

Additional Environmental Studies

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Moragolla Hydropower Project

Institutional Arrangements for Project Implementation

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1. Legislative and Administrative Framework

1.1 Central Environmental Authority

The Central Environmental Authority, established under the National Environmental Act (NEA) No 47 of 1980, is the Government's main environmental regulatory agency and is primarily responsible for enforcing the National Environment Act and formulating and implementing other environmental policies. The NEA has been amended twice to make improvements and to respond to the needs of the time:

1. National Environmental (Amended) Act No 56 of 1988; and
2. National Environmental (Amended) Act No 53 of 2000.

There are two main regulatory provisions in the NEA through which impacts on the environment from the process of development are assessed, mitigated and managed. These are:

1. The Environmental Impact Assessment (EIA) procedure for major development projects. Regulations pertaining to this process are published in Government Gazette Extraordinary No.772/72 dated 24 June 1993 and in several subsequent amendments.
2. The Environmental Protection License (EPL) procedure for the control of pollution. Regulations pertaining to this process are published in Government Gazette Extraordinary No. 1533/16 dated 25 January 2008.

1.1.1 Environmental Impact Assessment

The broader legal framework for the EIA process in Sri Lanka was laid down by the amendments made to the NEA in 1988. The provision relating to EIA is contained in Part IV C of the NEA and provides for the submission of two types of report: an Initial Environmental Examination (IEE) report or an Environmental Impact Assessment (EIA) report. These are required in respect of "prescribed projects" included in the EIA regulations¹. Prescribed projects in the Power Generation Sector include "construction of hydroelectric power stations exceeding 50 MW" and "installation of overhead transmission lines of length exceeding 10 km and voltage above 50 KV". Furthermore, any project or undertaking irrespective of its magnitude, if located partly or wholly within an Environmental Sensitive Area², will become a prescribed project requiring approval under the EIA regulations.

The EIA process is implemented through designated Project Approving Agencies (PAAs), listed in Government Gazette (Extra Ordinary) No. 859/14 dated 13 February 1995. The PAAs are line

¹ published in Government Gazette Extraordinary No.772/72 dated 24 June 1993 and in several subsequent amendments

² such as "60 meters from a bank of a public stream having a width of 25 metres or more at any point of its course"

ministries and agencies, and are responsible for administration of the EIA process under the NEA, which includes but is not limited to the following:

- Subject all prescribed projects to IEE/EIA requirements;
- Ensure and guide a proper scoping process for IEEs/EIAs;
- Draft Terms of Reference (ToR) for IEEs/EIAs;
- Establish, conduct and participate in Technical Evaluation and reviews during and after IEE/EIA report preparation;
- Ensure public notification of the availability of the EIA report for public review;
- Evaluate the comments received from the public and other agencies;
- Establish appropriate mitigation measures and ensure that they are incorporated in the approval conditions;
- Ensure implementation of the conditions through effective monitoring;
- Obtain concurrence of the CEA prior to taking a decision on approval of the EIA report.

As the Moragolla Hydropower Project is located in an area under the jurisdiction of Mahaweli Authority of Sri Lanka (MASL - see below) the MASL was designated by CEA as the appropriate PAA for this project.

In order to obtain environmental approval for a proposed project, the project proponent (PP) should submit either an Initial Environmental Examination (IEE) report or an Environmental Impact Assessment (EIA) report as required by the PAA. EIAs are required for projects considered likely to have significant impacts, determined by considering the context and intensity of the potential impacts.

The EIA Procedure

In the event that an EIA is required, the PAA in consultation with CEA is responsible for subjecting the preliminary information submitted by the project proponent to environmental scoping, in order to set the ToR for the EIA within 30 days from the date of acknowledging receipt of the preliminary information. The ToR is prepared by a Scoping Committee comprising experts in the relevant field, appointed by the PAA. In developing the ToR, the EIA regulations provide for the PAA to consider the views of state agencies and the public.

Upon submission of the EIA report by the project proponent, the PAA is required to determine whether the issues referred to in the ToR have been addressed and to notify the proponent of any inadequacies within 14 days. If inadequacies are identified, the proponent is required to make the necessary amendments and resubmit the report. Once accepted, the EIA is forwarded to the CEA by

the PAA, and notice is placed in a national newspaper published daily in Sinhala, Tamil and English, inviting the public to make written comments to the PAA within 30 days from the date of first appearance of the notice.

According to the legislation, public consultation is mandatory only at this stage of the EIA process, although informal consultation with NGOs, interested groups and civil society may also occur earlier, depending on the type of project and the degree of public interest. The notification specifies the times and places at which the EIA report will be available to the public. As a minimum the report would be available at the CEA, PAA and in appropriate government agencies in the project area. The environmental regulations have provisions for public hearings at the discretion of the PAA, although this is not mandatory. 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 Technical Evaluation Committee (TEC) appointed by the PAA then evaluates the EIA and requires the project proponent to respond to any queries. The TEC also evaluates the adequacy of the project proponent's response to any comments raised during the public comment period. Upon completion of the evaluation, the PAA with the concurrence of the CEA either grants approval for the implementation of the proposed project subject to specified conditions, or refuses approval, giving reasons for doing so. This decision must be made within 30 days of the receipt of responses from the project proponent. The PAA is required to specify a period within which the approved project should be completed. If 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 IEE Procedure

Upon review of the preliminary information provided by the project proponent (PP), if the PAA determines that the project would have no long-term adverse environmental impacts, an Initial Environmental Examination (IEE) may be considered adequate. Under such circumstances, the proponent is required to submit a detailed IEE report for review and approval by the PAA, identifying 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 project, the proponent will be required to undertake a detailed EIA. 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 IEE is not required by law to be opened to the public for comments and does not go through the public consultation process.

An Environmental Impact assessment Report (EIAR) for the Moragolla HP Project was prepared by the Ceylon Electricity Board (CEB) during the Feasibility Study period (2009-2012) and approval obtained from MASL in 2013. If the Construction Contractor intends to carry out any “Prescribed Project” that is not assessed in the current EIA report³, he is responsible for obtaining environmental approval from the appropriate PAA after going through the prevailing EIA process. The activities most likely to be classified as prescribed projects are expected to be:

- Inland deep mining and mineral extraction;
- Inland surface mining⁴; and
- Mechanized mining and quarrying operations of aggregate, marble, limestone, silica, quartz, and decorative stone within 1 kilometre of any residential or commercial areas.

1.1.2 Environmental Protection License

The Environmental Protection License (EPL) is a regulatory tool introduced under the provisions of the National Environmental (Amended) Act No 56 of 1988 to prevent or minimize the release of pollutants from industrial activities.

Regulations in Government Gazette Extraordinary No 1533/16 classify industrial activities according to their pollution potential. List A comprises 80 potentially high polluting industries; List B covers 33 medium polluting industries; and List C comprises 25 low polluting industries.

EPLs for List A and B industries are issued by the relevant Provincial / District offices of the CEA, while EPLs for List C industries are issued by the relevant local authority (Municipal Councils, Urban Councils or Pradeshiya Sabha: see Section 1.4). The EPL for List A industries is valid for one year while those for List B and C industries are valid for three years. For List A and B industries the project proponent must submit a duly filled application (obtained from CEA headquarters, provincial and district offices or downloaded from the CEA website) for each prescribed activity to the CEA provincial or district office, who will evaluate the application and decide upon issuing an EPL and the appropriate inspection fee. The proponent must then pay the prescribed fee to CEA headquarters or provincial/district office and submit the receipt to the relevant provincial or district office. A team of

³Ceylon Electricity Board (November 2012): Moragolla Hydropower Project, Feasibility Study, Final Report: Volume 3- Environmental Impact Assessment (Central Engineering Consultancy Bureau, Sri Lanka and Al-Habshi Consultants Office, Kuwait).

⁴ "mining" means excavating in, on, or below the surface for the purpose of evaluating and obtaining any minerals (ref. Mines and Minerals Act No 33 of 1992); this legislation therefore applies also to quarrying to obtain construction materials.

officers will then carry out an inspection and submit a report based on the site visit and the information provided. If the issue of EPL is recommended, the proponent can obtain the EPL upon payment of the license fee.

For List C industries the procedure is the same, except the Local Authority will appoint a Technical Evaluation Committee (TEC) that makes the final decision regarding the issue of EPL based on the field assessment report and information furnished by the industrialist/proponent.

The EPL can be renewed by submitting a renewal application three months prior to the date of expiry to the relevant authority, which will conduct a field inspection and determine whether the EPL should be renewed.

There are several activities associated with construction of the Moragolla Hydropower Project that come under the provisions of this regulation and the Contractor is responsible for obtaining the Environmental Protection License (EPL) in each case. The prescribed activities are: bulk petroleum liquid or liquefied petroleum gas storage or filling facilities; asphalt processing plants; concrete batching plants; mechanized mining activities; granite crushing (metal crushing) plants; incinerators; wastewater treatment plants; solid waste dumping yards; and toxic or hazardous waste treatment or disposal facilities.

1.2 Mahaweli Authority of Sri Lanka

The MASL was established in 1979 with the purpose of implementing the accelerated Mahaweli Ganga Development Scheme (MGDS). The Mahaweli Authority Act of 1979 empowered the MASL to use and develop the water resources of Mahaweli Ganga or any other neighbouring river basins for purposes of irrigation, hydropower generation, land settlement, etc. The MGDS involves integrated development and management of the land and water resources of Mahaweli and allied river basins. Its objectives are to develop, operate and maintain irrigation systems to expand farmland, increase agricultural production, increase hydropower generation, provide land to the farmer community, encourage employment generation and enterprise development, and conserve the environment, particularly in the watershed areas.

According to the Mahaweli Authority Act, the functions of the MASL in relation to, any Special Area⁵ shall be to:

a) Plan and implement the MGDS including the construction and operation of reservoirs, irrigation distribution systems and installations for the generation and supply of electrical energy. Provided

⁵Any area declared by the Minister by Order published in the Gazette, **which can be developed with the water resources of Mahaweli Ganga or any other major river to be a Special Area**, in relation to which the MASL may exercise, perform and discharge all or any of its powers, duties and functions.

however, that the function relating to the distribution of electrical energy may be discharged by any authority competent to do so under any other written law.

- c) Foster and secure the full and integrated development of any Special Area;
- d) Optimize agricultural productivity and employment potential and generate and secure economic and agricultural development within any Special Area;
- e) Conserve and maintain the physical environment within any Special Area;
- f) Further the general welfare and cultural progress of the community within any Special Area and administer the affairs of such Area;
- g) Promote and secure the participation of private capital, both internal and external, in the economic and agricultural development of any Special Area; and
- h) Promote and secure the co-operation of government departments, state institutions, local authorities, public corporations and other persons, whether private or public, in the planning and implementation of the MGDS and in the development of any Special Area.

Regulations for the control of reservoirs, natural and artificial waterways, and other water bodies and their environs are published in the Government Gazette Notification 431 dated 26 December 1980. According to these regulations no person shall engage in any development activity within any area coming under the purview of MASL without a proper approval obtained from the Authority.

The Forestry and Environmental Management (F&EM) Division of MASL, headed by a Director who is responsible to the Executive Director (Technical Services and River Basin Management), handles the environmental interventions of the Authority. The major activities carried out by the F&EM Division are: soil and water conservation; environmental education; conservation farming; biodiversity conservation; Geographical Information Systems (GIS) and remote sensing based mapping and database preparation; land use planning; sediment and river flow monitoring; water quality monitoring; and aquatic weed management in Mahaweli water bodies.

MASL also functions as a project approving agency (PAA) under the NEA in order to oversee the EIA process and grant environmental approval for prescribed projects in the Mahaweli Ganga watershed, such as the Moragolla Hydropower Project.

In addition to the above two key organizations and related legislative provisions, several other establishments will also be involved in evaluating and approving environmental and social safeguard measures of projects of this nature, as explained below.

1.3 Geological Surveys and Mines Bureau (GS&MB)

The GS&MB, established under the Mines and Minerals Act No. 33 of 1992, is responsible for licensing mining and exploitation for minerals. Mining licenses are issued only to qualified individuals and companies registered to do business in Sri Lanka. Mining is not permitted in Archaeological Reserves and within a specified distance of scheduled monuments. New mining licenses are subject to the EIA process, if the type and extent of mining is listed under the EIA regulations⁶. Additionally, the GS&MB has the power to stipulate conditions including the taking of financial deposits and insurance for the protection of environment. Regulations made by the GS&MB under the Act cover a variety of environmental stipulations, criteria and conditions for licensing and operating mines. The Act also deals with the disposal of mine wastes and the health, safety and welfare of miners. Reclamation of mines is a major problem in Sri Lanka and because of this, current practice requires the mining enterprise to make a deposit to cover the costs of reinstatement of mines. Mining rights on public and private land are subject to licensing by the GS&MB and all minerals wherever situated belonging to the State.

1.4 Local Authorities

Local authorities (LA) consist of Municipal Councils, Urban Councils and Pradeshiya Sabhas and constitute the third level of governance after the central government and provincial councils. Environmental management is a de-centralised responsibility, so the LAs are expected to play a major role in protecting the environment. Activities related to environmental management in the LA are generally coordinated by an Environmental Officer (EO), who receives all complaints from the public concerning environmental issues. This may lead to investigation of complaints and recommendations to responsible authorities for further action.

Industries carrying out activities of low polluting nature must obtain an Environmental Protection License (EPL) from the LA where the activity will be undertaken. As explained above, the LAs are empowered to issue EPLs for 25 types of low polluting activities listed in part C of the prescribed activities. Most construction activities for this project will be large enough to require an EPL from the CEA, but it is possible that certain other activities may only require licensing by the LA.

1.5 Prevention of Mosquito Breeding Act⁷

The Construction Contractors will be required by their contracts to comply with all national legislation that is in any way relevant to the activities they are conducting. This includes labour laws, health and safety legislation and many other legal provisions. In relation to the natural environment,

⁶Published in Government Gazette Notification No. 772/22 dated 24 June 1993.

⁷<http://sri.lankalaw.lk/revised-statutes/volume-vi/954.html>

there is one piece of legislation that covers an issue of critical importance for Sri Lanka, to which the contractor should pay particular attention: the Prevention of Mosquito Breeding Act (11 April 11 2007).

