IMPROVING THE METHODOLOGIES ADOPTED FOR ASSESSMENT OF ENVIRONMENTAL AND SOCIAL IMPACTS OF MINI HYDRO POWER PROJECTS

Eng. R.P.D.I Rohana

(118775C)

Dissertation submitted in partial fulfillment of the requirements for the Degree of Master of Science in Environmental Engineering and Management

Department of Civil Engineering

University of Moratuwa

Sri Lanka

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Declaration

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Research Supervisor

Dr. J.M.A Manathunge

Department of Civil Engineering

University of Moratuwa

March 2016

Abstract

This Research is aim to look at the environmental impacts related to Mini hydro projects in Sri Lanka and to determine the available methodologies for identification of Major Environmental Impacts and the options to mitigate the impacts or avoid impacts. It is also tried to look at the monitoring process conducted by project Monitoring Committee during the implementation of mitigations and the public participation in the IEE/EIA process.

In this research, twelve mini hydro projects were studies by collecting data from field studies and IEE reports by focusing Environmental Methodologies used and the Monitoring Process of the Projects. The collected data from the twelve Mini Hydro Power Projects are analyzed and discussed comparatively to standards and guidelines in Sri Lanka..

The research observed that the exact gap between predicted impact and the implemented impact is cannot be analysis. In addition, it was observed that the IEE report does not mentioned methods of impact identification. This is a weakness of submission IEE report as well as Term of Reference (TOR). TOR should be laid down the condition that the method of impact identification should be included in the IEE report. All the projects taken to research have neglected the monitoring process and which is an important part of IEE and EIA. The Environmental Monitoring process is not compressive and PP had violated mitigation as well as the conditions stipulated by the PAA. Hence, Monitoring process must be improved to implement of Predicted mitigations satisfactorily.

The IEE reports of Sri Lanka are not in unique order, similar to other countries like India. Sri Lanka must have proper stand guideline to be followed by Mini hydro Project

As per the studies, the Mini Hydro Projects have to face challenge such as heavy flood, blasting hazards, Landslides and soil erosion. These challenges can be overcome by proper planning and management.

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List of Abbreviations

CEA – central environmental Authority

DS- Divisional Secretariat

EIA Environmental Impact Assessment

GN- Grama Niladari

IEE – Initial Environmental Examination

MHP – Mini Hydro Power Project

NEPA – National Energy Acct

NGO – Non- Governmental Organizations

PAA – project Approving Agency

PP- Project Proponent

PS- Pradeshiya Sabha

TEC – Technical Evaluation Committee

TOR- Term of Reference

USAID- United State Agency for International Development

Chapter 1- Introduction

1. Introduction

This Research is aimed to look at the environmental impacts related to Mini hydro projects in Sri Lanka and to determine the available methodologies for identification of Major Environmental Impacts and the options to mitigate the impacts or avoid impacts. It tries to look at the monitoring process conducted by project Monitoring Committee during the implementation of mitigation and the public participation in the IEE/EIA process. The following chapter will introduce the history of IEE/EIA process, standard and legality behind the IEE/EIA process in Sri Lanka and other countries. It also includes the objective of the research and the reason for the selection of Mini Hydro Projects as the target Development Projects**.**

1.1 History of EIA /IEE Process in the World

Environmental Impact Assessment (EIA) is a system for identifying and introducing mitigation measures to prevent and avoid environmental adverse impacts caused by the development projects. EIA is also an effective instrument to achieve sustainable development.The concept of sustainable development was introduced at the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil in 1992. Principle 4 of the Rio Declaration, stated*"In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it."* Principle 17 stated that *"Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have significant adverse impacts on the environment and are subject to a decision of a competent national authority."* In other words, integration of environmental consideration into any development project is required and EIA is the system to achieve this goal. For this reason, EIA has become increasingly significant in recent years.

The origin of Environmental Impact Assessment system started with the enactment of the National Environmental Policy Act (NEPA) in 1969 by the U.S. In 1981, the US Agency for International Development (USAID) revised the National Environmental Policy Act (NEPA). By its revision, Environmental impact assessment (EIA) became a mandate to development assistance project. This was the first attempt to introduce EIA systems in the field of development assistance.

The objective of environmental impact assessment is to offer information to decision makers concerning matters that may be brought about as a result of decisions relating to a new project, program, plan or policy. Environmental impact assessment must realize decision-making based on the input information including potentially important factors and it must be beneficial to both the proponent and the people. Furthermore, environmental impact assessment is a technique that presents in a systematic manner a technical assessment of impacts on the environment that the project is likely to cause and explains the significance of predicted impact. As a result, it indicates the scope for modification or mitigation. Finally, it makes the concerned ministries/agencies to assess the potential results of the project before a decision is given. Project developers and administrative agencies who have a responsibility for environmental consideration can use environmental impact assessment technique to improve the quality of both the project plan and decision-making by identifying possible effects in the early stages. The specific objective of the environmental impact assessment system is as follows:

- To disclose significant environmental effects of proposed projects to decision-makers and the public.
- To identify ways to avoid or reduce environmental damage.
- To prevent adverse environmental impacts by requiring implementation of feasible alternatives or mitigation measures.
- To disclose reason of approvals for the projects with significant environmental impacts to the public.
- To foster interagency co-ordination.
- To enhance public participation. [1]

1.2 History of EIA /IEE Processing Sri Lanka

The concept of Environmental Impact Assessment was introduced in Sri Lanka in the early 1980s. The National Environmental Act No. 47 of 1980 was our basic national charter for protection and Management of the Environment. The National Environmental (Amendment) Act No. 47 of 1980 was enacted in 1988 in Sri Lanka. This was immediately followed by the Coast Conservation Act in 1981, which empowered the Director of Coast Conservation to request Environmental Impact Assessments for development projects located in the coastal zone of Sri Lanka.

However, until the passage of the amended National Environmental Act No. 57 of1988 impact assessments were not required for energy developments. However the Act of 1988 forms the primary basis for the legal and regulatory framework for energy developments in Sri Lanka today.

Prior to the passage of the amended National Environmental Act, considerable protests from the public focused governmental and public attention on the Environmental Impact Assessment process. The need to provide a legal framework for Environmental Impact Assessment and the training of professionals were recognized by the government even before the corresponding laws came up to operation . The amended National Environmental Act of 1988 is supported by a set of Orders and Regulations published by the Minister of Environment. These Orders and Regulations interpret the law and set down the requirements for preparing an environmental assessment that complies with the Act.

The first two Orders and 18 regulations were published by the Minister for Environment in 1993. One of the Orders designated 14 state agencies as project approving agencies, and the second Order specified the types of projects that required either an Initial Environmental Examination or a full Environmental Impact Assessment.

The first Order which designated, the project approving agencies, was revised in 1995and the agencies were separated up to two categories..

The prescribed projects that require environmental impact assessment have been categorized as follows:-.

Projects which are located wholly or partly within the coastal zone.
Projects which are located outside the coastal zone

The Environmental Impact Assessment Process in Sri Lanka requires immediate coordination between the developer and the Central Environmental Authority.

There are eight basic steps of the EIA process in Sri Lanka which should be observed the beginning with submittal of preliminary information about the project in(Table 1.1).

The preliminary information is submitted for the project Approving Agency to determine of whether or not an EIA report is required for the project. For this reason alone, the project proponent must discuss the project with the Project Approving Agency in the early stages of planning the project. Generally, the Preliminary Information submitted would include a general description of the project, location of the project, its scope and any other information requested by the Project Approving Agency. In the Preliminary Information its include maps of the area and general layout of the proposed energy development requested by the Project approving agency. The Preliminary Information Package would be similar to the information contained in a pre-feasibility reporting Sri Lanka. The list of issues to be discussed in the EIA is usually defined by the Project Approving Agency in consultation with the project proponent. This approach is somewhat different from the approach adopted in other countries where the Scoping Document forms the basis for the Terms of Reference (TOR) as other countries the project proponent is solely responsible for identifying the specific issues that will be addressed.

Generally, the Environmental Clearance for the project will include a number of conditions that the developer must comply with during the construction and operation of the project. These will include the mitigation and compensation measures that are proposed in the EIA, potentially additional measures recommended by the Central Environment Authority, and monitoring programs to assure

compliance with the commitments made in the EIA report**.** Prior to presenting the EIA in its final form it is often recommended that the project proponent submits a draft of the EIA to the Authority to gain comments and recommendations for preparing the final EIA. Generally, the Authority will provide comments on the draft of the EIA that will enable them to make a final review of the EIA and approve the EIA. The review process will consist of two basic procedures. The first aspect of the review will be to ensure that the legal requirements are addressed within the EIA report. This is to ensure that the EIA is comprehensive and fulfills the requirements that are identified in the legal framework. The second aspect of the review is relative to the technical aspects of the EIA. The review will focus on adequate description of the existing conditions in the proposed project site. This is followed by a review of the impact assessment of the project and a determination of the significance of the impacts that are anticipated during the construction and operation of the project.

The review of the impact assessment will concentrate on whether the assessment of impacts is believable and if there is sufficient support for the analysis of the impacts. This is then followed by a review of the mitigation and compensation measures that are proposed for incorporation into the design and operation of the project. One of the basic premises for review of the mitigation and compensation measures is to determine if the proposed measures will be effective in mitigating the impacts and what residual impacts will occur. This review will focus on both environmental and social impacts and the mitigation and compensation plans that will accompany those effects. The final aspect of the review will focus on the Environmental Management and Monitoring Plan. This plan is designed to enable implementation of the mitigation and compensation measures (including any rehabilitation program that is required) and will identify the organizations that will be responsible for the implementation.

In addition, the review of the Environmental Management and Monitoring Plan will evaluate the proposed monitoring programs that are to be designed to determine the actual effects of the project as well as to evaluate the effectiveness of the proposed mitigation and compensation measures. Based on the results of the review, the

Central Environment Authority will recommend either that the EIA be approved or rejected.

1.3 Major steps in the current EIA Procedure

1.3.1 EIA and IEE Process in Sri Lanka

1.3.1.1 The EIA Process

In the event that an EIA is required, the Project approving Agency in consultation with CEA is responsible for subjecting the preliminary information to environmental scoping, in order to set the Terms of Reference (TOR) for the EIA. The TOR is prepared by a Technical Evaluation Committee (TEC) comprising experts in the relevant field, appointed by the PAA. In developing the TOR, the regulations provide for the PAA to consider the views of state agencies and the public. Upon submission of the EIA by the proponent, the PAA is required to determine whether issues referred to in the TOR have been addressed and notify the proponent of any inadequacies within 14 days.

In the event any inadequacies are identified, the proponent is required to make necessary amendments and resubmit the report. Once accepted, in addition to the EIA being forwarded to the CEA by the PAA, notice is also placed in the Government Gazette and in a national newspaper published daily in Sinhala, Tamil and English languages inviting the public to make written comments, if any, to the PAA within 30 days from the date of first appearance of the notice. According to the legislation, public consultation is mandatory is only at this stage of the EIA process.

Informal consultation with NGOs, interested groups and civil society may occur during early stages of the EIA as determined by the PAA depending on the type of project and public interest in the project. The notification would specify the times and places at which the EIA would be available to the public. As a minimum the report would be available at the CEA, PAA and in a GOSL agency in the locality of the proposed project. The environmental regulations have provisions for public hearings on the project although it is not mandatory. The PAA can use its discretion and hold a public hearing if it would be in the interest of the public. The PAA is

required to forward all comments, either written or raised during any public hearing, to the project proponent for review and response within 6 days of completion of the public comment period. The proponent is required to respond to all such comments in writing to the PAA.

The TEC appointed by the PAA would then evaluate the EIA and require the project proponent to respond to any queries raised by the TEC. The TEC would also evaluate the adequacy of the proponent's response to any comments raised during the public comments period. Upon completion of the evaluation of the TEC, the PAA with the concurrence of the CEA would grant approval for the implementation of the proposed project subject to specified conditions or refuse approval for implementation of the project, with reasons for doing so. The notification must be made within 30 days of the receipt of responses from the proponent.

The PAA is required to specify a period within which the approved project should be completed. In the event the proponent is unable to complete the project within the specified period, written permission for an extension has to be obtained from the PAA, 30 days prior to the expiration date. The PAA is responsible for forwarding a report which contains a plan for monitoring the implementation of the approved project, to the CEA, within 30 days from granting approval. It is also the responsibility of the PAA to publish in the Government Gazette and in one national newspaper published in Sinhala, Tamil and English languages, granting approval for the project. It is mandatory that the project proponent informs the PAA of any alterations to the project as approved and/or the abandonment of the project. The PAA shall, where necessary, obtain fresh approval in respect of any such alterations that are intended to be made to the approved project. The PAA in consultations with the CEA would also determine the scope and the format of the supplemental report required to be submitted for such alterations.

1.3.1.2 The IEE Process

Upon review of the preliminary information provided by the proponent, if the PAA determines that the project would have no long-term adverse environmental impacts, an initial environmental examination (IEE) would be considered adequate. Under

such circumstances, the proponent will be required to submit a detailed IEE for review and approval by the PAA. The IEE will identify potential environmental and social issues and the complexity of possible remedial actions. Upon reviewing the IEE, if the TEC identifies any substantial environmental issues that may arise as a result of the proposed project, the proponent will be required to undertake a detailed EIA. In the event the IEE is considered adequate, then the project proponent is requested to prepare an Environmental Management Plan (EMP), to address any potential environmental and social issues as well as incorporate the PAA/CEA's approval conditions. The IEE review process is similar to the EIA review process, except for the level of detail and analysis involved, which is proportionate to the anticipated environmental and social impacts.

The CEA has developed a custom made IEE questionnaire for mini hydropower projects. The Environmental Questionnaire for Mini Hydro Projects is more detailed than the general IEE questionnaire and is designed to capture environmental issues specific to mini hydro projects. This questionnaire is used by the CEA/PAA to determine whether the potential project results in long term irreversible or complex environmental and social issues and if so, it warrants an EIA. If no EIA is required, the proponent is required to prepare an Environmental Management Plan (EMP) which contains remedial measures to address adverse environmental and social issues. The IEE is not required by law to be opened for the public for comments and does not go through the public consultation process required for an EIA.

The CEA review is based on the list of prescribed projects listed under provisions of Part IV C of the NEA No. 47 of 1980 as stipulated in Gazette (Extra Ordinary) No. 772/22 dated June 24, 1993. All prescribed projects have to be subjected to environmental assessments, either through IEEs or EIAs.

1.3.1.3EIA / IEE Procedural steps

This Process involves six major steps as in the Table 1.1

Table 1.1 EIA/IEE steps

	Steps	Time allowed for the PAA
1	Screening (Determining whether an EIA / IEE is required for a project)	6 days
2	Scoping (Determining the scope of the EIA / IEE study and issuing of Terms of Reference)	14 days for IEE and 30 days for EIA
3	Preparation of the EIA / IEE report	No time limit has been given since the project proponent is responsible for this.
4	Review of the EIA / IEE report The review involves both public and technical review	
5	(a) Public review (applicable only for EIAs) The project proponent needs to respond to the public comments received.	30 working days
6	(b) Technical review	21 days for IEE and 30 days for EIA.
7	EIA / IEE Decision Granting approval with terms and conditions or rejection with reasons.	
8	Post approval monitoring	

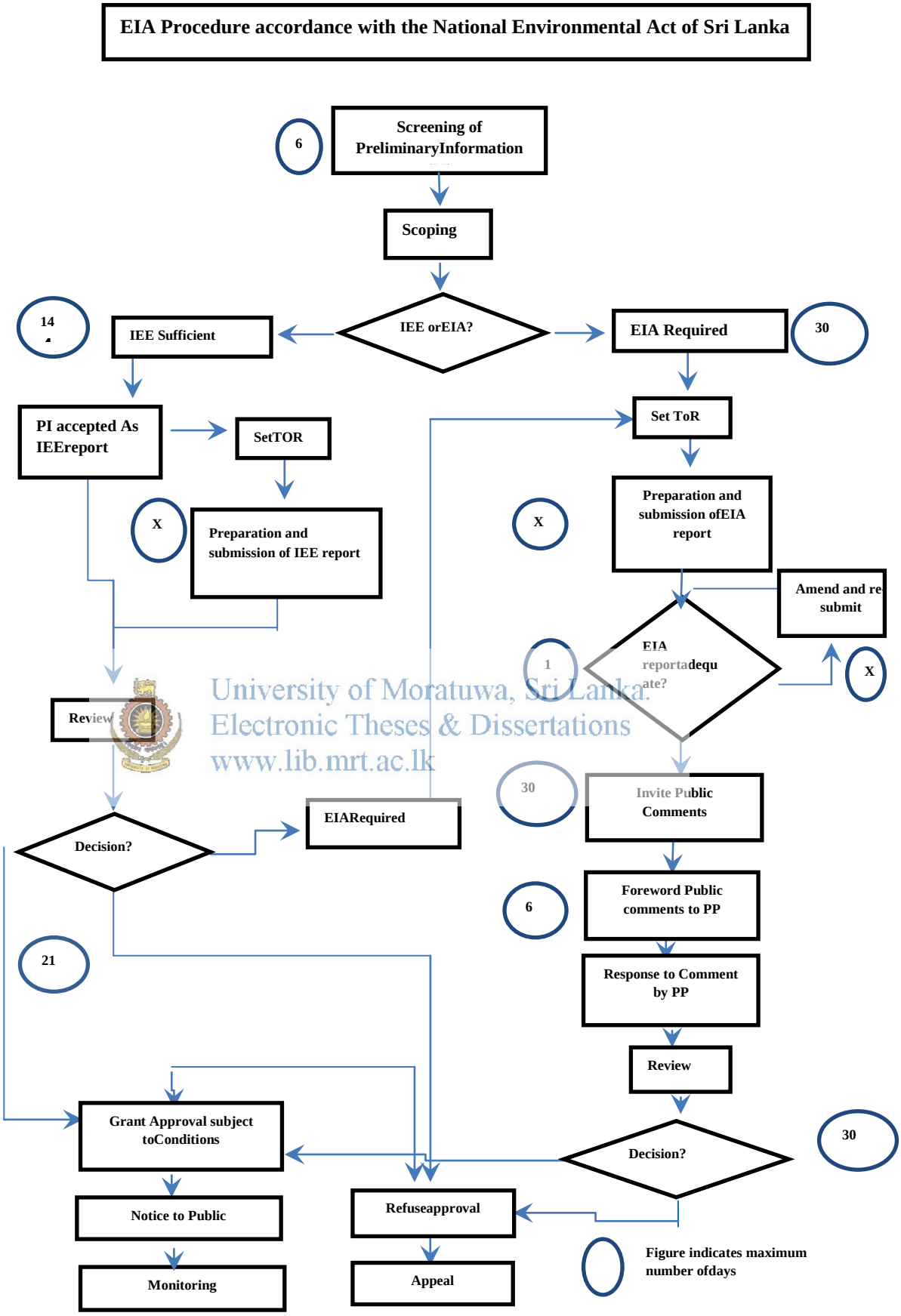

Figure: 1.1 - EIA Procedure accordance with the National Environmental Act of Sri Lanka

1.3.1.3 General Approaches and Methodologies for Assessment

The general principles that shall be used in evaluating the assessment methodologies are described below:

1.3.1.3.1 Description of the Environment: The characteristics of the environment shall be described in a way sufficient for identification and prediction of environmental impacts. Where necessary, baseline environmental surveys shall be carried out to determine the existing environmental conditions on the site and in all environs likely to be affected by the proposed project. The issues described in the EIA study brief shall be investigated and would typically include existing water and sediment quality, air quality, the existing noise environment, ecology, the cultural heritage and the man-made environment. These surveys shall normally include the site of the project, its access, and any other areas likely to be impacted during construction and operation (or decommissioning). The type and duration of baseline surveys shall be such that there will be adequate information taking account of natural variation to define the existing conditions. This information shall form the basis for predicting and evaluating the impacts from the project so that the study objectives can be met. Where appropriate, results from past studies can be used.

1.3.1.3.2 Impact Prediction: The assessment methodologies proposed shall be relevant to the issues to be addressed, shall have been used successfully in similar situations or be demonstrated as acceptable by recognized national/international organizations, and shall be capable of:

(i) Identifying potential impacts, which may be harmful or beneficial to the environment;

(ii) Identifying receivers, habitats or resources, which are vulnerable to change;

(iii) Defining the project/environment interactions;

(iv) Examining the chain of events or "pathways" linking cause with effect;

(v) Describing and predicting the reasonable case scenario and/or the worst case scenario, or such scenarios as required in the EIA study brief; and

(vi) Predicting the likely nature, extent and magnitude of the anticipated changes and effects such that an evaluation, in quantitative terms as far as possible,

1.3.1.3.3 Impact Evaluation:

The methodologies for evaluating the environmental impact shall be capable of addressing the following issues:

(i) The existing or projected environmental conditions without the project in place;

(ii) The projected environmental conditions with the project in place and the sum total of the environmental impacts taking into account all relevant existing, committed and planned projects;

(iii) A differentiation between the environmental impact caused by the project and that caused by other projects, and to what extent the project aggravates or improves the existing or projected environmental conditions;

(iv) The environmental impact during different phases of construction and development of the project; and

(v) The evaluation of the seriousness of the residual environmental impacts

1.3.1.3.4 Impact Quantification:

The impact quantification is an important part of an IEE or EIA. Because if, the impact is below the threshold level in keeping with the guideline then impact mitigation is not required Therefore, before the impact mitigation quantification is required to identify the required amount and method of Mitigation.

Dust Emission due Vehicle Movement

$$\mathbf{E = (0.81S)\left(\frac{S}{30}\right)\left(\frac{365-w}{365}\right)}\text{---------- Eq. (01)}$$

Where E = Dust Emission factor, lb per vehicle – mile

s- Silt content of road surface material %

S = average Vehicle speed mi/ hr

w = Mean annual number of days with 0.01 in (0.254mm) or more of rain fall

Mass balance Approaches

The law of conservation of matter states that matter is conserved--that is, neither created nor destroyed. Thus, if we know the amount of material that enters a chain of processes, and keep an account of all the amounts in different paths, we can calculate the quantities of materials that are hard to measure. For example, we can calculate the amount of material entering the atmosphere if we know the amounts that went in, the transformations, and the waste streams to land and water. This method is called the Mass or Material Balance technique.

An example of a process from everyday life is sewage treatment Wastewater is generated in your homes and is collected with the sewer system and transported to a treatment plant. When asked what happens to the sewage at the plant, most people say that the pollutants are removed from the water and the relatively "clean water" is then discharged to a water body. But what happens to the pollutants that are removed? In the treatment process, these pollutants are transferred from the water to the air, and to solid material known as sludge, or bios lids. and, a small amount remains in the "clean water." These waste products must be taken care of so that they do not affect the environment. A mass balance can be used to determine how much pollutant is in each of its various forms.

$$\sum C_{avg} = \frac{\sum CiQi}{\sum Qi} = \frac{\sum Mi}{\sum Qi}\text{----------Eq. (02)}$$

Where, C_{avg} = Average Concentration of Constituent for combined discharge stream

C_i = Concentration of Constituent in i_{th} discharge stream

Q_i = Flow for the i_{th} discharge stream

M_i=Mass of Constituent in i_{th} discharge stream

This mass balance equation can be used to determine

Average downstream concentration

Erosional Impact on water quality during construction or operation.

1.3.1.3.5Impact Mitigation: the methodologies proposed for mitigation shall give priority to avoidance of impacts. The assessment methods shall be capable of:

(i) Identifying and evaluating mitigation measures in order to avoid reduce or remedy the impacts;

(ii) Assessing the effectiveness of mitigation measures; and

(iii) Defining the residual environmental impacts, which are the net impacts remaining with the mitigation measures in place.

The assessment methodologies shall allow for the assessment and evaluation of the cumulative environmental effects if the following circumstances apply:

(a) The impacts arising from the project are predicted to extend beyond the boundaries of the project or over a long period of time;

(b) There may be interactions between the environmental impacts of the project, affecting the sum total of its environmental impacts; or

(c) There may be interactions between the environmental impacts of the project and the environmental impacts of other developments, resulting in accumulation of impacts and affecting the sum total of their environmental impacts.

1.4 Background of the Research

This project consists of a case study on selected twelve Mini hydropower plants in Sri Lanka. From this research, the environmental impacts during pre-construction, construction and operation stages were identified. The project includes a literature study on the possible environmental impacts from Mini hydropower, measures that can be taken to mitigate the impacts, information gathering about the twelve different

hydropower plants and an analysis part where the information in the literature review is connected to the situation at the twelve plants. The study has not included any name of Mini Hydro Power plants and stakeholders.

Infrastructure development such as roads and transmissions lines and the environmental impact related to it and mini hydropower plants with surrounding ecosystem have been considered.

1.5 Research needs

The majority of Mini Hydro schemes in Sri Lanka are owned by private sector investors. As a result the possibility of violate Environmental regulations is high. According to research and opinion of the people, it has been observed that the IEE process of the past completed Mini Hydro Projects is not comprehensive and they violate Environmental regulations. In addition to past report and views expressed by the people reveal. That there were many protests against the sever negative, social and environmental impact during the construction pre-construction and operation stages of Mini Hydro Power Projects. (Few of the projects are listed in the research).

The IEE process of Mini hydro project become more complicated due to the following reasons:-

1. The unforeseen impact is high and predicting them is difficult.
2. The projects are highly impacted with scenic beauty and natural resources
3. The geographical situation is more varying one project to other.
4. There is a wide gap between the IEE guideline and the real construction of the project.
5. In the case of multiple projects on the same river, The project activity in the upper part of the stream will directly affect the downstream project.
6. The majority of Developers are private companies and their primary objective is to earn profit and not to sickly comply with Environmental than amenable to regulations.
7. There is inadequate monitoring of Project activities because PAA does not have full time staff, funds and equipment needed for Mini Hydro Projects.

For the above reasons, it has been decided to find out the efficiency and effectiveness of environment impact assessment of the Mini Hydro Project in Sri Lanka.

1.6 Research objective

Based on the above needs the objective of the research is to answer the following questions:-

1. How does a Project proponent identify and predict the impact and to what extent does the proponent quantify the predicted impact?
2. What are the available methodologies for mitigation of Impact? How can they be improved
3. To what extent has the Project proponent implemented the EIA-recommended mitigation measures?
4. How do regulatory bodies ensure implementation of EIA-recommended mitigation measures?
5. How and to what extent did the public participate in the EIA process?
6. What were the likely downstream impacts of the project and to what extent did the proponent take them in to consideration?
7. How do regulatory bodies monitor the mitigation actions and the weaknesses of the Monitoring process?

This research has then proceeded to of activities mentioned below.

A literature survey was conducted through various media such as reference libraries and e- libraries.

The objective based questionnaire was prepared, finalized, and issued to selected twelve mini hydro project owners and stakeholders to gather necessary data.

The gathered data was processed and analyzed using analytic methodologies and interpreted the data for easy identifications.

At finally, according to the results obtained possible suggestions for the improvement have been discussed and a final consideration has been made.

Chapter 2- Literature Review

The purpose of this study, theoretical framework and findings on this topic has been explained further in this chapter.

2.1. Operation of Mini Hydro Projects

Mini Hydropower systems use the energy in flowing water to produce electricity or mechanical energy. The water flows via channel or penstock to turbine where it strikes the turbine, causing the shaft of the waterwheel or turbine to rotate. When generating electricity, the rotating shaft, which is connected to an alternator or generator, converts the motion of the shaft into electrical energy. This electrical energy may be used directly, stored in batteries, or inverted to produce utility-quality electricity.

Mini hydroelectric facility requires that a sizable flow of water and a proper height of fall of water, called head, are obtained without building elaborate and expensive facilities. Mini hydro plants can be developed at existing dams and have been constructed in connection with river and lake water-level control and irrigation schemes. A Mini hydropower project contains various components. The components, as shown in figure 2.1, start from water storage and ends in the transmission. Thus, the major components of a hydropower projects can be listed as follows:

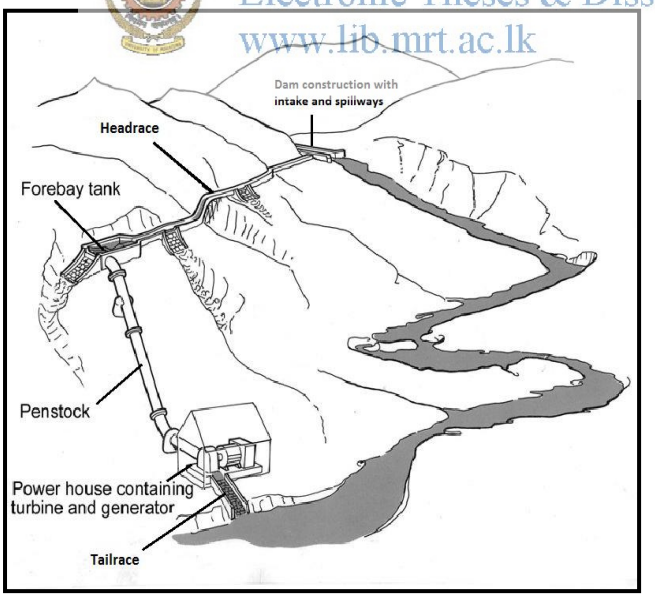

Figure 2.1 Components of a Mini Hydropower

Intake Dam (Weir): An impounding structure to store water for creating head and to assure the controlled and continuous flow.

- **Fore bay tank-** It is a pond-like structure at the top of the penstock, which regulates the fluctuation of water and it forms the connection between the channel and the penstock
- **Penstock:** A pipe from the fore-bay of the dam till the mouth of the turbine serving as a water conductor system.
- **Turbine**: The main electrical installation that helps to transform the mechanical energy of the water into the kinetic energy.
    - **Generator:** An electrical installation to transform mechanical energy of the turbines to electric energy.
    - **Powerhouse:** A civil structure used for electro mechanical installations.
    - **Tailrace channel:** A pool to release the water back into the flowing water body.
    - **Transmission mains:** Transmission units to supply produced electricity to the customer

2.2 Benefits of Mini Hydropower

Hydroelectric systems provide the following general benefits:

- Hydroelectric energy is a continuously renewable electrical energy source.
- Hydroelectric energy is non-polluting - no heat or noxious gases are released.
- Hydroelectric energy has no fuel cost and with low operating and maintenance costs, it is essentially inflation proof.
- Hydroelectric stations have a long life and many existing stations have been in operation for more than 25 years.
- Hydropower station efficiencies of over 90% are achieved making it the most efficient of energy conversion technologies.
- Hydropower offers a means of responding within seconds to changes in load demand.

2.3 Environmental Impacts of Mini Hydropower Projects

A hydropower scheme entails change in use of land and water. Magnitude of such change depends on the selected site configuration. An illustrative site configuration is shown below. The environmental impacts of MHPs are positive (favorable) and negative (undesirable) in nature.

2.3.1 Positive Impacts of MHPs

Positive environmental impacts of Mini hydropower projects are somehow ignored as a routine probably due to the fact that these projects are conveniently considered as demanding an environmental price. It is equally important to highlight and quantify (to the extent possible)

2.3.2Positive Socio-Economic Impacts

1. Project related infrastructure roads, health facilities, education facilities will help the local
2. Improvement in living standard of local people
3. Generation of employment opportunities locally. Direct employment during construction and indirect employment in allied activities
4. Check on migration from villages to towns, thereby checking urban concentration of population
5. It helps in checking deforestation which is taking place to meet food, fodder and fuel demands in rural, remote areas.
6. Small hydro does not require much expertise to build and operate. Components of small hydro projects are simple and fairly visible at site. They can become center of education.
7. In specific cases MHPs are eligible for carbon credits through reduction in CO_2 emission and adding sink for CO_2 via plantation schemes.

2.3.3Positive Ecological/Environmental Impacts

1. Clean and renewable source of energy. MHPs result in saving of non-renewable fuel resources such as coal, fossils.

2. It is benign source of power generation, harnessing only gravitational potential of water to make it yield energy in a continuum

3. Decrease of pollution due to cleaner energy source (hydro replacing diesel generation, electricity replacing polluting energy sources)

4. Increased water surface creates habitat for aquatic life in or near the weir ponding area. Receiving waters create dry mudflats which provide feeding sites for migratory birds and breeding habitat for resident species.

