development however, are soil erosion, submergence of land, deforestation, seismic impact and the rehabilitation of the displaced people. The power sector, now aware and concerned about the effects on the environment and ecology, has been preparing environmental impact assessment reports and action plans to mitigate the adverse impacts on environment.

The Valanthode SHEP was submitted by the State Government and KSEBL to the Ministry of Environment and Forest (MOEF&CC), Govt of India for Forest Clearnce. The expert committee of the MOEF&CC examined the proposal and requested the KSEBL to clarify the status of the biodiversity and the stability of the structures proposed to be developed for implementing the scheme. Against this background, the KSEBL entrusted the Centre for Innovation in Science and Social Action (CISSA), Thiruvananthapuram to assess the biodiversity status and structural stability of various components to be created based on our expertise to prepare the comprehensive report as part of the reply to Ministry of Environment, Forest and Climate Change (MOEF&CC), Govt of India. The CISSA formally entered into the agreement with KSEBL and successfully completed the study in a record of time.

The final technical report contains eight chapters which gave a total picture of the biodiversity of the area. The study covered project features, physical environment and biological environment covering forests, flora, ecology, fauna including wildlife, aquatic biology and possible impacts on them. Special attention has been given to the structural stability of the assets to be created.

At this juncture, I thank the Kerala State Electricity Board Limited, Kerala Forest Department, Subject Matter Specialists, LSG Officials etc for assisting this biodiversity study and the CISSA for bringing out the report in time.

Thiruvananthapuram
15.03.2024

Dr A G Pandurangan
Advisor & Project Coordinator, CISSA

ACKNOWLEDGEMENTS

The Project Coordinator and Joint coordinator wish to express their deep sense of gratitude and thanks,

- to Sri. Radhakrishnan, Former Director (Generation-Civil); Sri. A Shanavas, Former Director (Generation -Civil); Sri. Baburaj. O, Director (Generation-Civil), the Kerala State Electricity Board limited (KSEBL), Thiruvananthapuram for having confidence and awarding the Biodiversity Assessment Work.
- to Er. Haridas V. V, Chief Engineer, (Civil and Construction), North, Kozhikode for his kind co-operation, assistance in providing base document of the project and implementation of the study.
- to Kerala State Forest Department Particularly Dr. P. Pugazhendi IFS, Additional Principal Chief Conservator of Forests; Mr. Sanjayankumar IFS, Chief Conservator of Forests and Nodal Officer, F (C) Act , Forest Headquarters, Thiruvananthapuram for granting permission to take up the study.
- to the Deputy Conservator of Forest, Assistant Conservator of Forest, the Range Officer, Nilambur North Forest Division, Kerala Forest Department for providing logistic support in the field.
- to Dr.G.G. Gangadharan, President and Dr C Sureshkumar, General Secretary, CISSA for the support, encouragement and extending guidance for implementing the programme
- to Er. R. Ramesh, Former Executive Engineer, KSEBL for extending the technical support
- to Er Ajith, Assistant Executive Engineer, Office of Chief Engineer (North), Kozhikode for extending technical assistance
- to Er Abdul Karim. V. T, Assistant Executive Engineer and project Manager - in -charge, Nilambur for providing all the field and logistic support for conducting the field work.
- to Er Jazeel I.S, Assistant Engineer, Mrs. Shiney P.P, Sub Engineer, Sri. Muhammad Sadique. P, Overseer, Sri. Mujeeb.C.T and Sri. Saleem of Nilambur Project office for their field, logistic and local hospitality.
- Sri Benny of Thottappally for guiding and assisting in the field survey investigation.

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1. INTRODUCTION

Kerala is having a vast potential of hydro power still lying untapped. Hydro power, especially from small hydro power projects, is recognized as a renewable source of energy, which is economic, non-polluting, environmentally benign and need a relatively short time for implementation and not generally affected by the constraints associated with large hydroelectric projects. Also, such hydro power projects that are developed and operated in an economically viable, environmentally sound and socially responsible manner represent sustainable development at its best; that is to say "Development that meets the needs of the people today without compromising the ability of future generations to meet their own needs".

Realizing these facts, the State Government/ K.S.E. Board Ltd., have embarked on an ambitious programme for harnessing the known and yet to be known small hydropower resources of the state. The contribution of Small Hydro Power (or shall we say State's Hidden Potential), have become more significant as SHPs require minimum submergence, rehabilitation and minimal impact to environment. Despite a high initial cost and the work involved in steering the small hydro project to fruition, once installed the hydroelectric turbines offer the promise of clean green energy, almost for free.

Chaliyar basin is a mine of cascading small H.E schemes in Kerala. The Malabar migration during 70's created enough access to various tributaries of Chaliyar river of Western Ghats at various elevations. The forest involvement of different schemes identified in this basin is very minimal or practically nil. Preservation of forest and avoiding environmental impact is getting prime importance in the gestation of every project.

Valanthode Small H.E scheme is an environment friendly project in Chaliyar basin, which requires minimum forest land of just 1.4 Ha. This small HE Scheme is proposed as a run-of –the river scheme utilizing the inflow of Kurumanpuzha, in Chaliyar river basin. The river flow is intercepted by a gravity type weir and water is diverted to a fore bay tank through contour RCC Power canal and then a surface penstock carries the power draft to three Horizontal Francis turbines of installed capacity of 2.5 MW each. The total installed capacity of this small HEP is 7.5 MW and the annual power generation is 15.291 Mu (90% DY) under rated net Design Head of 89.44m.

1.1. Energy Demand versus Environmental Considerations

With 41 rivers, flowing down west-ward from the Western Ghats and joining the back waters and the Arabian Sea, Kerala has tremendous potential for hydel power generation. The total catchment area of these river systems within the political boundary of Kerala is 37884 km^2 (CWRDM, 1995). The State receives, on an average, about 3060 mm rain from South-West and North-East monsoons. The rainfall so obtained flows through the rivers and a number of rivulets criss-crossing the State to reach the sea or back waters in less than 48 hours leaving only a portion of the hydropower potential tapped / utilized at present.

Hydel power has become the main source of electric power in Kerala, because of the large number of rivers as mentioned above. Currently, about 70% of the total installed capacity for power generation in the state is from the hydel power project. An earlier estimate shows that the hydel power potential that can be developed at economical cost is 26 X 10^6 KW at 60% load factor within installed capacity of 3.6 X 10^6 KW (Govt. of Kerala, 1974). Inspite of the large number of rivers in the state and the high potential for power generation, only about 40% of the estimated potential is exploited so far (KSEB, 1998; Balaraman, 1999). Only 6 rivers of the 44, have been utilized for the development of hydel projects and remaining river systems are yet to be tapped for power generation.

Kerala's electricity requirement, peak demand to go up in the coming years as per the 20th power survey report of Central Electricity Authority (CEA, 2022). The Board struggle to balance the electricity demand and supply as the projected requirements for 2024-25 is expected to rise to 31,999 MU (Million Units) and peak demand to 5424 megawatts (MW). Data with the KSEBL indicated that electrical energy consumption has been steadily increasing in the state. Actual consumption in recent years were as follows; 2018-19 (21750.25 MU), 2019-20 (23058.91 MU) and 2020-21 (22504.32 MU). This shows that the state on an average witness a 3-4% increase every year. The 2023 summer months saw the peak demand at a new record of 5024 MW. In 2022-23 the State's annual energy requirements has stood at 27,607 MU. Production-wise, the internal generation meets only 30% and the rest is supplied from central generating stations and power purchases. However, KSEBL installed capacity in the power sector has risen from 2891.72 MW in 2013-14 to 3514.81 MW in 2022-23. In addition, Kerala is expected to add to its power generation capacity in 2023 through a slew of hydel initiatives. The power department has announced that from delayed hydel projects such as Pallivasal extension scheme (60MW), Poringalkuthu (24 MW), Thottiyar (40 MW) and Bhoothathankettu (24 MW) would be started power production soon. The KSEB, at present operating a number of schmes, improving expansion of the existing schemes and looking for new projects to meet the demand and avoid energy crisis in the future (Tables- 1,2 & 3).

Even with the implementation of all these schemes, Kerala will face a shortage in power. To face the anticipated gap between production and demand, a number of major hydel projects such as Puyankutty, Mananthavadi and Perinjankutty were proposed. All the major hydel projects are either dropped or kept pending due to environmental and socio-economic factors. Therefore, the Board is rethinking to set up several smaller hydel schemes which are more eco-friendly and put in use the shortest possible time. The present project is one such a thing being taken up for the biodiversity assessment.

It is well acknowledged that energy production, transformation, distribution and use have an important impact on the environment. These consequences may be general or site specific. Since the environmental forces are not a stable and static in nature, which are closely interrelated processes go on dynamically, sporadic instability makes the system highly sensitive. Therefore, any process of economic development must be geared to protect the environment, so that a system of organically integrated development may emerge. Nowadays, countries all over the world have begun to think about a policy on energy and look into a possibility of having energy systems with no or very limited environmental impacts. This is an outcome of the recognition that the seemingly boundless and bountiful nature has limits, and it is considered as one of the achievements of the last century.

1.2. Ecological Consequences of Hydel Projects

Hydel-power is the most important commercial renewable energy source, in the sense that it is the cheapest source of power generation and thought to be one of the cleanest sources of energy. India being blessed with a vast water resource potential, exploitation of these resources through various schemes is a major area of developmental activity of the Union and State Governments. Though the hydroelectric and irrigation projects have contributed a great deal in bringing about a wide range of changes in industrial development, agricultural production and other social aspects of life, their adverse effects have been felt on the environmental quality.

Major irrigation/ hydel projects in India have been executed mainly as civil engineering tasks neglecting their harmful effects on the ecosystem, soil quality, forestland, wildlife and other aspects of biosphere stability. When stress in such projects is laid on providing benefits to the downstream areas, environment of the catchment regions and upstream is invariably overlooked. This, as felt in main instances, resulted into rapid deforestation, loss of soil and water quality, extinction of plant species, endangered wildlife, natural hazards like earth – quake, imbalance in ecosystems, socio-economic and cultural instability, among many undesirable repercussions (Pandurangan and Nair, 1996). Further, recent studies have shown that hydropower is no more a 'zero emission technology', since hydel power stations contribute to green-house effect by giving off large amounts of both carbon dioxide and methane which accumulate in the atmosphere and trap solar heat. The main cause of this dam pollution is submergence of vegetational components, along with the accumulation of organic debris in the sediments of the reservoirs. The environment of the reservoir, devoid of oxygen and with relatively higher levels of nutrients, makes it ideal for methane producing decay process, while decaying plants breaking in the surface water produce CO_2 as does the rotting vegetation in oxygenated waters within a meter or so of the surface. These environmental processe are generally pertain to larger reservoirs and the impacts can be minimized by reducing the water holding capacity of the dams by suitabily modifying the projects by givning environmental considerations. In this background, the small hydroelectric schemes are handy and resolve many environmental issues that can be operated in an eco-friendly manner justifying concerns of all the stake holders who are all involved in this environmental ark.

1.3. Genesis of the Study

Kerala State Electricity Board Ltd., proposed for implementation of Valanthode Small Hydro Electric Project which is a run off-the-river scheme. It envisages construction of a diversion weir of maximum height of 9.5 meter and length of 101 meter across the Kurumanpuzha, a tributary of river Chaliyar. This will result in water impoundment of 0.22 Ha, of forest land which spread over river bed rock. It aims at generation of power in monsoon season only. The water stored in the weir is directed through open canal to fore bay tank and then to penstock for power generation. The water after power generation is let into the same river through the tailrace channel. The excess water will spill over the weir to the river itself during monsoon. The project with an installed capacity of 7. 5 MW and is expected to generate 15.291 million units per year as per KSEB proposal. During summer season power generation is not envisaged and there is no diversion of water to the canal from the reservoir. So, the project can ensure the presence of water in Kurumanpuzha round the year.

While implementing the project KSEB Limited is required 1.40 Ha of Forest land. Therefore, forest authorities from Deputy Conservator of Forest (DCF), Nilambur and Chief Conservator of Forest (CCF) from eastern circle were inspected and reported that 20 numbers of trees are to be felled in area proposed for diversion canal and 11 trees, 6 clumps of reeds and some undergrowth are expected to be submerged in FRL water level. The trees and other vegetal species present in the locality are not coming under endangered/threatened categories. The area proposed for the project is adjacent to forest land and wildlife presence was observed as per the local DFO's report. The authorities of KSEB Ltd. have claimed that no need of any forest land for constructing approach road to the project site and drawing transmission line to the substation. Finally, the State Forest Department recommended the project proposal for forest clearance from the Ministry of Environment, Forest and Climate Change (MoEF & CC), Govt of India.

KSEBL submitted the proposal of Valanthode Small hydro-electric project with the recommendations of Forest Department and State Government for consideration of Regional Empowered Committee, Ministry of Environment, Forest and Climate Change (MOEF&CC), Regional Office, Bengaluru. The Regional Empowered Committee considered the project subsequently and after a detailed discussions and deliberations, it was requested that KSEBL may submit the following additional informations such as:

1. The loss of Biodiversity and effect on special habitats such as nesting sites, spawning sites and special breeding grounds for fishes and other fauna.
2. Vulnerability of the structures proposed to be developed under the project to damage by flash floods which have earlier reported in this area.
3. Assessing suitable and viable alternative means of power generation using renewable energy.

In these circumstances, KSEBL approached the CISSA to undertake the assessment on the biodiversity of the project site, catchment area and downstream based on strong scientific basis and also to prepare the reply for the queries 1&2. The reply to the third question shall be prepared by the KSEBL itself. The clarifications sought out by the MOEF&CC in short demands assessment of biodiversity and on the geology aspects. Since the Board requested to complete the study in three months time from the date of approval, we carried out the study by rapid survey on the status of existing biodiversity as well as on the structural stability of the proposed structures from 18th October 2023 to 18th January, 2024. The study was further extended one more month till 18th February 2024. Now the data, collected from field investigation, laboratory, herbaria, traditional knowledge from locals etc were analysed and presented the report as on 18th March 2024. The report used as base document to prepare the reply for the questions raised by MOEF&CC and serves as supportive document to validate Boards claim. This final technical report gives a clear status of the biodiversity of the project area and the stability of the structures proposed to be developed while implementing the project.

1.4. Importance of Biodiversity Study of the project Area

Biodiversity can be defined as the variety and variability of life on earth. It is a measure of variation at the genetic, species and ecosystem level. Interestingly, it is not distributed evenly on earth, it is usually greater in the tropics as a result of the warm climate and high primary productivity in the tropical region. Tropical forest ecosystems cover less than 10% of earth's surface and contain 90% of the world's species. It provides essential life support systems and provide important ecological services such as supportive, provisioning, regulatory and cultural for sustaining life on earth. That is why any developmental activities in these regions invite cautious approach to minimize ecological impacts to safeguard biodiversity and thus promoting harmonious relationship between man and environment.

Today, the United Nations holding several summits on biodiversity under the theme 'Urgent Action on Biodiversity for Sustainable Development' and expected to bring attention to the Earth's declining biodiversity and demand immediate action to promote more sustainable practices. Biodiversity is being destroyed at a rate unprecedented in history as per the report of WWF (2020). Forests are being cut down, oceans are being polluted and wetlands devastated. This type of destruction is leaving much of the global fauna without the essential habitat they need to survive, let alone thrive.

Human development is the main cause of this destruction. With new cities popping up left and right, the impact on biodiversity will only become more significant. Rapid urbanisation is not unique to developed countries but also with similar rates of development occurring in underdeveloped countries. This type of development requires infrastructure, roads, industry, as well as buildings that need to be cooled down or heated up. This is a long way of saying: more cities need more energy. Energy demand is expected to increase significantly over the coming decades, with much of the new capacity coming from renewable energy sources such as wind, solar and hydropower. Increasing clean energy sources is absolutely essential to reducing greenhouse gas emissions and meeting the targets of the UN SDG's goal viz, clean energy, clean environment and balanced trade of between energy and biodiversity.

As advocated by UN, developing more renewable energy is key to our fight against climate change but it needs happen in a way that does not harm biodiversity. This is especially important for hydropower, which lies at the heart of the land-water-energy nexus. As the largest renewable energy, making up more than half of global renewable energy production, hydropower is part of the solution to protecting the planet's biosphere – and all life on Earth – by decarbonising the global economy, slowing the pace of climate change and preventing pollutants being emitted from fossil fuels.

As with any river-based infrastructure, hydropower projects also have a relationship to local biodiversity: the freshwater bodies on which they are built are home to over 140,000 described species, including 55 per cent of all fish. Rivers act as natural corridors for both aquatic and terrestrial species, helping maintain biodiversity value across landscapes. Rivers also provide essential services for humanity, including tourism, navigation, fishing and agriculture. Yet, the health of rivers continues to be challenged by growing pressures from human activities, including pollution, irrigation and agriculture and industry, as well as infrastructure such as dams and weirs. Studies show globally two-thirds of the longest rivers (over 1,000 km) are no longer free flowing and freshwater vertebrate populations have suffered an 83 percent decline between 1970 and 2014 with even higher rates amongst fish species. Even though, only a small part of this is caused by hydroelectric dams, but the sector needs to stand up to its responsibilities.

The construction of a hydropower project will inevitably change the river on which it is built. Identifying the extent of these impacts, and managing them responsibly, is crucial to ensure the conservation of biodiversity. The most common approach to managing biodiversity impacts from hydropower is by applying the mitigation hierarchy. The mitigation hierarchy – avoid, minimise, mitigate and compensate – is a sequential process. First, a project should always seek to avoid or prevent negative or adverse impacts. For hydropower, this can include changes in site selection or project design to avoid the flooding of critical biodiversity areas. When avoidance is not possible, projects should look to minimise adverse impacts. For example, a project can alter operational controls or implement environmental flows to minimise downstream impacts on river health. In cases where avoidance and minimisation are not practicable, projects should aim to mitigate and compensate the identified impacts. This can be done by restoring lost habitats and re-establishing biodiversity value to the affected area.

The internationally recognised Hydropower Sustainability Tools provide further guidance to industry on achieving good practice in hydropower development with regard to biodiversity conservation. By assessing themselves against the requirements of the Biodiversity and Invasive Species guidelines and assessment criteria, hydropower projects can demonstrate their commitment to biodiversity in line with international standards. The performance tools developed by International Hydropower Association, Greater London, United Kingdom address ecosystem values, habitats and issues such as threatened species and fish passage in the catchment, reservoir and downstream areas, as well as potential impacts arising from pest and invasive species associated with the planned project. The intent is that there are healthy, functional and viable aquatic and terrestrial ecosystems in the project-affected area that are sustainable over the long-term, and that biodiversity impacts arising from project activities are managed responsibly.

Impacts on terrestrial and aquatic connectivity, especially on migratory aquatic species, are among the most important priorities for hydropower developers and operators. The project handlers with the help of scientists should provide ladder for migratory species for migration on both ways and also ensure through constant monitoring. In order to help conserve biodiversity, industry, governments and NGOs need to work together to identify and address negative impacts of hydropower on biodiversity and come up with innovative solutions to avoid, minimise, mitigate and compensate these impacts as early as possible in the project cycle. Therefore, UN Biodiversity Summit is only one step on a long journey towards a truly sustainable development.

The issues outlined here is more towards larger hydropower project. However, small hydroelectric power schemes can be implemented by safeguarding the environment and biodiversity by proper assessment and also the benefit can be quickly harvested due to shortest possible time. That is why construction of small hydropower plants (<10 megawatts) is booming worldwide, exacerbating ongoing habitat fragmentation and degradation, and further fueling biodiversity loss. A systematic approach for selecting hydropower sites within river networks may help to minimize the detrimental effects of small hydropower on biodiversity. In addition, a better understanding of reach- and basin-scale impacts, is key for designing planning tools. We synthesize the available information on biodiversity at basin-scale and analyse its distribution to understand impacts of Valanthode Hydropower Scheme on biodiversity and ecosystem function. We then discuss state-of-the-art, spatially explicit planning tools and suggest how improved knowledge of the ecological and evolutionary impacts of hydropower can be incorporated into this project development. Such study can be used to balance the benefits of hydropower production with the maintenance of ecosystem services and biodiversity conservation. Adequate planning tools that consider basin-scale effects and interactions with other stressors, such as climate change, can maximize long-term conservation of biodiversity and ecosystem function. We then discussed the state-of-the-art report, that improve our understanding on the ecological and evolutionary impacts of the Valanthode project. The study can be used to balance the benefits of hydropower production with the maintenance of ecosystem services and biodiversity conservation.

Table-1: KSEB- Schemes Commissioned

Sl No	Station	Installed Capacity (MW)	Annual Energy (Mu)
(A)	**HYDRO**		
1	Pallivasal	37.50	284

2	Sengulam	50.8	182
3	Poringalkuthu left bank	32	170
4	Neriamangalam	52.50	237
5	Pannier	30	158
6	Sholayar	54	233
7	Sabarigiri	300	1338
8	Kuttiyadi	75	268
9	Idukki	780	2398
10	Idamalayar	75	380
11	Kallada	15	65
12	Peppara	3	11.5
13	Madupatty	2	6.4
14	Lower periyar	180	493
15	Kakkad	50	262
16	Poringal kuthu l/b ext	16	75
17	Kuttiyadi extension	50	75
18	Malampuzha	2.50	5.6
19	Chembukkadavu-i	2.70	6.24
20	Chembukkadavu-ii	3.75	9.65
21	Urumi-i	3.75	9.53
22	Urumi-ii	2.40	6.09
23	Malankara	10.50	65.00
24	Lower meenmutty	3.50	10.14
25	Neriamangalam ext	25	58.76
26	Kuttiyadi tail race	3.75	17.10
27	Kuttiyadi addt. Extension	100	240.50
28	Poozhithodu	4.8	10.97
29	Ranni perinadu	4	16
30	Vilangad	7.5	23.63
31	Augmentation schemes		
	a) Narakakkanam Diversion to Idukki		7
	b) Sabarigri Augmentation		125
	c) Panniar Augmentation		10
	d) Poringal –Idamalyar diversion		60
	e) Azhutha Diversion to Idukki		57
	f) Vazhikkadavu Diversion		24
	g) Vadakkepuzha Diversion		12

	h) Kuttiyar Diversion		37
	TOTAL	**1,976.95**	**7447.11**

Sl No	Station	Installed capacity (MW)	Annual Energy (Mu)
(B)	**Diesel/ thermal**		
1	Brahmapuram	106.6	606
2	Kozhikode	128	896
(C)	**Independent power producers**		
1	Maniyar (hydro)	12	36
2	Kuthunkal (hydro)	21	79
3	Kayamkulam (thermal)	359.58	2158
4	Bses cochin (thermal)	157	1099
5	Kasaragod	20	140
6	Iruttukanam small hep	3	11.92
(D)	**Wind**		
1	Kanjikode	2	5
	Grand total	**2786.13**	**12,478.03**

Table -2 : KSEB- Schemes Under Execution

Sl No	Name of Project	Installed Capacity (MW)	Annual Energy (Mu)
A	**Hydro**		
1	Pallivasal Extension	60	153.90
2	Adiyanpara	3.5	7.31
3	Thottiyar	40.00	99
4	Chathankottunada-II	6	14.76
5	Sengulam Augmentation		84
6	Barapole	15	36
7	Kakkayam	3	10.39
8	Mankulam	40	82.08
9	Anakkayam	7.5	27.09
10	Perumthenaruvi Stage I	6	25.77
11	Peechi	1.25	3.315
12	Chimoni	2.5	6.03
13	Vellathooval HEP	3.6	12.17
14	Bhoothathankettu	24	83.5
	Total	**212.35**	**668.945**

Table- 3 : KSEB- Schemes to be taken up Immediately

Sl No	Name of Project	Installed capacity (MW)	Annual Energy (Mu)
A	**Hydro (Major)**		
1	Athirappilly	163	233
2	Achencoil	30	75.81
3	Poringalkuthu HEP	24	45.02
B	**Hydro (Small)**		
1	Peechadu	3	7.7
2	Chinnar	24	76.45
3	Upper Kallar	2	5.14
4	Chembukkadavu III	6	14.92
5	Poovaramthodu	2.7	5.88
6	Olikkal	4.50	5.88
7	Ladrum	3.5	12.13
8	Pazhassi Sagar	15	42.14
9	Peruvannamoozhy	6	24.70
10	Western Kallar	5	17.41
11	Upper Sengulam Stage I	24	53.22
12	Marmala	7	20.21
	Grand Total	**319.7**	**639.61**

2. PROJECT AT A GLANCE

The demand of power is increasing day to day. The capacity addition during the recent period in Kerala was less, compared to the demand. The increase in demand of power leads us to think of efficient utilization of our water resources. Here the importance of small hydroelectric schemes arises. Even though the entire requirement of the state cannot be met from these small schemes, they have a significant role for minimizing the shortage of power. Moreover, small hydro schemes requires comparatively short gestation period, cheap and simple maintenance, low investment etc and there will not be any adverse effects on ecology and environment by the implementation of small schemes. The proposed Valnthode SHEP taps energy from water resources of Kurumanpuzha River. It is a run off the river scheme utilizing the inflow of Kurumanpuzha, in Chaliyar basin, with a Rated net design head of 89.44m. The catchment area of the scheme is 18.90km^2. The proposed installed capacity is 7.5 MW (3 X 2.50MW) and the annual generation expected from the scheme is about 15.291 Mu (90% DY).

2.1. Geographical Location

The proposed weir site of the scheme is located at 11^0 21'41" N Latitude and 76^0 06' 48" E Longitude. The GTS map of 58 A/3 covers the entire area of the scheme. The location of the scheme lies in Akampadam village of Chaliyar Panchayath of Nilambur Taluk in Malappuram District. The site is accessible from Kozhikode via Koduvally- Omassery- Thiruvambady- Koompara- Kakkadampoyil- Valanthodu-Thottapally. Up to Valanthode black top road is available. From Valanthode there exists a Panchayath road of about 3.20 km to access the weir site. A black top road, about 25 km, from Valanthode to Nilambur via Akampadam is also exists which is the shortest route from Nilambur which crosses KurumanPuzha at downstream (Fig. 1).

2.2. Topography and Physiographic Characteristics

The proposed scheme is in Kurumanpuzha, a tributary of Chaliyar river, which originate from Kolapattymala (+1778.00 m), Kurathimala (+2339.00 m) etc. and flows towards south and turns to east direction from the elevation (+515.00 m) and flows to south direction and then joins in Chaliyar river at Vadapuram about 3km from Nilambur. The river bed and the left flank are of exposed rock. The river is cascading with frequent falls and there is flow in summer also. The river course is mainly comprised of huge boulders and sheet rock. The terrain of river is not so suitable for storage schemes but the topography supports for developing small hydro schemes especially run off the river type.

The stream bed is characterized by presence of rock and accumulation of different size boulders both at the upstream and downstream. Exploratory drilling was conducted at different locations of the proposals to understand the bed rock nature for stability. At weir axis, exposed rocks are visible in the river bed. The right bank of weir axis is steep and rock is available at about a depth of 8.70m. The rock availability near fore bay is at about 9. Along the penstock alignment no sound rock is available at shallow depth and hence anchor block is to be designed in over burden soil. At the proposed power house location rock is available at a depth 8.30m. The core log and the report on geotechnical investigation carried out by GSI is used to assess the stability of the structures in this report.

The river Kurumanpuzha drains a catchment of about 18.90km^2 at the proposed weir site. The rain fall in this catchment mainly depends on South West monsoon. The presence of Kolapattymala and Kurathimala from which the Kurumanpuzha originates results in heavy rain fall in this catchment during monsoon. Hydrological studies of this scheme are conducted based on rain fall date available from the rain gauge stations at Urumi and Vattachira, maintained by KSE Board.

2.3. Project Components

The proposed Valanthode Small hydroelectric project involves construction of a gravity diversion weir (dam) of 101m length with 9.5m height. The water is diverted through the construction of rectangular open canal, that leads to a circular fore bay tank, a penstock pipe surface powerhouse having 3 Francis Turbines (2.5 MW each) with installed capacity of 7.5 MW. The power generated in this scheme is proposed to be transmitted to 66KV substation at Nilambur by constructing a 33 KV feeder bay at Nilambur substation and by drawing 25 Km single circuit of 33 KV line from Valanthode. The list of main components of the schemes are given below;

i. A Col-Grout masonry gravity diversion weir of length 101m (up to abutment) and top width 3m.

ii. A rectangular intake opening of 3.7m wide X 2.6m depth with safety rack arrangements.

iii. A box culvert length of 62m from intake chamber to power channel.

iv. A rectangular channel of 3m length with surplus weir arrangements.

v. A vertical lift gate arrangement near the entrance of the Box culvert for controlling the flow during maintenance / emergency.

vi. RCC rectangular power channel of 3.7m wide X 2.6m depth for length of 449.8m (excluding cross drainage works)

vii. An aqueduct of 20m length and vent way height 1.50m, at stream crossing.

viii. An emergency escape near natural stream

ix. An escape weir near fore bay.

x. A Circular fore bay tank of 25m dia and having live storage capacity 1471.88m^3

xi. A single line penstock pipe of dia 1.8m for a length 387.2m. (Spirally welded)

xii. A surface Power house of size 40m X 15 X 12M, installing 3 Nos. of horizontal Francis Turbine, each of 2500 KW.

xiii. A rectangular tail race pool of size 20 X 14m and a tail race leading channel of size 7.0 m X 1.60m for a length of about 50m.

In addition, major construction works involved are dealt separately;

2.3.1. Dam (Weir)

A Col- Grout masonry gravity weir is proposed across Kurumanpuzha at Thottapally. A rectangular intake opening of 3.7 m wide X 2.6m depth with safety rack arrangement is located in the right non overflow portion of the weir just near to the spillway portion. Through the intake opening water is diverted to a box culvert length of 62m. A surplus weir is provided at the inlet of power channel to drain out excess water, during flood. From box culvert, water is led to fore bay tank through a RCC rectangular channel to the length of 449.8m. A vertical lift gate may be provided near the entrance of the RCC rectangular canal for regulating water. A 387.2m long single line penstock that branches into 3 near the Powerhouse leads water to the turbines from the fore bay tank. After power generation, the tail water is proposed to be discharged to the same river through a channel of length about 50m.

2.3.2. Water conductor System

Two rectangular openings of 1.85m wide X 2.6m depth each with a pier in between on the right non-overflow section is proposed for intake. A safety rack of mesh opening of not more than 200mm clear opening should be suitably provided on the entry face of the rectangular openings for preventing the entry of floating debris etc into the intake opening. A scour sluice of 1m x 1m is also provided at the deepest point along the cross section of the weir cross section for flushing or for maintaining dry weather flow. Gates with suitable hoisting arrangements are provided for Sluice opening as well as for Intake openings at the right non overflow section.

2.3.2.1. Fore bay

The location of fore bay is at about 578m above mean sea level. A circular fore bay tank for two minutes live storage capacity with 3m storage depth is provided at the end of power canal to buffer the fluctuation in inflow due to sudden changes in plant operation. The rock level near fore bay is at 9.50m depth from the ground level (As per the DPR, Vol.1., KSEB). The depth of fore bay tank is 10.52m. The FSL of fore bay is at +722.03m and the MDDL is fixed at +719.03. The live storage capacity of fore bay is 1471.88m^3.

2.3.2.2. Penstock

Single line surface penstock (Spirally welded) of 1.80M diameter is provided from fore bay. The total length of penstock up to bifurcation point is 354.57m. The single line penstock pipe is bifurcated at two places to feed water to three machines. It branches first to two feeder pipes of dia 1.50m and 1.10m and then from the piper of 1.50m dia it branches to 1.10m dia feeder pipe. According to the terrain, 3 Nos of anchor blocks are provided along penstock route. The total length of penstock line is 387.71m.

2.3.3. Power House

A surface power house of size 40.00m x 15.00m is provided to install 3 machines of 2.50 MW horizontal Francis Turbine. The yard level is fixed at +631.5m and the service bay level at +632.00m. A switch yard of size 20m x 15m is proposed near power house site. The access to switch yard is provided from the approach road to power house.

2.3.4. Tail race

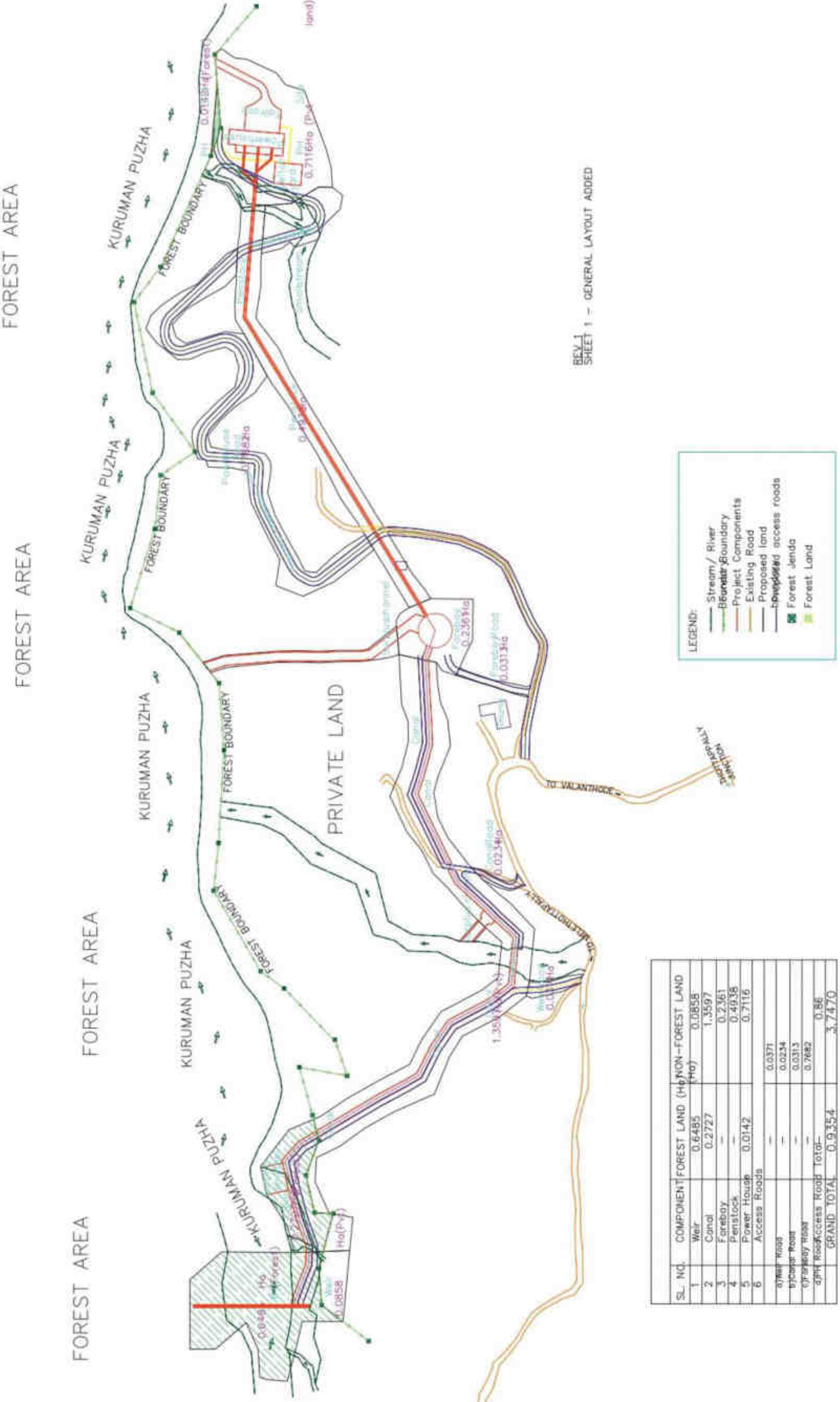
A tail race pool of size 20m x 14m x 3.5m and a rectangular tail race leading channel of about 50m long, 7.0m wide and 1.60m deep is provided to discharge the water back into the river. The maximum tail water level is at +631.5198m and minimum tail water level is at +630.5582m. The length of tail race leading channel is about 50.00m. The normal tail water level is at +631.1908m and the crest level of narrow crested weir at tail pool is fixed at +630.50m.

2.3.5. Power Evacuation

The power produced from this project, can be transmitted from the Switchyard adjacent to the Power House to the 66 KV Sub Station Nilambur by constructing 33 KV feeder bay at Nilambur and 33 KV line form Valanthode.

2.3.6 Land Requirement for the Project

About 5.90 Ha of land is required for the implementation of this project. The left bank, and right bank of the river course are forest land. The initial reaches of water conductor system (Box Culvert), tail race leading channel and dump yard of power house site etc. are falls in forest land. Some portion of access road from Valanthode to Thottappally junction passes through forest land and hence the development works could be done after getting permission from the Forest Department of State and Central agencies like MoEF&CC, Govt of India. The area of forest land requied for the project is approximately 1.40 Ha. All other project components such as fore bay, penstock, power house etc are located in private land which can be acquired by giving proper compensation to the owners. The total private land to be acquired comes to 4.50 Ha.



SL. NO.	COMPONENT	FOREST LAND (Ha)	NON-FOREST LAND (Ha)
1	Weir	0.6485	0.0858
2	Canal	0.2727	1.3597
3	Forebay	—	0.2361
4	Penstock	—	0.4938
5	Power House	0.0142	0.7116
6	Access Roads		
a)Weir Road		—	0.0371
b)Canal Road		—	0.0234
c)Forebay Road		—	0.0313
d)PH Road		—	0.7682
	Access Road Total	—	0.86
	GRAND TOTAL	0.9354	3.7470

Fig.1. Valanthode SHEP: Schematic representation

3. STUDY AREA

The study area spread over 18.19km^2 on the western side of the western ghats with undulated topography. The slopes are of varying degree from low to moderate till Thottappally where the dam site is located and in catchment area the slope is very deep and inaccessible. The area constituted the catchment, project location, submergible area, powerhouse area, downstream and near by environs. The river Kurumanpuzha, a tributary of Chaliyar river, drains thorugh the entire study area and joins in the Chaliyar at Vadapuram near Nilambur. The Valanthode Small Hydroelectric Project is located on this river at Thottappally in Akampadam Village under Chaliyar Panchayat of Nilambur Taluk and in Malappuram district. The weir site (dam) is located in latitude of 11^{0}21'41" North and longitude of 76^{0}6'48" East. The power house is proposed at the right bank of the river in latitude of 11^{0}21'35.40" North and longitude of 76^{0}6'38.10" East. The study area extends the altitude from $\pm$ 515m above msl (downstream to the powerhouse) to Kolapattymala ($\pm$ 1778m) and Kurathimala ($\pm$ 2339m). Many smaller streams and tributaries dissects the area into many irregular ridges, then joins to the Kuramanpuzha and thus the entire drainage pattern lies in the east-west direction. For the study purpose, we used the GTS map of 58A/3 which covers the entire area of the proposed scheme (Fig.1).

The study area is about 55km from Kozhikode city. It can be accessible from Kozhikode through Thiruvambadi, Kakkadampoyil, Valanthode and Thottappally. There is also an access from Nilambur to Valanthode via Akampadam which is the shortest route of about 25km and it crosses Kurumanpuzha at the downstream of the project area. From Valanthode junction there is a Panchayat Road of about 2.50km upto Thottappally junction. From Thottappally, the available 670m Panchayat Road has to be widened and realignment is required for maintaining the slope to make it trafficable. From this portion, a new road is to be laid of about 150m to reach the weir site and subsequent catchment and downstream areas. On the way to the weir site, there exists a church and from this point a private coup road cum footpath is available. Access to the powerhouse site and forebay is proposed this route and thus the existing private road for a stretch of 125m is to be renovated. In continutation to this road, a new road of about 650m has to be constructed to reach the powerhouse site. The entire project area was covered for the present study by foot as there is no facility available for accommodation or other convience at present.

The project area is located in tropical biome and heavily influenced by Southwest Monsoon which brings copious rainfall to an extent of over 6000mm per year. Due to undulated topography coupled with toprical climate, the study area harbours a good forest ecosystem that inhabits rich flora, fauna, wildlife, fishes, amphibians etc. The area has a mosaic of vegetation such as evergreen (±700m above msl), followed by semi-evergreen (± 550-700m above msl), moist deciduous below 550m msl and forms a part of downstream areas where powerhouse is located. The weir site lies in the midst of evergreen forest and the diversion canal, forebay tank passes through the semi-evergreen forest. In addition, there is a riparian forest all along the river border which dominated by evergreen elements.

The study area forms a natural habitat for a variety of faunal elements and wildlife and makes the area a dynamic functional ecosystem. There are reports of siting elephants, bisans, monkeys, nilgri Langur, sambardeer, spotted deer, barking deer, wild boar etc. A good number of butterflies, birds, reptiles, amphibians, fishes etc are also observed from the area. Therefore, the present study concentrate on all aspects of physical and biological environment as part of biodiversity assessment and based on the field and laboratory observations, conclusions are drawn to understand the merit of the schme without compromising the safety of the environment.

4. PHYSICAL ENVIRONMENT

4.1. Climate

The climate in the area is tropical monsoon with seasonally excessive rainfall during monsoon season. The average rainfall is 6817.3 mm per year. The two monsoons, namely, the south-west (SW) monsoon in summer and the North-East (NE) monsoon in winter, are the deciding factors in the climate of the basin. The SW monsoon begins in June and ends in September contributing to about 60% of the annual rainfall. The NE monsoon is experienced in the month of October–November contributing to about 25% of the total annual rainfall, January–May are the dry months of the year, about 15% of the total rainfall is received during this period. The coastal belt is humid and damp and relative humidity decreases towards the eastern parts of the basin. The climate of the basin is generally moderate. The maximum temperature ranges from approximately 22 to 33 °C and the minimum temperature ranges from approximately 22 to 26 °C. The average annual maximum temperature is 30.9 °C and minimum is 23.7 °C. The temperature starts rising from January reaching the peak in April. It decreases during monsoon months (Ambili, 2010).

Indian Meteorological Department (IMD) recently revised 2890.8 mm as the average annual rainfall of the state based on long period average (LPA) of 1971-2020. As per IMD, the bulk of the above rainfall around 70% is received during the south-west monsoon which sets in by June and extends up to September. The state also gets rains from the North-East monsoon during October to December, which amounts to 17% of annual rainfall. The balance 13% of the rainfall received during summer months of January to May.

4.2. Geological Setting and Soil Type

The Proposed HE project is part of Chaliar river system. The Chaliyar river basin is the third largest river basin in the state of Kerala in Southern India. The Chaliyar river originates from the Ilambalari hills in Gudalur taluk of Nilgiris district in Tamil Nadu, at an elevation of 2066 m above mean sea level. This interstate river has a total drainage area of 2923 km^2 of which 2535 km^2 lie in Kerala State and rest 388 km^2 in Tamil Nadu. The river has a length of about 170 km. In the lower reaches, the river is also known as Beyporepuzha. The main river is contributed by the important tributaries namely, Chaliyarpuzha, Karimpuzha, Kanchirapuzha, Kuthirapuzha, Kurumanpuzha, Iruvenhipuzha, Cherupuzha, Punnapuzha, Maruthapuzha etc.

The proposed scheme, as stated, is in the river Kurumanpuzha which originate from Kolapattymala (+1778.00 msl) and Kurathimala (+2339.00 msl). The river flows towards south and turns to east direction from the elevation of +515.00 msl and flows to south direction and then joins in Chaliyar river at Vadapuram. The riverbed and the left flank are of exposed rock. The river is cascading with frequent falls and also there is flow in summer. The river course is mainly comprised of huge boulders and sheet rock.

4.2.1. Sub-Basin Kurumanpuzha

Kurumanpuzha drains this sub-basin and flows south-easterly through the charnockite basement. The average bifurcation ratio (express the branching pattern of the stream network and is a measure of drainage density) is 3.95 (moderate dissection) and sub-elongated nature of the basin (Da = 0.23). The hypsometric curve (A curve showing the bifurcation ratio relationship of area to elevation for specified terrain) of Kurumanpuzha reflects its aged character. Morphostructural analysis of drainage network and lineaments throw light on the correlation of N–S trending lineaments and 1 &2 orders of streams. The third order streams belonging to show correspondence with the WNW–ESE trending lineaments (Table-4). An important feature is the sudden change in the flow direction from south in the upstream to ESE downstream and then to south is clearly visible in the fourth and fifth orders and is reflected as the arc-shaped geometry of the sub-basin.

Table- 4. Valanthode SHEP: Morphostructural analysis of the sub-basin Kurumanpuzha (Ambili, 2010).

Stream order	Related Lineament Trend
1&2	N-S
3	WNW–ESE
4 &5	WSW-ESE

4.2.2. Soil Types

The five different types of soils which occur in the Chaliyar river basin including Kurumanpuzha are coastal alluvium, riverine alluvium, lateritic soil, brown hydromorphic soil and forest loam. Coastal alluvium is predominantly of marine origin, with some fluvial sediment along the coast. Riverine alluvium is seen along the river valleys, cutting across the extensive laterite soils. The lateritic soil is the predominant soil type in the basin and it occurs in the midland and highland regions. The laterite soil is a weathered product derived under humid tropic conditions.

4.3. Rainfall and availability of water

The average annual rainfall in Chaliyar River basin is estimated from different raingauge stations is 3161 mm. About 70% of the rainfall in the river basin is received during southwest monsoon season (Jun–Aug), 20% during North-East monsoon season (Sep–Nov) and the remaining 10% during the non-monsoon months (Dec–May.). Average mansoon influx is as observed between 1997-2010 is 103.752mm^3. A Map depicting contours of equal precipitation amounts recorded during a specific time period is called Isohyetal Map (Fig. 2, Ambili, 2010).

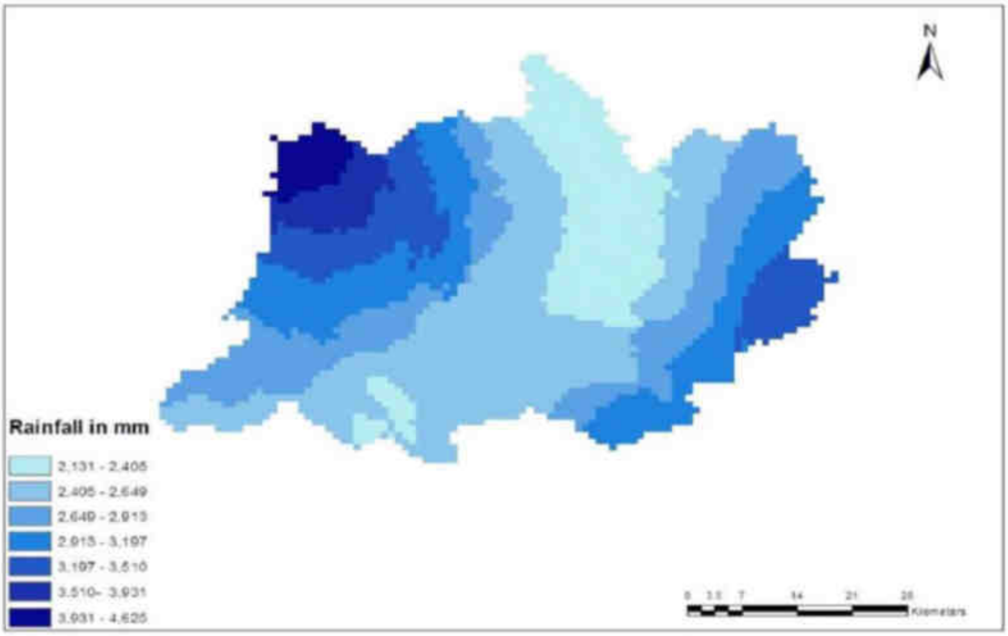


Fig. 2. Valanthode SHEP: Isohyetal Map of Chaliyar River Basin (including Kurumanpuzha)

4.3.1. Availability of Surface water

In order to understand the percentage time availability of flow in a particular month, monthly flow duration data for the summer months from the gauging stations of Karimanpuzha has been prepared by Centre for Water Resources Development and Management (CWRDM) shall be consulted (Anitha et al., 2014). The flow duration data is an important tool to appraise the flow values of various dependability and thus an indispensable simple tool for water availability studies. The data give an idea about the temporal distribution of flows in the summer months. The following table-5 shows 50%, 75% and 90% the percentage time of non-availability of flow in a particular month Kurumanpuzha where the proposed HEP is located. The streams are grouped on their dependability of water (50%, 75 % and 90% probability of water available, Colum 2 of the table). They were monitored by CWRDM, Kozhikode (Anitha, l.c) for each month. The result of Karimanpuzha is refereed in the table for a period of Dec to May the lean months.