This Act was passed for the purpose of preventing and eradicating all mosquito-borne diseases. Under this Act, it is the duty of every owner or occupier of any premises to cause: (a) open tins, bottles, boxes, coconut shells, split coconuts, tires or any other article or receptacle found in or within such premises, capable of holding water to be removed, destroyed or otherwise effectively disposed; (b) any well found in the premises and its surroundings to be maintained and kept in good repair so as to make it mosquito-proof and thereby prevent the breeding of mosquitoes; (c) any artificial pond or pool found in such premises to be emptied at least once in every week; (d) any casual collection of water within the premises that is conducive to mosquito breeding, to be regularly drained; (e) shrubs, undergrowth and all other types of vegetation, other than those grown for the purpose of food or those that are ornamental, found within or outside any building or structure within the premises used as a dwelling place, which has become a breeding place for mosquitoes, to be removed; (f) the removal and destruction of water plants that have the botanical name *Pistia stratiotes* and commonly known as “Diya Parandal”, “Kondepasei”, “Telpassy”, “Barawa Pasi”, “Nanayaviraddi” or water lettuce, and of any other water plant or plants, found within the premises, which may facilitate the breeding of mosquitoes.

2 Project Implementation

2.1 Project Organisation

2.1.1 Executing and Implementing Agencies

The Ministry of Power and Energy (MoP&E) is the Executing Agency of this project. The Ceylon Electricity Board (CEB), which is one of the four agencies⁸ comes under the purview of MoP&E, is the Implementing Agency or the Project Proponent. In order to ensure smooth functioning of the project, a Project Management Office (PMO), headed by a Project Director (PD) will be established by CEB. The PD will report directly to the Additional General Manager (Projects) –AGM (P) of CEB. The overall organization of the project is illustrated in Fig 1.

⁸ Other three agencies are: Lanka Electricity Company (Pvt) Limited, LTL Holdings (Pvt) Ltd. and Lanka Coal Company (pvt) Ltd

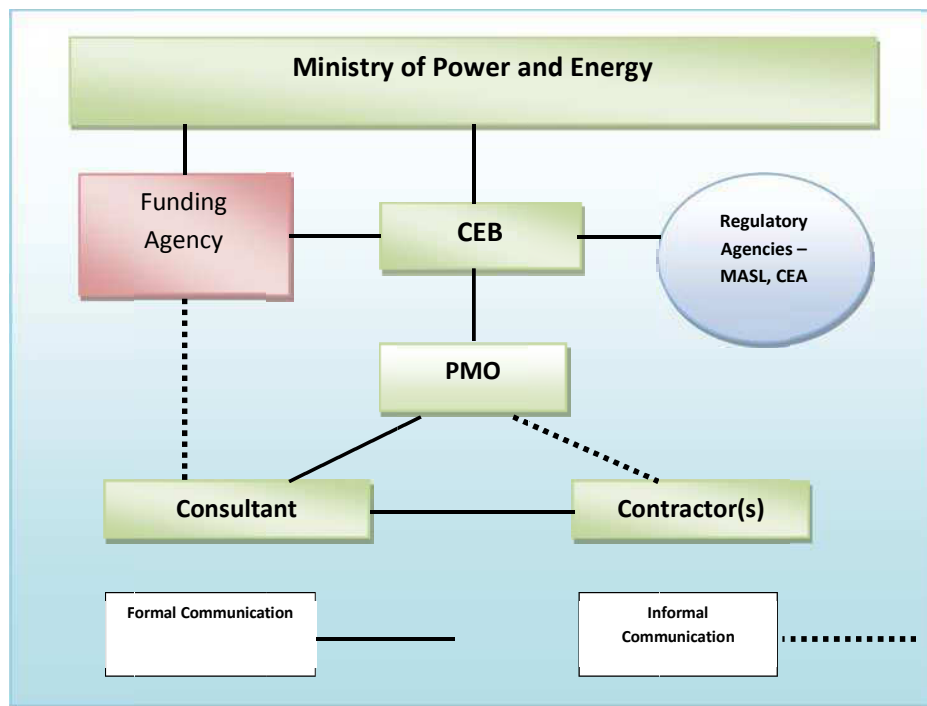


Fig 1: Overall Organisation of the Project

A Project Steering Committee (PSC) will be established by MoP&E immediately after the financial arrangements for project implementation are finalised.

The proposed composition of the PSC and their statutory responsibilities that may impinge on the project are as follows:

1.	Secretary, Ministry of Power & Energy	Chair Person
2.	Representative from the Ministry of Defence and Urban Development	Planning approval for infrastructure development facilities
3.	Representative from the Ministry of Lands and Land Development	Publish the relevant Gazette Notifications pertaining to land acquisition.
4.	Commissioner General of Lands or a representative	Prepare relevant documents for land acquisition
5.	Representative from the Mahaweli Authority of Sri Lanka (MASL)	Designated Project Approving Agency under the National Environmental Act. Responsible for compliance monitoring with conditions of the environmental approval
6.	Representative from the Department of External Resources	Loan disbursement

7.	Representative from the Central Environment Authority	Monitoring the environmental impacts of the project.
8.	Representative from the Survey General's Department	Carry out legal survey for land acquisition
9.	Representative from the National Water Supply and Drainage Board (NWS&DB)	Provide water supply for resettlement sites and other facilities
10.	Survey General (SD)	Legal survey of land and prepare Advance Tracing (AT) and Preliminary Plan (PP)
11.	Valuation Department (VD)	Valuation of the lands and prepare Valuation Reports (VR)
12.	Divisional Secretary, Udapalatha	Responsible for the following activities of the Land acquisition process: - Decide the legal owners of the land to be acquired. -Request the SD to survey the land and prepare AT and PP. -Request the VD to submit the VR. -Pay the compensation in respect of acquired lands and property.
13.	Divisional Secretary, Ganga Ihala Korale	

The PSC will act as the apex decision-making body for the project. The PSC will meet once every two months to review the progress of project activities, provide policy guidelines, resolve issues that may impede the progress of project implementation, and advice on remedial action. The PSC will provide a forum for deliberation of important aspects of the project among its members and facilitate inter-agency coordination.

2.1.2 Project team arrangement for implementation of the project EMP

The responsibility of implementing the project lies with the Project Proponent CEB who will appoint Contractor(s) to construct the various elements of the project once the financial arrangements are finalized, and a Consulting Engineer to supervise construction.

The PMO will co-ordinate the pre-construction, construction and commissioning of the project. An Environmental Management Office (EMO), which will form part of the PMO, will also be established. This will be staffed with an Environmental Specialist (Physical and Natural), Environmental Specialist

(Social) and supporting staff as shown in Figure 2. International Environmental and Social Specialists supported by qualified local specialists will also be appointed by the Supervision Consultant.

The contractor(s) are legally required to implement those elements of the project Environmental Management Plan that are allocated to them in the EMP document; and they will be required to report on this and any other environmental issues to the EMO at monthly intervals or more frequently if necessary. All main contractors will be required to appoint Environmental Officers, who will be the primary point of contact for all environmental issues in relation to construction activities.

The internal arrangement of the PMO is illustrated in Figure 2.

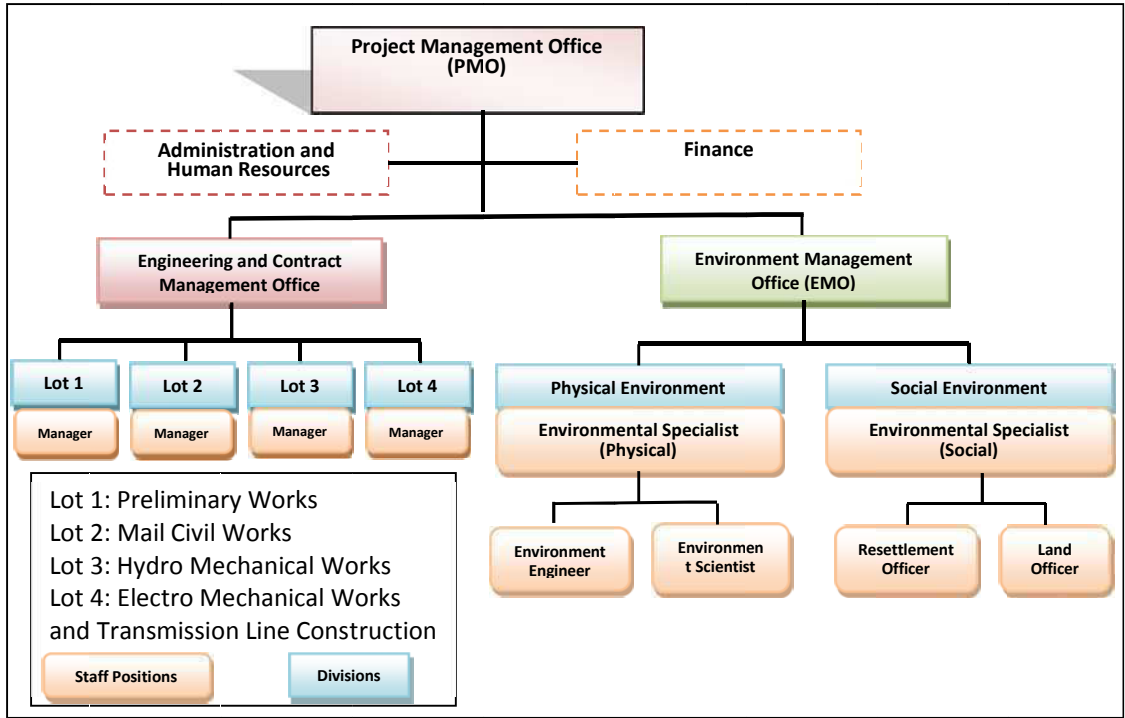


Fig. 2: Proposed structure of the Project Management Office

2.2 Responsibilities of the main organisations

The successful construction and operation of the MHPP will depend on many factors, which include the successful implementation of the various monitoring and mitigation measures set out in the EIA report and the EMP. To achieve this it is imperative that all the participants and organisations having a designated role in project execution and implementation act in a responsible manner and implement their duties professionally and diligently, as set out in the EMP. The main participants and their responsibilities are summarised below:

Agency	Project related responsibilities
Ministry of Power and Energy (MoP&E)	Executing Agency (EA) - Apex decision making body. Responsible for administration of loan / grant finance on behalf of the Government and Progress monitoring through establishment of a Project Steering Committee (PSC). Resolving issues that impede the progress of project implementation, through inter-agency coordination.
Ceylon Electricity Board (CEB)	Project Implementing Agency or the Project Proponent (PP).
Project Management Office (PMO)	Day-to-day project management and coordination: financial management; project administration; technical oversight (engineering and environmental); review and approval of the work of the Design Consultant. Also responsible for ensuring the project adheres to national law and the policy of the lender, including social and environmental safeguards.
Design Consultants (DC)	Detailed design of all elements of the project infrastructure; project planning and programme; calculation of project budgets; preparation of tender documents; inclusion of environmental mitigation measures in design, tender documents and budgets as specified in project EMP.
Supervision Consultants (SC)	Supervision of the work of the Contractors to ensure that all infrastructure is built as designed. Environmental Supervision to ensure that all mitigation is provided as specified in the project EMP (by Contractors, Design Consultants and other bodies).
Construction Contractor(S) (CC)	Construction of specific elements of the infrastructure according to designs, drawings and tender documents; provision of mitigation and monitoring impacts of construction activities as specified in the project EMP.
Mahaweli Authority of Sri Lanka (MASL)	Functions as the Project Approving Agency (PAA) under the National Environmental Act. Responsible for administering the EIA process, including scoping, preparing ToR, public disclosure, review of EIA report, decision-making and compliance monitoring which would involve compliance with conditions and the effectiveness of the mitigatory measures.
Central Environmental Authority (CEA)	Oversees the EIA implementation by the PAA, Monitor the quality of the environmental to ascertain the long term effects (if any). Issuing of EPL for prescribed activities.

3 Institutional Assessment

The outcome of the discussions had with the Deputy Director General (Environmental Management and Assessment) and the Director (EIA) of the Central Environmental Authority, Director (Forestry and Environmental Management) of Mahaweli Authority of Sri Lanka, Project Manager of Moragolla Hydropower Project Feasibility Study Review and Environmental Officer of Ceylon Electricity Board were used in this institutional assessment study.

3.1 Central Environmental Authority

3.1.1 EIA Unit

The EIA Unit, headed by the Director (EIA), functions under the Environmental Management and Assessment Division of CEA and is responsible for: administration of the EIA process; co-ordination between Project Approving Agencies (PAA's); preparation of manuals and guidelines on EIA; and maintenance of a database on EIA. Currently there are three Deputy Directors (DD), six Assistant Directors (AD), eight Senior Environmental Officers (SEO) and three Environmental Officers (EO) attached to the EIA Unit. All of them are graduates having at least a Second Class Honours Degree in environment related subjects such as Biological Science, Physical Science, Engineering, Geography, Agriculture or Built Environment, with post graduate qualifications in environment management related specialties; and in general the senior positions are occupied by those staff with the most experience.

Since its introduction in 1994, the CEA has gathered considerable experience and expertise in managing (over 800 EIAs and IEEs) the EIA process in Sri Lanka and has benefited from numerous capacity building and training projects supported by various donor agencies (NAREPP/IRG project funded by the World Bank, ISEA project funded by ADB and Netherlands funded capacity building project ect.,). However, it is understood that, although the CEA has achieved fairly high standards in implementing EIA procedures and also gained quite a lot of experience in monitoring of post-implementation impacts during the last decade (Upper Kotmale Hydropower Project financed by JICA, Southern Transport Development Project financed by ADB/JICA and Outer Circular Highway Project and Colombo-Katunayake Expressway financed by the Government of China), this is still a weak area that needs to be strengthened (according to the D(EIA) of CEA).

3.1.2 Environmental Pollution Control (EPC) Unit

The EPC Unit of CEA is responsible for management of the Environmental Protection License (EPL) scheme through: development of pollution control guidelines; review and upgrading the existing discharge and emission standards; and introduction of new mechanisms such as the load base

license scheme. This division is headed by the Director (EPC), who reports to the Deputy Director General (EPC). Currently there is one Deputy Director (DD), four Assistant Directors (AD), eight Senior Environmental Officers (SEO) and four Environmental Officers (EO) attached to this Unit. As in the EIA unit, all of the professional staff are science graduates, with post graduate qualifications in environment management related specialties. Issuing of EPL is now delegated to the Regional offices of CEA and Local Authorities (see below).

3.1.3 Regional Offices of CEA

The CEA operates Provincial and District offices that handle most of the compliance and enforcement functions at grass-roots level. These offices often function as the focal points for EIA⁹ and EPL matters in their area of jurisdiction and issue EPL for prescribed activities.