5. Improved ground water table enhancing greenery all around due to landscaping and tree planting.

6. Improvement towards vegetation and plantation associated with the project (compensatory a forestation) and thus providing sink for CO_2 emission

7. Improved habitat due to build environment.

Fauna – aquatic as well as terrestrial. [2]

Table 2.1 Negative Impacts of MHPs

No	Activity	Adverse Impact	Types of Impact (Long term/ shot term /recoverable /irrecoverable)	Methods of Quantification / Qualification	Possible Mitigation methods
01	Construction of road, dam, surface power house and switch yard, diversion tunnel, channel	1. Reservoir sedimentation and deterioration of water quality	1. Short term and recoverable Impact	1. Water quality analysis and Mass balance equation	1. Minimize erosion during construction Planting rapid growing vegetation surrounding the reservoir
		2. Air and noise pollution and disturbance to flora and fauna by work force	2. Short term and recoverable Impact	2. Emission factor calculation and noise level calculation	2. Noise and air emission minimize and sound barrier for noise.
		3. Visual intrusion caused by construction activity	3. Long and short term and recoverable and recoverable. impact	3. field study	3. Used the methods of mimic the natural appearance of them.
		4. Disturbance of recreational spots (e.g. waterfalls) and activities	4. Short term recoverable impact	4. Field study	4. Effort should be taken to minimize the disturbance
		5. Soil erosion due to removal of vegetation and excavation of construction material	5. Short term recoverable Impact	5.Field study and water quality analysis and Mass balance equation	5. Minimize erosion during construction Planting rapid growing vegetation
		6. Alteration in ground water flow	6. Short term recoverable impact	6.Ground water flow calculation and Geological study	6. Minimize the alteration of ground water flow by proving water flow path

					without disturbing natural flow path.
02	Construction of transmission line	1. Damaging flora due to right of way clearing 2. Endangering the lives of fauna 3. Visual intrusion	1.Long term irrecoverable impact 2. Long term irrecoverable Impact 3. Long term irrecoverable impact	1. Field study 2. Field study 3. Field study	1.Compensate damage and select path along the Minimum removal of vegetation 2. Precaution has to used minimize endanger of lives 3. Used the methods of mimic the natural appearance
03	Stream diversion through channel and conduit	1. Loss of habitat of fish and other aquatic flora and fauna 2. Decrease in dilution capacity of stream 3. Depletion in ground water recharge where diversion is taken off from effluent stream 4. Loss of waterfalls and other recreational activities	1. Long term recoverable Impact 2. Long term irrecoverable Impact 3. Long term recoverable Impact 4. Long-term irrecoverable Impact	1. Field study 2. Water quality analysis can be used. 3. Calculation stream flow discharge. 4.Field study	1. Environmental Flow must be maintained. 2. The action must be taken to minimize the contamination of other substance. 3. Maintain continuous environmental flow 4. Take all necessary actions to minimize the impact
04	Ponding	1. Flow disruption	1.Long term irrecoverable impact	1. Flow calculation	1. Take necessary actions to minimize the flow disruption

		2. Channel degradation during generation or spilling and flushing of silt from dam 3. Trapped nutrients and sediments, eutrophication 4. Changed water temperature 5. Changes in land uses: (a) submergence of agricultural and forest land (b) submergence of human settlement and displacement of population (c) submergence of monuments/sites of historic importance (d) loss of whitewater recreation. 6. Change in aquatic plant life and fish species 7. High evaporation rate 8. Sedimentation adversely affects fish spawning areas by burying them 9. Provides increased habitat for mosquitoes and snails which are vectors of diseases like malaria, yellow fever, dengue, encephalitis and schistosomiasis	2.Short term recoverable impact 3.Short term recoverable impact 4. short term recoverable impact 5.Long term recoverable impact 6. Long term recoverable Impact 7. Long term recoverable impact 8 Short term recoverable impact 9. Short term recoverable Impact	2. Calculate from stream flows 3. Water quality analysis 4. Observing the temperature through sensors. 5. Field study 6. Field survey or study 7. Pan evaporation can be used for evaporation rate measurement. 8.Calculate from Mass Balance equation 9. Field study	2. Use a Fore bay tank to control channel flow. 3. Appropriate water treatment has to be made. 4. Control water temperature prevents adverse effect for aquatic flora & fauna. 5. Compensate for the damage and appropriate actions must be taken to minimized damage. 6. Prevent eutrophication or water contamination due to pointed or non point Pollutant. 7. Prevent increase of temperature and maintain lower pond open surface. 8. Minimized the sediment by using soil-stabilizing water retaining equations. 9. The water gathering at river bank without flowing and waste water

05	Operation of hydropower station	1. Increase in pollution concentration in the downstream due to release of pollutants from residential areas, hydropower plant 2. Released water containing low dissolved oxygen 3. Fish mortality from turbine passage 4. Sonic impact: noise level may increase	1.Short term recoverable Impact 2. Short term recoverable Impact 3. Short term recoverable Impact 4. Short term recoverable Impact	1.Water quality Analysis 2. Water quality analysis or Mass balance equation. 3. Field study 4. Calculate the Noise Level or used Measuring Equipment.	1. Pollutant must be collect and dump. Pollutant concentration should be treated to allowable concentration before discharge in to the water. 2. Improve the Oxygen concentration. 3. Trash rack and fish screen must be placed at the intake. 4. Appropriate Noise minimized Process is used Ex. Sand bag wall, green belt.

2.3.5 Provision for Public Participation

Public participation is an important aspect of the EIA process in Sri Lanka. The provision for public participation is contained in the National Environmental Act (NEA).

Once an EIA report is submitted the National Environmental Act provides for public inspection and comment on the EIA report during a mandatory period of 30 days. EIA reports are available for perusal by the public in Sinhala, Tamil and English. These reports are usually kept for public inspection in the CEA Headquarter Library, the relevant Divisional Secretariat Office and Pradeshiya Sabha. Any member of the public may send their comments to the Central Environmental Authority or the respective Project Approving Agency, within 30 working days.

The Project Approving Agency (PAA) publishes notices in the National Newspapers inviting the public to inspect and comment on the EIA report within 30 days. The notice specifies where and when the EIA report can be inspected. The public have a right to obtain copies of the EIA report from the PAA by paying copying charges. A public hearing may also be held at the discretion of the PAA when it is thought that it would be in the public interest to do so.

The public comments received must be sent to the project proponent for response. The project proponent must respond to comments by making every effort to improve the project.

The IEE reports are not required to open for public comments for a mandatory period of 30 days. However, an IEE report shall be deemed to be a public document and shall open for inspection by the public.

In addition to the above mandatory requirement, the project proponents are always advised to have informal dialogues / consultation with the local people during the IEE/EIA study. The project proponent must ensure that the local people get accurate information about the project. If the local community is negatively affected by the

project, it is important that the project proponent consult them and obtain their support in proposing mitigation measures to minimize the impacts. [2]

2.3.6 Environmental Methodologies

Application of Methodologies in EIA Process

Environmental methodologies can be useful, although not specifically required throughout the impact assessment process. Table 2.2 identifies five activities and relevant useful methodologies. It is not necessary to use a methodology entirely in an impact study; it may be instructive to use portion of several methodologies for certain requisite activities. In that regard, methodology selection may be considered a part of an impact study.

Table 2.2 Application of Methodologies in EIA Process

	Process activity	Methodologies		Relative usefulness
1	Impact Identification	Matrices	Simple	High
			Stepped	Medium
		Networks		High
		Checklists	Simple	Medium
			Descriptive	Medium
2	Describing affected environment	Matrices	Simple	Low
			Stepped	-
		Checklists	Simple	High
			Descriptive	-

3	Impact prediction and assessment	Matrices	Simple	Medium
			Stepped	Medium
		Networks		Medium
		Checklists	Descriptive	High
			Scaling , rating, ranking	Low
4	Selection of proposed action (based on evaluation of alternatives)	Matrices	Simple	Medium
			Stepped	Low
		Checklists	Scaling , rating, ranking	Medium
			Weighting-scaling, rating, ranking	High
5	Study summarization and communication	Matrices	Simple	High
			Stepped	Low
		Checklists	Simple	Medium

2.3.6.1 Checklists – Checklists are standard lists of the types of impacts associated with a particular type of project. Checklists methods are primarily for organizing information or ensuring that no potential impact is overlooked. They comprise list questions on features the project and environments impacts. They are generic in nature and are used as aids in assessment

Three types

1. Simple: no information needed on magnitude or importance of impacts"

2. Descriptive, require information on magnitude or importance of impacts as well as indication on prediction methods and indicators."

3. Questionnaires, this is a questionnaire and Answer based analysis. In these methods three types of answer of “yes”, “no”, “may be" can be used. **2.3.6.2**

Matrices - Matrix methods identify interactions between various project actions and environmental parameters and components. They incorporate a list of project activities with a checklist of environmental components that might be affected by these activities. A matrix of potential interactions is produced by combining these two lists (placing one on the vertical axis and the other on the horizontal axis).

They should preferably cover both the construction and the operation phases of the project, because sometimes, the former causes greater impacts than the latter.

Table 2.3 Sample Modified Checklist for Small Reservoir Project

No.	Environmental Impacts	Direct	indirect	Short Term	Long Term	Reversible	Irreversible	Severe	Moderate	insignificant
1	Surface water Hydrology	x			x		x			x
2	Surface water quality	x			x		x	x		
3	Soil/erosion	x			x		x	x		
4	Geology	x			x		x	x		
5	Climate	x			x		x	x		
6	Wildlife Habitat	x			x		x	x		
7	Ecology of Fisheries	x			x		x	x	x	
8	Inundation area	x			x		x		x	
9	Water Quality and Quantity	x			x		x	x		
10	Water supply for downstream irrigation	x			x	x				x
11	Human and Animal toxics of water	x			x	x				x
12	Air quality		x		x		x			x
13	Reservoirs related recreation		x		x		x	x		
14	Visual resources - Natural and cultural Features	x			x		x	x		
15	Visual Resources - Reservoir	x			x		x			x
16	Visual resources - Natural or cultural landscape	x			x					x
17	Irrigation district	x			x	x		x		
18	Increase of the local revenue		x		x	x		x		
19	Employment for Irrigation farmers	x			x		x	x		
20	Land use development for Irrigation	x			x		x		x	

However, matrices also have their disadvantages: they do not explicitly represent spatial or temporal considerations, and they do not adequately address synergistic impacts. Sample Matrix shown in the Table 2.4.

2.3.6.3 Networks – These caused effect flow diagrams which are used to help in tracing the web relationships that exist between different activities associated with action and environmental system with which they interact. They are also important in identifying direct and cumulative impacts. They are more complex and need expertise for their effective use. A sample Network Analysis shown in Figure 2.2 [3]

Table 2.4- Environmental Impact Matrix

	Project Activities	Environmental Components														
		Physical							Biological			Human Environment				
		Geology	Ground Water Quality	Hydrology	Surface Water Quality	Air Quality	Noise Level	Vibration Level	Terrestrial Flora	Terrestrial Fauna	Stream Ecology	Land Use	Traffic	Socio Economic	Public Health	Risk
1.0	Pre-Construction Phase															
1.1	Geotechnical investigation and site survey	N														
1.2	Land Acquisition													S		
2.0	Construction Phase															
2.1	Site Clearing and Earthworks	S, Si		S, N			S, Si	S, N	P, N	P, N				S, B		
2.2	Establishment of Temporary Building				S, N							S, N			S, N	
2.3	Transportation of Materials and Equipment					S, N	S, N						S, N			
2.4	Storage and Handling of Construction Materials				S, N	S, N		S, N								
2.5	Construction of Access Road	S, Si			S, Si	S, Si	S, Si				S, Si			S,B		
2.6	Construction of Sanitary Landfill	S, Si	S, N		S, N									S,B		
2.7	Disposal of Construction and Biomass Waste				S, Si	S, Si										
3.0	Construction Phase															
3.1	Waste Transportation					L, Si							JI – L, Si J2 – N	N		N
3.2	Land filling Activities	L, Si				L, Si	Si	N								
3.3	Land Clearing for Opening of More Cell in Stages to Receive Waste	S, Si														
3.4	Leachate Generation		Si	B	Si	Si			N		N					
3.5	Landfill Gas Generation															
4.0	Post-Closure Phase															
4.1	Final Cover and Landscaping	N							N	N						
4.2	Leachate Generation		Si		Si											
4.3	Landfill Gas Generation					Si										
4.4	Waste Stabilization															N

LEGEND: S = Short Term , L = Long Term , P = Permanent , N = Not Significant , B = Beneficial , Si = Significant

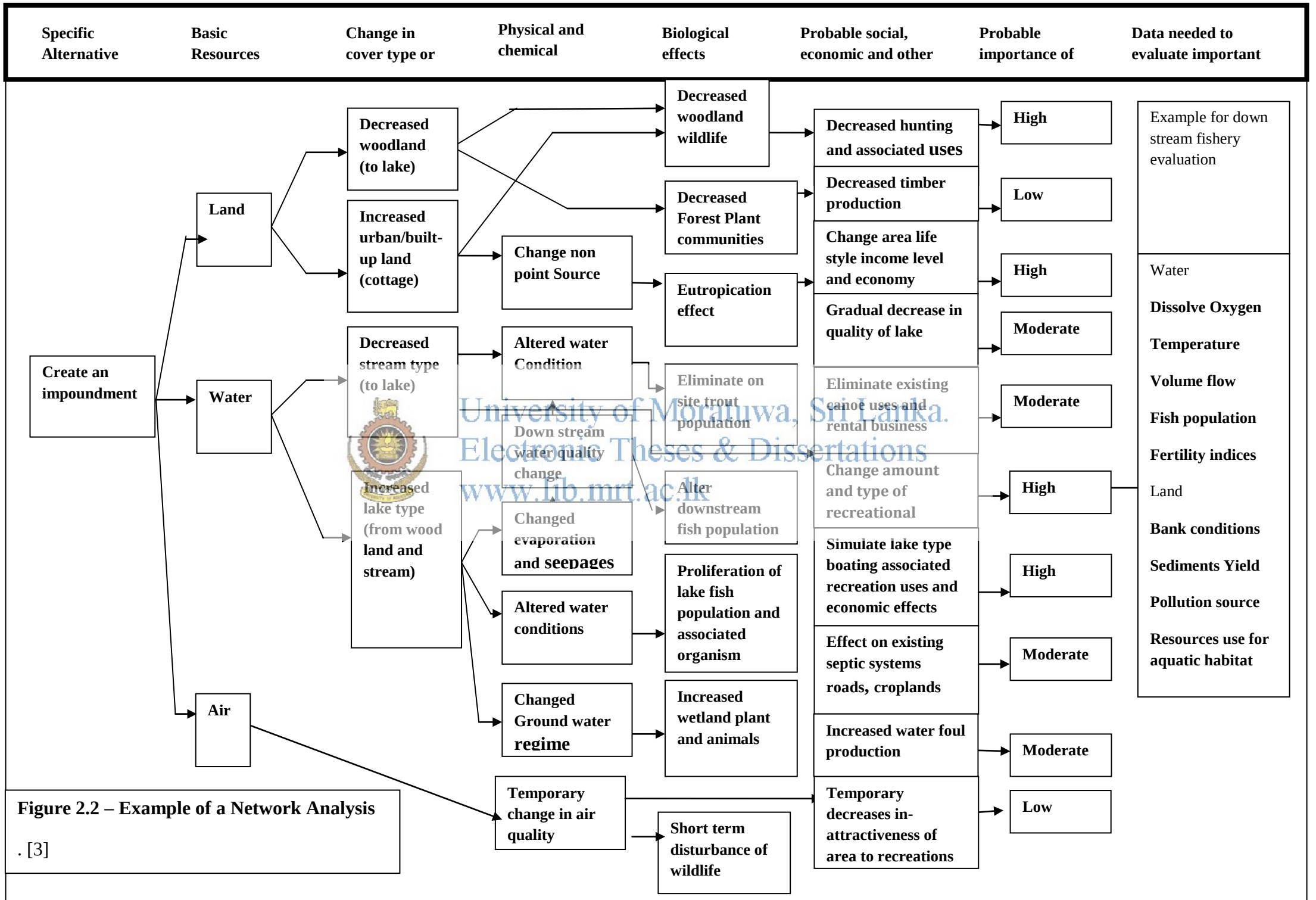

Figure 2.2 – Example of a Network Analysis

. [3]

2.3.6.4 Expert Opinion –This one is suitable for IEE/Scoping/TOR report preparation of sector checklist. In this method subject expert opinion is sought by small meeting, conference, seminar, several small groups. However there can be danger in this when excessive consultation is done and some unjustifiable impacts included in the ToR. This method is simple and required limited resources.

2.3.7 Baseline data collection

The term "baseline" refers to the collection of background information on the biophysical, social and economic settings proposed project area. Normally, information is obtained from secondary sources, or the acquisition of new information through field samplings, interviews, surveys and consultations with the public. The task of collecting baseline data starts right from the period of project inception; however, a majority of this task may be undertaken during scoping and actual EIA.

2.3.7.1 Baseline data is collected for two main purposes

To provide a description of the current status and trends of environmental factors (e.g., air pollutant concentrations) of the host area against which predicted changes can be compared and evaluated in terms of significance, and to provide a means of detecting actual change by monitoring once a project has been initiated

Only baseline data needed to assist prediction of the impacts contained in the ToR and scoping report should be collected.

2.3.8 Impact analysis and prediction

Predicting the magnitude of a development likely impacts and evaluating their significance is core of environmental assessment process. Prediction should be based on the available environmental baseline of the project area. Such predictions are described in quantitative or qualitative terms

2.3.9 Considerations in impact prediction

2.3.9.1 Magnitude of Impact: This is defined by the severity of each potential impact and indicates whether the impact is irreversible or, reversible and estimated

potential rate of recovery. The magnitude of an impact cannot be considered high if a major adverse impact can be mitigated.

2.3.9.2 Extent of Impact: The spatial extent or the zone of influence of the impact should always be determined. An impact can be site-specific or limited to the project area; a locally occurring impact within the locality of the proposed project; a regional impact that may extend beyond the local area and a national impact affecting resources on a national scale and sometimes trans-boundary impacts, which might be international.

2.3.9.3 Duration of Impact:

Environmental impacts have a temporal dimension and needs to be considered in an EIA. Impacts arising at different phases of the project cycle may need to be considered. An impact that generally lasts for only three to nine years after project completion may be classified as short-term. An impact, which continues for 10 to 20 years, may be defined as medium-term, and impacts that last beyond 20 years are considered as long-term.

2.3.9.4 Significance of the Impact:

This refers to the value or amount of the impact. Once an impact has been predicted, its significance must be evaluated using an appropriate choice of criteria. The most important forms of criterion are: Specific legal requirements e.g. national laws, standards, international agreements and conventions, relevant policies etc.

2.3.9.5 Public views and complaints

Threat to sensitive ecosystems and resources e.g. can lead to extinction of species and depletion of resources, which can result, into conflicts. Geographical extent of the impact e.g. has trans- boundary implications. Cost of mitigation, Duration (time period over which they will occur) Likelihood or probability of occurrence (very likely, unlikely, etc.), Reversibility of impact (natural recovery or aided by human intervention), Number (and characteristics) of people likely to be affected and their locations Cumulative impacts e.g. adding more impacts to existing ones. There is an

uncertainty in prediction due to lack of accurate data or complex systems. Precautionary principle is advocated in this scenario.

2.3.10 Impact prediction methodologies

Several techniques can be used in predicting the impacts. The choices should be appropriate to the circumstances. These can be based on Professional judgment with adequate reasoning and supporting data. This technique requires

2.3.11 Types of Environment

2.3.11.1Biological Environment

2.3.11.1.1 Aquatic

Aquatic ecosystem to be studied over an area at least between 2km upstream of the project site and at least 2 km downstream of the project site. The study should include the following:

(a) Fish species of commercial value

(b) Resident species

(c) Migratory species, their spawning ground, fish morphology, anatomy, feeding pattern, breeding pattern etc. Aquatic ecological analysis may be made following the methods outlined in Wetzeland Likens (1991) and APHA (1998). Periphyton, phytoplankton, macrobenthosand zooplankton should be studied for frequency, density, abundance and diversity indices.

2.3.11.1.2Terrestrial

An inventory of flora, listing of rare, endangered, economically important and medicinal plant species should be prepared and their frequency, abundance and density should be determined. Quadrate method is generally used for sampling.

2.3.11.1.3Flora

(a) Major forest products and dependability of the local communities on these such as fuel wood, edible species, construction material etc.

(b) Forest type

(c) Trees, shrubs, herbs

(d)Rare and endangered species

(e) Endemic species

(f) Economically important species

2.3.1.1.1.4 Fauna

(a) Aerial distance of National Park/Sanctuary/Biosphere Reserve etc., if any in the vicinity, from the project site

(b) Rare and endangered species

(c) Endemic species

(d) Species of special interest to local population and tourists

(e) Migratory route of animals, if any, in the project area

2.3.11.2 Socioeconomic Environment

2.3.11.2.1 Demographic Profile (gender-based details of the population)

(a) Rural/urban

(b) Population density

(c) SC/ST and others

(d) Literacy

(e) Employment and occupation

(f) Economic status (land holding/house holding)

2.3.9 Stake holders in IEE Process

Stake holder is any individual, group, agency or organization affected by a project and/or with concern or interest in a development project and its outcomes, or in common, resources impacted by a development project. A stakeholder should be treated as a 'Partner in Development' and not as opponent of the project.

2.3.12 Risk Assessment

Construction involves many separate activities that are carried out within the environmental conditions existing at the site. Environmental conditions will affect the construction activity, and the construction activity will also affect the environment. Thus, there are risks in undertaking the work, e.g., construction that is carried out in the wet season will normally have greater risks attached to it than work undertaken during the dry season the risk of undertaking any construction activity needs to be determined before the activity commences.

Risk = likelihood * Consequence

Risk is assessed as the likelihood that the activity will have an effect on the environment as well as the consequence of the effect occurring. It is often described like this: In all construction activities, there will be a range of likelihoods and consequences that will determine the degree of risk of the activity. Risk is also dependent on the location where the activity will happen, how the activity's location will affect sensitive receptors, and the duration of the activity. Activities of short duration normally have less risk than longer-duration activities.

The risk assessment process is undertaken with a risk assessment matrix. A number of stages are required to complete the matrix.

Table 2.5 - Likelihood Scale

likelihood	Definition	Score
Certain	Will occur during the activity at a frequency greater than every week if preventative measures are not taken.	5
Likely	Likely to occur more than once or twice during the	3

	activity, but less than weekly, if preventative measures are not taken.	
Unlikely	May occur once or twice during the activity if preventative measures are not taken.	2
Rare	Unlikely to occur during the activity.	1

Table 2.6 Consequence Scale

Consequence	**Definition**	**Score**
Catastrophic	Unprecedented damage or impacts involving the environment or surrounding communities. For Example: • Extreme loss of soil, water resources and water quality from storm water runoff; • Extreme pollution of soil and water resources, including major contamination from hazardous materials; • Widespread effects on ecosystems, with deaths of fauna/flora; • Widespread community impacts resulting in inconvenience, illness, or injury; and • Loss or destruction of archaeological sites. The occurrence of any of the above will almost certainly result in the work being halted and in a significant fine.	5
Major	Major damage to the environment or to surrounding communities. For example: • Major loss of soil, water resources, and water quality because of storm water runoff; • Major pollution of soil and water resources, including contamination from hazardous	3

	materials; • Significant effects on ecosystems, with isolated deaths of non-vulnerable flora and fauna • Significant annoyance or nuisance to communities; and • Major damage to, or forced displacement of, archaeological or historical sites. The occurrence of any of the above may result in work being halted and in a fine.	
Moderate	Limited adverse impacts on the environment or on surrounding communities. For example: • Localized, short-term noticeable changes in storm water quality, • Short-term minor changes in ecosystems, • Some annoyance or nuisance to communities, and • Isolated or partial damage to archaeological historical sites. The occurrence of any of the above may result in work being halted and in a fine.	2
Minor	No or minimal adverse environmental or social impacts. For example: • Localized, short – term noticeable changes in storm water quality, and water quality remains within tolerable limits; • Little noticeable effect on ecosystems; • No community complaints, or only an isolated few; and • No or minimal damage to archaeological or historical sites.	1

	After the occurrence of any of the above, there would be no likelihood of work being halted or a fine.	

Table 2.7- Risk Score Table

Likelihood	Consequence				
		Catastrophic	Major	Moderate	Minor
	Certain	25	15	10	5
	Likely	15	9	6	3
	Unlikely	10	6	4	2
	Rare	5	3	2	1

Risk: High: 15-25

Medium: 6-10

Low: 1-5

Chapter 3.- Methodology

3.0 Procedure

Thesis of the research started with a literature study in order to gain the needed knowledge about the environmental impacts that can be connected with Mini hydro powers. The gained information in the literature study has formed a base from which a model has been created. In the analysis, the model has been compared with the gathered information about the twelve hydropower plants

The survey samples are chosen from Authorities, stake holders and three key informants. The key informants were selected from Grama Niladari, Environment officers of Divisional Secretariat and a resident in the village. This survey is done using direct face to face interview with the informants and filling the questionnaire.***(Annex-A)***

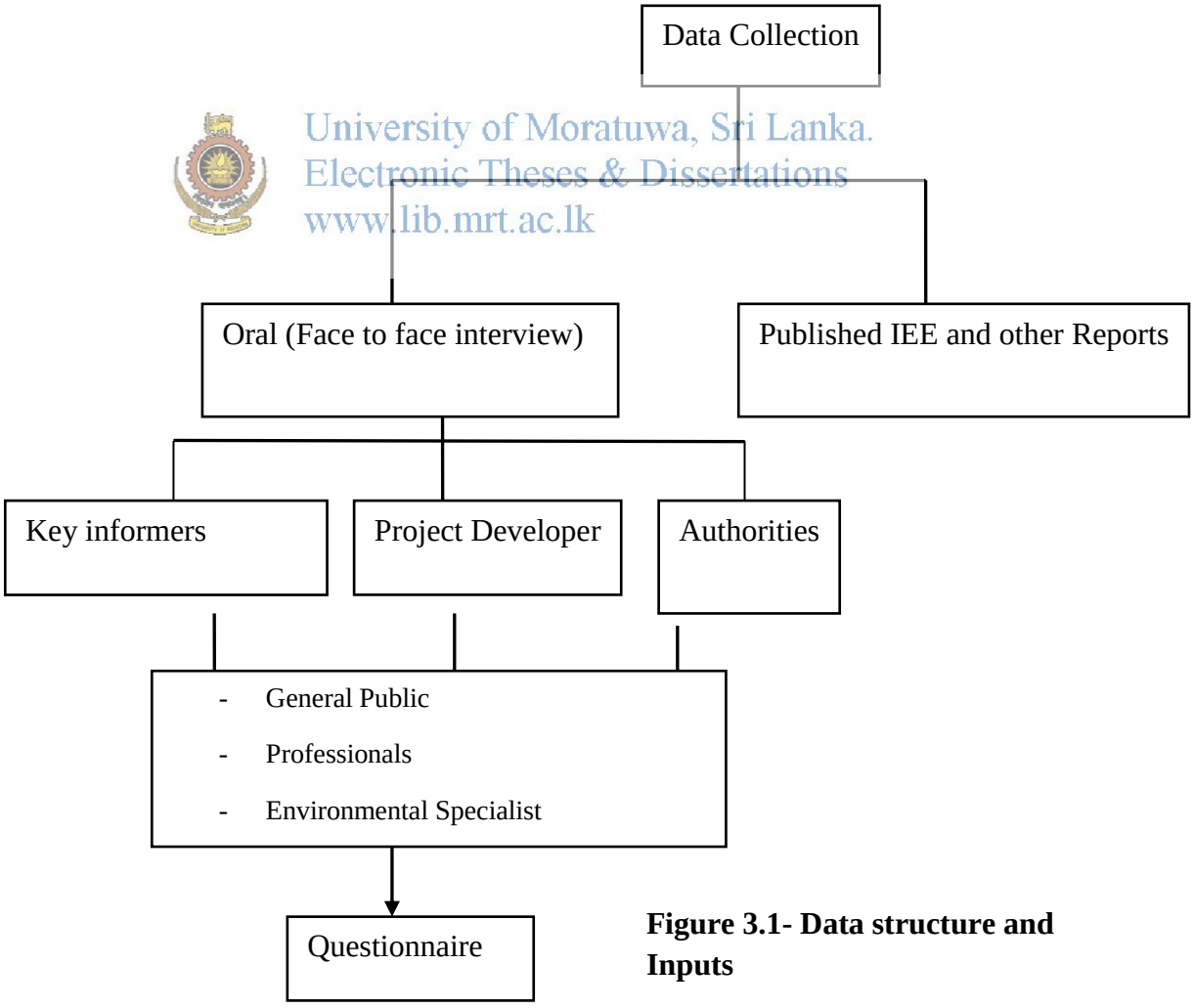

Figure 3.1- Data structure and Inputs

The data was collected from selected twelve Mini Hydro Projects. They were selected based on the following factors

- District of Location
- Project approving Agencies
- Geological Location
- Capacity of the project
- Time consuming for data collection

The data was collected according to the step shown in figure3.1.

The selected twelve Mini Hydro Projects were visited and minimized Environmental and Social negative Impacts and its avoided methodologies were observed they were compared with the predicted mitigation measures. Further, positive impact improved methodology was also observed.

Chapter 4- Observation and Analysis

The observations of the field studies and the data from questionnaires and IEE reports have been summarized in the table 4.1. The number of the project and the percentage value of success of impact prediction and implementation are included in the first column of Table 4.1 &final column of the table 4.2 respectively.

The Percentage of success of each predicted and implemented mitigation actions of the Projects are included in the Table 4.3. The percentage of success is plotted against the major impact predicted.

Percentage of Success of Impact Prediction =

[No of Projects predicted the Impact / Total Projects] x 100%

Table 4.1 – Summary of Questionnaire findings

Project No.	Location: DS Division PS or GN Division	Capacity of Project (MW)	Head(m)	Cost benefit analysis	Economic Feasibility	Study area (m)	No of field visit by TEC	No of Monitoring committee meeting during operation	No. of Bathing places were lost	No of People use the bathing place	Average Annual flow (m^3/s)	E flow (m3/s)	No. of Irrigation intake	No. of sand Mining families	Length of Transmission line (m)	No. of Resettled families	Frequency of closing power plant not adequate water flow /year	Date of Environmental Clearance	No of Scoping meeting	No of TEC Meeting	No of scoping members	Problem effect during IEE process	Dry season Power Control Water flow control method	Public involvement in IEE
01	Matale DS Palapathwela PS	6.00	12	Y	Y	500	20	2	2	50	62	1	1	1	4000	0	-	10.07.05	1	5	08	N	Change no of turbine	construction
02	AmbangangaKorale DS Aluthwela GN	4.55	7	Y	Y	500	5	2	10	40	62	1	1	3	3900	1	-	13.07.10	1	4	08	N	Change no of turbine	
03	Rathnapura DS Rathnapura PS	2.00	180	Y	Y	500	4	0	0	0	1.46	0.4	-	N	600	1	-	03.05.29	1		05	N	Change no of turbine	
04	Yatiyanthota DS	3.00	72	Y	Y	500	3	1	3	30	6.9	0.9	-	N	2000	0	-	10.02.01	1	3	07	Y	Change no of turbine	construction
05	Eheliyagoda DS Eheliyagoda PS	0.35	36	Y	Y	500	4	1	0	0	0.61	0	-	N	100	0	during dry season	08.0918	1	2	08	N	Change no of turbine	Pre - construction
06	Yatiyanthota DS	6.00	115	Y	Y	500	3	1	3	20	5.75	0.9	-	N	12000	0	-	02.08.30	1	1	06	N	Change no of turbine	
07	AmbgamuwaKoralaya DS & PS	4.85	116	Y	Y	500	3	1	0	0	5.2	0.6	-	N	500	0	-	03.09.22	1	2	06	N	Change no of turbine	
08	Kuruwita	6.50	165	Y	Y	500	2	1	0	0	6	0.3	-	N	18000	0	-	05.02.17	1	2	06	N	Change no of turbine	construction
09	Kuruwita	10.0	450	Y	Y	500	2	1	0	0	1.3 x 2	0.1	-	N	16000	0	-	01.04.19		1	06	N	Change no of turbine	construction
10	Ginigathhena DS Ambagamuwa PS	4.65	185	Y	Y	500	2	1	0	0	1.79	-	-	N	3000	0	-	09.02.04	1	2	07	N	Change no of turbine	
11	Ambagamuwa DS Ambagamuwa PS	3.00	100	Y	Y	500	3	1	1	15	1	0.1	-	N	3000	0	-	03.02.12	1	1	06	N	Change no of turbine	construction
12	Rathnapura GS Rathnapura PS	7.20	36	Y	Y	500	3	1	0	0	9.18	0.1	-	N	10000	0	-	04.02.09	1	2	06	N	Change no of turbine	construction

Table 4.1 – Summary of Questionnaire findings

Project Number	No of trees removed	Frequency of flood during construction	Blasting Work	No of Houses were damaged due to blasting	Soil erosion and Land slid [xxviii]	Poor sanitation during construction [xxix]	No of Jobs provided to Villagers [xxx]		Public protest against [xxxi]	Reasons for protest [xxxii]	Method of solving problem [xxxiii]	made of a fish ladder [xxxiv]	No of roads construction [xxxv]	No of bridge construction [xxxvi]	No of culvert construction [xxxvii]	Other benefits received for the villagers [xxxviii]	No of monitoring committee visit [xxxix]	Construction period (years) [xL]	reason for delaying construction [xLi]	Silting Removal frequency [XLii]	Catchment Area (km^2) [XLiii]	Project total Area (Ha) [Xliv]
							Permanent	Temporary														
01	200	1	Y	3	Y	N	4	12	Y	Damage to Properties due to blasting work	Pay Compensation	Y	1	1	3	Donate to School/ Temple	2	2.0	Due to flood	Once per a month		16
02	50	0	Y	0	Y	N	7	10	N	N/A	N/A	Y	1	1	0	Donate to Temple	3	2.5	No delay	Once per a month		22
03	100	0	Y	0	Y	N	3	15	N	N/A	N/A		1	0	4	N	0	2.5	No delay	Once per a two month	329	2.21
04	30	0	Y	2	Y	N	4	8	Y	Damage to Properties due to blasting work	Pay Compensation	N	2	1	0	Donate to School	2	2.0	machine failure and political influence	after flash flood		1.12
05	3	0	Y	0	Y	N	5	30	Y	Un awareness	aware people	N	0	0	0	made a water tank	0	1.5	No delay	4 time per year	7.1	
06	45	1	Y	0	Y	N	3	15	N	N/A	N/A	N	2	0	0	N	2	2.5	No delay	Once per a three month		
07	20	1	Y	0	Y	N	25	25	N	N/A	N/A	N	2	0	0	N	2	2.0	Fund allocation problem	Once per a month	26	
08	10	0	Y	15	Y	N	20	100	Y	Damage to Properties due to blasting work	Pay Compensation	N	5	1	0	N	3	2.0	No delay	Once per year minimum		
09	10	0	Y	3	Y	N	20	150	Y	Damage to Properties due to blasting work	Pay Compensation	N	2	1	1	N	3	2.5	No delay	4 times per a year		
10	40	0	Y	3	Y	N	6	25	Y	N/A	N/A	N	1	0	2	N	2	1.5	No delay	Once per two month	15.9	4
11	50	0	Y	0	Y	N	5	15	Y	Erosion and land slide	Pay Compensation	N	0	0	0	Donate to rural committee	3	2.5	No delay	Once per a month		
12	100	0	Y	0	Y	N		15	Y	Transmission line and inundation	Pay Compensation	N	1	2	0	Donate to committee of village	2	2.0	No delay	Once per a month	177.96	4