Table-5. Valanthode SHEP: The percentage time availability of flow in a particular month in Kurumanpuzha.

Month	Dependabilty	Percent of time of water Availability
Dec	50%	26.2
	75%	16.6
	90%	9
Jan	50%	11
	75%	1
	90%	0
Feb	50%	4.2
	75%	0
	90%	0
Mar	50%	1.5
	75%	0
	90%	0
Apr	50%	1.1
	75%	0
	90%	0
May	50%	8.1
	75%	2
	90%	0

The table gives an idea about the temporal distribution of flows in the summer months. It is observed that,

- In 90% group of the time of five summer months, ie from Jan to May there is no flow.
- in 75% group of the time of three summer months, ie from February to April there is no flow
- in 50 % group there is flow though inconsistently throughout

This observation takes to the conclusion that in months from June to November the water is plenty, but in other times the flow will not be steady.

4.3.2. Floods

Evaluating the possibilities of flood, its possible impact on the dam is to be understood while planning and designing a dam. Since flash floods due to soil creep, land slide and opening of the dams are fresh in memory, an attempt is made to consider these aspects as well. This is relevant as there are concerns of flood by and on the proposed SHEP.

4.3.2.1. Flash floods

A flash flood is a rapid flooding of low-lying areas: It may be caused by heavy rain associated with a severe thunderstorm, hurricane, Flash floods may also occur after the collapse of a natural ice or debris dam, or a human structure such as a man-made dam. Flash floods are distinguished from regular floods by having a timescale of fewer than six hours between rainfall and the onset of flooding. Flash floods can also deposit large quantities of sediments on floodplains. Flash flooding can also be caused by extensive rainfall released by hurricanes and other tropical storms.

4.3.2.2. Floods during 2018

On 16 August 2018, severe floods affected the Southern Indian state of Kerala, due to unusually high rainfall during the monsoon season. It was the worst flood in Kerala in nearly a century. Over 483 people died, and 15 went missing. About a million people were evacuated, mainly from areas between Chengannur and Palakkad. All 14 districts of the state were placed on red alert. According to the Kerala government, one-sixth of the total population of Kerala had been directly affected by the floods and related incidents. The Indian government had declared it a Level 3 Calamity, or "calamity of a severe nature". It is the worst flood in Kerala after the great flood of 99 that took place in 1924. (Wikipedia, 2024). 35 out of the 54 dams within the state were opened, for the first time in history. All five overflow gates of the Idukki Dam were opened at the same time, and for the first time in 26 years, 5 gates of the Malampuzha dam of Palakkad were opened. Heavy rains in Wayanad and Idukki caused severe landslides and had left the hilly districts isolated. The situation was regularly monitored by the National Crisis Management Committee, which also coordinated the rescue and relief operations as the dam got opened it has disrupted many lives living nearby (Wikipedia, 2024).

4.3.2.3. Floods during 2019

On 8th August 2019, due to heavy rainfall in the monsoon season, severe flood affected Kerala. As a security measure in the prevailing situation of heavy rains, the India Meteorological Department had issued a red alert in 9 districts in Northern and Central Kerala, orange alert in 3 districts of Central Kerala, and yellow alert in the remaining 2 districts of Southern Kerala. Thousands of people have been evacuated to safer places and relief camps. A total of 121 people has died due to rain-related incidents as of 19 August 2019.

The extreme rains were triggered by a depression toss the Arabian sea resulting in intense convection over Kerala. Every year parts of South Asia are hit by a period of heavy rains known as monsoons which usually fall between June and September. It is caused by a change of wind patterns over the region. This change causes heavy rains in the summer and long dry spells over the other months. In India, the monsoon rains can provide 70% of the country's rainfall for the year. The rain fall so quickly and heavily that it can cause sudden flooding. The rationale for the anomalous rainfall in 2018 might have recurred the extreme events in 2019; due to convection in the tropics, the high-frequency mode correlates better with the anomalous precipitation during the intervals of extreme events. (Wikipedia, 2024).

4.3.2.4. Flood impact on the proposed weir

The Possibility of local flash flood is not a meteorological event that can be predicted in this location. Chances of flash floods due to break of any upstream dam, barrage etc are ruled out as there are no structure in the catchment and upstream side. There were no significant floods in the basin for about last century. Since the reservoir is not a storage one and the weir is proposed to have automatic unlimited flow above the construction the safety factors will take care of the situation.

4.4. River System and water Characteristics

The physico-chemical characteristics of the river Kurumanpuzha have been assessed through sampling of river water for a period of three months and analysed using standard methods. Water samples were collected from the following sites.

i. Weir site, the proposed reservoir
ii. Upstream of the proposed weir
iii. Downstream of the weir site.
iv. Powerhouse area (tail water release end).
v. Downstream of the tail water release end.

Water temperature (^{0}C) and dissolved oxygen (mg/l) of the water samples were measured using a Temperature- oxygen-meter (YSI, USA) and pH of the water samples was recorded with a digital portable pH meter (YSI, USA). Biochemical oxygen demand (BOD) of the water samples was estimated by incubating water samples in a BOD incubator for 5 days at 20 ^{0}C; dissolved oxygen content (DO) before and after incubation was estimated following standard Winkler's method. Turbidity (NTU) was measured using a digital turbidity meter. Total suspended solids (TSS) were estimated by filtering a unit volume of water followed by measuring the weight of the filtrate after complete drying in an electric oven at 60 ^{0}C for one hour. Chloride content was measured by titrating water samples with silver nitrate using potassium chromate as indicator.

The water quality (Physio-chemical) parameters of water samples from the study area are shown in Table-6. The diversity and distribution of aquatic flora and fauna mainly depends upon the physio-chemical parameters of the water and hence information on the status and periodic variations has much significance in aquatic ecological assessment.

Temperature: In general, high elevation streams have comparatively low water temperature. In the study area, water temperature is found to be ranged from 20 to 25 ^{0}C in all the sampling sites. Aquatic biota is adapted to this range of temperature.

Dissolved Oxygen: Dissolved oxygen of the water samples ranged from 7.5 to 8.7 mg/L. In hill streams dissolved oxygen content of water is usually high due to turbulence of water.

pH: The pH of water was around 6.6, which indicate slight acidity.

BOD: Values of BOD ranged from 1.5 to 2.4 mg/L. BOD is an indicator of organic pollution. Values below 3 mg/L indicate absence of pollution.

Turbidity: Turbidity is the measure of relative clarity of a liquid. The turbidity of water directly influences the development of aquatic phyto planktons and flora.

Table- 6. Valanthode SHEP: Water quality parameters of different sampling sites

Sl. No.	Parameters	Site 1	Site 2	Site 3	Site 4	Site 5
1.	Temperature (^{0}C)	23.0	20.0	23.6	24.5	25.0
2.	Dissolved Oxygen (ml/L)	8.3	8.7	8.2	8.0	7.5
3.	pH	6.5	6.5	6.6	6.6	6.7
4.	T.S.S *mg/l*	24	23	24	26	27
5.	Chloride (mg/L)	7.0	6.0	8.0	8.0	9.0
6.	BOD (ml/L . 5 days)	1.8	1.5	2.0	2.1	2.4
7.	Turbidity (NTU)	0.2	0.2	0.21	0.23	0.23

4.5 Geomorphology

The land form in the area is ruggedly rolling topography in southern side and elongated ridges to wards NE side. This is a mergerzone of middle and highland mountains. Ridges trening NNW-SSE are typical in the area. The valley in which the HEP is proposed is sloping gently south (Fig. 3 & 4). The detailed Geomorphology is discussed in sections 5.7 and 6.7.

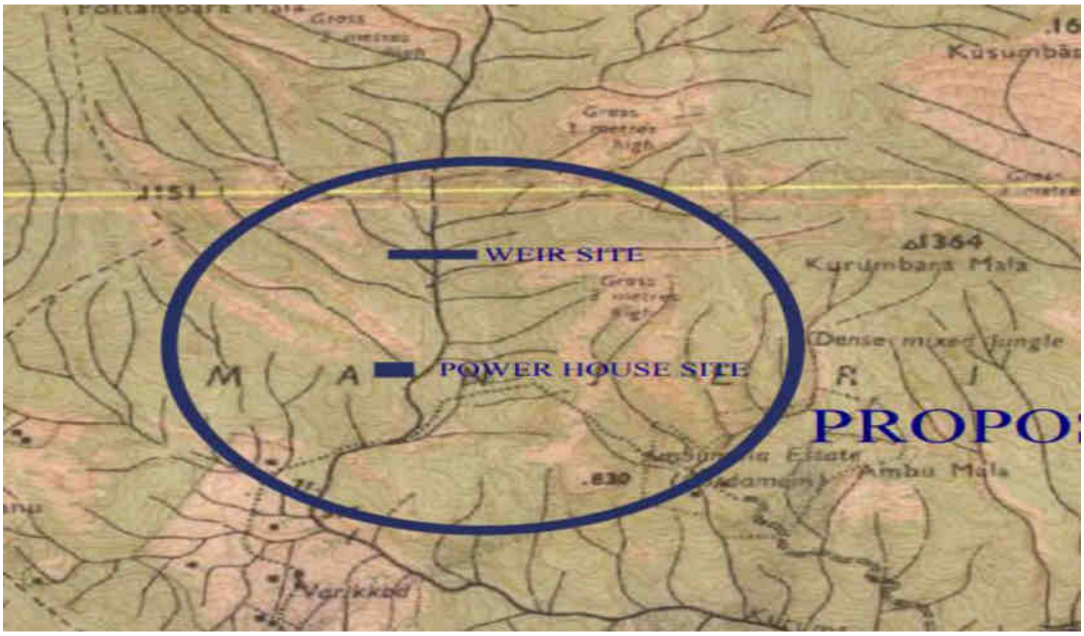


Fig. 3. Valanthode SHEP: Geomorphic Configuration in the Project Area

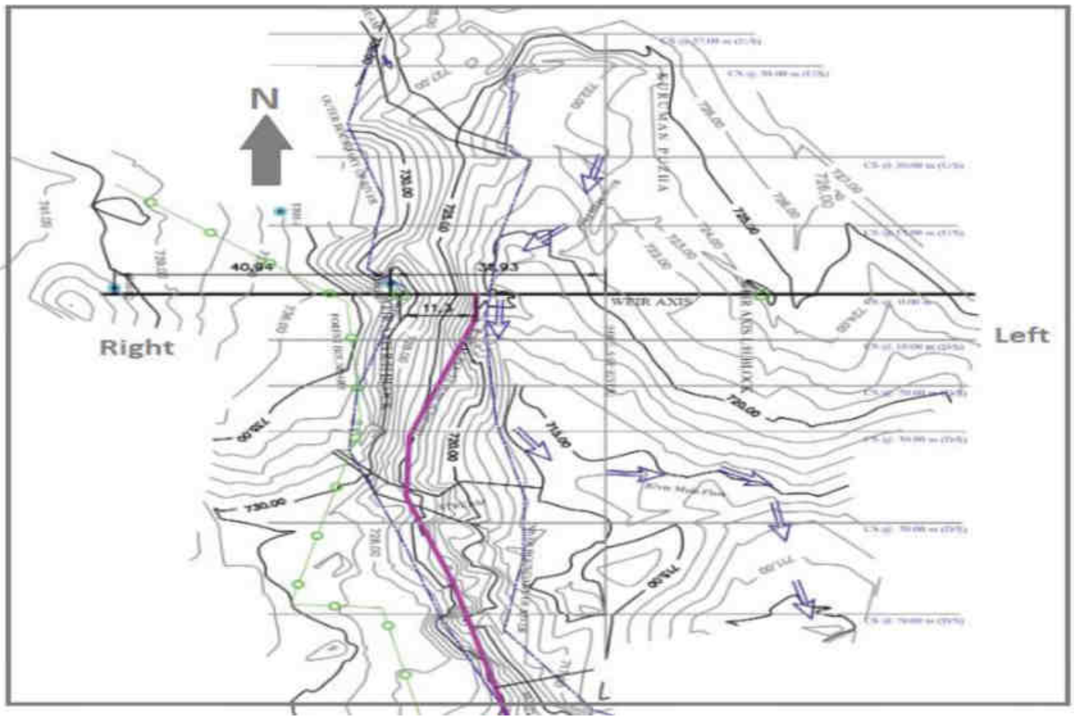


Fig. 4. Valanthode SHEP: Counter Configuration at the Proposed HEP Site

4.6 Landuse and Socio-economic Aspects

The total area of 4.5Ha., has been proposed to be acquired for the Valanthode Small Hydroelectric Project that is located in Akampadam Village of Nilambur taluk in Malappuram District. This area is a sloppy undulating land with gravelly lateritic soil type being put to use by the farmers for cultivating different crops like banana, coffee, areca, tapioca, tree spices etc. There are 14 land owners holding the 4.5 Ha., of land on the right side of the river Kurumanpuzha where the project components except the weir come in this area. Among them only four families hold both land and houses and the rest of them staying away from the project area and having only cultivated land with little maintenance.

5. THE STUDY

Field studies on land, water, forests, flora, fauna, aquatic life forms etc were conducted as per the terms of reference (ToR) from 18th October to 18th February 2024. The entire project area has been divided into catchment, dam site, submergible area, downstream and power house area for study purpose. The methodologies adopted for each subject were described in detail in this chapter. The entire study team comprising 9 subject experts were deployed, worked comprehensively and documented relevant data for futher analyses (plate-1).

5.1. Assessment of Forests

The vegetation of the project area at Valanthode SHEP could be classified under three major vegetation types prevalent in the Western Ghats, the Tropical wet evergreen forest, Tropical semi-evergreen forests and Tropical moist deciduous forests, mainly based on altitudinal variation. (Chandrasekharan 1962; Champion & Seth 1968; Pandurangan, 1990; Sivarajan and Mathew, 1997). In addition to this, a transitional sub-type- the Riparian vegetation is also found all along the river. Further a long patch of plantation area spread over to an extent of 4.5 Ha., where the canal to the powerhouse passes through is also included in the project area and hence studied.

5.2. Floristic Analysis

The standard methodology practiced in floristic study of an area is followed here. The proposed project area (the reservoir site, the catchment area above and the narrow patch of riparian and deciduous forest along the canal area up to the powerhouse point) were thoroughly explored. All the plants of the various forest types representing different strata (top story, middle story and the ground flora) were examined and documented. The detailed notes were taken in the field itself then and there. Special attention was paid to gather data pertaining to habit, habitat, altitude and other features like colour of the flowers, fruits, fragrants, hairiness of the plant and other relevant details which could not be deduced from the dired specimens. Photographs of interesting specimens were taken for record. The specimens were critically studied with the hand lens and field microscope, then determined the identity of the species by consulting various regional flora of the India and adjacent countries. Also consulted herbarium of Botanical Survey of India, Coimbatore (MH), Central National Herbarium (CNH) Howra and Herbarium of TBGRI (TBGT), Thiruvananthapuram. The data were arranged the family wise alphabetically by following Bentham and Hoooker's classification with certain delimitations of families proposed by Hutchinson (1979-1980). Nomenclature of the plant has been made up- to -date as far as possible. A checklist of all the species present in the total area was prepared showing their presence in different areas viz. catchment area, dam site and downstreams.

The data collected was further analyzed with respect to number of families, genera and species currently distributed in the study area. The life forms viz; Trees, Shrubs, Herbs, Climbers and Epiphytes were separately estimated. Endemism in the flora and presence of RET species were also analyzed. The presence of invasive and exotic species were separately recorded to observe the disturbance which had already happened in the area. With respect to economic and utilitarian point of view, plants were classified separately as Timber trees, Medicinal plants, NWFPs and Fibre plants, Wild edibles, Crop relatives etc.

5.3. Vegetation Analysis

Terrestrial vegetation in the project site and its environments are reserve forest in the upstream and left side of the river at dam site and downstream areas. On the right side of the river, private agricultural plantations are located. The vegetation comprises of (i) evergreen forest, (ii) Semi-evergreen forest, (iii) moist deciduous forest, (iv) thin stretch of riparian vegetation in both catchment and downstream areas and (v) agricultural plantation to an extent of 4.5 Ha., on the right side of the river course.

The structural composition of arborescent angiosperms was studied to evaluate the forest diversity of the area. The tree species and the undergrowth of the dam site and submerging area were recorded with all the species name and DBH in case of trees. Ten quadrats each from the catchment and downstream areas were laid down followed by the enumeration of all the woody elements of the flora, for which structural data have been gathered and interpreted. Endemic, rare and endangered taxa of arborescent angiosperms located in the study area are also evaluated.

Understory vegetation is a vital stratum of forests, including seedlings (< 1.5 m tall), shrubs, herbs, bryoids (i.e., mosses and lichens), and lianas. Both vascular (woody and non-woody) and nonvascular (liverworts, hornworts, and mosses) plants are essential components of understory vegetation (Bartels and Chen, 2013), which plays an important roles in forest ecosystem structure, functioning (e.g., biodiversity, regeneration, biomass, and nutrient content, as well as functional traits) and provision of ecological services (e.g., soil nutrient cycling and biological processes, water conservation, as well as mitigating emissions of greenhouse gas from carbon (C) sequestration and nitrogen (N) dynamics) (Balandier et al., 2022; Landuyt et al., 2019). They can also provide food, shelter, and habitat for animal species, especially for soil arthropods and large herbivores (Huffman et al., 2009). Nevertheless, the composition and distribution of understory vegetation are strongly influenced by competition (generalizability) or facilitation (specificity) from the overstory trees (Barbier et al., 2008; Wan et al., 2014; Barnes and Archer, 1999). The interaction between under- and over-story plays a critical role in driving the composition, structure, and function of forest ecosystems (Bartels and Chen, 2013), which is central to understanding the mechanisms of species coexistence, biodiversity maintenance, and forest management. Hence in the present survey evaluated both the under and over story of the study area as well as the catchment and downstream areas.

5.3.1. Vegetation

Although different methodologies are available for the study of vegetation, the phytosociological method is the one most widely used worldwide, that relies on prior knowledge of the distribution of flora, ecological and geological aspects (Molina, 1991).

The methodologies used for the evaluation of vegetation diversity of the study sites are as follows. 10 sample plots of 25 x 10 m size, were randomly laid in the different catchment and downstream areas. Only one plot each at dam site and water diversion area were laid down due to smaller area of 0.22 Ha of submergible/affected area.

For vegetation analysis, initial available data were gathered from the map of the area which was prepared by KSEBL. Based on this, exhaustive surveys were conducted in the area and data were generated on their locational characteristics, area-wise distribution, floristic composition etc. Structural data were collected from 22 sample plots of 25 x 10 m size laid in the entire project area as stated, including in the dam site. While laying the plots, representation of the forest types and also variation in their altitudinal distribution were also considered. As per the objectives of the study, structural data collection was restricted to arborescent species (above 60 cm dbh). while shrubs, herbs, creepers and seedling of the trees of the quadrats were evaluated separately. Initially, all the standing trees, shrubs and lianas above 60 cm dbh were enumerated and their dbh measured at a standard height of 1.37 m from the base. Buttressed tree species were measured above the buttressed portion. The data gathered from various plots were analysed in respect of different forest. Following are the phytosociological parameters worked out for each plots using the formulae (Phillips, 1959; Misra, 1968) given against each. Importance Value Index (IVI) of various species were also worked out as the sum of Relative density, Relative frequency and Relative dominance of each of them, to ascertain dominance in their community.

Density = $\frac{\text{Total no. of individuals}}{\text{Total no. of quadrats sampled}}$

% Frequency = $\frac{\text{No. of occurrence of each species}}{\text{Total no. of quadrats}} \times 100$

Basal area = $\frac{(gbh)2\ [\pi = 3.14]}{4\pi}$

Relative density = $\frac{\text{Density of each species} \times 100}{\text{Total density of all species}}$

Relative frequency = $\frac{\text{Frequency of each species} \times 100}{\text{Total frequency of all species}}$

Relative dominance = $\frac{\text{BA of each species} \times 100}{\text{Total BA of all species}}$

5.3.2. Biodiversity Indices

A diversity index is a quantitative measure that reflects how many types are (such as species) there in a dataset (a community). These indices are statistical representations of biodiversity in different aspects such as richness, evenness, dominance etc. When diversity indices are used in ecology, the types of interest are usually species, but they can also be other categories, such as genera, families, functional types, or haplotypes. The entities of interest are usually individual plants or animals, and the measure of abundance can be done, for example, on number of individuals, biomass or coverage etc. Although species richness (denoted as S) is often used as a measure of biodiversity which are more interested to ecologists and conservation biologists. The diversity indices that include both species richness and measures of abundance. This is because richness alone does not account for evenness across species. Based on the phytosociological analysis of the area, species diversity, dominance, richness and evenness were calculated using the following indices.

i. Simpson's index of dominance (Simpson, 1949)

$\lambda = \sum$ (ni (ni-1) /N (N-1)

Simpson (1949) developed an index of diversity which is a measure of probability, the less diversity, the greater the probability that two randomly selected individuals will be the same species. In the absence of diversity (1 species), the probability that two individuals randomly selected will be the same is 1. Simpson's Index is calculated as follows: The value of Simpson's ranges from 0 to 1, with 0 representing infinite diversity and 1 representing no diversity, so the larger the value, the lower the diversity. For this reason, Simpson's index is often as its complement (1- λ). Simpson's Dominance Index is the inverse of the Simpson's Index (1/D).

ii. Shannon index of species diversity (1948)

$H^1 = - \sum\{(ni/N) \log (ni/N)\}$

Another widely used index of diversity that also considers both species richness and evenness is the Shannon-Weiner Diversity Index, originally proposed by Claude Shannon in 1948. It is also known as Shannon's diversity index. The index is related to the concept of uncertainty. If for example, a community has very low diversity, we can be fairly certain of the identity of an organism we might choose by random (high certainty or low uncertainty). If a community is highly diverse and we choose an organism by random, we have a greater uncertainty of which species we will choose (low certainty or high uncertainty). The value of H ranges from 0 to Hmax. Hmax is different for each community and depends on species richness. (Note: Shannon-Weiner is often denoted H^1). In simple term, the index takes into account the number of species living in a habitat (richness) and their relative abundance.

iii. Menhinick's index of species richness (1964)

$$R = S/\sqrt{n}$$

A numeric vector of species counts. Details for a vector x of raw species counts, the Menhinick's richness index is frac {S} {√ {N}}, where N is the total number of counts and S is the total number of species observed. The index is only applicable for categorical data where all observations can be classified into a finite number of categories (species, types etc).

iv. Pielou's index of species evenness (1975)

$$E = H'/\log S$$

Pielou's evenness is an index that measures diversity along with species richness. While species richness is the number of different species in a given area, evenness is the count of individuals of each species in an area. A calculated value of Pielou's evenness ranges from 0 (no evenness) to 1 (complete evenness). When taken into account along with other indices such as Simpson's index or Shannon's index, a more thorough description of a community's structure can be interpreted.

where,

H^1 = Shannon index of species diversity

ni = Number of individuals of species,

i N = Total number of species in the community

λ = Index of dominance

S = Total number of species in the community

R = Richness index

E = Evenness index

5.3.3. Canal Diversion Area

Water from the wirer will be diverted to a canal and later it will be released through penstock pipes to the power house for electricity generation. The canal starts from the wirer area has got some portion as forest area and later go through the private agricultural land and finally to the power house. In power house also has some portion of forest land. As per the State Forest Department, 23 trees are to be felled and these were surveyed and reported in the subsequent chapter the findings.

5.4. Terrestrial Fauna and Wildlife

Information of the faunal life will serve as a base line data for taking adequate mitigative measures for minimizing the impact of a small dam, if at all, on the existence of wildlife and other faunal elements, in their natural habitat in future. Moreover, this study will also address certain facts, such as the loss of bio-diversity and effect on special habitats like nesting sites, spawning sites and special breeding grounds for fishes and other fauna, raised by the Regional Empowered Committee, MoEF & CC, regarding this small hydel project. Therefore, faunal diversity particularly Mammals, Birds, Butterflies and Reptiles were studied in the proposed Valanthode Small Hydroelectric Project site by adopting standard methodologies. The area was demarcated as the dam site, the catchment area and the downstream for a detailed field study. The left side of the river Kuruman puzha, the dam site and the catchment areas habours typical evergreen forest and the downstream is covered with moist deciduous forest. There is a semi-evergreen forest connecting evergreen and moist deciduous where diversion canal is to be developed. The riparian forest is distributed all along the river course. The right side of the river bank from dam site to power house is exposed to plantation and human settlement. They are engaged to fishing, collection of minor forest products like honey and plant tubers, medicinal plants etc for their sustenance. In the private plantation, the animals are kept away by electric fencing and occasionally using crackers. The proposed Valanthode small hydel project (VSHP), is a run off-the-river type as stated earlier and the present study was part of the documentation of faunal status and wildlife of the project area.

The diversity of mammals, birds and butterflies, reptilies etc., were studied using the line transect method. A total of six transects were laid, 2 each in the dam site, catchment area and the downstream. The transects laid in the dam site area were of 1 km in length, where as those in the catchment area and the downstream were of 2 Km in length. Transect walks were conducted twice in a month starting from 06 00 h in the morning. The mammals and birds will be active in the morning where as the butterflies will be active only after adequate sunlight, because they are cold blooded in nature. Whereas, the diversity of reptiles and amphibians (along with Aquatic Experts) were studied using quadrate method. Thirty quadrates of 5 x 5 M^2 were marked along the transects at a distance of 25 m for observing reptiles and amphibians. Amphibians were also searched along the river side. During the transect walk mammals, birds and butterflies were recorded as direct observations. Indirect evidences such as their calls, dung, hoof, pug mark, faecal matters and remnants of feeding were also noted and secondary data from the local people including the *Cholanaikan*, the only tribal community residing near the area were also collected. Nocturnal observations were done in the proposed dam site, for observing the nocturnal animals. Faunal distribution in the area and their relative composition under different classes are detailed in the subsequent chapters.

5.5. Aquatic Flora and Fauna

For the study of aquatic flora, planktons and benthic fauna quadrat methods were employed. Altogether 25 quadrats of 5 x 5m size were laid covering upstream, dam site, downstream, power house and tail race area etc. For fishes 5 samples each of the above-mentioned areas (25 samples) were collected for 3 months using different size and types of nets. Most of the fishes were identified in the field itself and released into the river. Few doubtful specimens were preserved in formalin for later identification using secondary data and keys. Information on fisheries was collected from the tribal fishermen in upstream and downstream zones of the river. Amphibians especially anurans which depends on aquatic habitats for completion of their life cycle also recorded as direct observation from the quadrats. Migratory and breeding behavior was established by constant observation of the microhabitats. Rare, endemic and threatened species of fishes will be listed as per the IUCN guidelines.

5.6. Agrobiodiversity

Agrobiodiversity is a critical subset of biodiversity that results through an interaction between the environments, genetic resources, management systems, and practices used by culturally diverse peoples and is significant from the perspective of biodiversity conservation. It results from natural selection processes and the intentional efforts of farmers, herders, and fishers over millennia. Loss of biodiversity in agriculture results from different factors such as commercial agriculture and the replacement of local varieties with genetically uniform high-yielding varieties, limiting the food sources to a minimum number of plants and animal species (today 75 % of the world's food is generated from only 12 plants and five animal species) and loss of natural habitats. Any biodiversity erosion of a locality can lead to significant ecological and environmental changes, many of which can have detrimental effects on both the natural habitat and human societies. Hence, a careful study has to be undertaken if the agro-biodiversity of an area is tampered with for converting the land area for any other activities.

A detailed study was conducted in the proposed project site to find out details of the existing agro-biodiversity of the area and the possible impact it will have once the area is used for project-related activities. For this, the entire area was physically inspected using an approved map made available for the purpose. The team interacted with the owners of the land to find out the varieties of crops cultivated and the presence of any rare and specific varieties available in the area. After preparing the details of the survey, it was again discussed with them so that there was no commission and omission in the report.

5.7. Geological factors, Risks and Solutions

"Engineering geological studies are important in all stages of the implementation of a dam project. The failure and rupture of more than a third of dams worldwide is the result of poor engineering geological studies at the dam site, which is a clear demonstration of the importance of geology for the successful design of dam projects" (Salmasi and John Abraham, 2023).

Applications of geological knowledge involve the following stages:

- Find surface and underground resources
- Identification and quality assessment of land, soils and water reserves
- Identify the internal materials that constitute the substrate Gain familiarity with land materials
- Study land processes and features and their impacts

The study was conducted by the Geology members of the team. Though the Project and the prospect covered are very small with no environmental issues all components of the EIA for Dam construction were investigated by the team by referring location and toposheet (Location: 50000 toposheet 58A/3).

5.7.1. Need for Current Geological Study

i. Kerala State Electricity board proposed a new HE project at Valanthode with very little impact on the Forest land and other environmental components. There was an unfounded and wrong information that a structure across this stream failed sometime in the past in the in the vicinity the same area or the same sub basin. Teams of KSEB and CISSA experts searched for the remnants of the structure or the scars. None was located. Though no history or memory corroborates the fact. It was decided to have a detailed study to clear up all confusions. Even after a concerted effort, we were not able to locate any of such dam, weir or barrage across this river at anytime in the current history ruling out the misinformation. More over, the history of the settlement in the area dates back to a few decades only. But such a gossip motivated the team to give special attention to the stability of the weir as well.

ii. Though the proposed project has a minimum resource demand like effected forest land, area of submergible reservoir etc, it was decided to conduct a study detailed enough to rule out all concerns like stability and suitability of the selection of the dam axis. Though the project was small, not even qualifying to call a dam (maximum height being 9.5m only) all components of a regular EIA for Gravity has been incorporated to this study.

5.7.1.1. Scheme of study

Methodology of two ways of analysis and understanding are explained here along with salient features of section 5.7.1 for Approach 1 is elaborated here. Observations are embodied in section 6.7 and Impact Analysis in section 7.5.

5.7.2. Analysis of the Stability factors of the Valanthode HE Project Weir: Approach -1

Stability factors and suitability factors of the reviewed project proposal is attempted in this section. The topic was addressed in 4 modes such as A, B, C and D.

A. All geological and geomorphic factors that contribute to stability and suitability are considered (Fig.5, section A) and their role in deciding the agreement to the proposal were studied before reaching to conclusions. These factors are studied in sections.

B. The failure modes recorded are listed (Fig. 5, section B) are considered for the current project and stability of the proposed Valanthode HEP weir is considered.

C. All possible details and features are considered by available data and still there are remote chance that a few unforeseen situations are unearthed and discussed in with solutions in detail in the chapters of findings and the probable impacts.

D. Once the project is up and running, preventive maintenance is a must and the same are discussed in chapters dealing with findings and impacts.

All details relating to non geological and hydrological factors are given in the following sections.

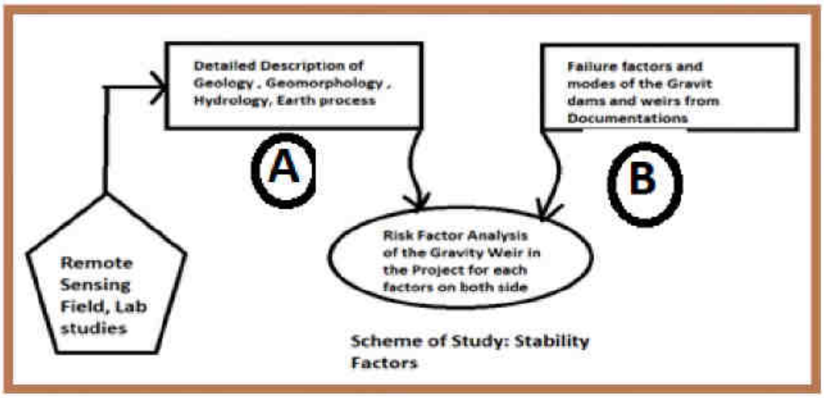


Fig. 5. Valanthode SHEP: Scheme of Stability and Suitability Factors

5.7.2.1. Levels of Collection of Information

The scheme of study/ observation has been designed in such a way to collect information on microscopic level that includes literature on regional basis on geomorphology and remote sensing. Information on field data such as local geomorphology, flow details were calculated by field survey. Microscopic details were studied in the lab to understand petrography, soil nature etc (Fig. 6).

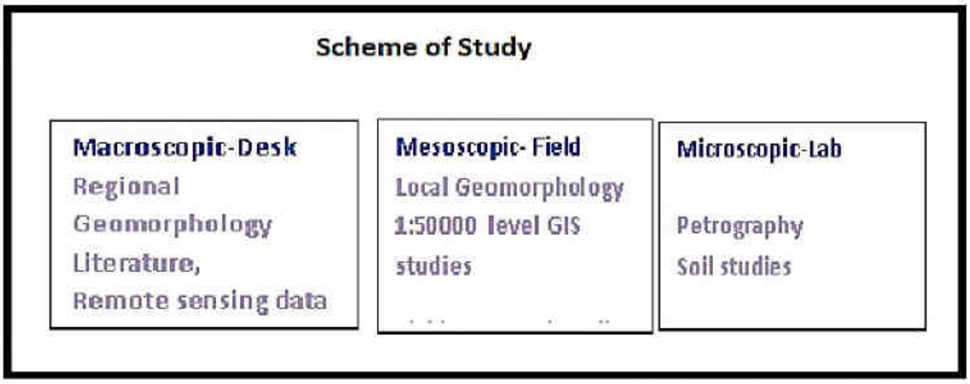


Fig. 6. Valanthode SHEP: Scheme of Study on Geological Aspects

5.7.3. Analysis of the Stability factors of the Valanthode HE Project: Approach- 2

Information flow regarding the Geological elements have two phases

i. Study of Rock engineering and identification of Risk factors and assessment
ii. Gathering information on Rock Engineering properties as construction goes

Phase- A of study detailed in 5.7.2 overlaps with this (5.7.3) approach. The material collected in Phase- A of Approach- 1 is considered for their engineering properties. Since the stability was a point of debate, special attention has been taken to discuss all the points concerned in a chapter on impacts (section -7.5). The Study was conducted in the field during winter months of 2023 -24, subsequent Desk and Lab studies were used for analysis. Usual EIA issues pertain to like loss of forest, flora, fauna, replacements of dwelling etc are least or minimum as this is run of river project and the weir is small when compared to the ones in larger projects. Moreover, majority of the land is not come under forest except for weir, like diversion canal, powerhouse or penstock components. The dam or weir is a run of river system with small storage when compared with typical Hydro Electrical dams. The study comprised all aspects of construction, maintained and management of the weir right from the concept of all components of the project were looked into.

5.7.3.1. The concept of the study

For both approaches, data collection is one and the same. All Geological data are collected at Remote sensing, mapping, geological traversing, pitting, drilling and laboratory levels. The Geological Components influencing dam design and construction and local Geological Factors effecting the construction of a dam are given in Tables 7 & 8 ; Fig 7.

Table- 7. Valanthode SHEP: Geological components influencing dam design and construction

Components	Controlling factors
Topography & geology	Size, Shape of Weir, Reservoir Dynamics, suitability and safety
Hydrology & water management	Reservoir Dynamics, Related Environmental factors
Climate & weather	Water availably as per design, design & construction of a dam, particularly with regard to issues such as flood management
Seismicity & Earthquake hazards	Seismic zone, Vulnerability to seismic episodes
Site investigation & geological considerations	Geology, Geomorphology, Geotrctonics, Geohydrology, Geomechanics

Table- 8. Valanthode SHEP: Local Geological factors effecting the construction of a Dam

Factors	Components
Rock Type	Heterogeneity; Weathering bearing capacity,
Weathering	composition, intensity of jointing, climatic setup geological age.
Attitude of Rocks	orientation thickness of rocks
Rock Structure	folded, faulted sheared Foliated Unconformity

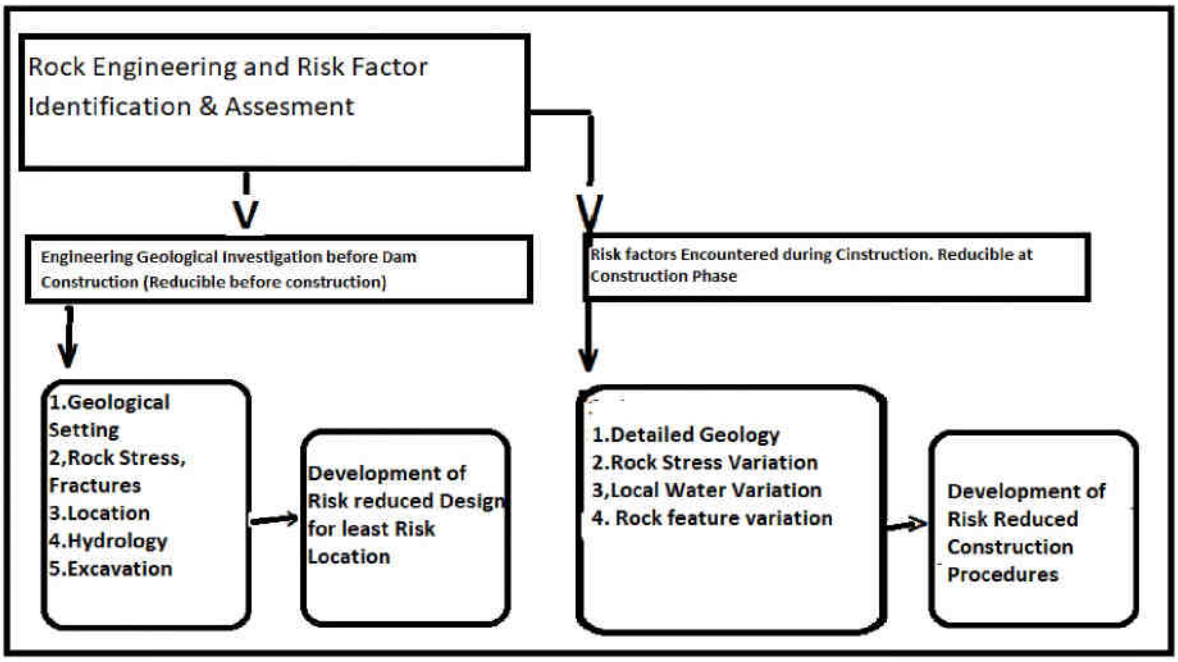


Fig. 7. Valanthode SHEP: Flow chart of information on Risk factors at different stages of Study and Construction

Local Geomorphological Factors effecting the construction of a dam and the site investigation and geological considerations are dealt in table 9 and 10.

The tables list the Geological process or products which bring in inherent structural, compositional properties that are controlling the construction or inducing risk of instability. Factors of Risk in section A of Approach-1 and the 1 of Approach- 2 are basically same but analyses separately for double check.

This Study aims to find the possibilities of contributory factors due to the geological, geotechnical, geomorphological factors contributing to the safety of the proposed Valanthode HE project weir. Here attempt has been made to introduce the correction factors at the construction level and best practice at maintenance level. Further attempt has been made to verify the aptness of selection of the weir axis in the geological frame work of the terrain.

Table- 9. Valanthode SHEP: Local Geomorphological Factors effecting construction of a dam

Components	Factors
Geomorphology of Catchment Area	slope characteristics shape and size total amount of water

Factors of velocity of water entering the reservoir	drainage pattern, drainage density, stream order and sinuosity of river
Geomorphology of Reservoir Area	size and shape reservoir rim configuration
Risk of landslides in reservoir	Slope, overburden Seepage of reservoir water Lowering resistance
Geomorphology of Dam site	Width of valley
Height of shoulder hills	Level of abutment foundation
Thickness of Alluvial fill	shoe string deposits buried channels seepage in foundation pore water pressure
Leakage and Seepage of Reservoir Water	pore water pressure causing uplift below the dam foundation groundwater level rise
Sedimentation in Reservoir	Siltation rate Area of reservoir Age of the dam

Table- 10. Valanthode SHEP: Site Investigation & Geological Considerations

Themes	Objectives	Tools & Techniques
Geology & rock mass properties	The geology of the site and the properties of the underlying rock mass play an important role in dam design and construction. The strength, deformation, and permeability characteristics of the rock mass can affect the stability of the dam and the safety of the impounded water.	Geomorphological studies, Remote Studies, Google map, 1:50,00 toposheets detailed contour maps, DPR details Detailed studies of the soil, laterite Borelogs of GSI Detailed Field studies of the outcrops , sections, excavations, Mesoscopic petrological studies Microscopically studies of rock samples
Geological structures	Geological structures such as faults, joints, and bedding planes can affect the stability of the dam and the behavior of the foundation and abutments. These structures can provide pathways for seepage and can also affect the behavior of the rock mass under loading	Regional studies of the lineaments, linear trends of geomomorphic bodies using remote sensing Google terrain map , trend of stream orders Detailed studies of the exposed foliations, foliations in exposures Borelogs of GSI (for faults and brecia)

Seismic hazards	Dams are typically designed to withstand seismic hazards, and the site investigation should include an assessment of the seismic hazard and the potential for earthquake-induced ground motions	Search for shearing in structural map, Study of the seismic zone map of GSI Collecting history of the Earthquakes in the vicinity Collection of Details of the nearby dams to consider probability of RIS
Soil and rock properties	the properties of the soil and rock fill used in the construction of the dam are also important. These properties can affect the stability of the embankment or concrete dam, as well as the long-term behavior of the dam under various loading conditions.	Geological map and sections by mapping on 1:50000 map, interpretation of Remote sensing Data
Groundwater conditions:	The groundwater conditions at the site can affect the stability of the dam and the safety of the impounded water. Site investigation should include an assessment of the groundwater conditions.	Porosity, permeability and chemistry of the aquifer rock Hydrological properties and orientation of the shears, faults and Joints
Construction materials:	The properties of these materials can affect the stability of the dam and the long-term behavior of the structure.	

5.7.4. Geological Factors to Consider for Dam construction and Risk Analysis

The shape of the valley, the strength of the land at the dam site, and the appropriate borrow pits are among the most important factors in selection of the site and the type of dam. (Refer Table- 7 and section 5.7.4.1). The study of rock type, stratification position and knowledge of geological structures such as creases, faults and seam are important considerations for a dam foundation. (Refer Table-8).

In areas where rock layering is known, the following decision may be taken as such i). it is better to choose a dam construction site where the axis of the dam is parallel to the layers or has a small angle with respect to the layers, ii) choose a place for the construction of the dam where the direction of the slope of the layers is upwards and iii) it is better if the slope of the layers is in the opposite direction of the water flow.

5.7.4.1. Factors for site selection

The study attempts the suitability of the proposed gravity weir site axis in the framework of the technical, social, fiscal factors. Physical factors include Topography, Geology, Foundation conditions, Availability of materials, Hydrologic conditions, Drainage details, Geotechnical and geomechanical aspects, Dimension of the weir, Characteristics of the catchment area, Earthquake vulnerability etc. All these factors are covered in different parts of this report and these factors of the currently selected site were compared to other alternatives in the sub basin and found to the right option. Details of each of the factor is discussed while elaborating on these themes.

5.7.5. Instability of Gravity Weir

In order to understand the possibilities of dam failures, the modes and reasons of the failure are to be understood before reaching to a conclusion on the stability of the proposed structure ruling out such possibilities even if they are rare or remote. Gravity dam failures can be grouped into three general categories: Sliding Gravity Dam Failure, Overturning of a gravity dam, Structural failure.

i. **Sliding Gravity Dam Failure:** When the dam slides over its foundation or one part of the dam slides over a part of itself, it is called a sliding failure. It occurs when the net horizontal forces acting on the gravity dam exceed the frictional resistance produced between the body of the dam and the foundation. The resistance may be due to friction alone, or it may be due to a combination of friction and shear strength, depending on how the dam was constructed.
ii. **Overturning of a gravity dam:** Horizontal and vertical forces such as water pressure, wave pressure, silt pressure, ice pressure, and uplift pressure can act against a gravity dam, creating overturning force or rotation of the structure. The structure resists this rotation by having adequate weight.
iii. **Structural failure**: Structural failure occurs when the tensile or compressive stresses in the dam exceed the strength of the materials that compose the dam. Masonry and concrete are weak in tension.

An object will reach its tipping point and fall over when the center of gravity passes past the base of the object as it is being tilted. You can increase the stability of an object by lowering its center of gravity or increasing the width of its base. Gravity dams (weirs) are subjected to various forces that can affect their stability and safety. These forces include water pressure, uplift pressure, earthquake forces, silt pressure, and wave pressure. Understanding and considering these forces is crucial in the design, construction, and maintenance of gravity dams. The forces that act on the gravity dam are the following: Weight of the dam, Horizontal hydrostatic pressure due to water, Uplift pressure due to water percolated under the dam, Earthquake pressure, Wind pressure, Wave pressure, Pressure due to silt deposited.

5.7.5.1. Instability factors of Gravity Weir

The forces to be resisted by a gravity dam fall into two categories namely, i) forces, such as weight of the dam and water pressure which are directly calculated from the unit weight of materials and properties of fluid pressure and ii) forces such as uplift, earthquake loads, silt pressure which are assumed only on the basis of assumptions of varying degree of reliability.

i. **Weight of the dam**: The self-weight of the gravity dam is a major resisting and stabilizing force of the dam. The resultant of the downward acting forces indicates the total weight of the dam at the center of gravity of the dam.
ii. **Horizontal hydrostatic pressure due to water:** One of the major external forces acting on a gravity dam is the water pressure. Hydrostatic pressure distribution can be used to determine the horizontal water pressure due to the water stored on the upstream side of the dam. On the upstream face of the dam, water exerts a horizontal force.
iii. **Uplift pressure due to water percolated under the dam:** Uplift forces occur as internal pressure in pores, cracks and seams within the body of the dam, at the contact between the dam and its foundation and within the foundation. Water flowing through the foundation's pores and cracks, as well as the water seeping through the body of the dam and through the joints between the body of the dam pushes the base of the dam in the upward direction. This pressure is called as Uplift pressure.
iv. **Earthquake pressure:** During an earthquake, seismic waves are produced that can effect different sections of the dam. The impact of earthquake is equivalent to imparting acceleration to the dam’s foundations in the direction of the wave. Earthquake (seismic) forces is associated with complex oscillating patterns of acceleration and ground motions, which generate transient dynamic loads due to inertia of the dam and the retained body of water. Horizontal and vertical accelerations are not equal, the former being of greater intensity.

v. **Wave pressure:** Waves are produced on the reservoir surface by the blowing winds. These winds cause a downstream wave pressure which depends on the wave height.

vi. **Pressure due to silt deposited**: The weight and the pressure of the submerged silt are to be considered in addition to weight and pressure of water. The weight of the silt acts vertically on the slope and pressure horizontally, in a similar fashion to the corresponding forces due to water. Earth pressures exerted on dams is the pressure applied by earth.

5.7.6. Local Geological Factors Effecting Construction of a Dam

- The important issues to be taken into consideration are related to rock mass properties, their attitude and presence of major deformation structures.
- As the reservoir and dam setup covers a considerably big area it is likely to bring in as many geological issues.
- Each site may have its own geological diversities in properties hence the elements of uncertainties and instability factors will be there.
- The dam site is especially important and it is only after the excavation for foundation and abutment is completed real picture of geology will emerge to be considered in final design.

I. **Rock Type:** Safety increases many folds if there is only monolithic rock type in its foundation and abutments. Igneous rock bodies being very large three dimensionally, offer such condition. The Strength of rock mass will depend upon its weathering state. The Bearing capacity, which will be an important factor in deciding the type of dam. The gravity dams, being huge in size are only made on very strong rocks. Hence, igneous and non-foliated metamorphic rocks will be most ideal. Foliated metamorphic rock gneisses, thickly bedded sandstones and strong limestone in comparatively dry regions have been found to perform well.

II. **Weathering State:** The weathering state of rocks will depend upon its composition, intensity of jointing, climatic setup of the area and geological age. In no case weathered rock be made as foundation ground for any type of dam. In fact, for large dams only fresh rock surface should be taken into consideration and if not naturally available then should be excavated up by scrapping.