The MHPP area comes under the jurisdiction of the Central Provincial office of CEA. This is headed by the Regional Director (Central Province), with two DDs, four ADs, eight SEOs and forty EOs. Qualifications and experience for each level are equivalent to those for the CEA as described above.

3.2 Mahaweli Authority of Sri Lanka

As explained above, the CEA designates the MASL as the Project Approving Agency (PAA) for the environmental approval process for proposed prescribed projects that are in the areas of MASL jurisdiction. The Forestry and Environmental Management (F&EM) Division of MASL functions as the “environment cell” to implement the requirements of the NEA. This division is headed by a Director who is qualified to MSc level in the field of Natural Resources Management, with more than 20 years of experience in relevant government departments. He is supported by four Deputy Directors, thirteen Environmental Officers, three Water Quality Officers and several support staff. All staff are qualified science graduates and most of them possess at least a MSc degree in environmental science or a related field, with periods of experience that are generally commensurate with their level of seniority (for example 5 or more years for EO grade).

3.3 Ceylon Electricity Board

In general, responsibility for implementing the Environmental Management and Monitoring Plan (EMMP) of MHPP lies with CEB as the project proponent. In practice this will be delegated to the Project Director and staff of the PMO, once it is established. The existing Environment Unit of CEB, which functions under DGM Transmission Design and Environment, will have the responsibility of

⁹Administration of IEE process for the projects and undertakings for which CEA functions as PAA are now totally delegated to Provincial offices. This involves all elements of the process, including scoping, issuing of ToR, review of report and decision-making.

monitoring the implementation of the EMMP and coordinating the monitoring activities with the Project Approving Agency, MASL and CEA.

The Environment Unit of CEB is the focal point for most of the environmental activities of CEB. Their main responsibilities include:

- Implementation of the complete environmental approval process for all the transmission projects of CEB, including preparation of EIA/IEE reports and obtaining the Environmental Approval.
- Coordination of the complete environmental approval process for the generation projects of CEB, including Public Consultations/ Public Hearings, and obtaining the Environmental Approval.
- Implementation of the Environmental and Social Assessment Process under the relevant Environmental/ Social guidelines of the respective funding agencies for all CEB projects.
- Monitoring the implementation of Environmental Management/Monitoring Plans for the ongoing projects of CEB.

Currently the staff of Environment Unit of CEB consists of three officers, namely Environmental Officer (Head of Environment Unit), Civil Engineer and one Electrical Superintendent. This does not provide sufficient staff numbers or technical specialisation to deal with the amount or range of activities for which the unit is responsible and the time targets set for most of the environmental approvals (which currently includes preparation of IEE reports for four (4)¹⁰ transmission line projects funded by ADB for which environmental approval is needed by the end of 2013, five (5)¹¹ environmental studies for JICA funded transmission line projects to be completed in early 2014 and two (2)¹² feasibility studies funded by JICA).

Considering the large number of activities involved in the Environmental Management and Monitoring Plan of MHPP it would be very difficult for the Environment Unit to handle the coordination / monitoring of the implementation of the EMMP without additional resources. It is recommended therefore the Environment Unit of CEB shall be strengthened after carrying out a detailed assessment of the workload and the staff requirement.

¹⁰ Anuradhapura-Vaunia-Mannar (220kV, 127km); Polpitiya-Pannipitiya (220kV, 70km); Thulhiriya-Kegalle (132kV, 22km); Mannar-Nedukudu (132kv, 32km)

¹¹ Veyangoda-Kirindiwela-Padukka (220kV, 41km); Polpitiya –habarana (123kV, 131km); Polpitiya-Kotmale (220kv, 27km); Veyangoda-Thulhiriya (132kV, 26km); Kirindiwela-Koggala (132kV, 12km)

¹² Feasibility study on Energy Diversification Enhancement of Sri Lanka and Peaking Power Generation Options of Sri Lanka

4 Institutional Strengthening

4.1 CEA, MASL and CEB

During research conducted for this institutional study, the current Director (EIA) of CEA expressed the view that most of the Environmental Management Plans received by CEA are not up to the expected quality. The Director also stated that the staff members of the EIA unit are not properly exposed to the EMP process and therefore do not have the knowledge or experience necessary to guide project proponents and consultants on preparation of good EMPs. To address this deficiency and raise the capacity of others who are in key positions in relation to the review/approval, implementation and supervision of the EMMP for the MHPP, it is proposed to have a training workshop on EMP for relevant members of CEA, PP and PAA. The content would be as follows:

Subject : “Environmental Management and Monitoring Plans”.

Target Group: Staff members of EIA unit of CEA, F&EM Division of MASL and Environment Unit of CEB who are involved in activities related to MHPP.

No of Participants: 20

Duration: 3 days (Including one day of practical work on EMP preparation)

Principal Resources Person: International Environment Specialist of Design/Supervision Consultant

Venue: Kotmale Holiday Resort

Purpose/Objectives of the training workshop:

- Expose participants to the purposes, principles and methods of EMP;
- Improve the level of appreciation and understanding of EMP implementation;
- Provide participants with the capacity and confidence to support the design and implementation of EMP;
- Enable participants to conduct training programmes for other organisations and thus allow for improved environmental performance within such organisations; and
- Inform the participants about the Moragolla HPP and its likely environmental impacts and mitigation, to assist them in fulfilling their roles in the project.

4.2 CEB

According to the Head of the Environment Unit of CEB, the training received by the staff of his Unit, in the work areas they are currently engaged in (especially in the field of Environmental Impact

Assessment of generation projects) is rather inadequate, compared to most of the other branches of CEB. For example, the Civil Engineer in the Environment Unit has never participated in a training programme focused on EIA process of projects.

Hence, it is proposed that the staff of the Environment Unit be provided with suitable training in order to improve the quality and accuracy of their outputs to the organisation (CEB) and particularly to the project (MHPP) in the area of environment protection and management.

4.3 PMO, Supervision Consultants and Construction Contractors

The PMO will be led by a director, appointed from the existing CEB senior staff, and he will be supported by a variety of technical and administrative positions as shown in Fig 2 above. Some of the technical staff will be existing CEB employees and others will be consultants, both domestic and international, employed on a contract basis, for the duration of the project, or for shorter fixed terms. The requirements of these positions will be decided in advance and specified in the job descriptions and advertisements. It is likely that all senior technical positions will require a higher degree and several years of relevant experience in similar positions. Senior staff in the Environment Management Office will require higher degrees in environmental management or other relevant specialism, plus previous work experience in preparing and implementing Environmental Management Plans, conducting environmental monitoring surveys, and/or other relevant activities.

The Terms of Reference for the Supervision Consultants will specify the requirements for all key positions, and this will include a Senior Environmental Specialist, plus two or more Environmental Specialists, who together will be responsible for supervising the work of the contractors to ensure they all provide the mitigation that is assigned to them in the project EMMP. Similarly the major Construction Contractors will each be required to provide a Senior Environmental Manager, who will be responsible for the Contractor's environmental performance, and in particular implementing the EMMP requirements. It is likely that the senior environmental specialists of both the Supervision Consultant and the Construction Contractors will also require a higher degree in a relevant subject plus several years of experience of similar work activities, preferably involving hydropower projects.

If these requirements are properly adhered to and staff of the required calibre are appointed, then all should have sufficient expertise and previous experience to be able to adequately fulfil their duties on this project without further extensive training or capacity building exercises. It would however still be advisable for CEB to provide a brief induction programme for all those involved in environmental matters in relation to the MHPP to ensure they are all fully informed of the specific requirements of the MHPP and their individual and collective responsibilities.

The training and induction course should include but not be limited to:

- Overview of Environmental Legislation in Sri Lanka;
- Relevant environmental Standards and Guidelines (water, air, noise etc.);
- National Involuntary Resettlement Policy (NIRP) principles;
- CEB's environmental policy;
- Requirements of the ADB Safeguard Policy Statement (2009);
- An introduction to the Environmental Management and Monitoring Plan of MHPP;
- Environmental responsibilities of all project staff;
- Site- and project-specific requirements such as the afforestation programme, watershed management plan, habitat creation and biodiversity conservation plan, etc;
- Dissemination of extra information as required during the course of the construction works.

5 Complaint Handling and Grievance Redress Mechanism

5.1 Grievance Redress Mechanism

Construction activities of hydropower projects, especially where Involuntary Resettlement is involved, might give rise to grievances among Affected Persons (APs), however much the potential sources of conflict have been addressed in Environmental Management Plans and Resettlement Plans and Policies. Grievances may be related to social issues such as eligibility criteria and entitlements, location of resettlement sites, quality of services at those sites, allocation of houses, livelihoods and social and cultural issues, etc. Grievances may also be related to environmental issues such as dust generated due to clearing and grubbing works, vibration and damages to structures, noise, traffic congestion, decrease in water level and water pollution in private and public wells due to blasting and tunnelling, damage to tea plantations and agricultural lands, etc.

Social grievances occur mostly at the time of implementation of the Resettlement Action Plan; and complaints on environmental issues and public nuisances generally occur during the construction period. Both types of grievances are different in nature. However, it is imperative to have a mechanism in place to examine each and find solutions in a transparent manner, to demonstrate to the people that their grievances are examined carefully. A Grievance Redress Mechanism (GRM) is essential for smooth implementation of the project. The main objective of establishing a GRM is to

resolve problems in an efficient, timely and cost-effective manner in a cordial environment with the participation of all stakeholders including affected parties.

It is preferable to resolve the grievances and disputes at the community level and as and when they occur. Donor agencies are inevitably highly concerned about the grievance redress and dispute resolution mechanisms in the implementation of development projects. The GRM should be able to provide benefits to both the project and affected parties by setting up the following objectives:

- Provide a forum for redressing grievance and disputes at the lowest feasible level;
- To create effective communication between the project and affected parties;
- To build up productive relationships among the stakeholders including affected parties;
- Provide access to allow affected parties to negotiate and influence the decisions and policies of the project which might adversely affect them;
- Mitigate or prevent adverse impacts of the project on the environment and produce appropriate corrective or preventive action;
- To harmonize both project and affected parties' activities.

5.2 Complaints Management

All complaints regarding social and environmental issues are usually received either orally or in writing by the Project Proponent (PP) or the Construction Contractor (CC). A key part of the GRM is the requirement for the PP /CC to maintain a registry of complaints received at the respective project site offices. A sample complains registry is given in Annex 1.

All complainants shall be treated respectfully, politely and with sensitivity. Every possible effort should be made by the PP or the CC to resolve the issues referred to in the complaint within their purview. However, there may be certain problems that are more complex and cannot be solved through project-level mechanisms. Such grievances will be referred to the Grievance Redress Committee (GRC, see below). The proposed complaint handling and Grievance Redress Mechanism for the Moragolla project is illustrated in Figure 3.

5.3 Grievance Redress Committee (GRC)

The Moragolla Hydropower Project, in keeping with the ADB and national safeguard policies, will set up a Grievance Redress Committee (GRC), which will function as an independent body to find solutions to grievances and disputes among the affected and concerned parties.

The appointment of the GRC will be notified to the general public by publication of a notice in national newspapers in three languages ie., Sinhala, Tamil and English. The local community will also be informed about the grievance handling procedures of the project through Grama Niladharis¹³ of the area and displaying notices at important public places within the Divisional Secretariat Divisions of Udapalatha and Ganga Ihala Korale.

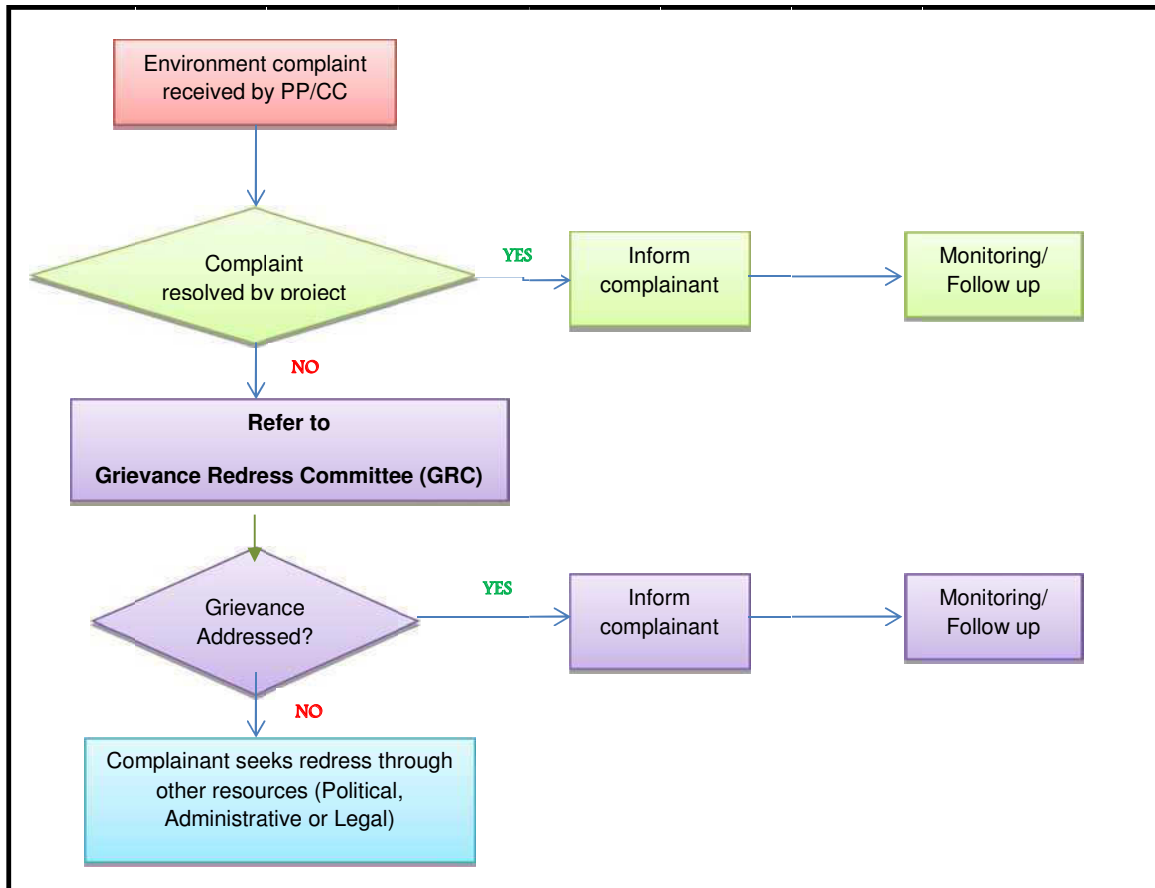


Fig. 3 : Complaint handling and Grievance Redress Mechanism

(PP= Project Proponent (Ceylon Electricity Board); CC= Construction Contractor)

¹³ GramaNiladhari (Village leader) is a Sri Lankan public official appointed by the central government to carry out administrative duties in a GramaNiladhari division, which is a subunit of a divisional secretariat. The duties of a GramaNiladhari include the reporting of issuing of permits, gathering statistics, maintaining the voter registry and keeping the peace by settlement of personal disputes. They are responsible for keeping track of any criminal activity in their area and issuing character certificates on behalf of residents when requested.