Y- Yes **N- No**

Table 4.2 Extracted Predicted and Implemented Environmental Impact mitigations

Predicted Environmental Impact		Predicted Environmental Impact Mitigation	Quantitatively analysis done or Not	Implemented Environmental Impact Mitigation by Project Proponent	Mitigation Predicted & Implemented Project Numbers & Remarks	Predicted %
1	**Geological and Geotechnical aspects**					**72.22**
	Impact due to the blasting activities	Blasting Operation Should be carried out under the supervision qualified Mining Engineer and relevant state agencies	Not Analysis	Apply control Blasting Method (Jack hammer is used to remove hard surfaces) under supervision of GSMB /PS/DS	1/2/3/4/5/6 /7/8/9/10/11/12	100.00
	Geological Change of the River	Necessary approval has to be taken from PAA & state agencies	Partially Analyzed	Approval has been taken from the PAA & State agencies	1/2/4/6/7/8 /9/10/11/12 * not mentioned in 3/5	83.33
	Slop stabilities	slop stability preventive measures has to be taken	Partially Analyzed	Water retaining structures or gabion wall was constructed by using boulders.	1/2/6/10 * not mentioned in others	33.33

2	**Hydrological Aspects**					**100.00**
	Impact due to interruption of downstream flow	Environmental & social flow should be released	Partially Analyzed	90% of dry season flow of the river is release through unregulated opening as E flow but it depends on the PAA requirement.	1/2/3/4/5/6 /7/8/9/10/11/12	100.00
	Impact irrigation water release during construction and operation	After valuation of effect compensation has to pay for the effected parties. Tailrace outlet located above the irrigation cannel more than 10m.	Analyzed	Required water was supply by pumping water during construction period. - Tailrace outlet located above the irrigation cannel compensation arrangement for loss of income due to water interruption.	1/2/6 * not mentioned in others as Not applicable	100.00
3	**Transmission line**					**87.50**
	Removal of Vegetation cover along the transmission Line	Vegetation removal has to be done with consultation of State agencies	Partially Analyzed	Vegetation removed with state agencies concurrence and compensate to the villagers	1/2/6/7/8/9/ 10/11/12 * not mentioned in 3/4/5	75.00
	Transmission line travel through private Land and paddy	Make agreement with farmer organization and land owners and		Make agreement with farmer organization and land owners and compensate to the properties	1/2/3/4/5/6	100

	fields.	compensate to the damage.	Partially Analyzed	damage.	/7/8/10/11/12 * not mentioned in 9	
4	**Erosion prevention and surface drainage**					**53.33**
	River bank erosion due to earth cover and boulders removal	Prepare and submit detail river bank stabilization Plan.	Not Analyzed	Use Boulder paving along the erodible area in the river. Planting trees and construction of rubble retaining walls.	1/2/3/4/5/6 /8/10/11/12 * not mentioned in 7/9	83.33
	Soil Erosion due to disturbing earth	Appropriate conservation method has to be used depend on the location	Not Analyzed	Use Grass turf or tree planting to stabilize the slop and some other landscaping and surface covering practices	1/2/3/4/5/6 /8/10/11/12 * not mentioned in 7/9	83.33
	River scour at the end of tailrace due to energy and velocity of the outlet waters	Place Energy dissipating device and improving of River Bank stabilization	Not analyzed	Use Boulder paving along the erodible area in the river and concrete or boulder steps is used to energy dissipating of the outlet water.	1/2/4/5 /8/10/11/12 * not mentioned in	66.67

					3/6/7 /9	
	Soil conservation during dry periods due to dust formation	Work has to be done during dry season with using conservation techniques	Not Analyzed	Work has to be done during dry season with using conservation techniques such as benching /terracing	1/2 * not mentioned in others	16.67
	Disturbance to the river sensitive area (sensitive area is defined by the state agencies)	Except key activities others will not be permitted (eg. Construction of Weir, head & tailrace channels, forebay, Powerhouse etc)	Partially Analyzed	No other activities done with in the river sensitive area except key activities.	1/2 * not mentioned in others	16.67
5	**Ecology**					**44.44**
	Fish entry in to the water conveyance system	Trash rack & fish screen should be placed at the mouth of the intake	Partially Analyzed	Trash rack and fish screen had been placed at the mouth of intake.	1/2/3/4/5/6 /7/8/11/12 * not mentioned in 9 /10	83.33
	Fish migration up & down stream	Fish ladder has to be construct as per the approved design by the	Partially Analyzed	Fish ladder has been constructed as per the PAA requirement.	1/2	16.67

		PAA			* others are not mentioned	
	Movement of Small terrestrial animals across the head race channel	Build an Over Passes (as per the approved size and strength) at 100 m of the open channel and cover concrete slab (over pass) with a grass layer to mimic the naturalness to the habitat.	Not analyzed	Build an Over Passes at 100 m or closed slap of the open channel and cover concrete slab with a grass layer to mimic the naturalness to the habitat	7/8/10/12 * Others are not mentioned	33.33
6	**Noise pollution**					**100.00**
	Noise Impact at Construction Stage	Noise level at the Boundaries of the Project site shall confirm to the levels stated in Schedule III of National Environmental(Noise control Regulations No. 01 of 1996)	Not Analyzed	Noise has been controlled to standard values at the boundaries by using construction of noise barriers such as sand bag walls, green belt etc	1/2/3/4/5/6 /7/8/9/10//11/ 12	Noise Impact at Operation Stage
	Noise Impact at Operation Stage	Noise level at the Boundaries of the Project site shall confirm to the levels stated in Schedule I & II of National Environmental(Noise control Regulations No. 01 of 1996)	Not Analyzed	Noise has been controlled to standard values at the boundaries by using construction of noise barriers such as sand bag walls, green belt etc	1/2/3/4/5/6 /7/8/9/10//11/ 12	100.00

7	**Transport of Equipment and materials**					**59.99**
	Possible mass movement due to fluctuation and loosing of earth	Slop stability should be maintained and monitor continuously	Not Analyzed	Slop stabilities monitor by pp and maintained	2 not mentioned in others	8.33
	Noise and dust formation during loading and unloading	Minimize disturbance of noise and dust formation	Not Analyzed	It was done in a controlled manner	1/2/3/4/5/6 /7/8/10/11/12 * not mentioned in 09	91.67
	Fine dust blowing from open toped truck	Loads are covered when transporting	Not Analyzed	Loads were covered when transporting	1/2/6/7/8/ 10/11/12 * not mentioned in 3/4/5/9	66.67
	Generation of dust nuisance during dry season	During dry season it should be dampen the exposed area	Not Analyzed	During dry season it was dampen the exposed area	1/2/6/8/11/12 * not mentioned in others	50.00

	Heavy load movement (across the bridges and culvert and road as per the limit of weight transport approval has to be taken)	It has to be done with the concurrence of RDA,PRDA,PS	Not Analyzed	It has been taken approval from the RDA,PRDA,PS as per the requirement	1/2/3/5/6 /7/8/10/11/12 * not mentioned in 4/9	83.33
8	**Safety**					**50.00**
	Safety of road users and adjacent land occupants	Prepare a safety procedure for road users and adjacent land occupants and follow	Not Analyzed	Prepare a safety procedure and followed.	1/2/8/11/12 * not mentioned in others	41.67
	Safety of Workers	Prepare a safety procedure for workers and follow. it must be comply with Safety regulation under the factory ordinance	Not Analyzed	Prepare a Safety procedure and followed comply with Safety regulation under the factory ordinance	1/2/3/7/8/11/12 * not mentioned in 4/5/6/ 9/10	58.33

9	**Disposal of liquid and solid waste in to water bodies**					**46.67**
	Spoil Materials (soil & Rock etc) removal during excavation and surface preparation	They must be used for site leveling, and back filling purposes. Also, The post constructed un usable materials should be disposed with consultation with PS	Not Analyzed	Those spoil materials used for site leveling, back filling, retaining walls and river terracing. The balance materials were disposed in to a Pradesiyasabha approved dump site.	1/2/3/4/5/6 7/11/12 * not mentioned in 8/9/10	75.00
	Transformer Oil Discharge in to water bodies	Preventive action has to be taken	Not Analyzed	They were collect and pump or disposed in to an approved dump site.	6/7/11/12 * not mentioned in others	33.33
	Sewage or any liquid effluent discharge from dwelling and camp site.	Preventive action has to be take n	Not Analyzed	They were collected in to a bin and dump in to approve dump site.	6/7/11/12 * not mentioned in 1/2/3/4/5/ /8/9/106	33.33
	Solid waste stagnate within the premises	It must be disposed with consultation with PradesiyaSabha (PS)	Not Analyzed	They were disposed with consultation of PS	1/2/4/7/11/12 * not	50.00

					mentioned in others	
	Sanitation facilities for the workers	It must be provided the sanitation facilities	Not Analyzed	Toilet and other sanitation facilities were provided.	1/2/4/5/8* not mentioned in others	41.67
10	**Sediment**					**70.83**
	Sediment accumulation at the weir site	Flushing of sediment should be carried out	Not Analyzed	Flushing of sediments carried out using a flushing gate at the weir	1/2/5/6 /7/8/10/11/12 * not mentioned in 3/4/9	75.00
	Sediment accumulate in settling tank	Collect and dump in to PS approved dump site	Not Analyzed	Collected the sediment and dump them PS approved dump site	1/2/5/6 /7/8/11/12 * not mentioned in 3/4/9/10	66.67
11	**Sociological Impacts**					**71.42**
	Resettlement of People	Families resettle as their satisfaction	Analyzed	Families resettle as their satisfaction	1/2 * not mentioned in	100.00

					others	
	Flood & land slid effect during construction and operation	Establish a possible warning system for people and take remedies for minim damages. Damage recovers by compensation.	Not Analyzed	Establish a possible warning system and recovery and damage compensation program.	1/2/4/6 /7/8/11/12 * not mentioned in 3/5/9/10	66.67
	Timely water release for irrigation purposes	Establish a reliable communication system and Manual operating water valve operate.	Analyzed	Establish a reliable communication system and Manual operating water valve operate.	1/2 * Not applicable for others	100.00
	Impact on stream bathing families	Provide proper bathing facilities	Analyzed	The PP constructed bathing places with cemented steps for bathing purposes.	1/2/5 * not mentioned in others	25.00
	Impact on Irrigation water release	Reestablished irrigation channel and compensate for the paddy land owners for disturbance	Not Analyzed	Reestablished a new irrigation channel and compensate for the paddy land owners for disturbance	1/2/6 * Not applicable others	100.00
	Irrigational out let operational impact	Irrigation outlet is planning to operate manually.		Irrigation outlet is constructed to operate manually.	1/2 * not mentioned in	100.00

			Not Analyzed		others as NA	
	Donation to development work in the village	2% of the annual profit should donate to the village for development work.	Analyzed	Few development work has been done	Only 2 * not mentioned in others	8.33
12	**Fire safety**					**91.67**
	Impact on sudden fire in power station	Firefighting system shall be provided and maintained in proper manner	Not Analyzed	Firefighting system is established	1/2/3/4/5/6 /7/8/10/11/12 * not mentioned in 9	91.67
13	**Tourism of the area**					**100.0**
	Tourism of the area	The PP should not be obstructed the visitors by any activities of the project.	Not Analyzed	The weir was constructed during dry season therefore no activities obstructed the visitors.	Only in 10 * not mentioned in others as not applicable	**100.0**

Table 4.3 Monitoring Framework

Predicted Environmental Impact		Impact Monitoring Parameters	Whether monitored or not	Responsible Persons to monitoring		Risk Analysis	Damages Observed
				EMOP	Actual		
1	**Geological and Geotechnical aspects**						
	Impact due to the blasting activities	Noise Pollution Air Pollution Ground Vibration	No Evidence for Proper Monitoring	GSMB/PS/DS/Monitoring Committee	Project Proponent	No	Few Houses were Crack during blasting (E.g. Projects 01,04,08)
	Geological Change of the River Length of the diversion Aquatic flora and Fauna effected		Monitored during Scoping Stage	PS/DS/Monitoring Committee	Project Proponent	No	
	Slop stabilities	Slop stability preventive measures	Projects 3& 5 were not monitored by MC	. PS/DS/Monitoring Committee	Project Proponent	No	Land slide and destroy of Houses (E.g. Project 11)
2	**Hydrological Aspects**						

	Impact due to interruption of down stream flow	Environmental & social flow and Water quality	It is monitored by Project monitoring committee few times (less than 03) except Projects 3 &5	PS/DS/Monitoring Committee	Project Proponent	No	E-flow values are varying standards of 90% of dry season flow of the river.
	Impact irrigation water release during construction and operation	- Location of Irrigation Channel -Quantity of Water Requirement - Time duration	Effect this impact is only for the Projects of 01, 02 & 06 and the committee has monitor projects less than 3 times as per the QA.	PS/DS/Monitoring Committee	Project Proponent	No	Compensate farmer for loss of income due to water interruption.
3	**Transmission line**						
	Removal of Vegetation cover along the transmission Line	No of Trees removed. Soil Erosion Damages to Properties Slop instability	It is monitored by Project monitoring committee few times (less than 03) except Projects 3 &5	PS/DS/Monitoring Committee	Project Proponent	No	Projects nos. 01, 02, 03, 11 &12 had been removed more than 50 trees. Compensate Villagers for loss of properties.
	Transmission line travel through private Land and paddy fields	No of Lands and Faddy fields	It is monitored by Project monitoring	PS/DS/Monitoring Committee	Project Proponent	No.	Compensate Villagers and farmer for loss of income due to loss

		Soil Erosion Damages to Properties Slop instability	committee few times (less than 03) except Projects 3 &5				of land and fields. .
4	**Erosion prevention and surface drainage**						
	River bank erosion due to earth cover and boulders removal	Detail of riverbank stabilization Plan. Etc. Places of River Bank erosion with in the site Boundaries. Preventive actions.	It is monitored by Project monitoring committee few times (less than 03)	PS/DS/Monitoring Committee	Project Proponent	No	River widening Loss of habitat Loss of vegetation,
	Soil Erosion due to disturbing earth	Soil erosion No of Erodible Places	It is monitored by Project monitoring committee few times (less than 03)	PS/DS/Monitoring Committee	Project Proponent	No	Soli eroded places Sedimentation in to the river basin.
	River scour at the end of tailrace due to energy and velocity of the outlet waters	Energy dissipating device and methods were used.	It is monitored by Project monitoring committee few times (less than	PS/DS/Monitoring Committee	Project Proponent	No	River scours at the end of tailrace.

			03).				
	Soil conservation during dry periods due to dust formation	Dust emissions	Dust emission, was not measured and monitored properly.	PS/DS/Monitoring Committee	Project Proponent	No	The properties in side and out side covered with dust.
5	**Ecology**						
	Fish entry in to the water conveyance system	Size and standard of Trash rack & fish screen.	It is monitored by Project monitoring committee few times (less than 03)	DS/PS/Monitoring Committee	Project Proponent	No	-
	Fish migration up & down stream	Standard and size of Fish ladder	It is monitored by Project monitoring committee few times (less than 03)	It is monitored by Project monitoring committee few times (less than 03)	Project Proponent	No	-
	Movement of Small terrestrial animals across the head race channel	No of Over Passes Standard size and strength and span of over pass Coverage of concrete slab (over pass)	It is monitored by Project monitoring committee few times (less than 03)	DS/PS/Monitoring Committee	Project Proponent	No	Blocking of open channel by filling of soil due to landslides Closing of small terrestrial animal paths.

6	**Noise pollution**						
	Noise Impact at Construction and Operation Stage	Noise levels at the Critical point and the critical boundaries of the site. Restricted works during nighttime.	No evidence for noise level measurement and controlling it	DS/PS/ Monitoring Committee	Project Proponent	No	Complain received from the Villagers.
7	**Transport of Equipment and materials**						
	Possible mass movement due to fluctuation and loosing of earth	No of places Slop salability-improving methods.	There is no attention on this impact by the Projects.	DS/PS/ Monitoring Committee	Project Proponent	No	Soil erosion and slop instability of the access roads.
	Noise and dust formation during loading and unloading	Noise level Dust emission measurement.	No evidence for monitoring	DS/PS/ Monitoring Committee	Project Proponent	No	Impact for movement of animal and the human across the near area and the properties of villages at site boundaries.
	Fine dust blowing from open	Visual inspection		DS/PS/ Monitoring	Project	No	Impact for movement of

	toped truck	adequate	No evidence for monitoring	Committee	Proponent		animal and the properties of villages at the access road boundaries.
8	**Safety**						
	Safety of Workers	Safety Plan & Procedure. No of accidents	There is no any accident is occurred any projects. Few projects have been monitored by MC during construction phase.	DS/PS/ Monitoring Committee	Project Proponent	No	Accident for workers.
9	**Disposal of liquid and solid waste in to water bodies**						
	Spoil Materials (soil & Rock etc) removal during excavation and surface preparation	No of Places Methods of re used of spoil materials	It is monitored by Project monitoring committee few times (less than 03)	DS/PS/ Monitoring Committee	Project Proponent	No	Land sliding
	Transformer Oil Discharge in to water bodies	No of places Frequency of discharge.	It is monitored by Project monitoring	DS/PS/ Monitoring Committee	Project Proponent	No	Water pollution in down stream

			committee few times (less than 03)				
	Sewage or any liquid effluent discharge from dwelling and camp site.	No of places Frequency of discharge	There is no evidence to be monitoring such an Impact.	DS/PS/ Monitoring Committee	Project Proponent	No	Water pollution in down stream
	Solid waste stagnate within the premises	No of places Frequency of discharge	It is monitored by Project monitoring committee few times (less than 03)	DS/PS/ Monitoring Committee	Project Proponent	No	Water pollution in down stream
	Sanitation facilities for the workers	No of Bath rooms No of Wash rooms(toilets)	It is monitored by Project monitoring committee few times (less than03)	DS/PS/ Monitoring Committee	Project Proponent	No	Water pollution in down stream
10	**Sediment**						
	Sediment accumulation at the weir site	Height of accumulations	It is monitored by Project monitoring committee few times (less than 03) and due to received few complains.	DS/PS/ Monitoring Committee	Project Proponent	No	Blocking of water flow.

	Sediment accumulate in settling tank	Height of accumulations	It is monitored by Project monitoring committee few times (less than 03) and due to received few complains. 1/2/6/7/8/11/12	DS/PS/ Monitoring Committee	Project Proponent	No	Blocking of water flow.
11	**Sociological Impacts**						
	Resettlement of People	-No of families resettle - their satisfaction	It is monitored by Project monitoring committee few times (less than 03). 1/2/6/7/8/11/12	DS/PS/ Monitoring Committee	Project Proponent	No	-
	Flood & land slid effect during construction and operation	-Warning system for flood - Frequency of flooding	It is monitored by Project monitoring committee few times (less than 03) 1/2/4/6 /7/8/11/12	DS/PS/ Monitoring Committee	Project Proponent	No	Damage to properties

	Timely water release for irrigation purposes	Communication System Frequency of water release	It is monitored by Project monitoring committee few times (less than 03) 1/2	DS/PS/ Monitoring Committee	Project Proponent	No	Water Disturbance to farmers in time
	Impact on stream bathing families	No of Places The facilities No of Persons bathing in for a place	It is monitored by Project monitoring committee few times (less than 03) 1/2 /5	DS/PS/ Monitoring Committee	Project Proponent	No	Loss of bathing place for the downstream users.
	Donation to development work in the village	No of developments Annual allocation by the project	It is monitored by Project monitoring committee few times (less than 03) 1/2 /5	DS/PS/ Monitoring Committee	Project Proponent	No	-
12	**Fire safety**						
	Impact on sudden fire in power station	Established fire fighting system Guidance for the uses Condition of Fire Fighting	No evidence for monitoring	DS/PS/ Monitoring Committee	Project Proponent	No	-
13	**Tourism of the area**						

	Tourism of the area	No of Places Access points	It has monitor during construction MC of project 10.	DS/PS/ Monitoring Committee	Project Proponent	No	Loss of income for the villagers.

Table 4.4 Summary of Impact mitigation Prediction

	Impact	**Impact predicted (percentage) %**
1	Geological and Geotechnical aspects	72.22
2	Hydrological Aspects	100.00
3	Transmission line	87.50
4	Erosion prevention and surface drainage	53.33
5	Ecology	44.44
6	Noise pollution	100.00
7	Transport of Equipment and materials	72.91
8	Safety	50.00
9	Disposal of liquid and solid waste in to water bodies	46.67
10	Sediment	70.83
11	Sociological Impacts	71.42
12	Fire safety	91.67
13	Tourism of the area	100.00

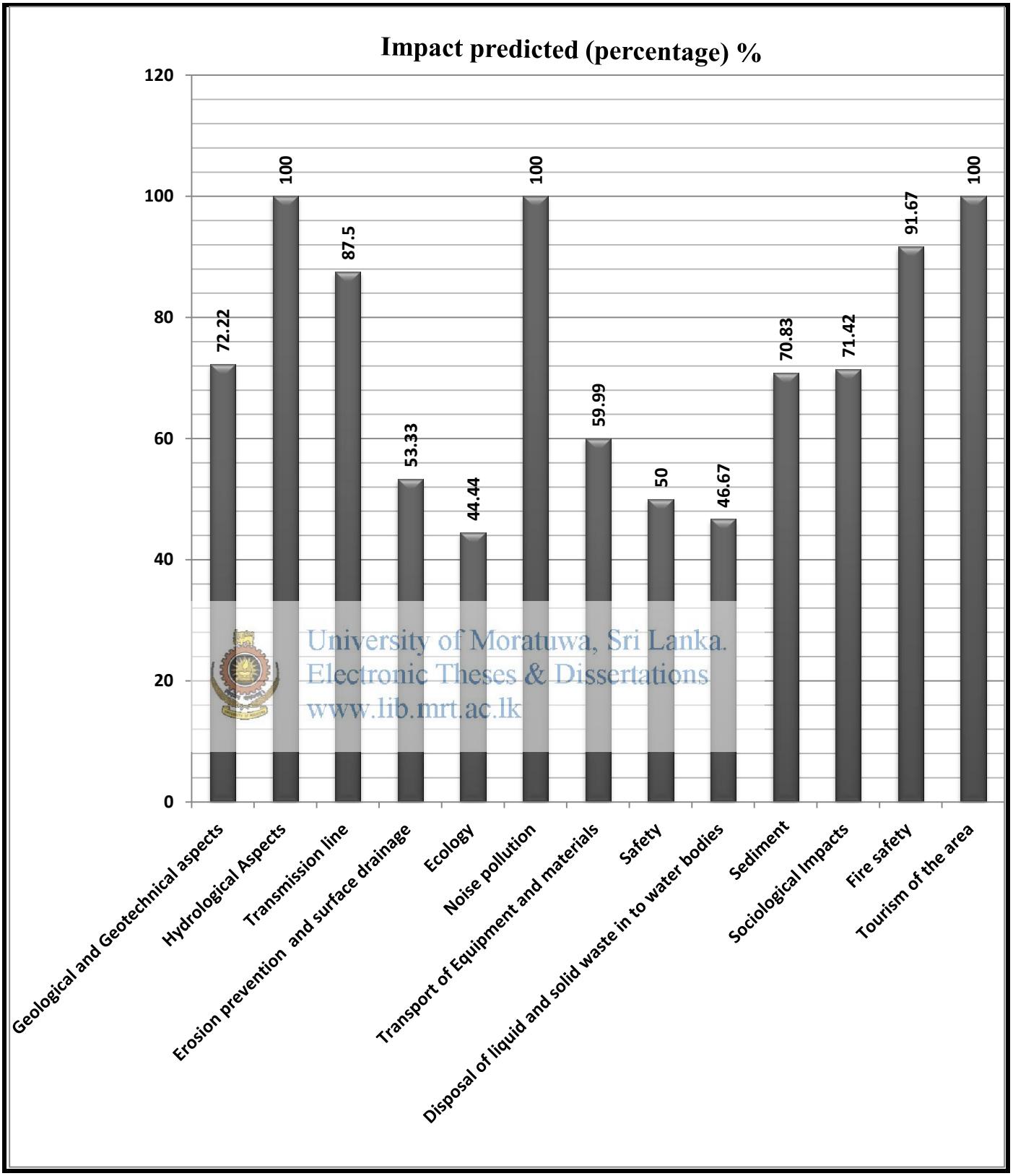

Figure 4.1 Impact Predicted percentage

Table 4.5 –Analysis of Environmental Methodologies

Project	Checklist Methods			Matrices Method	Network Methods	+ Expert Opinion	Over layer Method
	Simple	* Questionnaire	Quantitative				
Project 01	-	Yes	-	-	-	Yes	-
Project 02	-	Yes	-	-	-	Yes	-
Project 03	-	Yes	-	-	-	Yes	-
Project 04	-	Yes	-	-	-	Yes	-
Project 05	-	Yes	-	-	-	Yes	-
Project 06	-	Yes	-	-	-	Yes	-
Project 07	-	Yes	-	-	-	Yes	-
Project 08	-	Yes	-	-	-	Yes	-
Project 09	-	Yes	-	-	-	Yes	-
Project 10	-	Yes	-	-	-	Yes	-
Project 11	-	Yes	-	-	-	Yes	-
Project 12	-	Yes	-	-	-	Yes	-

***** *This refers the questionnaire is issued by CEA.*

+ This is a method of summon meeting and discuss impact by stakeholders and expert parties.

Chapter 5 - Discussion

Selected Projects were analyzed separately for their Predicted and implemented Mitigation and violation to standards and conditions. All the 12 Mini Hydro Projects had been processed under Initial Environmental Examination by the scoping committee at the screening stage.

5.1 Selected Case Studies on Predicted Impact mitigation and Implemented Impact mitigation

In terms of environmental impacts, the cutting or clearing of very steep hills, rock blasting and soil dumping into paddy lands have created serious soil erosion. The filling of lands and wetlands without adequate drainage system has posed environmental threats as this could lead to flooding problems in the future, especially during the rainy season. Dust pollution has become unbearable in some areas. Rock blasting and heavy vehicle movement have caused noise pollution, thereby negatively affecting the lives of the people near to the construction site. Considering the following key impacts and their Predicted mitigation measures were considered as per the table 4.2 for evaluating 12 MHPs.

1. Geological and Geotechnical aspects
2. Hydrological Aspects
3. Transmission line
4. Erosion prevention and surface drainage
5. Ecology
6. Noise pollution
7. Transport of Equipment and materials
8. Safety
9. Disposal of liquid and solid waste in to water bodies
10. Sediment
11. Sociological Impacts
12. Fire safety
13. Tourism of the area

5.1.1Geological and Geotechnical aspects

Under this impact, following significant impacts had been considered

5.1.1.1Blasting activities

The explosive materials were purchased under permit of Assistant Explosive controller of District Secretaries Office. As required this material were stored under police security .The blasting types and explosive material used also varying with the scale of Rock blasting are involving. All the 12 projects had identified the blasting activities as a Predicted Environmental impact and had done controlled blasting for the given mitigation measures. The Villagers had protested against the blasting activities of Project no. 01, 04, 08 and 09 on the ground rock blasting had caused damage to their properties the figure 5.1 shows a crack which had occur on a wall of house due to blasting. .The project proponents had planned compensation for the valued damage to the properties of the houses. This process had been monitored by Divisional Secretary, Pradesiya Sabahal and qualified Mining Engineer as per the explanation of PPs. This impact caused to the properties was predicted by all the project proponents.

Remedies for the issues

Rock blasting procedure should be standardized and a standard guideline for Rock blasting should be given. Rock blasting must be given priority because, in comparison to other hazards. It invites the selection of alternative place for the project if a protest occurs. It is also suggested that the following pre activities must be taken in to account in order to minimize the blasting impacts of the project.

Blasting time must be scheduled to prevent any clash with local activities. Warning signal must be sent prior to the blasting activity for the purpose of safety

Noise barriers and ground vibration controlling methods must be used to prevent adverse effect on terrestrial fauna, people and their properties.

To measure the blasting effect initially and after survey the surrounding houses to find out the visual crack effect.

Figure 5.1 - Crack of wall due to blasting activities.

5.1.1.2 Geological Change of the River

This impact is not a crucial impact for the Mini Hydro Project. The ability of geological change of the river is less for small capacity Mini hydro Power projects. .But, in the case of river widening or removal of loose soil or rock boulders this is effective. Therefore, it is required to obtain necessary approval from the state agencies and PAA prior to the removal of those and widening. This impact has been pre identified by all the Projects except Project No 03 & 05. (Predicted 83%)

5.1.1.3 Slope stabilities Slope stability is determined by the balance of **shear stress** and **shear strength**. A previously stable slope may be initially affected by preparatory factors; making the slope conditionally unstable. The method chosen for

improving slope stability depends on many factors, including the type or the projected type of slope failure, soil characteristics and site constraints. Frequently, more than one method of mitigation technique is required.

The Villagers have protested against the land sliding and slope failure of Project no. 11 as per the table .4.1 and also according to the table 4.2 projects Nos. 1, 2, 6 & 10 have predicted this as an environmental impact in IEE report. In the mitigation of the impact the IEE reports identified techniques such as water retaining structures, gabion wall, grass turfing and tree planting.

Remedies for the issues

The typical techniques of slope instability mitigation can be used for drainage improvement, earth work and Structural Improvements such as Mechanically Stabilized Earth (MSE), Retaining walls, Soil nailing, Tie backs, reticulated micro piles, Piles or drilled shafts It must be selected according to the economy and easy applicability. The following figure 5.2 and figure 5.3. Shows some improvement of stability constructed by the two of the projects, but, the figure 5.2 improvement is inadequate for slope stabilities.

Figure 5.2 - Retaining wall

Figure 5.3 Grass Turfing

5.1.2 Hydrological Aspects

Impact due to interruption of downstream flow (E flow and social flow) All the selected Mini hydro projects are run of river types and, hence the water flow used by the project is released back to the river at the tailrace. Therefore water interruption occurs in between intake and tailrace. Therefore, eco system in between this area must retain. The CEA guideline provides this environmental flow should be 90% of dry season water flow value. But, in this survey it has been found out the E flow value has been decided without taking the guidelines in to consideration. Even if the MHPs was implemented before the releasing of the guideline the pp is bounded to update their design values according to the guidelines. All the Mini hydro projects have predicted this impact and they have implemented the impact mitigation in compliance with the IEE reports. Although the impact was mitigated by providing an e flow, few projects do not operate and maintenance as per the instruction given by the PAAs. It has been found out one Mini Hydro projects did not take remedial actions to remove the deposits. As a result the E flow gate was blocked by the deposited silt and thus the water flow through the opening was blocked.

Remedial actions suppose

The overall objective of environmental flow recommendations is to ensure that sufficient water is made available to support the needs of the entire rive rain ecosystem. It is necessary to assess the most appropriate methods for the Environmental flow assessments using the most appropriate methods available at the time. Previously, these assessments focused largely on minimum flow requirements for in stream fauna (such as fish and invertebrates). However, new methodologies that incorporate natural variability in stream flow, and the high flow water requirements of entire riverine ecosystems; this must be surveyed and calculated during pre-feasibility stage.

5.1.3 Impact of irrigation water release during construction and operation

This Impact was predicted only by three projects numbers 1, 2 & 6. This impact does not involving in the other Projects because there is no irrigational channel located in the project area. The predicted mitigation was implemented by the three projects. According to the predicted mitigation, water should be released to each farmer community requirement and Priority has to be given to water supply for the irrigation purposes and not for the Power generation. Irrigation water requirement should not be interrupted any stage. But, water flow was interrupted during the construction period and therefore demand for water for irrigation works was supplied by the project proponent by pumping or temporary outlet depending on the demand. If the interruptions to the irrigation water supply occur adequate compensation arrangement will be provided according to the loss of income and damages. The project proponents had discussion with the stake holders and farmer organization initially to find out their requirement for the construction and rehabilitation of the irrigation cannel. The possible impact on irrigation channel was solved at the initial stage of the project. As a result there were no protests or appeal about water release for the irrigation purposes. The implemented mitigation was adequate.

Remedial measures to reduce impact

The construction activities should be done off seasons in order to minimize the water release for the irrigation purposes. The selection of Project area outside the irrigational channel inlet during design stage is best practices in order to avoid lengthening the project time and the cost of Project.

5.1.4Transmission line

The electricity generated is stepped up to 33 kV and it is connected to nearest grid substation of Ceylon Electricity Board. The energy travelling along or short distance before connecting to the Grid substation will greatly depend on the length of the transmission. The transmission length of selected Projects usually vary from 100 m to 18000m as shown in the Table 4.1. The average transmission length is 6091m. This length is long length compare to the other Power Projects. This is caused adverse impact on vegetation removal in area and energy loss of the Power plant.

Environmental and social impact due to the construction of transmission line

5.1.4.1 Removal of Vegetation covers along the transmission Line

This impact was identified all the projects but it was not mentioned as a predicted impact mitigation in Project Nos.3,4&5. According to the mitigation action, the removal of the vegetation should be done with concurrence of state agencies and the villages must be paid compensation for the damage caused.