III. **Attitude of Rocks**: In the case of stratified rocks, the orientation and thickness of rocks in relation to the dam axis and resultant force direction plays a very important role. The horizontal rocks or *rocks dipping by less than 50* degrees do not offer good foundation condition as it may come in parallelism with resultant force direction. If rock beds are *thicker than the dam height* the whole dam with foundation will remain in one rock. However, if the thickness is less, then rocks in foundation and abutment may differ. In such cases, care should be taken in deciding the foundation of the dam, which should be placed in the strongest rock bed.

5.7.7. Local Geomorphological Factors Effecting Construction of a Dam

i. **Geomorphology of Catchment Area:** Geomorphology of catchment in terms of slope characteristics apart from shape and size of the catchment area are important in deciding the total amount of water available to a river.

ii. **Factors of velocity of water entering the reservoir:** Geomorphic components such as drainage pattern, drainage density, stream order and sinuosity of river control the velocity of water entering the reservoir.

iii. **Geomorphology of Reservoir Area:** The volume filled may have different size and shape depending upon the geomorphology of the area and the length and height of the dam. The reservoir rim formed by the topography of the area will result into its linear, oval, semicircular to irregular shapes.

iv. **Danger of landslides in reservoir:** The possibilities of landslides increase with increasing slope. The scars of previous landslides and slopes showing creeping should be figured and mended. The reservoir water may also lead to increase in groundwater level leading to lowering of frictional resistance along the discontinuity surfaces aggravating future landslides.

v. **Geomorphology of Dam site:** The important geomorphic consideration at dam site is the narrow river valley section. The narrower is the river valley smaller will be the length of the dam and lower will be the cost. Sometimes this becomes the only criteria for the selection of dam site to economize its construction, leaving (ignoring) other factors. The river valley may have varying width depending upon its stage and antiquity

vi. **Height of the shoulder Hills:** It is important, on to which the two sides of dam are going to rest i.e. the abutment foundation. It should be well above the dam height so as to prevent spilling of water in sideways.

vii. **Thickness of Alluvial fill:** The River may have varying thickness of sediment deposit, termed as valley fill. As rivers shift their course sideways, due lateral accretion of sediment and vertically due to deposition of sediment layer by layer. The coarse of sediments (gravels and coarse sand) are deposited in its channel and are left back as shoe string deposits. When dam is made and reservoir filling starts, water percolating downward through sediment deposits find easy to escape through these so called highly porous and permeable zone of sediments termed as buried channels, resulting not only loss of stored water but also problem of seepage in foundation leading to development of pore water pressure. Such buried channels are to be explored, identified and sealed and be abutted and in no case, they should lie below the dam.

viii. **Leakage and Seepage of Reservoir Water**: Another pertinent issue is leakage and seepage of water from reservoir which not only undermines the very purpose of reservoir but also cause excessive pore water pressure causing uplift below the dam foundation. Leakage is defined as water loss along the linear openings as stream threads and seepage of water is a loss as diffuse flow through interconnected pores. The causes of leakage can be ascribed to presence of fault and shear zones, high incidence of joints in rocks etc. while seepage may take place along alluvial fill, through the dam and through the foundation material. Another consequence of leakage and seepage of water is groundwater level rise in rocks surrounding the reservoir, which may add to the problem of land sliding. The only positive effect of this rise termed as bank storage, its discharge in reservoir during lean period when reservoir water level is well below the requirement.

ix. **Sedimentation in Reservoir**: The damming of river will automatically stop the river sediment in reservoir, which were ought to go downstream and get distributed all along its course. Though it is very rare to have rate of sedimentation in reservoir as a decisive factor in deciding the location of the dam but, it is a profound factor in deciding the dead storage capacity, as the life of a reservoir is based on this space, which is eventually got to be filled by silt but in designed life of the dam. The decision for height of the dam may also have to take the rate of sedimentation into account, as the total reservoir capacity minus the dead storage will control the total water available for the dam is intended for.

5.7.8. Framework of Important Factors in Choosing the Site of Dam

i. **Weak Structural Features:** Folding, faulting, shear zones and joints are unfavourable geological structures for a dam site. Folds and faults develop several fractures and crushing of rock which are responsible for the problems of settlement, uplift and leakage. Shear zones and joints when present in dam site rocks bring weakness to the dam foundation orientation of bedrock layers, which is referred to as dip direction. For optimal stability, dams should be located on beds that dip towards the upstream side, as these positioning results in the water's resultant force acting against the dam's toe. It should be noted that the dip angle of the beds can also influence the dam's stability, with variations throughout the dam's extent potentially causing overload, folding, and defects.

ii. **Thick Mantle of Overburden:** Over burden in a dam site includes the loose river sand and silt at the valley floor and the unconsolidated in-situ disintegration of the parent rock or by transportation from higher reaches. If the overburden in a dam site is very thick compared to the dam height, the construction of the concrete or masonry dams here involves deep excavation to obtain bed rock with consequent increase in the dam height and project cost. Even an earth dam if founded on such permeable overburden, it will create problem of leakage.

iii. **Deep Weathering of Bed Rock:** If the bed rock is highly weathered, it becomes soft with reduction of its strength to sufficient extent. When a heavy structure like the concrete or masonry dam is founded on such soft rock mass, it may create problem of settlement and crack of the dam body. For the dam foundation, it is necessary to excavate the weathered rock and expose the fresh bed rock. If the depth of weathering is very high, it may involve deep excavation and consequent increase of the dam height and escalation of construction cost.

iv. **Karstic Condition and Cavities:** Solution of limestone may result innumerable sinkholes and solution cavities or caves of various dimensions giving rise to the karstic feature. Cavities may also be formed in some non-soluble rocks by water action or by leaching of soft material from such rocks.

v. **Permeable Boulder Bed:** Boulder deposit of riverine, fluvio-glacial or glacial origin when present in a dam site, excessive leakage is always expected. Unconsolidated boulders and pebbles may also occur as scree or terrace in the abutments of a dam site and create problems of foundation stability and leakage.

vi. **Soft Sedimentary Rock:** Soft sedimentary rocks like claystone, mudstone, shale and clay-siltstone incapable of bearing load of heavy structures when exist in a dam site may give rise to the problem of plastic deformation settlement or shear failure. Smooth surface of shale or claystone occurring alternated with sandstone with low dip towards downstream may bring failure of the dam by slide.

vii. **Buried Channel:** Such channels are deeply eroded sub-surfaces in the bed rock subsequently filled up by pervious material like sand, pebbles and cobbles and as such existence of such features at a dam site endangers excessive leakage of stored water.

viii. **Kaolinisation:** The process of a kaolinisation of felspar is associated with selective decomposition and weathering of pegmatite and coarse-grained granite. Starting from surface, such zones of soft white-clayey mass generally extend downwards as irregular pockets surrounded by hard rocks. A site with zones of kaolinisation cause problem of founding concrete dam and spillway structure.

ix. **Old Slides**: An area with old slides indicate instability. In some dam sites slide scars are found at the upper reaches of the banks with slided material like soil, debris or rock chunks at the bottom parts. In the Himalayan terrain of Sikkim and Darjeeling, old slides are seen in several places. An old slide plane may be activated when construction of a dam imposes new stress condition in the site.

x. **Reservoir Siltation:** It is an indirect effect of dam construction in an area with unstable landforms all around. When a dam is constructed with reservoirs in slide-prone areas, it may bring problem of reservoir siltation by wide-scale slides at the fringe areas of the reservoir. The problem is very acute in the reservoir areas of some dams constructed in the Himalayan terrain.

Recapitulate

This section sets the background, methodology and concept for the analysis and identification of the risk factors in Geology related fields. Here the ground is set, in section 5.7 on data input and further analyses are done in section 6.7 (please refer the chapter *findings and evaluation). In section 5.7.1, the need and scheme of approach are introduced. Two types of analyses are proposed for finding i) Risk factors due to the intervention of Geological factors and their sub sets on the Gravity dam with defined instability features and mode of failures and ii) Risk factors that are evidently prevailing at the start of the project, and those which will be appearing during construction. Flow charts are provided with details of the concepts. Input factors of the Geological elements and subsets in four tables are discussed along with geological factors effecting construction. Instability factors are detailed.*

Plate - 1. Valanthode SHEP: Study Team

A- Weir site- upstream visit / B - Tree enumeration / C- Experts in discussions
D - Scaling the weir site / E - Examining rock structure / F - Team at downstream

6.THE FINDINGS AND EVALUATION

The study has been designed in such a way to document available data on the physical settings and the various biological components that inhabit the study area. These data thus obtained from field and laboratory were analysed objectively. The findings, in fact, evaluated the merits of the proposed hydel project without compromising the safety of the environment.

6.1. Forest Types

The project area harbours evergreen forest in the catchment area and dam site from 700m above sea level, moist deciduous in downstream and powerhouse area from 600m downwards. There is a well well-developed riparian forest are observed along the river basin. A small strip of semi-evergreen forest patch has been observed from dam site to 650m where both evergreen and deciduous elements are well represented. There are some bamboo brakes and grassland rock outcrops occasionally seen on the catchment area. Each of these ecosystems are dealt separately so as to give a clear picture of the forest wealth of the area (Plate-2).

6.1.1. Tropical Wet Evergreen Forest

This forest type is the predominant vegetation of the proposed project area, mainly in the catchment and the proposed reservoir. The catchment area or the water shed area on the left side of the river is a continuation of dense evergreen forest, extended upto Vellarimala of Waynad district. The main association of this forest is *Cullenia- Palaquium-Myristica* type. The dominating tree species of the forest are very huge trees of *Cullenia exarillata* Robyns, *Palaquium ellipticum* (Dalz.) Baill and *Myristica dactyloides* Gaertn. The other trees found here include large buttressed trees *Elaeocarpus tuberculatus* Roxb., *Machilus glaucescens* (Nees.) Wight and Toona *ciliata* Roem. mixed with *Dillenia bracteata* Wight, *Dimocarpus longan* Lour., *Elaeocarpus serratus* L., *Garcinia gummi-gutta* (L.) Robson, *Garcinia cambogioides* (Murray) Headland and *Syzygium cumini* (L.) Skeels. The second strata are composed of medium trees such as *Cinnamomum malabatrum* (Burm. f.) Blume, *Ficus beddomei* King, *Hydnocarpus pentrandrus* (Buch.-Ham.) Oken, *Meigoyne pannosa* (Dalz.) Sinclair, *Monosis conferta* (Benth.) Jeffry, *Syzygium lateum* (Buch.-Ham.) Gandhi, *Tetrapilus* *dioicus* (Roxb.) Johnson, *Xanthophyllum flavescens* Roxb. etc. large lianas include *Gnetum edule* (Willd.) Blume, *Entada phaseoloides* (L.) Merr. and *Salacia beddomei* Gamble straggle on the trees.

The third story is composed of saplings of many of the above trees, mixed with shrubs such as *Agrostistachys indicia* Dalz., *Barleria courtallica* Nees, *Clerodendrum infortunatum* L., *Debregeasia longifolia* (Burm. f.) Wedd., *Dichapetalum gelonioides* (Roxb.) Engl., *Indianthus virgatus* (Roxb.) Suksathan & Borch s., *Ixora agasthyamalayana* Sivad. & Mohanan, *Lepiaanthes erecta* (Thw.) Leenh., *Memecylon edule* Roxb., *Pilea crenulata* (Sw.) Urb., *Psychotria flavida* Talbot, *Saprosma foetens* (Wight) Schum, *Thottea siliquosa* (Lam) Ding Hou etc. This story has many shrubby climbers like *Ancistrocladus heyneanus* Wall. ex Graham, *Calamus rheedei* Griff., *Erythropalum scandens* Blume, *Jasminum malabaricum* Wight, *Persicaria chinensis* (L.) Gross, *Piper hymenophyllum* Miq., *Smilax zeylanica* L., *Strychnos aenea* Hill, *Thunbergia mysorensis* (Wight) Anderson etc.

The forest floor is dominated with herbs such as *Elateostema lineolatum* Wight, *Coleus malabaricus* Benth., etc whereas small scattered plants of Anaphyllum *wightii* Schott, *Arisaema nilamburense* Sivad., *Ophiopogon intermedius* D. Don etc are also observed. Epiphytes include orchids like *Acampe ochracea* (Lindl.) Hochr., *Liparis viridiflora* (Blume)Lindl. and *Pholidota imbricata* Hook. Epiphytic Melastomataceae member *Medinilla beddomei* Clarke is found abundantly.

6.1.2. Tropical Semi-evergreen Forest

In continuation to the evergreen vegetation, towards the lower sides, near the proposed reservoir is composed of semi-evergreen forests where deciduous elements mix up with the evergreen flora. Tree components include true riverine species like *Holigarna arnottiana* Hook. f., (Charu), *Hopea parviflora* Bedd. (Kambakam), and *Xanthophyllum flavescens* Roxb. (Mottal). Other evergreen trees found here are *Artocarpus hertophyllus* Lam. (Plavu), *Cullenia exarillata* A. Robyns (Vediplavu), *Dimocarpus longan* Lour. and *Elaeocarpus tuberculatus* Roxb. (Bhadraksham). Presence of deciduous trees such as *Macranga peltata* Mull. Arg. and *Mallotus tetracoccus* (Roxb.) Kurz. are the indication of the high exposure of the area to sunlight.

The second story composes of seedling of above trees along with shrubs such as *Antidesma montanum* Blume, *Debregeasia longifolia* (Burm. f.) Wedd., *Goniothalamus wynaadensis* Bedd., *Indianthus virgatus* (Roxb.) Suksathan & Borchs., *Ixora agasthyamalayana* Sivad. & Mohanan, *Leea indica* (Burm. f.) Merr. and *Thottea siliquosa* (Lam) Ding Hou. Shrubby climbers *Adenia hondala* (Gaertn.) W.J. de Wilde and *Smilax zeylanica* L. straggled on the shrubs and trees.

The ground flora consists of herbs such as *Canscora diffusa* (Vahl) R. Br. ex. Roem. & Schult., *Henckelia pradeepiana* Nampy, Manudev et Weber, Impatiens *scapiflora* Heyne ex Wall., Sonerila *sahyadrica* Giri & Nayar, Utricularia *reticulata* Sm. etc growing on the moist rocks, whereas aquatic herbs like *Lagenandra toxicaria* Dalz. and *Limnophila heterophylla* Benth. grow in water lodged condition. Other herbs found on the forest floor are *Anaphyllum wightii* Schott, *Elateostema lineolatum* Wight and *Rostellularia mollissima* (Nees)Nees. Epiphytic orchid species *Liparis viridiflora* (Blume) Lindl. and Melastomataceae climber *Medinilla beddomei* Clarke are found growing on the trees.

6.1.3. Moist Deciduous Forest

It is seen along the downstream of the river Valanthode starting from 650 above MSL, which include power house and further down till confluence with main river Chaliar. The top story is occupied by the species such as Bombax ceiba, Dillenia pentagyna, *Tectona grandis, Terminalia bellarica*, *T. paniculata, Xylia xylocarpa* etc. They are often supported with root buttresses and reach up to the highest of 42-45m. The second story reach 15-20m hight and composed of species like *Aporusa, Careya, Baccaurea, Evodia, Gmelina, Macaranga, Mallotus, Sterculia,* etc. The third story occupies by the species of *Antidesma, Glochidion, Helectres, Tabernaemontana*, etc. Climbers are more frequent and represented by *Anamirta, Ancistrocladus, Asparagus, Calycopteris, Dioscorea, Smilax, Strichnos, Zigzyphus* etc. Epiphytes such as *Cleisostoma, Pholidota, Rhynchostylis* etc. are commonly find here. Herbacious flora such as *Andrographis paniculata, Begonia malabrica, Globba ophioglossa, Impatiens scapiflora, I. viscosa, Thottea siliquosa* are seen growing naturally.

6.1.4. Riparian Forest

It is a patch of riverine vegetation seen on the border of the river, often dominated by evergreen elements. The life forms in this community are peculiar in having inherent capacity of withstanding inundation during monsoon floods and tidal action of river water. Puri *et. al.,* (1983) recognized this vegetation as a type under the edaphic pre-climaxes in tropical forest of India. It is seen in areas of catchment, dam site and submergible and downstream to the power house. Since this vegetation is dominated by evergreen elements, it is almost merged with evergreen patches at catchment and dam site areas whereas at downstream area surrounded with deciduous elements riparian vegetation is distinct with some variation of floral components mixing with deciduous elements. To get clear picture both are described here separately.

6.1.4.1 Riparian Forest in catchment and submergible areas:

Tree components include true riverine species like Holigarna arnottiana Hook. f., (Charu), *Hopea parviflora* Bedd. (Kambakam), and *Xanthophyllum flavescens* Roxb. (Mottal). Other evergreen trees found here are *Artocarpus hertophyllus* Lam. (Plavu), *Cullenia exarillata* A. Robyns (Vediplavu), *Dimocarpus longan* Lour. and *Elaeocarpus tuberculatus* Roxb. (Bhadraksham). Presence of deciduous trees such as *Macranga peltata* Mull. Arg. and *Mallotus tetracoccus* (Roxb.) Kurz. are indication of the high exposure of the area to sunlight here and there.

The second story composes of seedling of above trees along with shrubs such as *Antidesma montanum* Blume, *Debregeasia longifolia* (Burm. f.) Wedd., *Goniothalamus wynaadensis* Bedd., *Indianthus virgatus* (Roxb.) Suksathan & Borchs., *Ixora agasthyamalayana* Sivad. & Mohanan, *Leea indica* (Burm. f.) Merr., Thottea siliquosa (Lam) Ding Hou etc. Shrubby climbers like *Adenia hondala* (Gaertn.) W.J. de Wilde and *Smilax zeylanica* L. are straggled on the shrubs and trees.

The ground flora consists of herbs such as *Canscora diffusa* (Vahl) R. Br. ex. Roem. & Schult., *Henckelia pradeepiana* Nampy, Manudev et Weber, *Impatiens scapiflora* Heyne ex Wall., Sonerila *sahyadrica* Giri & Nayar, *Utricularia reticulata* Sm., etc are growing on the moist rocks, whereas aquatic herbs namely Lagenandra toxicaria Dalz. and Limnophila heterophylla Benth. grow in water lodged ground. Other herbs found on the forest floor are *Anaphyllum wightii* Schott, *Elateostema lineolatum* Wight, *Rostellularia mollissima* (Nees)Nees., etc. Epiphytic orchid species like *Liparis viridiflora* (Blume) Lindl. and Melastomataceae climber *Medinilla beddomei* Clarke are found growing on the trees.

6.1.4.2 Riparian Forest in downstream area

This is a narrow patch of riverine vegetation on the border of the river where the diversion canal begins and continues up to powerhouse and beyond. Very few trees are seen in this patch. Besides true riparian elements such as *Holigarna arnottiana* Hook. f., *Madhuca neriifolia* H.J. Lam. and *Myristica dactyloides* Gaertn., a few evergreen trees such as Bischofia javanica Blume, Cinnamomum malabatrum (Burm. f.) Blume, *Dimocarpus longan* Lour., *Elaeocarpus tuberculatus* Roxb., *Machilus glaucescens* (Nees.) Wight, *Terminalia bellerica* (Gaertn.) Roxb. and *Toona ciliata* Roem. are also seen. On the open border of the patch deciduous element like *Macranga peltata* Mull. Arg. is observed.

The second story is occupied by seedlings of trees such as *Antidesma montanum* Blume, Polyspora obtusa (Wall. ex. Wt. & Arn.) Nissalo & Choo, *Xanthophyllum flavescens* Roxb., etc Syzygium *cumini* (L) Skeels, Dimocarpus *longan* Lour., *Terminalia bellerica* (Gaertn.) Roxb etc. Shrubs include *Debregeasia longifolia* (Burm. f.) Wedd., *Homonoia riperia* Lour., *Indianthus virgatus* (Roxb.) Suksathan & Borchs., *Leea indica* (Burm. f.) Merr., *Psychotria flavida* Talbot, Thottea siliquosa (Lam) Ding Hou etc. Climbers such as *Ancistrocladus heyneanus* Wall. ex Graham, *Elaegnus conferta* Roxb., *Erythropalum scandens* Blume, *Pothos scandens* L. and *Thunbergia mysorensis* (Wight) Anderson are also straggled among the trees and shrubs.

The ground flora is composed of *Elateostema lineolatum* Wight, Impatiens *grandiflora*, I. Viscosa, *Ischaemum ciliare* Retz. and *Ophiopogon intermedius* D. Don., etc.

6.2. Floristic Analysis

The study area had alredy received considerable attention of field botanists due to rich vegetation and floristic diversity (Sivarajan and Philip Mathew, 1997). The flora is dominated by the Angiosperms which are categorized habit wise for analysis. Also discussed the importance of Endemic and RET species and economic potential of plant resources available in the study area.

6.2.1. Flora of the Area

The vegetation is characteristically dominated by flowering plants. The study resulted in documentation of 260 species coming under 224 genera in 82 families. The life forms constituted a major share of herbs (37%), followed by trees (34%), Climbers (13%), shrubs (12%) and epiphytes (4%) (Table-11; Annexure-1). On further analysis, it was found out that only 35 species (13%) of which 8 trees of 11 individuals are distributed in the dam site area, but at the same 225 species (87%) are distributed in both catchment and downstream areas. In short, the proposed project has little impact on the flora of the area.

6.2.2. Endemic and RET Species

The term endemic refers to population or a species having restricted distribution to a particular ecological habitat or geographical range. Such taxa are called endemics and the phenomenon is known as endemism. The western Ghats, where the project is proposed, is known for high degree of endemism and is often compared with oceanic islands (Nayar, 1980; Ahammedulla and Nayar, 1987; Pandurangan, 1984.) The study identified 20 endemic species of Western Ghats which are growing in the whole of project area. Among these, eight species have representated in the dam site in addition to their distribution in the whole project area. (Table-12; Plate -3). Among the endemics, five species come under RET category and all of them are well represented and safe in the catchment area, hence not affected by the dam. (Table- 13; Plate- 4).

6.2.3. Tree Species

The investigation recorded 88 species from the project area and thus form dominant component of the flora. Out of these, members of only 9 species are found in the dam site and duplicates of all of them are well represented in the catchment and downstreams areas. Of these 88 trees, 24 species belong to merchantable trees and has lot of trade values. Among that only 3 timber yielding trees are reported from the dam site (Table-14; Plate-5). Important mechantable trees are *Artocarpus heterophyllus* Lam., *A. hirsutus* Lam., *Dysoxylum malabaricum* Bedd.ex Hiern, *Hopea parviflora* Bedd., *H. ponga* (Dennst.) Mabb., *Mangifera indica* L., *Mesua ferrea* L., *Terminalia bellerica* (Gaertn) Roxb., *T. alata* Heyne ex Roth., T. *paniculata* Roth., *Pterocarpus marsupium* Roxb.etc (Table-15; Plate-6)

6.2.4. Medicinal Plants

Medicinal Plants are very important forest produce that is taking care of health security of the local population. Locals living in and around the project area standardized the medicinal properties of these species by trial-and-error methods over a long period and they regularly use these resources for treatment of several diseases. Hence, a National Medicinal Plant Board, under Ministry of AYUSH, Govt of India, was established to promote medicinal Plant conservation, cultivation, and sustainable utilization. The present analysis enumerated 44 medicinal plants of the western Ghats of which 4 species occur in the dam site and all other species including these 4 were distributed in the entire project areas (Table- 16; Plate- 7).

6.2.5. Wild Edible Plants

Wild edibles are native plants grow and produce edible fruits, seeds, leaves or tubers in natural habitats, without being cultivated. These species play a major role in meeting the nutritional requirement of the local and tribal population. Such forest produces are collected and consumed by tribal communities and are even sold in nearby public markets as forest products. Bamboo rice is a good example. In the present study, 19 wild species yielding fruits, seeds or wild spice produces were recorded from the catchment area of the project. (Table – 17).

6.2.6. NWFPs and Fibre Plants

Other than timber trees, Forest is always a supply source of many other economically important products, generally called as Non-Wood Forest Products such as rattans, fibre, back dammar, wild camboge etc. These are generally a source of income for the forest tribes, who collect them and supply to the outside market. In the present analysis, it is found that 17 species belonging to NWFPs such as medicinal resources, wild spices, fibres, hill tamarind, sambrani etc were identified and recorded from the catchment area. Important among them are *Canarium strictum* Roxb., *Calamus rheedei* Griff., *Garcinia conicarpa* wight, *G. gummi-gutta* (L.) Roninson, *Spatholobus parviflorus* (Roxb.ex DC) O. Ktze., *Sterculia guttata* Roxb.ex DC etc (Table-18; plate-8).

6.2.7. Wild Relatives of Crop Plants

The locals grow a number of agri-horticultural crops in their settlement as stated earlier. At the same time, many wild relatives of cultivated crops are grown naturally in the western Ghats including in the project area and thus form a potential gene bank. The wild relatives can be grouped under camboge, cinnamon, clove, jack, millet, nutmegs, peppers, zingibers etc. The study identified 16 crops relatives that are grown in the project areas of which two are distributed in the dam site and submergible area and the balance well distributed in the entire project area with no immediate threat for their existence (Table- 19; Plate -9). In addition, 19 species, one or other way have edible potential treated under section- 6.2.5 and could be considered as wild relatives of crop plants. These wild relatives are very important for improvement of cultivated crops in future.

6.2.8. Exotic Species

The project area particularly downstream and dam site areas have been invaded by exotic flowering plants which in turn indicate the anthropogenic presence. They may be introduced as ornamental and are escaped from the cultivation and get naturalized in due course. To find out their country of origin and nature of spreading, the following literatures were consulted. (Mahewari and Paul 1975; Rao and Suryanarayana, 1979). Generally, the fast-growing exotic weeds hinder the regeneration of other species by spreading extensively and there by offering a stiff completion to the young seedlings in terms of space, nutrients intake and light energy. Presently the project area harbours 28 exotic weeds of which 6 species are recorded in the dam site which indicate the disturbances have already been there. (Table-20; Plate- 10).

Table- 11. Valanthode SHEP: Floristic analysis

Total Number of Families	**82**
Total genera	**224**
Total number of Species	**260**
Herbs	**97 (37%)**
Trees	**88 (34%)**
Climbers	**34 (13%)**
Shrubs	**32 (12%)**
Epiphytes	**11 (4%)**
Endemic species	**20**
RET species	**Five**
Timber trees	**24**
Medicinal plants	**44**

Crop relatives	**16**
Wild edible plants	**19**
NWFPs and Fibre plants	**17**
Exotics	**28**

Table- 12. Valanthode SHEP: List of Endemic Plants

Sl. No	**Family & Plant Name**	**Endemism**	**Areas observed**		
			Catchment	**Dam site**	**Down stream**
	ACANTHACEAE				
1	*Barleria courtallica* Nees	Endemic to Western Ghats	+		
	ANACARDIACEAE				
2	*Holigarna arnottiana* Hook. f.	Endemic to Western Ghats	+	+	+
	ANONACEAE				
3	*Goniothalamus wynaadensis* Bedd.	Endemic to Western Ghats	+	+	
4	*Polyalthia fragrans* (Dalz.) Bedd.	Endemic to Western Ghats	+		
	ARACEAE				
5	*Arisaema nilamburense* Sivad.	Endemic to Western Ghats	+		
6	*Anaphyllum wightii* Schott	Endemic to Western Ghats	+	+	
	BALSAMINACEAE				
7	*Impatiens scapiflora* Heyne ex Wall.	Endemic to Western Ghats	+	+	
	BOMBACACEAE				
8	*Cullenia exarillata* A. Robyns	Endemic to Western Ghats	+	+	
	CONVOLVULACEAE				
9	*Argyreia nellygherrya* Choisy	Endemic to Western Ghats	+		
	CLUSIACEAE				
10	*Garcinia conicarpa* Wight	Endemic to Western Ghats	+		+
	DIPTEROCARPACEAE				
11	*Hopea ponga* (Dennst.) Mabb.	Endemic to Western Ghats	+		
	EUPHORBIACEAE				

12	*Baccaurea courtallensis* (Wt.) Muell-Arg.	Endemic to Western Ghats	+		
	GESNERIACEAE				
13	*Henckelia pradeepiana* Nampy, Manudev et Weber	Endemic to Western Ghats	+	+	
	HYPOCRATACEAE				
14	*Salacia beddomei* Gamble	Endemic to Western Ghats	+		
	MALVACEAE				
15	*Julostylis polyandra* Ravi & Anil Kumar	Endemic to Western Ghats			+
	MELASTOMATACEAE				
16	*Sonerila sahyadrica* Giri & Nayar	Endemic to Western Ghats	+	+	
	MELIACEAE				
17	*Dysoxylum malabaricum* Bedd. ex Hiern	Endemic to Western Ghats	+		
	MYRTACEAE				
18	*Syzygium mundagam* (Bourd.) Chithra	Endemic to Western Ghats	+		
	RUBIACEAE				
19	*Ixora agasthyamalayana* Sivad. & Mohanan	Endemic to Western Ghats	+	+	
	SAPOTACEAE				
20	*Palaquium ellipticum* (Dalz.) Baill.	Endemic to Western Ghats	+		

Table- 13. Valanthode SHEP: List of RET PLANTS

Sl. No	**Family & Plant Name**	**RET status**	**Areas observed**		
			Catchment	**Dam site**	**Down stream**
	DIPTEROCARPACEAE				
1	*Hopea ponga* (Dennst.) Mabb.	Vulnerable	+		
	MALVACEAE				
2	*Julostylis polyandra* Ravi & Anil Kumar	Endangered			+
	MELIACEAE				
3	*Dysoxylum malabaricum* Bedd. ex Hiern	Endangered	+		

	MYRISTICACEAE				
4	*Myristica dactyloides* Gaertn	Vulnerable	+		+
	SAPOTACEAE				
5	*Palaquium ellipticum* (Dalz.) Baill.	Endangered	+		

Table- 14. Valanthode SHEP: List of Trees

Sl. No	Family & Plant Name	Life form	Areas observed		
			Catchment	Dam site	Down stream
	ANACARDIACEAE				
1	*Holigarna arnottiana* Hook. f.	Tree		+	+
2	*Mangifera indica* L.	Tree	+		
3	*Spondias pinnata* (L.f.) Kurz	Small tree	+		
	ANONACEAE				
4	*Meigoyne pannosa* (Dalz.) Sinclair	Tree	+		
5	*Polyalthia fragrans* (Dalz.) Bedd.	Tree	+		
	APOCYNACEAE				
6	*Alstonia scholaris* (L.) R. Br.,	Tree	+		
7	*Wrightia tinctoria* (Roxb.) R. Br	Tree	+		
	ARECACEAE				
8	*Caryota urens* L.	Tree	+		
	ASTERACEAE				
9	*Monosis conferta* (Benth.) Jeffry	Tree	+		+
	BOMBACACEAE				
10	*Cullenia exarillata* A. Robyns	Tree	+	+	
11	*Bombax ceiba* L.	Tree	+		
	BURSERACEAE				
12	*Canarium strictum* Roxb.	Tree	+		
13	*Garuga pinnata* Roxb.	Tree	+		
	CLUSIACEAE				
14	*Calophyllum polyanthum* Wall. Ex Choisy	Tree	+		
15	*Garcinia conicarpa*Wight	Tree	+		+
16	*Garcinia cambogioides* (Murray) Headland	Tree	+		
17	*Garcinia gummi-gutta* (L.) Robson	Tree	+		
18	*Mesua ferrea* L.	Tree	+		
	COMBRETACEAE				

19	*Terminalia bellerica* (Gaertn.) Roxb.	Tree			+
20	*Terminalia alata* Heyne ex Roth,	Tree	+		
21	*Terminalia paniculata* Roth	Tree	+		
	DICHAPETALACEAE				
22	*Dichapetalum gelonioides* (Roxb.) Engl.	Tree	+		
	DILLENIACEAE				
23	*Dillenia bracteata* Wight	Tree	+		
	DIPTEROCARPACEAE				
24	*Hopea parviflora* Bedd.	Tree		+	
25	*Hopea ponga* (Dennst.) Mabb.		+		
	EBENACEAE				
26	*Diospyros paniculata Dalz.*	Tree	+		
	ELAEOCARPACEAE				
27	*Elaeocarpus munronii* (Wt.) Mast.	Tree	+		
28	*Elaeocarpus serratus* L.	Tree	+		
29	*Elaeocarpus tuberculatus* Roxb.	Tree	+	+	+
	EUPHORBIACEAE				
30	*Antidesma montanum* Blume	Tree		+	+
31	*Baccaurea courtallensis* (Wt.) Muell-Arg.	Tree	+		
32	*Bischofia javanica* Blume	Tree			+
33	*Glochidion malabaricum* Bedd.	Small tree	+		
34	*Macranga peltata* Mull. Arg.	Tree		+	+
35	*Mallotus philippensis* (Lamk.) Muell.-Arg.	Tree			+
36	*Mallotus tetracoccus* (Roxb.) Kurz.	Tree		+	+
	FABACEAE (Caesalpinioideae)	Tree			
37	*Bauhinia malabarica* Roxb.	Tree	+		
38	*Cassia fistula* L.	Tree	+		
	FABACEAE (Papilionoideae)				+
39	*Erythrina stricta* Roxb.	Tree			+
40	*Pterocarpus marsupium* Roxb.	Tree	+		
	FLACOURTIACEAE				
41	*Flacourtia montana* Grah.	Tree	+		
42	*Hydnocarpus pentrandrus* (Buch.-Ham.) Oken	Tree	+		
43	*Scolopia crenata* (Wt & Arn.) Clos.	Tree	+		
	LAMIACEAE				
44	*Clerodendrum infortunatum* L.	Tree	+		

45	*Vitex altissima* L. f.	Tree	+		
	LAURACEAE				
46	*Actinodaphne malabarica* Balak.	Tree	+		
47	*Cinnamomum malabatrum* (Burm. f.) Blume	Tree	+		+
48	*Litsea coriacea* (Heyne ex Meisn.) Hook.f.,	Tree	+		
49	*Litsea floribunda* (Bl.) Gamble,	Tree	+		
50	*Neolitsea cassia* (L.) Kosterm.,	Tree	+		
51	*Machilus glaucescens* (Nees.) Wight	Tree	+		+
	MALVACEAE				
52	*Julostylis polyandra* Ravi & Anil Kumar	Tree			+
	MELASTOMATACEAE				
53	*Memecylon edule* Roxb.	Tree	+		
	MELIACEAE				
54	*Dysoxylum malabaricum* Bedd. ex Hiern	Tree	+		
55	*Toona ciliata* Roem.	Tree	+		+
	MORACEAE				
56	*Artocarpus hertophyllus* Lam.	Tree		+	
57	*Artocarpus hirsutus* Lam.	Tree			+
58	*Ficus beddomei* King	Tree	+		
59	*Ficus exasperata* Vahl	Tree			+
60	*Ficus nervosa* Heyne ex Roth	Tree	+		
61	*Ficus hispida* L. f.	Tree			+
	MYRISTICACEAE				
62	*Myristica dactyloides* Gaertn	Tree	+		+
63	*Knema attenuata* (Hook.f. et Thoms.) Warb.	Tree	+		
	MYRTACEAE				
64	*Syzygium cumini* (L) Skeels	Tree	+		+
65	*Syzygium gardneri* Thwaitsii	Tree	+		
66	*Syzygium lateum* (Buch-Ham.) Gandhi	Tree	+		
67	*Syzygium mundagam* (Bourd.) Chithra	Tree	+		
	OLEACEAE				
68	*Chionanthus mala-elengi* (Dennst.) Green	Tree	+		

69	*Tetrapilus dioicus* (Roxb.) Johnson	Tree	+		
	PITTOSPORACEAE				
70	*Pittosporum neelgherrense* Wight & Arn.	Tree			+
	POACEAE				
71	*Bambusa bambos* (L.) Voss	Tree grass	+		
72	*Ochlandra scriptoria (Dennst.)Fischer*	Tree grass	+	+	+
	RUBIACEAE				
73	*Ixora agasthyamalayana* Sivad. & Mohanan	Small tree	+	+	
74	*Ixora brachiata* Roxb.	Small tree	+		
75	*Lasianthus acuminatus* Wt.	Small tree	+		
	SAPINDACEAE				
76	*Allophylus cobbe* (L.) Raeusch	Small tree	+		
77	*Dimocarpus longan* Lour.	Tree	+	+	+
78	*Lepiaanthes erecta* (Thw.) Leenh.	Small tree	+		
79	*Schleichera oleosa* (Lour.) Oken	Tree	+		
	SAPOTACEAE				
80	*Madhuca neriifolia* H.J. Lam.	Tree			+
81	*Palaquium ellipticum* (Dalz.) Baill.	Tree	+		
	STERUCULIACEAE				
82	Pterospermum rubiginosum Heyne ex Wt	Tree	+		
83	*Sterculia guttata* Roxb.ex DC.	Tree	+		
	SYMPLOCACEAE				
84	*Symplocos cochinchinensis* (Lour.) Moore ssp. *laurinia* (Retz.) Nooteb.,	Tree			
	THEACEAE				
85	*Polyspora obtusa* (Wall. ex. Wt. & Arn.) Nissalo & Choo	Tree	+		+
	TILIACEAE				
86	*Grewia tiliifolia* Vahl	Tree			+
	URTICACEAE				
87	*Debregeasia longifolia* (Burm. f.) Wedd.	Small tree	+	+	+
	XANTHOPHYLLACEAE				
88	*Xanthophyllum flavescens* Roxb.	Tree	+	+	+

Table- 15. Valanthode SHEP: List of Timber Trees

Sl. No	Family & Plant Name of Timber	Common name	Areas observed		
			Catchment	Dam site	Down stream
	ANACARDIACEAE				
1	*Mangifera indica* L.	Mavu	+		
	APOCYNACEAE				
2	*Alstonia scholaris* (L.) R. Br.	Ezhilampala	+		
	BOMBACACEAE				
3	*Bombax ceiba* L.	Tree	+		
	CLUSIACEAE				
4	*Mesua ferrea* L.	Tree	+		
	COMBRETACEAE				
5	*Terminalia bellerica* (Gaertn.) Roxb.	Thanni			+
6	*Terminalia alata* Heyne ex Roth	Thenpavu	+		
7	*Terminalia paniculata* Roth	Maruthu	+		
	DIPTEROCARPACEAE				
8	*Hopea parviflora* Bedd.	Kambakam		+	
9	*Hopea ponga* (Dennst.) Mabb.	Irumbakam	+		
	FABACEAE (Caesalpinioideae)				
10	*Cassia fistula* L.	Konna	+		
	FABACEAE (Papilionoideae)				+
11	*Pterocarpus marsupium* Roxb.	Venga	+		
	LAMIACEAE				
12	*Vitex altissima* L. f.	Myla	+		
	MELIACEAE				
13	*Dysoxylum malabaricum* Bedd. ex Hiern	Akil	+		
`14	*Toona ciliata* Roem.	Kattu-vepu	+		+
	MORACEAE				
15	*Artocarpus hertophyllus* Lam.	Anjali		+	
16	*Artocarpus hirsutus* Lam.	Plavu			+
	MYRTACEAE				
17	*Syzygium cumini* (L) Skeels	Njaval	+		+
	OLEACEAE				
18	*Tetrapilus dioicus* (Roxb.) Johnson	Edana	+		
	POACEAE				
19	*Bambusa bambos* (L.) Voss	Mula	+		
20	*Ochlandra scriptoria* (Dennst.)Fischer	Eeta	+	+	+
	SAPINDACEAE				
21	*Schleichera oleosa* (Lour.) Oken	Tree	+		
	SAPOTACEAE				

22	*Madhuca neriifolia* H.J. Lam.	Ilippa			+
23	*Palaquium ellipticum* (Dalz.) Baill.	Pali	+		
	TILIACEAE				
24	*Grewia tiliifolia* Vahl	Unnam			+

Table- 16. Valanthode SHEP: List of Medicinal Plants

Sl. No	Family & Plant Name of Medicinal Plants	Common name	Areas observed		
			Catchment	Dam site	Down stream
	ACANTHACEAE				
1	*Asystasia gangetica* (L.) Aanderson	Upputhali			+
	AMARANTHACEAE				
2	*Achyranthes aspera* L.	Kadaladi			+
	ANACARDIACEAE				
3	*Holigarna arnottiana* Hook. f.	Charu		+	+
4	*Mangifera indica* L.	Mavu	+		
	APOCYNACEAE				
5	*Alstonia scholaris* (L.) R. Br.,	Ezhilampala	+		
6	*Wrightia tinctoria* (Roxb.) R. Br	Danthapala	+		
	ARACEAE				
7	*Anaphyllum wightii* Schott	Keeri kizhangu	+		
8	*Lagenandra toxicaria* Dalz.	Neer kizhangu		+	
9	*Pothos scandens* L.	Ana paruva			+
	ARISTOLOCHIACEAE				
10	*Thottea siliquosa* (Lam) Ding Hou	Alpam	+		+
	ASTERACEAE				
11	*Elephantopus scaber* L.	Aanachuvadi	+		+
	BURSERACEAE				
12	*Canarium strictum* Roxb.	Kunthirikkam	+		
	CAMPANULACEAE				
13	*Lobelia nicotianifolia* Roth	Kattu pokayila			+
	CLUSIACEAE				
14	*Garcinia gummi-gutta* (L.) Robson	Kudampuli	+		
15	*Mesua ferrea* L.	Nagakesaram	+		
	COMBRETACEAE				
16	*Terminalia bellerica* (Gaertn.) Roxb.	Thanni			+
	ELAEOCARPACEAE				
17	*Elaeocarpus serratus* L.	Kara	+		
18	*Elaeocarpus tuberculatus* Roxb.	Bhadraksham	+		+

	FABACEAE (Caesalpinioideae)				
19	*Cassia fistula* L.	Konna	+		
	FABACEAE (Mimosoideae)				
20	*Senegalia caesia* (L.) Maslin, Seigler & Ebinger	Incha			+
	FABACEAE (Papilionoideae)				
21	*Desmodium heterophyllum* (Willd.) DC.	Cherupulladi	+		+
22	*Mucuna pruriens* (L.)DC.	Naikurna	+		
23	*Pterocarpus marsupium* Roxb.	Venga	+		
	FLACOURTIACEAE				
24	*Hydnocarpus pentrandrus* (Buch.-Ham.) Oken	Marotty	+		
	LAMIACEAE				
25	*Vitex altissima* L. f.	Mayila	+		
	LAURACEAE				
26	*Cinnamomum malabatrum* (Burm. f.) Blume	Vayana	+		+
27	*Machilus glaucescens* (Nees.) Wight	Kulirmavu	+		+
	LILIACEAE				
28	*Smilax zeylanica* L.	Kareelanchi	+	+	
	LOGANIACEAE				
29	*Strychnos aenea* Hill	Valli-kanjiram	+		
	MALVACEAE				
30	*Sida cordifolia L.*	Kurunthotti	+		
31	*Sida rhombifolia* L.	Kurunthotti			+
	MARANTACEAE				
32	*Indianthus virgatus* (Roxb.) Suksathan & Borchs.	Kattu-koova		+	+
	MELASTOMATACEAE				
33	*Memecylon edule* Roxb.	Kasavu	+		
	MELIACEAE				
34	*Dysoxylum malabaricum* Bedd. ex Hiern	Akil	+		
35	*Toona ciliata* Roem.	Kattu-veppu	+		+
	MENISPERMACEAE				
36	*Cyclea peltata* (Lam.)Hook. f. & Thoms.)	Padathali	+		
	MYRISTICACEAE				
37	*Myristica dactyloides* Gaertn	Kattu-jathy	+		+
	MYRSINACEAE				
38	*Embelia ribes* Burm. f.	Vizhal	+		+
	MYRTACEAE				
39	*Syzygium cumini* (L) Skeels	Njaval	+		+
	OLEACEAE				

40	*Myxopyrum smilacifolium* Blume	Chathura mulla	+		+
	PIPERACEAE				
41	*Piper hymenophyllum* Miq.	Kattu-kurumulaku	+		+
	PITTOSPORACEAE				
42	*Pittosporum neelgherrense* Wight & Arn.	Analivegam			+
	RUBIACEAE				
43	*Pavetta indica L.*	Pavatta	+		
	SAPINDACEAE				
44	*Allophylus cobbe* (L.) Raeusch.	Mukkannan pezhu	+		

Table- 17. Valanthode SHEP: List of Wild Edible Plants

Sl. No	Family & Plant Name	Edible part	Areas observed		
			Catchment	Dam site	Down stream
	ANACARDIACEAE				
1	*Mangifera indica* L.	Fruit	+		
2	*Spondias pinnata* (L.f.) Kurz	Fruit	+		
	CLUSIACEAE				
3	*Garcinia conicarpa* Wight	Fruit	+		+
4	*Garcinia gummi-gutta* (L.) Robson	Fruit	+		
	ELAEGNACEAE				
5	*Elaegnus conferta* Roxb.	Fruit			+
	ELAEOCARPACEAE				
6	*Elaeocarpus serratus* L.	Fruit	+		
	EUPHORBIACEAE				
7	*Aporusa lindleyana* (Wt.) Baill.	Fruit	+		
8	*Antidesma montanum* Blume	Fruit		+	+
9	*Baccaurea courtallensis* (Wt.) Muell-Arg.	Fruit	+		
	FLACOURTIACEAE				
10	*Flacourtia montana* Grah.	Fruit	+		
	HYPOCRATACEAE				
11	*Salacia beddomei* Gamble	Fruit	+		
	LAURACEAE				
12	*Cinnamomum malabatrum* (Burm. f.) Blume	Spice	+		+
	MORACEAE				

13	*Artocarpus hertophyllus* Lam.	Fruit		+	
14	*Artocarpus hirsutus* Lam.	Fruit			+
	MYRTACEAE				
15	*Syzygium cumini* (L) Skeels	Fruit	+		+
	PIPERACEAE				
16	*Piper hymenophyllum* Miq.	Spice	+		+
	POACEAE				
17	*Bambusa bambos* (L.) Voss	Seeds	+		
	RHAMNACEAE				
18	*Zizyphus oenoplia* (L.) Miller	Fruits	+		+
	SAPOTACEAE				
19	*Madhuca neriifolia* H.J. Lam.	Fruit			+

Table- 18. Valanthode SHEP: List of NWFPs and Fibre Plants

Sl. No	Family & Plant Name	Parts used	Areas observed		
			Catchment	Dam site	Down stream
	ARECACEAE				
1	*Calamus rheedei* Griff.	Rattan	+		
	BURSERACEAE				
2	*Canarium strictum* Roxb.	Black dammar	+		
	CLUSIACEAE				
3	*Garcinia conicarpa* Wight	Wild camboge	+		+
4	*Garcinia gummi-gutta* (L.) Robson	Wild camboge	+		
5	*Mesua ferrea* L.	Naga kesaram	+		
	COMBRETACEAE				
6	*Terminalia bellerica* (Gaertn.) Roxb.	Bellirica			+
	FABACEAE (Mimosoideae)				
7	*Senegalia caesia* (L.) Maslin, Seigler & Ebinger	Fibre			+
	FABACEAE (Papilionoideae)				
8	*Spatholobus parviflorus* (Roxb. ex DC.) O. Ktze.	Fibre	+		
	LAURACEAE				
9	*Cinnamomum malabatrum* (Burm. f.) Blume	Wild cinnamon	+		+
10	*Machilus glaucescens* (Nees.) Wight	Sambrani	+		+
	LILIACEAE				
11	*Smilax zeylanica* L.	Fibre	+	+	

12	**MYRISTICACEAE**				
13	*Myristica dactyloides* Gaertn	Wild mace	+		+
14	*Knema attenuata* (Hook.f. et Thoms.) Warb.	Wild mace	+		
	STERUCULIACEAE				
15	*Helicteres isora* L.	Fibre	+		
16	*Sterculia guttata* Roxb.ex DC.	Fibre	+		
	TILIACEAE				
17	*Grewia tiliifolia* Vahl	Fibre			+