5.4 Institutional Arrangements for GRM

The Additional District Secretary of the Kandy District will function as the Chairperson of the GRC. Members to represent the Affected Persons (AP) at the GRC will be appointed from among respected persons¹⁴ in the area on the recommendations of the Divisional Secretaries of Udapalatha and Ganga lhal Korale. Other members of the GRC shall be the Project Director (PD) of the PMO, a senior representative of the Design and Supervision Consultant and representative(s) of the Contractor(s). An officer nominated by the Project Director of the MHPP will serve as the Secretary to the GRC. An honorarium will be paid to the members of the GRC; the required funds for operation of the GRC will be borne by CEB.

A suitable place and other facilities to conduct the meetings of the GRC will be provided by MHPP. However, GRC meetings can also be held at any other suitable location for the convenience of the affected parties (eg. in case of ill health or any other valid reasons).

The GRC is expected to meet at least once a month, although more meetings may be held depending on the number of complaints received. The GRC may make field visits where necessary and these will be facilitated by MHPP.

5.5 Terms of Reference (ToR) of GRC

The GRM will be established by CEB during the pre-construction stage, so that the GRC and grievance redress procedures are in place and functioning before land acquisition, resettlement and project construction activities begin. The following is a draft ToR for the GRC, which CEB will consider and incorporate or amend as necessary:

- The GRC will examine any kind of dispute or grievance arising out of implementation of the Resettlement Plan (RP) and Environmental Management and Monitoring Plan (EMMP) and resolve such disputes and grievances in a transparent manner.
- GRC will not deal with matters that are pending in a court of law.
- The GRC will not have any jurisdiction over the amount of compensation determined by the Chief Government Valuer.
- The decision of the GRC is deemed final, although a dissatisfied complainant may seek redress through the Sri Lankan legal system if they so wish.
- Only authorized members will be allowed to participate in the GRC meetings (including the relevant Affected Persons and their representatives).

¹⁴Such as Senior Citizens; Priest of the Temple, Church or Kovil; Headmaster of school etc.,

- A decision on a particular dispute/grievance will be made unanimously or on a majority vote basis.
- The disputes and grievances will be resolved on the first day of the hearing or within 2 – 4 weeks of the first hearing where the issues may be more complicated and more information is required to arrive at a decision.
- A Hearing of certain disputes or grievances may be postponed and a new date be fixed if more evidence is required to make decisions.
- The decision of the GRC will be intimated to the Project Director and the aggrieved party in writing within a week from the meeting.
- The following general conditions should also apply: Persons who make appeals to the GRC shall attend the meetings of the GRC in person. In a case where the appellant is unable to attend the meeting on the appointed date due to sickness or other unavoidable circumstances, he/she can nominate a close relative or other representative in writing.
- No legal professionals are allowed to represent an appellant.
- Appellants may request an alternative date to attend at a particular meeting of the GRC if they are physically unfit to attend the meeting or due to other unavoidable circumstances.

Annex 1: Sample Complaints Registry

COMPLAINTS REGISTRY

Moragolla Hydropower Project

[illegible]

**SURVEY OF RIVER WATER QUALITY IN THE MORAGOLLA
PROJECT AREA IN THE MONSOON SEASON
FOR REVIEW OF FEASIBILITY STUDY AND PREPARATION
OF DETAILED DESIGN AND BIDDING DOCUMENTS
MORAGOLLA HYDROPOWER PROJECT, SRI LANKA**

Final Report

**Prepared by
National Building Research Organization**

**Prepared for
NIPPON KOEI Co Ltd - Moragolla Hydropower Project**

September 2013



**National Building Research Organization
Ministry of Disaster Management
99/1, Jawatte Road, Colombo 05, Sri Lanka**



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Executive Summary

Introduction

The Ceylon Electricity Board (CEB) plans to develop a new 30.0 MW hydropower project at Moragolla in Kandy District. The project components are: 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weliganga, 38.5 ha (1.98 MCM) reservoir with a Full Supply Level (FSL) at 548 m, a 3.1 km underground tunnel, surge shaft and penstock on the left bank of the river, and the powerhouse and the tail race outfall opposite the confluence with the Atabage Oya.

Nippon Koei Co. Ltd., the consultant appointed by CEB for the project assigned the National Building Research Organization (NBRO) to conduct an additional survey of river water quality in the project area in the monsoon season with the intension of investigating the differences in water quality between stations and between dry and wet seasons and to determine the reasons for all significant changes.

Monitoring river water quality

Water samples were collected from the Mahaweli Ganga at four stations numbered as L1 (Kotamale Oya), L2 Mahaweli Ganga (near Pattunupitiya school), L5 (about 300 m upstream from the proposed dam location) and L9 (downstream from the confluence of Mahaweli Ganga and Atabage Oya). The pH, Temperature, Dissolved Oxygen and Turbidity, Biochemical Oxygen Demand (BOD₅), Ammonia, Nitrate, Total Phosphorus, Total Suspended Solids, Faecal Coliforms and Total Coliforms were analyzed, and water quality status in monsoon, seasonal variations and compatibility with proposed national standards; “Ambient Water Quality – EA1P-DHV-2000” are reported.

Results and discussion

The water quality in stations L1 and L9 shows a closer resemblance to each other because; these two locations receive discharge water from Kothmale reservoir as environmental flow and tailrace discharge, respectively. Also, water draining from Nawalapitiya area influences the quality at L2 & L5.

Comparison of results with proposed water quality standards recommended for specific uses suggests that water in this part of the Mahaweli Ganga is not suitable for drinking, bathing or irrigation, in any of the seasons especially because of its high turbidity and bacterial content (Total coliforms).

Conclusion

The concentrations of most of the analysed parameters in the Mahaweli Ganga at tested locations are quite high in the wet season in comparison to dry. This evidence pollution from run-off containing fertilizers (Nitrogen and Phosphorus), sediment from erosion and other anthropogenic matter (Faecal coliforms) suggesting that water in this part of the Mahaweli Ganga is not suitable for drinking (after simple or conventional treatment), bathing or irrigation, in any of the seasons when compared with the proposed Ambient Water Quality standards.

The damming will create a permanent barrier against the natural flow discharge. However, the water will retain behind the dam only for a shorter period because this power project is a run on river type hydropower. Similarly, downstream water quality impacts are also considered to be low in the monsoon season because in addition to environmental flow, intermittent spills may also contribute to the river flow of the section between dam and the tailrace outfall enabling adequate dilution to pollutants.

1. Introduction

The Ceylon Electricity Board (CEB) plans to develop a new 30.0 MW hydropower project at Moragolla in Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha (1.98 MCM) reservoir with a Full Supply Level (FSL) at 548 msl. The water from the reservoir will be diverted through a 3.1 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya.

A Feasibility Study (FS) was conducted in 2009, and this included an Environmental Impact Assessment (EIA) which is expected to be approved by the Mahaweli Authority of Sri Lanka (MASL). In 2012, CEB appointed Nippon Koei Co., Ltd (NK) to review the FS, prepare detailed designs and tender documents for project construction and to upgrade the EIA to comply with the Safe Guard Policy of the Asian Development Bank, the principal funding agency (Safeguard Policy Statement, ADB, Manila, 2009).

To upgrade the EIA, additional surveys were conducted in certain key fields in 2013, to supplement existing baseline conditions and to update the assessment of environmental impacts.

In addition to above studies, a survey of river water quality in the Mahaweli River at proposed Moragolla Hydropower Project area has been proposed in the monsoon season (September). The Nippon Koei Co. Ltd, Moragolla Hydropower Project appointed National Building Research Organisation (NBRO) to conduct this survey. This report presents the river water quality in the Mahaweli River at the Proposed Project area in the monsoon season (September).

This report presents the study conducted for river water quality as described in the Terms of Reference (ToR), shown in **Annex 1**, and includes following aspects:

- Differences in water quality between stations during the Monsoon season
- Differences between dry and wet seasons, and reasons for all significant changes
- Differences in Dry (March), with the first onset of rains (May) and Monsoon (September) surveys

2. Rationale

A survey of water quality in the Mahaweli Ganga was conducted by the National Building Research Organisation (NBRO) in March and May 2013. The period includes dry season and the end of the period. The river water quality data collected in this period does not reflect the condition in the monsoon season.

The objective of this additional survey is therefore to investigate water quality in the river during the monsoon and examine the seasonal differences by comparing results with the earlier surveys.

3. Approach

The ToR required collecting duplicate water samples from the Mahaweli Ganga at four stations numbered as L1, L2, L5 and L9 same stations as the previous survey¹ (refer location map, Fig.1) and water should be analyzed for total of ten water quality parameters, namely, pH, Temperature, Turbidity, Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD₅), Ammonia, Nitrate, Total Phosphorus (TP), Total Coliforms (TC) and Faecal Coliforms (FC). The Dissolved Oxygen content was also analysed in this survey because this determinand is a main parameter in previous surveys; March and May.

3.1 Sample collection, transportation and preservation

Samples were collected on 17.09.2013 during Monsoon period between 09.00 am and 11.45 am by the NBRO staff (**Annex 2**). Description of sampling locations and GPS references are given in **Annex 3**. Photographs taken during sampling are given in Fig.2.

Sample collection, preservation, transportation and analysis for physicochemical parameters were carried out according to the Standard Methods². The bacteriology (Faecal Coliforms and Total Coliforms) sampling and analysis were done according to the Specification for Potable Water³. Different devices were used in sampling depending on the method requirement. Accordingly, samples for general water quality parameters were collected by flinging a clean plastic bucket, tied to a rope, to the flowing water stream. Bottles having a ground-glass stopper and flared mouth were used for the collection of water samples for the determination of Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) whilst pre sterilized bottles were used for the collection of samples for bacteriological analysis. Duplicate water samples were collected from each location within 10 minutes from the collection of first sample. Accordingly, the sampling program covered collection of 8 samples from 04 locations.

The water samples collected for water quality parameters except for DO, BOD and bacteriological analysis were transferred securely into clean plastic screw-top containers, and those collected for Dissolved Oxygen were fixed at site by adding MnSO₄ and alkali-iodize - azide reagents. All samples were labelled with location No, date and specific parameter to be analysed. Carefully packed samples in separate cooler boxes with ice were then transported to the NBRO laboratory, Colombo on the same day. A temperature of 4 -10⁰ C was maintained during transportation. In the laboratory, the samples were stored at 4⁰ C until analysis was performed.

3.2. Analysis of samples for water quality parameters

The pH, Temperature and Turbidity were measured at site using calibrated meters. The analysis was commenced on the following day of the sampling event and continued for 05 days.

Annex 4 presents the methodology followed in sampling and analysis.

Fig.3 shows the photographs taken during the sample analysis in the laboratory.

¹ Final Report: Water quality in the Mahaweli Ganga- upstream and downstream of the proposed dam at Moragolla (NBRO, 2013)

² Standard Methods for the Examination of Water and Wastewater, American Public Health Association, AWWA, WEF, 20th Edition, 1998.

³ Specification for potable water, Bacteriological requirement, Sri Lanka Standards, 614:1983, Part 2

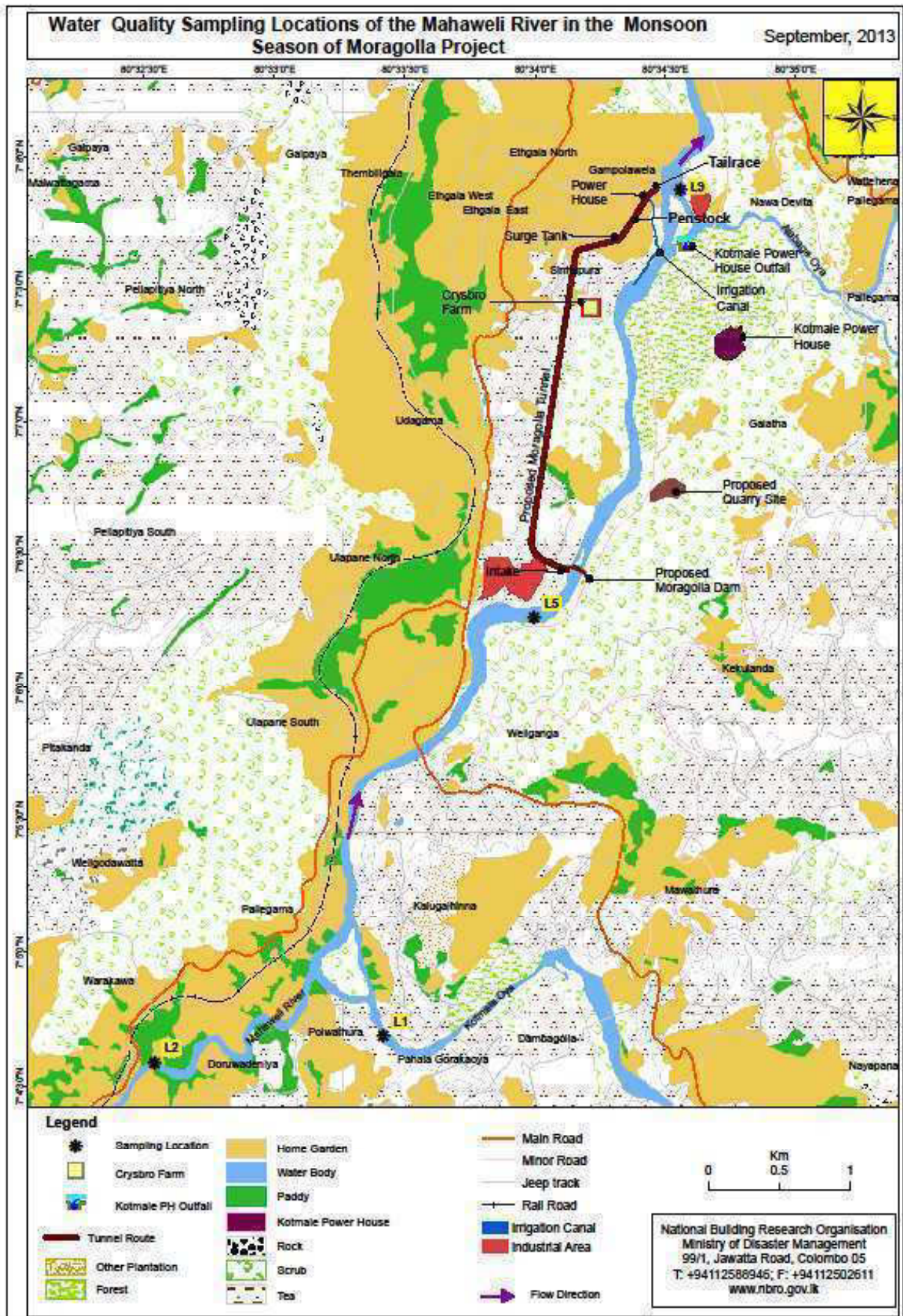


Fig 1. Map of survey area and sampling locations





	
<p>Sampling Location L1- Kothmale Oya</p>	<p>Sampling Location- L2 Mahaweli Ganaga near Pattunupitiya school</p>
	
<p>Sampling Location L5- Mahaweli river 300m upstream from the proposed dam location</p>	<p>Sampling Location L9- Mahaweli Ganga after the confluence of Atabage Oya</p>

Fig.2 Photographs taken during sampling



Fig.3. Photographs taken during laboratory analysis

4. Results and Discussion

The **Table 1** and **Annex 5** presents the results of river water quality analysis and the data are shown graphically in **Fig.4**.