Remedial action In this method, the PAA should mentioned the proper compensation standard to follow the Project Proponent to follow the valuation standards and other required action must be clearly direct by the PAA. The no of trees removed to install the transmission line, the number of cut down, the types of trees, the number of trees planted to minimize the damage must be taken in to consideration in order to decide as the value.

5.1.4.2 Transmission line travel through private Land and paddy fields

This impact is also same as the removal vegetation long the path of the line.

5.1.5Erosion prevention and surface drainage

Erosion occurs when the top layer of the soil is swept away by natural or man-made forces, making it extremely difficult to grow any vegetation on the site. Erosion can turn a once healthy, vibrant land into arid, lifeless terrain and further cause landslides and earth slip. Erosion happens at construction sites and other areas where the land has been disturbed. Erosion prevention is the most effective and inexpensive method for reducing overall environmental impacts associated with construction activities. Erosion control practices primarily involve preserving the natural vegetation when possible or stabilizing exposed soils with temporary covers or permanent vegetation and structural Improvements. In the Mini Hydro Projects erosion is occurred considerably under the following stages:-

5.1.5.1 River bank erosion due to earth cover and boulders removal

This mainly occurs due to weak embankment of arriver due to lose soil and boulder on embankment. This impact was identified all the Projects except Project nos. 7&9. River bank erosion is usually very high during floods caused by heavy rain.. It can be avoided or minimized using mitigation actions like placing boulder, gabion filled with rubble, rubble machinery walls and planting trees. According to the monitoring committee reports, mitigation measures were not implemented by few of the projects.

5.1.4.2 Soil Erosion due to disturbing earth

The erosion due to disturbing earth was identified as an impact by all the Projects except Project nos. 7&9. The controls often involve the creation of a physical barrier, such as vegetation or rock, to absorb some of the energy of the wind or water that

cause erosion. Constructing channel over the column support can minimize the excavation or disturbance to the earth.

Remedial action

The projects used Grass turf tree planting, surface covering and other methods of landscaping to stabilize the slop as the predicted mitigation. Figure 5.4 & 5.7 show typical soil erosion during the field surveying done by the Projects. The remedial actions taken for such soil erosion is shown in Figure 5.3. Which also enhances the scenic beauty of the project.

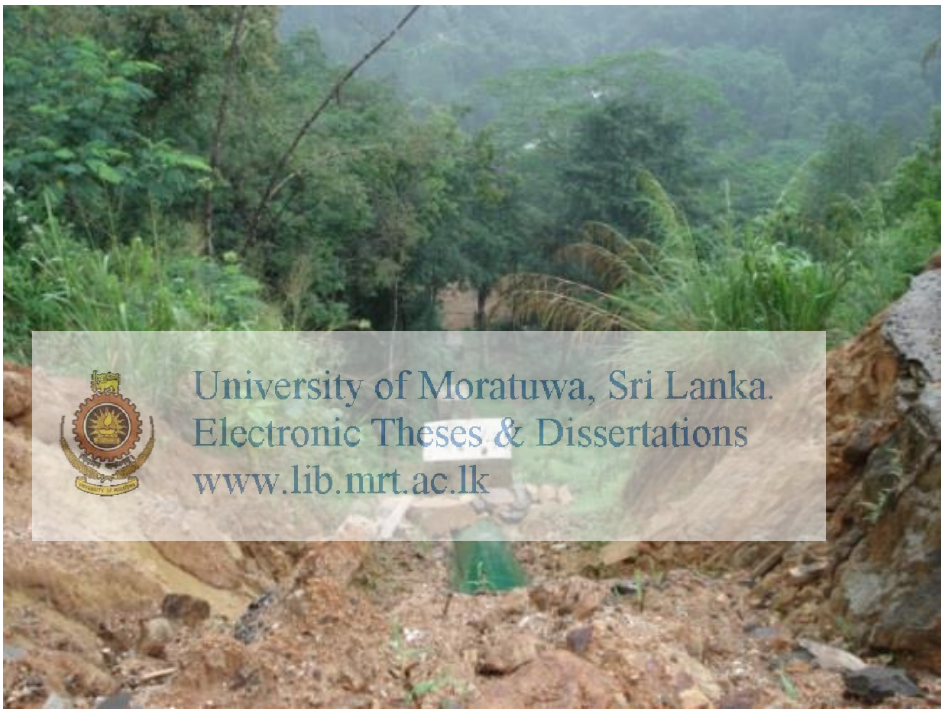

Figure 5.4 – Disturbed Soil erosion

The impact mitigations were not exactly implemented according to the as the given instructions given by the PAA. Few complaints had been made to the PAAs and the monitoring committee had monitored them.

5.1.5.3River scours at the end of tailrace due to energy and velocity of the outlet waters

Scouring happens as the results of increase the velocity of the water on a massive scale. The velocity or energy of the water outlet must be reduced or the bank erodible area should be hardened to minimize the river scour. If tailrace is constructed through excavation of hard rock, erosion will not be an impact. If the rock is weak or weathered, it can be improved by the applying reinforcement with the concrete**.**

All the projects identified the impact except project nos. 3, 6 & 7.In order to achieve the predicted mitigation, Boulder paving along the erodible area in the river is applied and concrete or boulder steps should be used. This would prevent energy dissipating of the outlet water at the tailrace.

5.1.5.4 Soil conservation during dry periods due to dust formation

This impact has to be minimized during dry season using conservation techniques such as benching or terracing.

5.1.5.5 Disturbance to the river sensitive area (sensitive area is defined by the state agencies)

The sensitive area is defined by the PAA and it is about 60 m reservation. The Project No 01 & 02 predicted the impact and conditions given for predicted mitigation. According to the these conditions river contraction cannot be constructed except for key activities (key activities of construction –weir head tailrace channels, fore bay, Powerhouse etc)

5.1.6 Ecology

Ecology is the scientific study of interactions of organisms with one another and with the physical and chemical environment. Ecological impact has identified in categories terrestrial fauna as well as aquatic fauna.

Predicted Impact mitigation for Aquatic Fauna

5.1.6.1 Fish entry in to the water conveyance system

All the projects except project numbers 09 & 10 identified and predicted the impact mitigations which is done by placing Trash rack & fish screen at the mouth of the intake. This had been constructed by all the Mini hydro Projects, although this has not been mentioned in IEE report as a predicted impact. As per observation at the site, this fine screen will not prevent small fish going through it.

The common faults which have to be considered during the design stage of the screens are damaging mesh panels, damaging screen seals, screens that are not fully seated, screens that have been removed to avoid clogging problems and screens that are heavily clogged, which lead to velocity hot-spots where fish face the rise of becoming impinged on the screens. These problems can be overcome with appropriate design and by good maintenance that is backed up by monitoring and enforcement. .

5.1.5.2 Fish migration up & down stream

The mitigation of fish migration impact is to make a fish ladder. A fish ladder, also known as a fish way, provides a detour route for migrating fish past a particular obstruction on the river. Designs vary depending on the obstruction, river flow, and species of fish affected, but the general principle is the same for all fish ladders: the ladder contains a series of ascending pools that are reached by swimming against a stream of water. Fish leap through the cascade of rushing water, rest in a pool, and then repeat the process until they are out of the ladder. The survival of many fish species depends on migrations up and down of the river.

The Project numbers 1 and 2 have identified this impact but it has been implemented by only project number 02 which constructed a Project Fish ladder in keeping with the requirement laid down by P.A.A.

Remedial measures

During field study, It was found out that the designing of the fish ladder must be improved for the fish ladder must be improved for the fish to survive when they move through it. It may be suggested them a fish cover over the fish ladder may be maid for the fish to travel freely without endangering their life., This is a key requirement for all mini hydro projects to help the migration of aquatic fauna

5.**1.7Predicted Impact Mitigation for terrestrial fauna**

5.1.7.1Movement of Small terrestrial animals across the head race channel

The headrace cannel water travels very long distances and hence it passes through small terrestrial animal crossing points. Therefore this impact is effect terrestrial migration pattern as well as their habitats. The Projects number.7, 8, 10 and 12 have identified this impact and predicted mitigation has been implemented. The predicted mitigation measures are to build an over passes forever 100 m for the cleaned and cover this with a concrete slab and in order to mimic the naturalness to the habitat to cover the slab with grass layer.

Remedial measure

It may be suggested that if the open headrace channel travels on concrete columns as in the figure 5.5, the small terrestrial animal can pass under the channel. Although it is more costly than other models, it will reduces earth disturbance due to excavation of the channel and the impact on the movement of terrestrial fauna.

Figure 5.5-Headrace Open channel constructed on the Columns.

5.1.8Noise pollution

This impact has been predicted and the predicted mitigation has been implemented by all the projects. However, according to the views of the villagers the noise level control has not been implemented properly in few of the projects.

5.1.8.1 Noise Impact at Operation Stage

Predicted mitigation action was that the noise level at the Boundaries of the Project site shall confirm to the levels stated in Schedule I& II of National Environmental (Noise control Regulations No. 01 of 1996).

5.1.8.2 Noise impact at Construction stage

Predicted mitigation action was that the noise level at the Boundaries of the Project site shall confirm to the levels stated in Schedule III of National Environmental (Noise control Regulations No. 01 of 1996

Implemented impact mitigation was that the noise has been controlled to standard values at the boundaries by using construction of noise barriers such as sand bag walls, green belt etc.

Remedial Measures

Position plant and machinery as far away as possible from noise sensitive areas.
Machinery should be suitable for the work to be carried out, properly maintained and operated.
If the machine is stationary, fit an acoustic enclosure where necessary. Where possible use mains electricity rather than a generator supply. Switch off all equipment when not in use.
Try to keep the noisier work for the middle of the day. Quieter work is best kept for the beginning or end of the day.

5.1.9Transport of Equipment and materials

This impact was identified and predicted impact mitigation under the following different categories.

5.1.9.1 Possible mass movement due to fluctuation and loosing of earth

The PP provides predicted mitigation as the mitigation slope stability should be maintained and monitored continuously. The road has been constructed with well slope stability. The slope stability check continuously prevents any mass movement of the Project area. Only Project no.02 identified this impact.

5.1.9.2 Noise and dust formation during loading and unloading

Predicted impact has been identified by all the Projects except the Project no 09. All the impact predicted that the PP should take necessary actions to Minimize disturbance of noise and dust formation during the construction Periods. In other

wards the work has to be done in a controlled manner prevent and minimize the impact.

Remedial Measures suggested

Dust formation can be overcome by

Dampening of material.
Reducing drop heights where possible.
Protecting activities from wind, which can make the problem worse

Noise generation

- Loading and unloading must be done with controlling to minimize noise generation
- Loading and unloading can be carried out in a closed system or with sound barriers.

5.1.9.3 Fine dust blowing from open toped truck

The other Projects except Project nos. 3, 4, 5& 9 identified this impact as a predicted impact and it given condition that the loads must be covered while loads transporting. This impact was probably flows majority of the Projects, but this impact is not a key impact of the projects.

5.1.9.4 Generation of dust nuisance during dry season

This impact was identified by projects numbers.1, 2, 6, 8,11butothers did not identified as an impact. It provided mitigation that during dry season exposed area should be dampening by using water prevents generation of dust nuisance. The predicted mitigation has been implemented by Projects nos.1, 2, 6, 8 &11.

Remedial measures

The dust nuisance during dry season can be prevented or avoided by providing proper wind barrier in the area.

5.1.9.5Heavy load movement (across the bridges and culvert and road as per the limit of weight transport approval has to be taken)

This is not always an effective impact only a probable impact. This impact was predicted by all the projects except projects no 4& 9.The predicted mitigation is that heavy load transportation has to be done under the concurrence of Provincial Road development Authority, Road development authority and Pradesiya Sabha.

5.1.10 Safety

5.1.10.1 Safety of road users and adjacent land occupants

This impact was predicted by Projects 1, 2, 8, 11& 12 and Predicted mitigation was to prepare a safety procedure and follow up. (Predicted 42 %)

5.1.10.2 Safety of Workers

This impact was predicted by Projects 1,2, 3,7,8,11& 12 and Predicted mitigation was to Prepare a safety procedure and follow up but it must comply with Safety regulation under the factory ordinance This is a social impact and there were not herd any accidents during Project construction and operation. (Predicted 58 %)

5.1.11Disposal of liquid and solid waste in to water bodies

This impact was identified by Projects nos. 1,2,4,5,6,8,10,11 &12. As the mitigation measures the pp should be prepared for solid and liquid waste management plan and it must be approved by PAA. The approved plan must be followed by the PP.

5.1.12 Spoil Materials (soil & Rock etc) removal during excavation and surface preparation

This impact was used as the predicted environmental impact by all the project except projects no 8,9&10.The predicted mitigation was that the PP must use spoil materials for site leveling, and back filling purposes. Also, the post constructed un-

usable materials should be disposed with consultation with PS. The records obtained show that few projects has violated this impact mitigation as shown in figure 5.6.

Figure 5.6 – Spoil Rocks heap in the river bank

5.1.13Transformer Oil Discharge in to water bodies

This impact was identified by projects nos. 6, 7, 11& 12 and implemented mitigation is that oil must be collected, pumped or disposed in to an approved dump site.

5.1.14 Sewage or any liquid effluent discharge from dwelling and camp site.

This impact was identified by projects nos. 6, 7, 11& 12 and implemented mitigation is that sewage or liquid be collected in to a bin and dump it in to an approved dumpsite.

5.1.15Solid waste stagnate within the premises

The impact was identified by projects nos. 1, 2, 4, 7, 11& 12 and implemented mitigation is that solid waste must be disposed with consultation with Pradesiya Sabha (PS).

5.1.16Sanitation facilities for the workers

The impact was identified by projects nos. 1, 2, 4, 5 & 8 and mitigation was that pp should be providing the proper sanitation facilities. The PPs had provided toilet and sanitation facilities for the workers

5.1.17Sediment

5.1.17.1 Sediment accumulation at the weir site

A particle can be transported in the discharge both as bed load and as suspended matter. An exact delimitation is not possible, as the influence in particular the flow velocity - can be very different according to the discharge character. The particles that flow through the river are deposited at the weir due to slowdown of the flow velocity at the weir. The deposited fine particles must be removed to prevent change of pond capacity. The impact was identified by projects nos. 1, 2, 5, 6, 7, 8, 10, 11& 12 and the implemented mitigation is the flushing of sediment should be carried out frequently prevent sludge accumulation .

5.1.17.2 Sediment accumulate in settling tank

The water drawn from the river and fed to the turbine will usually carry a suspension of small particles. This sediment will be composed of hard abrasive materials such as sand which can cause extensive damage and rapid wear to turbine runners. To remove this material the water flow must be slowed down in settling basins so that the silt particles will settle on the basin floor. The deposit formed is then periodically flushed away.

From the size of the smallest particle allowed into the penstock the maximum speed of the water in the settling basin can be calculated as the slower the water flows the lower the carrying capacity of the water for particles. The water speed in the settling basin can be slowed down by increasing the cross section area of the channel. For each maximum size of the particles the optimum size of the settling tank can be calculated. The impact was identified by projects nos. 1, 2, 5, 6, 7, 8, 11& 12 and implemented mitigation is Collected the sediment and dump them PS approved dump site

5.1.18 Sociological Impacts

5.1.18.1 Resettlement of People

Any person, who as a result of the implementation of the Project, loses the right to own, use, or otherwise benefit from a built structure, land (residential, agricultural, pasture or undeveloped/unused land), annual or perennial crops and trees, or any other fixed or moveable asset, either in full or in part, permanently or temporarily. Not all PAP need to move due to the Project. PAP may include:

- **Physically Displaced People** – People subject to physical displacement.
- **Economically Displaced People -** People subject to economic displacement.

Physical Displacement

Loss of shelter and assets resulting from the acquisition of land associated with the project that requires the affected person(s) to move to another location. The mitigation measures were identified as Compensation or Payment in cash or in kind at replacement value for an asset or a resource that is acquired or affected by the Project at the time the assets need to be replaced. The impact was identified by projects nos. 1&2 and implemented mitigation is compensation or move to predetermined locations. Other projects do not discuss this impact due to it being inapplicable to other Projects.

5.18.2 Flood & land slid effect during construction and operation

Landslides occur when the stability of a slope changes from a stable to an unstable condition. A change in the stability of a slope can be caused by a number of factors, acting together or alone .Natural causes of landslides include, groundwater pressure acting to destabilize the slope, erosion of the toe of a slope by rivers or weakening of a slope through adding loads to barely stable slope, absence of vertical vegetative structure, soil nutrients and soil structures.

Landslides are aggravated by human activities which can be deforestation, cultivation and construction. Main human causes are vibrations from machinery, blasting, earthwork which alters the shape of a slope, removal of deep rooted vegetation and construction.

Flooding of the land for Mini Hydro Power has an extreme environmental impact: it destroys forest, wildlife habitat, agricultural land, and scenic lands.

The project mitigation measure points out that the damage should be minimized by preventing the adverse impact caused by the above activities and actions be taken to minimize the damage to the peoples by establishing a possible warning system and also implement remedies to minimum damages. Damages could be recovered by paying compensation. This impact is discussed in project ct nos. 1, 2, 4, 6, 7, 8, 11 and 12.

5.1.18.3 Timely water release or irrigation water management

Water management is an important element of irrigated crop production. Efficient irrigation systems and water management practices can help maintain farm profitability in an era of limited, higher cost water supplies. Efficient water management may also reduce the impact of irrigated production on offsite water quantity and quality. However, measures to increase water-use efficiency may not be

sufficient to achieve environmental goals in the absence of other adjustments within the irrigated sector. As often the case, technology is not the whole solution anywhere, but it is part of the solution almost everywhere. This impact is discussed in Project no.01& 02 only.

5.1.18.4 Impact on stream bathing families

The upstream and downstream water quality was not affected by hydropower generation. Therefore, impact on bathing is occurred between intake and tailrace of the Power House. This effect can be minimized by selecting a shorter distance between them as in Project numbers 01 and 02Projects numbers 1,2 and 5which identified this impacts. The mitigation measures was that the PP provides proper bathing facilities as per the no of lost places. . The projects numbers. 01 & No.02 implemented mitigation measures by constructing bathing places with cemented steps for bathing purposes.

As per the field observations, it was found out that Project Proponent had not constructed agreed number of bathing places. This part has been missed by the monitoring committee too.

5.1.18.5 Donation to development work in the village

This is a PP proposed impact and this was implemented only by the number 2 Project. But, this is a good proposal to improve the living condition of the villagers and prevent un-necessary protest against Mini Hydro projects.

5.1.19 Fire safety

The Power House should have proper Fire fighting system to prevent fire impact which can be due to leakage of current or any other disaster. The PAA has given impact mitigation to PP It shall provide and maintained fire fighting system to a proper manner. All the projects predicted this impact and implemented the predicted mitigation.

5.2 Observed Issues regarding the construction activities by the Monitoring committee reports

5.2.1 Project Number 04

Small soil erosion was observed in the area due to an opening on the ground slope and surface water flow during the rainy days.

The Project had constructed the base wall Retention structure which was for maintained properly

Cracks were observed nearby houses of villagers and according to NBRO observation, the project work activity has not been effect for crack

PP had not been taken safety precaution for vertical bank built on earlier created side of channel and penstock path during construction.

Temporary hut has been constructed at the Power House area

5.2.2 Project Number -07

Few landslides had occurred due to loose soil movement and poor construction Practices.

Fore bay location was shifted from initialed approved point

Heavy flood had occurred during operation Phase and it caused damaged to Power plant with sliding of loose soil surrounding the Power plant.

5.2.3Project Number –08

Considerable soil erosion was observed in the area.

The Public staged a protest against the PP when a crack occurred on house during blasting activities.

5.2.4 Project Number – 10

- The excavated soil was heaped on the slope of the earth which could enhance soil erosion and silt deposit in the riverbed.

5.2.5 Project Number – 12

Boulders and soil heaped on right hand side of the river bank without considering mitigation actions.

Two land slid were observed along the channel path after excavation activities

There were cracks in wall and ground floor of two houses due to the blasting activities.

NBRO recommended the soil nail methods for stabilizing the slope of soil.

There were public complaints against the projects activities.

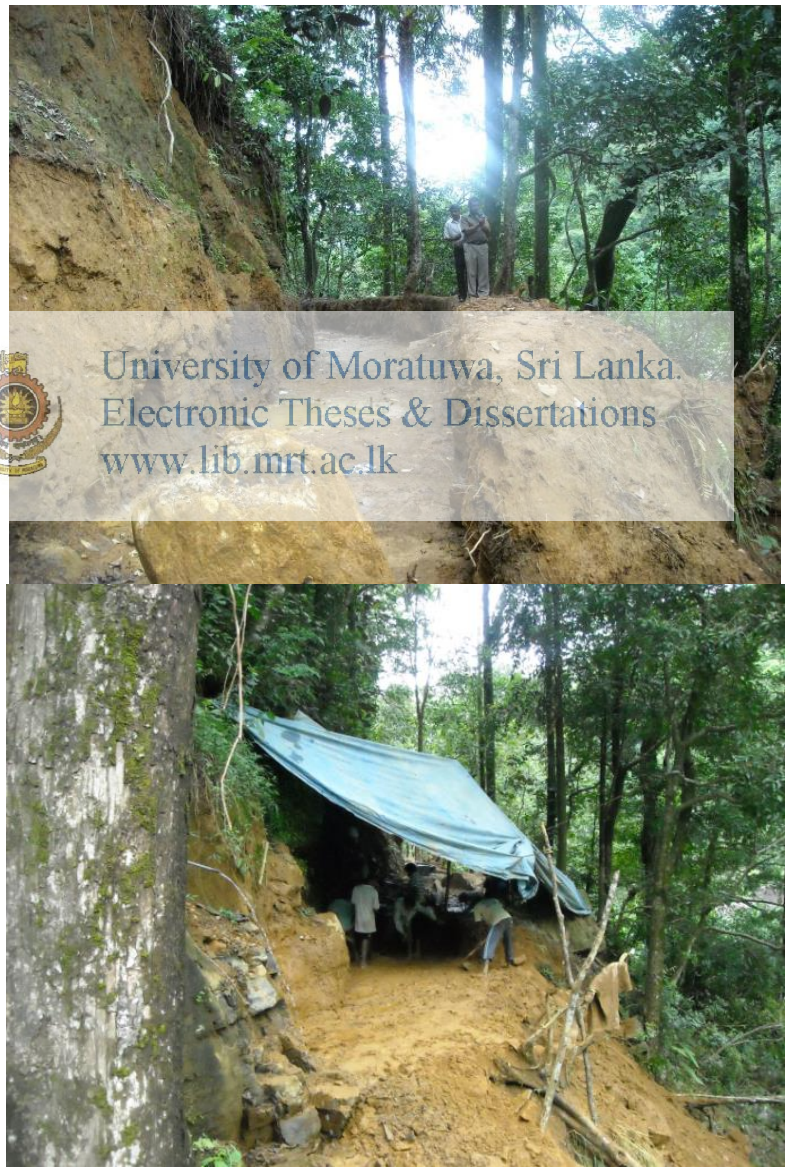

Figure 5.7 - Ground earth surface disturbance and violation conditions

5.3 Environmental Monitoring Weakness Identified

It is one of the most important components of IEE /EIA and it will used to ensure that

Impacts do not exceed the established legal standards

Checking the implementation of Mitigation measures

Providing early warning of potential Environmental damage

5.3.1 Types of Monitoring

5.3.1.1 Baseline Monitoring- A survey has to be conducted before construction begins and this survey should be conducted on basic environmental parameters in the area surrounding the proposed project before construction begins. Subsequent monitoring can assess the changes in those parameters over time, against the baseline. As per the project Proponent and Project Approving agencies, all the project has been done prefeasibility studies and baseline monitoring was conducted by the PP and they have reported the basic environmental parameters. But in the case something like hydrologic monitoring all data and land used pattern have been obtained from the relevant authorized institutes.

5.3.1.2 Impact monitoring

The physical, biological, socio-economic, and cultural parameters within the project area must be measured during the period of project construction and operation in order to detect environmental changes, which may have occurred as a result of project implementation. This part of monitoring has been done by the Scoping committee at the scoping process. Impact prediction of this monitoring process is based on the views and comments of the stakeholder institutions

According to the questionnaire results scoping committee of every project has conducts at least one field surveying to identify environmental, social & cultural impacts.

5.3.1.3 Compliance Monitoring

This is the periodic or continuous recording of specific environmental quality indicator or pollution levels to ensure project compliance with recommended protection standards. The main aim of EIA compliance monitoring is to provide the information required to ensure that project implementation has the least possible negative environmental impacts, and all possible positive impacts, in the project affected area. The main aim of EIA compliance monitoring is to provide the information required to ensure that project implementation has the least possible negative environmental impacts and all possible positive impacts, in the project affected area [9]

These types of Monitoring have been done for the air pollution, Water quality and noise & vibration pollution in the Projects. Water Quality analysis has not been done any of the projects during three stages of pre-construction, construction & operation stages. Noise level analysis Noise level monitoring has been done five of the twelve Projects. Vibration analysis which is an important phenomenon to determine the damage has not been done any projects it is phenomenon the damage of the village houses and landslides had not been done by any one of the projects. Air pollution analysis is not much effective in the Mini Hydro projects, because all the projects are done small scale and the using heavy machinery to minimum for the projects none of the project had done pollution analysis, but they had taken but they had taken preventive action for the impact.

According to the experienced and literature survey during the research the following issues arising for ineffective monitoring process of the every project.

1. Lack of fund allocation for the project activities is one of reason. The schedule monitoring process requires visits many times. The PAA should arrange meals and accommodation facilities when the monitoring committee has to travel long distance to visit the project. But there is a limitation on the administrative charge available to the PAA. If we increased the

administrative charge it is a burden to the PP. It becomes burden to the PP. It discourages the PP.

2. Lack of staff available in the Environment cell of Project Approving agencies has a tremendous effect for the weakening of Environmental Monitoring Process.

3. Lack of capacity building of officers is effective reason for weak monitoring process.
4. The monitoring process is not properly scheduled and not allocating time for monitoring process is weakening few projects,
5. The appointed monitoring committee members do not have sufficient background knowledge of the Project, and therefore they are unable to monitor exactly with the baseline conditions. The committee members cannot spend lot of time in the monitoring process.

Considering the above facts the following remedial actions may be proposed the monitoring regulations and guideline has to be revised. In addition actions has to be taken to appoint a separate work group with proper skilled development Programs must be appointed.

The monitoring committee must be appointed from the people who have lived for a long period in the village. Then massage can be sent to the Monitoring Committee of the PP violates violate regulation mitigation Process. The process at the monitoring is done by P.P they may be able to identify the issues related any protest, and complaint against the PP. But this is a not a practical solution, and we must take necessary action to prevent social, cultural and Environmental impacts.

5.4 Environmental Impact Identification Methodologies Used and Issues

There are many types of EIA methods. But, only the most suitable methods but only the most suitable methods for Mini Hydro Projects such as checklist, Matrixes, Network and expert opinion methods have been discussed. The selected projects

were categorized according to their impact identification methodologies. This is shown in table 4.3.

. The impact analyses of twelve projects indicate that the Predicted impact was missing in some project sand this may have been due to poor usage of EIA the methodologies,

Several activities are required to conduct an environmental impact study including identified impact, preparation of description of the affected environmental impact prediction and assessment and selection of the proposed action from a set of alternatives being evaluated to meet identified needs. There are eighteen EIA methods and they have been arranged against seven activities in the Table3.1. The each of the methods has advantage and limitation.

Table 5.1 Type of Methods used in EIA activities

	Types of Methods in EIA	Define Issues (Scoping)	Impact Identification	Described Affected Environment	Impact Prediction	Impact assessment	Decision Making	Communication of Results
1	Analogs(Case studies)	X	X			X	X	
2	Checklists (Simple, descriptive, Questionnaire)		X	X				X
3	Decision focus checklist (MCDM:MAUM:DA: Scaling: weight)					X	X	X
4	Expert opinions(professional judgment, Delphi, adoptive, environment assessment, simulation, modeling)		X		X	X		
5	Expert Systems(Impact identification prediction, assessment, decision making	X	X	X	X	X	X	
6	Laboratory testing scale model		X		X			
7	Literature reviews		X		X	X		
8	Matrices (simple, stepped, scoring)	X	X		X	X	X	X
9	Monitoring (baseline)			X		X		
10	Monitoring (field studies of analogs)				X	X		
11	Networks		X	X	X			
12	Overlay mapping(GIS)			X	X	X		X
13	Photographs and Photo montages			X	X			X
14	Qualitative modeling			X	X			
15	Quantitative modeling			X	X			
16	Risk Assessment	X	X	X	X	X		
17	Scenarios				X		X	
18	Trend Extrapolation			X	X			

X- Potential for direct usage direct usage of method for listed activity

MCDM - Multi criteria Decision Making **MAUM** - Multi Distribute utility Measurement

DA- Decision Analysis **GIS** - Geographical Information System

The checklists method lists local environmental factors, which are likely to be affected where a development is planned. This list can contain broad categories of factors as flora, fauna, hydrological regimes, surface water bodies and the atmosphere. These methods can be categorized again as Simple, Questionnaire and quantitative. The typical checklist developed for mini Hydro Power is shown in table 5.1

Table 5.2 – Sample Checklist for a Mini Hydro Power Projects.

No	Environmental Impact	Impact		Short term Impact	Long Term Impact	Reversible Impact	Irreversible Impact	No Change
		Positive	Negative					
A	Preconstruction Stage							
1	Resettlement of People							
2	loss of bathing places							
3	Removal of vegetation							
B	Construction Stage							
4	Soil erosion							
5	Land sliding							
6	Water quality							
7	Noise Impact							
8	Vibration Impact							
9	Safety impact							

10	Solid waste Generation							
11	Sedimentation							
12	Air pollution							
13	Change in Land Pattern							
14	Liquid waste generation							
15	Removal of vegetation							
16	Human Health							
17	impact on cultural location							
18	Change of drainage Pattern							
19	impact on aquatic Fauna							
20	Impact on Terrestrial fauna							
21	Impact on Terrestrial flora							
22	Infrastructure development							
23	Lost of							
24	Inundation of properties							
C	Operation Stage							
24	Inundation properties							
25	Water Eutrification							
26	Fish Migration							
27	Aquatic flora & fauna							
28	Terrestrial Flora & Fauna							
29	Siltation							
30	Air pollution							

31	Noise pollution							
32	Job opportunity							
33	Recreation and tourism potential							

Impact of all the projects were identified by answering questionnaires provided by the Project Approving Agencies. Hence, in all the project Impact has identified using questionnaire type checklist methods none of the projects has quantified possible impacts.

The matrix consists of a horizontal list of development activities displayed against a vertical list of environmental factors. The matrix is used to identify impacts by systematically checking each development activity against each environmental parameter. This types of impact analysis is for detailed impact analysis of project. This is essentially used for large and complex projects, but it can also be used for Mini Hydro Project impact identification. A developed matrix is sown below in table 5.2

The network analysis is complicated and identified impacts inter connections. However, in practice it can be applied by considering secondary and more impacts of the each activities.

Table 5.3 – Sample Matrix for the Mini Hydro Project

`	Activities	Impact zone	Air Quality	Noise & vibration	Soil quality	Surface water Hydrology	Surface water quality	Ground water	Ground water quality	Erosion and sedimentation	River Geomorphology	Terrestrial Flora	Terrestrial fauna	Aquatic Flora	Aquatic Fauna	Endangered species	Protected area	Change in land used pattern	Land take	Agriculture	Forestry	Fisheries and aquatic	Solid waste generation	Cultural locations
1	Construction of access roads	Up stream																						
		Construction Site																						
		Down stream																						
2	Setting up of construction workers' camp	Up stream																						
		Construction Site																						
		Down stream																						
3	Handling and storage of construction materials	Up stream																						
		Construction Site																						
		Down stream																						
4	Disposal of solid and liquid wastes	Up stream																						
		Construction Site																						
		Down stream																						

5	**Site clearance of vegetation and top soils**	**Up stream**																					
		Construction Site																					
		Down stream																					
6	**Clearance of vegetation for transmission line**	**Up stream**																					
		Construction Site																					
		Down stream																					
7	**Construction of temporary coffer dams to divert the stream for construction**	**Up stream**																					
		Construction Site																					
		Down stream																					
8	**Earth moving and blasting**	**Up stream**																					
		Construction Site																					
		Down stream																					
9	**Quarrying and transport of rock, sand and gravel**	**Up stream**																					
		Construction Site																					
		Down stream																					

10	**Concrete work**	**Up stream**																					
		Construction Site																					
		Down stream																					
11	**Installation of electrical & mechanical equipments**	**Up stream**																					
		Construction Site																					
		Down stream																					
12	**Installation of switch yard and transmission line**	**Up stream**																					
		Construction Site																					
		Down stream																					
13	**Filling of the ponding area**	**Up stream**																					
		Construction Site																					
		Down stream																					
14	**Operation of Power Plant**	**Up stream**																					
		Power Plant																					
		Down stream																					

6.0 Conclusion and Recommendations

6.1 Conclusion

The research observed that the exact gap between predicted impact and the implemented impact is cannot be analysis because, the given predicted impact did not apply to the projects at any time. However it is responsibility of PAA and scoping committee to predict the exact impact. It was observed that the IEE report does not mentioned methods of exact identification. This is a weakness of submission IEE report as well as Term of Reference (TOR). TOR should be laid down the condition that the method of impact identification should be included in the IEE report. All the projects taken to research have neglected the monitoring process and which is an important part of IEE and EIA. The Environmental Monitoring process is not compressive and PP had violated mitigation as well as the conditions stipulated by the PAA. Hence Monitoring process must be improved to implement of Predicted mitigations satisfactorily.