Table- 19. Valanthode SHEP: List of Wild Relatives of Crop Plants

Sl. No	**Family & Plant Name**	**Related Crop plant**	**Areas observed**		
			Catchment	**Dam site**	**Down stream**
	ANACARDIACEAE				
1	*Mangifera indica* L.	Mango	+		
	CLUSIACEAE				
2	*Garcinia cambogioides* (Murray) Headland	Camboge	+		
3	*Garcinia conicarpa* Wight	Camboge	+		+
4	*Garcinia gummi-gutta* (L.) Robson	Camboge	+		
	LAURACEAE				
5	*Cinnamomum malabatrum* (Burm. f.) Blume	Cinnamon	+		+
	MARANTACEAE				
6	*Indianthus virgatus* (Roxb.) Suksathan & Borchs.	Arrowroot		+	+
	MORACEAE				
7	*Artocarpus hertophyllus* Lam.	Jack		+	
8	*Artocarpus hirsutus* Lam.	Jack			+
	MYRISTICACEAE				
9	*Myristica dactyloides* Gaertn	Nutmeg	+		+
	MYRTACEAE				

10	*Syzygium cumini* (L) Skeels	Jamun	**+**		**+**
11	*Syzygium gardneri* Thwaitsii	Tree	**+**		
12	*Syzygium lateum* (Buch-Ham.) Gandhi	Jamun	**+**		
13	*Syzygium mundagam* (Bourd.) Chithra	Tree	**+**		
	OLEACEAE				
14	*Jasminum malabaricum* Wight	Jasmine	**+**		**+**
	PIPERACEAE				
15	*Piper hymenophyllum* Miq.	Black pepper	**+**		**+**
	POACEAE				
16	*Eleusine indica* (Linn.) Gaertn.	Ragi			**+**

Table- 20. Valanthode SHEP: List of Exotic Plants

Sl. No	**Family & Plant Name**	**Nativity**	**Areas observed**		
			Catchment	**Dam site**	**Down stream**
	AMARANTHACEAE				
1	*Achyranthes aspera* L.	Pan tropical			+
	ASTERACEAE				
2	*Ageratum conyzoides* L.	Tropical America	+	+	+
3	*Acmella radicans* (Jacq.) Jansen	Central America			+
4	*Bidens pilosa* L.	Pan tropical			+
5	*Blumea lacera* (Burm. f.) DC.	Pan tropical			+
6	*Chromolaena odorata* (L.) King & Rob.	Tropical America			+
7	*Crassocephalum crepioides* (Benth.)S. Moore	Tropical America			+
8	*Elephantopus scaber* L.	Pan tropical	**+**		**+**

9	*Galinsonga parviflora* Cav.	Herb			+
10	*Mikania scandens* (L.) Willd.	South east Asia			+
11	*Synedrella nodiflora* (L.) Gaertn.	West Indies			+
	CAMPANULACEAE				
12	*Lobelia nicotianifolia* Roth	South east Asia		+	+
	CAPPARACEAE				
13	*Cleome viscosa* L.	Pan tropical			+
	CONVOLVULACEAE				
14	*Ipomoea hedrifolia* L.	Pan tropical			+
	CYPERACEAE				
15	*Cyperus compressus* Linn.	Pan tropical		+	+
16	*Cyperus haspan* Linn.	Pan tropical			+
	FABACEAE (Mimosoideae)				
17	*Mimosa diplotricha* Wright ex Swanv.	Tropical America		+	+
18	*Mimisa pudica* L.	Tropical America			+
	FABACEAE (Papilonoideae)				
19	*Centrocema pubescens* Benth.	Tropical America	+		+
	LAMIACEAE				
20	*Callicarpa tomentosa* (L.) Murray	Southeast Asia			+
	MALVACEAE				
21	*Sida acuta* Burm. f.	Pan tropical			+
22	*Urena lobata* L.	Pan tropical			+
	MELASTOMATACEAE				
23	*Miconia crenata* (Vahl) Mich.	South America	+	+	+
	MORACEAE				

24	*Ficus hispida* L. f.	Southeast Asia, Australia	+		+
	POACEAE				
25	*Axonopus compressus* (Sw.) P. Beauv.	North and South America			+
	RUBIACEAE				
26	*Spermacoce hispida* L.	Pan tropical	+	+	+
27	*Spermacoce mauritiana Osea Gideon ex Verd.*	Pan tropical			+
28	*Richardia scabra* L.	Tropical America			+

Plate - 2.Valanthode SHEP: Vegetation Types

A- Evergreen vegetation of catchment area / B - Butressed Elaeocarpus tuberculatus tree
C- Forest floor in evergreen forest / D- Semievergreen vegetation
E - Moist deciduous forest / F - Riparian vegetation

Plate - 3. Valanthode SHEP: Endemic Species

A- Anaphyllum wightii / B - Garcinia conicarpa / C-Cullenia exarillata / D-Barleria courtallica
E - Ixora agasthyamalayana / F - Goniothalamus wynaadensis
G - Henckelia pradeepiana / H -Baccaurea courtallense

Plate - 4 . Valanthode SHEP : RET Plants

A- Julostylis polyandra / B-Palaquim ellipticum / C Hopea ponga
D- Myristica beddomei

Plate - 5. Valanthode SHEP: Common Trees

A- Xanthophyllum flavescens / B - Mallotus tetracoccus / C- Terminalia alata / D- Syzygium cumini
E -madhuca neriifolia / F- Syzygium laetum / G- Dichapetalum gelonioides
H-lepianthes erecta / I- Mallotus philippensis

Plate - 6. Valanthode SHEP: Timber Trees

A- Bombax ceiba / B- Elaeocarpus serratus / C- Artocarpus hirsutus / D- Elaeocarpus tuberculatus
E- Grewia tiliifolia / F - Holigarna arnottiana / G- Knema attenuata
H - Hopea parviflora / L- Terminalia paniculata

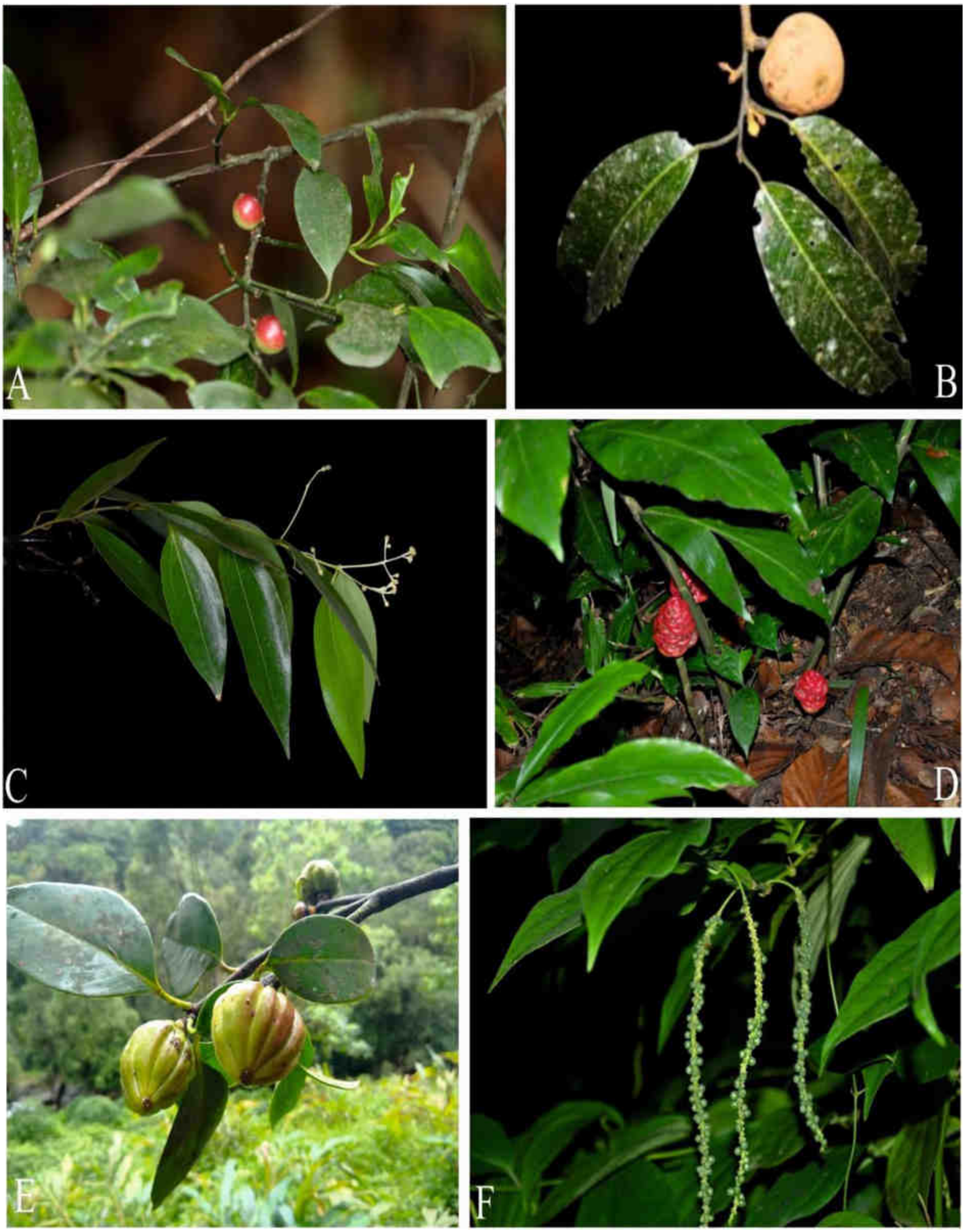
Plate - 7. Valanthode SHEP: Medicinal Plants

A- Thottea siliquosa / B-Smilax zeylanica / C- Sida rhombifolia / D- Mucuna pruriens
E -Pittosporum neelgherrense / F -Pterocarpus marsupium
G- Allophylus cobbe / H- Mesua ferrea

Plate - 8. Valanthode SHEP: NWFPs and Fibre Plants

A-Sterculia guttata / B - Calamus rheedei / C- Canarium strictum
D- Helicteres isora / E- Grewia tiliifolia / F- Terminalia bellirica

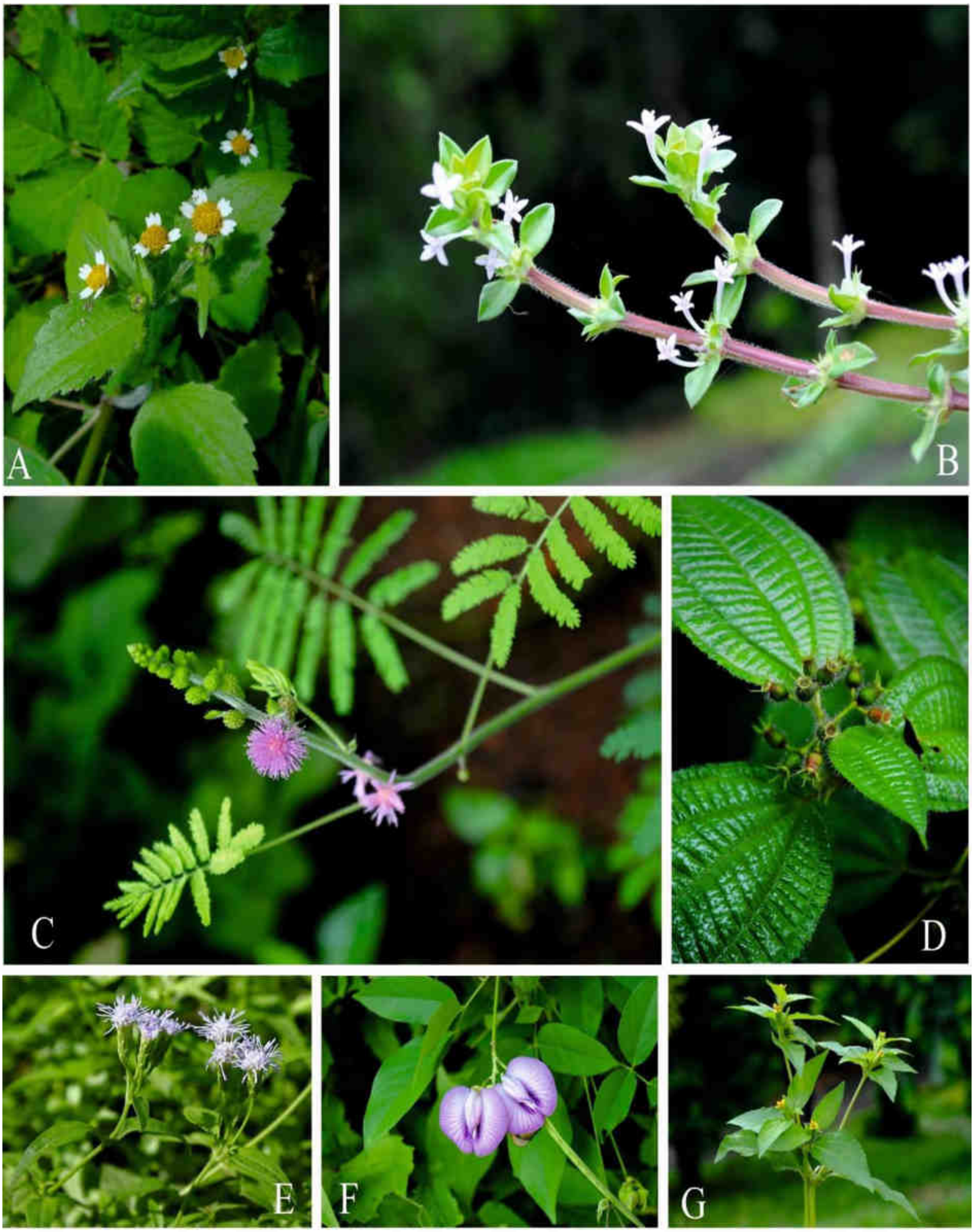
Plate - 9.Valanthode SHEP: Wild relatives of cultivated crops



A- Garcinia cambogioides / B - Myristica dactyloides / C- Cinnamomumalabatrum

D- Zingiber zerumbet / E- Garcinia conicarpa / F -Piper hymenophyllum

Plate - 10. Valanthode SHEP: Exotic Plants



A- *Galinsoga parviflora*/ B- *Spermacoce hispida* / C- *Mimosa diplotricha* / D-*Miconia crenata*
E- *Chromolaena odorata* / F- *Centrosema pubescens* / G- *Synedrella nodiflora*

6.3. Vegetation Analysis

Terrestrial vegetation in the project site and its environments are reserve forest in the upstream and left side of the river at dam site and downstream areas. On the right side of the river, private agricultural plantations are located. The vegetation comprises of (i) evergreen forest, (ii) semi-evergreen (iii) moist deciduous forest, (iv) thin stretch of riparian vegetation in both catchment and downstream areas and (v) agricultural plantation.

The structural composition of arborescent angiosperms was studied to evaluate the forest diversity of the area. The tree species and the undergrowth of the dam site, submerging area and canal diversion area were recorded with all the species name and DBH in case of trees. Ten quadrats each from the catchment and downstream areas were laid down followed by the enumeration of all the woody elements of the flora, for which structural data have been gathered and interpreted.

6.3.1. Dam Site

Based on the study map provided by KSEBL and the spot analysis, it is understood that the submerging area is only 0.22 Ha. or 52 cents. Among that, two third of the area forms existing river bed and only a little portion is extended to the both sides of the river. Here vegetation is very less and restricted to the riverine flora commonly found throughout the river banks of Kurumanpuzha. The evaluation recorded only 8 tree species above 60cm GBH, considered as trees, with a total of 11 numbers. (Table-21). *Dimocarpous longan, Elaeocarpus tuberculatus* and *Tetrapilus dioicus* are represented two numbers each. Rest of them are represented only one species each.

In the dame site maximum submerging area is of river bed and there is no ground flora as such. But on bothsides seedlings of the above-mentioned tree species were present which are below 60 cm DBH. We could locate only one reed clump in the submerging area which is also flowered and at dying stage. No rare or endangered species was recorded from this area. Seedlings of the following endemic species of western Ghats such as *Goniothalamus wynadensis, Anaphyllum wightii, Cullenia exarillata, Sonerila sahyadrica, Ixora agasthyamalayana* were observed in the submergible area and all of them are below 60 cm DBH. However, only few individuals are observed but they have wide distribution through the riverine vegetation and in the upstream areas. Hence, no threat can be expected for these species once the project is implemented.

6.3.2. Catchment Area

From the 10 quadrats (2500 m^2), a total of 27 tree species above 60 cm DBH representing 136 individuals are recorded in the catchment area (Table-22). Based on the IVI of the tree species found in the catchment area, they can be grouped as the dominant species where IVI is above 20. The dominant species in the catchment areas are *Elaeocarpus tuberculatus,* followed by *Dimocarpous logan, Cullenia exarillata, Elaeocarpus serratus* etc. Moderate dominant species represents *Syzygium cumini, Myristica dactyloides, Dillinia indica, Syzygium lateum, Palanquin ellipticum* with the IVI ranges from 11 to 20. Rest of the 18 species has got the IVI value of below 10 which indicate the random occurrence. Since, all the species are of components of evergreen forest which indicate the true forest type of the catchment area.

6.3.2.1. Under Growth of the catchment area

Based on the quadrats study, 41 species of undergrowth were recorded (Table-23). They include seedlings of tree species, shrubs, herbs, climbers and ground covering creepers. The dam will not affect the existence of any of these species since they are growing above the submergible area.

6.3.2.2. Biodiversity Index

Various biodiversity indices of the catchment area were calculated to determine the richness and diversity of the area. They are such as Simpson Index (having value of λ= 0.9424), Shanon Index (H^1 3.0369), Menhinicks index of species richness (1.8008) and Pilous index of species evenness (2.1191). These values were found to be near or similar to the evergreen patches of Western Ghats Forests (Table-24).

The Simpson index measure the probability of two individual selected at random from a sample will belong to the same species and ranges values from 0-1. Based on the value (0.7424), the catchment area is having more diversity of up to 75%. The Shanon-Wiener Index of diversity is based on information theory. The information content is measure of the amount of uncertainty. The index is zero, if there is only one species and maximum when all the species are represented by the same number of individuals. It generally falls values between 1.5 -3.5 and rarely exceeds 4.5. In this study the index shows the value of 3.0369 which indicate the diversity of the area is more than 60%. The value is slightly less than Simpson index but it has more inclusive and falls with diversity value of adjacent areas of the western Ghats. Likewise in case of species richness (1.8008) and species evenness index (2.1191) also corroborates the better diversity of the species and their well distribution in the catchment area.

6.3.3. Downstream Area

In the downstream area, 10 quadrats (2500 m^2) were laid and a total of 21 species representing 105 individuals were recorded (Table-25). Based on the Relative Density, Relative Frequency, Relative Dominance and IVI of the tree species found in the downstream area, the dominant species are *Terminalia bellarica* followed by *Toona ciliata, Hoppea Ponga, Persea Macrantha, Elaeocarpus tuberculatus* etc. Physiognomically three storeys of tree elements could be identified within distinct canopy structures. The upper storey which is about 30 – 45 m composed of *Persia macrantha, Toona ciliata, Terminalia bellarica Vitex altissima* etc. The second storey (22-30m) consists of *Persia macrantha, Toona ciliata, Terminalia bellarica, Vitex altissima, Nephelium logan, Syzygium cumini, Elaeocarpus tuberculatus, Madhuca neerifolia, Cinnamomum malabatrum, Myristica beddomii, Dillinia indica, Myristica dactyloides, Malottus philipensis* etc. The third storey which is less than 15m include the seedlings of the tree species mentioned above as well as listed shrubs and herbs including climbers and creepers.

6.3.3.1. Undergrowth of the Downstream area

The survey on the downstream area recorded 25 species of undergrowth. They include seedlings of tree species, shrubs, herbs, climbers and ground covering creepers. The dam will not affect the existence of any of these species as the water conducting systems, penstock and powerhouse are located in the private areas on the right side of the bank (Table-26).

6.3.3.2. Diversity Index of the downstream area

The diversity indices calculated for the downstream area are given in Table-27. Here the value of Simpson Index is λ is 0.8274, Shannon Index (H^1) is 2.6585, Menhinicks index of species richness is 2.049 and Pilous index of species evenness is 2.010 indicated that this ecosystem is moist deciduous with slight disturbance but with over all good diversity still present. Species richness and evenness indices fairly confirmed the well distribution of deciduous species throughout the downstream area.

In tropical rainforests, the range of tree species count per ha is from about 20 to a maximum of 223 (Proctor et al., 1983; Whitmore, 1984). The tree species count obtained from the catchment area (ie 2500m^2) of 27 species represented 136 individuals and downstream area with 21 species numbering 105 trees is comparable with tropical wet evergreen mixed forest of Nelliyampathy Hills (30/1ha) (Chandrashekara & Ramakrishnan, 1994). Therefore, our findings corroborate with observations of adjacent areas in Western Ghats especially on the aspects of vegetation composition.

6.3.4. Vegetation of the Canal Diversion Area

The diversion canal passes through the private land where coffee, banana, tree spices etc are cultivated. Borders of the plantations has a few scattered invasive trees such as *Ficus hispida* L. f., *Macranga peltata* Mull. Arg. and *Mallotus tetracoccus* (Roxb.) Kurz etc. Besides many trees of *Artocarpus hirsutus* Lam. (Anjili) are seen here and there. The study identified 12 tree species representing 23 individuals which will be affected during the canal construction and this observation is more or less falls with the observation of the State Forest Department (Table-28).

Plantation area, especially banana and coffee, is well maintained, but the unattended boarders are with invasive shurbs such as *Chromolaena odorata* (L.) King & Rob., *Miconia crenata* (Vahl) Mich., *Sida rhombifolia* L., *Triumfetta rhomboidea* Jacq. etc. Climbers such as *Cayratia pedata* (Lam.) Juss. ex Gagnep., *Jasminum malabaricum* Wight and *Thunbergia mysorensis* (Wight) Anderson are found occasionally, whereas overgrowth of the very thorny invasive climbers such as *Hibiscus furcatus* Willd., and *Mimosa diplotricha* Wright ex Swanv. make the area un approachable. The invasive *Mikania scandens* (L.) Willd., is seen colonizing extensively in many areas.

Most of the herbs seen in the area are of invasive and exotic nature such as *Acmella radicans* (Jacq.) Jansen, *Achyranthes aspera* L., *Ageratum conyzoides* L., *Asystasia gangetica* (L.) Aanderson, *Blumea lacera* (Burm. f.) DC., *Spermacoce hispida* L. and *Synedrella nodiflora* (L.) Gaertn. A very few native herbs such as *Impatiens humblotiana* Baill., *Lobelia nicotianifolia* Roth, *Osbeckia octandra* DC., *Scleromitrion neesianum* (Arn.) Nandikar are also found.

Table- 21. Valanthode SHEP: List of Trees in the Submerging Area

Sl No	**Species name**	**DBH (cm) and Clean Bole Height(m)**		
1	Artocarpus heterophyllus	DBH	**145**	
		CBH	**5.0**	
2	Syzygium lateum	DBH	**100.0**	
		CBH	**4.0**	
3	Dimocarpous longan	DBH	**105**	**86**
		CBH	**4.0**	**6.0**
4	Tetrapilus dioicus	DBH	**105**	**80**
		CBH	**3.0**	**5.0**
5	Monosis conferta	DBH	**180**	
		CBH	**12.0**	
6	Elaeocarpus tuberculatus	DBH	**100**	**87.0**
		CBH	**8.0**	**5.0**
7	Hopea parviflora	DBH	**145**	
		CBH	**10**	
8	Garcinia gummi-gutta	DBH	**95**	
		CBH	**8.0**	
	Total		**8**	**3**

Table- 22. Valanthode SHEP: IVI of the Tree species found in the Catchment Area.

Sl no	**Species name**	**Total**	**Occurrence of species**	**density**	**% Frequency**	**Relative density**	**Relative Freequency**	**Relative dominance**	**IVI**
1	Elaeocarpus tuberculatus	8	6	0.80	60	5.970	6.677	21.063	33.71
2	Syzygium cumini	6	6	0.60	60	4.478	6.677	4.758	15.913
3	Garcinia gummi-gutta	4	4	0.40	40	2.985	4.444	2.208	9.637
4	Elaeocarpus serratus	12	4	1.20	40	8.956	4.444	10.051	23.451

5	Dimocarpus logan	14	8	1.40	80	10.448	8.889	9.686	29.023
6	Getum ula Climber	2	2	0.20	20	1.492	2.222	0.194	3.908
7	Myristica dactyloides	8	6	0.80	60	5.970	6.677	2.776	15.423
8	Persia macrantha	2	2	0.20	20	1.492	2.222	1.006	4.72
9	Xanthophyllu m flavacense	4	2	0.20	40	1.492	4.444	2.037	7.973
10	Dillinia indica	6	4	0.60	40	4.477	4.444	4.831	13.752
11	Macanga peltata	4	2	0.40	20	2.985	2.222	1.136	6.343
12	Sterculia guttata	2	2	0.20	20	1.492	2.222	0.349	4.063
13	Artrocapus hectrophyllus	4	4	0.40	40	2.985	4.444	1.567	8.996
14	Antidesma menase	4	2	0.40	20	2.985	2.222	0.544	5.751
15	Vernonia arborea	2	2	0.20	20	1.492	2.222	0.462	4.176
16	Palanquin rotundum	2	2	0.20	20	1.492	2.223	3.418	7.133
17	Syzygium luteum	12	6	1.20	60	8.996	6.677	2.427	18.1
18	Ficus beddomii	2	2	0.20	20	1.492	2.222	2.849	6.563
19	Miliusa wightiana	2	2	0.20	20	1.492	2.222	0.267	3.981
20	Toona ciliata	2	2	0.20	20	1.492	2.222	2.208	5.922
21	Diospyros ebenam	2	2	0.20	20	1.492	2.222	0.357	4.071
22	Mesua ferrea	4	2	0.40	20	2.985	2.222	4.173	9.38
23	Olea dioica	2	2	0.20	20	1.492	2.222	0.487	4.201
24	Cullenia exarillata	14	4	1.40	40	10.448	4.444	9.223	24.115
25	Palanquin ellipticum	8	4	0.80	40	5.970	4.444	7.932	18.346
26	Garcenia cambogia	2	2	0.20	20	1.492	2.222	2.411	6.125
27	Canarium strictum	2	2	0.20	20	1.492	2.222	2.086	5.8
		136	86	13.4	900	100.0	100.0	100.0	300

Table – 23. Valanthode SHEP: Under growth of the Catchment Area

No	Species Name	No of Individual
1	Ixsora agastamalayana	20
2	Thumbergia mysoorensis	2
3	Syzygium luteum	4
4	Arisaema	40
5	Terminalia chebula	4 seedlings
6	Schumannianthus virgatus	8 clumps
7	Clavcaria hepatophila	8
8	Sarcandra chloranthoides	18
9	Pellionia heyneana	Several Patches
10	Elatostema lineolatum	Several patches
11	Ochlandra travancorica	30 clumps
12	Allophyllus cobbe	4
13	Milusa wigthii	2
14	Flacourtia montana	Many seedlings
15	Mesua ferrea	Many seedlings
16	Legenandra ovata	Several patches
17	Piper nigram	Many individuals
18	Psycotrea species	Many seedlings
19	Saprosma foetida	8 seedlings
20	Axonopus compresses	Many
21	Smilax zeylanica	7
22	Clerodendron infortunatum	Many
23	Pteridum (Fern)	Ground flora
24	Polygonum chinensis	Boundary of the forest
25	Lycopetalum gelenoides	7
26	Mymecelon edule	5
27	Salacia beddomei	3
28	Thottea Sp	5
29	Pothos seandens	Several
30	Gophandra tetranda	8
31	Thottea Silicosa	Several
32	Meiogyne pannosa	6
33	Palaquium ellipticum Seedlings	Several
34	Agrostemma indica	6
35	Calamus tranvancoricus	6 clumps
36	Barleria courtallica	Several
37	Rhingoglassan notonianum	Ground cover
38	Clausena astroindica	7
39	Xanthophyllum flavasence	Several
40	Ancistrocladus heyaneanus	5
41	Erythropalam populifolium	Several

Table- 24. Valanthode SHEP: Biodiversity indices of Catchment Area

Sl No	Index	Values
1	Simpson Index λ	0.7424
2	Shanon –Wiener Index (H’)	3.0369
3	Menhinicks index of species richness R=S/ √n	1.8008
4	Pilous index of species evenness E =H/logS	2.1191

Table- 25. Valanthode SHEP: IVI of the tree species found in the Downstream Area.

No		Total	Density	% Frequency	R. Density	R. Frequency	R.Dominance	IVI
1	Syzygium luteum	3	0.30	30	2.857	4.000	0.692	7.549
2	Nephelium logan	6	0.60	40	5.714	5.333	3.358	14.405
3	Syzygium cumini	2	0.20	20	1.904	2.667	5.472	10.043
4	Olea dioica	4	0.40	30	3.809	4.000	0.737	8.546
5	Terminalia bellarica	22	2.20	90	20.952	12.00	22.867	55.819
6	Toona ciliata	7	0.70	50	6.667	6.667	17.417	30.751
7	Golchidion zeylanivus	4	0.40	30	3.809	4.000	2.530	10.339
8	Elaeocarpus tuberculatus	5	0.50	30	4.761	4.000	11.418	20.179
9	Madhuca neerifolia	3	0.30	30	2.857	4.000	2.718	9.575
10	Holigarna arnottiana	4	0.40	30	3.809	4.000	0.789	8.598
11	Bischofia javanica	5	0.50	30	4.761	4.000	2.385	11.146
12	Hopea ponga	6	0.60	60	5.714	8.000	6.730	20.444
13	Cinnamomum malabatrum	3	0.30	30	2.857	4.000	0.561	7.418
14	Vitex altisima	4	0.40	40	3.809	5.333	6.235	15.377
15	Myristica beddomii	1	0.10	10	0.952	1.333	1.262	3.547
16	Macanga peltata	6	0.60	60	5.714	8.000	2.885	16.599

17	Persia macrantha	6	0.60	60	5.714	8.000	7.441	21.155
18	Dillinia indica	2	0.20	20	1.904	2.667	1.087	5.658
19	Myristica dactyloides	3	0.30	30	2.857	4.000	0.513	7.370
20	Malottus philipensis	3	0.30	30	2.857	4.000	0.513	7.370
21	Hydnocarpus wightianus	6	0.60	30	2.857	4.000	2.894	9.751
		105	10.5	750	100	100	100	300

Table- 26. Valanthode SHEP: Undergrowth of Downstream Area

No	Species Name	Numbers
1	Thumbergia mysoorensis (Climber)	2
2	Erythropalum populifolium (Climber)	3
3	Schumannianthus virgatus	5 clumps
4	Pterigota allata Seedlings	2
5	Antidesma menasu seedlings	5
6	Monosis conferta	6
7	Smilax zeylanica	1
8	Lepianthus Sp	1
9	Ficus beddomi seedling	1
10	Cullenia exarillata seedling	1
11	Thottea siliquosa	2
12	Thottea duchartrei	4
13	Leea wightii	1
14	Palaquium ellipticum seedlings	5
15	Murdania Sp	10
16	Electrostemma leineolatum	20
17	Gordenia obtuse	10
18	Homonoia riparia	10
19	Xanthophyllum flavescens seedlings	10
20	Nephelium longon seedlings	15
21	Dioscorea Sp	5
22	Pellionia heyneana Wedd.	6
23	Pelisantus Sp	7
24	Laportea crenulata Gaud.	10
25	Dalbergia Sp	2

Table- 27. Valanthode SHEP: Diversity indices of the Downstream Area.

Sl No	Index	Value
1	Simpson Index λ	0.8274

2	Shanon Index (H’)	2.6585
3	Menhinicks index of species richness R=S/ √n	2.049
4	Pilous index of species evenness E =H/logS	2.010

Table- 28. Valanthode SHEP: List of Tree Species in diversion canal area.

Sl No	Species name	DBH (cm) and Clean Bole Height(m)							
1	Lannea coromandelica (Houtt.) Merr.	DBH	130						1
		CBH	6.0						
2	Dillenia pentagyna	DBH	110						1
		CBH	15.0						
3	Nephelium logan	DBH	120	200	83				3
		CBH	25.0	20.0	8.0				
4	Elaeocarpus tuberculatus	DBH	175	80	100				3
		CBH	15.0	10.0	10.0				
5	Toona ciliata	DBH	230	110	196	154			4
		CBH	15.0	25.0	20.0	10.0			
6	Mangifera indica	DBH	110						1
		CBH	10.0						
7	Elaeocarpu serratus	DBH	130	165					2
		CBH	6.0	15.0					
8	Artrocarous heterophyllus	DBH	160						1
		CBH	15.0						
9	Percea macrantha	DBH	180	185					2
		CBH	8.0	25.0					
10	Palanquin ellipticum	DBH	260						1
		CBH	25.0						
11	Terminalia chebula	DBH	170	180	130				3
		CBH	15.0	6.0	10.0				
12	Schleichera oleosa	DBH	175						1
		CBH	15.0						

6.4. Terrestrial Fauna/ Wildlife

The study area is spread over 18.90 km^2 and composed of mosaic of vegetation and man-made plantations along the right bank of the river. The State Forest Department while considering the project had observed the sighting of wildlife movements especially the elephants, near the proposed weir site. Based on this information, our study focused on the observation of faunal elements and other larger mammals present in the area. The findings on wildlife are discussed in the following sections.

6.4.1. Butterflies

The diversity of butterflies in an area indicates the status of an ecosystem and they are one among the most enchanting and charismatic group of organisms in the earth. Butterflies are distributed in diverse habitats ranging from cold temperate to very hot deserts. Although certain species like the painted lady (*Vanessa cardui*) are found in colder areas where the temperature falls below 0^0c, many others prefer the warm and moist habitats of the tropics. About 20,000 species of butterflies have been reported from all over the world. In the tropics, the South American region harbour's the greatest number of the butterflies (6,000 species), followed by the Oriental region (3,500 species). India has 1,501 species of butterflies, of which peninsular India hosts 350 species, the Western Ghats with 339 species, of which 37 species are endemic and Kerala inhabits 316 species.

It is assumed that the butterflies came into existence about 130 million years ago during the Cretaceous period along with the flowering plants. That may be the reason, the abundance of butterfly species in a given area is based on the suitability of habitat along with the availability of larval food plants (Pollard and Yates,1993).

Ninety-four species of butterflies, under 24 genera and 5 families were recorded from the Valanthode small hydel project area (Table-29; Plate- 11). Among the five families, Nmphalidae represented maximum number of 39 species, followed by Lycaenidae (19 species), Papilionidae (15 species), Pieridae (14 species), and Hesperiidae (7 species). Family wise, percentage frequency of Nmphalidae was the highest (41.49 %), followed by Lycaenidae (20.21%), Papilionidae (15.96%), Pieridae (14.89 %) and Hesperiidae (7.45%). The distribution of different species did not showed specifications with respect to different areas of the proposed project site. Among the 94 species, 7 are endemic to the Western Ghats, 16 species are belong to rare category and 8 are coming under Wildlife Protection Act (1972) and the rest are common. Out of 7 endemics, the Malabar tree nymph (*Idea malabarica)* and Tamil catseye (*Zipaetis saitis*) are south Indian endemic. Even though both of them are seen in pristine wet evergreen forest, usually at 300-914 m ASL, the later is protected under Schedule II of the Indian Wildlife Protection Act (1972) (Mathew, 2014). Two among this, the Malabar rose (*Pachliopta pandiyana*) and the Southern birdwing (*Troides minos*), the largest butterfly species of the Western Ghats are endemic to the Western Ghats. The rest, the Tamil lacewing (*Cethosia nietneri*), Tamil tree brown (*Lethe drypetis*) and the Tamil yeoman (*Cirrochroa thais*) are endemic to south India and Sri Lanka.

6.4.1.1 . Mud puddling behaviour of butterflies

Butterflies are usually nectarivorus, and relay on a variety of flowers for nectar, rich in sugar. But this nectar lacks some essential nutrients like some mineral salts and amino acids essential for physiological activities. These they acquire from natural mud puddlers on rocky depression, animal urine, dung, bird droppings, human sweat, rotting over ripe fruits, dead bodies etc (Kehimkar, 2016). Usually, hundreds of males of a single or many species congregate at damp sand or mud puddles for sucking the salt. During the study in Kurumanpuzha, where the Valanthode small hydroelectric project is coming, we observed 35 species of butterflies having the habit of mud puddeling (Table-30; Plate- 12). The study was conducted during the dry months, so there were many mud puddles in the downstream, dam site and the upstream area and made easy access to the mud puddlers. That may the reason for more number of mud puddler occurring the study area when compared with mud puddeling in other areas such as New amarambalam reserved forest (Sharma *et al*., 2002). Among the species, the Plain puffin *(Appias indra)* of the family Pieridae, congregation was more when compared with other species throughout the river. This may be due to local migration of this particular species as mentioned by Sharma *et al*., 2002.

6.4.2. Reptiles

Reptiles are mostly nocturnal in nature and special care has been taken for observation. The study documented that the Class reptilia is represented by 16 species, in 8 families and under the order Squamata (Table-31; Plate- 13). Among the recorded species, 7 were lizards and the nine were snakes. A total of 173 species in 24 families under three orders have been reported from Kerala (Palot, 2015). Reptalian diversity is less observed in the area during the study because they are exist in low densities and are cryptic and secretive (Raxworthy, 1988). The existence of king cobra came to know through secondary source by interviewing the local tribe, the Chola Naiken.

6.4.3. Birds

The field study recorded 77 species of birds, under 29 families and 11 orders (Table-32; Plate- 14). Among the 11 orders, Passeriformes represented maximum number of 37 species (48%), followed by Coraciformes with 11 species. Common species found in the site was Red whiskered bulbul, Black bulbul, Black drongo, Goldenbacked wood pecker, Jungle myna, common myna, Jungle crow and Yellow browed bulbul. Out of the 16 endemic birds of the Western Ghats and Kerala, the following 4 species were observed in the project area.

i. Blueringed parakeet (Psittacula *columboides*).
ii. Malabar grey hornbill (*Tockus griseus*).
iii. Southern tree pie (Dendrocitta leucogastra)
iv. Small sunbird (*Nectarinia minima*)

6.4.4. Mammals

The mammalian data presented here is based on direct sighting, indirect evidences and secondary informations. The mammalian diversity revealed, the presence of 28 species, under 17 families and 7 orders (Table-33; Plate-15). As the project area experiences human interactions, the direct sighting of the common animals like Bonnet macaque- *Macaca radiata* , Sambar - *Cervus unicolor,* Barking deer - *Muntiacus muntjack,* Mouse deer- *Tragulus meminna,* Gaur- *Bos gaurus,* Wild boar- *Sus scrofa*, Elephant - *Elephas maximus,* Malabar giant squirrel- *Ratufa indica,* Palm squirrel- *Funambulus palmarum,* Common mongoose- *Herpestes edwardsii,* Wild dog- *Cuon alpinus* and Toddy cat - *Paradoxurus hermaphrodites* are very scanty. This condition prevails both in private plantation, where the project is coming up and also at the fringes of the natural forest, bordering the river. The indirect evidences and the secondary information from the tribal community revealed the presence of these common animals and others in the interior forest, where the disturbance is comparatively low (Plate-16).

Table- 29. Valanthode SHEP: List of Butterflies

Sl. No.	*Family / Common name*	*Scientific name*	Areas observed		
			Catchm ent	Dam site	Down stream
	Family -Nymphalidae				
1	Baby fivering [2]	*Ypthima philomela*	●	●	●

2	Blue Admiral	*Kaniska canace*	●	●	●
3	Blue tiger	*Tirumala limniace*	●	●	●
4	Chestnut-streaked sailer	*Neptis jumbah*	●	●	●
5	Clipper [2]	*Parthenos sylvia*	●	●	●
6	Club beak [2]	*Libythea myrrha*	●	●	●
7	Commander	*Moduza procris*	●	●	●
8	Common bushbrown	*Mycalesis perseus*	●	●	●
9	Common evening brown	*Melanitis leda*	●	●	●
10	Common fivering	*Ypthima baldus*	●	●	●
11	Common fourring	*Ypthima ceylonica*	●	●	●
12	Common Indian crow	*Euploea core*	●	●	●
13	Common leopard	*Phalanta phalanta*	●	●	●
14	Common palm fly [2]	*Elymnias hypermnestra*	●	●	●
15	Common sailor	*Neptis hylas*	●	●	●
16	Common wanderer [2]	*Pareronia valeria*	●	●	●
17	Cruiser [2]	*Vindula erota*	●	●	●
18	Danid eggfly [3]	*Hypolimnas misippus*	●	●	●
19	Dark blue tiger	*Tirumala septentrionis*	●	●	●
20	Gladeye bush brown [2]	*Malesis patnia*	●	●	●
21	Glassy tiger	*Parantica aglea*	●	●	●
22	Great eggfly	*Hypolimnas bolina*	●	●	●
23	Great evening brown [2]	*Melanitis zitenius*	●	●	●
24	Grey count [2]	*Tanaecia lepidea*	●	●	●
25	Lemon pansy	*Junonia lemonias*	●	●	●
26	Malabar tree nymph [1]	*Idea malabarica*	●	●	●
27	Map butterfly [2]	*Cyrestis thyodamas*	●	●	●
28	Niger	*Orostriaena medus*	●	●	●
29	Oriental common lascar	*Pantoporia hordonia*	●	●	●
30	Plain tiger	*Danaus chrysippus*	●	●	●
31	Rustic	*Cupha erymanthis*	●	●	●
32	Staff sergeant [2]	*Athyma selenophora*	●	●	●
33	Striped tiger	*Danaus genutia*	●	●	●
34	Tamil catseye [1]	*Zipaetis saitis*	●	●	●
35	Tamil lacewing [1]	*Cethosia nietneri*	●	●	●
36	Tamil tree brown [1]	*Lethe drypetis*	●	●	●
37	Tamil Yeoman [1]	*Cirrochroa thais*	●	●	●
38	Tawny coster	*Acraea violae*	●	●	●
39	Yellow pansy	*Junonia hierta*	●	●	●
	***Family* -Papilionidae**				
40	Blue mormon	*Papilio polymnestor*	●	●	●
41	Buddha peacock [2]	*Papilio buddha*	●	●	●

42	Common blue bottle	*Graphium sarpedon*	●	●	●
43	Common jay	*Graphium doson*	●	●	●
44	Common mime [3]	*Chilasa clytia*	●	●	●
45	Common mormon	*Papilio polytes*	●	●	●
46	Common rose	*Pachliopta aristolochiae*	●	●	●
47	Crimson rose [3]	*Pachliopta hector*	●	●	●
48	Lime butterfly	*Papilio demoleus*	●	●	●
49	Malabar banded swallowtail	*Papilio liomedon*	●	●	●
50	Malabar rose [1]	*Pachliopta pandiyana*	●	●	●
51	Paris peacock[2]	*Papilio paris*	●	●	●
52	Red Helen	*Papilio helenus*	●	●	●
53	Southern birdwing [1]	*Troides minos*	●	●	●
54	Tailed Jay	*Graphium agamemnon*	●	●	●
	***Family*- Pieridae**				
55	Chocolate albatross [3]	*Appias lyncida*	●	●	●
56	Common albatross [2]	*Appias albina*	●	●	●
57	Common emigrant	*Catopsilia pomona*	●	●	●
58	Common grass yellow	*Eurema hecabe*	●	●	●
59	Common gull [3]		●	●	●
60	Common jezebel	*Delias eucharas*	●	●	●
61	Common wanderer	*Pareronia valeria*	●	●	●
62	Giant orange tip	*Hebomoia glaucippe*	●	●	●
63	Lesser gull [3]	*Cepora nadina*	●	●	●
64	Mottled emigrant	*Catopsilia pyranthe*	●	●	●
65	Three spot grass yellow	*Eurema blanda*	●	●	●
66	Psyche	*Leptosia nina*	●	●	●
67	Yellow orange tip	*Ixias pyrene*	●	●	●
68	Plain puffin [3]	*Appias indra*	●	●	●
	***Family*- Lycaenidae**				
69	Angled pierrot [2]	*Caletac aleta*	●	●	●
70	Banded blue pierrot	*Discolampa ethion*	●	●	●
71	Common cerulean	*Jamides celeno*	●	●	●
72	Common imperial	*Cheritra freja*	●	●	●
73	Common line blue	*Prosous nora*	●	●	●
74	Common pierrot [3]	*Castalius rosimon*	●	●	●
75	Dark cerulean	*Jamides bochus*	●	●	●
76	Gram blue [3]	*Euchrysops cnejus*	●	●	●
77	Indian Sun beam [2]	*Curetis thetis*	●	●	●
78	Lime blue	*Chilades lajus*	●	●	●
79	Monkey puzzle	*Rathinda amor*	●	●	●
80	Pale grass blue	*Zizeeria maha*	●	●	●

81	Plum judy	*Abisara echerius*	●	●	●
82	Pointed ciliate blue	*Anthene lycaenina*	●	●	●
83	Red pierrot	*Talicada nyseus*	●	●	●
84	Tiny grass blue	*Zizula hylax*	●	●	●
85	Whitedisc hedge blue	*Celataxia albidisca*	●	●	●
86	Yamfly	*Loxura atymnus*	●	●	●
87	Zebra blue	*Syntauruus plinius*	●	●	●
	***Family*- Hesperidae**				
88	Common banded demon	*Notocrypta paralysos*	●	●	●
89	Dark palm dart	*Telocota ancilla*	●	●	●
90	Giant redeye	*Gangara thyrsis*	●	●	●
91	Moore's Ace	*Halpe porus*	●	●	●
92	Restricted demon	*Notocrypta curvifascia*	●	●	●
93	Tamil grass dart	*Taractroera ceramas*	●	●	●
94	Water snow flat	*Tagiades litigiosa*	●	●	●

Status

1. Western Ghats endemic
2. Rare
3. Protected under schedule II of the Wildlife Protection Act (1972).

Table-30. Valanthode SHEP: List of Mud Puddlers

Sl. No.	Family/Species	Scientific name	Areas observed		
			Catchment	Dam site	Down stream
	Family: PAPILIONIDAE				
1	Common bluebottle	*Graphium sarpedon*	•	•	•
2	Blue mormon	*Papilio polymnestor*	•	•	
3	Paris peacock	*Papilio paris*	•	•	•
4	Red Helen	*Papilio helenus*	•	•	•
	Family: PIERIDAE				
5	Common grass yellow	*Eurema hecabe*	•	•	•
6	Common emigrant	*Catopsilia pomona*	•	•	•
9	Common jezebel	*Delias eucharas*	•	•	•
11	Three spot grass yellow	*Eurema blanda*	•	•	•
12	Plain puffin	*Appias indra*	•	•	•
	Family -Nymphalidae				
13	Blue Admiral	*Kaniska canace*	•	•	•
14	Blue tiger	*Tirumala limniace*	•	•	•
15	Clipper	*Parthenos sylvia*	•	•	•
16	Club beak	*Libythea myrrha*	•	•	•
17	Commander	*Moduza procris*	•	•	•

18	Common Indian crow	*Euploea core*	•	•	•
19	Map butterfly	*Cyrestis thyodamas*	•	•	•
20	Plain tiger	*Danaus chrysippus*	•	•	•
21	Rustic	*Cupha erymanthis*	•	•	•
22	Striped tiger	*Danaus genutia*	•	•	•
	Family- Lycaenidae				
23	Angled pierrot [2]	*Caletac aleta*	•	•	•
24	Banded blue pierrot	*Discolampa ethion*	•	•	•
25	Common cerulean	*Jamides celeno*	•	•	•
26	Common line blue	*Prosous nora*	•	•	•
27	Common pierrot [3]	*Castalius rosimon*	•	•	•
28	Indian Sun beam [2]	*Curetis thetis*	•	•	•
29	Lime blue	*Chilades lajus*	•	•	•
30	Pale grass blue	*Zizeeria maha*	•	•	•
31	Pointed ciliate blue	*Anthene lycaenina*	•	•	•
32	Red pierrot	*Talicada nyseus*	•	•	•
33	Tiny grass blue	*Zizula hylax*	•	•	•
34	Whitedisc hedge blue	*Celataxia albidisca*	•	•	•
35	Zebra blue	*Syntauruus plinius*	•	•	•