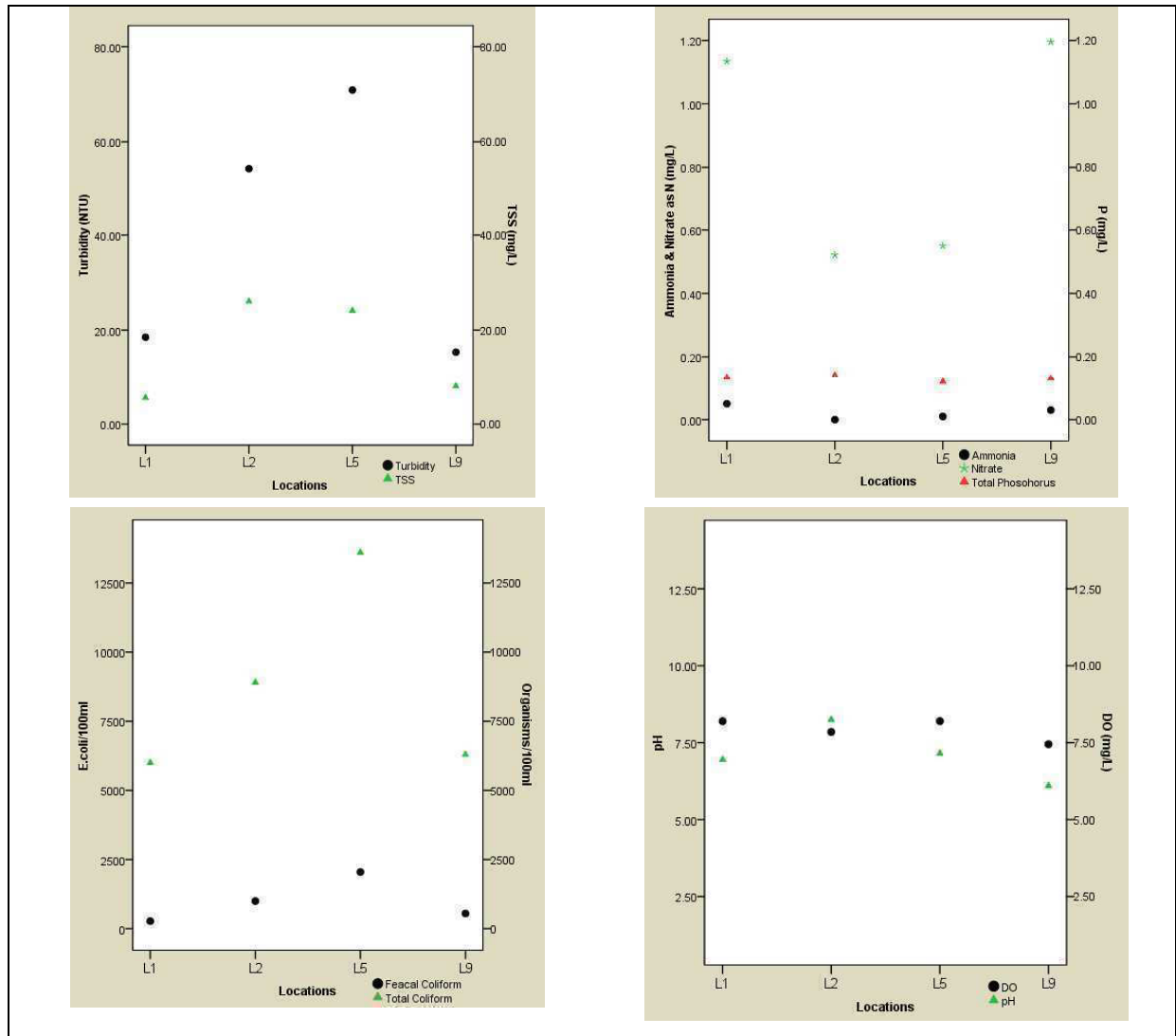


Fig 4. Variations in water quality between stations
(Values are the average of two duplicate samples)

Table 1. Results of water quality in Dry (March), First onset of rains (May) and Monsoon (September) surveys

Category No.	Location	pH	Temperature °C	Turbidity NTU	DO mg/L	BOD ₅ mg/L	Ammonia (as N) mg/L	Nitrate (as N) mg/L	TP (as P) mg/L	TSS (mg/L)	FC E.coli/100ml)	TC (Coliform Organisms/ 100ml)
Monsoon (September) Survey												
	L1	6.95	20.8	18.5	8.2	1.0	0.05	1.134	0.134	5.5	274	6000
	L2	8.25	20.5	54.3	7.8	1.4	0	0.521	0.142	26.1	1000	8900
	L5	7.15	20.3	70.9	8.2	<1	0.01	0.55	0.120	24.1	2050	13600
	L9	6.10	19.3	15.3	7.5	1.2	0.03	1.195	0.131	8.0	550	6300
Dry (March) Survey												
	L1	7.05	27.2	4.0	14.4	<1	0	0.2875	0.097	2.4	200	1000
	L2	7.10	25.3	20.6	6.9	<1	0.03	0.33	0.040	12.7	850	11700
	L5	7.30	26.0	33.9	7.2	<1	0.04	0.326	0.039	15.9	900	14100
	L9	7.0	25.1	3.7	7.4	<1	0.03	0.27	0.106	2.7	540	9000
First onset of rains (May) Survey												
	L1	6.6	21.8	14.4	8.2	1	0.14	0.803	0.084	4.8	158	5550
	L2	7.1	23.7	25.8	7.4	<1	0.37	0.6365	0.020	32.2	1200	205000
	L5	6.5	21.5	30.5	8.2	1.3	0.17	0.463	0.106	32.7	5000	110000
	L9	6.95	21.5	118.5	6.1	<1	0.16	0.4105	0.138	58.5	350	105000
Ambient Water Quality – EA IP-DHV-2000												
2- Drinking water – Simple Treatment	Simple	6.0-8.5	-	5 (max)	6 (min)	3 (max)	-	5 (max)	0.23 (0.7 as PO ₄) max	-	600 (max)	5000
3-Bathing		6.0-9.0	-	-	5 (min)	4 (max)	-	5 (max)	0.23(0.7 as PO ₄) max	-	50	1000
4-Fish & Aquatic life		6.0-8.5	-	-	3 (min)	4 (max)	0.94 (max) (pH < 7.5)	5(max)	0.23(0.7 as PO ₄) max	-	-	20000
5-Drinking water – Conventional Treatment		6.0-9.0	-	-	4 (min)	5 (max)	-	5 (max)	0.23 (0.7 as PO ₄) max	-	-	5000
6- Irrigation & Agriculture		6.0-8.5		-	3 (min)	5 (max)	-	5 (max)	0.23(0.7 as PO ₄) max	-	-	1000

Non compliance with Category 2

Values are the average of 2 duplicate samples

4.1 Differences in water quality between stations during the Monsoon season

The pH, Temperature, DO, BOD, TP and Ammonia at 4 stations do not show noticeable differences among each other in the season. However, differences are observed in turbidity, TSS and Nitrates. The measured turbidity values are very high at L2 & L5; Avg. 70.9 NTU and 54.35 NTU respectively, and much low values at L1 and L9 (Avg. 18.5 and 15.35 NTU). Values for TSS also showed a similar pattern in which measured TSS at L2 and L5 are as high as 26.05 and 24.1 mg/l, but that is low at L1 & L9 (5.05 and 8.05 mg/l respectively).

The Nitrates show an opposite distribution where the average nitrate levels at L1 and L9 are as high as 1.13 mg/l and 1.19 mg/l, but the levels are low at L2 and L5, 0.52 mg/l and 0.55 mg/l respectively. In this survey, one set of data was collected to represent seasons. Actual cause for increased nitrates at L1 and L9 cannot be explained with this.

However, it appears that the water quality in Kotmale has played a significant role in the water quality of L1 and L9. During the monsoon season reservoir undergo turnover and mixing and as a result bottom nutrients may come to upper layers where nitrogenous compounds decompose resulting conversion to Nitrates (NO_3 ; the ultimate stable form of N). Therefore, there is a possibility that nitrogen levels could be high in the environmental flow and tailrace discharge of Kotmale reservoir.

The measured values of faecal indicator bacteria at L1 and L9 are almost closer to each other and similarly at L2 and L5.

These results indicate that the water quality in stations L1 and L9 shows closer resemblance to each other. The reason for this could be the influence of Kothmale reservoir on the river water quality, because; these two locations receive discharge water from Kothmale reservoir as environmental flow and tailrace discharge, respectively. At the time of sampling, flow in L9 may presumably be dominated by the Kotmale tailrace discharge; but flow data are required to conclude this.

Similarly, the levels of determinands at stations L2 and L5 resemble each other especially in TSS, Nitrates, TP, and faecal coliform content. The water quality at two stations (L2 and L5) is dominated by water draining from Nawalapitiya area.

4.2 Suitability of water for different uses

The proposed Standard; “Ambient Water Quality – EA1P-DHV-2000” was used to indicate suitability water in the river reach for different uses. The proposed standard specifies seven user categories:

- Category 1 - Nature conservation
- Category 2 - Drinking water with simple treatment
- Category 3 - Bathing
- Category 4 - Fish and aquatic life
- Category 5 - Drinking water with conventional treatment
- Category 6 - Irrigation and agriculture
- Category 7 - Minimum Quality

These comparisons suggest that pH, DO, BOD, Nitrate and Total Phosphorus levels at 4 locations meets requirements for all six uses (Categories 2-7), and in addition, faecal coliform levels at L1 and L9 conform with Category 2 water use (drinking water after simple treatment) But, other parameters, turbidity and total coliforms, exceed the Category 2 limit.

Also, the results show that during the monsoon season, water at all locations do not satisfy the quality requirement for Category 3 (bathing) or use in irrigation (Category 6) because the faecal and total coliform counts exceed the limits. Further, at all locations, the water is not suitable for drinking after conventional treatment (Category 5) because values for total coliforms exceeded the respective limit.

The damming will create a permanent barrier against the natural flow discharge. However, the water will retain behind the dam only for a shorter period because this power project is a run on river type hydropower. Nevertheless, sediment may enter and accumulate behind the dam during the wet season as a result of rain triggered soil erosion, but the quantities may not be significant because of shorter retention time in the rainy season. Therefore, in this season, the possible occurrence of reservoir eutrophication is unlikely. Similarly, downstream water quality impacts are also considered to be low in the monsoon season because in addition to environmental flow, intermittent spills may also contribute to the river flow of the section between dam and the tailrace outfall enabling adequate dilution to pollutants.

4.3. Differences between dry and wet season

A graphical presentation of the water quality in dry (March) and wet season (September) is presented in the Fig. 5.

This figure shows that at most stations the concentration of most of the analysed parameters are high in the wet season, in comparison dry season. Accordingly, the values of Dissolved oxygen are generally higher under high flow conditions because of increased atmospheric exchange caused by high surface turbulence. The suspended solids, plant nutrients (nitrate and phosphate) and other contaminants such as ammonia and faecal bacteria are also high in the wet season, most likely because of runoff of erosion prone land contaminated with fertilizers and other matter of anthropogenic origin.