The IEE reports of all the twelve Projects are not in unique order, similar to other countries like India. Sri Lanka must have proper stand guide line to be followed by Mini hydro Project

As per the studies, the Mini Hydro Projects have to face challenge such as heavy flood, blasting hazards, Landslides and soil erosion. These challenges can be overcome by proper planning and management.

6.2 Recommendations

As per the results of this research following recommendations were made.

1. Selection of scoping committee members has to be improved because some stakeholders were missing while selecting Scoping committee members.
2. Monitoring committee must be appointed from stakeholders and subject experts.
3. The benefits for the villagers have to be satisfactory level in order to prevent un-necessary delay of projects due to protest by the Villagers.
4. The Project proponent should analyze the environment and social damage which may cause by the implementation of the Project and they must take precautions to overcome or minimized.
5. Standard guideline must be prepared to Mini hydro projects and it must be include conditions and procedure applicable to all part of Sri Lanka.
6. Attention must be paid mostly for E flow designing, Blasting process of the projects, in order to meet the disaster situation blasting procedure and hazard preventive methods must be laid down. Insurance policy also should be introduced.

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[5]Coast Conservation Act No 57 of 1981 and Coast Conservation (Amendment) Act No 64 of 1988

[6] Fauna and Flora (Protection ordinance No 2 of 1937) and Fauna and Flora (amendment) act No.49 of 1993 National Environmental Act. No 56 of 1988 Ibid, section 23Z

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[8] IEE reports of Projects

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Chapter 1- Introduction

1. Introduction

This Research is aimed to look at the environmental impacts related to Mini hydro projects in Sri Lanka and to determine the available methodologies for identification of Major Environmental Impacts and the options to mitigate the impacts or avoid impacts. It tries to look at the monitoring process conducted by project Monitoring Committee during the implementation of mitigation and the public participation in the IEE/EIA process. The following chapter will introduce the history of IEE/EIA process, standard and legality behind the IEE/EIA process in Sri Lanka and other countries. It also includes the objective of the research and the reason for the selection of Mini Hydro Projects as the target Development Projects**.**

1.1 History of EIA /IEE Process in the World

Environmental Impact Assessment (EIA) is a system for identifying and introducing mitigation measures to prevent and avoid environmental adverse impacts caused by the development projects. EIA is also an effective instrument to achieve sustainable development.The concept of sustainable development was introduced at the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil in 1992. Principle 4 of the Rio Declaration, stated*"In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it."* Principle 17 stated that *"Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have significant adverse impacts on the environment and are subject to a decision of a competent national authority."* In other words, integration of environmental consideration into any development project is required and EIA is the system to achieve this goal. For this reason, EIA has become increasingly significant in recent years.

The origin of Environmental Impact Assessment system started with the enactment of the National Environmental Policy Act (NEPA) in 1969 by the U.S. In 1981, the US Agency for International Development (USAID) revised the National Environmental Policy Act (NEPA). By its revision, Environmental impact assessment (EIA) became a mandate to development assistance project. This was the first attempt to introduce EIA systems in the field of development assistance.

The objective of environmental impact assessment is to offer information to decision makers concerning matters that may be brought about as a result of decisions relating to a new project, program, plan or policy. Environmental impact assessment must realize decision-making based on the input information including potentially important factors and it must be beneficial to both the proponent and the people. Furthermore, environmental impact assessment is a technique that presents in a systematic manner a technical assessment of impacts on the environment that the project is likely to cause and explains the significance of predicted impact. As a result, it indicates the scope for modification or mitigation. Finally, it makes the concerned ministries/agencies to assess the potential results of the project before a decision is given. Project developers and administrative agencies who have a responsibility for environmental consideration can use environmental impact assessment technique to improve the quality of both the project plan and decision-making by identifying possible effects in the early stages. The specific objective of the environmental impact assessment system is as follows:

- To disclose significant environmental effects of proposed projects to decision-makers and the public.
- To identify ways to avoid or reduce environmental damage.
- To prevent adverse environmental impacts by requiring implementation of feasible alternatives or mitigation measures.
- To disclose reason of approvals for the projects with significant environmental impacts to the public.
- To foster interagency co-ordination.
- To enhance public participation. [1]

1.2 History of EIA /IEE Processing Sri Lanka

The concept of Environmental Impact Assessment was introduced in Sri Lanka in the early 1980s. The National Environmental Act No. 47 of 1980 was our basic national charter for protection and Management of the Environment. The National Environmental (Amendment) Act No. 47 of 1980 was enacted in 1988 in Sri Lanka. This was immediately followed by the Coast Conservation Act in 1981, which empowered the Director of Coast Conservation to request Environmental Impact Assessments for development projects located in the coastal zone of Sri Lanka.

However, until the passage of the amended National Environmental Act No. 57 of1988 impact assessments were not required for energy developments. However the Act of 1988 forms the primary basis for the legal and regulatory framework for energy developments in Sri Lanka today.

Prior to the passage of the amended National Environmental Act, considerable protests from the public focused governmental and public attention on the Environmental Impact Assessment process. The need to provide a legal framework for Environmental Impact Assessment and the training of professionals were recognized by the government even before the corresponding laws came up to operation . The amended National Environmental Act of 1988 is supported by a set of Orders and Regulations published by the Minister of Environment. These Orders and Regulations interpret the law and set down the requirements for preparing an environmental assessment that complies with the Act.

The first two Orders and 18 regulations were published by the Minister for Environment in 1993. One of the Orders designated 14 state agencies as project approving agencies, and the second Order specified the types of projects that required either an Initial Environmental Examination or a full Environmental Impact Assessment.

The first Order which designated, the project approving agencies, was revised in 1995and the agencies were separated up to two categories..

The prescribed projects that require environmental impact assessment have been categorized as follows:-.

Projects which are located wholly or partly within the coastal zone.
Projects which are located outside the coastal zone

The Environmental Impact Assessment Process in Sri Lanka requires immediate coordination between the developer and the Central Environmental Authority.

There are eight basic steps of the EIA process in Sri Lanka which should be observed the beginning with submittal of preliminary information about the project in(Table 1.1).

The preliminary information is submitted for the project Approving Agency to determine of whether or not an EIA report is required for the project. For this reason alone, the project proponent must discuss the project with the Project Approving Agency in the early stages of planning the project. Generally, the Preliminary Information submitted would include a general description of the project, location of the project, its scope and any other information requested by the Project Approving Agency. In the Preliminary Information its include maps of the area and general layout of the proposed energy development requested by the Project approving agency. The Preliminary Information Package would be similar to the information contained in a pre-feasibility reporting Sri Lanka. The list of issues to be discussed in the EIA is usually defined by the Project Approving Agency in consultation with the project proponent. This approach is somewhat different from the approach adopted in other countries where the Scoping Document forms the basis for the Terms of Reference (TOR) as other countries the project proponent is solely responsible for identifying the specific issues that will be addressed.

Generally, the Environmental Clearance for the project will include a number of conditions that the developer must comply with during the construction and operation of the project. These will include the mitigation and compensation measures that are proposed in the EIA, potentially additional measures recommended by the Central Environment Authority, and monitoring programs to assure

compliance with the commitments made in the EIA report**.** Prior to presenting the EIA in its final form it is often recommended that the project proponent submits a draft of the EIA to the Authority to gain comments and recommendations for preparing the final EIA. Generally, the Authority will provide comments on the draft of the EIA that will enable them to make a final review of the EIA and approve the EIA. The review process will consist of two basic procedures. The first aspect of the review will be to ensure that the legal requirements are addressed within the EIA report. This is to ensure that the EIA is comprehensive and fulfills the requirements that are identified in the legal framework. The second aspect of the review is relative to the technical aspects of the EIA. The review will focus on adequate description of the existing conditions in the proposed project site. This is followed by a review of the impact assessment of the project and a determination of the significance of the impacts that are anticipated during the construction and operation of the project.

The review of the impact assessment will concentrate on whether the assessment of impacts is believable and if there is sufficient support for the analysis of the impacts. This is then followed by a review of the mitigation and compensation measures that are proposed for incorporation into the design and operation of the project. One of the basic premises for review of the mitigation and compensation measures is to determine if the proposed measures will be effective in mitigating the impacts and what residual impacts will occur. This review will focus on both environmental and social impacts and the mitigation and compensation plans that will accompany those effects. The final aspect of the review will focus on the Environmental Management and Monitoring Plan. This plan is designed to enable implementation of the mitigation and compensation measures (including any rehabilitation program that is required) and will identify the organizations that will be responsible for the implementation.

In addition, the review of the Environmental Management and Monitoring Plan will evaluate the proposed monitoring programs that are to be designed to determine the actual effects of the project as well as to evaluate the effectiveness of the proposed mitigation and compensation measures. Based on the results of the review, the

Central Environment Authority will recommend either that the EIA be approved or rejected.

1.3 Major steps in the current EIA Procedure

1.3.1 EIA and IEE Process in Sri Lanka

1.3.1.1 The EIA Process

In the event that an EIA is required, the Project approving Agency in consultation with CEA is responsible for subjecting the preliminary information to environmental scoping, in order to set the Terms of Reference (TOR) for the EIA. The TOR is prepared by a Technical Evaluation Committee (TEC) comprising experts in the relevant field, appointed by the PAA. In developing the TOR, the regulations provide for the PAA to consider the views of state agencies and the public. Upon submission of the EIA by the proponent, the PAA is required to determine whether issues referred to in the TOR have been addressed and notify the proponent of any inadequacies within 14 days.

In the event any inadequacies are identified, the proponent is required to make necessary amendments and resubmit the report. Once accepted, in addition to the EIA being forwarded to the CEA by the PAA, notice is also placed in the Government Gazette and in a national newspaper published daily in Sinhala, Tamil and English languages inviting the public to make written comments, if any, to the PAA within 30 days from the date of first appearance of the notice. According to the legislation, public consultation is mandatory is only at this stage of the EIA process.

Informal consultation with NGOs, interested groups and civil society may occur during early stages of the EIA as determined by the PAA depending on the type of project and public interest in the project. The notification would specify the times and places at which the EIA would be available to the public. As a minimum the report would be available at the CEA, PAA and in a GOSL agency in the locality of the proposed project. The environmental regulations have provisions for public hearings on the project although it is not mandatory. The PAA can use its discretion and hold a public hearing if it would be in the interest of the public. The PAA is

required to forward all comments, either written or raised during any public hearing, to the project proponent for review and response within 6 days of completion of the public comment period. The proponent is required to respond to all such comments in writing to the PAA.

The TEC appointed by the PAA would then evaluate the EIA and require the project proponent to respond to any queries raised by the TEC. The TEC would also evaluate the adequacy of the proponent's response to any comments raised during the public comments period. Upon completion of the evaluation of the TEC, the PAA with the concurrence of the CEA would grant approval for the implementation of the proposed project subject to specified conditions or refuse approval for implementation of the project, with reasons for doing so. The notification must be made within 30 days of the receipt of responses from the proponent.

The PAA is required to specify a period within which the approved project should be completed. In the event the proponent is unable to complete the project within the specified period, written permission for an extension has to be obtained from the PAA, 30 days prior to the expiration date. The PAA is responsible for forwarding a report which contains a plan for monitoring the implementation of the approved project, to the CEA, within 30 days from granting approval. It is also the responsibility of the PAA to publish in the Government Gazette and in one national newspaper published in Sinhala, Tamil and English languages, granting approval for the project. It is mandatory that the project proponent informs the PAA of any alterations to the project as approved and/or the abandonment of the project. The PAA shall, where necessary, obtain fresh approval in respect of any such alterations that are intended to be made to the approved project. The PAA in consultations with the CEA would also determine the scope and the format of the supplemental report required to be submitted for such alterations.

1.3.1.2 The IEE Process

Upon review of the preliminary information provided by the proponent, if the PAA determines that the project would have no long-term adverse environmental impacts, an initial environmental examination (IEE) would be considered adequate. Under

such circumstances, the proponent will be required to submit a detailed IEE for review and approval by the PAA. The IEE will identify potential environmental and social issues and the complexity of possible remedial actions. Upon reviewing the IEE, if the TEC identifies any substantial environmental issues that may arise as a result of the proposed project, the proponent will be required to undertake a detailed EIA. In the event the IEE is considered adequate, then the project proponent is requested to prepare an Environmental Management Plan (EMP), to address any potential environmental and social issues as well as incorporate the PAA/CEA's approval conditions. The IEE review process is similar to the EIA review process, except for the level of detail and analysis involved, which is proportionate to the anticipated environmental and social impacts.

The CEA has developed a custom made IEE questionnaire for mini hydropower projects. The Environmental Questionnaire for Mini Hydro Projects is more detailed than the general IEE questionnaire and is designed to capture environmental issues specific to mini hydro projects. This questionnaire is used by the CEA/PAA to determine whether the potential project results in long term irreversible or complex environmental and social issues and if so, it warrants an EIA. If no EIA is required, the proponent is required to prepare an Environmental Management Plan (EMP) which contains remedial measures to address adverse environmental and social issues. The IEE is not required by law to be opened for the public for comments and does not go through the public consultation process required for an EIA.

The CEA review is based on the list of prescribed projects listed under provisions of Part IV C of the NEA No. 47 of 1980 as stipulated in Gazette (Extra Ordinary) No. 772/22 dated June 24, 1993. All prescribed projects have to be subjected to environmental assessments, either through IEEs or EIAs.

1.3.1.3EIA / IEE Procedural steps

This Process involves six major steps as in the Table 1.1

Table 1.1 EIA/IEE steps

	Steps	Time allowed for the PAA
1	Screening (Determining whether an EIA / IEE is required for a project)	6 days
2	Scoping (Determining the scope of the EIA / IEE study and issuing of Terms of Reference)	14 days for IEE and 30 days for EIA
3	Preparation of the EIA / IEE report	No time limit has been given since the project proponent is responsible for this.
4	Review of the EIA / IEE report The review involves both public and technical review	
5	(a) Public review (applicable only for EIAs) The project proponent needs to respond to the public comments received.	30 working days
6	(b) Technical review	21 days for IEE and 30 days for EIA.
7	EIA / IEE Decision Granting approval with terms and conditions or rejection with reasons.	
8	Post approval monitoring	

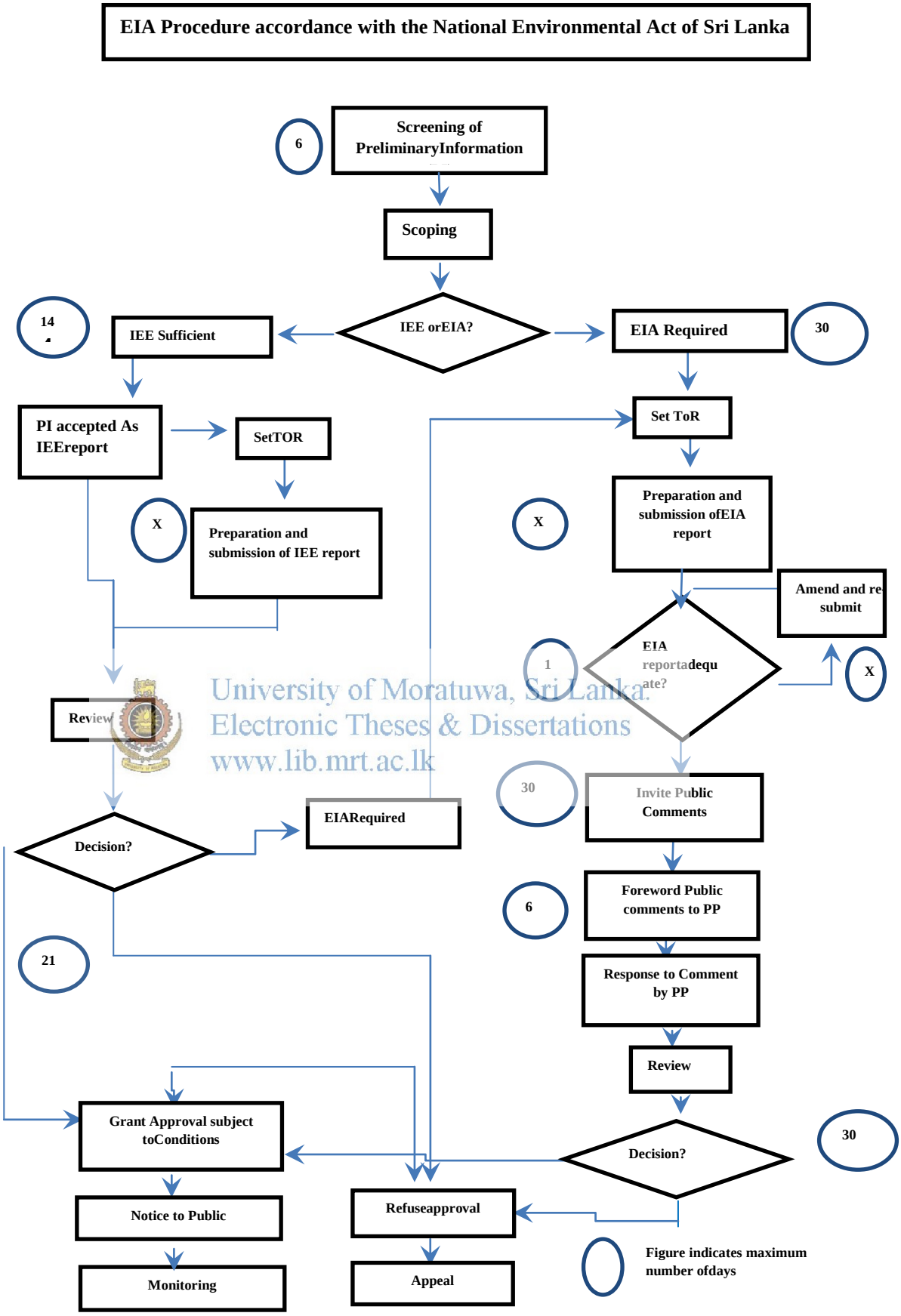

Figure: 1.1 - EIA Procedure accordance with the National Environmental Act of Sri Lanka

1.3.1.3 General Approaches and Methodologies for Assessment

The general principles that shall be used in evaluating the assessment methodologies are described below:

1.3.1.3.1 Description of the Environment: The characteristics of the environment shall be described in a way sufficient for identification and prediction of environmental impacts. Where necessary, baseline environmental surveys shall be carried out to determine the existing environmental conditions on the site and in all environs likely to be affected by the proposed project. The issues described in the EIA study brief shall be investigated and would typically include existing water and sediment quality, air quality, the existing noise environment, ecology, the cultural heritage and the man-made environment. These surveys shall normally include the site of the project, its access, and any other areas likely to be impacted during construction and operation (or decommissioning). The type and duration of baseline surveys shall be such that there will be adequate information taking account of natural variation to define the existing conditions. This information shall form the basis for predicting and evaluating the impacts from the project so that the study objectives can be met. Where appropriate, results from past studies can be used.

1.3.1.3.2 Impact Prediction: The assessment methodologies proposed shall be relevant to the issues to be addressed, shall have been used successfully in similar situations or be demonstrated as acceptable by recognized national/international organizations, and shall be capable of:

(i) Identifying potential impacts, which may be harmful or beneficial to the environment;

(ii) Identifying receivers, habitats or resources, which are vulnerable to change;

(iii) Defining the project/environment interactions;

(iv) Examining the chain of events or "pathways" linking cause with effect;

(v) Describing and predicting the reasonable case scenario and/or the worst case scenario, or such scenarios as required in the EIA study brief; and

(vi) Predicting the likely nature, extent and magnitude of the anticipated changes and effects such that an evaluation, in quantitative terms as far as possible,

1.3.1.3.3 Impact Evaluation:

The methodologies for evaluating the environmental impact shall be capable of addressing the following issues:

(i) The existing or projected environmental conditions without the project in place;

(ii) The projected environmental conditions with the project in place and the sum total of the environmental impacts taking into account all relevant existing, committed and planned projects;

(iii) A differentiation between the environmental impact caused by the project and that caused by other projects, and to what extent the project aggravates or improves the existing or projected environmental conditions;

(iv) The environmental impact during different phases of construction and development of the project; and

(v) The evaluation of the seriousness of the residual environmental impacts

1.3.1.3.4 Impact Quantification:

The impact quantification is an important part of an IEE or EIA. Because if, the impact is below the threshold level in keeping with the guideline then impact mitigation is not required Therefore, before the impact mitigation quantification is required to identify the required amount and method of Mitigation.

Dust Emission due Vehicle Movement

$$\mathbf{E = (0.81S)\left(\frac{S}{30}\right)\left(\frac{365-w}{365}\right)}\text{---------- Eq. (01)}$$

Where E = Dust Emission factor, lb per vehicle – mile

s- Silt content of road surface material %

S = average Vehicle speed mi/ hr

w = Mean annual number of days with 0.01 in (0.254mm) or more of rain fall

Mass balance Approaches

The law of conservation of matter states that matter is conserved--that is, neither created nor destroyed. Thus, if we know the amount of material that enters a chain of processes, and keep an account of all the amounts in different paths, we can calculate the quantities of materials that are hard to measure. For example, we can calculate the amount of material entering the atmosphere if we know the amounts that went in, the transformations, and the waste streams to land and water. This method is called the Mass or Material Balance technique.

An example of a process from everyday life is sewage treatment Wastewater is generated in your homes and is collected with the sewer system and transported to a treatment plant. When asked what happens to the sewage at the plant, most people say that the pollutants are removed from the water and the relatively "clean water" is then discharged to a water body. But what happens to the pollutants that are removed? In the treatment process, these pollutants are transferred from the water to the air, and to solid material known as sludge, or bios lids. and, a small amount remains in the "clean water." These waste products must be taken care of so that they do not affect the environment. A mass balance can be used to determine how much pollutant is in each of its various forms.

$$\sum C_{avg} = \frac{\sum CiQi}{\sum Qi} = \frac{\sum Mi}{\sum Qi}\text{----------Eq. (02)}$$

Where, C_{avg} = Average Concentration of Constituent for combined discharge stream

C_i = Concentration of Constituent in i_{th} discharge stream

Q_i = Flow for the i_{th} discharge stream

M_i=Mass of Constituent in i_{th} discharge stream

This mass balance equation can be used to determine

Average downstream concentration

Erosional Impact on water quality during construction or operation.

1.3.1.3.5Impact Mitigation: the methodologies proposed for mitigation shall give priority to avoidance of impacts. The assessment methods shall be capable of:

(i) Identifying and evaluating mitigation measures in order to avoid reduce or remedy the impacts;

(ii) Assessing the effectiveness of mitigation measures; and

(iii) Defining the residual environmental impacts, which are the net impacts remaining with the mitigation measures in place.

The assessment methodologies shall allow for the assessment and evaluation of the cumulative environmental effects if the following circumstances apply:

(a) The impacts arising from the project are predicted to extend beyond the boundaries of the project or over a long period of time;

(b) There may be interactions between the environmental impacts of the project, affecting the sum total of its environmental impacts; or

(c) There may be interactions between the environmental impacts of the project and the environmental impacts of other developments, resulting in accumulation of impacts and affecting the sum total of their environmental impacts.

1.4 Background of the Research

This project consists of a case study on selected twelve Mini hydropower plants in Sri Lanka. From this research, the environmental impacts during pre-construction, construction and operation stages were identified. The project includes a literature study on the possible environmental impacts from Mini hydropower, measures that can be taken to mitigate the impacts, information gathering about the twelve different

hydropower plants and an analysis part where the information in the literature review is connected to the situation at the twelve plants. The study has not included any name of Mini Hydro Power plants and stakeholders.

Infrastructure development such as roads and transmissions lines and the environmental impact related to it and mini hydropower plants with surrounding ecosystem have been considered.

1.5 Research needs

The majority of Mini Hydro schemes in Sri Lanka are owned by private sector investors. As a result the possibility of violate Environmental regulations is high. According to research and opinion of the people, it has been observed that the IEE process of the past completed Mini Hydro Projects is not comprehensive and they violate Environmental regulations. In addition to past report and views expressed by the people reveal. That there were many protests against the sever negative, social and environmental impact during the construction pre-construction and operation stages of Mini Hydro Power Projects. (Few of the projects are listed in the research).

The IEE process of Mini hydro project become more complicated due to the following reasons:-

1. The unforeseen impact is high and predicting them is difficult.
2. The projects are highly impacted with scenic beauty and natural resources
3. The geographical situation is more varying one project to other.
4. There is a wide gap between the IEE guideline and the real construction of the project.
5. In the case of multiple projects on the same river, The project activity in the upper part of the stream will directly affect the downstream project.
6. The majority of Developers are private companies and their primary objective is to earn profit and not to sickly comply with Environmental than amenable to regulations.
7. There is inadequate monitoring of Project activities because PAA does not have full time staff, funds and equipment needed for Mini Hydro Projects.

For the above reasons, it has been decided to find out the efficiency and effectiveness of environment impact assessment of the Mini Hydro Project in Sri Lanka.

1.6 Research objective

Based on the above needs the objective of the research is to answer the following questions:-

1. How does a Project proponent identify and predict the impact and to what extent does the proponent quantify the predicted impact?
2. What are the available methodologies for mitigation of Impact? How can they be improved
3. To what extent has the Project proponent implemented the EIA-recommended mitigation measures?
4. How do regulatory bodies ensure implementation of EIA-recommended mitigation measures?
5. How and to what extent did the public participate in the EIA process?
6. What were the likely downstream impacts of the project and to what extent did the proponent take them in to consideration?
7. How do regulatory bodies monitor the mitigation actions and the weaknesses of the Monitoring process?

This research has then proceeded to of activities mentioned below.

A literature survey was conducted through various media such as reference libraries and e- libraries.

The objective based questionnaire was prepared, finalized, and issued to selected twelve mini hydro project owners and stakeholders to gather necessary data.

The gathered data was processed and analyzed using analytic methodologies and interpreted the data for easy identifications.

At finally, according to the results obtained possible suggestions for the improvement have been discussed and a final consideration has been made.

Chapter 2- Literature Review

The purpose of this study, theoretical framework and findings on this topic has been explained further in this chapter.

2.1. Operation of Mini Hydro Projects

Mini Hydropower systems use the energy in flowing water to produce electricity or mechanical energy. The water flows via channel or penstock to turbine where it strikes the turbine, causing the shaft of the waterwheel or turbine to rotate. When generating electricity, the rotating shaft, which is connected to an alternator or generator, converts the motion of the shaft into electrical energy. This electrical energy may be used directly, stored in batteries, or inverted to produce utility-quality electricity.

Mini hydroelectric facility requires that a sizable flow of water and a proper height of fall of water, called head, are obtained without building elaborate and expensive facilities. Mini hydro plants can be developed at existing dams and have been constructed in connection with river and lake water-level control and irrigation schemes. A Mini hydropower project contains various components. The components, as shown in figure 2.1, start from water storage and ends in the transmission. Thus, the major components of a hydropower projects can be listed as follows:

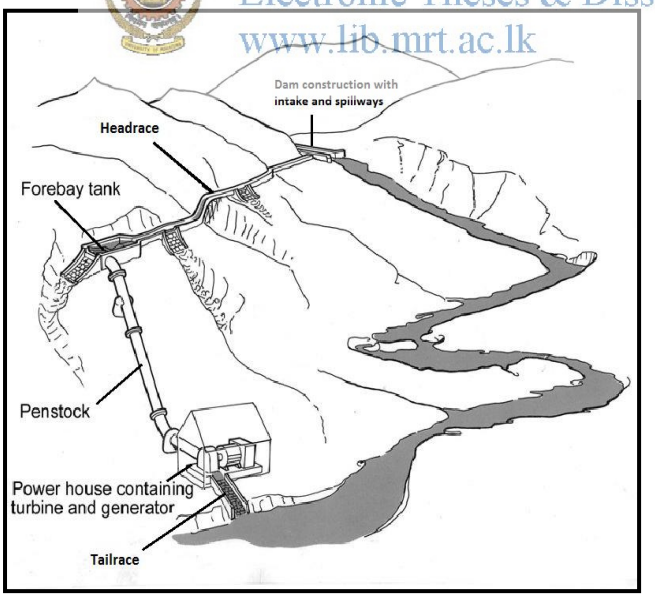

Figure 2.1 Components of a Mini Hydropower

Intake Dam (Weir): An impounding structure to store water for creating head and to assure the controlled and continuous flow.

- **Fore bay tank-** It is a pond-like structure at the top of the penstock, which regulates the fluctuation of water and it forms the connection between the channel and the penstock
- **Penstock:** A pipe from the fore-bay of the dam till the mouth of the turbine serving as a water conductor system.
- **Turbine**: The main electrical installation that helps to transform the mechanical energy of the water into the kinetic energy.
    - **Generator:** An electrical installation to transform mechanical energy of the turbines to electric energy.
    - **Powerhouse:** A civil structure used for electro mechanical installations.
    - **Tailrace channel:** A pool to release the water back into the flowing water body.
    - **Transmission mains:** Transmission units to supply produced electricity to the customer

2.2 Benefits of Mini Hydropower

Hydroelectric systems provide the following general benefits:

- Hydroelectric energy is a continuously renewable electrical energy source.
- Hydroelectric energy is non-polluting - no heat or noxious gases are released.
- Hydroelectric energy has no fuel cost and with low operating and maintenance costs, it is essentially inflation proof.
- Hydroelectric stations have a long life and many existing stations have been in operation for more than 25 years.
- Hydropower station efficiencies of over 90% are achieved making it the most efficient of energy conversion technologies.
- Hydropower offers a means of responding within seconds to changes in load demand.

2.3 Environmental Impacts of Mini Hydropower Projects

A hydropower scheme entails change in use of land and water. Magnitude of such change depends on the selected site configuration. An illustrative site configuration is shown below. The environmental impacts of MHPs are positive (favorable) and negative (undesirable) in nature.

2.3.1 Positive Impacts of MHPs

Positive environmental impacts of Mini hydropower projects are somehow ignored as a routine probably due to the fact that these projects are conveniently considered as demanding an environmental price. It is equally important to highlight and quantify (to the extent possible)

2.3.2Positive Socio-Economic Impacts

1. Project related infrastructure roads, health facilities, education facilities will help the local
2. Improvement in living standard of local people
3. Generation of employment opportunities locally. Direct employment during construction and indirect employment in allied activities
4. Check on migration from villages to towns, thereby checking urban concentration of population
5. It helps in checking deforestation which is taking place to meet food, fodder and fuel demands in rural, remote areas.
6. Small hydro does not require much expertise to build and operate. Components of small hydro projects are simple and fairly visible at site. They can become center of education.
7. In specific cases MHPs are eligible for carbon credits through reduction in CO_2 emission and adding sink for CO_2 via plantation schemes.

2.3.3Positive Ecological/Environmental Impacts

1. Clean and renewable source of energy. MHPs result in saving of non-renewable fuel resources such as coal, fossils.

2. It is benign source of power generation, harnessing only gravitational potential of water to make it yield energy in a continuum

3. Decrease of pollution due to cleaner energy source (hydro replacing diesel generation, electricity replacing polluting energy sources)

4. Increased water surface creates habitat for aquatic life in or near the weir ponding area. Receiving waters create dry mudflats which provide feeding sites for migratory birds and breeding habitat for resident species.