Table-31. Valanthode SHEP: List of Reptiles

Sl. No.	Order/Family/Species	Scientific name	Areas observed		
			Catchment	Dam site	Down stream
	Order: Squamata /Family: Agamidae				
1	Oriental garden lizard	*Calotes versicolor*	•	•	•
2	Malabar green calotes	*Calotes calotes*	•	•	
3	Flying lizard	*Draco dussumieri*	•	•	•
4	South Indian rock agama	*Psammophilus dorsalis*			
	Family: Monilesaurus				
5	Forest calotes	*Calotes rouxi*	•	•	•
	Family: Scincidae				
6	Common skink	*Mabuya carinata*	•	•	•
	Family: Varanidae				
7	The common monitor	*Varanus bengalensis*	•		
	Family: Pythonidae				
8	Python*	*Python moluus*	•	•	
	Family: Colubridae				
9	Oriental rat snake	*Ptyas mucosus*	•	•	•
10	Checkered keel back or Asiatic water snake	*Xenochrophis piscator*	•	•	•

11	The Green whip snake	*Ahaetulla nasutus*	•	•	•
	Family: Elapidae				
12	The common kriat	*Bungarus caeruleus*	•	•	•
13	Indian cobra	*Naja naja*	•		
14	The King cobra*	*Ophiophagus hannah*	•		
	Family: Viperidae				
15	Russells viper	*Vipera russelli*	•	•	•
16	Pit viper	*Trimeresurus gramineus*	•	•	•

* Secondary Data

Table-32. Valanthode SHEP: List of Birds

Sl. No.	**Common Name**		**Areas observed**		
	I. Order: Falconiformes /Family: Accipitridae	**Scientific Name**	Catchment	Dam site	Down stream
1	Brahminy kite	*Haliastur indus*	•	•	•
2	Shikra	*Accipiter badius*	•	•	•
3	Black Eagle	*Ictinaetus malaiensis*	•	•	•
	II. Order: Galliformes/Family: Phasianidae				
4	Grey junglefowl	*Gallus sonneratii*	•	•	•
5	Red spurfowl	*Galloperdix spadicea*			
6	Common peafowl	*Pavo cristatus*	•	•	•
	III. Order: Podicipediformes/ Family: phalacrocoracidae				
7	Little cormorant	*Phalacrocorax niger*	•	•	•
	IV. Order: Ciconiiformes /Family: Ardeidae				
8	Cattle egret	*Bubulcus ibis*	•	•	•
9	Little egret	*Egretta garzetta*	•	•	•
10	India pond heron	*Ardeola grayii*	•	•	•
11	Indian peafowl	*Pavo cristatus*			
	VI. Order Columbiformes / Family: Columbidae				
12	Emerald dove	*Chalcophaps indica*	•	•	•

13	Yellow-footed Green Pigeon	*Treron phoenicoptera*	•	•	•
14	Indian spotted dove	*Streptopelia chinensis*	•	•	•
15	Blue rock pigeon	*Columbia livia*	•	•	•
	VII. Order: Gruiformes/ Family: Rallidae				
16	White breasted waterhen	*Amaurornis phoenicurus*	•	•	•
	VIII. Order: Psittaciformes/ Family: Psittacidae				
17	Bluewinged parakeet	*Psittacula columboides*	•	•	•
18	Roseringed parakeet	*Psittacula krameri*	•	•	•
19	Indian lorikeet	*Loriculus vernalis*	•	•	•
20	Blossomheaded parakeet	*Psittacula cyanoephala*			
	IX. Order: Cuculiformes/Family: Cuculidae				
21	Asian Koel	*Eudynamys scolopaceae*	•	•	•
	Family: Apodidae				
22	Palm swift	*Cypsiurus balasiensis*	•	•	•
23	House swift	*Apus affinis*	•	•	•
	Family: Strigiformes				
24	Jungle owlet	*Glaucidium radiatum*	•	•	•
	XI. Order: Coraciiformes/ Family: Meropidae				
25	Chestnut-headed bee-eater	*Merops leschenaulti*	•	•	•
26	Small green bee-eater	*Merops orientalis*	•	•	•
	Family: Alcedinidae				
27	White-breasted kingfisher	*Halycon smyrnensis*	•	•	•
28	Lesser pied kingfisher	*Ceryle rudis*	•	•	•
	Family: Coraciidae				
29	The Indian roller	*Coracias benghalensis*	•	•	•
	Family: Corvidae				
30	House crow	*Corvus splendens*	•	•	•
31	Jungle crow	*Corvus macrorhynchos*	•	•	•

32	Whitebellied tree pie	*Dendrocitta leucogastra*	•	•	•
33	Indian tree pie	*Dendrocitta vagabunda*	•	•	•
	Family: Bucerotidae				
34	Malabar grey hornbill	*Ocyceros griseus*	•	•	•
35	Great Indian hornbill	*Buceros bicornis*	•	•	•
	XII. Order: Piciformes/ Family: Capitonidae				
36	Malabar Crimsonthroated barbet	*Megalaima rubricapilla*	•	•	•
37	Small green barbet	*Megalaima viridis*	•	•	•
	Family: Picidae				
38	Goldenbacked woodpecker	*Dinopium benghalense*	•	•	•
39	Malherbe's goldenbacked woodpecker	*Chrysocolaptes lucidus*	•	•	•
40	Heart spotted woodpecker	*Hemicircus canente*	•	•	•
	XIII. Order: Passeriformes/ Family: Oriolidae				
41	Oriole	*Oriolus oriolus*	•	•	•
42	Black headed oriole	*Oriolus xanthornus*	•	•	•
	Family: Dicruridae				
43	Black drongo	*Dicrurus macrocercus*	•	•	•
44	Large racket-tailed drongo	*Dicrurus paradiseus*	•	•	•
45	Ashy drongo	*Dicrurus leuophaeus*			
	Family: Sturnidae				
46	Southern grackle	*Gracula religiosa*	•	•	•
47	Southern jungle myna	*Acridotheres fuscus*	•	•	•
48	Common myna	*Acridotheres tristis*	•	•	•
	Family: Pycnonotidae				
49	Southern redwhiskered bulbul	*Pycnonotus jocosus*	•	•	•
50	Yellowbrowed bulbul	*Hypsipetes indicus*	•	•	•
51	Red vented bulbul	*Pycnonotus cafer*	•	•	•
52	South Indian black bulbul	*Pycnonotus madagasariensis*	•	•	•

	Family: Muscicapidae				
53	Rufous babbler	*Turdoides subrufus*	•	•	•
54	Whitethroated babbler	*Dumetia hyperythra*	•	•	•
55	Paradise flycatcher	*Terpsiphone paradisi*	•	•	•
56	Southern ashy wren-warbler	*Prinia socialis*	•	•	•
57	Greenish leaf warbler	*Phylloscopus trochiloides*	•	•	•
58	Tailor bird	*Orthotomus sutorius*	•	•	•
59	Bourdillon's blackbird	*Turdus merula*	•	•	•
60	Indian blue chat	*Erithacus brunneus*	•	•	•
61	Indian blue rock thrush	*Monticola solitarius*	•	•	•
62	Malabar whistling thrush	*Myiophoneus horsfeldii*	•	•	•
63	Southern magpie robin	*Copsychus saularis*	•	•	•
64	Orangeheaded ground thrush	*Zoothera citrina*	•	•	•
	Family: Campephagidae				
65	Scarlet minivet	*Pericrocotus speciosus*	•	•	•
	Family: Paridae				
66	Southern yellowcheeked tit	*Parus xanthogenys*	•	•	•
	Family: Sittidae				
67	Velvetfronted nuthatch	*Sitta frontalis*	•	•	•
	Family: Motacillidae				
68	Grey wagtail	*Motacilla cinerea*	•	•	•
69	Forest wagtail	*Motacilla indica*	•	•	•
	Family: Estrildidae				
70	White rumped munia	*Lonchura striata*	•	•	•
71	Spotted munia	*Lonchura punctulata*	•	•	•
72	Black headed munia	*Lonhura malacca*	•	•	•
	Family: Dicaeidae				
73	Tickell's flowerpecker	*Dicaeum erythrorhynchos*	•	•	•
	Family: Nectariniidae				
74	Small sunbird	*Nectarinia minima*	•	•	•

75	Lotens sunbird	*Nectarinia lotenia*			
76	Indian purple rumped sunbird	*Nectarinia zeylonica*	•	•	•
77	Little spider-hunter	*Arachnothera ongirostris*	•	•	•

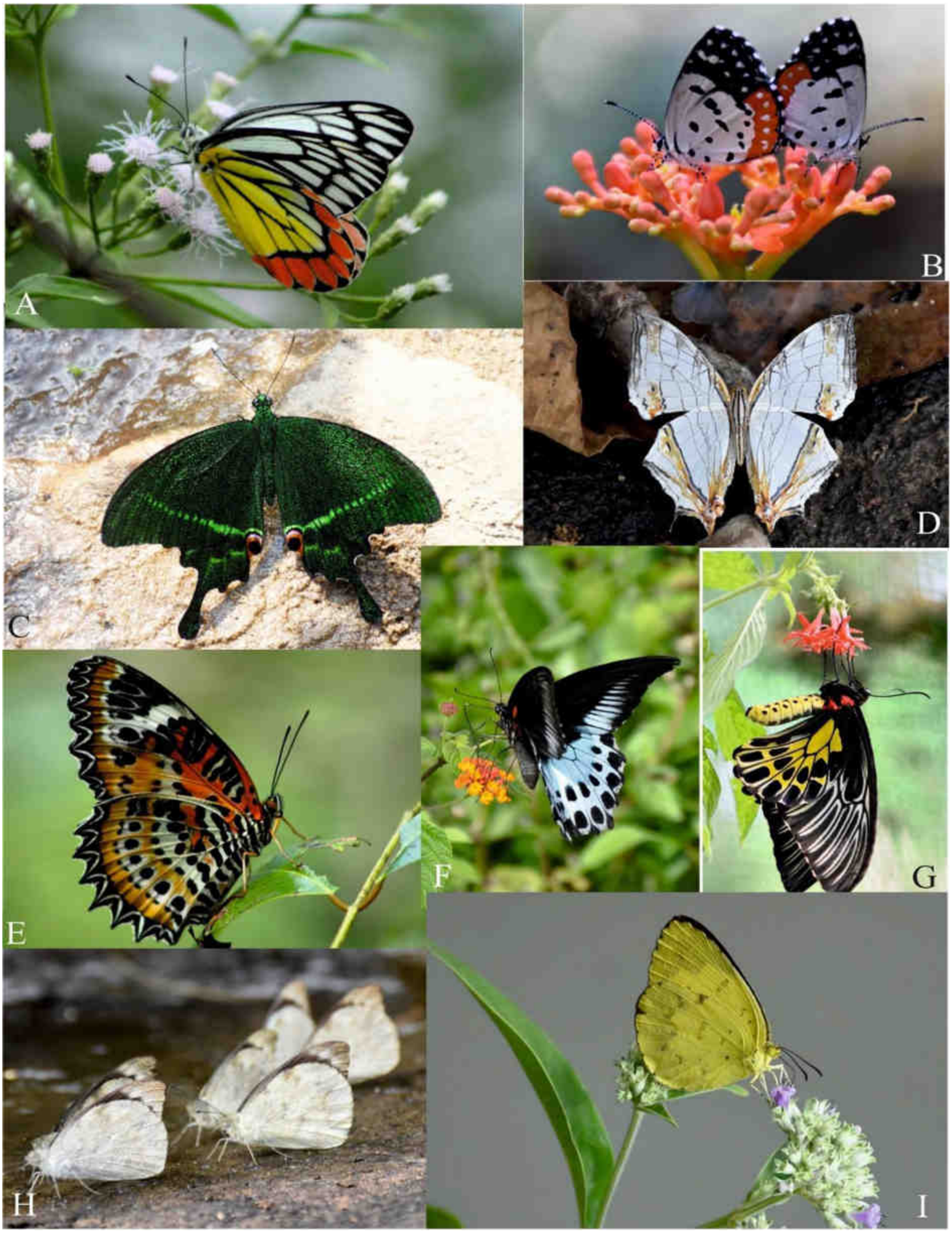
Table-33. Valanthode SHEP: List of Mammals

Sl. No.	Order/Family/Species	Scientific Name	Areas observed		
	Order: Primates **Family: Cercopithecidae**		Catchment	Dam site	Down stream
1	Lion-tailed macaque ***	*Macaca silenus*	•	•	
2	Bonnet macaque *	*Macaca radiata*	•	•	•
3	Nilgiri langur ***	*Trachypithecus johni*	•	•	•
4	Hanuman langur ***	*Semnopithecus entellus*	•	•	•
	Order: Artiodactyla **Family: Cervidae**				
5	Sambar *	*Cervus unicolor*	•	•	•
6	Spotted deer ***	*Axis axis*			•
7	Barking deer *	*Muntiacus muntjack*	•	•	•
	Family: Tragulidae				
8	Mouse deer *	*Tragulus meminna*	•	•	•
	Family: Bovidae				
9	Gaur *	*Bos gaurus*	•	•	•
	Family: Suidae				
10	Wild boar *	*Sus scrofa*	•	•	•
	Order: Proboscidea **Family: Elephantidae**				
11	Asiatic elephant *	*Elephas maximus*	•	•	•
	Order: Rodentia **Family: Sciuridae**				
12	Malabar giant squirrel *	*Ratufa indica*	•	•	•
13	Palm squirrel *	*Funambulus palmarum*	•	•	•
14	Flying squirrel *	*Petaurista petaurista*	•	•	
	Family: Hystricidae				
15	Porcupine **	*Hystrix indica*	•	•	•

	Order: Carnivora **Family: Mustelidae**				
16	Otter **	*Lutra* sp.	•	•	•
	Family: Herpestidae				
17	Common mongoose *	*Herpestes edwardsii*	•	•	•
	Family: Canidae				
18	Wild dog *	*Cuon alpinus*	•	•	•
	Family: Ursidae				
19	Sloth bear ***	*Melurus ursinus*	•	•	•
	Family: Viverridae				
20	Small Indian civet ***	*Viverricula indica*	•	•	
21	Toddy cat **	*Paradoxurus hermaphroditus*	•	•	
	Family: Felidae				
22	Leopard **	*Panthera pardus*	•	•	•
23	Tiger ***	*Panthera tigris*	•	•	•
	Order: Lagomorpha **Family: Leporidae**				
24	Blacknaped hare *	*Lepus nigricollis*	•	•	•
	Order: Chiroptera **Family: Pteropodidae**				
25	Indian flying fox*	*Pteropus giganteus*	•	•	•
26	Fulvous fruit bat*	*Rousettus leshenaulti*	•	•	•
	Family: Vespertilionidae				
27	Kelaarts pipistrelle*	*Pipistrellus ceylonicus*	•		
	Family: Rhinolophidae				
28	Blyth's Horseshoe Bat*	Rhinolophus lepidus	•		

* - Direct observation
** - Indirect observation
*** -Secondary information

Plate - 11. Valanthode SHEP : Butterflies

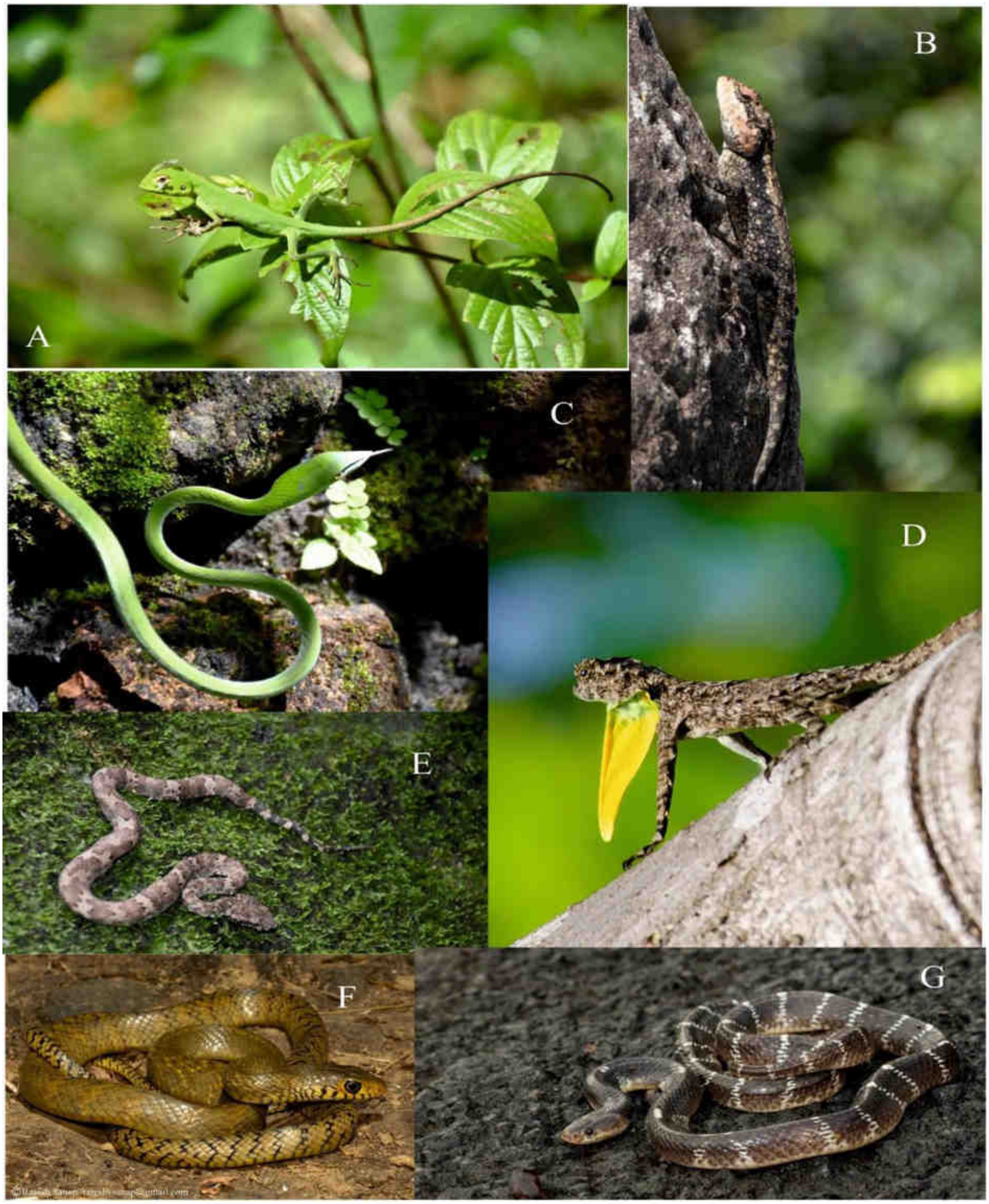


A- Common jezebel / B- Red pierrot / C- Paris peacock / D - Map butterfly / E- Tamil lacewing
F - Blue mormon / G- Southern birdwing / H - Plain puffin / I- Three spot grass yellow

Plate - 12. Valanthode SHEP : Mud puddlers

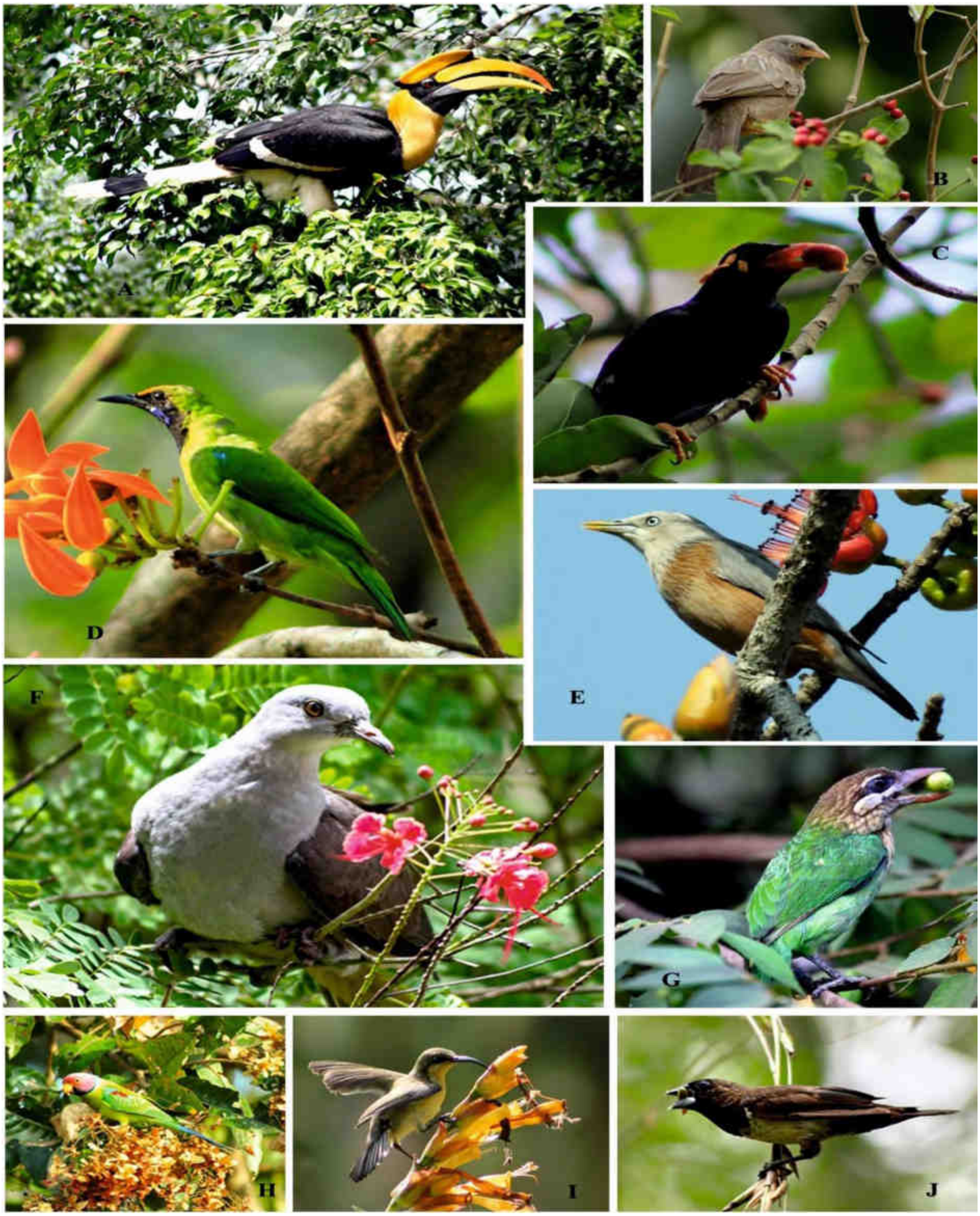
A- Zebra blue / B- white disc hedge blue / C- Plain tiger / D- Blue mormon & Common blue bottle
E- Map butterfly / F- Blue bottle / G- Club beak / H- commander / I- Common lime blue
J - Plain puffin / K- Angled pierrot / L- Rustic

Plate - 13. Valanthode SHEP : Reptiles



A- Malabar green calotes / B - South Indian rock agama / C- Green whip snake
D- Flying lizard / E -Pit viper / F -Oriental rat snake / G- Common krait

Plate - 14 Valanthode SHEP : Birds



A - Great Indian hornbill / B - Jungle babbler / C- Southern grackle / D - Golden-fronted leafbird
E- Blyth's starling / F- Mountain imperial pigeon / G- small green barbet / H - Blossom-headed parakeet
I- Loten's sunbird / J -White-rumped munia

Plate - 15. Valanthode SHEP : Mammals

A- Asian elephant / B- Porcupine / C- Bonnet macaque | D - Blyth's horseshoe bat / E- Black naped hare
F - Malabar giant squirrel / G- Three striped palm squirrel / H - toddy cat | I- Wild dog

Plate - 16. Valanthode SHEP : Indirect Observations

A- Scat of wild dog / B- Pellets of Malabar giant squirrel / C- Scat of otter / D - Scat of wild cat
E- Toddy cat scat / F - Elephant dung / G- Footprints of wild cat and mouse deer / H - Footprints of gaur

6.5. Aquatic Flora and Fauna

The status of aquatic biology of the river has been assessed through periodic sampling and analysis of water and aquatic life forms such as aquatic flora, planktons, benthic fauna, fishes, fox etc. Also assed the existence of special habitats like breeding grounds and spawning sites to ensure the viable population of aquatic resources. The data generated during the study on the physio-chemical and biological aspects of the river system largely reveal the river ecology pertaining to the project area and its catchment zone.

6.5.1. Aquatic Flora: Planktons and benthic fauna

Phytoplanktons of the area are represented by (i) Cyanophyta (Nostocales), (ii) Chlorophyta (Chaetophorales and Zygnematales), while zooplanktons are identified in different groups namely (i) Cladocera, (ii) Copepoda, (iii) Diptera, (iv) Protozoa and (v) Rotifera. The benthic fauna consists mainly of insect larvae and worms. Phytoplankton, zooplankton, benthos, fishes and amphibians are obtained from the sampling sites consisted of most common species found in almost all the rivers of Western Ghats.

6.5.2. Fishes and Fisheries

On frequent sampling in upstream and downstream areas only three species of fishes were found, Anguilla bengalensis, Puntius fasciatus and Garra mullya. At the same time from the words of tribal fishermen certain areas of the river downstream to the Kozhippara falls ie. 500 M downstream to the power house presence of Neolissochilus stracheyi also reported. The study recorded a total of 21 species of fishes from the Kurumanpuzha river system up to Chaliyar confluence point from the secondary information (Table -34; Plate-17). Out of the 21 species of fishes, 20 are coming under the group of 'Low Risk least concern'. The only fish, Ompok bimaculatus, is coming under the category of 'Low Risk near threatened'.

The fishery in the upstream and downstream area of the proposed weir is mainly depending upon the three species of fishes mentioned earlier. Commercial fishery as such does not exist in the proposed project area or in any part of the river up to Chaliar confluence considered in the present study. Tribal people in settlements of upstream and downstream areas occasionally catch fishes for their own consumption.

In the downstream area of the weir up to 10 km of the power house and beyond, 21 species of fishes found distributed are given in Table-35. Of the 21 species obtained, only three are commonly found in all the areas of upstream, downstream and power area on frequent sampling. Separate breeding grounds as such do not exist in these areas. The existing puddles in the upstream and downstream areas formed in summer months will not be affected any way due to the construction of weir and the small area of reservoir. However, several deep pools and protected 'refuges' with gravel beds and boulders usually used for egg-laying by stream fishes exist in the catchment and downstream areas of the river.

6.5.3. Amphibians (Frogs)

In the study area up to 10 km downstream from the weir site, 14 species of Anurans are found. Of the 14 species obtained, only one, Pseudo philautus wynadeansis belong to endangered category, four species under near threatened category and all others are common and comes under Low risk least concern category (Table-36 ; Plate-18). Most of the species except Micrixalus sp. are found in all the areas of upstream, downstream and power area on frequent sampling. Separate breeding grounds and tadpoles are found exist in these areas. On distribution analysis, it was found out that only three are reported from the upstream and five from weir site. However, almost all the 14 species were reported in the downstream areas covering power house and beyond (Table-37). The breeding grounds in existing puddles in the upstream and downstream areas formed in summer months will not be affected any way due to the project and the small area of reservoir without any submergence.

6.5.4. Special Habitats / Breeding Grounds

6.5.4.1. Habitat

Upstream and downstream of the river is sufficiently catered by perennial streams on both the banks. As in other rivers the upper reaches are the oxygen generator of the entire river system, which supports all the biota init including fishes. The riffles and falls are found to be copious in both upstream and downstream. Also, stagnant puddles nourished with algal and planktonic growth are frequently seen as the breeding grounds of aquatic fauna especially of *Puntius faciatus*.

6.5.4.2. Special habitats, Breeding grounds, spawning sites

Usually, the stream fishes are breeding in highly oxygenated water puddles after the falls and riffles. In the proposed project area of the river such areas exist in the upstream and downstream of the proposed weir site. The lentic water in the rocky basins provides suitable spawning sites to the fishes. As the upstream area is represented by a very few species, limited in three numbers there is no competition or multi species habitat compatibility issues found in the area. Since the project is of run off the river mode, and operating only during the monsoon season, in any way it will not affect these microhabitats. Bottom of the river in most of the area is rocky with boulders, pebbles, and gravel. In 'refuges' found in these areas with pebbles and gravel, shoals of juvenile fishes of Puntius faciatus were found in both upstream and downstream.

Amphibians especially Anurans, usually breeding habitats are wet banks of the river and the number of vegetation types may influence species composition, because vegetation provides shelter and calling sites for anurans, which breed mainly in lentic water bodies. Foam nests of certain species were evidenced during the study. In summer months the puddles in rocky platforms nourished with dripping banks serves as breeding grounds for Anurans (Plate-19). Numerous such microhabitats are found in both upstream and downstream of the weir. However, as the project is designed and planned to operate in a way not having much alterations in the normal course of the river and with a very small reservoir area housing within the river bed, there will not be any impact over these microhabitats.

Table-34. Valanthode SHEP: Fish fauna of the Project Area

Sl. No.	Scientific name of species	Status
1.	*Amblypharyngodon melettinus*	LR-lc
2.	*Anabas testudinius*	LR-lc
3.	*Anguilla bengalensis*	LR-lc
4.	*Aplocheilus lineatus*	LR-lc
5.	*Barelius gatensis*	LR-lc
6.	*Danio aequipinnatus*	LR-lc
7.	*Danio malabaricus*	LR-lc
8.	*Garra mullya*	LR-lc
9.	*Lepidocephalus thermalis*	LR-lc
10.	*Mystus armatus*	LR-lc
11.	*Mystus malabaricus*	LR-lc
12.	*Neolissochilus stracheyi*	LR-lc
13.	*Ompok bimaculatus*	LR-nt
14.	*Parambassis thomassi*	LR-lc
15.	*Parluciosoma daniconius* (*Rasbora daniconius*)	LR-lc
16.	*Puntius amphibius*	LR-lc
17.	*Puntius aurilius*	LR-lc

18.	*Puntius fasciatus melanampyx*	LR-lc
19.	*Puntius filamentosus*	LR-lc
20.	*Puntius ticto*	LR-lc
21.	*Wallagu attu*	LR-lc

LR-nt: Low Risk nearly threatened; LR-lc: Low risk least concern.

Table- 35. Valanthode SHEP: Area wise distribution of Fishes

Sl. No	Name of species	Upstream	Weir site	Downstream up to power house site	Downstream beyond powerhouse site
1.	*Amblypharyngodon melettinus*	-	-	-	+
2.	*Anabas testudinius*	-	-	-	+
3.	*Anguilla bengalensis*	+	+	+	+
4.	*Aplocheilus lineatus*	-	-	-	+
5.	*Barelius gatensis*	-	-	-	+
6.	*Danio aequipinnatus*	-	-	-	+
7.	*Danio malabaricus*	-	-	-	+
8.	*Garra mullya*	+	+	+	+
9.	*Lepidocephalus thermalis*	-	-	-	+
10.	*Mystus armatus*	-	-	-	+
11.	*Mystus malabaricus*	-	-	-	+
12.	*Neolissochilus stracheyi*	-	-	-	+
13.	*Ompok bimaculatus*	-	-	-	+
14.	*Parambassis thomassi*	-	-	-	+
15.	*Parluciosoma daniconius* (*Rasbora daniconius*)	-	-	-	+
16.	*Puntius amphibius*	-	-	-	+
17.	*Puntius aurilius*	-	-	-	+
18.	*Puntius fasciatus melanampyx*	+	+	+	+
19.	*Puntius filamentosus*	-	-	-	+
20.	*Puntius ticto*	-	-	-	+
21.	*Wallagu attu*	-	-	-	+

+ Present **- Absent**

Table- 36. Valanthode SHEP: Amphibians observed during the study

Order, Family	Sl.No.	Scientific name of species	Status
Order: Anura **Family: Bufonidae**	1	*Duttaphrynus melanostictus*	**LR-lc**
	2	*Duttaphrynus parietalis*	LR-nt
Family: **Dicroglossidae**	**3**	*Hoplobatrachus tigerinus*	**LR-lc**
	4	*Minervarya keralensis*	**LR-lc**
	5	*Fejervarya limnocharis*	**LR-lc**
	6	*Euphlyctis cyanophlyctis*	**LR-lc**
	7	*Euphlyctis hexadactylas*	**LR-lc**
Family: Ranidae	**8**	*Indosylvirana temporalis*	LR-nt
	9	*Clinotarsus curtipes*	LR-nt
Family: Rhacophoridae	**10**	*Rhacophorus malabaricus*	**LR-lc**
	11	*Pseudo philautus wynadeansis*	**EN**
	12	*Polypedates maculatus*	**LR-lc**
Family: Micrixalidae	**13**	*Micrixalus fuscus*	LR-nt
	14	*Micrixalus sylvaticus*	**LR-dd**

EN-Endangered LR-nt: Low Risk nearly threatened; LR-lc: Low risk least concern: LR-dd: Low risk data deficient.

Table -37. Valanthode SHEP: Area wise distribution of Amphibians

Sl. No	Name of species	Upstream	Weir site	Downstream up to power house site	Downstream beyond powerhouse site
1	*Duttaphrynus melanostictus*	+	+	+	+
2	*Duttaphrynus parietalis*	+	+	+	+
3	*Hoplobatrachus tigerinus*	-	-	+	+
4	*Minervarya keralensis*	-	-	+	+
5	*Fejervarya limnocharis*	+	+	+	+

6	*Euphlyctis cyanophlyctis*	-	-	+	+
7	*Euphlyctis hexadactylas*	-	-	+	+
8	*Indosylvirana temporalis*	-	+	+	+
9	*Clinotarsus curtipes*	-	+	+	+
10	*Rhacophorus malabaricus*	-	-	-	+
11	*Pseudo philautus wynadeansis*	-	-	+	+
12	*Polypedates maculatus*	-	-	-	+
13	*Micrixalus fuscus*	-	-	-	+
14	*Micrixalus Sylvaticus*	-	-	+	+

+ Present **- Absent**

Plate -17. Valanthode SHEP: Fishes

A- Puntius fasciatus / B - Anguilla bengalensis / C- Garra mullya
D- Gillnet sampling / E -Neolissochilus stracheyi / F -Mystus armatus

Plate - 18. Valanthode SHEP: Frogs

A- Duttaphrynus parietalis / B - Indosylvirana temporalis / C- Minervarya keralensis
D- Rhacophorus malabaricus / E -Clinotarsus curtipes / F -Pseudo philautus wynadeansis

Plate - 19. Valanthode SHEP: Habitats and Breeding grounds

A- Falls & Riffles / B - Stagnant puddles / C- Aquatic breeding ground
D- Foam nest of Anuran / E -Fingerlings / F -Tadpoles

6.6. Agrobiodiversity

Field survey and discussion with farmers of the area proposed to be acquired for the project yielded the following:

The area is being owned by 14 farmers. Out of them 10 farmers are not following cultivation practices in their left-over crops which resulted in the overgrowth with weeds. The primary crops in the cultivated area include Robusta-type Coffee, black pepper (Panniyur and local varieties), and Banana (Nendran and Mysur Poonan). Apart from this, vegetables and fruit crops are cultivated in the kitchen garden attached to their house. The agricultural crops currently seen in the area can be grouped into the following categories (Table-38).

Table-38. Valanthode SHEP: Agrobiodiversity of diversion canal to Power house

Category	**Crops**
Fruits	Jack, Mango, Banana, Papaya, Guava
Tubers	Cassava, Colocasia
Commercial Crops	Sugarcane, Cashew
Spices	Cardamom, Cinnamon, Nutmeg, Black Pepper, Ginger
Beverages	Arecanut, Coca, Coffee
Vegetables	Amaranth, Okra, Bitter gourd, Brinjal, Chilli, Tomato
Ornamentals	Marigold, Button rose, Chrysanthinum, Bongainvilla, Rose, Jasmine
Medicinal and Aromatic Plants	Lemon grass, Vetiver, Chethikoduveli, Chittadalotakam, Thulsi

All the crops listed above are commonly cultivated in different parts of Kerala and do not belong to any rare or uncommon varieties. The yield of these crops is far below the state average due to the lack of proper management of agronomic operations. Apart from cultivated crops, the area also contained trees such as Mukkanni, Neeli, Thanni, Red akil, Maruthu, Kunthirikkam, Nephelia, Unnam, Nelli etc which are used as shade trees to protect their cardamom, coffee and tree spice crops.

6.7. Geological framework and Structural Stability

6.7.1. Physiographic Features

Since the location, coordinates, accessibility are discussed in other areas of the report only features pertain to land form and related process are highlighted in this section. The physiographic description detailed are of the section of the Kurumanpuzha subbasin showing 3rd order stream in which the new Weir is proposed.

The Nilambur valley borders the Nilgiris and Wayanad mountain ranges, characterized by rolling topography with mounds and knolls composed of banded magnetite quartzite and hill ranges formed by charnockite. Drained by the southerly flowing Chaliyar River and its tributaries, the valley represents a low-level tract enclosed by lofty mountains. Rugged topography with numerous mounds and ridges surrounds small, flat lands. The study area was subjected to Geographic Information System and the following themes were mapped viz., Drainage pattern, Elevation, Slope, Stream Density Flow accumulation etc (Fig.8).

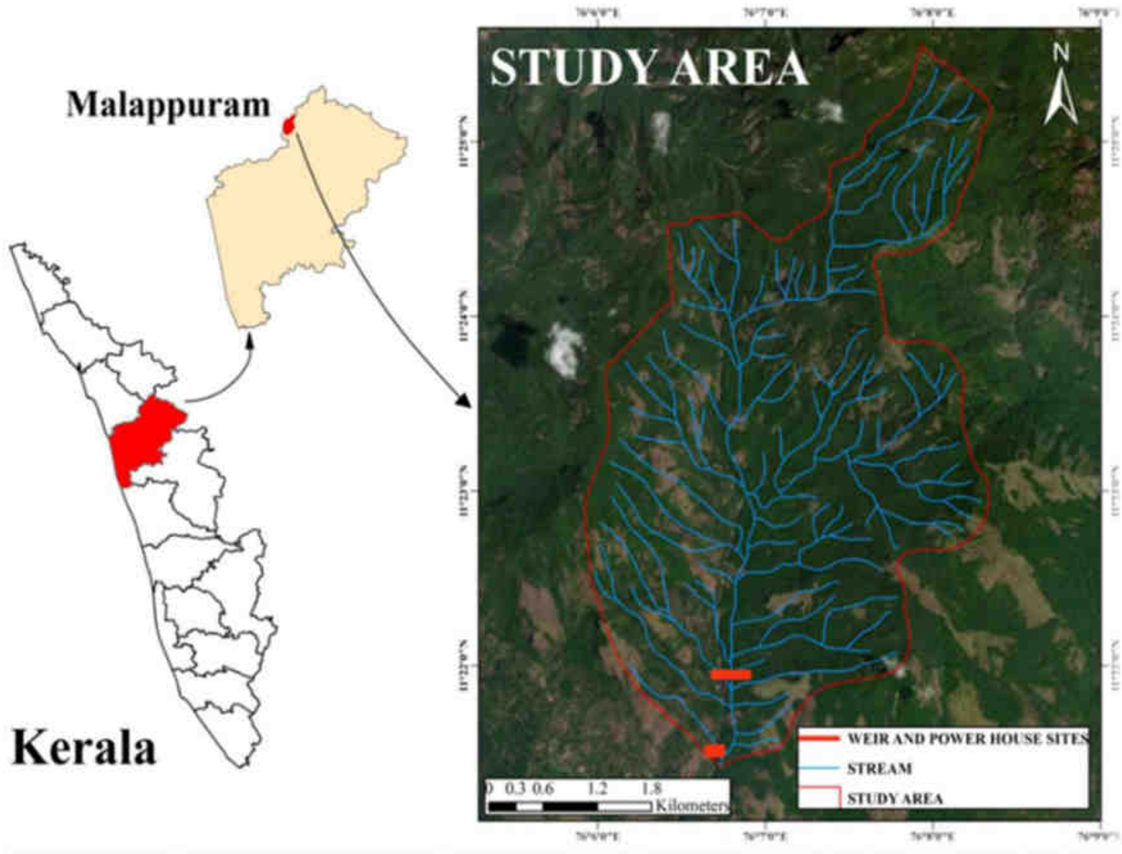


Fig. 8. Valanthode SHEP: Kurumanpuzha River System and Weir Site

6.7.2. Regional Geology

The Geological Regional framework and rock assemblies are described in this section along with the regional maps. None of the regional geologic factors contribute any unsuitability for the project or structural instability for the weir.

The metamorphic terrain in the southern India known as southern granulite terrain (SGT) consists of major units of the granulites, gneisses, greenstones and younger acid and basic intrusions. The northern flank of the Palghat gap consists of metasedimentary sequence of khondalite and cal-granulite with crystalline limestone bands. Ancient supracrustals are represented by ultramafate and metasedimentary schistose rocks found to occur as en-echelon linear bands and enclaves within the charnockite and gneisses. The rocks of peninsular gneissic complex are exposed in the northern parts of Kerala and comprise sheared hornblende-biotite gneiss, biotite-hornblende gneiss, foliated granite and pink granite gneiss. The Khondalite group of rocks includes calc-granulites, quartzite and garnetiferous–sillimanite gneiss and paragneisses of pelitic parentage and are well-developed in the southern part and Charnockite and charnockite gneiss have preponderance over all other crystalline rocks covering 40–50% of the total area. Charnockite group of rocks shows great diversity in lithology comprising pyroxene granulite, hornblende pyroxenite, magnetite quartzite, charnockite, hypersthene-diopside gneisses and cordierite gneiss. Migmatite includes a variety of gneissic rocks and is a dominant litho-assemblage. Quartzofeldspathic gneiss, garnet-biotite gneiss, hornblende gneiss, hornblende-biotite gneiss. (Ambili *et al.*, 2022). The Regional study area exhibits two distinct geological belts based on rock exposure patterns: (i) the Charnockite Group predominates, covering a significant portion, and (ii) the Migmatite Complex is situated towards the east. The Charnockite Group comprises charnockite or charnockite gneiss, boasting the most extensive areal distribution. In contrast, the Migmatite Complex consists of biotite-hornblende gneiss (or hornblende-biotite gneiss) and quartzo-feldspathic gneiss or garnet-biotite gneiss. The granite-greenstone terrane to the north and granulite facies crustal blocks to the south characterize the geological composition of Southern Peninsular India. In the Wynad-Nilambur region, lowlands are flanked by the elevated Wynad and Nilgiris hills to the east and north. Rock formations vary widely, with the Wynad Group comprising small meta-ultra mafic bodies and the Peninsular gneissic complex exhibiting granite and hornblende-biotite gneiss (GSI, 2005). The study area encompasses rocks from the Archaean age, including the Peninsular Gneissic Complex - II spanning the Archaean to Paleoproterozoic Period, as well as Neo-Proterozoic acid intrusives and Meso-Proterozoic basic intrusives. The dominant rock type, charnockite, is surrounded by hornblende-biotite gneiss and Proterozoic intrusives such as pegmatite veins and meta-gabbro. Mesozoic dolerite and gabbro dykes represent the youngest intrusions, while extensive laterization and migmatization are prevalent in the southeast. Foliation trends display predominant NE-SW to NW-SE orientations, with minor shearing observed in charnockite and biotite gneiss formations. Other rock types found in the study area include amphibolite, metapyroxenites, actinolite schist, and gabbro (Shaji et al., 2014). The Chaliar is an open bowl-shaped valley sandwiched between the Nilgiri Charnockite Massif in the east and the Northern Kerala Massif in the west. The area exposes Archean volcano-sedimentary sequences that occur as enclaves within the Peninsular Gneissic Complex, represented by various gneisses and charnockite (Fig. 9).

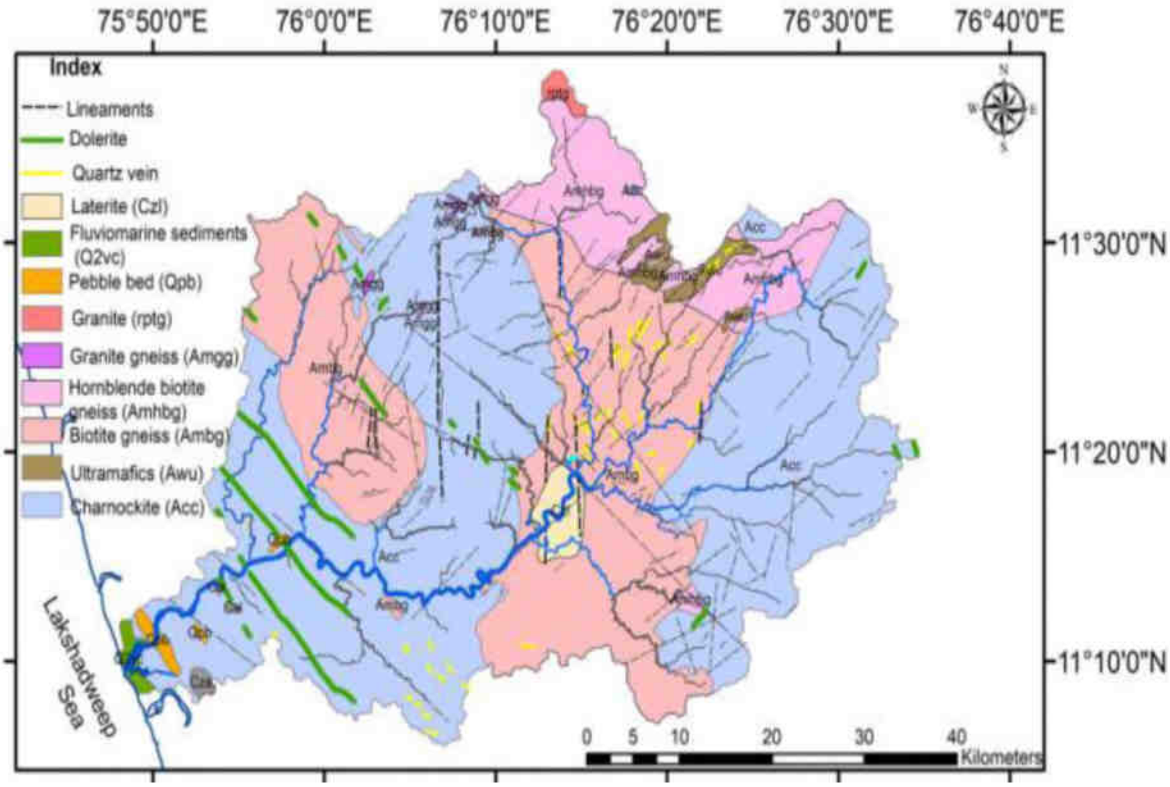


Fig. 9. Valanthode SHEP: Geological map of Chaliar basin (after Ambili et al., 2022)

Younger basic intrusive in Kerala, mainly represented by dyke swarms in NNW–SSE to NW–SE trend, cut across all the metamorphic rocks and the earlier structural trends. Their unmetamorphosed nature and stratigraphic relation with the country rocks prompted their correlation to the Deccan trap volcanism. The basic dykes have been emplaced into the migmatites and charnockite in NNW–SSE to NW–SE and ENE–WSW directions along distensional and shear fractures, respectively. Granites occur as later emplacements along crustal fractures and faults. The Achenkovil–Tamraparni tectonic zone, the Attapadi shear zone, Bavali shear zone and the Moyar shear zone are all marked by granitic emplacements. Some of them are located at Ambalavayal, Kalpetta, Pariyaram, Munnar, Chengannur and Angadimogar. Pegmatite veins occur throughout the terrain and are mineralogically classified as simple and complex based on mineralisation (Soman, 2002). The Tertiary sedimentary formations lie unconformably over the Precambrian rocks. Mio-Pliocene sedimentary rocks are fairly widespread in the southern coastal belt, their remnants being noticeable in the central and northern coastal areas. This change in the dynamic equilibrium of the river may have far reaching consequences and may lead to excessive deposition in upstream and erosion in downstream. Hence, detailed geomorphological investigation of catchment, reservoir and dam site area is being carried out (Fig. 10).