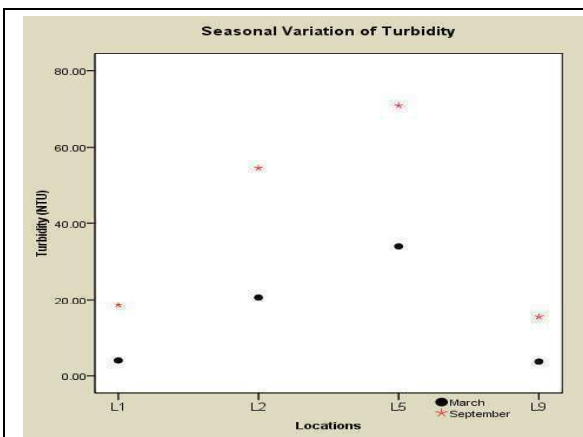


Fig 5.1 Variations of Turbidity

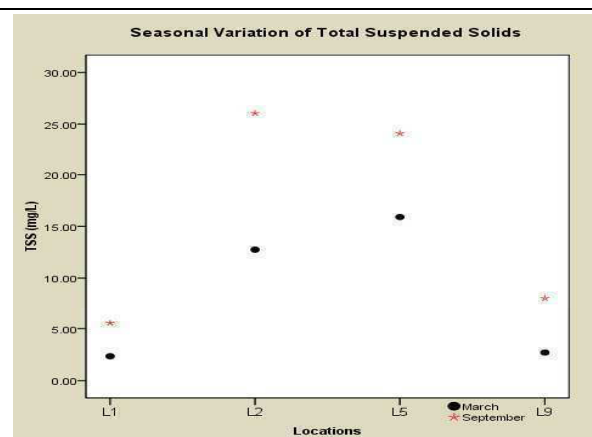


Fig 5.2 Variations of Total Suspended Solids

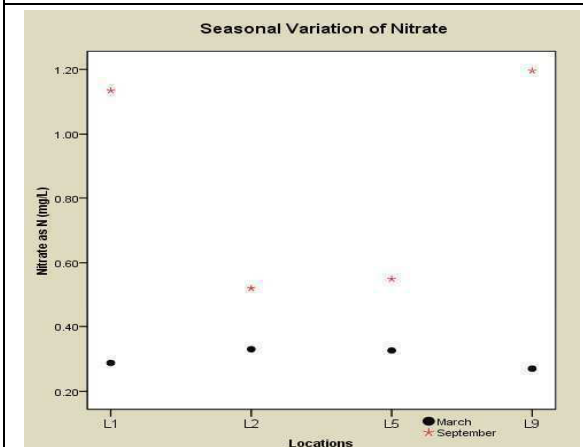


Fig 5.3 Variations of Nitrate

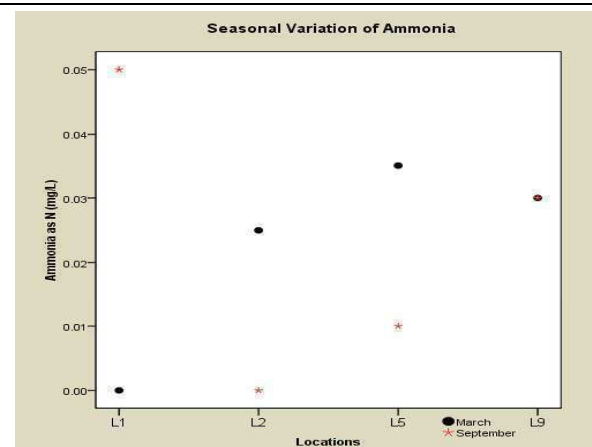


Fig 5.4 Variations of Ammonia

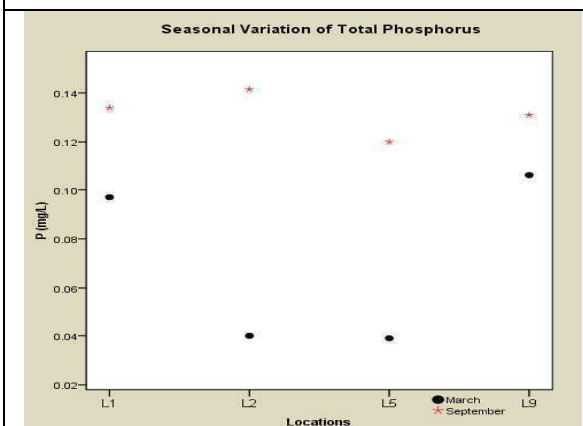


Fig 5.5 Variations of Total Phosphorus

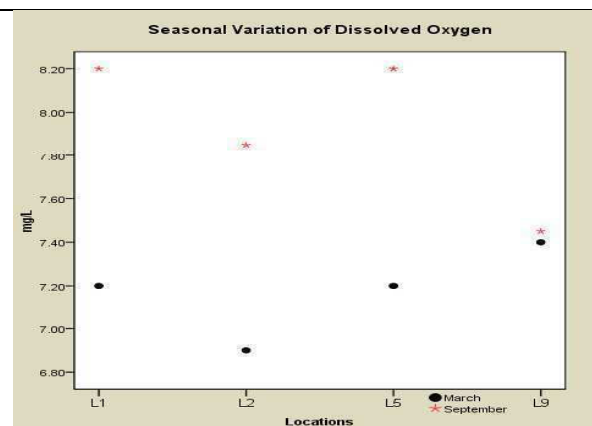


Fig 5.6 Variations of Dissolved Oxygen

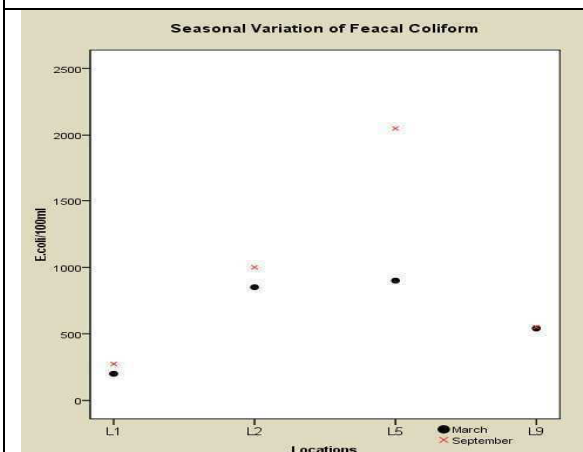


Fig. 5.7 Variations of Faecal Coliforms

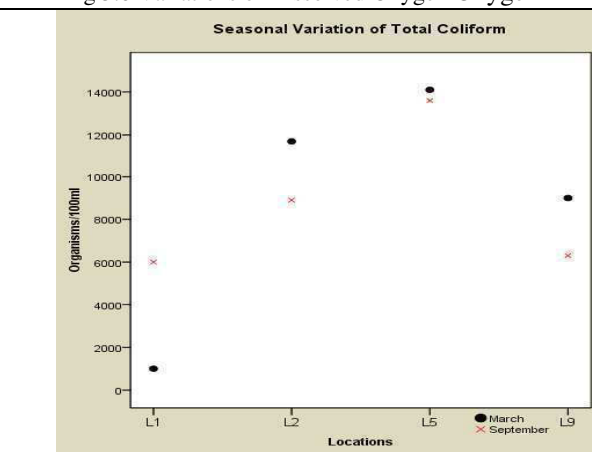


Fig 5.8 Variations of Total Coliforms

Fig 5 Variations in water quality (Dry and wet seasons) Values are the average of two duplicate samples

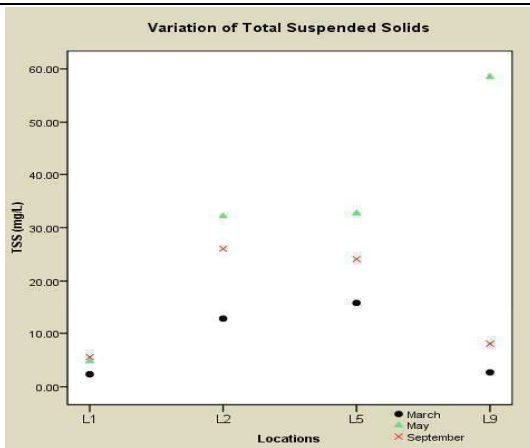


Fig 6.1 Variations of Total Suspended Solids

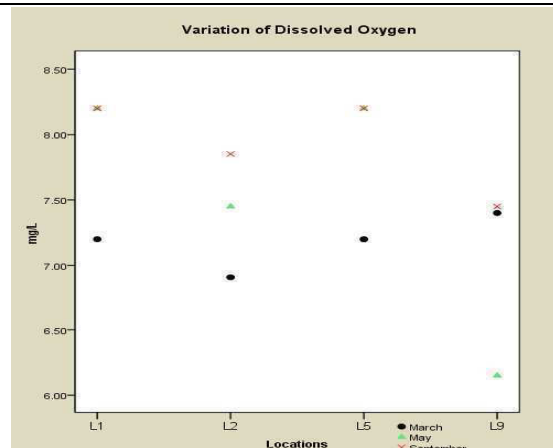


Fig 6.2 Variations of Turbidity

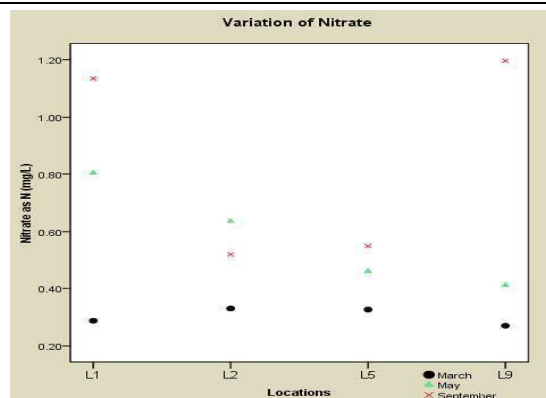


Fig 6.3 Variations of Nitrate

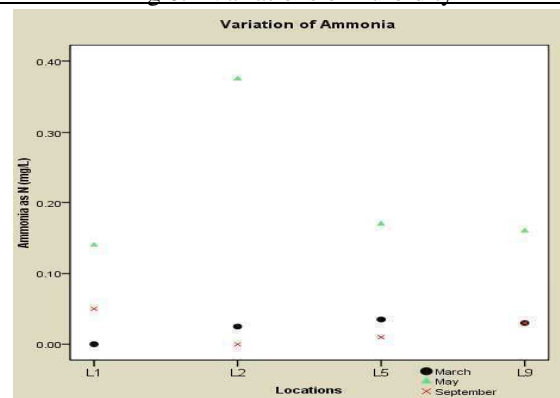


Fig 6.4 Variations of Ammonia

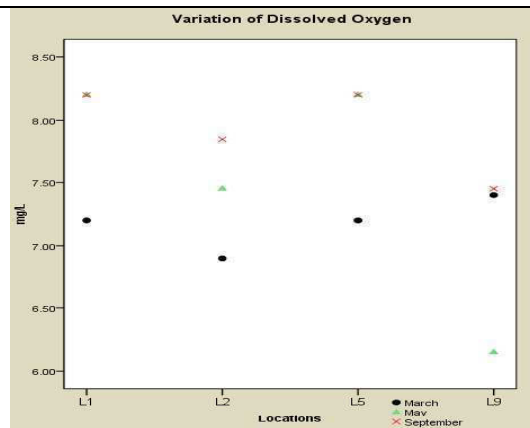


Fig 6.5 Variations of Dissolved Oxygen

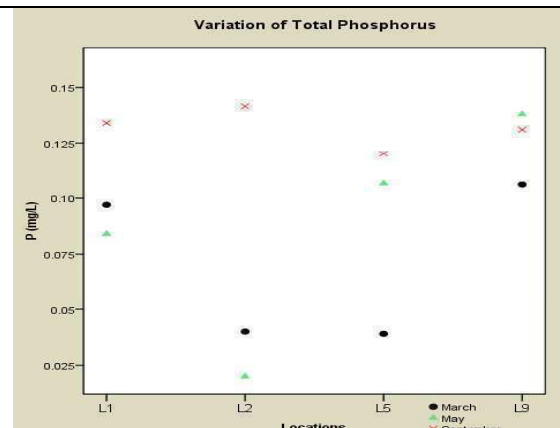
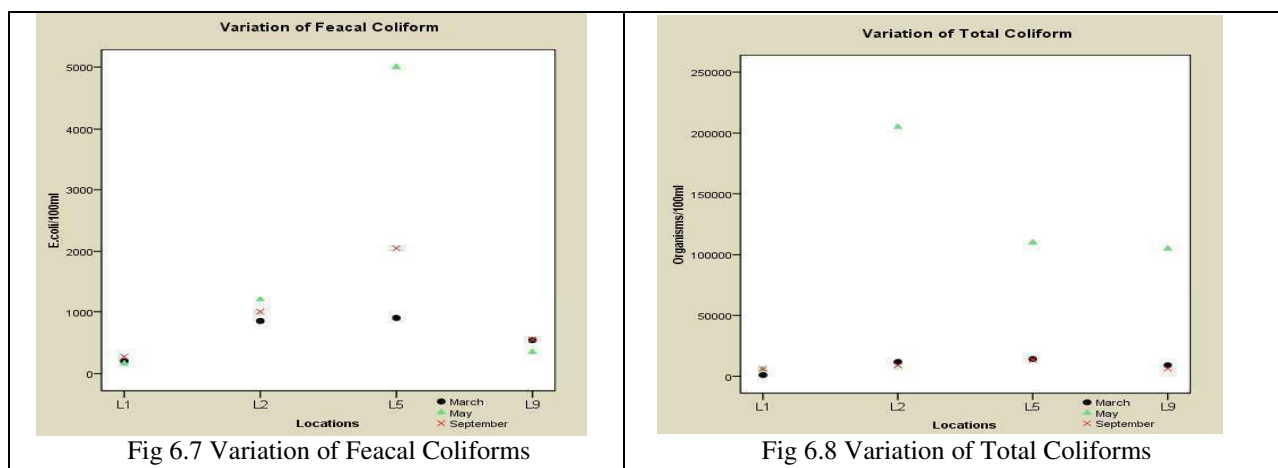


Fig 6.6 Variations of Total Phosphorus



4.4 Differences in Dry (March), with the first onset of rains (May) and Monsoon (September) surveys

The results of water quality in the Mahaweli Ganga at stations L1, L2 L5 and L9 in all three surveys; March, May and September are tabulated in Table 1. and are graphically presented in Fig. 6. These graphs and the discussion in Sections 4.1-4.3 show that there is a temporal and seasonal variation in river water quality.

The concentration of water quality determinands appear to be influenced by the increased runoff of the first onset of rainfall (May) and with the monsoon rains (September). The higher suspended load in the initial onset of rains is seen in the river water quality in May, but the levels tend to lower due to dilution during monsoon period (September). This pattern is shown in the results of ammonia at all four stations and the bacterial counts; Total coliforms at stations L2, L5 and L9. The Total coliform bacteria inhabit in natural environment, mostly associated with soils and plant debris. In the event of first onset of rainfall in May, runoff draining the land enters into the river and soil inhabiting TC may also be carried with the rains resulting very high numbers at the survey in May. Higher values of TC have been reported at L2 and L5 (water draining from Nawalapitiya area) and L9 (draining from Atabage Oya catchment). But at L1, the value is lower because Kotamala reservoir acts as a buffer and under decay results lower TC values in the environmental flow discharge.

TSS values at all locations except L1 show increase with the onset of rains and decrease in the monsoon season. Turbidity values increase at stations; L1, L2, L9 in May with the onset of rains, however, the value decrease only in L9 with first onset of rains and increase further at stations L1 and L2 with the monsoon rains. The station L5 shows different pattern in turbidity level with rains.

Nitrogen and Phosphorus levels are considered, the values of Nitrates tend to increase with the onset of rains at all locations. This is due to run-off contaminated with fertilizers of Nitrogen origin. But only at the location L2 decrease during monsoon while at other locations are in the increasing trend. The levels of phosphorus are considered, stations L5 and L9 show increase with the rains however, L1 and L2 show different results.