5. Improved ground water table enhancing greenery all around due to landscaping and tree planting.

6. Improvement towards vegetation and plantation associated with the project (compensatory a forestation) and thus providing sink for CO_2 emission

7. Improved habitat due to build environment.

Fauna – aquatic as well as terrestrial. [2]

Table 2.1 Negative Impacts of MHPs

No	Activity	Adverse Impact	Types of Impact (Long term/ shot term /recoverable /irrecoverable)	Methods of Quantification / Qualification	Possible Mitigation methods
01	Construction of road, dam, surface power house and switch yard, diversion tunnel, channel	1. Reservoir sedimentation and deterioration of water quality	1. Short term and recoverable Impact	1. Water quality analysis and Mass balance equation	1. Minimize erosion during construction Planting rapid growing vegetation surrounding the reservoir
		2. Air and noise pollution and disturbance to flora and fauna by work force	2. Short term and recoverable Impact	2. Emission factor calculation and noise level calculation	2. Noise and air emission minimize and sound barrier for noise.
		3. Visual intrusion caused by construction activity	3. Long and short term and recoverable and recoverable. impact	3. field study	3. Used the methods of mimic the natural appearance of them.
		4. Disturbance of recreational spots (e.g. waterfalls) and activities	4. Short term recoverable impact	4. Field study	4. Effort should be taken to minimize the disturbance
		5. Soil erosion due to removal of vegetation and excavation of construction material	5. Short term recoverable Impact	5.Field study and water quality analysis and Mass balance equation	5. Minimize erosion during construction Planting rapid growing vegetation
		6. Alteration in ground water flow	6. Short term recoverable impact	6.Ground water flow calculation and Geological study	6. Minimize the alteration of ground water flow by proving water flow path

					without disturbing natural flow path.
02	Construction of transmission line	1. Damaging flora due to right of way clearing 2. Endangering the lives of fauna 3. Visual intrusion	1.Long term irrecoverable impact 2. Long term irrecoverable Impact 3. Long term irrecoverable impact	1. Field study 2. Field study 3. Field study	1.Compensate damage and select path along the Minimum removal of vegetation 2. Precaution has to used minimize endanger of lives 3. Used the methods of mimic the natural appearance
03	Stream diversion through channel and conduit	1. Loss of habitat of fish and other aquatic flora and fauna 2. Decrease in dilution capacity of stream 3. Depletion in ground water recharge where diversion is taken off from effluent stream 4. Loss of waterfalls and other recreational activities	1. Long term recoverable Impact 2. Long term irrecoverable Impact 3. Long term recoverable Impact 4. Long-term irrecoverable Impact	1. Field study 2. Water quality analysis can be used. 3. Calculation stream flow discharge. 4.Field study	1. Environmental Flow must be maintained. 2. The action must be taken to minimize the contamination of other substance. 3. Maintain continuous environmental flow 4. Take all necessary actions to minimize the impact
04	Ponding	1. Flow disruption	1.Long term irrecoverable impact	1. Flow calculation	1. Take necessary actions to minimize the flow disruption

		2. Channel degradation during generation or spilling and flushing of silt from dam 3. Trapped nutrients and sediments, eutrophication 4. Changed water temperature 5. Changes in land uses: (a) submergence of agricultural and forest land (b) submergence of human settlement and displacement of population (c) submergence of monuments/sites of historic importance (d) loss of whitewater recreation. 6. Change in aquatic plant life and fish species 7. High evaporation rate 8. Sedimentation adversely affects fish spawning areas by burying them 9. Provides increased habitat for mosquitoes and snails which are vectors of diseases like malaria, yellow fever, dengue, encephalitis and schistosomiasis	2.Short term recoverable impact 3.Short term recoverable impact 4. short term recoverable impact 5.Long term recoverable impact 6. Long term recoverable Impact 7. Long term recoverable impact 8 Short term recoverable impact 9. Short term recoverable Impact	2. Calculate from stream flows 3. Water quality analysis 4. Observing the temperature through sensors. 5. Field study 6. Field survey or study 7. Pan evaporation can be used for evaporation rate measurement. 8.Calculate from Mass Balance equation 9. Field study	2. Use a Fore bay tank to control channel flow. 3. Appropriate water treatment has to be made. 4. Control water temperature prevents adverse effect for aquatic flora & fauna. 5. Compensate for the damage and appropriate actions must be taken to minimized damage. 6. Prevent eutrophication or water contamination due to pointed or non point Pollutant. 7. Prevent increase of temperature and maintain lower pond open surface. 8. Minimized the sediment by using soil-stabilizing water retaining equations. 9. The water gathering at river bank without flowing and waste water

05	Operation of hydropower station	1. Increase in pollution concentration in the downstream due to release of pollutants from residential areas, hydropower plant 2. Released water containing low dissolved oxygen 3. Fish mortality from turbine passage 4. Sonic impact: noise level may increase	1.Short term recoverable Impact 2. Short term recoverable Impact 3. Short term recoverable Impact 4. Short term recoverable Impact	1.Water quality Analysis 2. Water quality analysis or Mass balance equation. 3. Field study 4. Calculate the Noise Level or used Measuring Equipment.	1. Pollutant must be collect and dump. Pollutant concentration should be treated to allowable concentration before discharge in to the water. 2. Improve the Oxygen concentration. 3. Trash rack and fish screen must be placed at the intake. 4. Appropriate Noise minimized Process is used Ex. Sand bag wall, green belt.

2.3.5 Provision for Public Participation

Public participation is an important aspect of the EIA process in Sri Lanka. The provision for public participation is contained in the National Environmental Act (NEA).

Once an EIA report is submitted the National Environmental Act provides for public inspection and comment on the EIA report during a mandatory period of 30 days. EIA reports are available for perusal by the public in Sinhala, Tamil and English. These reports are usually kept for public inspection in the CEA Headquarter Library, the relevant Divisional Secretariat Office and Pradeshiya Sabha. Any member of the public may send their comments to the Central Environmental Authority or the respective Project Approving Agency, within 30 working days.

The Project Approving Agency (PAA) publishes notices in the National Newspapers inviting the public to inspect and comment on the EIA report within 30 days. The notice specifies where and when the EIA report can be inspected. The public have a right to obtain copies of the EIA report from the PAA by paying copying charges. A public hearing may also be held at the discretion of the PAA when it is thought that it would be in the public interest to do so.

The public comments received must be sent to the project proponent for response. The project proponent must respond to comments by making every effort to improve the project.

The IEE reports are not required to open for public comments for a mandatory period of 30 days. However, an IEE report shall be deemed to be a public document and shall open for inspection by the public.

In addition to the above mandatory requirement, the project proponents are always advised to have informal dialogues / consultation with the local people during the IEE/EIA study. The project proponent must ensure that the local people get accurate information about the project. If the local community is negatively affected by the

project, it is important that the project proponent consult them and obtain their support in proposing mitigation measures to minimize the impacts. [2]

2.3.6 Environmental Methodologies

Application of Methodologies in EIA Process

Environmental methodologies can be useful, although not specifically required throughout the impact assessment process. Table 2.2 identifies five activities and relevant useful methodologies. It is not necessary to use a methodology entirely in an impact study; it may be instructive to use portion of several methodologies for certain requisite activities. In that regard, methodology selection may be considered a part of an impact study.

Table 2.2 Application of Methodologies in EIA Process

	Process activity	Methodologies		Relative usefulness
1	Impact Identification	Matrices	Simple	High
			Stepped	Medium
		Networks		High
		Checklists	Simple	Medium
			Descriptive	Medium
2	Describing affected environment	Matrices	Simple	Low
			Stepped	-
		Checklists	Simple	High
			Descriptive	-

3	Impact prediction and assessment	Matrices	Simple	Medium
			Stepped	Medium
		Networks		Medium
		Checklists	Descriptive	High
			Scaling , rating, ranking	Low
4	Selection of proposed action (based on evaluation of alternatives)	Matrices	Simple	Medium
			Stepped	Low
		Checklists	Scaling , rating, ranking	Medium
			Weighting-scaling, rating, ranking	High
5	Study summarization and communication	Matrices	Simple	High
			Stepped	Low
		Checklists	Simple	Medium

2.3.6.1 Checklists – Checklists are standard lists of the types of impacts associated with a particular type of project. Checklists methods are primarily for organizing information or ensuring that no potential impact is overlooked. They comprise list questions on features the project and environments impacts. They are generic in nature and are used as aids in assessment

Three types

1. Simple: no information needed on magnitude or importance of impacts"

2. Descriptive, require information on magnitude or importance of impacts as well as indication on prediction methods and indicators."

3. Questionnaires, this is a questionnaire and Answer based analysis. In these methods three types of answer of “yes”, “no”, “may be" can be used. **2.3.6.2**

Matrices - Matrix methods identify interactions between various project actions and environmental parameters and components. They incorporate a list of project activities with a checklist of environmental components that might be affected by these activities. A matrix of potential interactions is produced by combining these two lists (placing one on the vertical axis and the other on the horizontal axis).

They should preferably cover both the construction and the operation phases of the project, because sometimes, the former causes greater impacts than the latter.

Table 2.3 Sample Modified Checklist for Small Reservoir Project

No.	Environmental Impacts	Direct	indirect	Short Term	Long Term	Reversible	Irreversible	Severe	Moderate	insignificant
1	Surface water Hydrology	x			x		x			x
2	Surface water quality	x			x		x	x		
3	Soil/erosion	x			x		x	x		
4	Geology	x			x		x	x		
5	Climate	x			x		x	x		
6	Wildlife Habitat	x			x		x	x		
7	Ecology of Fisheries	x			x		x	x	x	
8	Inundation area	x			x		x		x	
9	Water Quality and Quantity	x			x		x	x		
10	Water supply for downstream irrigation	x			x	x				x
11	Human and Animal toxics of water	x			x	x				x
12	Air quality		x		x		x			x
13	Reservoirs related recreation		x		x		x	x		
14	Visual resources - Natural and cultural Features	x			x		x	x		
15	Visual Resources - Reservoir	x			x		x			x
16	Visual resources - Natural or cultural landscape	x			x					x
17	Irrigation district	x			x	x		x		
18	Increase of the local revenue		x		x	x		x		
19	Employment for Irrigation farmers	x			x		x	x		
20	Land use development for Irrigation	x			x		x		x	

However, matrices also have their disadvantages: they do not explicitly represent spatial or temporal considerations, and they do not adequately address synergistic impacts. Sample Matrix shown in the Table 2.4.

2.3.6.3 Networks – These caused effect flow diagrams which are used to help in tracing the web relationships that exist between different activities associated with action and environmental system with which they interact. They are also important in identifying direct and cumulative impacts. They are more complex and need expertise for their effective use. A sample Network Analysis shown in Figure 2.2 [3]

Table 2.4- Environmental Impact Matrix

	Project Activities	Environmental Components														
		Physical							Biological			Human Environment				
		Geology	Ground Water Quality	Hydrology	Surface Water Quality	Air Quality	Noise Level	Vibration Level	Terrestrial Flora	Terrestrial Fauna	Stream Ecology	Land Use	Traffic	Socio Economic	Public Health	Risk
1.0	Pre-Construction Phase															
1.1	Geotechnical investigation and site survey	N														
1.2	Land Acquisition													S		
2.0	Construction Phase															
2.1	Site Clearing and Earthworks	S, Si		S, N			S, Si	S, N	P, N	P, N				S, B		
2.2	Establishment of Temporary Building				S, N							S, N			S, N	
2.3	Transportation of Materials and Equipment					S, N	S, N						S, N			
2.4	Storage and Handling of Construction Materials				S, N	S, N		S, N								
2.5	Construction of Access Road	S, Si			S, Si	S, Si	S, Si				S, Si			S,B		
2.6	Construction of Sanitary Landfill	S, Si	S, N		S, N									S,B		
2.7	Disposal of Construction and Biomass Waste				S, Si	S, Si										
3.0	Construction Phase															
3.1	Waste Transportation					L, Si							JI – L, Si J2 – N	N		N
3.2	Land filling Activities	L, Si				L, Si	Si	N								
3.3	Land Clearing for Opening of More Cell in Stages to Receive Waste	S, Si														
3.4	Leachate Generation		Si	B	Si	Si			N		N					
3.5	Landfill Gas Generation															
4.0	Post-Closure Phase															
4.1	Final Cover and Landscaping	N							N	N						
4.2	Leachate Generation		Si		Si											
4.3	Landfill Gas Generation					Si										
4.4	Waste Stabilization															N

LEGEND: S = Short Term , L = Long Term , P = Permanent , N = Not Significant , B = Beneficial , Si = Significant

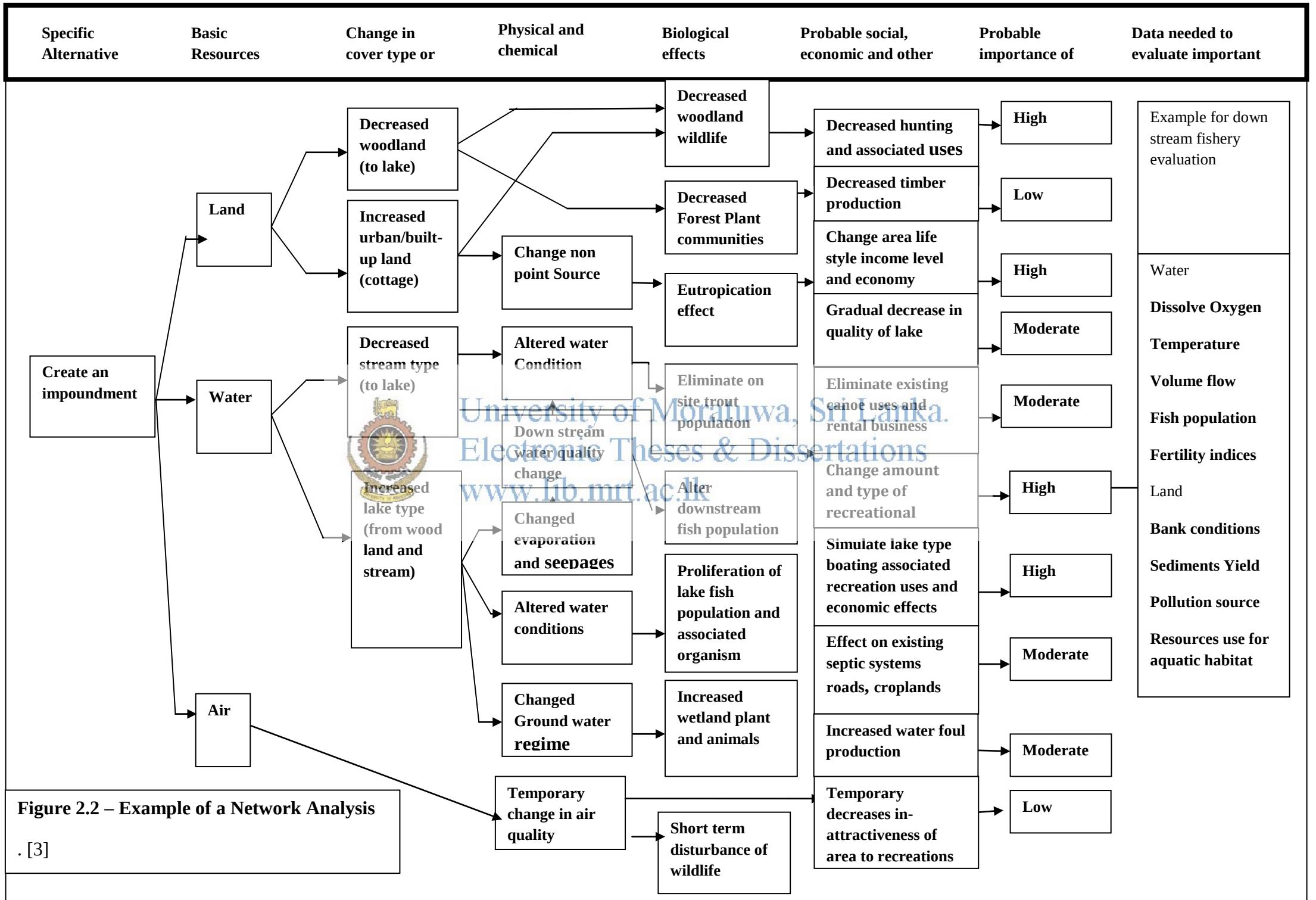

Figure 2.2 – Example of a Network Analysis

. [3]

2.3.6.4 Expert Opinion –This one is suitable for IEE/Scoping/TOR report preparation of sector checklist. In this method subject expert opinion is sought by small meeting, conference, seminar, several small groups. However there can be danger in this when excessive consultation is done and some unjustifiable impacts included in the ToR. This method is simple and required limited resources.

2.3.7 Baseline data collection

The term "baseline" refers to the collection of background information on the biophysical, social and economic settings proposed project area. Normally, information is obtained from secondary sources, or the acquisition of new information through field samplings, interviews, surveys and consultations with the public. The task of collecting baseline data starts right from the period of project inception; however, a majority of this task may be undertaken during scoping and actual EIA.

2.3.7.1 Baseline data is collected for two main purposes

To provide a description of the current status and trends of environmental factors (e.g., air pollutant concentrations) of the host area against which predicted changes can be compared and evaluated in terms of significance, and to provide a means of detecting actual change by monitoring once a project has been initiated

Only baseline data needed to assist prediction of the impacts contained in the ToR and scoping report should be collected.

2.3.8 Impact analysis and prediction

Predicting the magnitude of a development likely impacts and evaluating their significance is core of environmental assessment process. Prediction should be based on the available environmental baseline of the project area. Such predictions are described in quantitative or qualitative terms

2.3.9 Considerations in impact prediction

2.3.9.1 Magnitude of Impact: This is defined by the severity of each potential impact and indicates whether the impact is irreversible or, reversible and estimated

potential rate of recovery. The magnitude of an impact cannot be considered high if a major adverse impact can be mitigated.

2.3.9.2 Extent of Impact: The spatial extent or the zone of influence of the impact should always be determined. An impact can be site-specific or limited to the project area; a locally occurring impact within the locality of the proposed project; a regional impact that may extend beyond the local area and a national impact affecting resources on a national scale and sometimes trans-boundary impacts, which might be international.

2.3.9.3 Duration of Impact:

Environmental impacts have a temporal dimension and needs to be considered in an EIA. Impacts arising at different phases of the project cycle may need to be considered. An impact that generally lasts for only three to nine years after project completion may be classified as short-term. An impact, which continues for 10 to 20 years, may be defined as medium-term, and impacts that last beyond 20 years are considered as long-term.

2.3.9.4 Significance of the Impact:

This refers to the value or amount of the impact. Once an impact has been predicted, its significance must be evaluated using an appropriate choice of criteria. The most important forms of criterion are: Specific legal requirements e.g. national laws, standards, international agreements and conventions, relevant policies etc.

2.3.9.5 Public views and complaints

Threat to sensitive ecosystems and resources e.g. can lead to extinction of species and depletion of resources, which can result, into conflicts. Geographical extent of the impact e.g. has trans- boundary implications. Cost of mitigation, Duration (time period over which they will occur) Likelihood or probability of occurrence (very likely, unlikely, etc.), Reversibility of impact (natural recovery or aided by human intervention), Number (and characteristics) of people likely to be affected and their locations Cumulative impacts e.g. adding more impacts to existing ones. There is an

uncertainty in prediction due to lack of accurate data or complex systems. Precautionary principle is advocated in this scenario.

2.3.10 Impact prediction methodologies

Several techniques can be used in predicting the impacts. The choices should be appropriate to the circumstances. These can be based on Professional judgment with adequate reasoning and supporting data. This technique requires

2.3.11 Types of Environment

2.3.11.1Biological Environment

2.3.11.1.1 Aquatic

Aquatic ecosystem to be studied over an area at least between 2km upstream of the project site and at least 2 km downstream of the project site. The study should include the following:

(a) Fish species of commercial value

(b) Resident species

(c) Migratory species, their spawning ground, fish morphology, anatomy, feeding pattern, breeding pattern etc. Aquatic ecological analysis may be made following the methods outlined in Wetzeland Likens (1991) and APHA (1998). Periphyton, phytoplankton, macrobenthosand zooplankton should be studied for frequency, density, abundance and diversity indices.

2.3.11.1.2Terrestrial

An inventory of flora, listing of rare, endangered, economically important and medicinal plant species should be prepared and their frequency, abundance and density should be determined. Quadrate method is generally used for sampling.

2.3.11.1.3Flora

(a) Major forest products and dependability of the local communities on these such as fuel wood, edible species, construction material etc.

(b) Forest type

(c) Trees, shrubs, herbs

(d)Rare and endangered species

(e) Endemic species

(f) Economically important species

2.3.1.1.1.4 Fauna

(a) Aerial distance of National Park/Sanctuary/Biosphere Reserve etc., if any in the vicinity, from the project site

(b) Rare and endangered species

(c) Endemic species

(d) Species of special interest to local population and tourists

(e) Migratory route of animals, if any, in the project area

2.3.11.2 Socioeconomic Environment

2.3.11.2.1 Demographic Profile (gender-based details of the population)

(a) Rural/urban

(b) Population density

(c) SC/ST and others

(d) Literacy

(e) Employment and occupation

(f) Economic status (land holding/house holding)

2.3.9 Stake holders in IEE Process

Stake holder is any individual, group, agency or organization affected by a project and/or with concern or interest in a development project and its outcomes, or in common, resources impacted by a development project. A stakeholder should be treated as a 'Partner in Development' and not as opponent of the project.

2.3.12 Risk Assessment

Construction involves many separate activities that are carried out within the environmental conditions existing at the site. Environmental conditions will affect the construction activity, and the construction activity will also affect the environment. Thus, there are risks in undertaking the work, e.g., construction that is carried out in the wet season will normally have greater risks attached to it than work undertaken during the dry season the risk of undertaking any construction activity needs to be determined before the activity commences.

Risk = likelihood * Consequence

Risk is assessed as the likelihood that the activity will have an effect on the environment as well as the consequence of the effect occurring. It is often described like this: In all construction activities, there will be a range of likelihoods and consequences that will determine the degree of risk of the activity. Risk is also dependent on the location where the activity will happen, how the activity's location will affect sensitive receptors, and the duration of the activity. Activities of short duration normally have less risk than longer-duration activities.

The risk assessment process is undertaken with a risk assessment matrix. A number of stages are required to complete the matrix.

Table 2.5 - Likelihood Scale

likelihood	Definition	Score
Certain	Will occur during the activity at a frequency greater than every week if preventative measures are not taken.	5
Likely	Likely to occur more than once or twice during the	3

	activity, but less than weekly, if preventative measures are not taken.	
Unlikely	May occur once or twice during the activity if preventative measures are not taken.	2
Rare	Unlikely to occur during the activity.	1

Table 2.6 Consequence Scale

Consequence	**Definition**	**Score**
Catastrophic	Unprecedented damage or impacts involving the environment or surrounding communities. For Example: • Extreme loss of soil, water resources and water quality from storm water runoff; • Extreme pollution of soil and water resources, including major contamination from hazardous materials; • Widespread effects on ecosystems, with deaths of fauna/flora; • Widespread community impacts resulting in inconvenience, illness, or injury; and • Loss or destruction of archaeological sites. The occurrence of any of the above will almost certainly result in the work being halted and in a significant fine.	5
Major	Major damage to the environment or to surrounding communities. For example: • Major loss of soil, water resources, and water quality because of storm water runoff; • Major pollution of soil and water resources, including contamination from hazardous	3

	materials; • Significant effects on ecosystems, with isolated deaths of non-vulnerable flora and fauna • Significant annoyance or nuisance to communities; and • Major damage to, or forced displacement of, archaeological or historical sites. The occurrence of any of the above may result in work being halted and in a fine.	
Moderate	Limited adverse impacts on the environment or on surrounding communities. For example: • Localized, short-term noticeable changes in storm water quality, • Short-term minor changes in ecosystems, • Some annoyance or nuisance to communities, and • Isolated or partial damage to archaeological historical sites. The occurrence of any of the above may result in work being halted and in a fine.	2
Minor	No or minimal adverse environmental or social impacts. For example: • Localized, short – term noticeable changes in storm water quality, and water quality remains within tolerable limits; • Little noticeable effect on ecosystems; • No community complaints, or only an isolated few; and • No or minimal damage to archaeological or historical sites.	1

	After the occurrence of any of the above, there would be no likelihood of work being halted or a fine.	

Table 2.7- Risk Score Table

Likelihood	Consequence				
		Catastrophic	Major	Moderate	Minor
	Certain	25	15	10	5
	Likely	15	9	6	3
	Unlikely	10	6	4	2
	Rare	5	3	2	1

Risk: High: 15-25

Medium: 6-10

Low: 1-5

Chapter 3.- Methodology

3.0 Procedure

Thesis of the research started with a literature study in order to gain the needed knowledge about the environmental impacts that can be connected with Mini hydro powers. The gained information in the literature study has formed a base from which a model has been created. In the analysis, the model has been compared with the gathered information about the twelve hydropower plants

The survey samples are chosen from Authorities, stake holders and three key informants. The key informants were selected from Grama Niladari, Environment officers of Divisional Secretariat and a resident in the village. This survey is done using direct face to face interview with the informants and filling the questionnaire.***(Annex-A)***

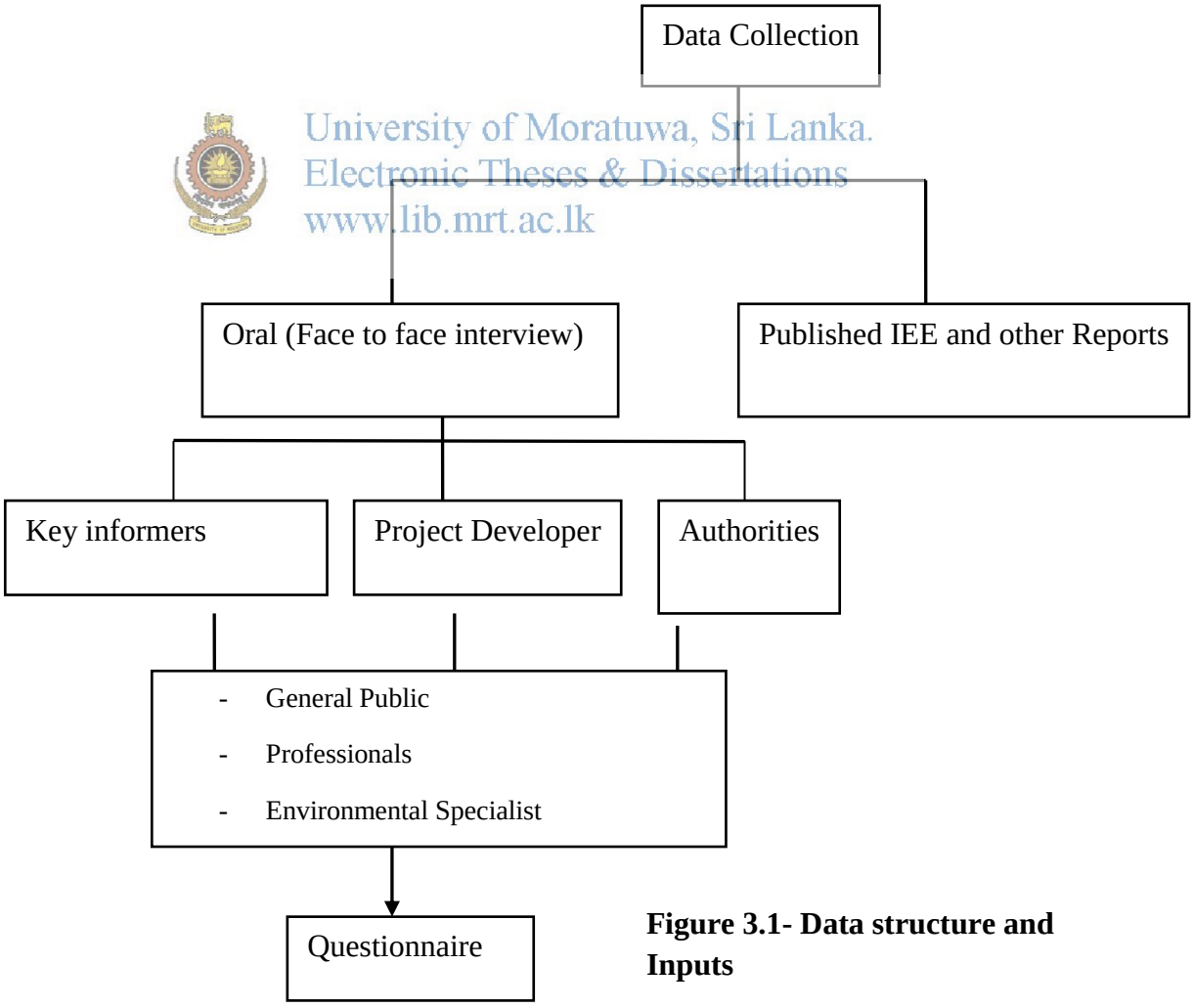

Figure 3.1- Data structure and Inputs

The data was collected from selected twelve Mini Hydro Projects. They were selected based on the following factors

- District of Location
- Project approving Agencies
- Geological Location
- Capacity of the project
- Time consuming for data collection

The data was collected according to the step shown in figure3.1.

The selected twelve Mini Hydro Projects were visited and minimized Environmental and Social negative Impacts and its avoided methodologies were observed they were compared with the predicted mitigation measures. Further, positive impact improved methodology was also observed.

Chapter 4- Observation and Analysis

The observations of the field studies and the data from questionnaires and IEE reports have been summarized in the table 4.1. The number of the project and the percentage value of success of impact prediction and implementation are included in the first column of Table 4.1 &final column of the table 4.2 respectively.

The Percentage of success of each predicted and implemented mitigation actions of the Projects are included in the Table 4.3. The percentage of success is plotted against the major impact predicted.

Percentage of Success of Impact Prediction =

[No of Projects predicted the Impact / Total Projects] x 100%

Table 4.1 – Summary of Questionnaire findings

Project No.	Location: DS Division PS or GN Division	Capacity of Project (MW)	Head(m)	Cost benefit analysis	Economic Feasibility	Study area (m)	No of field visit by TEC	No of Monitoring committee meeting during operation	No. of Bathing places were lost	No of People use the bathing place	Average Annual flow (m^3/s)	E flow (m3/s)	No. of Irrigation intake	No. of sand Mining families	Length of Transmission line (m)	No. of Resettled families	Frequency of closing power plant not adequate water flow /year	Date of Environmental Clearance	No of Scoping meeting	No of TEC Meeting	No of scoping members	Problem effect during IEE process	Dry season Power Control Water flow control method	Public involvement in IEE
01	Matale DS Palapathwela PS	6.00	12	Y	Y	500	20	2	2	50	62	1	1	1	4000	0	-	10.07.05	1	5	08	N	Change no of turbine	construction
02	AmbangangaKorale DS Aluthwela GN	4.55	7	Y	Y	500	5	2	10	40	62	1	1	3	3900	1	-	13.07.10	1	4	08	N	Change no of turbine	
03	Rathnapura DS Rathnapura PS	2.00	180	Y	Y	500	4	0	0	0	1.46	0.4	-	N	600	1	-	03.05.29	1		05	N	Change no of turbine	
04	Yatiyanthota DS	3.00	72	Y	Y	500	3	1	3	30	6.9	0.9	-	N	2000	0	-	10.02.01	1	3	07	Y	Change no of turbine	construction
05	Eheliyagoda DS Eheliyagoda PS	0.35	36	Y	Y	500	4	1	0	0	0.61	0	-	N	100	0	during dry season	08.0918	1	2	08	N	Change no of turbine	Pre - construction
06	Yatiyanthota DS	6.00	115	Y	Y	500	3	1	3	20	5.75	0.9	-	N	12000	0	-	02.08.30	1	1	06	N	Change no of turbine	
07	AmbgamuwaKoralaya DS & PS	4.85	116	Y	Y	500	3	1	0	0	5.2	0.6	-	N	500	0	-	03.09.22	1	2	06	N	Change no of turbine	
08	Kuruwita	6.50	165	Y	Y	500	2	1	0	0	6	0.3	-	N	18000	0	-	05.02.17	1	2	06	N	Change no of turbine	construction
09	Kuruwita	10.0	450	Y	Y	500	2	1	0	0	1.3 x 2	0.1	-	N	16000	0	-	01.04.19		1	06	N	Change no of turbine	construction
10	Ginigathhena DS Ambagamuwa PS	4.65	185	Y	Y	500	2	1	0	0	1.79	-	-	N	3000	0	-	09.02.04	1	2	07	N	Change no of turbine	
11	Ambagamuwa DS Ambagamuwa PS	3.00	100	Y	Y	500	3	1	1	15	1	0.1	-	N	3000	0	-	03.02.12	1	1	06	N	Change no of turbine	construction
12	Rathnapura GS Rathnapura PS	7.20	36	Y	Y	500	3	1	0	0	9.18	0.1	-	N	10000	0	-	04.02.09	1	2	06	N	Change no of turbine	construction

Table 4.1 – Summary of Questionnaire findings

Project Number	No of trees removed	Frequency of flood during construction	Blasting Work	No of Houses were damaged due to blasting	Soil erosion and Land slid [xxviii]	Poor sanitation during construction [xxix]	No of Jobs provided to Villagers [xxx]		Public protest against [xxxi]	Reasons for protest [xxxii]	Method of solving problem [xxxiii]	made of a fish ladder [xxxiv]	No of roads construction [xxxv]	No of bridge construction [xxxvi]	No of culvert construction [xxxvii]	Other benefits received for the villagers [xxxviii]	No of monitoring committee visit [xxxix]	Construction period (years) [xL]	reason for delaying construction [xLi]	Silting Removal frequency [XLii]	Catchment Area (km^2) [XLiii]	Project total Area (Ha) [Xliv]
							Permanent	Temporary														
01	200	1	Y	3	Y	N	4	12	Y	Damage to Properties due to blasting work	Pay Compensation	Y	1	1	3	Donate to School/ Temple	2	2.0	Due to flood	Once per a month		16
02	50	0	Y	0	Y	N	7	10	N	N/A	N/A	Y	1	1	0	Donate to Temple	3	2.5	No delay	Once per a month		22
03	100	0	Y	0	Y	N	3	15	N	N/A	N/A		1	0	4	N	0	2.5	No delay	Once per a two month	329	2.21
04	30	0	Y	2	Y	N	4	8	Y	Damage to Properties due to blasting work	Pay Compensation	N	2	1	0	Donate to School	2	2.0	machine failure and political influence	after flash flood		1.12
05	3	0	Y	0	Y	N	5	30	Y	Un awareness	aware people	N	0	0	0	made a water tank	0	1.5	No delay	4 time per year	7.1	
06	45	1	Y	0	Y	N	3	15	N	N/A	N/A	N	2	0	0	N	2	2.5	No delay	Once per a three month		
07	20	1	Y	0	Y	N	25	25	N	N/A	N/A	N	2	0	0	N	2	2.0	Fund allocation problem	Once per a month	26	
08	10	0	Y	15	Y	N	20	100	Y	Damage to Properties due to blasting work	Pay Compensation	N	5	1	0	N	3	2.0	No delay	Once per year minimum		
09	10	0	Y	3	Y	N	20	150	Y	Damage to Properties due to blasting work	Pay Compensation	N	2	1	1	N	3	2.5	No delay	4 times per a year		
10	40	0	Y	3	Y	N	6	25	Y	N/A	N/A	N	1	0	2	N	2	1.5	No delay	Once per two month	15.9	4
11	50	0	Y	0	Y	N	5	15	Y	Erosion and land slide	Pay Compensation	N	0	0	0	Donate to rural committee	3	2.5	No delay	Once per a month		
12	100	0	Y	0	Y	N		15	Y	Transmission line and inundation	Pay Compensation	N	1	2	0	Donate to committee of village	2	2.0	No delay	Once per a month	177.96	4