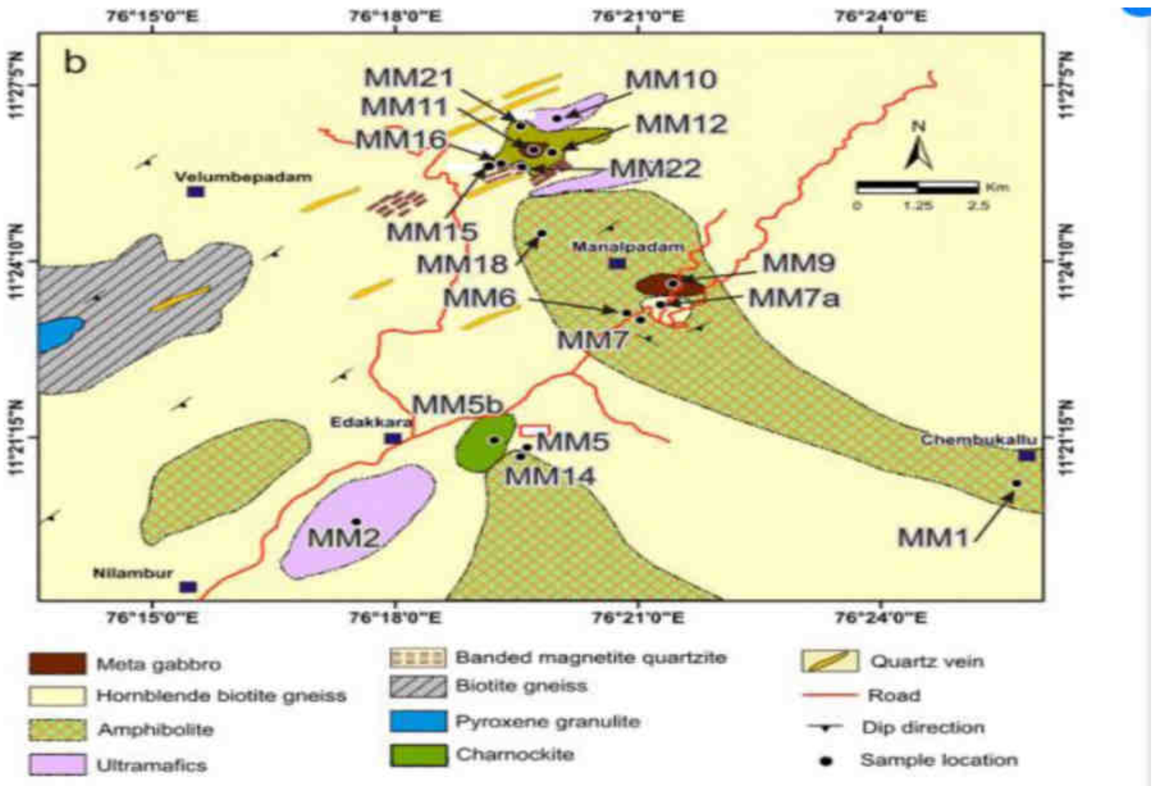


Fig. 10. Valanthode SHEP: Geological map of Malappuram district (after Geological Survey of India, 2005).

6.7.3. Local Geology

The geological frame work of the local area can be generalised as a Precambrian basement and a secondary cover above the crystalline. Detailed description of the basement and the laterite above are given in description of the Project site (Section 6.7.3.1).

Local Geological framework and rock assemblies are studied in the project area. The general Geological frame work discussed in Section 6.7.2 and depicted in Geological maps (Figs. 9 and 10) are true here as well. The dominant rock types in the area are foliated hornblende biotite gneiss, amphibolites (occurring both as massive exposures and as enclaves within the hornblende biotite gneiss), and massive charnockites. These gneisses are migmatitic at places. Rock types belonging to the Charnockite Group comprise the high hills on the eastern and western sides of the study area. Laterite capping, though of less thickness, is widespread throughout the area obscuring geological details in many places. Therefore, none of the geologic factors provide any inherent unsuitability for the project or structural instability for the weir.

i. **Top Secondary cover:** The topo-litho-sequence, coupled with variations in rainfall and temperature, alternating wet and dry conditions from the western coast to high ranges in the east, and swift-flowing rivers, contribute to diverse natural vegetation and soil types. Laterite, hill, and forest soils cover the area extensively, with lateralization prevalent in some areas, reaching thicknesses exceeding 10 meters. Hill soils typically occur at elevations over 80 meters above mean sea level (MSL). These soils generally exhibit a texture ranging from loam to clay loam, with gravel content averaging between 10% and 50%. Additionally, subsoils contain boulders, contributing to the reddish-brown to yellowish-reddish-brown colouration. Forest soils derive from Archaean-age crystalline rocks and exhibit an immature profile due to slow weathering processes.
ii. **Crystalline Basement Rocks:** Geologically the Chaliyar river basin is characterized by charnockites, metapelites, schists, gneisses and quartz reefs of Pre-Cambrian age (Hariharan, 2001; Ambili, 2010). Details are similar to the descriptions in section 6.7.2. Futher characterisation is done in following sections from 6.7.3.1 to 6.7.4.

6.7.3.1. Geology of the Project Site

Detailed Geological framework of the different parts and rock assemblies of the project area are detailed here. The crystalline overlaid by secondary rocks form the general scheme of lithological assembly. While considering the Secondary, (or sedimentary) assembly not much of importance is given to Sedimentary unit as these units are not involved in construction and that will be removable as overburden. The next consideration is materials forming part of the silt, material getting erosion, mass for the land slide etc.

i. **Secondary cover over basement Rocks**

By the tropical weathering of crystalline rocks occur as residual formation, capping over the older rocks. laterites of Pleistocene age and alluvial formations of Recent to sub-Recent age. Laterites are found as both primary (in situ) as well as secondary (transported) material. They are exposed as irregular patches with varying thickness from one geomorphic unit to the other. The recent alluvial formation includes coastal sand, river alluvium and valley fill. These are composed of fine to medium grained sand. The weathering abutment grade varies from W0 to WI in the river bed, and it is W-III to W-IV over the steep slopes of the right

ii. **Basement Lithology**

The subsurface investigation identified various rock types namely, charnockite, hornblende biotite gneiss, granite gneiss and pyroxene granulite. The rock type exposed at the western end of the weir site is charnockite, within granite gneiss, classified as migmatite with ptygmatic fold patterns (Fig. 11 to 15). The general gneissosity / foliation is trending N 40° E - S 40°W with a steep dip towards the northeast.

Fig. 11. Valanthode SHEP: Charnockite getting Migmatised

Fig. 12. Valanthode SHEP: Jointed contact between Charnockite and Migmatite

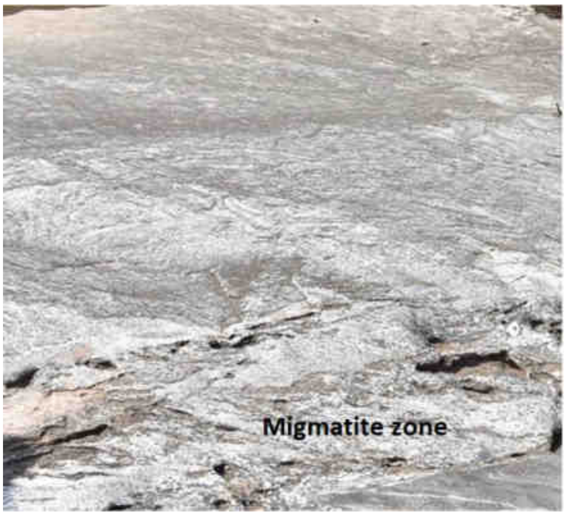


Fig. 13. Valanthode SHEP: Migmatite gneiss assembly

Fig. 14. Valanthode SHEP: Ptygmatic folds

Fig. 15. Valanthode SHEP: Ptygmatic folds seen in the migmatited gneiss in the eastern section of weir axis.

6.7.3.2. Geological structures

The structures seen in the basement rocks can be grouped as primary and secondary structures. Primary structural planes are, colour bands as seen in the metasedimentary assemblage (S0 planes), as contact planes (S0), bands, planes and structures due to migmatisation etc. As these planes do not have any relevance on stability or structure of the weir or construction of a small weir not much importance.

Secondary structures include Foliations (S1), joints etc. No faults of any size are seen in the area. No shear structures too are seen in the area. These are describes along with the lithological description of individual areas.

a. **Joint planes:** Joint planes are exposed in crystalline rocks of the area. They are oriented is different directions and are spaced in different locations. One good thing noticed is that there are no gap between the joint planes that allow filtration of water. Since water does not fill them, the stress is not transmitted through. The joint planes do not show any sign of shearing or weathering (Fig. 16).

Fig. 16. Valanthode SHEP: Joint planes exposed in Riverbed at the weir axis.

b. **Migmatite Structures:** There are two types of Migmatitic structures such as the one earlier grey migmatite structures (Fig. 17) and later pink granitic migmatite structure.

Fig. 17. Valanthode SHEP: Two sets of Joint planes in dam axis

6.7.4. Basement Lithology

a. **Charnockites:** Charnockites dominate the study area, comprising most of the geological formations. Charnockite is a granulite facies rock characterized by index minerals like orthopyroxene and K-feldspar. They are defined by orthopyroxene-bearing anhydrous rocks of metamorphic and magmatic origin. (Frost and Frost, 2008). The rock shows a typical granulitic texture. These massive rocks are exposed over the hills in localities around the study area. The charnockites present in the region typically display a dark grayish-green colour and range from medium to coarse-grained. The rock primarily comprises orthopyroxene, hornblende, plagioclase, quartz, and feldspar and exhibits a granulitic texture characterized by medium to coarse-grained plagioclase and pyroxenes. (Fig. 18 and 19)

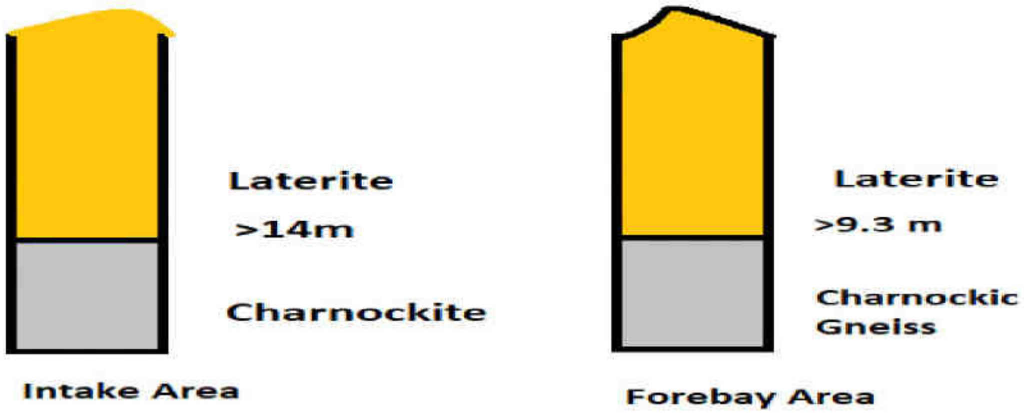


Fig. 18. Valanthode SHEP: Lithological configuration of Charnockite Areas

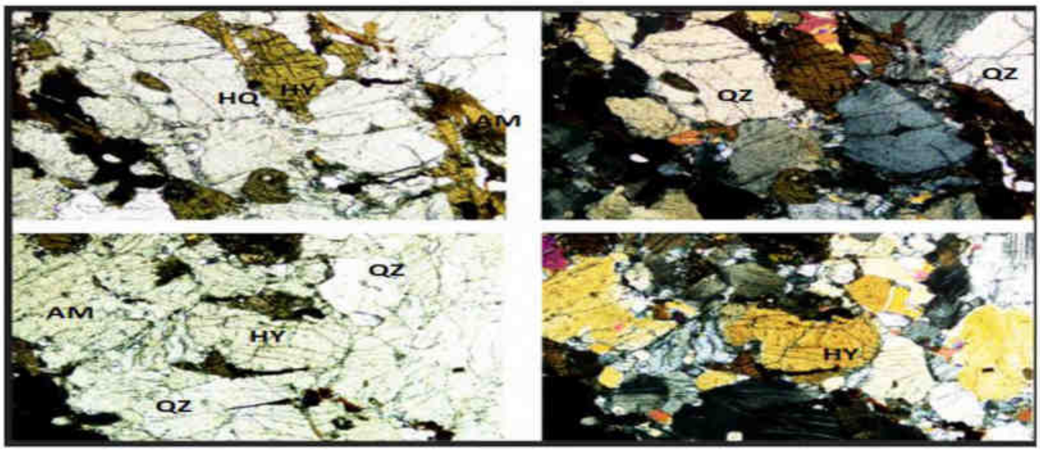


Fig. 19. Valanthode SHEP: Charnockite under microscope; QZ- Quartz, HY- Hypersthene, AM- Amphibole.

Megascopically quartz grains are identified by their fresh appearance, vitreous lustre, conchoidal fracture, and absence of cleavage, and they are bluish-green. Pyroxenes are determined by their sub-vitreous lustre, dark colour and two sets of prismatic cleavage. Hornblende is identified as grey to black colour, prismatic nature and subconchoidal fracture. Plagioclase is green to light grey, having prismatic cleavage and hardness. They can be found as boulders along road cuttings and in active quarries. Some areas exhibit well-defined gneissic foliation within the rock.

Microscopically, quartz is identified by its low relief, first-order grey interference colour and wavy extinction. Pyroxenes are identified by their high relief, strong pleochroism, high-order interference colours and predominant cleavages. Plagioclase has low relief and lamellar twinning was observed. Hornblende has well-developed two-directional cleavages, high relief, pleochroism in shades of yellow-green, and inclined extinction.

b. **Hornblende-biotite gneiss:** Hornblende-biotite gneiss (TTG) represents the most prevalent rock type within the study area. Hornblende biotite gneiss is a variety of gneiss in which the mineral grains are arranged in a preferred orientation in the direction of foliation. It is a holocrystalline rock with a gneissic texture. The rock features alternating bands of dark-coloured domains, primarily amphibole and biotite, and light-coloured quartzo-feldspathic domains, exhibiting distinct gneissosity. This medium to coarse-grained rock consists mainly of plagioclase and amphiboles, alongside K-feldspar, quartz, biotite, and opaque minerals (Fig. 14). The TTG gneisses demonstrate well-defined banding and foliation, with gneissosity evident in some sections through the alignment of hornblende/biotite grains (Fig.20 & 22 A).

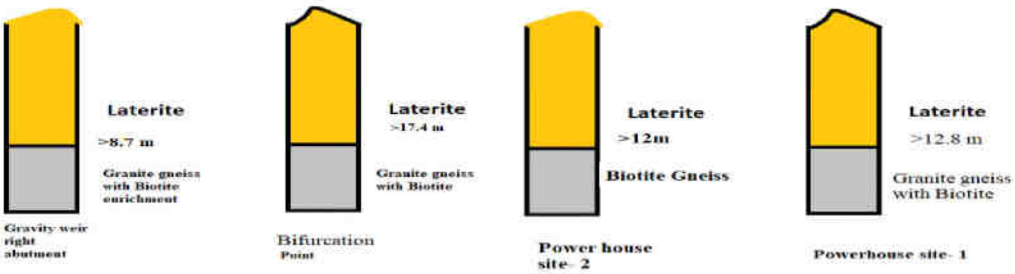


Fig. 20. Valanthode SHEP: Lithological configuration of Biotite gneiss Areas

Quartz grains are identified in thin sections by their wavy extinction. Plagioclase is identified by its low relief, first-order grey interference colour and polysynthetic twinning. Biotite is distinguished by its brown-to-yellow pleochroism, basal cleavage, good relief and parallel extinction. Megascopically, quartz is identified by its vitreous lustre, white colour, conchoidal fracture. Feldspar is determined by its subvitreous lustre and grey colour. Biotite is identified by its flaky nature and pearly lustre.

c. **Granite/granite gneiss:** Another common rock type in this terrain is reddish-grey coloured Granite/Granite Gneiss. Gneisses are laminated rocks of the mineralogical composition of granite. The gneissic fabric reflects the predominance of quartz and feldspars and a general lack of micaceous minerals. Granitic rocks are considered a part of the peninsular gneiss, which are foliated. The rock is medium to coarse-grained and greyish white, pinkish white, or pink. Parallel arrangement of quartz and biotite flakes define a distinct foliation in the granitic rocks. Megascopically, quartz is identified by its vitreous lustre and conchoidal fracture. Feldspar is determined by its subvitreous lustre and colour. Biotite is identified by its flaky nature and pearly lustre. Large K-feldspar augens and pegmatitic veins are common in this granitic rock. The nature of the granite-gneiss varies laterally as well as with depth. The rock is jointed, and the banding between the light and dark minerals is distinctive in gneisses (Fig. 21 & 22 B).

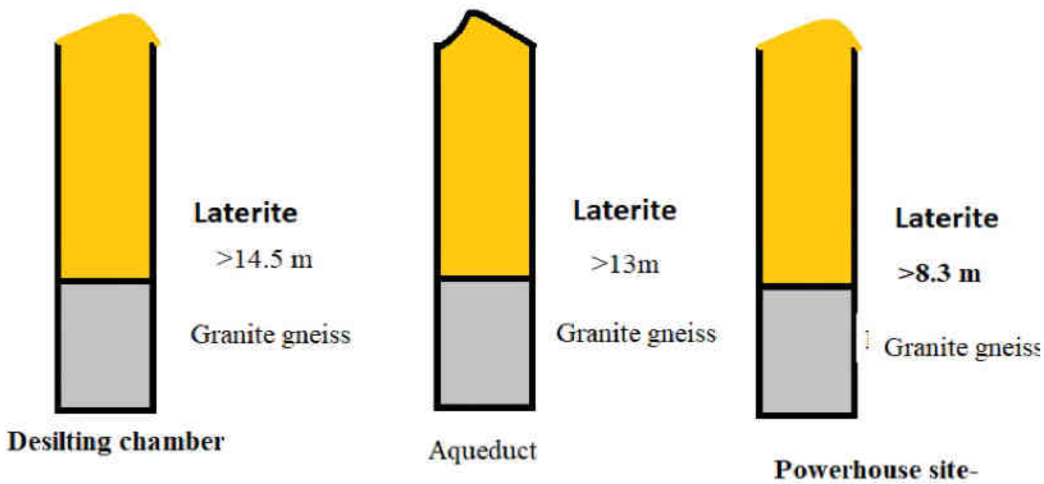


Fig. 21. Valanthode SHEP: Lithological configuration of Granitic gneiss Areas

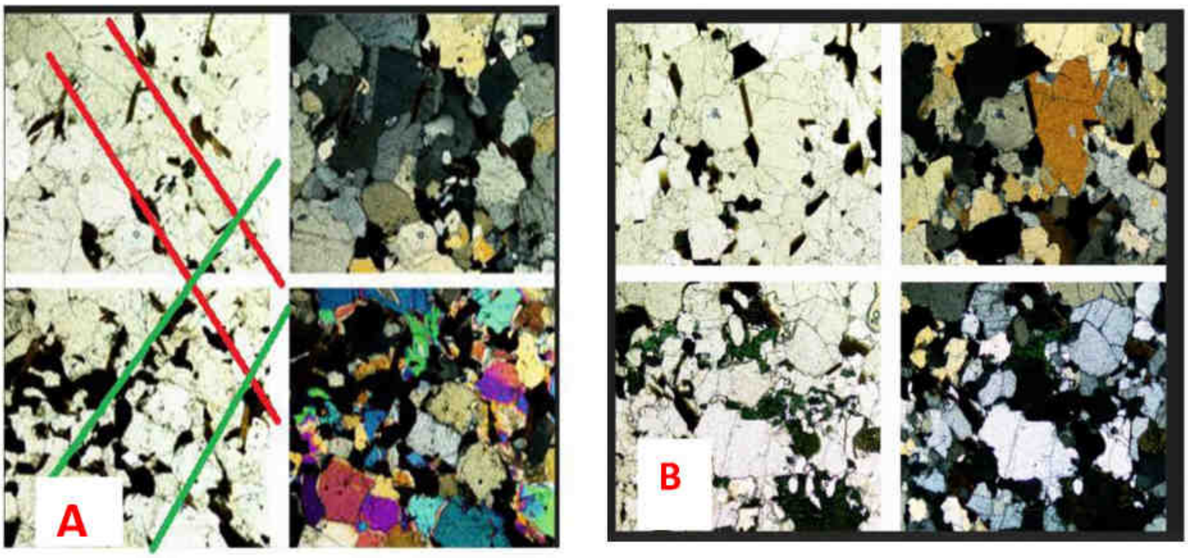


Fig. 22. Valanthode SHEP: A- Biotite gneiss showing 2 foliation direction, B- Granitic gneiss

6.7.4.1. Subsurface Information Based on Lithosections

The assessment of subsurface geology at the Valanthode Small H.E.P (Hydroelectric Power) powerhouse site involves the generation of twelve litho sections by the Geological Survey of India (GSI) for comprehensive geotechnical evaluation. These litho sections serve as crucial tools for understanding the geological composition and structure beneath the site. Reports from the GSI highlight that the prevailing gneissosity in the area trends in the direction of N50°E to S 40° W, exhibiting a steep dip towards the east. This observation stems from the analysis of raw data gathered from twelve boreholes conducted during the initial subsurface investigations at the Valanthode Small H.E.P powerhouse.

The dominant basement rock in this region is charnockite, forming the foundational geological framework upon which subsequent formations rest. However, this charnockite is intersected by other rock types, such as hornblende biotite gneiss and granite gneiss, indicating a complex geological history with multiple phases of metamorphism and intrusion. The bore logs compiled by the GSI reveal satisfactory core recovery rates overall, with most values falling within the good, fair and excellent range according to the Rock Quality Designation (RQD) assessment. Nevertheless, some drilled depths exhibit poor RQD values due to inadequate core recovery in those areas.

Individual observations from the boreholes drilled at the powerhouse site provide detailed insights into the geological characteristics encountered during the subsurface investigations. These observations are critical data points for assessing the site's geological stability and suitability for the hydroelectric powerhouse's construction and operation.

6.7.4.2. Lithological Descriptions from Bore Holes of Valanthode Small H.E.P powerhouse

A more detailed description of various strata encountered at the bored locations (12 boreholes of the first phase) is given in the following sections. The lithology is broadly classified into three strata. Stratum I, represents the overburden, unconsolidated sediments, laterite, soils, etc. Overburden refers to the unconsolidated material, such as soil and loose rock, that overlies bedrock. Lateritic soils are typically formed in tropical and subtropical regions by the weathering of underlying rocks. They often exhibit a reddish-brown colour due to the presence of iron oxides. Stratum II and Stratum III represent the hard rock underlying Stratum I. RQD is a measure of the rock mass quality obtained from core samples, with higher values indicating better rock integrity and lower degrees of fracturing (Table-39).

Table- 39. Valanthode SHEP: Sub-surface data through boreholes

BH1 Location : Intake

Stratum	Depth to top (m)	Thickness (m)	Lithology
I		4.00	lateritic soil
II	14.00	10.00	transitions from lateritic soil to charnockite
III	15.60	1.5	hornblende biotite gneiss.

BH2 Location Gravity weir axis

Stratum	Depth to top (m)	Thickness (m)	Lithology
I		5.50	lateritic soil
II	14.00	10.00	granite gneiss
III	15.60		hornblende biotite gneiss.

BH3 Location Gravity weir

Stratum	Depth to top (m)	Thickness (m)	Lithology
I		8.70	lateritic soil
II	8.70	10.00	granite gneiss
III	20.20		biotite gneiss.

BH4 Location Desilting chamber

Stratum	Depth to top (m)	Thickness (m)	Lithology
I		5.50	lateritic soil
II	14.50	26.6	charnockite gneiss

BH5 Location Aquaduct

Stratum	Depth to top (m)	Thickness (m)	Lithology
I		14.5	lateritic soil
II	14.50	20.78	granite gneiss

BH6 Location Forebay

Stratum	Depth to top (m)	Thickness (m)	Lithology
I		9.30	lateritic soil
II	9.30	10.10	charnockite gneiss

BH9 Location Bifurcation point

Stratum	Depth to top (m)	Thickness (m)	Lithology
I		17.40	lateritic soil
II	17.40	12.5	Weathered Biotite gness

BH10 Location Power house 2

Stratum	Depth to top (m)	Thickness (m)	Lithology
I		12.0	lateritic soil
II	12.0	10.5	Biotite gness

BH11 Location Power house 3

Stratum	Depth to top (m)	Thickness (m)	Lithology
I		12.85	lateritic soil
II	12.85	10.70	Granite gness

BH12 Location Power house 1

Stratum	Depth to top (m)	Thickness (m)	Lithology
I		8.30	lateritic soil
II	8.30	10.73	Granite gness

6.7.5. Geology of the different components of the Project

i. **Intake Area:** Top cover is laterite more than 4 m thickness followed by weathered charnockite boulders for about 10m. Below the Weathered Charnockite zone, Biotite gneiss are seen more crystalline than the overlying rock mass.

ii. **Gravity weir axis:** Top cover is laterite more than 5.5 m thickness followed by weathered charnockite boulders for about 10m. Below the Weathered Charnockite zone, Biotite gneiss are seen more crystalline than the overlying rock mass. Foliation directions are

The prominent joints observed at the weir site are

- N —S, dipping 30° towards East
- N 70°W — S 70° E, dipping 80° towards S 70° W
- N 70° E — S 70° W, dipping 85° towards N 70° W

The boreholes enter the bedrock stratum at a depth of 5.50 and 8.70 meters. The lithology observed here consists of granite gneiss with varying pyroxene granulite and charnockite. The rock is moderately weathered up to a depth of 6 meters, indicating some degree of decomposition and alteration due to weathering processes. In borehole 3, mafic-enriched zone observed from 14.48 to 16.80 meters. Mafic minerals like amphibole and pyroxene are typically darker and have higher densities than felsic minerals like quartz and feldspar (Fig. 23).

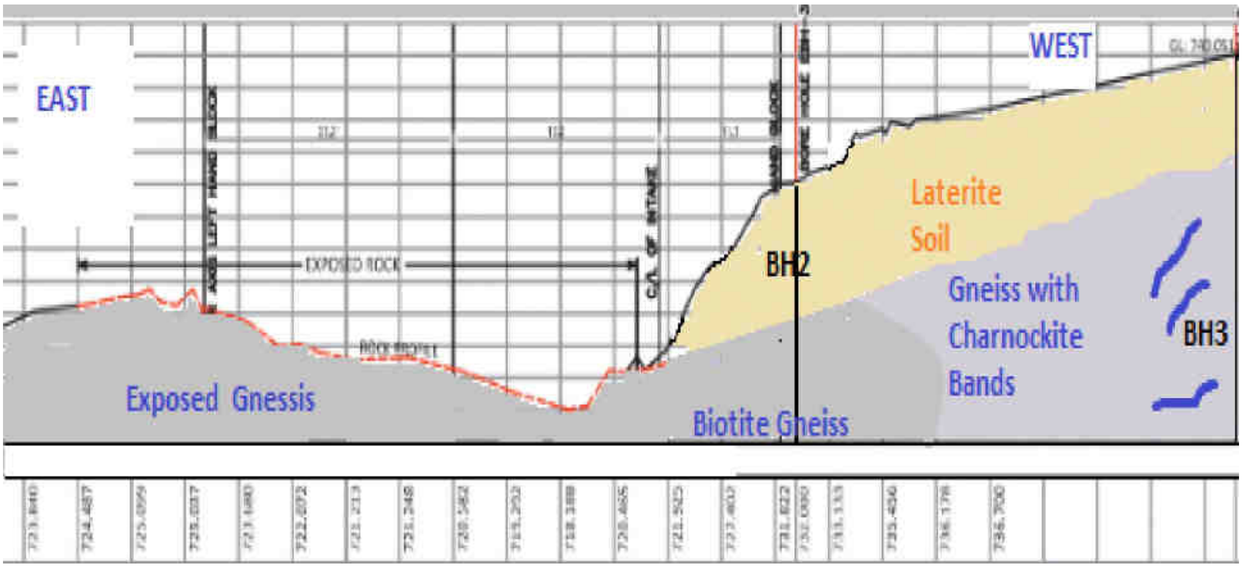


Fig. 23. Valanthode SHEP: Lithological cross section along the weir axis modified after GSI

iii. **Desilting chamber:** Top cover is laterite more than 5.5 m thickness followed by weathered charnockite gneiss. At a depth of 14.50 meters (borehole 4) the borehole reaches the bedrock stratum. The lithology observed here is charnockite gneiss. Joints are observed in the core.

iv. **Aqueduct:** Top cover is laterite more than 14.5 m (borehole 5) thickness followed by fine grained granite. Joints are sub-horizontal, suggesting that the fractures are roughly parallel to the ground surface. The rock here is slightly weathered, indicating some degree of decomposition and alteration due to weathering processes.

v. **Fore bay:** Top cover is laterite more than 9.30 m (borehole 6). At a depth of 9.30 meters, the borehole reaches the bedrock stratum. The lithology observed here is charnockite gneiss. Foliations are sub-horizontal, suggesting that the foliation planes are roughly parallel to the ground surface. The rock here is slightly weathered, indicating the degree of decomposition and alteration due to weathering processes.

vi. **Bifurcation point:** Top cover is laterite more than 17.40 m (borehole 9). The lithology observed here is moderately weathered biotite gneiss.

vii. **Power house:** Three boreholes were sunk to get the real situation. Bore hole 10 showed an overburden of 12.0 meters. Borehole 11 showed 12.85m. Borehole 12 showed 8.30 m. The bed rock is mainly granitic gneiss and changes to biotite gneiss. Joints and foliations are present. However, the foliations found are not well-developed and hence it will not create any stability issue.

viii. **Penstock:** There are no *insitu* outcrops. Drilling attempt did not give any considerable result in boreholes.

6.7.6. Regional Geomorphology

The Kerala is a unique physiographic province of 600 km long in NNW-SSE and 35–120 km wide in ENE-WSW directions. The physiography is marked with Western Ghat mountains occurring at 800 m a.s.l. in the eastern fringe forming and the eastern boundary of the state. The other geomorphic features, namely the slopes, the lateritic uplands and the coastal plains, occur sequentially and in parallelism to the west of the Western Ghats with gradual descending elevations (Nair, 1987; Ramasamy et al., 2019). For example, the slope that rims the western part of the Western Ghat mountains occurs at 800 to 40 m a.s.l., followed by the marginally raised lateritic uplands at the elevation of 40–20 m a.s.l. along the western slope. While the highly folded and the fractured/faulted Western Ghat Mountains are made up of hard crystalline rocks of Archaean age, the marginally raised lateritic uplands/red soils are the leached-out products of the underlying Charnockites. In contrast, the coastal plains are marked by clays, silts and sands of Quaternary pe most coastal plains, that forms the western part and the boundary of the state, at the elevation of 20–0 m a.s.l. (Ramasamy et al., 2021; Fig. 24).

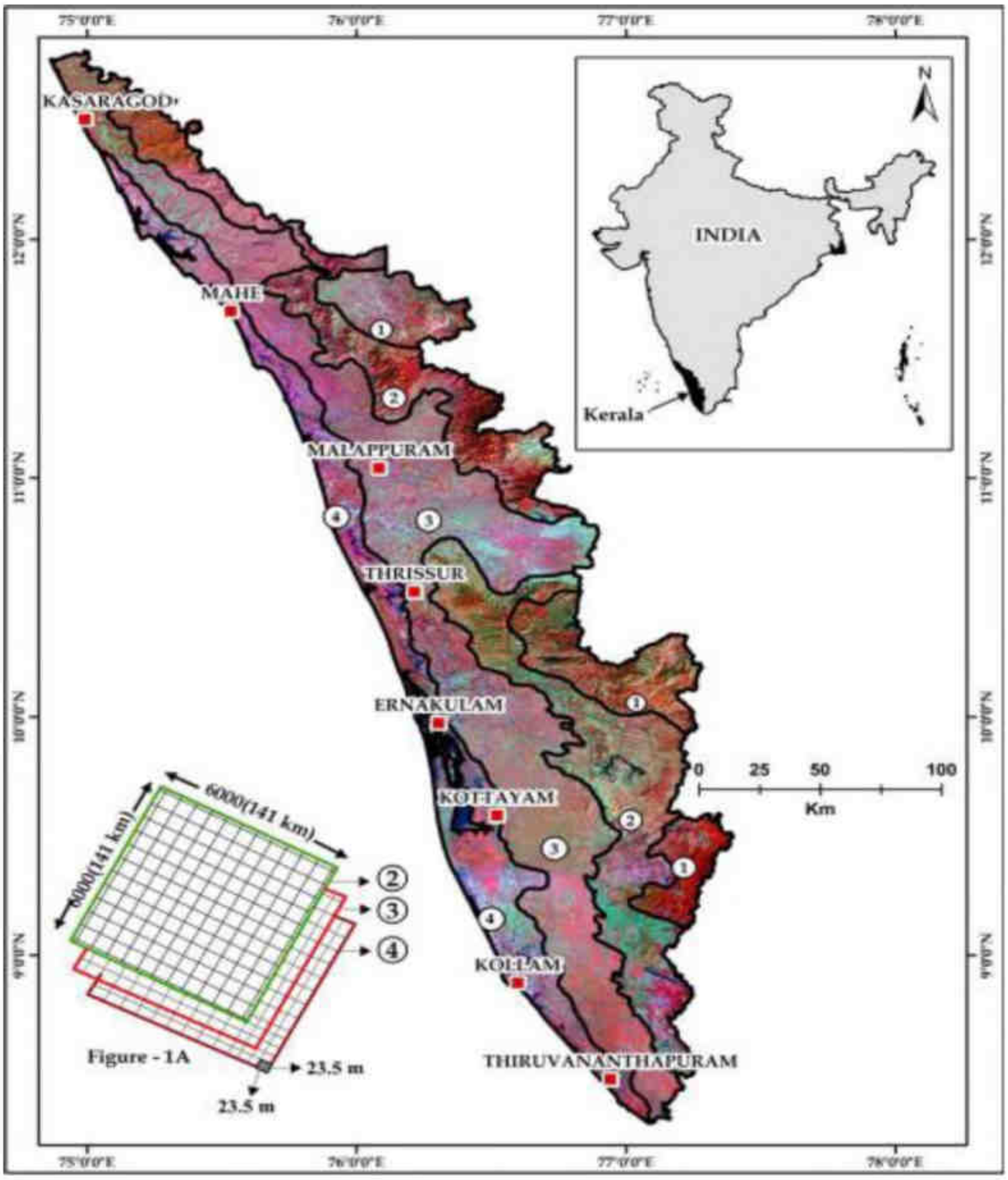


Fig. 24. Valanthode SHEP: Geomorphology of Kerala. (1) Plateaus and escarpments, (2) composite slope and structural valleys, (3) marginally raised Lateritic uplands and (4) coastal plains (Ramasamy et al., 2021)

6.7.7. The River System

River system analyzed in basin and sub-basin level on Geomorhic, drainage pattern, lineament and water availability (Section 3.3), flood (3.3.2) from regional to sub-basin level (3.2.1). None of the hydrological factors provide any inherent unsuitability for the project or structural instability for the weir.

Kerala has got 41 west-flowing and 3 east-flowing rivers and all of them are originating from the Western Ghats. The total annual yield of all these rivers together is 78 billion Cubic

Meters (Water Resources of Kerala, 1974). The peculiarity of the rivers flowing across Kerala is short length of the river and the elevation difference between the high and the low land leading to quick flow of water collected from the river basin and quickly discharged into the Arabian sea.

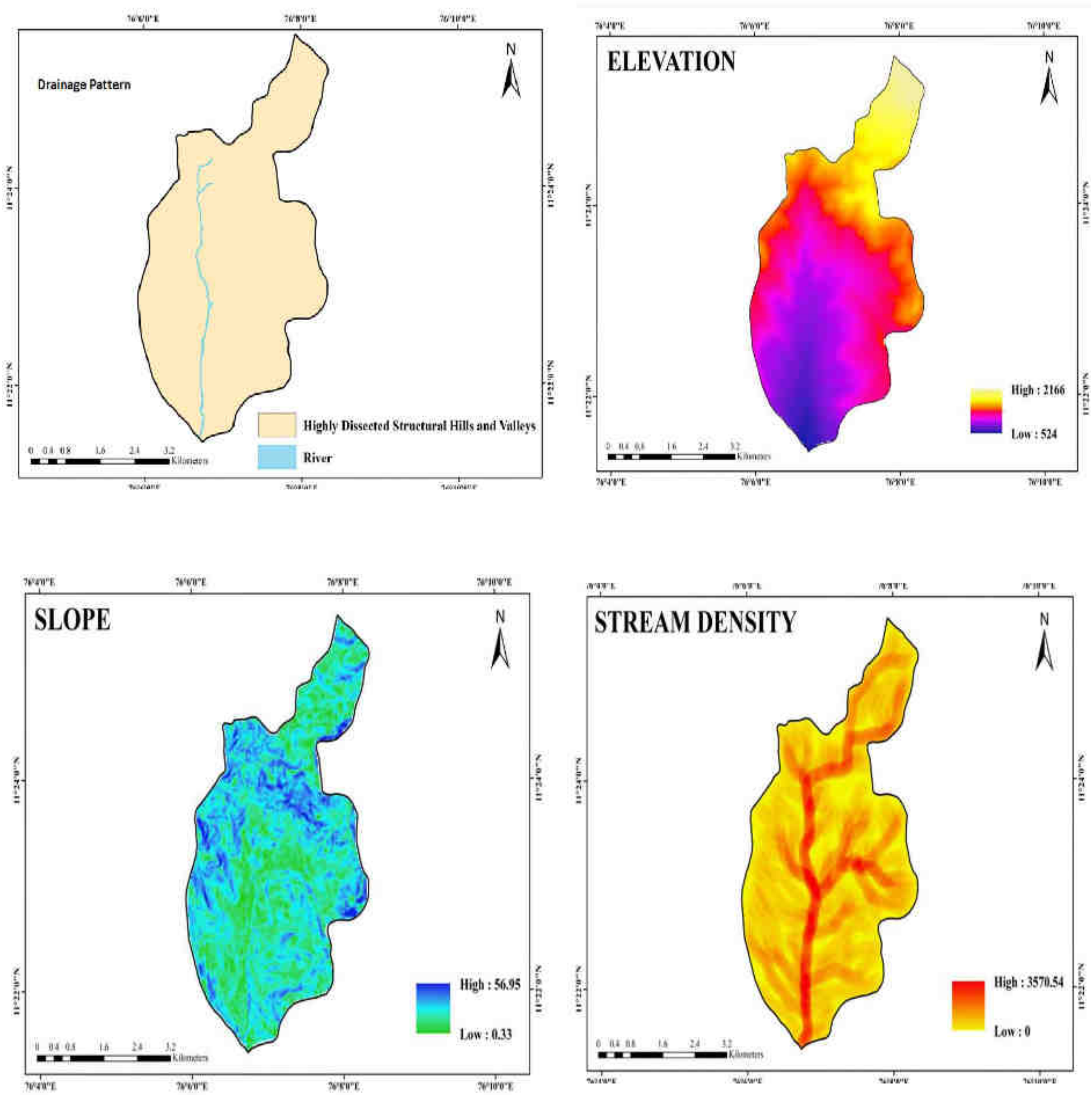
The major drainage system in the area consists of the Chaliyar river and its tributaries, originating mainly from the Nilgiri and Wayanad hills, forming rapids and waterfalls. The valley's physiography can be broadly divided into hills, hill slopes, and rolling plains with low mounds. The hills exhibit narrow crests and steep slopes covered with thick vegetation, while the plains have a rolling topography with laterite or alluvium and occasional rock outcrops. With an average elevation of 60.96 m (200') above mean sea level, the valley is primarily drained by the Chaliyar River, which flows southward before changing course southwest and westward, exhibiting meandering patterns in the plains.

Several rivers and streams crisscross Nilambur, originating from the Western Ghats. The Chaliyar river, a significant river in Kerala, supports biodiversity and provides water for irrigation. The proposed scheme lies in Kurumanpuzha, a tributary of the Chaliyar river, originating from Kolapattymala, Kurathimala, flowing southward and then eastward before joining the Chaliyar river at Vadapuram, approximately 3 km from Nilambur. The riverbed and adjacent areas exhibit exposed rock formations, with frequent cascades and large boulders along the river course.

The soil composition in the region is primarily laterite, typical of tropical areas with high rainfall, significantly shaping the landscape of Nilambur and its surroundings. The region is renowned for teak plantations, altering the natural vegetation cover and hydrology. Alluvial plains along the banks of the Chaliyar river support agriculture and are formed by sediment deposition. Waterfalls, a common feature in the Western Ghats region, including Nilambur, contribute to its geomorphology through rock erosion by rivers and streams (Plate. 20).

Conservation efforts are crucial for maintaining the geomorphological diversity of Nilambur, which is shaped by its location, topography, river systems, soil composition, and human activities such as forestry and agriculture.

Plate- 20.Valanthode SHEP: Different themes of GIS imageries



6.7.7.1. Chaliar River System

Chaliyar river is the fourth longest river in Kerala at 169 km in length (Area 2923 Sq Km). The Chaliyar is also known as Chulika river, Nilambur river or Beypore river as it nears the sea. It mainly flows through Malappuram district. Its tributaries flow through both the districts of Malappuram and Kozhikode. It originates at Ilambaleri hills of Nilgiri Mountains in Nilgiris district (Ooty district). It flows mainly through the erstwhile region of Eranad (present-day Malappuram district), and finally empties into the Arabian Sea at Beypore port, opposite to Chaliyam harbour (Wikipedia, 2024).

Geomorphologically, the Chaliyar drainage basin includes parts of distinct provinces like the Wayanad plateau and the Nilgiri hills at higher altitude, the Nilambur valley forming the slopes of the foot hills and low lands adjoining the main trunk of the Chaliyar river. The lowest reaches of the Chaliyar main channel shows a sudden change in the geomorphology beyond 110 km from the source in the downstream direction. The channel takes a sharp bend at 110 km and beyond this the river shows meanders at consistent intervals. The main stream Chaliyar is a 7th order stream and the drainage network analysis shows that the pattern is dendritic combined with rectangular. The latter is the more characteristic for the area close to the confluence of Punnapuzha with Chaliyar river (Ambili, 2010).

The proposed scheme is in Kurumanpuzha as stated, a tributary of Chaliyar river, which originates in the high lands of Wyanad hills. The river is characterised with cascading water falls and mainly comprised of huge boulders and sheet rock and suitable for small hydroelectric scheme (Fig. 25).

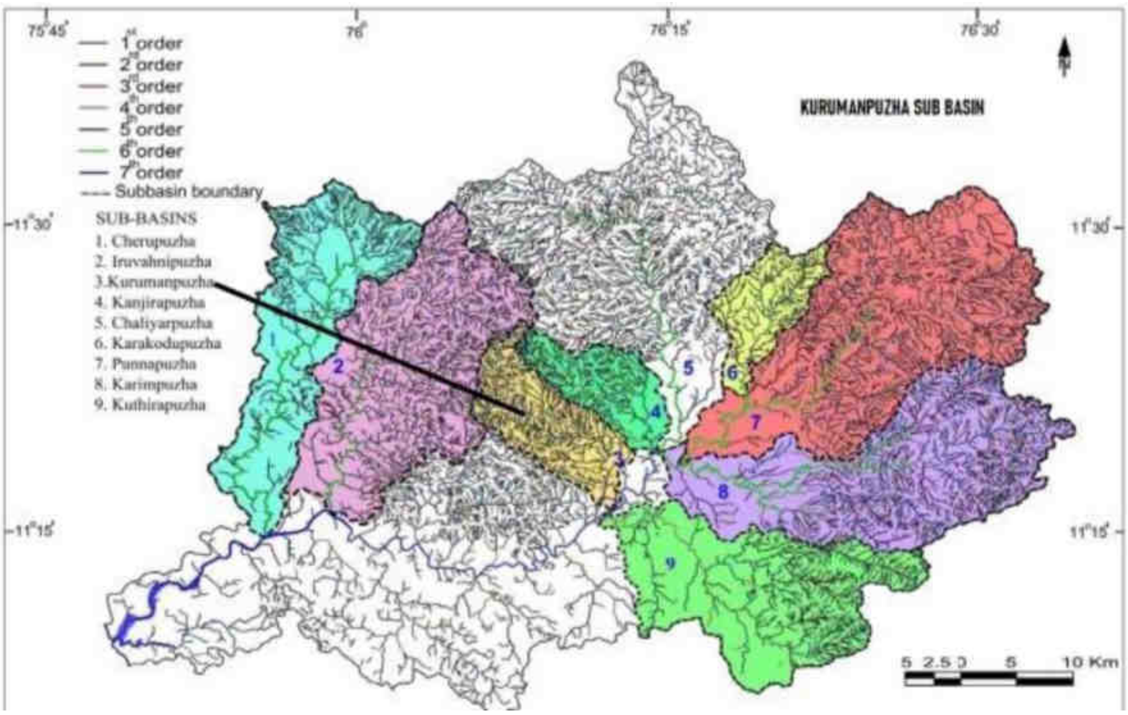


Fig. 25. Valanthode SHEP: Drainage pattern of the Sub-basin (Ambili, 2010)

6.7.8. Lineaments

Lineamental impacts on Geology and Geomorphology are examined in relation with Earthquake and Reservoir Induced Seismicity. A lineament is a linear feature in a landscape which is an expression of an underlying geological structure such as a fault. Typically, a lineament will appear as a fault-aligned valley, a series of fault or fold-aligned hills, a straight coastline or indeed a combination of these features. Fracture zones, shear zones and igneous intrusions such as dykes can also be expressed as geomorphic lineaments.

Lineaments are often apparent in geological or topographic maps and can appear obvious on aerial or satellite photographs. The term 'megalineament' has been used to describe such features on a continental scale. Lineaments are associated with Landslides and Earthquakes (Table-40; Fig. 26 and 27).