Comparison of results with proposed water quality standards recommended for specific uses suggests that water in this part of the Mahaweli Ganga is not suitable for drinking (after simple or conventional treatment), bathing or irrigation, in any of the seasons especially because of its high turbidity and bacterial content (Total coliforms).
 Fig 6. Variation in water quality (March, May and September surveys)
 Values are the average of two duplicate samples

5. Conclusion

In conclusion, it can be stated that at all stations the concentration of most of the analysed parameters are quite high in the wet season, in comparison to dry. This evidence pollution from run-off containing fertilizers (Nitrogen and Phosphorus), sediment from erosion and other anthropogenic matter (Faecal coliforms). This may be due to land use pattern in the Mahaweli catchment which dominated with tea cultivations, agriculture among the other.

The damming will create a permanent barrier against the natural flow discharge. However, the water will retain behind the dam only for a shorter period because this power project is a run on river type hydropower. In this season, the possible occurrence of reservoir eutrophication is unlikely. Similarly, downstream water quality impacts are also considered to be low in the monsoon season because in addition to environmental flow, intermittent spills may also contribute to the river flow of the section between dam and the tailrace outfall enabling adequate dilution to pollutants.

Annexure

Annex 1 _____

Terms of Reference (ToR)

**TERMS OF REFERENCE FOR ADDITIONAL STUDIES IN THE NATURAL
ENVIRONMENT**

MORAGOLLA HYDROPOWER PROJECT

**REVIEW OF FEASIBILITY STUDY AND PREPARATION OF DETAILED DESIGN &
BIDDING DOCUMENTS**

**SURVEY OF RIVER WATER QUALITY IN THE MORAGOLLA PROJECT AREA IN
THE MONSOON
SEASON**

1. BACKGROUND

The Ceylon Electricity Board (CEB) plans to develop a new 30.0 MW hydropower project at Moragolla in Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with a 5 gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha, 1.98 MCM reservoir with a full supply level (FSL) at 548 m asl. Water will be diverted through a 3km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya

A feasibility study (FS) for the project was conducted in 2009, and this included an Environmental Impact Assessment (EIA)^I which is expected to be approved by the Mahaweli Authority of Sri Lanka (MASL) in the near future. In 2012 CEB appointed Nippon Koei Co., Ltd (NK) to review the FS and prepare detailed designs and tender documents for project construction; and to upgrade the EIA to comply with the Safeguard Policy^{II} of the Asian Development Bank, the principal funding agency.

To upgrade the EIA, surveys were conducted in certain key fields in 2013, to supplement existing baseline data and update the assessment of impacts. Some further study is now needed, so that mitigation measures can be properly planned and designed.

2. RATIONALE

A survey of water quality in the Mahaweli Ganga in the vicinity of the project area was conducted by the National Building Research Organisation (NBRO) in May-July 2013. The aim of this work was to: a) investigate the present quality of water in the river; b) determine the nature, extent and likely sources of any pollution; and c) predict the quality of water impounded in the Moragolla reservoir, and discharged downstream when the scheme is operating.

The period in which the study was conducted only allowed sampling in March and May 2013, so the data did not properly examine conditions in the monsoon season. An additional small-scale survey is therefore required in order to correct this anomaly. The objective of this survey is to investigate water quality in the river during the monsoon and examine seasonal differences by comparison with the results of the earlier surveys, and discuss the reasons for any significant water quality changes.

3. SCOPE OF WORK

1. This work will be conducted by a nationally – recognised environmental consultancy company, with 10 years or more of professional experience in environmental survey, analysis, data interpretation and report preparation, including extensive experience of water quality surveys in rivers.
2. The field surveys will be planned and led by a senior water quality expert with at least 10 years of practical experience in planning and interpretation of river water quality surveys and data analysis.

^I Ceylon Electricity Board (2012): *Moragolla Hydropower Project, Feasibility Study*. Final Report: Volume 3 Environmental Impact Assessment (Central Engineering Consultancy Bureau)

^{II} Asian Development Bank (2009) Safeguard Policy Statement. ADB, Manila, 90pp.
(<http://www.adb.org/site/safeguards/policy-statement>).

- 3 The contractor shall collect duplicate water samples from the Mahaweli Ganga at four stations only. Stations are numbered L1, L2, L5 and L9 and the locations are shown on Fig 1 (Page 3) of the NBRO water quality report
- 4 Water samples shall be collected in August 2013, and all samples shall be collected on the same day, between 08.00 and 13.00 hours. Samples should be collected in rapidly flowing water, as far from the bank as feasible, and the same collection technique shall be used at each station.
- 5 Samples shall be transported promptly to a suitable Government-accredited laboratory, under controlled temperature conditions that are appropriate for the tests to be conducted. All analyses shall be performed on the same day as sample collection, or at the latest on the following day.
- 6 Laboratory analyses must be performed by a laboratory that is fully accredited by the Government to perform the analyses specified in this study and a copy of the relevant accreditation certificates shall be included in the report appendix.
- 7 Temperature, turbidity and pH should be measured on site using suitable, accurately calibrated meters. In the laboratory the duplicate water samples shall be analysed for total suspended solids, BOD₅, nitrate, ammonia, total phosphorus, total coliforms and faecal coliforms using standard analytical procedures.
- 8 The results of the analyses shall be presented and discussed in a report, which shall be set out as shown in Box 1 below. The text should be divided into each of the main sections indicated (Executive Summary, Introduction, etc) and each section should be further subdivided as necessary. The text in each section should cover at least the topics shown in the annotations, plus any other topics necessary to provide an informed discussion of the issues.
- 9 The report should be written in the style of an academic paper and should be concise and informative and written in grammatically correct, good quality English.
- 10 The report will be read by professional persons who are not experts in water quality, so any technical terms must be explained in footnotes or a glossary.

4 PROGRAMME

The works shall be commenced immediately after signing the Contract Agreement. The draft report shall be submitted to NK within one month from the date of signing the Contract Agreement: 3 hard copies and 1 soft copy (in a single MS Word file). NK will review the report and provide their comments, which the expert shall address in full within two weeks of receipt. The expert shall then submit the final version of the report: 3 hard copies and 1 soft copy (in a single MS Word file).

Box 1 : Lay out and content of Report on Water Quality of the Mahaweli River in the Moragolla Project area during the monsoon season

The project; reasons for this study; aims and objectives	
EXECUTIVE SUMMARY	Concise summary of the report, key findings and recommendations
INTRODUCTION	The project; reasons for this study; aims and objectives
APPROACH	How this work was done. Full written descriptions of: sample collection; sample storage and transportation; field analyses; laboratory analyses. With a map of the sampling stations and photographs of work being conducted on site and in the laboratory.
RESULTS & DISCUSSION	<p>A detailed discussion of the results, in particular examining; a) differences between stations during this survey; and b) differences between dry and wet seasons (shown by comparisons with the data collected by the previous survey).Reasons for all significant differences should be discussed, and wet season water quality should be assessed by reference to appropriate standards.</p> <p>Data should be presented in tables and graphical form, in the same way as the previous survey, and the data from all three survey periods should be shown on the same graphs to assist in the discussion.</p>
CONCLUSION	Overall conclusions regarding: water quality in the project area during the monsoon season; the main differences from the dry season, and the reasons for those differences.
APPENDICES	<p>1 TOR; tables of data collected by this survey; details of all analytical methods and laboratory quality control procedures; certificates showing that the laboratory is accredited by the government for performing the analyses involved in this study</p>

Annex 2

Study team

Study team

Key staff

Name	Designation
Ms S V Dias	Senior Scientist
	Water Quality Specialist
Ms S A M S Dissanayake	Senior Scientist
Mr Vimukthi Sumanasekara	Scientist
Ms H.T.J. Seneviratne	Scientist

Laboratory analysis team

Name	Designation
Ms P D C Pathiraja	Technical Assistant
Ms P H D Silva	Technical Assistant

Support staff

Name	Designation
Mr N Krishnamoorthi	Field Assistant
Mr A Premaratne	Field Assistant
Mr Chamath Vithanage	Laboratory Attendant

Annex 3_____

GPS reference of sampling locations and descriptions

GPS reference of sampling locations and descriptions

Sample location reference	GPS reference	Description of location
L1- Kothmale Oya	80° 55' 65.84" 7° 07' 78.92"	<p>The sample location is at Kothmale Oya about 1km upstream from the confluence of the Mahaweli and the Kothmale Oya. The river section is relatively high gradient rocky terrain having exposed bed rock out crops. In this section water flows through a cascade of pools separated with short drops. In pools there was very little surface turbulence and at drops the flow was highly turbulent. In this section isolated water pools filled during high flow conditions were also present. These were cut-off from the main river stream due to reduced flow conditions. The water appeared colourless and clear. Aquatic organisms were observed on the water surface of pools. Both river banks were consisting of exposed bed rock out crops and disturbed riparian vegetation. At right hand side isolated plots of tea cultivations were observed in addition to trees and shrubs.</p> <p>There were rains during sampling.</p>
L2 - Mahaweli Ganga – closes to 13/6 culvert of the Ulapane – Nawalpitiya Road	80° 54' 19.18" 7° 07' 65.34"	<p>Sample was collected from the Mahaweli Ganga near Pattunupitiya school. There were home gardens and isolated small tea plots present on the right hand side. On the Left bank, the riparian vegetation was dominated with a thick strip of Bamboo trees. Sand mining sites were located from 50 m upstream from the sampling location.</p> <p>The water was more turbid and muddy in colour and high in velocity.</p> <p>There were rains during sampling.</p>
L5-Mahaweli Ganga – at bathing point and sand mining point	80° 56' 62.02" 7° 10' 41.82"	<p>The sampling location is about 300m upstream from the proposed dam location. The area is used for sand mining. Sand mining activities were observed during sampling. The water was turbid and muddy in colour.</p> <p>The disturbed riparian vegetation consisted of shrubs and herbs; dominated with grasses. Ulapane Industrial zone was visible over the left bank of river.</p> <p>There were rains during sampling.</p>
L9 - Mahaweli Ganga- near the confluence of Mahaweli Ganga and Atabage Oya	80° 57' 66.60" 7° 13' 09.12"	<p>The sampling location is about 50 m downstream from the confluence of Mahaweli Ganga (right arm stream) and Atabage Oya. The “Maga Neguma” Metal Crusher is located about 10 m upstream from the sampling point. Kothmale HPP tailrace outfall is located upstream to this location. During the sampling event it was observed the tailrace released high flow of water with high turbulence and muddy colour. The stream bottom substrate consists of large to moderate size boulders. Left hand side of the riparian vegetation consist of shrubs and herbs, dominated with grasses. Right hand side is consisted of shrubs and stream bank dominated with Bamboo trees.</p>

Annex 4

Analytical Methods and Quality Control procedures

1. Analytical Methods

Parameter	Method Reference	Description of the Method
pH	APHA 4500 H-B Electrometric method	pH and Temperature were measured using <i>pH meter, brand ; pH 5+ pH^oC of EUTECH Instrument Singapore origin</i> . The meter was first calibrated using NIST pH 4.01 and pH 6.86 buffer solutions (NIST; National Institute of Standard Technology). The pH and Temperature of water samples were taken after calibration by immersing electrode and the probe
Temperature	APHA 2550 B Electrometric method	
Turbidity	APHA - 2130 B Nephelometric method	<p>Turbidity was measured using Turbidity meter: <i>TN-100/T-100 Portable Turbidity meter EUTECH instruments Singapore origin</i>. The meter follows the ISO 7027 standard.</p> <p>Turbidity meter was first calibrated using series of Environmental Protection Agency (EPA) approved standards (CAL 1:800, CAL 2:100, CAL 3: 20, CAL 4: 0.02).</p> <p>The 800 NTU vial was inserted into the sample well, aligning the mark on the vial with mark on the meter. Vial was pressed down until it snaps fully into the instrument and then covered using the light shield cap.</p> <p>Meter was switched “ON” and calibration function Calibration was repeated for CAL 2, CAL 3 & CAL 4 calibration standards. The vial was then rinsed and then filled with the sample water. The capped vial was then placed inside the sample well and aligned the vial’s index mark with the meter’s index mark. The meter was set “ON” and the reading appeared in the display was taken as the measurement.</p>
Dissolved Oxygen	APHA-4500-O-C Azide modification	<p>Water samples were collected in a 300 ml bottles having a ground-glass stopper and a flared mouth without entrapping air bubbles. Dissolved oxygen in the sample was fixed by adding 2 mL of MnSO₄ and 2 mL of alkali-iodize –azide reagents to the bottle at the site. Then the bottle was stoppered carefully to avoid air bubbles and mixed well by inverting the bottle a few times. These bottles were transported to the laboratory at 4 to 10 °C. In the determination of DO, 2.0mL of conc. H₂SO₄ was added to the bottle and mixed well until dissolution of precipitate is completed. A 200 mL portion from this sample was titrated with 0.025M Na₂SO₄ solution to a pale yellow color. Then few drops of starch solution were added and titration was continued to first appearance of blue color.</p> <p>Calculation For titration of 200mL sample,</p> <p>1mL 0.025N Na₂SO₄ = 1mg DO/L</p>

Parameter	Method Reference	Description of the Method
Biochemical Oxygen Demand	APHA 5210-B 5-Day BOD test	<p>Water samples were collected in a 300 ml bottles having a ground-glass stopper and a flared mouth without entrapping air bubbles. To prevent entry of air in to bottles during incubation water was added to the flared mouth of the bottle and then capped with plastic cap. For each measurement two bottles were prepared in the above manner and transported to the laboratory at 4-10°C. Of the two sets, the dissolved oxygen in one set was determined on the following day. This gives the Initial oxygen levels. The bottles in the other set were incubated at 20°C for 5 days. After 5 days the DO was determined similar to first set. This gives remaining oxygen after five days</p> <p>Determination of BOD $\text{BOD mg/l} = \text{Initial dissolved oxygen level in the sample} - \text{Final dissolved oxygen level in the sample}$ (Initial dissolved oxygen is the value measured as dissolved oxygen)</p>
Nitrate	APHA 4500-NO ₂ -B Photometry	10 mL of sample was taken to the sample vial and color was developed by crushing Nitrate test tablet supplied by the manufacturer. The developed color was then measured using Lovibond, Maxi Direct SN 10-1083 photometer made in Germany. The Method used is APHA 4500-NO ₂ -B. The reading appeared on the meter was taken as the measured value
Ammonia	APHA-4500-NH ₃ F	10 mL of sample was taken to a sample vial and color was developed using ammonia No.1 and No.2 tablets supplied by the manufacturer. The developed color was then measured using Lovibond Maxi Direct SN 10-1083 photometer made in Germany. The Method used is APHA-4500-NH ₃ F. The reading appeared on the meter was taken as the measured value.
Total phosphorus	APHA 4500- P-D Stannous Chloride method	<p>In the laboratory 100 mL of sample was digested with 1mL of H₂SO₄ acid and 0.4 g solid (NH₄)₂S₂O₈ until a final volume of 10 mL was reached. The digested sample was then cooled, diluted to 30 mL with distilled water, and neutralized with NaOH. The sample was made up to 100 mL in a volumetric flask with distilled water. Then the color was developed by adding 4.0 mL Ammonium Molybdate reagent I (NH₄Mo₇O₂₄.4H₂O) and 0.5 mL stannous chloride reagent I (SnCl₂.2H₂O). After 10 minutes, colour was measured at 690 nm using UV visible spectrophotometer and compared with a calibration curve prepared using series of standard phosphate solution of KH₂PO₄ and the distilled water blank. In the analysis of dissolved Phosphated the digesion part was omitted.</p> <p>Calculation</p> $\text{mg P/l} = \frac{\text{mg P (in approximately final volume)}}{\text{ml sample}} \times 1000$ <p>The result phosphorus was expressed as P mg/L.</p>