Y- Yes **N- No**

Table 4.2 Extracted Predicted and Implemented Environmental Impact mitigations

Predicted Environmental Impact		Predicted Environmental Impact Mitigation	Quantitatively analysis done or Not	Implemented Environmental Impact Mitigation by Project Proponent	Mitigation Predicted & Implemented Project Numbers & Remarks	Predicted %
1	**Geological and Geotechnical aspects**					**72.22**
	Impact due to the blasting activities	Blasting Operation Should be carried out under the supervision qualified Mining Engineer and relevant state agencies	Not Analysis	Apply control Blasting Method (Jack hammer is used to remove hard surfaces) under supervision of GSMB /PS/DS	1/2/3/4/5/6 /7/8/9/10/11/12	100.00
	Geological Change of the River	Necessary approval has to be taken from PAA & state agencies	Partially Analyzed	Approval has been taken from the PAA & State agencies	1/2/4/6/7/8 /9/10/11/12 * not mentioned in 3/5	83.33
	Slop stabilities	slop stability preventive measures has to be taken	Partially Analyzed	Water retaining structures or gabion wall was constructed by using boulders.	1/2/6/10 * not mentioned in others	33.33

2	**Hydrological Aspects**					**100.00**
	Impact due to interruption of downstream flow	Environmental & social flow should be released	Partially Analyzed	90% of dry season flow of the river is release through unregulated opening as E flow but it depends on the PAA requirement.	1/2/3/4/5/6 /7/8/9/10/11/12	100.00
	Impact irrigation water release during construction and operation	After valuation of effect compensation has to pay for the effected parties. Tailrace outlet located above the irrigation cannel more than 10m.	Analyzed	Required water was supply by pumping water during construction period. - Tailrace outlet located above the irrigation cannel compensation arrangement for loss of income due to water interruption.	1/2/6 * not mentioned in others as Not applicable	100.00
3	**Transmission line**					**87.50**
	Removal of Vegetation cover along the transmission Line	Vegetation removal has to be done with consultation of State agencies	Partially Analyzed	Vegetation removed with state agencies concurrence and compensate to the villagers	1/2/6/7/8/9/ 10/11/12 * not mentioned in 3/4/5	75.00
	Transmission line travel through private Land and paddy	Make agreement with farmer organization and land owners and		Make agreement with farmer organization and land owners and compensate to the properties	1/2/3/4/5/6	100

	fields.	compensate to the damage.	Partially Analyzed	damage.	/7/8/10/11/12 * not mentioned in 9	
4	**Erosion prevention and surface drainage**					**53.33**
	River bank erosion due to earth cover and boulders removal	Prepare and submit detail river bank stabilization Plan.	Not Analyzed	Use Boulder paving along the erodible area in the river. Planting trees and construction of rubble retaining walls.	1/2/3/4/5/6 /8/10/11/12 * not mentioned in 7/9	83.33
	Soil Erosion due to disturbing earth	Appropriate conservation method has to be used depend on the location	Not Analyzed	Use Grass turf or tree planting to stabilize the slop and some other landscaping and surface covering practices	1/2/3/4/5/6 /8/10/11/12 * not mentioned in 7/9	83.33
	River scour at the end of tailrace due to energy and velocity of the outlet waters	Place Energy dissipating device and improving of River Bank stabilization	Not analyzed	Use Boulder paving along the erodible area in the river and concrete or boulder steps is used to energy dissipating of the outlet water.	1/2/4/5 /8/10/11/12 * not mentioned in	66.67

					3/6/7 /9	
	Soil conservation during dry periods due to dust formation	Work has to be done during dry season with using conservation techniques	Not Analyzed	Work has to be done during dry season with using conservation techniques such as benching /terracing	1/2 * not mentioned in others	16.67
	Disturbance to the river sensitive area (sensitive area is defined by the state agencies)	Except key activities others will not be permitted (eg. Construction of Weir, head & tailrace channels, forebay, Powerhouse etc)	Partially Analyzed	No other activities done with in the river sensitive area except key activities.	1/2 * not mentioned in others	16.67
5	**Ecology**					**44.44**
	Fish entry in to the water conveyance system	Trash rack & fish screen should be placed at the mouth of the intake	Partially Analyzed	Trash rack and fish screen had been placed at the mouth of intake.	1/2/3/4/5/6 /7/8/11/12 * not mentioned in 9 /10	83.33
	Fish migration up & down stream	Fish ladder has to be construct as per the approved design by the	Partially Analyzed	Fish ladder has been constructed as per the PAA requirement.	1/2	16.67

		PAA			* others are not mentioned	
	Movement of Small terrestrial animals across the head race channel	Build an Over Passes (as per the approved size and strength) at 100 m of the open channel and cover concrete slab (over pass) with a grass layer to mimic the naturalness to the habitat.	Not analyzed	Build an Over Passes at 100 m or closed slap of the open channel and cover concrete slab with a grass layer to mimic the naturalness to the habitat	7/8/10/12 * Others are not mentioned	33.33
6	**Noise pollution**					**100.00**
	Noise Impact at Construction Stage	Noise level at the Boundaries of the Project site shall confirm to the levels stated in Schedule III of National Environmental(Noise control Regulations No. 01 of 1996)	Not Analyzed	Noise has been controlled to standard values at the boundaries by using construction of noise barriers such as sand bag walls, green belt etc	1/2/3/4/5/6 /7/8/9/10//11/ 12	Noise Impact at Operation Stage
	Noise Impact at Operation Stage	Noise level at the Boundaries of the Project site shall confirm to the levels stated in Schedule I & II of National Environmental(Noise control Regulations No. 01 of 1996)	Not Analyzed	Noise has been controlled to standard values at the boundaries by using construction of noise barriers such as sand bag walls, green belt etc	1/2/3/4/5/6 /7/8/9/10//11/ 12	100.00

7	**Transport of Equipment and materials**					**59.99**
	Possible mass movement due to fluctuation and loosing of earth	Slop stability should be maintained and monitor continuously	Not Analyzed	Slop stabilities monitor by pp and maintained	2 not mentioned in others	8.33
	Noise and dust formation during loading and unloading	Minimize disturbance of noise and dust formation	Not Analyzed	It was done in a controlled manner	1/2/3/4/5/6 /7/8/10/11/12 * not mentioned in 09	91.67
	Fine dust blowing from open toped truck	Loads are covered when transporting	Not Analyzed	Loads were covered when transporting	1/2/6/7/8/ 10/11/12 * not mentioned in 3/4/5/9	66.67
	Generation of dust nuisance during dry season	During dry season it should be dampen the exposed area	Not Analyzed	During dry season it was dampen the exposed area	1/2/6/8/11/12 * not mentioned in others	50.00

	Heavy load movement (across the bridges and culvert and road as per the limit of weight transport approval has to be taken)	It has to be done with the concurrence of RDA,PRDA,PS	Not Analyzed	It has been taken approval from the RDA,PRDA,PS as per the requirement	1/2/3/5/6 /7/8/10/11/12 * not mentioned in 4/9	83.33
8	**Safety**					**50.00**
	Safety of road users and adjacent land occupants	Prepare a safety procedure for road users and adjacent land occupants and follow	Not Analyzed	Prepare a safety procedure and followed.	1/2/8/11/12 * not mentioned in others	41.67
	Safety of Workers	Prepare a safety procedure for workers and follow. it must be comply with Safety regulation under the factory ordinance	Not Analyzed	Prepare a Safety procedure and followed comply with Safety regulation under the factory ordinance	1/2/3/7/8/11/12 * not mentioned in 4/5/6/ 9/10	58.33

9	**Disposal of liquid and solid waste in to water bodies**					**46.67**
	Spoil Materials (soil & Rock etc) removal during excavation and surface preparation	They must be used for site leveling, and back filling purposes. Also, The post constructed un usable materials should be disposed with consultation with PS	Not Analyzed	Those spoil materials used for site leveling, back filling, retaining walls and river terracing. The balance materials were disposed in to a Pradesiyasabha approved dump site.	1/2/3/4/5/6 7/11/12 * not mentioned in 8/9/10	75.00
	Transformer Oil Discharge in to water bodies	Preventive action has to be taken	Not Analyzed	They were collect and pump or disposed in to an approved dump site.	6/7/11/12 * not mentioned in others	33.33
	Sewage or any liquid effluent discharge from dwelling and camp site.	Preventive action has to be take n	Not Analyzed	They were collected in to a bin and dump in to approve dump site.	6/7/11/12 * not mentioned in 1/2/3/4/5/ /8/9/106	33.33
	Solid waste stagnate within the premises	It must be disposed with consultation with PradesiyaSabha (PS)	Not Analyzed	They were disposed with consultation of PS	1/2/4/7/11/12 * not	50.00

					mentioned in others	
	Sanitation facilities for the workers	It must be provided the sanitation facilities	Not Analyzed	Toilet and other sanitation facilities were provided.	1/2/4/5/8* not mentioned in others	41.67
10	**Sediment**					**70.83**
	Sediment accumulation at the weir site	Flushing of sediment should be carried out	Not Analyzed	Flushing of sediments carried out using a flushing gate at the weir	1/2/5/6 /7/8/10/11/12 * not mentioned in 3/4/9	75.00
	Sediment accumulate in settling tank	Collect and dump in to PS approved dump site	Not Analyzed	Collected the sediment and dump them PS approved dump site	1/2/5/6 /7/8/11/12 * not mentioned in 3/4/9/10	66.67
11	**Sociological Impacts**					**71.42**
	Resettlement of People	Families resettle as their satisfaction	Analyzed	Families resettle as their satisfaction	1/2 * not mentioned in	100.00

					others	
	Flood & land slid effect during construction and operation	Establish a possible warning system for people and take remedies for minim damages. Damage recovers by compensation.	Not Analyzed	Establish a possible warning system and recovery and damage compensation program.	1/2/4/6 /7/8/11/12 * not mentioned in 3/5/9/10	66.67
	Timely water release for irrigation purposes	Establish a reliable communication system and Manual operating water valve operate.	Analyzed	Establish a reliable communication system and Manual operating water valve operate.	1/2 * Not applicable for others	100.00
	Impact on stream bathing families	Provide proper bathing facilities	Analyzed	The PP constructed bathing places with cemented steps for bathing purposes.	1/2/5 * not mentioned in others	25.00
	Impact on Irrigation water release	Reestablished irrigation channel and compensate for the paddy land owners for disturbance	Not Analyzed	Reestablished a new irrigation channel and compensate for the paddy land owners for disturbance	1/2/6 * Not applicable others	100.00
	Irrigational out let operational impact	Irrigation outlet is planning to operate manually.		Irrigation outlet is constructed to operate manually.	1/2 * not mentioned in	100.00

			Not Analyzed		others as NA	
	Donation to development work in the village	2% of the annual profit should donate to the village for development work.	Analyzed	Few development work has been done	Only 2 * not mentioned in others	8.33
12	**Fire safety**					**91.67**
	Impact on sudden fire in power station	Firefighting system shall be provided and maintained in proper manner	Not Analyzed	Firefighting system is established	1/2/3/4/5/6 /7/8/10/11/12 * not mentioned in 9	91.67
13	**Tourism of the area**					**100.0**
	Tourism of the area	The PP should not be obstructed the visitors by any activities of the project.	Not Analyzed	The weir was constructed during dry season therefore no activities obstructed the visitors.	Only in 10 * not mentioned in others as not applicable	**100.0**

Table 4.3 Monitoring Framework

Predicted Environmental Impact		Impact Monitoring Parameters	Whether monitored or not	Responsible Persons to monitoring		Risk Analysis	Damages Observed
				EMOP	Actual		
1	**Geological and Geotechnical aspects**						
	Impact due to the blasting activities	Noise Pollution Air Pollution Ground Vibration	No Evidence for Proper Monitoring	GSMB/PS/DS/Monitoring Committee	Project Proponent	No	Few Houses were Crack during blasting (E.g. Projects 01,04,08)
	Geological Change of the River Length of the diversion Aquatic flora and Fauna effected		Monitored during Scoping Stage	PS/DS/Monitoring Committee	Project Proponent	No	
	Slop stabilities	Slop stability preventive measures	Projects 3& 5 were not monitored by MC	. PS/DS/Monitoring Committee	Project Proponent	No	Land slide and destroy of Houses (E.g. Project 11)
2	**Hydrological Aspects**						

	Impact due to interruption of down stream flow	Environmental & social flow and Water quality	It is monitored by Project monitoring committee few times (less than 03) except Projects 3 &5	PS/DS/Monitoring Committee	Project Proponent	No	E-flow values are varying standards of 90% of dry season flow of the river.
	Impact irrigation water release during construction and operation	- Location of Irrigation Channel -Quantity of Water Requirement - Time duration	Effect this impact is only for the Projects of 01, 02 & 06 and the committee has monitor projects less than 3 times as per the QA.	PS/DS/Monitoring Committee	Project Proponent	No	Compensate farmer for loss of income due to water interruption.
3	**Transmission line**						
	Removal of Vegetation cover along the transmission Line	No of Trees removed. Soil Erosion Damages to Properties Slop instability	It is monitored by Project monitoring committee few times (less than 03) except Projects 3 &5	PS/DS/Monitoring Committee	Project Proponent	No	Projects nos. 01, 02, 03, 11 &12 had been removed more than 50 trees. Compensate Villagers for loss of properties.
	Transmission line travel through private Land and paddy fields	No of Lands and Faddy fields	It is monitored by Project monitoring	PS/DS/Monitoring Committee	Project Proponent	No.	Compensate Villagers and farmer for loss of income due to loss

		Soil Erosion Damages to Properties Slop instability	committee few times (less than 03) except Projects 3 &5				of land and fields. .
4	**Erosion prevention and surface drainage**						
	River bank erosion due to earth cover and boulders removal	Detail of riverbank stabilization Plan. Etc. Places of River Bank erosion with in the site Boundaries. Preventive actions.	It is monitored by Project monitoring committee few times (less than 03)	PS/DS/Monitoring Committee	Project Proponent	No	River widening Loss of habitat Loss of vegetation,
	Soil Erosion due to disturbing earth	Soil erosion No of Erodible Places	It is monitored by Project monitoring committee few times (less than 03)	PS/DS/Monitoring Committee	Project Proponent	No	Soli eroded places Sedimentation in to the river basin.
	River scour at the end of tailrace due to energy and velocity of the outlet waters	Energy dissipating device and methods were used.	It is monitored by Project monitoring committee few times (less than	PS/DS/Monitoring Committee	Project Proponent	No	River scours at the end of tailrace.

			03).				
	Soil conservation during dry periods due to dust formation	Dust emissions	Dust emission, was not measured and monitored properly.	PS/DS/Monitoring Committee	Project Proponent	No	The properties in side and out side covered with dust.
5	**Ecology**						
	Fish entry in to the water conveyance system	Size and standard of Trash rack & fish screen.	It is monitored by Project monitoring committee few times (less than 03)	DS/PS/Monitoring Committee	Project Proponent	No	-
	Fish migration up & down stream	Standard and size of Fish ladder	It is monitored by Project monitoring committee few times (less than 03)	It is monitored by Project monitoring committee few times (less than 03)	Project Proponent	No	-
	Movement of Small terrestrial animals across the head race channel	No of Over Passes Standard size and strength and span of over pass Coverage of concrete slab (over pass)	It is monitored by Project monitoring committee few times (less than 03)	DS/PS/Monitoring Committee	Project Proponent	No	Blocking of open channel by filling of soil due to landslides Closing of small terrestrial animal paths.

6	**Noise pollution**						
	Noise Impact at Construction and Operation Stage	Noise levels at the Critical point and the critical boundaries of the site. Restricted works during nighttime.	No evidence for noise level measurement and controlling it	DS/PS/ Monitoring Committee	Project Proponent	No	Complain received from the Villagers.
7	**Transport of Equipment and materials**						
	Possible mass movement due to fluctuation and loosing of earth	No of places Slop salability-improving methods.	There is no attention on this impact by the Projects.	DS/PS/ Monitoring Committee	Project Proponent	No	Soil erosion and slop instability of the access roads.
	Noise and dust formation during loading and unloading	Noise level Dust emission measurement.	No evidence for monitoring	DS/PS/ Monitoring Committee	Project Proponent	No	Impact for movement of animal and the human across the near area and the properties of villages at site boundaries.
	Fine dust blowing from open	Visual inspection		DS/PS/ Monitoring	Project	No	Impact for movement of

	toped truck	adequate	No evidence for monitoring	Committee	Proponent		animal and the properties of villages at the access road boundaries.
8	**Safety**						
	Safety of Workers	Safety Plan & Procedure. No of accidents	There is no any accident is occurred any projects. Few projects have been monitored by MC during construction phase.	DS/PS/ Monitoring Committee	Project Proponent	No	Accident for workers.
9	**Disposal of liquid and solid waste in to water bodies**						
	Spoil Materials (soil & Rock etc) removal during excavation and surface preparation	No of Places Methods of re used of spoil materials	It is monitored by Project monitoring committee few times (less than 03)	DS/PS/ Monitoring Committee	Project Proponent	No	Land sliding
	Transformer Oil Discharge in to water bodies	No of places Frequency of discharge.	It is monitored by Project monitoring	DS/PS/ Monitoring Committee	Project Proponent	No	Water pollution in down stream

			committee few times (less than 03)				
	Sewage or any liquid effluent discharge from dwelling and camp site.	No of places Frequency of discharge	There is no evidence to be monitoring such an Impact.	DS/PS/ Monitoring Committee	Project Proponent	No	Water pollution in down stream
	Solid waste stagnate within the premises	No of places Frequency of discharge	It is monitored by Project monitoring committee few times (less than 03)	DS/PS/ Monitoring Committee	Project Proponent	No	Water pollution in down stream
	Sanitation facilities for the workers	No of Bath rooms No of Wash rooms(toilets)	It is monitored by Project monitoring committee few times (less than03)	DS/PS/ Monitoring Committee	Project Proponent	No	Water pollution in down stream
10	**Sediment**						
	Sediment accumulation at the weir site	Height of accumulations	It is monitored by Project monitoring committee few times (less than 03) and due to received few complains.	DS/PS/ Monitoring Committee	Project Proponent	No	Blocking of water flow.

	Sediment accumulate in settling tank	Height of accumulations	It is monitored by Project monitoring committee few times (less than 03) and due to received few complains. 1/2/6/7/8/11/12	DS/PS/ Monitoring Committee	Project Proponent	No	Blocking of water flow.
11	**Sociological Impacts**						
	Resettlement of People	-No of families resettle - their satisfaction	It is monitored by Project monitoring committee few times (less than 03). 1/2/6/7/8/11/12	DS/PS/ Monitoring Committee	Project Proponent	No	-
	Flood & land slid effect during construction and operation	-Warning system for flood - Frequency of flooding	It is monitored by Project monitoring committee few times (less than 03) 1/2/4/6 /7/8/11/12	DS/PS/ Monitoring Committee	Project Proponent	No	Damage to properties

	Timely water release for irrigation purposes	Communication System Frequency of water release	It is monitored by Project monitoring committee few times (less than 03) 1/2	DS/PS/ Monitoring Committee	Project Proponent	No	Water Disturbance to farmers in time
	Impact on stream bathing families	No of Places The facilities No of Persons bathing in for a place	It is monitored by Project monitoring committee few times (less than 03) 1/2 /5	DS/PS/ Monitoring Committee	Project Proponent	No	Loss of bathing place for the downstream users.
	Donation to development work in the village	No of developments Annual allocation by the project	It is monitored by Project monitoring committee few times (less than 03) 1/2 /5	DS/PS/ Monitoring Committee	Project Proponent	No	-
12	**Fire safety**						
	Impact on sudden fire in power station	Established fire fighting system Guidance for the uses Condition of Fire Fighting	No evidence for monitoring	DS/PS/ Monitoring Committee	Project Proponent	No	-
13	**Tourism of the area**						

	Tourism of the area	No of Places Access points	It has monitor during construction MC of project 10.	DS/PS/ Monitoring Committee	Project Proponent	No	Loss of income for the villagers.

Table 4.4 Summary of Impact mitigation Prediction

	Impact	**Impact predicted (percentage) %**
1	Geological and Geotechnical aspects	72.22
2	Hydrological Aspects	100.00
3	Transmission line	87.50
4	Erosion prevention and surface drainage	53.33
5	Ecology	44.44
6	Noise pollution	100.00
7	Transport of Equipment and materials	72.91
8	Safety	50.00
9	Disposal of liquid and solid waste in to water bodies	46.67
10	Sediment	70.83
11	Sociological Impacts	71.42
12	Fire safety	91.67
13	Tourism of the area	100.00

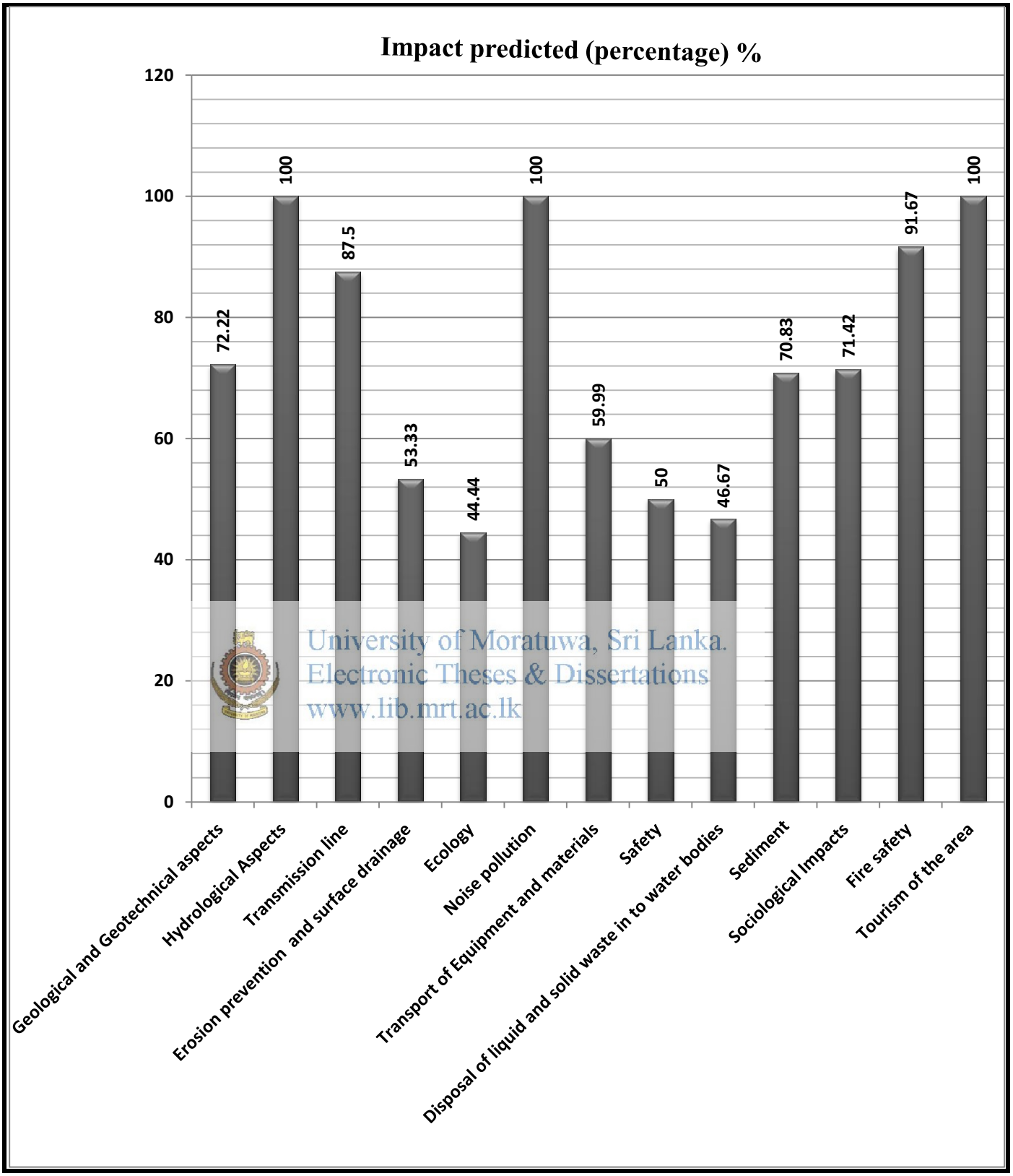

Figure 4.1 Impact Predicted percentage

Table 4.5 –Analysis of Environmental Methodologies

Project	Checklist Methods			Matrices Method	Network Methods	+ Expert Opinion	Over layer Method
	Simple	* Questionnaire	Quantitative				
Project 01	-	Yes	-	-	-	Yes	-
Project 02	-	Yes	-	-	-	Yes	-
Project 03	-	Yes	-	-	-	Yes	-
Project 04	-	Yes	-	-	-	Yes	-
Project 05	-	Yes	-	-	-	Yes	-
Project 06	-	Yes	-	-	-	Yes	-
Project 07	-	Yes	-	-	-	Yes	-
Project 08	-	Yes	-	-	-	Yes	-
Project 09	-	Yes	-	-	-	Yes	-
Project 10	-	Yes	-	-	-	Yes	-
Project 11	-	Yes	-	-	-	Yes	-
Project 12	-	Yes	-	-	-	Yes	-

***** *This refers the questionnaire is issued by CEA.*

+ This is a method of summon meeting and discuss impact by stakeholders and expert parties.

Chapter 5 - Discussion

Selected Projects were analyzed separately for their Predicted and implemented Mitigation and violation to standards and conditions. All the 12 Mini Hydro Projects had been processed under Initial Environmental Examination by the scoping committee at the screening stage.

5.1 Selected Case Studies on Predicted Impact mitigation and Implemented Impact mitigation

In terms of environmental impacts, the cutting or clearing of very steep hills, rock blasting and soil dumping into paddy lands have created serious soil erosion. The filling of lands and wetlands without adequate drainage system has posed environmental threats as this could lead to flooding problems in the future, especially during the rainy season. Dust pollution has become unbearable in some areas. Rock blasting and heavy vehicle movement have caused noise pollution, thereby negatively affecting the lives of the people near to the construction site. Considering the following key impacts and their Predicted mitigation measures were considered as per the table 4.2 for evaluating 12 MHPs.

1. Geological and Geotechnical aspects
2. Hydrological Aspects
3. Transmission line
4. Erosion prevention and surface drainage
5. Ecology
6. Noise pollution
7. Transport of Equipment and materials
8. Safety
9. Disposal of liquid and solid waste in to water bodies
10. Sediment
11. Sociological Impacts
12. Fire safety
13. Tourism of the area

5.1.1Geological and Geotechnical aspects

Under this impact, following significant impacts had been considered

5.1.1.1Blasting activities

The explosive materials were purchased under permit of Assistant Explosive controller of District Secretaries Office. As required this material were stored under police security .The blasting types and explosive material used also varying with the scale of Rock blasting are involving. All the 12 projects had identified the blasting activities as a Predicted Environmental impact and had done controlled blasting for the given mitigation measures. The Villagers had protested against the blasting activities of Project no. 01, 04, 08 and 09 on the ground rock blasting had caused damage to their properties the figure 5.1 shows a crack which had occur on a wall of house due to blasting. .The project proponents had planned compensation for the valued damage to the properties of the houses. This process had been monitored by Divisional Secretary, Pradesiya Sabahal and qualified Mining Engineer as per the explanation of PPs. This impact caused to the properties was predicted by all the project proponents.

Remedies for the issues

Rock blasting procedure should be standardized and a standard guideline for Rock blasting should be given. Rock blasting must be given priority because, in comparison to other hazards. It invites the selection of alternative place for the project if a protest occurs. It is also suggested that the following pre activities must be taken in to account in order to minimize the blasting impacts of the project.

Blasting time must be scheduled to prevent any clash with local activities. Warning signal must be sent prior to the blasting activity for the purpose of safety

Noise barriers and ground vibration controlling methods must be used to prevent adverse effect on terrestrial fauna, people and their properties.

To measure the blasting effect initially and after survey the surrounding houses to find out the visual crack effect.

Figure 5.1 - Crack of wall due to blasting activities.

5.1.1.2 Geological Change of the River

This impact is not a crucial impact for the Mini Hydro Project. The ability of geological change of the river is less for small capacity Mini hydro Power projects. .But, in the case of river widening or removal of loose soil or rock boulders this is effective. Therefore, it is required to obtain necessary approval from the state agencies and PAA prior to the removal of those and widening. This impact has been pre identified by all the Projects except Project No 03 & 05. (Predicted 83%)

5.1.1.3 Slope stabilities Slope stability is determined by the balance of **shear stress** and **shear strength**. A previously stable slope may be initially affected by preparatory factors; making the slope conditionally unstable. The method chosen for

improving slope stability depends on many factors, including the type or the projected type of slope failure, soil characteristics and site constraints. Frequently, more than one method of mitigation technique is required.

The Villagers have protested against the land sliding and slope failure of Project no. 11 as per the table .4.1 and also according to the table 4.2 projects Nos. 1, 2, 6 & 10 have predicted this as an environmental impact in IEE report. In the mitigation of the impact the IEE reports identified techniques such as water retaining structures, gabion wall, grass turfing and tree planting.

Remedies for the issues

The typical techniques of slope instability mitigation can be used for drainage improvement, earth work and Structural Improvements such as Mechanically Stabilized Earth (MSE), Retaining walls, Soil nailing, Tie backs, reticulated micro piles, Piles or drilled shafts It must be selected according to the economy and easy applicability. The following figure 5.2 and figure 5.3. Shows some improvement of stability constructed by the two of the projects, but, the figure 5.2 improvement is inadequate for slope stabilities.

Figure 5.2 - Retaining wall

Figure 5.3 Grass Turfing

5.1.2 Hydrological Aspects

Impact due to interruption of downstream flow (E flow and social flow) All the selected Mini hydro projects are run of river types and, hence the water flow used by the project is released back to the river at the tailrace. Therefore water interruption occurs in between intake and tailrace. Therefore, eco system in between this area must retain. The CEA guideline provides this environmental flow should be 90% of dry season water flow value. But, in this survey it has been found out the E flow value has been decided without taking the guidelines in to consideration. Even if the MHPs was implemented before the releasing of the guideline the pp is bounded to update their design values according to the guidelines. All the Mini hydro projects have predicted this impact and they have implemented the impact mitigation in compliance with the IEE reports. Although the impact was mitigated by providing an e flow, few projects do not operate and maintenance as per the instruction given by the PAAs. It has been found out one Mini Hydro projects did not take remedial actions to remove the deposits. As a result the E flow gate was blocked by the deposited silt and thus the water flow through the opening was blocked.

Remedial actions suppose

The overall objective of environmental flow recommendations is to ensure that sufficient water is made available to support the needs of the entire rive rain ecosystem. It is necessary to assess the most appropriate methods for the Environmental flow assessments using the most appropriate methods available at the time. Previously, these assessments focused largely on minimum flow requirements for in stream fauna (such as fish and invertebrates). However, new methodologies that incorporate natural variability in stream flow, and the high flow water requirements of entire riverine ecosystems; this must be surveyed and calculated during pre-feasibility stage.

5.1.3 Impact of irrigation water release during construction and operation

This Impact was predicted only by three projects numbers 1, 2 & 6. This impact does not involving in the other Projects because there is no irrigational channel located in the project area. The predicted mitigation was implemented by the three projects. According to the predicted mitigation, water should be released to each farmer community requirement and Priority has to be given to water supply for the irrigation purposes and not for the Power generation. Irrigation water requirement should not be interrupted any stage. But, water flow was interrupted during the construction period and therefore demand for water for irrigation works was supplied by the project proponent by pumping or temporary outlet depending on the demand. If the interruptions to the irrigation water supply occur adequate compensation arrangement will be provided according to the loss of income and damages. The project proponents had discussion with the stake holders and farmer organization initially to find out their requirement for the construction and rehabilitation of the irrigation cannel. The possible impact on irrigation channel was solved at the initial stage of the project. As a result there were no protests or appeal about water release for the irrigation purposes. The implemented mitigation was adequate.

Remedial measures to reduce impact

The construction activities should be done off seasons in order to minimize the water release for the irrigation purposes. The selection of Project area outside the irrigational channel inlet during design stage is best practices in order to avoid lengthening the project time and the cost of Project.

5.1.4Transmission line

The electricity generated is stepped up to 33 kV and it is connected to nearest grid substation of Ceylon Electricity Board. The energy travelling along or short distance before connecting to the Grid substation will greatly depend on the length of the transmission. The transmission length of selected Projects usually vary from 100 m to 18000m as shown in the Table 4.1. The average transmission length is 6091m. This length is long length compare to the other Power Projects. This is caused adverse impact on vegetation removal in area and energy loss of the Power plant.

Environmental and social impact due to the construction of transmission line

5.1.4.1 Removal of Vegetation covers along the transmission Line

This impact was identified all the projects but it was not mentioned as a predicted impact mitigation in Project Nos.3,4&5. According to the mitigation action, the removal of the vegetation should be done with concurrence of state agencies and the villages must be paid compensation for the damage caused.

Remedial action In this method, the PAA should mentioned the proper compensation standard to follow the Project Proponent to follow the valuation standards and other required action must be clearly direct by the PAA. The no of trees removed to install the transmission line, the number of cut down, the types of trees, the number of trees planted to minimize the damage must be taken in to consideration in order to decide as the value.

5.1.4.2 Transmission line travel through private Land and paddy fields

This impact is also same as the removal vegetation long the path of the line.

5.1.5Erosion prevention and surface drainage

Erosion occurs when the top layer of the soil is swept away by natural or man-made forces, making it extremely difficult to grow any vegetation on the site. Erosion can turn a once healthy, vibrant land into arid, lifeless terrain and further cause landslides and earth slip. Erosion happens at construction sites and other areas where the land has been disturbed. Erosion prevention is the most effective and inexpensive method for reducing overall environmental impacts associated with construction activities. Erosion control practices primarily involve preserving the natural vegetation when possible or stabilizing exposed soils with temporary covers or permanent vegetation and structural Improvements. In the Mini Hydro Projects erosion is occurred considerably under the following stages:-

5.1.5.1 River bank erosion due to earth cover and boulders removal

This mainly occurs due to weak embankment of arriver due to lose soil and boulder on embankment. This impact was identified all the Projects except Project nos. 7&9. River bank erosion is usually very high during floods caused by heavy rain.. It can be avoided or minimized using mitigation actions like placing boulder, gabion filled with rubble, rubble machinery walls and planting trees. According to the monitoring committee reports, mitigation measures were not implemented by few of the projects.