Table- 40. Valanthode SHEP: List of major lineaments and number of Earthquakes associated with each lineament (Ganesh Raj et al., 2013)

Sl.no.	Name of the Lineament	Length	Direction	No. of EQ occurrences
1	Kasaragod – Muliyaru	30 km	N 80^0E	
2	Cheruvattur	25 km	N 25^0w	
3	Kuppam	35 km	N 60^0E	
4	Talipparamba	30 km	N 35^0E	
5	Bavali (F)	70 km	N 60^0W	
6	Poliyur – Kuttiyadi (F)	25 km	N 42^0W	
7	Kinalur – Kulattur	60 km	N 20^0W	2
8	Baypore	30 km	N 60^0E	
9	Baypore – Malampuzha	75 km	N 65^0W	
10	Vadakumbaram – Perintalmana	25 km	N 80^0W	
11	Kanhirapuzha	40 km	N 75^0E	
12	Kunda hills – Mannarakat	25 km	N 10^0W	
13	Mannarkat	20 km	N 30^0E	
14	Palaiyur – Attapadi (F)	30 km	N 8^0W	
15	Bharathapuzha	80 km	E – W	
16	Kerala (F)	140 km	N 30^0W	3
17	Kuriarkutti	30 km	N 38^0W	

18	Periyar (F)	95 km	N 52^0W	1
19	Anakulam – Kizhillam	35 km	N 82^0E	
20	Kumarkutti	40 km	N 80^0E	
21	Padagiri – Periyar	33 km	N 5^0 E	
22	Maraiyur (F)	25 km	N 35^0W	
23	Nedumkandam – Kandalur (F)	50 km	N 25^0E	
24	Devikulam	40 km	N 10^0W	
25	Nedumkandam	30 km	N 50^0W	
26	Arakulam – Palliyakudi	45 km	N 70^0W	
27	Arakulam – Periyar	38 km	N 50^0W	
28	Pirmedu – Periyar	35 km	E – W	
29	Mundakayam – Thanikudi	50 km	E – W	
30	Pirmedu	38 km	N 27^0W	1
31	Chavakad – Vaikam	95 km	N 30^0W	2
32	Kandanadu – Kanjikozhi	35 km	N – S	
33	Ambalapuzha – Ariyur	40 km	E – W	
34	Achankovil (F)	50 km	N 60^0W	
35	Punalur	50 km	N 52^0E	1
36	Kulathupuzha	45 km	N 20^0E	3
37	Kallada (F)	58 km	N 52^0W	
38	Churanadu – Edathora	33 km	N 85^0W	
39	Adur - Tadikad	40 km	N 30^0W	
40	Pulimathu – Attingal	25 km	N 42^0W	1
41	Shornur	55 km	N55^0 W	1

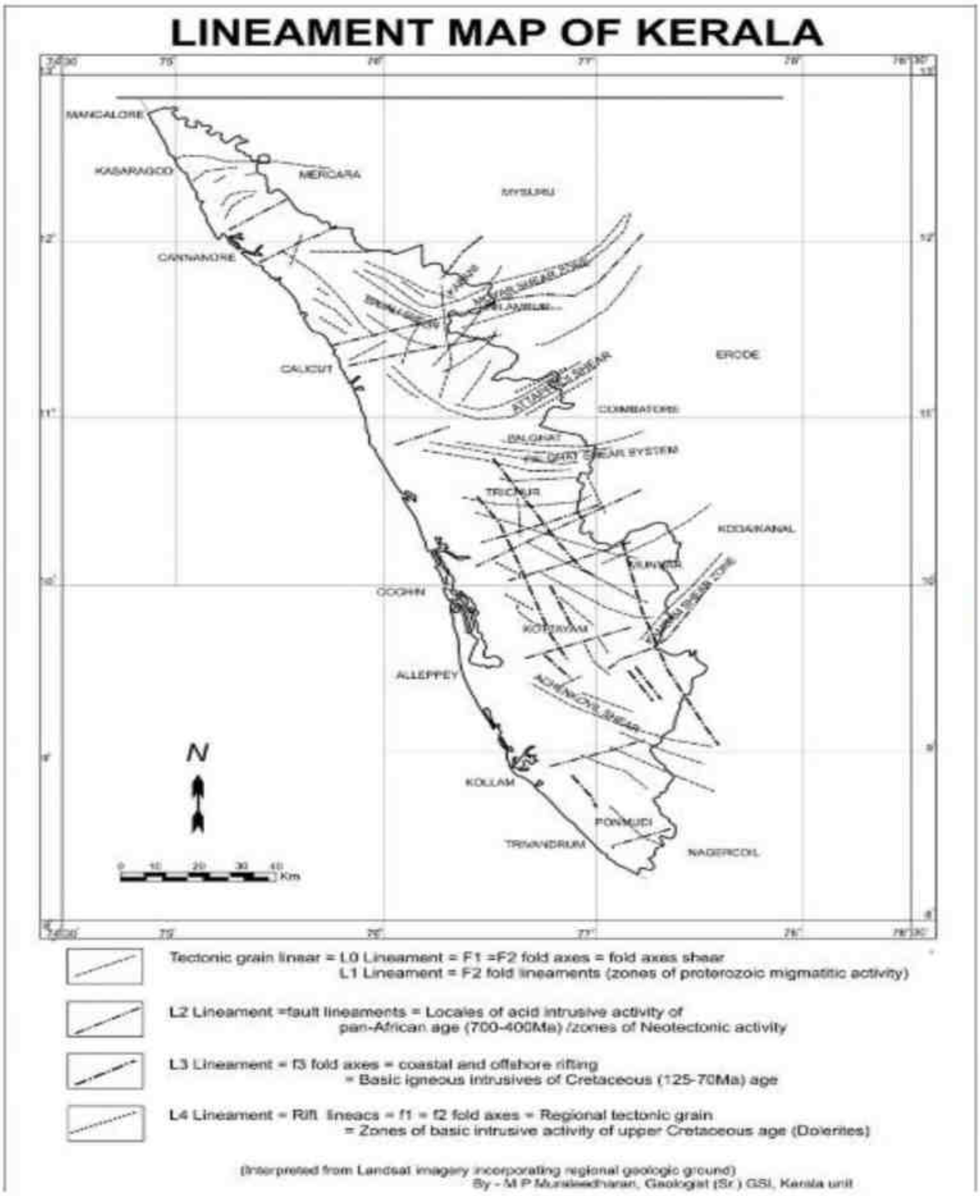


Fig. 26. Valanthode SHEP: Lineaments of Kerala (Ganesh Raj et al., 2013)

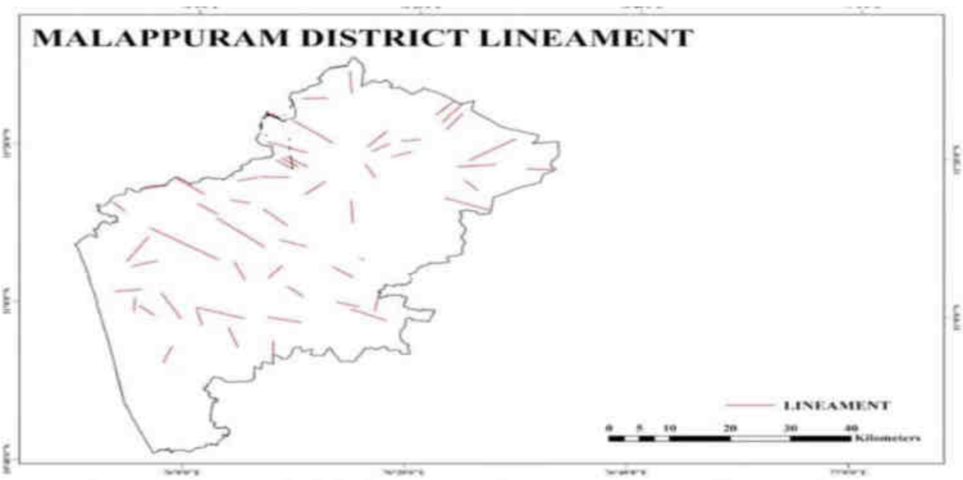


Fig. 27. Valanthode SHEP: Lineament map of Malapuram district

6.7.9. Seismic Events

The seismic hazard map of India was updated in 2000 by the Bureau of Indian Standards (BIS). There are not major changes in the map with respect to Kerala. All districts in the state lie in Zone III. The maximum intensity expected in these areas would be around MSK VII. It must be noted that BIS estimates the hazard, based in part, on previous known earthquakes. Similarly, all of the Lakshadweep Island also lie in Zone III. Since the earthquake database in India is still incomplete, especially with regards to earthquakes prior to the historical period (before 1800 A.D.), these zones offer a rough guide of the earthquake hazard in any particular region and need to be regularly updated. As per the map, the country is divided into four seismic hazard zones, i.e., low hazard (zone II) to very high hazard (zone V) (Fig. 28).

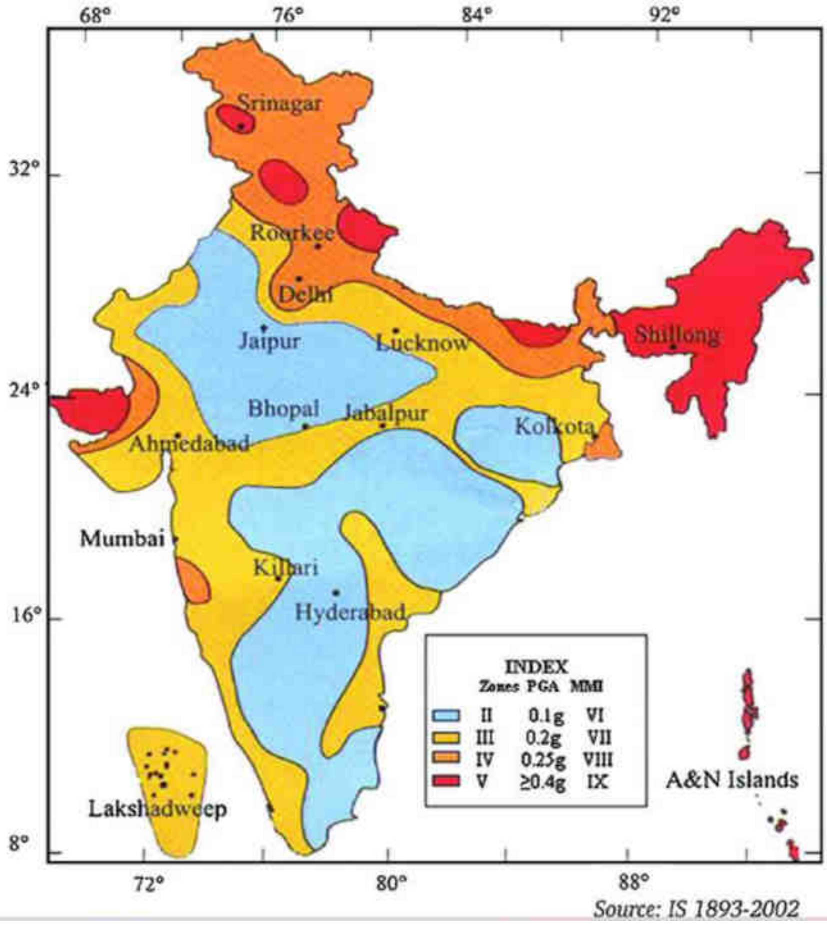


Fig. 28. Valanthode SHEP: Seismic zonation map of India, by Bureau of Indian Standards (IS-2002). As per the map, the country is divided into four seismic hazard zones, i.e., low hazard (zone II) to very high hazard (zone V).

6.7.9.1. Earthquake History:

Seismic activity in the recent past has occurred in clusters under zone III along the border with Tamil Nadu, primarily in the districts of Idukki and Palakkad. A number of faults have been identified in Kerala out of which a few, like the Periyar Fault are active. However, it must be stated that proximity to faults does not necessarily translate into a higher hazard as compared to areas located further away, as damage from earthquakes depends on numerous factors such as subsurface geology as well as adherence to the building codes.

6.7.9.2. Significant Earthquakes in Kerala

Brief outlines of known earthquakes occurred in this region which either had observed intensities of **V or higher** (historical events) or had known magnitudes of **M 4.5 or more** (instrumented events). General locations are provided for historical events for which "generalized" epicentral co-ordinates are available. Some events which were significant for other reasons are also included. This list will be updated whenever newer information is available. Please note that Magnitude and Intensity are NOT THE SAME. All events are within the state or union territory covered on this page unless stated otherwise (Table- 41).

Table- 41. Valanthode SHEP: List of major Earthquakes incidents of the State-Red shaded area is the nearest occurrence (Ganesh Raj et al., 2013)

Year	Latitude	Longitude	Magnitude	Location
1821	9.5	76.6	3.7	Changanasserry
1823	9.5	76.6	5	Changanasserry
1823	9.5	76	4.3	Changanasserry
1841	9.5	76.6	3.7	Changanasserry
1849	9.5	76.6	4.3	Changanasserry
1856	8.7	77	4.3	Palod
1856	8.7	77	4.3	Palod
1856	9.5	76	4.3	Changanasserry
1858	11.4	76	4.3	Koduvalli
1858	11.4	76	5	Koduvalli
1901	12	75.5	5	Calicut
1953	9.9	76.3	5	Piravam
1953	9.6	76.5	5	Kottayam
1959	11.8	75.5	4	Tellicherry
1961	11.3	75.8	4	Calicut
1964	11.3	75.8	3.3	Calicut
1984	11.3	75.8	3	Calicut
1986	10.2	76.7	3	Idamalayar
1988	9.8	77.2	4.5	Nedumkandam

1988	9.8	77.2	4.1	Nedumkandam
1988	9.8	77.2	3.4	Nedumkandam
1988	8.7	76.9	3.6	Attingal
1989	10.6	76.3	3	Wadakancheri
1993	10.6	76	3.6	Chavakad
1993	10.6	76.2	3.6	Wadakancheri
1993	9	76.9	3.6	Punalur
1993	8.9	77	3.6	Punalur
1994	8.7	76.8	3.6	Attingal
1994	10.75	76.21	4.3	Wadakancheri
2000	9.7	76.73	4.9	Erattupetta
2001	9.7	76.8	4.8	Erattupetta

6.7.10. Reservoir Induced Seismicity (RIS)

Induced seismicity is typically earthquakes and tremors that are caused by human activity that alters the stresses and strains on Earth's crust. (Wikipedia, 2024) RIS is the incidence of earthquake triggered due to impoundment of water behind a dam. Many people believe that reservoirs trigger earth tremors due to load of water. However, the magnitude of forces associated with an earthquake is several orders bigger compared to the additional load of water in the reservoir. The change in stresses due to water load is too small to cause fracture in the earth's crust. Most induced seismicity is of a low magnitude. The RIS may be associated with some of the large dams and reservoirs, there is adequate evidence to demonstrate that some of the large dams have not shown RIS. In some areas, earthquakes have occurred after the reservoirs were created but there is no conclusive evidence that these were caused by the reservoirs. Yet, another view is that the water seeped from the dam provides a lubricant effect and triggers small quakes. In fact, this is a positive feature as it helps in release of energy in small shots which are less damaging than a big earthquake. While there is no complete agreement on this issue, a general belief is that earthquakes are caused by the filling of reservoir at sites where natural stresses in the underlying rock mass have developed to a state close to rupture (Mishra and Jain, 2022).

6.7.11. Preconstruction Geological Situation and Stability

Plan for the proposed dam axis is given below (Fig. 29). The axis is N80W- S80 E which is almost at right angles to the strike of dominant foliation and joint planes. Elongation of the ridge is in the same direction in a regional level. Towards East, the Geomechanical properties are conducive to build the weir. There are least weathered, though foliated no traces of planes of weakness. They are migmatised but do not show any anisomerism. However, for stability purposes, it will be excavated to level of +717m. Though the present conditions do not show necessarily the following concerns might pop up requiring treatment or mitigations.

i. Appearance of weathered zone before +717m Excavation
ii. Appearance of shear zone before +717m Excavation
iii. Appearance of jointed zone before +717m Excavation
iv. Appearance of weathered zone before +717m Excavation
v. Appearance of piping before +717m Excavation
vi. Appearance of piping in Reservoir Zone
vii. Appearance of weathered zone in Reservoir Zone
viii. Landslide/ mudslide prone wall in reservoir

As mitigation for items 1 to 5 excavation levels can be extended partially in the effected areas beyond +717 m kevel or the zone can be subjected to a grout curtain. For situations 6 &7 grouting is the fix. For item 8 regular preventive actions against landslide can be adopted. Luckly the DPR has provision for them.

Plan of the proposed Weir

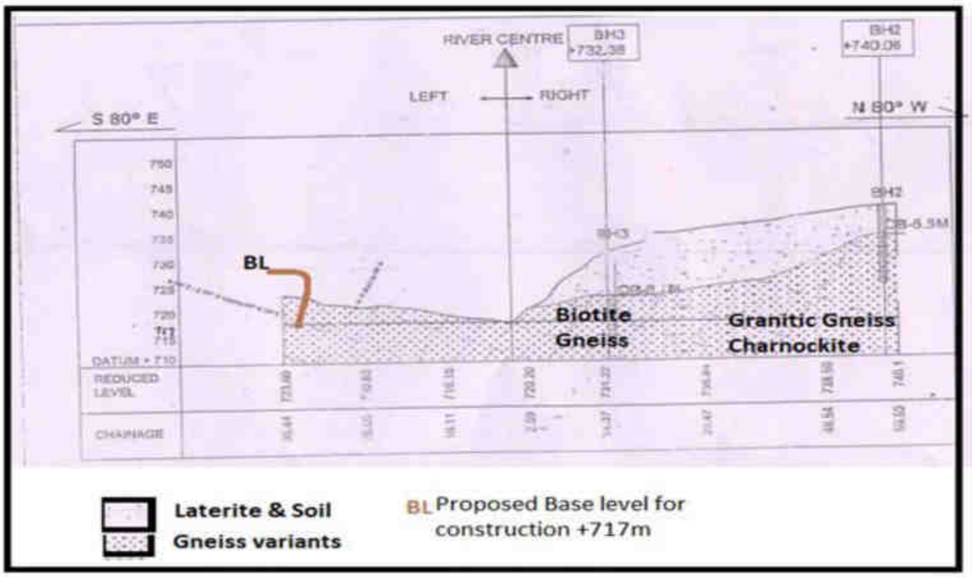


Fig. 29. Valanthode SHEP: Axis of the weir with information of Geological features

Recapitulate

This section complies pertinent information for resolving the suitability of the proposed HE project and the stability of the Gravity weir proposed in the area. A part of the basic information is lodged in section 4.1 to 4.5. Section 6.7.2 deals on Regional Geology with maps and details of the settings. Section 6.7.3 focuses with general nature of the rock succession followed by the section 6.7.3.1 on Geology of the project area. Section 6.7.4 deals the subsurface features and section 6.7.4.2 details with Rocks and soils from 12 GSI boreholes. Section 6.7.5 handles with rocks like Charnockite, and variants of gneisses pertain to different components of the project. Section 6.7.6 dicuesses on Regional Geomorphology and 6.7.7 on River systems. Section 6.7.8 points to the Lineaments of the State with regional and district maps. Seismic details are embodied in section 6.7.9 and Reservoir Induced Seismicity (RIS) in section 6.7.10. All these informations are used for analysis in chapter 7.5 on assessment of impacts.

7. ASSESSMENT OF IMPACTS

The probable impacts could arise as an outcome of implementation of SHEP on lithospheric, hydrospheric, biospheric and socio-economic conditions. These impacts resulted from the modifications of the local environmental traits due to the submergence of land, biodiversity, animal habitats, hydrological changes etc. As mentioned in the introduction of this report, these impacts could be assessed only through location and project-specific study carried out in a holistic manner. Assessement here refers to analysing and evaluating impacts on ecosystems. Analysis is the objective task of identifying actions, taking measurement of baseline conditions and predicting the changes to these baseline conditions that are likely to occur as a result of the action. Evaluation is subjective task which depends on the application of human values. It involves determining the significance of the effects to the affected parties.

It is, now, well acknowledged that environment and development should go hand in hand and should not belittle the worth of one at the cost of the other. The importance of environment and biodiversity considerations in protecting and maintaining resource base, on which development depends, is therefore very crucial. While any developmental activity will have some impacts on the physical and biological environment, the overriding considerations in the selection and implementation of development strategies has to be minimization of ecological cost and maximization of benefits. By keeping this ecological ground rule in mind, the assessment of probable impacts, especially during and after the formation of reservoir, are dealt with based on the data collected during the present study on each systems or sub-systems that exist in the project area.

7.1 On landscape and submergence

The project area harbours forest types that could be broadly categorized into an evergreen, semi-evergreen, moist deciduous and riparian. These vegetation areas are already fall under reserve forests category and be gets protection by the State Forest Department. On left side of the river, the forests from highlands bordering Wayanad to till confluence with Chaliyar, is a contiguous batch and will not face any alteration as the project activities are confined with right side of the river. Most of the project activities like contruction of diversion canal, fore bay tank, penstock, power house etc are being carried out in private plantation area. However, the following impacts may arise and suggestions are given to reduce the impacts at managible level.

i. While constrcting the weir across the river Kurumanpuzha, the blast noise may occur and threat the wildlife of the area. Therefore, care should be taken to reduce the noise while construction activities being carried out.

ii. The formation of reservoir, though minimized to the extent possible to an area of 0.22 Ha or 52 cents, would submerge the existing river bed which form two third of the submergible area and the rest are a little portion extended to both sides of the river where riparian vegetation exist. Here the study recorded 8 tree species representing 11 individuals having over 60cm GBH would be submerged (Table-21). This observation is tally with State Forest Department record. In addition, about 27 herbs which are common to the entire project area also will be affected. For the loss of tree species, replanting double the numbers in consultation with the Forest Department is recommended. Fortunately, the provision is already made in the DPR itself.

iii. The project affects a thin riparian vegetation along the right side of the river below the weir, where construction of diversion canal starts and then proceeds to private land. In this area, the study identified 12 tree species of 23 individulas that could be eventually harvested. This has to be compensated adequeatly by replanting as a restoration measure in consultation with the State Forest Department (Table-28).

iv. During the construction of weir, open canal, power house etc enourmous muck will be accumulated which needs to be disposed carefuly without disturbing the existing forest and aquatic ecosystems.

These are the few negative impacts on the vegetation of the area. These impacts can be minimized to the bearest minimum by careful planning during execution of the construction and restoration activities to compensate the tree components being lost.

7.2. On vegetation

7.2.1. Forest Communities

The assessment identified the four vegetation types, as stated, namely evergreen, semi-evergreen, moist deciduous, riparian etc and also analysed species composition in each forest communities. The phytosociological studies deal with relative frequency, relative density, relative dominance and Important Value Index (IVI) confirmed that each forest communities have its own species specific, life forms and dominance for their successful establishment. The different biodiversity indices namely, Simpson's index of dominance, Shannon index of species diversity, Menhinice's index of species richness and Pielou's index of species eveness have revealed the diversity and dominance of species composition of each forest types at catchment, dam site, downstream, canal diversion area and assessed the health of the forest ecosystems. The evergreen forest in the catchment area having more than 60% diversity and remain intact even if the project is implemented as the submergence is limited to 0.22 Ha. with a provision of overflow of the weir to manage excess inflow during monsoon. However, in downstream along the open diversion canal, power house, switch yard areas etc where moist deciduous forest exists faced slight disturbance due to plantation activities of adjacent areas and still hold good diversity of species. These observations on the nature and health of the ecosystems are a positive outcome of the study and the present project would affect only 1.40 Ha. of forest land which comes to 0.07% of the project area. It shows that 99.93% of the project area will be intact if they follow the precaution and restoration prescribed in section 7.1. The benefit of the project cannot be overlooked as it envisages to produce 15.291 Mu per year and that after implementation (bearing initial cost), the hydroelectric turbines offer the promise of clean energy almost for free (KSEB, 2015, DPR-Vol.1).

7.2.2. Flora

The study area is dominated by the flowering plants and holds 260 species belonging to 224 genera and 82 families. The life forms of these species and the percentage of each are categorized into herbs (37%), trees (34%), climbers (13%), Shrubs (12%) and epiphytes (4%) based on their nature of habits. The species wise analysis indicated that over 60% of them belonging to evergreen and the rest are of deciduous stock. From the conservation point of view, the study area harbours 20 endemics and of which 5 are coming under RET category (Table-12 & 13). Among the endemics, 8 of are available in submergible area in addition to catchment, downstreams and no RET species found in the weir site along with submergence, hence not affected by the dam constrction. The flora, from the economic prospects, represents 88 trees including 24 timber species (Table-14 & 15), 44 medicinal plants (Table -

16), 19 wild edible plants (Table-17), 17 NWFPs and Fibre plants (Table 18), 16 wild relatives of crop plants (Table-19) etc. The locals and forest tribes are harvest these resources for their sustenance. Among these, 8 trees (3 timbers), 4 medicinal, one NWFP, 2 crop relatives are observed in the submergence area which is negligible when compared to their distribution in catchment, downstream areas and hence the population of these species will be stable if the project is implemented. Interstingly, the project area along the borders of the right side of the river face extensive colonization of 28 exotic weeds from the regions of Pantropical, Austrialia, Africa, American Continents, South East Asia etc. The spread indicated the human disturbance along the right side of the river where plantation crops are raised. Many of these estates (almost ten) are not well maintained and provide congenial habited for spread of exotic weeds such as *Acmella radicans, Bidens pilosa, Chromolaena odorata, Elephantopus scaber, Mikania scandens, Ipomoea hedrifolia, Mimosa diptotricha, Centrocema pubescens, Miconia crenata* etc. In some estates they are so dense and cannot cross the area especially with the prickly ones, *Mimosa diplotricha*. These weeds especially *Chromolaena, Mikania and Mimosa* are to be removed periodically otherwise, they will enter the adjacent forest areas and bid competition with native species for space, nutriants, pollinators etc for their survival. Their extension of colonization has already been noticed in moist deciduous forest at downstream areas.

7.3. Terrestrial Fauna and Wildlife

The impact on terrestrial fauna due to the proposed Valanthode small hydroelectric project (VSHP), is negligible. Because this is a run of-the-river type project, which felicitate building up of diversion weir of height 9.5 meters and length of 101 meters, resulting in water impoundment of 0.22 Ha. of forest land only, which spread over the river bed rock. The private land where the major share of the project components coming up is with banana, coffee, tapioca plantation and other crops. These crops in the private lands are often raided by monkeys (*Bonnet macaque, Macaca radiata*), Sambar (*Cervus unicolor),* Barking deer (*Muntiacus muntjack),* Mouse deer (*Tragulus meminna),* Gaur (*Bos gaurus),* Wild boar (*Sus scrofa)*, Elephant *(Elephas maximus) etc from adjacent forests*. The planters use grilled fences and crackers to prevent these animals from entering their fields. This often results in man-wildlife conflicts, which are very minimal in the Valanthode project area but severe in other forest areas in Kerala especially, Idukki and Wayanad districts. If this condition prevails and adding to this many resorts are mushrooming will generate large quantity of waste, both degradable and non degradable, attract wild animals, naturally in future conflict may escalate. Therefore, if these private plantations are acquired, after paying adequate compensations to landowners and build up this small hydroelectric project, it will reduce the man-wildlife conflicts and distract the wild animals to the private land. At present the forest areas are intact and only at the fringes there are human disturbances. This can be reduced by implementing strict preventive measures and by awareness programmes to the people.

7.4. Aquatic Fauna and Breeding Grounds

Construction of impoundments in rivers will affect aquatic ecology of upstream and downstream areas of the river. However, the present project being a run-of-the river scheme, the impacts anticipated on aquatic life forms are less significant. On completion of the project, a reservoir with a surface area of only less than a Hectare at MWL will be formed. The upstream stretch of the proposed reservoir will have no change in aquatic ecology as a lotic (free flowing) system will be contined through out the year. The downstream stretch from the dam up to the tailrace confluence point (1.5 km) there will not be any change in water flow after the project implemented and hence will not affect in any way the aquatic habitats and component life forms. Moreover, the project operation has a provision for allowing ecological flow through operational adjustments. The perennial streams from the right bank will further augment water flow in the river stretch below the weir and therefore drying up of the river stretch will not arise and the continuous water flow will support the aquatic flora and fauna, especially fishes. Overall, the project seems environment friendly and will not cause any adverse impacts to the existing aquatic and allied habitats, microhabitats and its ecological processes.

7.4.1. Management measures for fishes and aquatic ecology

One of the major problems associated with the construction of weir and canal system is caused by the use of explosive chemicals and establishment of labour colonies in close proximity to the river course, without enough facilities for sanitation and sewerage disposal. This may adversely affect the microhabitats, alter the existence of aquatic micro-organisms and even breeding grounds of aquatic fauna including fishes and amphibians. Earthworks and unorganized dumping of construction debris and refuse from labour camps will add to its seriousness. These materials will reach the river during rains or by other means and pose serious pollution of the river water. This can be avoided by setting up labour camps at safe distance from the river bank with adequate facilities for sanitation, sewerage treatment and solid waste disposal. Also, the use of chemical explosives shall be avoided.

7.4.1.1 Provision of providing fish ladders

Since there are no serious impacts expected due to the project up on the aquatic life forms, there is no need to take any mitigation measures to protect the fisheries, as is done in other such occasions. Except Anguilla, no migratory species of commercial importance is present in the upstream of dam site. Since Anguilla is very common throughout the downstream areas, there is no necessity for providing fish ladders.

While constructing the canal system utmost care should be taken to avoid any instances which hinder free drain of surface water to the river system in its right bank.

7.5. Stability of the proposed gravity weir

The present study aims to find the stability of the proposed HE weir in geological and structural angles. Only geological, geotechnical, geomorphological factors contributing to the suitability and structural safety of the proposed Valanthode HE projects weir alone are discussed here. Attempt has been made to introduce the correction factors at the construction level and best practices at maintenance level. Further attempt has been made to verify the aptness of selection of the weir axis in the geological frame work of the terrain. The overall plan of the study is dealt in various chapters and sections as follows;

1. Climate, Soil, Rain fall and Landscape in Sections 4.1 to 4.3 and 4.5
2. Methodology in section 5.7
3. Findings in section 6.7
4. Stability Analysis in section 7.5

In Methodology Section (5.7), two approaches for converging to a scientific conclusion were discussed as Approach-1 involves the analysis of the stability factors of the Valanthode HE project Weir and Approach-2 focused on analysis of the stability factors of the entire Valanthode HE project. Approach-1 brings in suitability for site selection through multivariate factors for the weir proposed in DPR. In Approach-2, all geological and related items discussed in section-3 dealing with physical environment and section-6.7 on findings of the geology related items were investigated independent of dam design. Need for a mitigation before or any time during the construction of the dam are also discussed.

7.5.1. A Quick Recap of the Background

A gravity dam is constructed from concrete or stone masonry to hold back water by using only the weight of the material and its resistance against the foundation to oppose the horizontal pressure of water pushing against it from upstream. All sections of the dam are stable and independent of any other dam section. All the forces arising in a gravity dam as due to the thrust of the impounded water and the massive weight of the dam material are assumed to be directly transmitted to the foundation rocks. Hence the strength of the foundation rocks is the most critical factor (Wikipedia, 2024).

While considering factors like the advantages and disadvantages of the location, structural, lithological and geotechnical factors (sections 5.7 and 6.7) are considered along with other conventional features of the proposed structure. Litho log prepared by Geological Survey of India is used to interpret the subsurface geology and the possibilities of risk factors due to the geological, geotechnical, geomorphologic elements contributing to the safety of the proposed Valanthode HE projects weir.

7.5.2. Classification of the Risk Factors

Risk factors that contribute to instability factors or retarding their effectiveness are classified into the following three categories as A, B and C (Fig.30).

A. **Unconditional No Risk group**: These Risks are i) which are totally irrelevant to the area but are included in list of items that looked into. For example, the ice related issue, ii). Risk factors that exist in the current location but are not stuffiest to attract a threat to stability or retard the effectiveness of the dam in a foreseeable future. No modification, alternate site selection, choosing alternate design or construction or mitigation of any risk is required. Irrelevant risks are avoided in the analysis.
B. **Risks Unearthed During Construction**: Certain Risk factors though dormant and hiding (mostly below the earth surface), suddenly make themselves visible at the preparatory or construction levels anywhere in the project component like weir axis, abutment or reservoir. These factors might be real threat to the safety of the structure or loss of effectiveness. A simple example is water seepage structure in

reservoir, foundation or abutment met at construction level. Mitigation is required. DPR may or might not foresee this eventuality and set aside cost for that purpose.

C. **Risks after Completion**: Certain risk factors might not be contributing any risk currently or even in the construction phase or even in the foreseeable years to come. But due to the change of rhythm and dynamics, variations can happen on these risk contributors. Only subsections A & B will be considered for construction cost and this subsection C is normally treated as "act of nature" and the owner takes the hit even without an insurance support (Fig. 30). A few steps are suggested to prevent or lower the impacts.

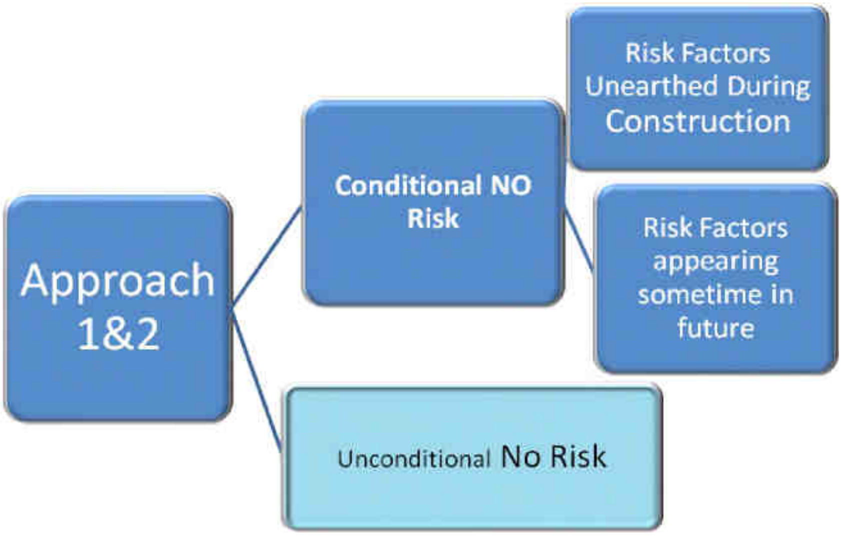


Fig. 30. Valanthode SHEP: Classification of Risk factors

7.5.3. Identification of Threats and Risks

Risk Identification path is shown in Fig. 31. All input data (Table-42) were estimated against the instability factors of Gravity weirs with all Regional and Local data to get the list of threats. Each of the threats is analyzed for Risk as given the flow chart and Table- 43.

Table- 42. Valanthode SHEP: Input elements data for Approach-1

Type of Input	Elements	Description Location	No of Elements
Geology related	Factors for site selection	Section 5.7.2	13
Geology related	Local Geomorphological Factors effecting construction of a dam	Section 6.7.6	9

Geology related	Framework of Important Factors in Choosing the Site of Dam	Section 5.7.8	13
Structural & stability factors	Instability factors of Gravity Weir section	Section 5.7.4.1	6
Geology	Foundation Issues		4
Structural & stability factors	factors of Gravity Weir Failure	Section 5.7.5	6

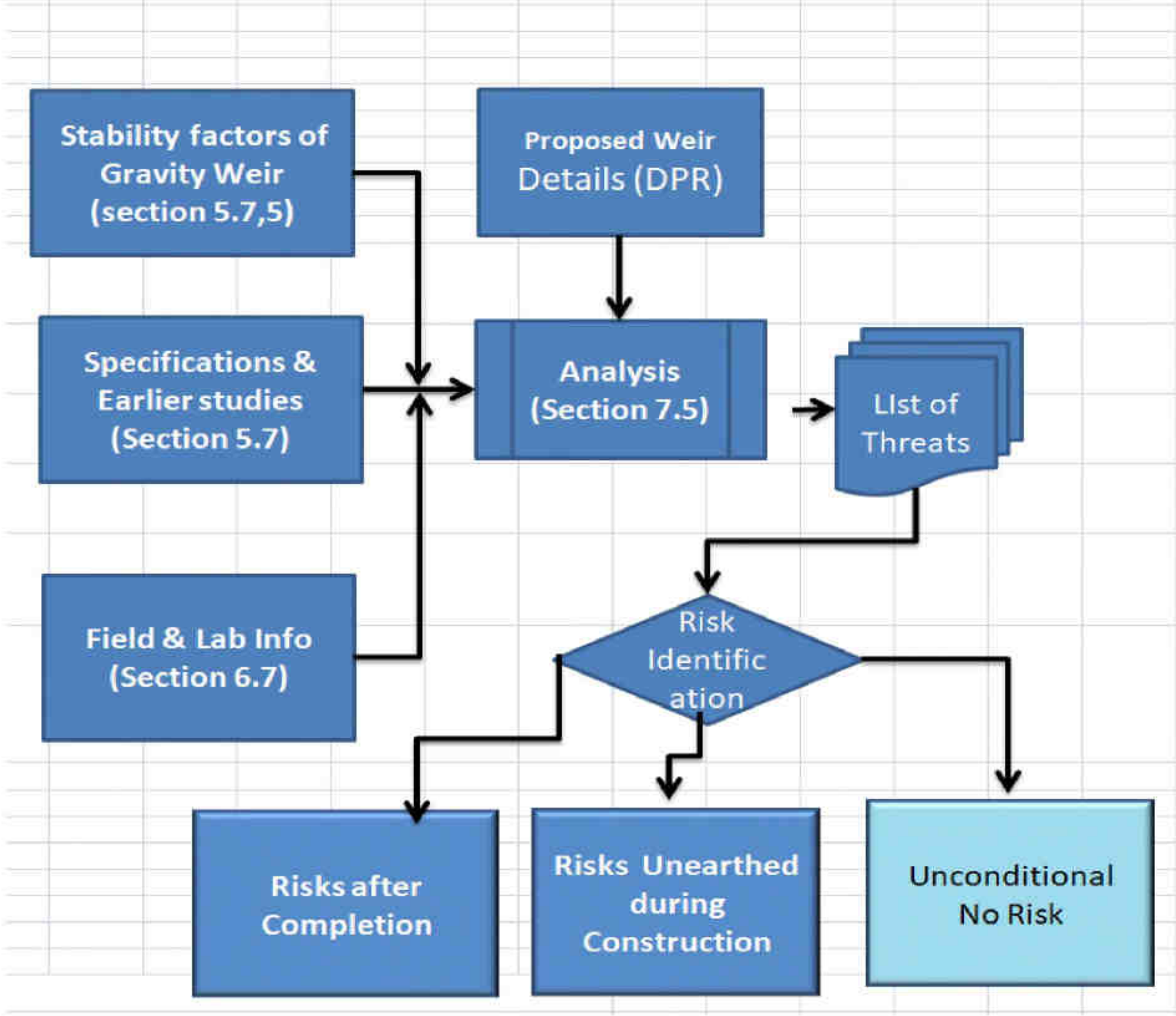


Fig .31. Valanthode SHEP: Steps of Risk Identification

Table -43. Valanthode SHEP: Validation of Instability factors

Instability factors	Summary of Observation	Stability
Weight of the dam	Concrete, low centre of gravity, overflow, short (8m) on fresh rock bed	Stable
Pressure due to water	Dam only 8 m high, small but heavy reservoir,	Stable

Uplift pressure due to water percolated under the dam	The bed rocks of the reservoir and the weir axis are solid, non fractured, non weathered and with soil or silt component . No void space to hold water. Bore hole data also confirms this	Stable
Earthquake pressure. Reservoir Induced seismicity	Earthquake zone III. No deep crustal lineaments to transmit tremor from elsewhere. Earthquake history do not suggest any event. No scope for any RIS	Stable
Wave pressure	No heavy wind experienced in the rugged terrain. Dam is relatively lower RL. No chances of any splash waves due to falling of rock mass or landslide to reservoir.	Stable
Pressure due to Silting	No siltation in the reservoir as most of the side walls are blank and devoid of Vegetation	Stable

7.5.3.1. Input

Input Elements listed in Table-42 and Fig. 32 were collected from:

- Remote Sensing, Geographic Information System Studies, Field studies and Petrography Studies
- Specifications and earlier studies are done by reference to earlier dam incident reports, Geological frame work of Gravity dams
- Earlier Meteorological details, Seismic data, Earth quake data etc are referred from literature and internet.
- Stability factors of the Gravity dam were collected from literature and described in section 5.7.5.
- DPR and related drawings gave information on the proposed weir at Valanthode.

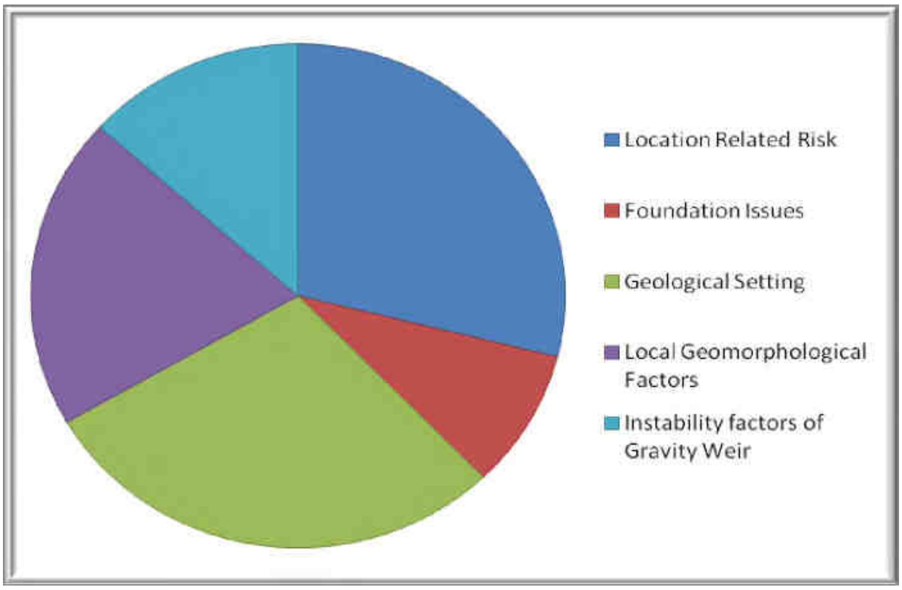


Fig 32. Valanthode SHEP: Input Data

7.5.3.2. Results of Stability Analysis

The process and product of the analysis are given in Fig. 33. and input factors are given in Table 42 & 43 and analysis are given in table 44 to 45

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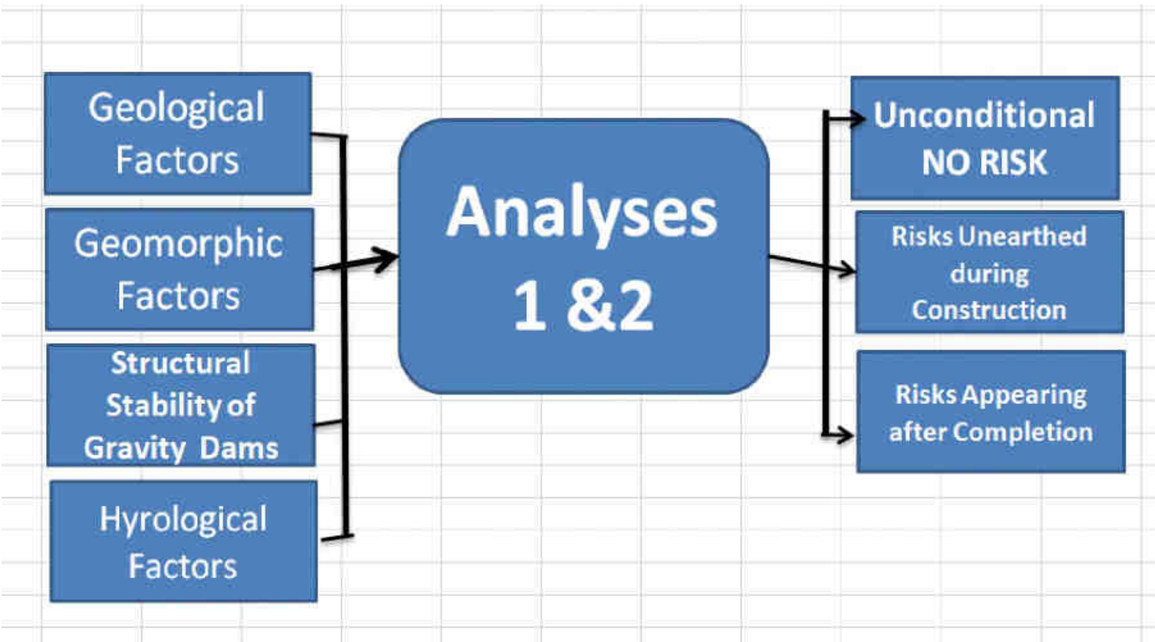

Fig.33. Valanthode SHEP: Scheme of analysis

A. **Unconditional NO Risk**: These are the possible elements of stability issue or unfavorable situation. A total 49 items were analyzed to decide if

i. Total withdrawal from the project or

ii. Location Change or

iii. Technology Change or

iv. Cost or

v. Change the lay of the land or

vi. Mitigation before starting the construction to match with the conditions or prerequisites of the project as of now.

This is what is where is analysis without considering the outcome in the future. The analysis concluded that 100 % unconditional NO Risk at this pint of time, as per the conditions. Figure 34 tells that no prep work or mitigation is required in the area except the logistic preparedness.

Table- 44. Valanthode SHEP: Statistics of Risk Factors and their Classification

Observation Areas	**Total No**	**Unconditional No Risk**	**Risk appearing during Construction**	**Mitigation before Construction**
Location Related Risk	13	13	0	0
Foundation Issues	4	4	0	0
Geological Setting	13	13	5	0
Local Geomorphological Factors	9	9	0	0
Instability factors of Gravity Weir	6	6	0	0
Total	**49**	**49**	**5**	**0**

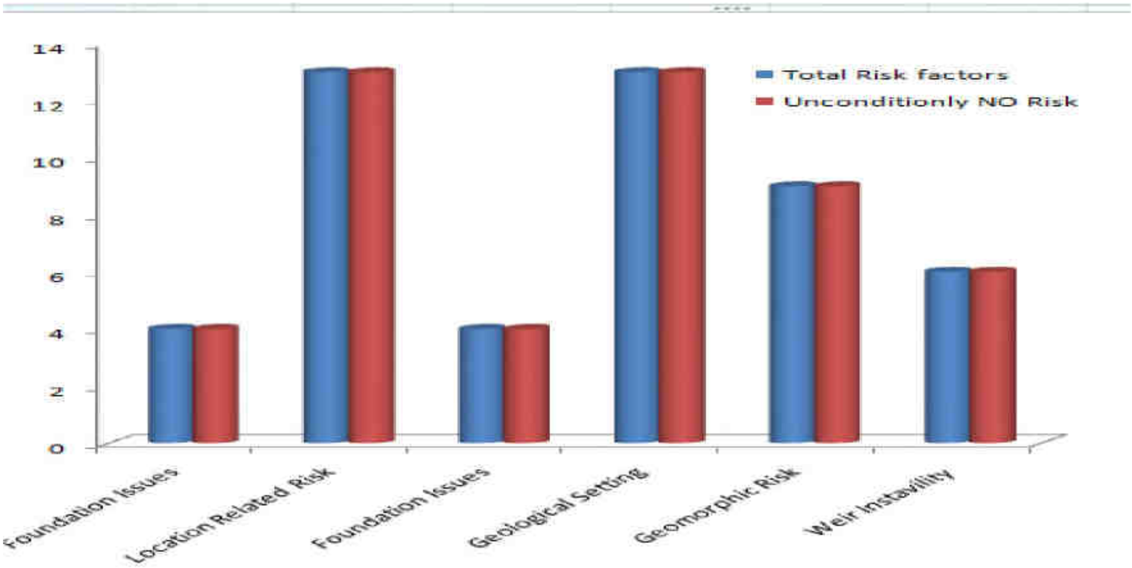

Fig. 34. Valanthode SHEP: Statistics of the Unconditionally no risk in different areas of the project. Graph shows nowhere in the project a preconstruction mitigation is required (Section 7.5.3.2.A)

B. **Threats and Risks Unearthed During the Construction**: Once the processes are started and the construction is progressing there are possibilities of varying probability to unearth some of the issues. There are mainly 8 possible issues that can appear during the construction are given in Tabl-45. Possibility of this is not certain nor zero. It can happen or need not happen. Maximum possibility is during the excavation for foundation in the weir axis. East side of the weir axis is all exposed rock but on the western side the crystalline rock is deeper. why do we miss such cases. Basically because, i) the drilling data is far and wide, ii) the drilling should get better quality results as good core recovery and iii) Geophysical survey for these items are to be done (Fig.35).

Table- 45. Valanthode SHEP: List of Risks appearing during the Construction

Location	Threat	Possible Mitigation	Envisaged in DPR
Weir axis	Appearance of weathered zone before +717m Excavation	Removal of weathered zone till fresh surface comes up. Concrete grout curtain	Yes

Weir axis	Appearance of shear zone before +717m Excavation	Removal of sheared zone till fresh surface comes up. Concrete grout curtain	YES
Weir axis	Appearance of jointed zone before +717m Excavation	Removal of jointed zone till fresh surface comes up. Concrete grout curtain	NO
Weir axis	Appearance of piping before +717m Excavation	Removal of piping zone till fresh surface comes up. Concrete grout curtain fill the void space	NO
Reservoir	Appearance of piping before +717m Excavation	Removal of piping zone till fresh surface comes up. Concrete grout curtain fill the void space	NO
Reservoir	Appearance of weathered zone before +717m Excavation	Removal of weathered zone till fresh surface comes up. Concrete grout curtain	No
Reservoir	Leakage and Seepage of Reservoir Water	Fill the open space grout curtain	NO
Reservoir	Landslide/ mudslide prone wall in reservoir	Adopt efficient land slide prevention methods	N0

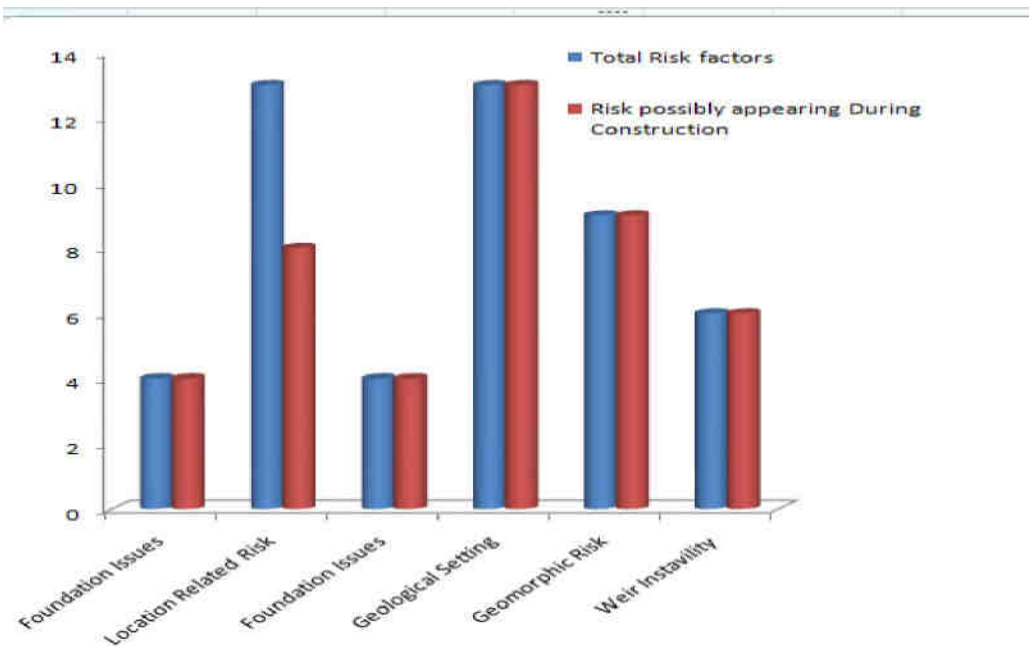

Fig. 35. Valanthode SHEP: Statistics of the Risks that can be unearthed in different areas of the project while construction is on. Mitigation measure (Section 7.5.3.2.B)

A long after construction also similar features can be noticed during desilting of the reservoir. Risk list and mitigation measures are given in Table-46. Weathering, shearing, seepage and land slide possibility are important risks in this group. This being a far remote chance and hence, it is not added to the estimation part.