5.1.4.2 Soil Erosion due to disturbing earth

The erosion due to disturbing earth was identified as an impact by all the Projects except Project nos. 7&9. The controls often involve the creation of a physical barrier, such as vegetation or rock, to absorb some of the energy of the wind or water that

cause erosion. Constructing channel over the column support can minimize the excavation or disturbance to the earth.

Remedial action

The projects used Grass turf tree planting, surface covering and other methods of landscaping to stabilize the slop as the predicted mitigation. Figure 5.4 & 5.7 show typical soil erosion during the field surveying done by the Projects. The remedial actions taken for such soil erosion is shown in Figure 5.3. Which also enhances the scenic beauty of the project.

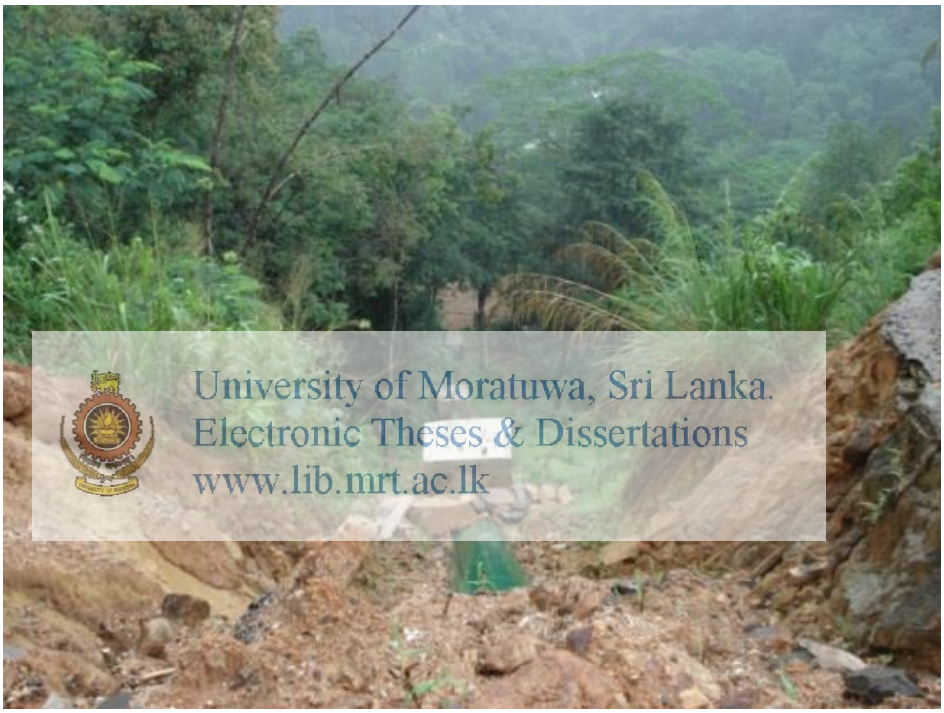

Figure 5.4 – Disturbed Soil erosion

The impact mitigations were not exactly implemented according to the as the given instructions given by the PAA. Few complaints had been made to the PAAs and the monitoring committee had monitored them.

5.1.5.3River scours at the end of tailrace due to energy and velocity of the outlet waters

Scouring happens as the results of increase the velocity of the water on a massive scale. The velocity or energy of the water outlet must be reduced or the bank erodible area should be hardened to minimize the river scour. If tailrace is constructed through excavation of hard rock, erosion will not be an impact. If the rock is weak or weathered, it can be improved by the applying reinforcement with the concrete**.**

All the projects identified the impact except project nos. 3, 6 & 7.In order to achieve the predicted mitigation, Boulder paving along the erodible area in the river is applied and concrete or boulder steps should be used. This would prevent energy dissipating of the outlet water at the tailrace.

5.1.5.4 Soil conservation during dry periods due to dust formation

This impact has to be minimized during dry season using conservation techniques such as benching or terracing.

5.1.5.5 Disturbance to the river sensitive area (sensitive area is defined by the state agencies)

The sensitive area is defined by the PAA and it is about 60 m reservation. The Project No 01 & 02 predicted the impact and conditions given for predicted mitigation. According to the these conditions river contraction cannot be constructed except for key activities (key activities of construction –weir head tailrace channels, fore bay, Powerhouse etc)

5.1.6 Ecology

Ecology is the scientific study of interactions of organisms with one another and with the physical and chemical environment. Ecological impact has identified in categories terrestrial fauna as well as aquatic fauna.

Predicted Impact mitigation for Aquatic Fauna

5.1.6.1 Fish entry in to the water conveyance system

All the projects except project numbers 09 & 10 identified and predicted the impact mitigations which is done by placing Trash rack & fish screen at the mouth of the intake. This had been constructed by all the Mini hydro Projects, although this has not been mentioned in IEE report as a predicted impact. As per observation at the site, this fine screen will not prevent small fish going through it.

The common faults which have to be considered during the design stage of the screens are damaging mesh panels, damaging screen seals, screens that are not fully seated, screens that have been removed to avoid clogging problems and screens that are heavily clogged, which lead to velocity hot-spots where fish face the rise of becoming impinged on the screens. These problems can be overcome with appropriate design and by good maintenance that is backed up by monitoring and enforcement. .

5.1.5.2 Fish migration up & down stream

The mitigation of fish migration impact is to make a fish ladder. A fish ladder, also known as a fish way, provides a detour route for migrating fish past a particular obstruction on the river. Designs vary depending on the obstruction, river flow, and species of fish affected, but the general principle is the same for all fish ladders: the ladder contains a series of ascending pools that are reached by swimming against a stream of water. Fish leap through the cascade of rushing water, rest in a pool, and then repeat the process until they are out of the ladder. The survival of many fish species depends on migrations up and down of the river.

The Project numbers 1 and 2 have identified this impact but it has been implemented by only project number 02 which constructed a Project Fish ladder in keeping with the requirement laid down by P.A.A.

Remedial measures

During field study, It was found out that the designing of the fish ladder must be improved for the fish ladder must be improved for the fish to survive when they move through it. It may be suggested them a fish cover over the fish ladder may be maid for the fish to travel freely without endangering their life., This is a key requirement for all mini hydro projects to help the migration of aquatic fauna

5.**1.7Predicted Impact Mitigation for terrestrial fauna**

5.1.7.1Movement of Small terrestrial animals across the head race channel

The headrace cannel water travels very long distances and hence it passes through small terrestrial animal crossing points. Therefore this impact is effect terrestrial migration pattern as well as their habitats. The Projects number.7, 8, 10 and 12 have identified this impact and predicted mitigation has been implemented. The predicted mitigation measures are to build an over passes forever 100 m for the cleaned and cover this with a concrete slab and in order to mimic the naturalness to the habitat to cover the slab with grass layer.

Remedial measure

It may be suggested that if the open headrace channel travels on concrete columns as in the figure 5.5, the small terrestrial animal can pass under the channel. Although it is more costly than other models, it will reduces earth disturbance due to excavation of the channel and the impact on the movement of terrestrial fauna.

Figure 5.5-Headrace Open channel constructed on the Columns.

5.1.8Noise pollution

This impact has been predicted and the predicted mitigation has been implemented by all the projects. However, according to the views of the villagers the noise level control has not been implemented properly in few of the projects.

5.1.8.1 Noise Impact at Operation Stage

Predicted mitigation action was that the noise level at the Boundaries of the Project site shall confirm to the levels stated in Schedule I& II of National Environmental (Noise control Regulations No. 01 of 1996).

5.1.8.2 Noise impact at Construction stage

Predicted mitigation action was that the noise level at the Boundaries of the Project site shall confirm to the levels stated in Schedule III of National Environmental (Noise control Regulations No. 01 of 1996

Implemented impact mitigation was that the noise has been controlled to standard values at the boundaries by using construction of noise barriers such as sand bag walls, green belt etc.

Remedial Measures

Position plant and machinery as far away as possible from noise sensitive areas.
Machinery should be suitable for the work to be carried out, properly maintained and operated.
If the machine is stationary, fit an acoustic enclosure where necessary. Where possible use mains electricity rather than a generator supply. Switch off all equipment when not in use.
Try to keep the noisier work for the middle of the day. Quieter work is best kept for the beginning or end of the day.

5.1.9Transport of Equipment and materials

This impact was identified and predicted impact mitigation under the following different categories.

5.1.9.1 Possible mass movement due to fluctuation and loosing of earth

The PP provides predicted mitigation as the mitigation slope stability should be maintained and monitored continuously. The road has been constructed with well slope stability. The slope stability check continuously prevents any mass movement of the Project area. Only Project no.02 identified this impact.

5.1.9.2 Noise and dust formation during loading and unloading

Predicted impact has been identified by all the Projects except the Project no 09. All the impact predicted that the PP should take necessary actions to Minimize disturbance of noise and dust formation during the construction Periods. In other

wards the work has to be done in a controlled manner prevent and minimize the impact.

Remedial Measures suggested

Dust formation can be overcome by

Dampening of material.
Reducing drop heights where possible.
Protecting activities from wind, which can make the problem worse

Noise generation

- Loading and unloading must be done with controlling to minimize noise generation
- Loading and unloading can be carried out in a closed system or with sound barriers.

5.1.9.3 Fine dust blowing from open toped truck

The other Projects except Project nos. 3, 4, 5& 9 identified this impact as a predicted impact and it given condition that the loads must be covered while loads transporting. This impact was probably flows majority of the Projects, but this impact is not a key impact of the projects.

5.1.9.4 Generation of dust nuisance during dry season

This impact was identified by projects numbers.1, 2, 6, 8,11butothers did not identified as an impact. It provided mitigation that during dry season exposed area should be dampening by using water prevents generation of dust nuisance. The predicted mitigation has been implemented by Projects nos.1, 2, 6, 8 &11.

Remedial measures

The dust nuisance during dry season can be prevented or avoided by providing proper wind barrier in the area.

5.1.9.5Heavy load movement (across the bridges and culvert and road as per the limit of weight transport approval has to be taken)

This is not always an effective impact only a probable impact. This impact was predicted by all the projects except projects no 4& 9.The predicted mitigation is that heavy load transportation has to be done under the concurrence of Provincial Road development Authority, Road development authority and Pradesiya Sabha.

5.1.10 Safety

5.1.10.1 Safety of road users and adjacent land occupants

This impact was predicted by Projects 1, 2, 8, 11& 12 and Predicted mitigation was to prepare a safety procedure and follow up. (Predicted 42 %)

5.1.10.2 Safety of Workers

This impact was predicted by Projects 1,2, 3,7,8,11& 12 and Predicted mitigation was to Prepare a safety procedure and follow up but it must comply with Safety regulation under the factory ordinance This is a social impact and there were not herd any accidents during Project construction and operation. (Predicted 58 %)

5.1.11Disposal of liquid and solid waste in to water bodies

This impact was identified by Projects nos. 1,2,4,5,6,8,10,11 &12. As the mitigation measures the pp should be prepared for solid and liquid waste management plan and it must be approved by PAA. The approved plan must be followed by the PP.

5.1.12 Spoil Materials (soil & Rock etc) removal during excavation and surface preparation

This impact was used as the predicted environmental impact by all the project except projects no 8,9&10.The predicted mitigation was that the PP must use spoil materials for site leveling, and back filling purposes. Also, the post constructed un-

usable materials should be disposed with consultation with PS. The records obtained show that few projects has violated this impact mitigation as shown in figure 5.6.

Figure 5.6 – Spoil Rocks heap in the river bank

5.1.13Transformer Oil Discharge in to water bodies

This impact was identified by projects nos. 6, 7, 11& 12 and implemented mitigation is that oil must be collected, pumped or disposed in to an approved dump site.

5.1.14 Sewage or any liquid effluent discharge from dwelling and camp site.

This impact was identified by projects nos. 6, 7, 11& 12 and implemented mitigation is that sewage or liquid be collected in to a bin and dump it in to an approved dumpsite.

5.1.15Solid waste stagnate within the premises

The impact was identified by projects nos. 1, 2, 4, 7, 11& 12 and implemented mitigation is that solid waste must be disposed with consultation with Pradesiya Sabha (PS).

5.1.16Sanitation facilities for the workers

The impact was identified by projects nos. 1, 2, 4, 5 & 8 and mitigation was that pp should be providing the proper sanitation facilities. The PPs had provided toilet and sanitation facilities for the workers

5.1.17Sediment

5.1.17.1 Sediment accumulation at the weir site

A particle can be transported in the discharge both as bed load and as suspended matter. An exact delimitation is not possible, as the influence in particular the flow velocity - can be very different according to the discharge character. The particles that flow through the river are deposited at the weir due to slowdown of the flow velocity at the weir. The deposited fine particles must be removed to prevent change of pond capacity. The impact was identified by projects nos. 1, 2, 5, 6, 7, 8, 10, 11& 12 and the implemented mitigation is the flushing of sediment should be carried out frequently prevent sludge accumulation .

5.1.17.2 Sediment accumulate in settling tank

The water drawn from the river and fed to the turbine will usually carry a suspension of small particles. This sediment will be composed of hard abrasive materials such as sand which can cause extensive damage and rapid wear to turbine runners. To remove this material the water flow must be slowed down in settling basins so that the silt particles will settle on the basin floor. The deposit formed is then periodically flushed away.

From the size of the smallest particle allowed into the penstock the maximum speed of the water in the settling basin can be calculated as the slower the water flows the lower the carrying capacity of the water for particles. The water speed in the settling basin can be slowed down by increasing the cross section area of the channel. For each maximum size of the particles the optimum size of the settling tank can be calculated. The impact was identified by projects nos. 1, 2, 5, 6, 7, 8, 11& 12 and implemented mitigation is Collected the sediment and dump them PS approved dump site

5.1.18 Sociological Impacts

5.1.18.1 Resettlement of People

Any person, who as a result of the implementation of the Project, loses the right to own, use, or otherwise benefit from a built structure, land (residential, agricultural, pasture or undeveloped/unused land), annual or perennial crops and trees, or any other fixed or moveable asset, either in full or in part, permanently or temporarily. Not all PAP need to move due to the Project. PAP may include:

- **Physically Displaced People** – People subject to physical displacement.
- **Economically Displaced People -** People subject to economic displacement.

Physical Displacement

Loss of shelter and assets resulting from the acquisition of land associated with the project that requires the affected person(s) to move to another location. The mitigation measures were identified as Compensation or Payment in cash or in kind at replacement value for an asset or a resource that is acquired or affected by the Project at the time the assets need to be replaced. The impact was identified by projects nos. 1&2 and implemented mitigation is compensation or move to predetermined locations. Other projects do not discuss this impact due to it being inapplicable to other Projects.

5.18.2 Flood & land slid effect during construction and operation

Landslides occur when the stability of a slope changes from a stable to an unstable condition. A change in the stability of a slope can be caused by a number of factors, acting together or alone .Natural causes of landslides include, groundwater pressure acting to destabilize the slope, erosion of the toe of a slope by rivers or weakening of a slope through adding loads to barely stable slope, absence of vertical vegetative structure, soil nutrients and soil structures.

Landslides are aggravated by human activities which can be deforestation, cultivation and construction. Main human causes are vibrations from machinery, blasting, earthwork which alters the shape of a slope, removal of deep rooted vegetation and construction.

Flooding of the land for Mini Hydro Power has an extreme environmental impact: it destroys forest, wildlife habitat, agricultural land, and scenic lands.

The project mitigation measure points out that the damage should be minimized by preventing the adverse impact caused by the above activities and actions be taken to minimize the damage to the peoples by establishing a possible warning system and also implement remedies to minimum damages. Damages could be recovered by paying compensation. This impact is discussed in project ct nos. 1, 2, 4, 6, 7, 8, 11 and 12.

5.1.18.3 Timely water release or irrigation water management

Water management is an important element of irrigated crop production. Efficient irrigation systems and water management practices can help maintain farm profitability in an era of limited, higher cost water supplies. Efficient water management may also reduce the impact of irrigated production on offsite water quantity and quality. However, measures to increase water-use efficiency may not be

sufficient to achieve environmental goals in the absence of other adjustments within the irrigated sector. As often the case, technology is not the whole solution anywhere, but it is part of the solution almost everywhere. This impact is discussed in Project no.01& 02 only.

5.1.18.4 Impact on stream bathing families

The upstream and downstream water quality was not affected by hydropower generation. Therefore, impact on bathing is occurred between intake and tailrace of the Power House. This effect can be minimized by selecting a shorter distance between them as in Project numbers 01 and 02Projects numbers 1,2 and 5which identified this impacts. The mitigation measures was that the PP provides proper bathing facilities as per the no of lost places. . The projects numbers. 01 & No.02 implemented mitigation measures by constructing bathing places with cemented steps for bathing purposes.

As per the field observations, it was found out that Project Proponent had not constructed agreed number of bathing places. This part has been missed by the monitoring committee too.

5.1.18.5 Donation to development work in the village

This is a PP proposed impact and this was implemented only by the number 2 Project. But, this is a good proposal to improve the living condition of the villagers and prevent un-necessary protest against Mini Hydro projects.

5.1.19 Fire safety

The Power House should have proper Fire fighting system to prevent fire impact which can be due to leakage of current or any other disaster. The PAA has given impact mitigation to PP It shall provide and maintained fire fighting system to a proper manner. All the projects predicted this impact and implemented the predicted mitigation.

5.2 Observed Issues regarding the construction activities by the Monitoring committee reports

5.2.1 Project Number 04

Small soil erosion was observed in the area due to an opening on the ground slope and surface water flow during the rainy days.

The Project had constructed the base wall Retention structure which was for maintained properly

Cracks were observed nearby houses of villagers and according to NBRO observation, the project work activity has not been effect for crack

PP had not been taken safety precaution for vertical bank built on earlier created side of channel and penstock path during construction.

Temporary hut has been constructed at the Power House area

5.2.2 Project Number -07

Few landslides had occurred due to loose soil movement and poor construction Practices.

Fore bay location was shifted from initialed approved point

Heavy flood had occurred during operation Phase and it caused damaged to Power plant with sliding of loose soil surrounding the Power plant.

5.2.3Project Number –08

Considerable soil erosion was observed in the area.

The Public staged a protest against the PP when a crack occurred on house during blasting activities.

5.2.4 Project Number – 10

- The excavated soil was heaped on the slope of the earth which could enhance soil erosion and silt deposit in the riverbed.

5.2.5 Project Number – 12

Boulders and soil heaped on right hand side of the river bank without considering mitigation actions.

Two land slid were observed along the channel path after excavation activities

There were cracks in wall and ground floor of two houses due to the blasting activities.

NBRO recommended the soil nail methods for stabilizing the slope of soil.

There were public complaints against the projects activities.

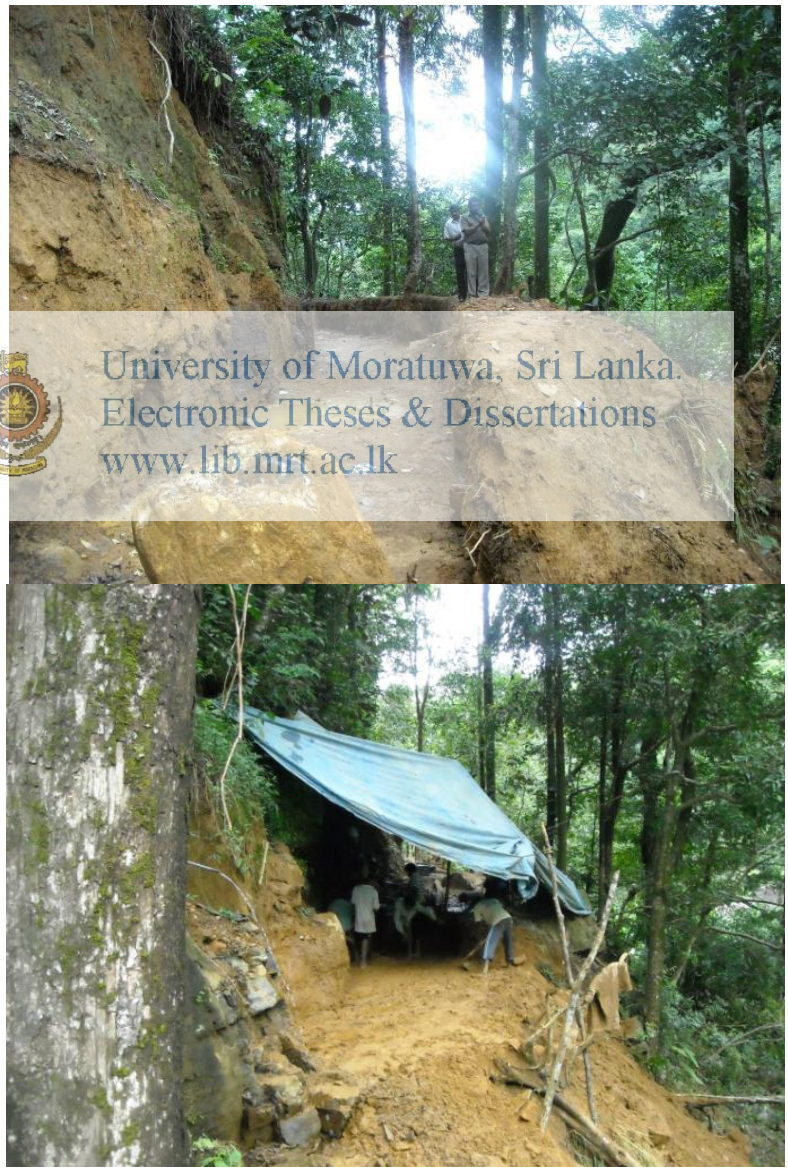

Figure 5.7 - Ground earth surface disturbance and violation conditions

5.3 Environmental Monitoring Weakness Identified

It is one of the most important components of IEE /EIA and it will used to ensure that

Impacts do not exceed the established legal standards

Checking the implementation of Mitigation measures

Providing early warning of potential Environmental damage

5.3.1 Types of Monitoring

5.3.1.1 Baseline Monitoring- A survey has to be conducted before construction begins and this survey should be conducted on basic environmental parameters in the area surrounding the proposed project before construction begins. Subsequent monitoring can assess the changes in those parameters over time, against the baseline. As per the project Proponent and Project Approving agencies, all the project has been done prefeasibility studies and baseline monitoring was conducted by the PP and they have reported the basic environmental parameters. But in the case something like hydrologic monitoring all data and land used pattern have been obtained from the relevant authorized institutes.

5.3.1.2 Impact monitoring

The physical, biological, socio-economic, and cultural parameters within the project area must be measured during the period of project construction and operation in order to detect environmental changes, which may have occurred as a result of project implementation. This part of monitoring has been done by the Scoping committee at the scoping process. Impact prediction of this monitoring process is based on the views and comments of the stakeholder institutions

According to the questionnaire results scoping committee of every project has conducts at least one field surveying to identify environmental, social & cultural impacts.

5.3.1.3 Compliance Monitoring

This is the periodic or continuous recording of specific environmental quality indicator or pollution levels to ensure project compliance with recommended protection standards. The main aim of EIA compliance monitoring is to provide the information required to ensure that project implementation has the least possible negative environmental impacts, and all possible positive impacts, in the project affected area. The main aim of EIA compliance monitoring is to provide the information required to ensure that project implementation has the least possible negative environmental impacts and all possible positive impacts, in the project affected area [9]

These types of Monitoring have been done for the air pollution, Water quality and noise & vibration pollution in the Projects. Water Quality analysis has not been done any of the projects during three stages of pre-construction, construction & operation stages. Noise level analysis Noise level monitoring has been done five of the twelve Projects. Vibration analysis which is an important phenomenon to determine the damage has not been done any projects it is phenomenon the damage of the village houses and landslides had not been done by any one of the projects. Air pollution analysis is not much effective in the Mini Hydro projects, because all the projects are done small scale and the using heavy machinery to minimum for the projects none of the project had done pollution analysis, but they had taken but they had taken preventive action for the impact.

According to the experienced and literature survey during the research the following issues arising for ineffective monitoring process of the every project.

1. Lack of fund allocation for the project activities is one of reason. The schedule monitoring process requires visits many times. The PAA should arrange meals and accommodation facilities when the monitoring committee has to travel long distance to visit the project. But there is a limitation on the administrative charge available to the PAA. If we increased the

administrative charge it is a burden to the PP. It becomes burden to the PP. It discourages the PP.

2. Lack of staff available in the Environment cell of Project Approving agencies has a tremendous effect for the weakening of Environmental Monitoring Process.

3. Lack of capacity building of officers is effective reason for weak monitoring process.
4. The monitoring process is not properly scheduled and not allocating time for monitoring process is weakening few projects,
5. The appointed monitoring committee members do not have sufficient background knowledge of the Project, and therefore they are unable to monitor exactly with the baseline conditions. The committee members cannot spend lot of time in the monitoring process.

Considering the above facts the following remedial actions may be proposed the monitoring regulations and guideline has to be revised. In addition actions has to be taken to appoint a separate work group with proper skilled development Programs must be appointed.

The monitoring committee must be appointed from the people who have lived for a long period in the village. Then massage can be sent to the Monitoring Committee of the PP violates violate regulation mitigation Process. The process at the monitoring is done by P.P they may be able to identify the issues related any protest, and complaint against the PP. But this is a not a practical solution, and we must take necessary action to prevent social, cultural and Environmental impacts.

5.4 Environmental Impact Identification Methodologies Used and Issues

There are many types of EIA methods. But, only the most suitable methods but only the most suitable methods for Mini Hydro Projects such as checklist, Matrixes, Network and expert opinion methods have been discussed. The selected projects

were categorized according to their impact identification methodologies. This is shown in table 4.3.

. The impact analyses of twelve projects indicate that the Predicted impact was missing in some project sand this may have been due to poor usage of EIA the methodologies,

Several activities are required to conduct an environmental impact study including identified impact, preparation of description of the affected environmental impact prediction and assessment and selection of the proposed action from a set of alternatives being evaluated to meet identified needs. There are eighteen EIA methods and they have been arranged against seven activities in the Table3.1. The each of the methods has advantage and limitation.

Table 5.1 Type of Methods used in EIA activities

	Types of Methods in EIA	Define Issues (Scoping)	Impact Identification	Described Affected Environment	Impact Prediction	Impact assessment	Decision Making	Communication of Results
1	Analogs(Case studies)	X	X			X	X	
2	Checklists (Simple, descriptive, Questionnaire)		X	X				X
3	Decision focus checklist (MCDM:MAUM:DA: Scaling: weight)					X	X	X
4	Expert opinions(professional judgment, Delphi, adoptive, environment assessment, simulation, modeling)		X		X	X		
5	Expert Systems(Impact identification prediction, assessment, decision making	X	X	X	X	X	X	
6	Laboratory testing scale model		X		X			
7	Literature reviews		X		X	X		
8	Matrices (simple, stepped, scoring)	X	X		X	X	X	X
9	Monitoring (baseline)			X		X		
10	Monitoring (field studies of analogs)				X	X		
11	Networks		X	X	X			
12	Overlay mapping(GIS)			X	X	X		X
13	Photographs and Photo montages			X	X			X
14	Qualitative modeling			X	X			
15	Quantitative modeling			X	X			
16	Risk Assessment	X	X	X	X	X		
17	Scenarios				X		X	
18	Trend Extrapolation			X	X			

X- Potential for direct usage direct usage of method for listed activity

MCDM - Multi criteria Decision Making **MAUM** - Multi Distribute utility Measurement

DA- Decision Analysis **GIS** - Geographical Information System

The checklists method lists local environmental factors, which are likely to be affected where a development is planned. This list can contain broad categories of factors as flora, fauna, hydrological regimes, surface water bodies and the atmosphere. These methods can be categorized again as Simple, Questionnaire and quantitative. The typical checklist developed for mini Hydro Power is shown in table 5.1

Table 5.2 – Sample Checklist for a Mini Hydro Power Projects.

No	Environmental Impact	Impact		Short term Impact	Long Term Impact	Reversible Impact	Irreversible Impact	No Change
		Positive	Negative					
A	Preconstruction Stage							
1	Resettlement of People							
2	loss of bathing places							
3	Removal of vegetation							
B	Construction Stage							
4	Soil erosion							
5	Land sliding							
6	Water quality							
7	Noise Impact							
8	Vibration Impact							
9	Safety impact							

10	Solid waste Generation							
11	Sedimentation							
12	Air pollution							
13	Change in Land Pattern							
14	Liquid waste generation							
15	Removal of vegetation							
16	Human Health							
17	impact on cultural location							
18	Change of drainage Pattern							
19	impact on aquatic Fauna							
20	Impact on Terrestrial fauna							
21	Impact on Terrestrial flora							
22	Infrastructure development							
23	Lost of							
24	Inundation of properties							
C	Operation Stage							
24	Inundation properties							
25	Water Eutrification							
26	Fish Migration							
27	Aquatic flora & fauna							
28	Terrestrial Flora & Fauna							
29	Siltation							
30	Air pollution							

31	Noise pollution							
32	Job opportunity							
33	Recreation and tourism potential							

Impact of all the projects were identified by answering questionnaires provided by the Project Approving Agencies. Hence, in all the project Impact has identified using questionnaire type checklist methods none of the projects has quantified possible impacts.

The matrix consists of a horizontal list of development activities displayed against a vertical list of environmental factors. The matrix is used to identify impacts by systematically checking each development activity against each environmental parameter. This types of impact analysis is for detailed impact analysis of project. This is essentially used for large and complex projects, but it can also be used for Mini Hydro Project impact identification. A developed matrix is sown below in table 5.2

The network analysis is complicated and identified impacts inter connections. However, in practice it can be applied by considering secondary and more impacts of the each activities.

Table 5.3 – Sample Matrix for the Mini Hydro Project

`	Activities	Impact zone	Air Quality	Noise & vibration	Soil quality	Surface water Hydrology	Surface water quality	Ground water	Ground water quality	Erosion and sedimentation	River Geomorphology	Terrestrial Flora	Terrestrial fauna	Aquatic Flora	Aquatic Fauna	Endangered species	Protected area	Change in land used pattern	Land take	Agriculture	Forestry	Fisheries and aquatic	Solid waste generation	Cultural locations
1	Construction of access roads	Up stream																						
		Construction Site																						
		Down stream																						
2	Setting up of construction workers' camp	Up stream																						
		Construction Site																						
		Down stream																						
3	Handling and storage of construction materials	Up stream																						
		Construction Site																						
		Down stream																						
4	Disposal of solid and liquid wastes	Up stream																						
		Construction Site																						
		Down stream																						

5	**Site clearance of vegetation and top soils**	**Up stream**																					
		Construction Site																					
		Down stream																					
6	**Clearance of vegetation for transmission line**	**Up stream**																					
		Construction Site																					
		Down stream																					
7	**Construction of temporary coffer dams to divert the stream for construction**	**Up stream**																					
		Construction Site																					
		Down stream																					
8	**Earth moving and blasting**	**Up stream**																					
		Construction Site																					
		Down stream																					
9	**Quarrying and transport of rock, sand and gravel**	**Up stream**																					
		Construction Site																					
		Down stream																					

10	**Concrete work**	**Up stream**																					
		Construction Site																					
		Down stream																					
11	**Installation of electrical & mechanical equipments**	**Up stream**																					
		Construction Site																					
		Down stream																					
12	**Installation of switch yard and transmission line**	**Up stream**																					
		Construction Site																					
		Down stream																					
13	**Filling of the ponding area**	**Up stream**																					
		Construction Site																					
		Down stream																					
14	**Operation of Power Plant**	**Up stream**																					
		Power Plant																					
		Down stream																					

6.0 Conclusion and Recommendations

6.1 Conclusion

The research observed that the exact gap between predicted impact and the implemented impact is cannot be analysis because, the given predicted impact did not apply to the projects at any time. However it is responsibility of PAA and scoping committee to predict the exact impact. It was observed that the IEE report does not mentioned methods of exact identification. This is a weakness of submission IEE report as well as Term of Reference (TOR). TOR should be laid down the condition that the method of impact identification should be included in the IEE report. All the projects taken to research have neglected the monitoring process and which is an important part of IEE and EIA. The Environmental Monitoring process is not compressive and PP had violated mitigation as well as the conditions stipulated by the PAA. Hence Monitoring process must be improved to implement of Predicted mitigations satisfactorily.

The IEE reports of all the twelve Projects are not in unique order, similar to other countries like India. Sri Lanka must have proper stand guide line to be followed by Mini hydro Project

As per the studies, the Mini Hydro Projects have to face challenge such as heavy flood, blasting hazards, Landslides and soil erosion. These challenges can be overcome by proper planning and management.

6.2 Recommendations

As per the results of this research following recommendations were made.

1. Selection of scoping committee members has to be improved because some stakeholders were missing while selecting Scoping committee members.
2. Monitoring committee must be appointed from stakeholders and subject experts.
3. The benefits for the villagers have to be satisfactory level in order to prevent un-necessary delay of projects due to protest by the Villagers.
4. The Project proponent should analyze the environment and social damage which may cause by the implementation of the Project and they must take precautions to overcome or minimized.
5. Standard guideline must be prepared to Mini hydro projects and it must be include conditions and procedure applicable to all part of Sri Lanka.
6. Attention must be paid mostly for E flow designing, Blasting process of the projects, in order to meet the disaster situation blasting procedure and hazard preventive methods must be laid down. Insurance policy also should be introduced.

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