Table -46. Valanthode SHEP: Unforeseen negative geological features and Mitigation

Location	Timeline	Unforeseen geological features	Mitigation
Reservoir	Reservoir Desilting	Weathered rock or Laterite appears	Removal of the secondary debris. Concrete grout curtain
Reservoir	Reservoir Desilting	Sheared, jointed fractured rock appears	Removal of fractured debris. Concrete grout curtain. Sealing the void spaces
Reservoir	Reservoir Desilting	Landslide factors, loose boulders	Remedial action and landslide prevention Anchoring or bolting the loose bouldering
Reservoir	Reservoir Desilting	Seepage and leakage	Remedial action and landslide prevention Anchoring or bolting the loose bouldering

C. There are certain factors that can shift to a negative side for a dam in later times. Examples are Climate and water availability, change in the rate of siltation etc, these will change suddenly or gradually. These factors cannot be considered in a scientific precision. Preventive maintenance is the best practice protocol. Table-47 shows the preventive maintenance that is to be while HE Project is Up and Running.

Table- 47. Valanthode SHEP: Preventive Maintenance Activities (geological) for proposed weir.

Action	Location	Narration
Prevention of Land use change	Whole catchment	Change in Landuse will change the sediment budget and hydrological condition accelerating the siltation
Soil Conservation	Whole catchment	Contour bunds, Rills and gullies should be filled with suitable soil, vegetative soil barriers to be developed

Ban construction upstream	Whole catchment	Geotechnical intervention on the slope Flow conditions altered
Ban rock blasting	Whole catchment	Triggers seismic vibration though small. A possible negative action
Regulate Bore wells	Whole catchment	Risk of changing hydrological factors
Alert on Land slide or soil slip	Whole catchment	Avoiding flash flood and sediment movement to reservoir
Repairing eroded area	Whole catchment	Eroded surface add to the siltation, add to infiltration and vegetation loss. Restore and reseed
Flow and precipitation measurement	Whole Project	For planned operation
Desiltation	Reservoir, spillways and conduits	Maintains reservoir capacity
Periodical Monitoring upstream	Upstream	Monitoring of development in the watershed that would materially increase runoff from storms.
Periodical Monitoring Down stream	Downstream	Monitoring of development downstream and updating the emergency notification plan to include new houses or other occupied structures

7.5.4. Analysis of Factors of Suitability and Stability.

A statistical analysis was carried out by using 49 items (geological factors) which are responsible for stability of the weir. The results related to Location related Risk, Foundation issue, Geological setting, Local Geomorphic factors, and instability factors etc are considered and found out that all 49 of them are qualified "Unconditionally as No Risk," and hence No mitigation action required before the construction (Table-48).

Table- 48. Valanthode SHEP: Factors of Suitability and Stability

Geological Factors	**Criteria**	**Condition of the current HE project**	**Risk**
Location Related Risk			
Topography	Control Size, Shape of Weir, Reservoir Dynamics, suitability and safety	Right topography at weir, penstock and power house Fig.3.	No Risk No mitigation

Hydrology	Water availably as per design, design & construction of a dam,	Matching conditions Section 4.3.1	No Risk Unconditional now
Seismo tectonic and seismic risk analysis	Location in Seismic Zone	Earthquake Zone III only. No history of earthquake in the area	No Risk Unconditional now
Reservoir Induced Risks	Large Reservoir or cluster of Reservoir	Small Run of River Reservoir	No Risk
Karst hydrogeology	Water soluble rocks and fragile land	Hard rocks with no secondary coating or covering	No Risk
Water Availability	Water availability as designed	Water available as run of river project 4.3.1	No Risk
Land use/ Land cover	Land materials will be brought in and reservoir filled	No land slide possibilities	No Risk Unconditional now
Width of the stream	As narrow as possible is better	Only 101 m long Fig.4.	No risk No mitigation required
Width of the River Valley	Construction is to be done in a narrower valley	Selected site is a narrow valley Fig.4.	No risk No mitigation required
Construction material	Freely available from vicinity	Plenty of out crop	No Risk

Slope of the Stream Bed:	Stream bed should slope as little as possible	Slope only 1 in 70	No risk No mitigation required
Flood	Flooding can cause damages	No Flooding even in 2018, 2019 floods in the area	No Risk
Thickness of overburden	As thin as possible	Overburden 0-12.5 m on the western side. No overburden on the east side (see Fig.33.)	No Risk Partial overburden to be removed
Instability factors of Gravity Weir			
Weight of the dam	The self weight of the gravity dam is a major resisting and stabilizing force of the dam.	The resultant of the downward acting forces indicates the total weight of the dam at the center of gravity of the dam	No Risk
Horizontal hydrostatic pressure due to water	The major external forces acting on a gravity dam is the water pressure	Hydrostatic pressure is small as the dam is short and thin	No Risk
Uplift pressure due to water percolated under the dam	Uplift forces occur as internal pressure in pores, cracks and seams within the body of the dam	No pore, fissure pores, porosity and permeability below the foundation	No Risk
Earthquake pressure	During an earthquake, siesmic waves are produced	Earthquake Zone III only . No history of	No Risk Unconditional now

	that can effect different sections of the dam	earthquake in the area	
Wave pressure	Waves are produced on the reservoir surface by the blowing winds	Small reservoir area.	No Risk
Pressure due to silt deposited	The weight and the pressure of the submerged silt are to be considered in addition to weight and pressure of water.	Silt quantity will be smaller as the catchment area is rocky	No Risk
Foundation			
Geomechanical properties of rocks	These properties can affect the stability of the embankment or concrete dam, as well as the long-term behavior of the dam under various loading conditions.	No negative Geomechanical properties in the rocks of the area	No Risk
Karst hydrogeology;	These rocks cave in	No carbonate or cly horizon or any soluble rocks	No Risk
Siesmic Risk	Earth quakes can break foundation	Earthquake Zone III only . No history of earthquake in the area	No Risk Unconditional Now
Orientation of Bed rock layers	Stability relies on the dip of the bed rock layers . Ideal	Formation dip towards west while	No risk No mitigation required

	one is the one dipping upstream	weir axis is N80W-S80E	
Risk Factors Considered before construction **Reducible Before Construction by mitigation or location change**			
Geological Setting			
Weak Structural Features	Folding, faulting, shear zones and joints are unfavourable geological structures for a dam site.	No folding, faulting, shear zones are seen. Joints are not close to each other	No Risk
Thick Mantle of Overburden	Extra removal of overburden costs more	About 12.5 m of overburden along the dam axis. Excavation for foundation will take care. Fig. 29.	No Risk
Deep Weathering of Bed Rock	Weathered rock portion to be removed at extra cost	No deep weathered zone found in the weir axis. If any weathered thin layers are found on excavation that can be done. DPR foresees that eventuality	No Risk Unconditional Now
Karstic Condition and Cavities	Soluble rocks induce instability	No such rocks in the area. Section 6.7.2	No risk
Permeable Boulder Bed	Permeable Boulders induce instability	No such rocks in the area. Section 6.7.2	No risk

Soft Sedimentary Rock	Sedimentary rocks induce instability	No such rocks in the area. Section 6.7.2	No risk
Buried Channel	Buried channels destabilize the big structure	No Buried channels in the weir or Reservoir site. Section 6.7.2	No Risk
Kaolinisation	Kaolinisation of Feldspars cause weakness in concrete assembly	No Kaolinisation in Project site. Section 6.7.2	No Risk
Old Slides	Old slides indicate instability	No old slides in the Area	No risk
Reservoir Siltation	Possibility of reservoir siltation bring in instability	No Possibility of reservoir siltation	No Risk
Rock Type	Heterogeneity of rock assembly bearing capacity etc, introduce instability	No Heterogeneity of rock assembly or depletion in bearing capacity of Rocks in the area. Section 6.7.2	No Risk
Attitude of Rocks	Orientation and thickness of rocks can induce instability	No orientation or thickness of rocks induce instability in the area as there is no porous or permeable	No Risk
Soil and rock properties	Soil of different properties like composition consistence and texture can induce instability	No soil type encountered in soils here. The soil occurring will be	No Risk

		removed while excavation	
Local Geomorphological Factors Effecting Construction of a Dam			
Geomorphology of Catchment Area	Geomorphology of catchment in terms of slope characteristics apart from shape and size of the catchment area are important in deciding the total amount of water available to a river.	Slope, shape, size are favarouble. Water availability is discussed. Section 4.3.1 and Geomorphology in section 4.5, fig.3, fig.8, Fig.19 and 20.	No Risk
Factors of velocity of water entering the reservoir	Geomorphic components such as drainage pattern, drainage density, stream order and sinuosity of river control the velocity water entering the reservoir	Velocity of water entering the reservoir was observed and recorded in DPR, All God	No Risk Unconditional
Geomorphology of Reservoir Area	The volume filled may have different size and shape depending upon the geomorphology of the area and the length and height of the dam.	Geomorphology of the land does not induce any risk, please refer Fig. 11 to 15	No Risk
Geomorphology of Dam site	The important geomorphic consideration at dam site is the narrow river valley section. The narrower is the river valley smaller will be	Valley and dam axis are short and do not risk. Please refer Fig. 3, 11 to 15.	No Risk

	the length of the dam and lower will be the cost.		
Height of the shoulder hills	Important, on to which the two sides of dam are going to rest i.e. the abutment foundation. It should be well above the dam height so as to prevent spilling of water in sideways	Shoulders have higher elevation. Please refer Fig.4.	No Risk
Thickness of Alluvial fill	The River may have varying thickness of sediment deposit, termed as valley fill. As rivers shift their course sideways, due lateral accretion of sediment and vertically due to deposition of sediment layer by layer.	River is flowing mostly in a crystalline terrain. No Alluvial fill in the reservoir area. Whatever secondary stuff will be removed while excavation. Fig. 29.	No Risk
Leakage and Seepage of Reservoir Water			
Sedimentation in Reservoir:	Sedimentation in the reservoir area can reduce the volume of the reservoir	Catchment area though crystalline has lateritic soil above that if land use patterns are not controlled there can be excessive sediment transport.	No Risk But monitoring is required.
Leakage and Seepage of Reservoir Water	Leakage in reservoir can end up in water loss and structural issues	No leakage found now. When the reservoir is fully filled	No Risk Unconditional

		test should be done and grout curtain should be provided	
Geomorphology of catchment	Geomorphology of catchment in terms of slope characteristics apart from shape and size of the catchment area are important in deciding the total amount of water available to a river.	Slope, shape, size are favarouble. Water availability is discussed	No Risk Suitable

After setting a ground for the scientific probe into a question which is spatially and temporally sensitive to cyclic and evolutionary change in section 5.7, collection of information of spatial and temporal changes in section 4.3 and 6.7, the collected information were analyzed. It is found that there are no risk factors that need intervention at this level. Our team recommend the implementation of the project as proposed by a work flow chart in fig 36.

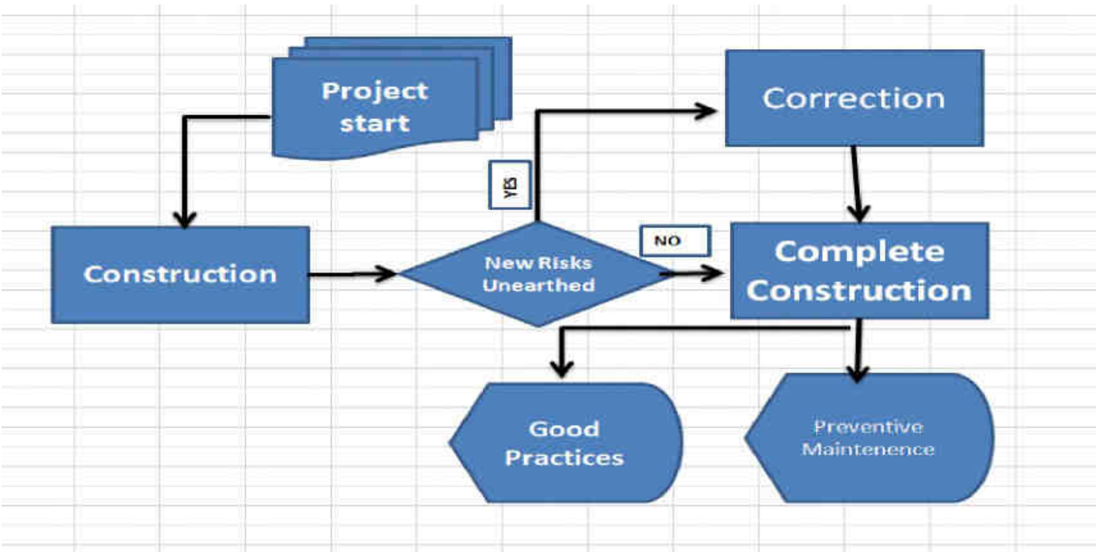

Fig. 36. Valanthode SHEP: Proposed work flow of the HE Project

Recapitulate

The Geological study assessed that there are no geological or climatic factors that induces to rethink, rework or withdraw from this proposed project. There are no points to relocate or revise the proposal as there are no threats that will have to make good before the construction. The concept behind introducing the 45 elements of these fields are given in the sections 5.7.1 to 5.7.4. The data considered are elaborated as Finding in section 6.7. Risks are identified in section 7.5.3, risks are classified (section 7.5.2) as Unconditional No risk, Conditional risk and risk after completion. Of the 45-element risk contributing factors 100% of them do not offer any risk at this level of assessment. However, 5 risks can up during the construction stage and later during the operation and maintenance phase 4 more can come up. But none of them are preventing us from going ahead with the current proposal. The study team is supporting the Project. Salient content of this section is that work can go ahead right now. We have however pointed some Risks that might be unearthed during construction and their remedial measures for being alert and aware. The chances of their occurrence are of are of varying probabilities and so that we can go ahead for now with the proposal in DPR. The Analyses results indicate that there are 100% Unconditional NO Risk condition before the construction. There are 5 Conditional risk that might appear during construction mostly in weir axis area and 4 risks that might pop us during the management or maintenance of the HE project. Appearance of these risk are in low probability hence the Project can go ahead as per plan.

7.6 On Agrobiodiversity

Based on the survey and related discussion with farmers the following conclusions are arrived at. None of the cultivated plants in the surveyed area belong to rare or endangered species or have characteristics such as high yield, pest and disease resistance, or characteristics which could be used for future breeding related activities. They all come under commonly cultivated and released varieties. Hence, the conversion of 4.5 Ha. of agricultural land for the Valanthode Small Hydroelectric Project will not adversely affect the agro-biodiversity of crops in Kerala.

8.CONCLUSION

Energy crisis in Keala is a major issue as the supply of energy is not in pace with the day to day increase in demand of energy. The main sources of energy are thermal, nuclear and hydro electric power. The development of nuclear and thermal projects has the least scope in Kerala's socio-economic and political scenario. The main affordable source of energy is hydro power. But due to some impediments such as environmental and socio-economic factors, many of major hydro electric projects were dropped or postponed. The development of major hydro schemes with large submergence of land could not be taken up due to issues relating to forest and environmental clearance. Thus, the development of small HE Schemes becomes significant now a days.

The scope of Small HE Schemes are limited and its contribution to the system will be quite small as compared to the demand, but implementation of series of such schemes would have a noticeable effect in the power generation sector. Small hydro electric schemes would provide an opportunity for the development of rural area. The advantage of this type of scheme is that it can be completed within a shorter period when compared to other sources of energy, quick benefits are derived with out much ecological disturbance.

It is an accepted fact that Kerala has so far explored only about $1/3^{rd}$ of the already identified hydro power potential though much effort has been spared to conceive Hydro Electric Projects, many have been entangled in Environment and Forest related issues. Tapping the hydropower with least disturbance to the surroundings became the core issue while planning a hydro electric project. By considering all these facts the KSEBL proposed Valanthode Small HE Schemes which is a run-of the river scheme utilizing the inflow of Kurumanpuzha, in Chaliyar basin, with a rated net design head of 89.44m. The catchment area of the scheme is $18.90km^2$. The proposed installed capacity is 7.5 MW (3X 2.50MW) and the annual generation expected from the scheme is about 15.291 Mu (90%DY). The scheme envisages construction of a gravity diversion weir in Kurumanpuzha at Thottappally. The water is diverted from the heading up upstream of diversion weir at FRL level to the powerhouse located in the right bank of Kurmanpuzha and will be utilized for power generation. The project is to be operated as a part of the Kerala State Power grid. All the project components except weir are proposed at the right bank of the river in private plantations by avoiding / reducing forest land.

The project was forwarded to Ministry of Environment and Forest (MOEF&CC), Govt of India for consideration and forest clearance. The expert committee raised certain points to safeguard biodiversity of the area and also concerns about the stability of the structure to be developed under the scheme. The CISSA was entrusted after observing official formalities for preparing the status of biodiversity of the project area. Accordingly, subject experts were deployed and they covered various biological components such as forests flora, fauna, wildlife, aquatic system etc along with physical environment and geological aspects.

The biodiversity assessment and structural stability of the proposed Valanthode SHEP were carried out to find the answers to the questions raised by the Regional Empowered Expert Committee of the Ministry of Environment, Forest and Climate Change (MOEF&CC), Govt of India while considering the project for the forest clearance. The answers are given based on the present study in respect of the following questions.

1. **The loss of bio-diversity and effect on special habitats such as nesting sites, spawning sites and special breeding grounds for fishes and other fauna**

1 A. The present status of biodiversity of the project area

- **i.** There are four types of forest occur namely evergreen, semi-evergreen, moist deciduous and riparian. The evergreen forest spread over the entire catchment area, a small batch of semi-evergreen existing as continum between evergreen and moist deciduous just below the weir site. The mosit deciduous spread from correspond to penstock area to the entire downstream upto power house and beyond towards the confluence with Chaliyar river. The riparian forest exists all along the river border on both sides of the river Kurumanpuzha.
- **ii.** The phytosociological and biodiversity indices analyses confirmed that these forest ecosystems are well developed, distributed with species specific. The species composition predominantly evergreen followed by the deciduous stock, their diversity and abundance are more than 60% in the entire river basin.

iii. The flora is dominated by flowering plants. A total of 260 species belonging to 224 genera and 82 families. The life form is composed of herbs with 37%, followed by trees (34%), climbers (13%), shrubs (12%) and epiphytes (4%). There are 20 endemics including 5 RET species identified in the project area. No RET species is found in the dam site and its submergence environs. The flora holds species of 88 trees including 24 timbers, 44 medicinal, 19 wild edibles, 17 NWFPs, 16 wild crop relatives etc. The project area is also experienced the distribution of 28 exotic species which become hinderance to the native flora.

iv. The fauna and wildlife recorded as such are butterflies (94 species) including 35 mud puddlers, reptiles (16 species), birds (77 species), mammals (28 species) etc. They move freely throughout project area but restricting their movements on the right side of the river bank due to human presence.

v. The aquatic flora and fauna include phytoplanktons (2 orders), zooplanktons (5 orders), benthic fauna consits mainly of insect larvae and worms. The study recorded 21 species of fishes of which 3 species are wildely distributed in the up and downstreams and 14 species of frogs.

vi. Agrobiodiversity contains banana, coffee, cardamom, cassava, cinnamon, nutmug, black pepper, ginger etc.

1B. Probable impacts on Biodiversity of the project area.

i. The forest areas already fall within the reserve category and get protection by the State Forest Department. However, while constructing the weir across the river, the blast noise may threaten the wildlife. The KSEB should take precaution to reduce the noise and maintain the labour force outside the forest area.

ii. While implementing the project, a total of 34 trees having more than 60cm at DBH will be lost. This includes 11 individuals at submergence and 23 numbers along the construction of the diversion canal. The study recommends double the numbers for the replanting in consultation with State Forest Department as the project DPR having provision for the same.

iii. The muck generated during the construction needs to be carefully disposed without disturbing the forest and aquatic ecosystems.

iv. The extensive spread of exotic weeds along the right side of the river bank indicated the human activities associated with agricultural operations.

v. The impact on terrestrial fauna is negligible because of the impoundment water limited to 0.22 ha. and infact help water availability for larger mammals. The project minimizes man-wildlife conflict while implementing the project by purchasing the private land, where enough forege is available, with adequate compensation. The wild animals distract from the private land and try to sustain within the forest.

vi. The study confirmed that the river system has enough special habitat such as breeding grounds and spawning sites throughout the river spread over to the catchment, dam site, downstream etc and hence proposed small hydro electric scheme will not affect the aquatic flora, fauna, fishes and frogs. Except, the fish and Anguilla, no migratory species of commercial importance is present in the upstream of the dam site. Since, Anguilla is very common throughout the downstream areas, there is no necessary for providing fish ladders.

vii. The Agri-Horticultural crops cultivated in the private land to an extent of 4.5 Ha. will become part of the project area by acquiring from them. None of the crops belong to rare or endangered species or have any special characteristics such as high yield, pest and disease resistance. Hence, the project will not affect the agrobiodiversity of crops in Kerala.

2. Vulnerability of the structures proposed to be developed under this project to damage by flash floods which have earlier reported in this area.

2A. The answers, for the sake of clarity, are given in both narrative and short form based on the Components of the question and the Location of answers in the Report:

i. There was one structure which failed in flash flood?

There was an unfounded misinformation that a structure across this stream failed sometime in the past in the vicinity of the area or somewhere in the basin or subbasin. This team curious on the details and mode of failures, searched for the remnants of the structure or the scars. None was located. No history or memory corroborates the fact. It was decided to have a detailed study to clear up all confusions. **Even after a**

concerted effort, we were not able to locate any of such dam, weir or barrage across this river at anytime in the current history totally ruling out the misinformation (Section 5.7.1). More over the history of the settlement in the area dates back to a few decades only. But such a gossip motivated the team to give special attention to the stability of the weir as well.

ii. **Possibility of Flash flood in the Area**:

Section 4.3.2, deals Flood impact on the proposed weir. Two possibilities of flash flood damages can be imagined i) Increase of water flow by cloud burst turning to a flash flood, a total meteorological event. Such events are not common in the area, ii) Flash floods due to breakage of a dam or barrage in the upstream as there are no water retaining structures anywhere in the upstream or iii) Flash floods due to a mega size landslide event. **No slope in the upstream area can trigger a landslide of a considerable size. All three possibilities of flash flood are ruled out.** In 2018 and 2019, there were devastating rains damaging roads and houses in middle and Southern part of the state. These flood events could not make an impact in Chaliar system as in the southern Kerala (Sections 4.3.2.2 and 4.3.2.3).

iii. **Probability of a flash flood damaging the structure partially or fully:**

The possibility of such events was happening one century after the previous one. **By the merit of design, the proposed weir will survive the impacts as the water will run over and will not give in by the inherent structural instability and the regular mode of failure.**

iv. **Mode of Failure of the Gravity Weir:**

Section 5.7.5 deals with mode of failure like Instability of Gravity Weir (5.7.5A), Overturning of a gravity dam (5.7.5.B), Structural Failures (5.7.5.C). **These modes were matched with Risk factors in Analysis- 1 (Section 5.7.2) and found that with risk factors are not in a possible range enough to trigger a failure.**

v. **Instability factors of the gravity weir:**

Section 5.7.5.1 focusses the instability factors like Weight of the dam, Pressure due to water, Uplift pressure due to water percolated under the dam, Earthquake pressure. Reservoir Induced seismicity, Wave pressure, Pressure due to Silting. These factors were matched with Risk factors in Analysis-1 (Section 5.7.2) and **found that**

with risk factors are not in a possible range enough to trigger a failure. Alternatively, these factors were validated against the design and found to be stable.

vi. **Analysis of possibilities in combination of geological, hydrological and seismic factors:**

Sections 5.7.2 and 7.5 discuss the Concept, inputs, analyses and Results in different sections and Tables. **The structure describes in DPR can withstand Flash floods, Earthquakes etc.**

2B. Concise Form

Finally, it is concluded that there are no geological or Climatic factors that induces to rethink, withdraw from this project. There are no points to relocate or revise the proposal as there are no threats that will have to be made good before the construction. Construction Work can go ahead right now. We have however pointed, some Risks that might be unearthed during Construction and their remedial measures for being alert and aware. The chances of the occurrence are of varying possibilities and so that we can wait till as we are there. Only geological, geotechnical, geomorphological factors contributing to the suitability and structural safety of the proposed Valanthode HE projects weir alone are discussed here (Remaining themes and areas are presented elsewhere in the report). Attempt has been made to introduce the correction factors at the construction level and best practices at maintenance level. Further attempt has been made to verify the aptness of selection of the weir axis in the geological frame work of the terrain.

Vulnerability of the proposed Weir at Valanthode HE project was subjected to study as per the DPR description, Common Failure modes, structural factors of the Gravity weirs, Risk factors from Meteorological (Flash flood) and Risk factors from Geological, Geomorphological, Hydrological and seismic realms which trigger or combine to contribute triggering factors for failure to assess the stability of the weir in reference. **Results show with the design and specifications as in DPR, the weir is stable enough to stand the flood situations. The team has found that information on earlier dam break in the area is not true. Further all other risk factors were also analyzed and weir is found stable.**

The study team assessed and evaluated the physical environment, biodiversity aspects, project features and the stability of the structures proposed to be developed in this project for giving adequate safe guard to the environment. A few impacts can affect on tree species but can be minimized and managed by adopting the mitigative measures as suggested. The impacts on flora, wildlife and aquatic systems are negligible, the proposed weir is also stable based on the analyses of all the possible risk factors that may arise in future. Therefore, the study team is substantiating with scientific evidences to alloy the unfound fear of this hydel scheme and unanimously supporting the project.

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Annexure – 1

Valanthode SHEP: List of Plants Species Recorded from the Project Area

Sl. No	Family & Plant Name	Life form	Areas observed		
			Catchment	Dam site	Down stream
	ACANTHACEAE				
1	*Andrographis paniculata* (Burm. f.) Wall. Ex Nees	Herb			+
2	*Asystasia gangetica* (L.) Aanderson	Herb			+
3	*Barleria courtallica* Nees	Shrub	+		
4	*Justicia japonica Thunb.*	Herb	+		+
5	*Phaulopsis imbricate* (Forssk.) Sweet	Herb	+		+
6	*Rostellularia mollissima* (Nees) Nees	Herb		+	
7	*Thunbergia fragrans* Roxb.	Climber			+
8	*Thunbergia mysorensis* (Wight) Anderson	Climber	+		+
	AMARANTHACEAE				
9	*Achyranthes aspera* L.	Herb			+
10	*Cyathula prostrate* (L.) Blume	Herb			+
	ANACARDIACEAE				
11	*Holigarna arnottiana* Hook. f.	Tree		+	+
12	*Mangifera indica* L.	Tree	+		
13	*Spondias pinnata* (L.f.) Kurz	Small tree	+		
	ANCESTROCLADACEAE				
14	*Ancistrocladus heyneanus* Wall. ex Graham	Climber	+		+
	ANONACEAE				
15	*Meigoyne pannosa* (Dalz.) Sinclair	Tree	+		
16	*Goniothalamus wynaadensis* Bedd.	Shrub		+	
17	*Polyalthia fragrans* (Dalz.) Bedd.	Tree	+		
	APOCYNACEAE				
18	*Alstonia scholaris* (L.) R. Br.	Tree	+		
19	*Wrightia tinctoria* (Roxb.) R. Br	Tree	+		
	ARACEAE				
20	*Arisaema nilamburense* Sivad.	Herb	+		
21	*Arisaema leschenaultii* Blume	Herb	+		
22	*Anaphyllum wightii* Schott	Herb	+	+	

23	*Lagenandra toxicaria* Dalz.	Herb		+	
24	*Pothos scandens* L.	Climber			+
	ARALIACEAE				
25	*Schefflera venulosa* (Wt. & Arn.) Harms	Epiphytic shrub	+		
	ARECACEAE				
26	*Calamus rheedei* Griff.	Woody climber	+		
27	*Caryota urens* L.	Tree	+		
	ARISTOLOCHIACEAE				
28	*Thottea siliquosa* (Lam) Ding Hou	Shrub	+	+	+
	ASTERACEAE				
29	*Ageratum conyzoides* L.	Herb			+
30	*Acmella radicans* (Jacq.) Jansen	Herb			+
31	*Bidens pilosa* L.	Herb			+
32	*Blainvillea acmella (L.) Philip.*	Herb	+		+
33	*Blumea lacera* (Burm. f.) DC.	Herb			+
34	*Crassocephalum crepioides* (Benth.) S. Moore	Herb			+
35	*Chromolaena odorata* (L.) King & Rob.	Shrub			+
36	*Elephantopus scaber* L.	Herb	+		+
37	*Galinsonga parviflora* Cav.	Herb			+
38	*Mikania scandens* (L.) Willd.	Herb			+
39	*Monosis conferta* (Benth.) Jeffry	Tree	+		+
40	*Synedrella nodiflora* (L.) Gaertn.	Herb			+
41	*Vernonia cinerea* (L.) Less.	Herb			+
	BALANOPHORACEAE				
42	*Balanophora fungosa* Forst. & Forst.	Parasitic herb	+		
	BALSAMINACEAE				
43	*Impatiens grandis* Heyne ex Wall.	Herb	+		+
44	*Impatiens humblotiana* Baill.	Herb			+
45	*Impatiens minor* (DC.) Suresh	Herb	+		
46	*Impatiens scapiflora* Heyne ex Wall.	Herb		+	
47	*Impatiens viscosa* Bedd.	Herb	+		
	BOMBACACEAE				
48	*Cullenia exarillata* A. Robyns	Tree	+	+	
49	*Bombax ceiba* L.	Tree	+		
	BEGONIACEAE				
50	*Begonia malabarica* Lam.	Herb	+		

51	*Begonia roxburghii* (Miq.) A. DC.	Herb			+
	BURSERACEAE				
52	*Canarium strictum* Roxb.	Tree	+		
53	*Garuga pinnata* Roxb.	Tree	+		
	CAMPANULACEAE				
54	*Lobelia nicotianifolia* Roth	Shrub			+
	CAPPARACEAE				+
55	*Cleome viscosa* L.	Herb			+
	CLUSIACEAE				
56	*Calophyllum polyanthum* Wall. ex Choisy	Tree	+		
57	*Garcinia conicarpa* Wight	Tree	+		+
58	*Garcinia cambogioides* (Murray) Headland	Tree	+		
59	*Garcinia gummi-gutta* (L.) Robson	Tree	+		
60	*Mesua ferrea* L.	Tree	+		
	COMBRETACEAE				
61	*Calycopteris floribunda* (Roxb.) Poiret	Woody climber	+		
62	*Terminalia bellerica* (Gaertn.) Roxb.	Tree			+
63	*Terminalia alata* Heyne ex Roth	Tree	+		
64	*Terminalia paniculata* Roth	Tree	+		
	COMMELINACEAE				
65	*Commelina benghalensis* L.	Herb	+	+	+
66	*Cyanotis cristata* (L.) D. Don	Herb	+		
67	*Murdannia vaginata* (L.) Bruckn	Herb	+		
	CONVOLVULACEAE				
68	*Argyreia nellygherrya* Choisy	Woody Climber	+		
69	*Ipomoea hedrifolia* L.	Herb			+
70	*Ipomoea pes-tigridis* L.	Herb			+
	CYPERACEAE				
71	*Carex filicina* Nees	Herb			+
72	*Cyperus compressus* Linn.	Herb			+
73	*Cyperus distans* L. f.	Herb	+		
74	*Cyperus halpan* Linn.	Herb			+
75	*Fimbristylis aestivalvis* (Retz.) Vahl	Herb			+
76	*Fimbristylis dichotoma* (Linn.) Vahl	Herb		+	+
77	*Fimbristylis miliacea (L.) Vahl*	Herb	+		
78	*Scleria lithosperma* (Linn.) Sw.	Herb		+	

79	*Pycreus paniculatus (*Vahl) Nees	Herb			+
	DICHAPETALACEAE				
80	*Dichapetalum gelonioides* (Roxb.) Engl.	Tree	+		
	DILLENIACEAE				
81	*Dillenia bracteata* Wight	Tree	+		
	DIOSCOREACEAE				
82	*Dioscorea oppositifolia* L.	Climber			
	DIPTEROCARPACEAE				
83	*Hopea parviflora* Bedd.	Tree		+	
84	*Hopea ponga* (Dennst.) Mabb.	Tree			
	EBENACEAE				
85	*Diospyros paniculata Dalz.*	Tree	+		
	ELAEGNACEAE				
86	*Elaegnus conferta* Roxb.	Woody climber			+
	ELAEOCARPACEAE				
87	*Elaeocarpus munronii* (Wt.) Mast.	Tree	+		
88	*Elaeocarpus serratus* L.	Tree	+		
89	*Elaeocarpus tuberculatus* Roxb.	Tree	+	+	+
	ERIOCAULACEAE				
90	*Eriocaulon xeranthemum Mart.*	Herb	+	+	
	ERYTHROPALACEAE				
91	*Erythropalum scandens* Blume	Woody climber	+		+
	EUPHORBIACEAE				
92	*Agrostistachys indicia* Dalz.	Shrub	+		
93	*Aporusa lindleyana* (Wt.) Baill.	Small tree	+		
94	*Antidesma montanum* Blume	Tree		+	+
95	*Baccaurea courtallensis* (Wt.) Muell-Arg.	Tree	+		
96	*Bischofia javanica* Blume	Tree	+		+
97	*Bridelia scandens* (Roxb.) Willd.	Wody climber	+		
98	*Euphorbia hirta* L.	Herb	+		+
99	*Glochidion malabaricum* Bedd.	Small tree	+		
100	*Homonoia riperia* Lour.	Shrub	+		+
101	*Macranga peltata* Mull. Arg.	Tree		+	+
102	*Mallotus philippensis* (Lamk.) Muell.-Arg.	Tree			+

103	*Mallotus tetracoccus* (Roxb.) Kurz.	Tree		+	+
104	*Phyllanthus gardnerianus* (Wt.)Baill.	Herb	+		
	FABACEAE (Caesalpinioideae)	Tree			
105	*Bauhinia malabarica* Roxb.	Tree	+		
106	*Cassia fistula* L.	Tree	+		
	FABACEAE (Mimosoideae)				
107	*Entada phaseoloides* (L.) Merr.	Lianae	+		
108	*Mimosa diplotricha* Wright ex Swanv.	Straggling shrub			+
109	*Mimisa pudica* L.	Herb			+
110	*Senegalia caesia* (L.) Maslin, Seigler & Ebinger	Woody climber			+
	FABACEAE (Papilionoideae)				
111	*Erythrina stricta* Roxb.	Tree			+
112	*Centrocema pubescens* Benth.	Herb	+		+
113	*Crotalaria retusa* L.	Herb	+		
114	*Desmodium triquetrum* (L.) DC.	Herb	+		
115	*Desmodium heterocarpon* (L.) DC.	Herb	+		
116	*Desmodium heterophyllum* (Willd.) DC.	Herb	+		+
117	*Mucuna pruriens* (L.)DC.	Climber	+		
118	*Pterocarpus marsupium* Roxb.	Tree	+		
119	*Spatholobus parviflorus* (Roxb. ex DC.) O. Ktze.	Woody climber	+		
	FLACOURTIACEAE				
120	*Flacourtia montana* Grah.	Tree	+		
121	*Hydnocarpus pentrandrus* (Buch.-Ham.) Oken	Tree	+		
122	*Scolopia crenata* (Wt & Arn.) Clos.	Tree	+		
	GENTIANACEAE				
123	*Canscora diffusa* (Vahl) R. Br. ex. Roem. & Schult.	Herb		+	
	GESNERIACEAE				
124	*Henckelia pradeepiana* Nampy, Manudev et Weber	Herb		+	
	HAEMODORACEAE				
125	*Ophiopogon intermedius* D. Don	Herb	+		+
	HYPOCRATACEAE				

126	*Salacia beddomei* Gamble	Woody climber	+		
	HYPOXIDACEAE				
127	*Molineria trichocarpa* (Wight) Balakr.	Herb	+		
128	*Peliosanthes teta* Andr.	Herb	+		+
	ICACINACEAE				
129	*Gomphandra tetrandra* (Wall.) Sleumer	Shrub	+		
	LAMIACEAE				
130	*Callicarpa tomentosa* (L.) Murray	Shrub			+
131	*Clerodendrum infortunatum* L.	Tree	+		
132	*Coleus malabaricus* Benth.	Herb	+		
133	*Vitex altissima* L. f.	Tree	+		
	LAURACEAE				
134	*Actinodaphne malabarica* Balak.	Tree	+		
135	*Cinnamomum malabatrum* (Burm. f.) Blume	Tree	+		+
136	*Litsea coriacea* (Heyne ex Meisn.) Hook. f.	Tree	+		
137	*Litsea floribunda* (Bl.) Gamble,	Tree	+		
138	*Neolitsea cassia* (L.) Kosterm.,	Tree	+		
139	*Machilus glaucescens* (Nees.) Wight	Tree	+		+
	LEEACEAE				
140	*Leea indica* (Burm. f.) Merr.	Shrub		+	+
	LENTIBULARIACEAE				
141	*Utricularia reticulata* Sm	Aquatic herb		+	
	LILIACEAE				
142	*Smilax zeylanica* L.	Climbing shrub	+	+	
	LOGANIACEAE				
143	*Fagraea ceilanica* Thunb.	Epiphytic shrub	+		
144	*Strychnos aenea* Hill	Woody climber	+		
	LORANTHACEAE				
145	*Dendrophthoe falcata* (L. f.) Ettingsh	Parasitic shrub	+		
146	*Microsolen parasiticus* (L.) Dancer	Parasitic shrub	+		

	MALVACEAE				
147	*Hibiscus furcatus* Willd.	Climber			+
148	*Julostylis polyandra* Ravi & Anil Kumar	Tree			+
149	*Sida acuta* Burm. f.	Shrub			+
150	*Sida cordifolia L.*	Shrub	+		
151	*Sida rhombifolia* L.	Shrub			+
152	*Urena lobata* L.	Shrub			+
	MARANTACEAE				
153	*Indianthus virgatus* (Roxb.) Suksathan & Borchs.	Shrub		+	+
	MELASTOMATACEAE				
154	*Medinilla beddomei* Clarke	Epiphytic climber	+	+	
155	*Memecylon edule* Roxb.	Tree	+		
156	*Miconia crenata* (Vahl) Mich.	Shrub			+
157	*Osbeckia octandra* DC.	Shrub			+
158	*Sonerila sahyadrica* Giri & Nayar	Herb		+	
159	*Sonerilla rheedii Wall. Ex Wight & Arn*	Herb	+		
	MELIACEAE				
160	*Dysoxylum malabaricum* Bedd. ex Hiern	Tree	+		
161	*Toona ciliata* Roem.	Tree	+		+
	MENISPERMACEAE				
162	*Cyclea peltata* (Lam.)Hook. f. & Thoms.)	Climber	+		
	MORACEAE				
163	*Artocarpus hertophyllus* Lam.	Tree		+	
164	*Artocarpus hirsutus* Lam.	Tree			+
165	*Ficus beddomei* King	Tree	+		
166	*Ficus exasperata* Vahl	Tree			+
167	*Ficus nervosa* Heyne ex Roth	Tree	+		
168	*Ficus hispida* L. f.	Tree			+
	MYRISTICACEAE				
169	*Myristica dactyloides* Gaertn	Tree	+		+
170	*Knema attenuata* (Hook.f. et Thoms.) Warb.	Tree	+		
	MYRTACEAE				
171	*Syzygium cumini* (L) Skeels	Tree	+		+
172	*Syzygium gardneri* Thwaitsii	Tree	+		
173	*Syzygium lateum* (Buch-Ham.) Gandhi	Tree	+		

174	*Syzygium mundagam* (Bourd.) Chithra	Tree	+		
	MYRSINACEAE				
175	*Embelia ribes* Burm. f.	Woody climber	+		+
176	*Maesa indica* (Roxb.) A. DC.	Shrub	+		
	OLEACEAE				
177	*Chionanthus mala-elengi* (Dennst.) Green	Tree	+		
178	*Jasminum malabaricum* Wight	Woody climber	+		+
179	*Myxopyrum smilacifolium* Blume	Woody climber	+		+
180	*Tetrapilus dioicus* (Roxb.) Johnson	Tree	+		
	ORCHIDACEAE				
181	*Acampe ochracea* (Lindl.) Hochr.	Epiphyte	+		
182	*Bulbophyllum sterile* (Lam.) Suresh	Epiphyte			
183	*Dendrobium ovatum* (L.) Kraenzl.	Epiphyte	+		
184	*Liparis viridiflora* (Blume) Lindl.	Epiphyte	+	+	
185	*Luisia zeylanica* Lindl.	Epiphyte	+		
186	*Pholidota imbricata* Hook.	Epiphyte	+		
187	*Zeuxine longilabris* (Lindl.) Benth. ex Hook. f.	Herb	+	+	
	OXALIDACEAE				
188	*Biophytum condolleanum* Wigh.		+		+
	PASSIFLORACEAE				
189	*Adenia hondala* (Gaertn.)W.J. de Wilde	Climber		+	
	Passiflora foetida L.	Climber			+
	PIPERACEAE				
190	*Peperomia pellusida* (L.) HBK	Herb			+
191	*Piper hymenophyllum* Miq.	Climber	+		+
	PITTOSPORACEAE				
192	*Pittosporum neelgherrense* Wight & Arn.	Tree			+
	PLANTAGINACEAE				
193	*Dopatrium junceum* (Roxb.)Buch.-Ham ex Benth	Aquatic herb			+
194	*Limnophila heterophylla* Benth.	Aquatic herb		+	
195	*Torenia bicolor* Dalz.	Herb	+		

	PODOSTEMACEAE				
196	*Polypleurum wallichii* (R. Br. ex. Griff.) Warm	Aquatic herb			+
	POACEAE				
197	*Arundinella ciliatea* (Roxb.) Nees ex Miq.				+
198	*Axonopus compressus* (Sw.) P. Beauv.	Herb			+
199	*Bambusa bambos* (L.) Voss	Wody grass	+		
200	*Chrysopogon zeylanicus* (Nees ex Studel) Thw.	Herb	+		
201	*Cyrtococcum trigonum* (Retz.) A. Camus	Herb	+		+
202	*Digitaria ciliaris* (Retz.) Koel.	Herb			+
203	*Dimeria thwaitesii* Hack	Herb			+
204	*Eleusine indica* (Linn.) Gaertn.	Herb			+
205	*Eragrostis unioloides* (Retz.) Nees ex Steud.	Herb			+
206	*Ischaemum ciliare* Retz.	Herb	+		+
207	*Ochlandra scriptoria* (Dennst.) Fischer	Woody grass	+		+
208	*Panicum repens* L.	Herb			+
209	*Paspalum scorbiculatum* L.	Herb			+
210	*Pogonatherum paniceum* (Lam.) Hackel	Herb			+
211	*Pennisetum hohenackeri* Hochst. ex Steud.	Herb			+
212	*Themeda triandra Forssk.*	Herb			+
213	*Tripogon bromoides* Roemer & Schult.	Herb		+	+
	POLYGALACEAE				
214	*Polygala arvensis* Willd.	Herb	+		+
	POLYGONACEAE				
215	*Persicaria chinensis* (L.) Gross	Climber	+		+
	RANUNCULACEAE				
216	*Naravalia zeylanica* (L.) DC.	Climber	+		
	RHAMNACEAE				
217	*Gouania microcarpa* DC.	Woody climber			+
218	*Zizyphus oenoplia* (L.) Miller	Woody Climber	+		+

	RUTACEAE				
219	*Clausena heptaphylla* (Roxb.)Wt. & Arn.	Shrub	+		
220	*Toddalia asiatica* (L.) Lamk.	Woody climber			+
	RUBIACEAE				
221	*Chassalia ophioxyloides* (Wall.) Carib	Shrub	+		
222	*Diodia teres* Walter	Herb			+
223	*Hedyotis corymbosa (L.) Lam.*	Herb	+		+
224	*Ixora agasthyamalayana* Sivad. & Mohanan	Small tree	+	+	
225	*Ixora brachiata* Roxb.	Small tree	+		
226	*Lasianthus acuminatus* Wt.	Small tree	+		
227	*Neurocalyx calycinus* (R. Br. ex Benn.)Rob.	Herb	+		
228	*Ophiorrhiza mungos* L.	Herb	+		
229	*Pavetta indica L.*	Shrub	+		
230	*Psychotria flavida* Talbot	Shrub	+		+
231	*Richardia scabra* L.	Herb			+
232	*Rubia cordifolia* L.	Climber	+		
233	*Saprosma foetens* (Wight) Schum	Shrub	+		
234	*Scleromitrion neesianum* (Arn.) Nandikar	Herb			+
235	*Spermacoce hispida* L.	Herb			+
236	*Spermacoce mauritiana* Osea Gideon ex Verd.	Herb			+
	SAPINDACEAE				
237	*Allophylus cobbe* (L.) Raeusch.	Small tree	+		
238	*Dimocarpus longan* Lour.	Tree	+	+	+
239	*Lepiaanthes erecta* (Thw.) Leenh.	Small tree	+		
240	*Schleichera oleosa* (Lour.) Oken	Tree	+		
	SAPOTACEAE				
241	*Isonandra perrottiana* A. DC.	Shrub	+		
242	*Madhuca neriifolia* H.J. Lam.	Tree			+
243	*Palaquium ellipticum* (Dalz.) Baill.	Tree	+		
	STERUCULIACEAE				
244	*Helicteres isora* L.	Shrub	+		
245	*Pterospermum rubiginosum* Heyne ex Wt	Tree	+		
246	*Sterculia guttata* Roxb.ex DC.	Tree	+		

	SYMPLOCACEAE				
247	*Symplocos cochinchinensis* (Lour.) Moore ssp. *laurinia* (Retz.) Nooteb.	Tree			
	THEACEAE				
248	*Polyspora obtusa* (Wall. ex. Wt. & Arn.) Nissalo & Choo	Tree	+		+
	TILIACEAE				
249	*Grewia tiliifolia* Vahl	Tree			+
250	*Triumfetta rhomboidea* Jacq.	Shrub			+
	URTICACEAE				
251	*Debregeasia longifolia* (Burm. f.) Wedd.	Small tree	+	+	+
252	*Elateostema lineolatum* Wight	Herb	+	+	+
253	*Laportea interrupta* L. Chew.	Shrub	+		
254	*Pilea melastomoides* (Poiret) Wedd.	Herb	+		
255	*Pellionia heyneana* Wedd.	Herb			+
256	*Pouzolzia zeylanica (L.) Benn.*	Herb			+
	VITACEAE				
257	*Cayratia pedata* (Lam.) Juss. ex Gagnep.	Climber			+
258	*Tetrastigma nilagiricum* (Miq.) Shetty	Climber			+
	XANTHOPHYLLACEAE				
259	*Xanthophyllum flavescens* Roxb.	Tree	+	+	+
	ZINGIBERACEAE				
260	*Zingiber zerumbet* (L.) Sm.	Herb	+		

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