Parameter	Method Reference	Description of the Method
Total Suspended Solids	APHA 2540 D	<p>Glass-fibre filter papers were used in the determination of suspended solids. First, the filter papers were washed with distilled water and dried in an oven at 103°C to 105°C for 1hour. Then the initial measurements were taken to 0.001g accuracy until constant weight is reached.</p> <p>The sample was then stirred with a magnetic stirrer at a speed to shear larger particles, if practical, to obtain a more uniform particle size. While stirring, a measured volume (100ml) was pipetted onto the pre weighed filter paper seated on glass-fibre filter. Vacuum suction was applied to filter the sample. The trapped suspended solids in the filter paper were dried in an oven at 103°C to 105°C for 1hour and cooled in desiccators to balance temperature and then weighed to 0.001g accuracy. This cycle of drying cooling, desiccating and weighing was repeated until a constant weight was obtained.</p> <p>The suspended solids content in the sample was then determined using following calculation.</p> <p>Calculation</p> $\text{Mg Total Suspended Solids/L} = \frac{(\text{A-B}) \times 1000}{\text{Sample volume, mL}}$ <p>Where:</p> <p style="margin-left: 40px;">A = weight of filter + dried residue, mg B = weight of filter, mg</p>
Faecal Coliforms and Total Coliforms	SLS 614: 1983 Part 2 Membrane filtration method	<p>250 ml capacity sterilized glass bottles with attached twin thread were used for the collection of samples for analysis of Faecal and Total Coliforms.</p> <p>In the sampling, first the bottle was lowered to the water by unwinding the cord slowly. The bottle was immersed in the water completely, and once the bottle was judged to be sufficiently filled, the thread was rewound and bottle was brought up. Some water was discarded if the bottle was completely filled.</p> <p>In the laboratory, for the analysis of Faecal Coliforms, 100 ml of sample was filtered through a 0.45 µm grid marked membrane filter paper and the filter was placed in MFC agar and incubated at 44.5 °C for 24 hours.</p> <p>For the Total Coliforms, 100 mL of sample was filtered and filter was placed on M-Endo agar LES (Sigma origin) media and incubated at 36 °C for 24 hours. Colonies which showed a characteristic appearance of blue colour on the filter paper counted as Faecal Coliforms. No confirmation was done to Faecal Coliforms since MFC agar was used as the medium and it is specific for Faecal Coliforms (especially <i>E.coli</i>) as per SLS (1983). In detecting Total Coliform counts, colonies with metallic yellow sheen in M- Endo agar LES medium were sub cultured to phenol red lactose broth and all tubes showing acid and gas production were recorded as confirmed Total Coliforms after incubation of 36 °C for 48 hours.</p> <p>Confirmed Coliforms were expressed as Total Coliform counts per 100 ml. Confirmed Faecal Coliforms were expressed as Faecal Coliform counts per 100 ml.</p>

2. Quality Control procedures

- The NBRO is registered in the Central Environmental Authority (CEA)- Laboratory as Consultant/ Specialist for Technical Guidance (Reg. No. 07/LM/Cons/10/2008).
Copy of certificate - 2013 and a Letter indicating participation in Proficiency testing programs with CEA are given below. .
- Quality Control for the analysis of all the parameters was carried as per the procedures given in the Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF- 20th edition (APHA).
- All chemicals used in the analysis were of Analytical Grade (AR).
- The pH meter was calibrated before commencing the sample measurements using pH 4.01 and pH 6.86 buffer solutions (traceable to National Institute of Standards and Technology - NIST).
- Turbidity meter was calibrated using a series of Environmental Protection Agency (EPA) approved) calibration standards of 800 NTU, 200 NTU, 20 NTU and 2 NTU before commencing sample measurements.
- Dissolved Oxygen and BOD analysis - Glucose Glutamic acid (GGA) standard check solution was checked for reliability of the sample analysis. The GGA control is a standardized solution to determine the quality of the seed, where its recommended BOD₅ concentration is 198 mg/l \pm 30.5 mg/l. The dilution water blank was used to confirm the quality of the dilution water that was used to dilute the samples. This is necessary because impurities in the dilution water may cause significant alterations in the results.
- In the Nitrates analysis, standard KNO₃ (strength was 1.00 mL= 100 μ g NO₃⁻) was prepared as per APHA and 0.1 mg/L solution as a known sample and deionized water was checked for an each set of sample analysis.
- In the Ammonia testing standard solution of NH₄Cl was used as the standard (1.00 mL =1.22 mg NH₃). For each set of sample analysis 0.01 mg NH₃/L solution as a known sample and deionized water as a blank were checked.
- For the Total Phosphates analysis, standard phosphate solution of KH₂PO₄ was used to prepare the calibration curve (The strength was 1.00 mL=50.0 g PO₄³⁻P). In each set of analysis, 6 samples at a time; 3 water samples, 1 known standard sample, 1 spiked sample and a blank sample (deionized water) were digested and analyzed.

- In the Faecal Coliforms and Total Coliforms quality control procedures were carried out according to APHA.

This includes:

- Checking incubator temperatures:
 - Faecal Coliforms - 44.5⁰ C Total Coliform - 37⁰C
 - Performance of Autoclaves Sterilization using sterilization tapes - temperature 121⁰C, pressure 15 lbs)
- Blank sample testing - Dilution water (KH₂PO₄ buffer) blanks were analyzed during the sample analysis. Three dilution blanks were filtered during the sample analysis for each set of analysis (beginning/ middle and at the end) and tested for Faecal and Total Coliforms.
- The Balance (electronic top loading balance AUW 120 D, Shimadzu, Japan) used for the preparation of reagents was calibrated from an accredited institution. (Calibration date - 15 08.2012 - Copy given below.



Central Environmental Authority

Consultant / Specialist for Technical Guidance

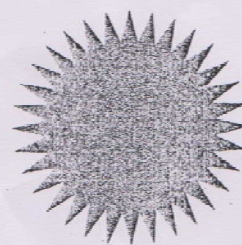
This is to certify that

National Building Research Organization.....of
99/1, Jawatta Road, Colombo 05.....

Registered as a Consulting Agency for Technical Guidance on
Pollution Control Activities for the year 2013

Reg. No.:
07/LM/Cons/01/2008

Signature
Deputy Director General
Environmental Pollution Control



Validity Period:
From: 01.01.2013 to: 31.12.2013

Signature
Director General
Central Environmental Authority

Certificate - NBRO registration in Central Environmental Laboratory as Consultant/ Specialist for Technical Guidance (Reg. No. 07/LM/Cons/10/2008)

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Your Ref.

අපේ යොමුව
எமது தொடர்பு
Our Ref.

දිනය
திகதி
Date

19.08.2013

මධ්‍යම පරිසර අධිකාරිය

மத்திய சுற்றாடல் அதிகாரசபை

Central Environmental Authority



"පරිසර පියස", 104, ඩෙන්සිල් කොබ්බෑකඩුව මාවත, බත්තරමුල්ල, ශ්‍රී ලංකාව.

"பரிசர பியச", 104, டென்சில் கொப்பெகடுவ மாவத்தை, பத்தரமுல்ல, ஸ்ரீ லங்கா.

"Parisara Piyasa", 104, Denzil Kobbekaduwa Mawatha, Battaramulla, Sri Lanka.

Web : www.cca.lk

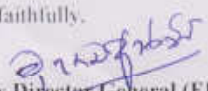
To whom it may concern

This is to certify that the Environment Laboratory of the National Building Research Organization is a registered laboratory under CEA for environmental monitoring and analysis since the year 2008 up to date.

They have participated in proficiency testing programmes and will be taking part in the CEA PT programme, which is scheduled to be held in mid September 2013.

This letter is issued on request of Ms. S.V. Dias, Director (Environment Division), NBRO.

Yours faithfully,


Deputy Director General (EPC)
Envtl pollution Control Division
Central Environmental Authority

Chairman	Tel : 2872361, 2872348 Fax : 2872347	Director General	Tel : 2872359 Fax : 2872608	Gen. Office	Tel : 2872278, 2873447, 7877277-280, 2873448 Hot Line : 2888999	Media Unit : 2873449
Deputy Director General	HRD, Admin & Finance Division Tel : 2865296 Fax : 2872301	Envl. Pollution Control Division	Tel : 2873453 Fax : 2872605	Envl. Mgt & Assess. Division	Tel : 2872388 Fax : 2872296	Envl. Edn. & Awareness Division Tel : 2872297 Fax : 2872609
Directors	2872607 (Admin) 2872301 (HRD), 7877290 (Finance) 2872601 (Admin), 2863984 (Finance)	2873452 (EPC), 2872606 (Lab) 2882335 (WM)	2872346 (NRM), 2876643 (EIA) 2867263 (R&D)	2867266 (EPA) Fax : 2872609	2872604 (Legal) (Western Province) Tel : 2862831 Fax : 2863293	

පරිසර හා පුනර්ජනනීය විද්‍යාවේ අමාත්‍යාංශය | சுற்றாடல் மற்றும் புதுப்பிக்கத்தக்க சக்தி அமைச்சு | Ministry of Environment and Renewable Energy

Letter indicating participation in Proficiency testing programs with CEA



... Continuation Sheet

CALIBRATION CERTIFICATE

Issued by an Accredited
Calibration Laboratory

Calibration Certificate

Certificate No. SS – 1208426



CUSTOMER National Building Research Organization No 99/1 Jawatta Road Colombo 05		DESCRIPTION Electronic Top Loading Balance (Dual range)	SERIAL No. D 449911128
		Capacity (Max.): 120 g / 42 g Resolution : 0 to 42 g: 0.01 mg 42 g to 120 g : 0.1 mg	IDENTIFICATION NO. Not given
MANUFACTURER & MODEL NO. SHIMADZU, AUW 120 D		RECEIVED CONDITION Not applicable	
REQUEST RECEIVED ON : 2012 June 19		REFERENCE : C 1205218/03	
CALIBRATION DATE 2012 August 15	LOCATION OF CALIBRATION Laboratory National Building Research Organization	TEST CONDITIONS Temperature : $24 \pm 2^{\circ}\text{C}$ Relative humidity : $55 \pm 10\%$	
REFERENCE STANDARD Set of weights of accuracy class E2 (Eq. No: MA/004), traceable to Primary standard maintained at Korea Research Institute of Standards and Science, KRISS & Physikalisch Technische Bundesanstalt (PTB). (Our Ref: IML-344)			
METHOD OF CALIBRATION The balance was calibrated generally in accordance with the test method manual Ref. No MM/MA/01 – Calibration of Electronic Balance. The balance scale was externally adjusted 50 g with weight of accuracy class E2 before the calibration.			

Calibration certificate – Balance; AUW 120 D, Shimadzu, Japan

Annex 5

The river water quality

Water quality of river water

Date of sampling 17th September 2013

Category No.*	Location	Sample code	pH	Temperature °C	Turbidity NTU	Dissolved Oxygen mg/L	BOD ₅ mg/L	Ammonia (as N) mg/L	Nitrate (as N) mg/L	Total Phosphorus (as P) mg/L	Total Suspended Solids (mg/L)	Faecal Coliforms (E.coli /100ml)	Total Coliforms (Coliform Organisms /100ml)
* A m b i e n t W a t e r	L 1	D1-1	7.1	20.9	16.3	8.3	1.0	0.04	1.151	0.159	4.2	300	5600
		D1-2	6.8	20.7	20.7	8.1	1.0	0.06	1.118	0.109	6.9	248	6400
	L 2	D2-1	8.2	20.7	53.3	7.8	1.4	0.00	0.514	0.146	27.2	900	8800
		D2-2	8.3	20.3	55.4	7.9	1.5	0.00	0.529	0.137	24.9	1100	9000
	L 5	D5-1	7.4	20.6	78.6	8.2	<1	0.00	0.541	0.120	25.2	2100	13600
		D5-2	6.9	20.1	63.2	8.2	<1	0.01	0.550	0.120	23.0	2000	13600
	L 9	D9-1	6.1	19.4	15.5	7.4	1.4	0.04	1.120	0.119	8.2	400	6600
		D9-2	6.1	19.2	15.2	7.5	1.0	0.02	1.179	0.143	7.9	700	6000
	2Q	Drinking water – Simple Treatment	6.0-8.5	-	5 (max)	6 (min)	3 (max)	-	5 (max)	0.23 (0.7 as PO ₄) max	-	600 (max)	5000
3 ⁴ L	Bathing		6.0-9.0	-	-	5 (min)	4 (max)	-	5 (max)	0.23 (0.7 as PO ₄) max	-	50	1000
4 ¹ L	Fish & aquatic life		6.0-8.5	-	-	3 (min)	4 (max)	0.94 (max) (pH < 7.5)	5(max)	0.23 (0.7 as PO ₄) max	-	-	20000
5 ^Y	Drinking water – Conventional Treatment		6.0-9.0	-	-	4 (min)	5 (max)	-	5 (max)	0.23 (0.7 as PO ₄) max	-	-	5000
6 ^E	Irrigation & Agriculture		6.0-8.5		-	3 (min)	5 (max)	-	5 (max)	0.23 (0.7 as PO ₄) max	-	-	1000

AIP-DHV-2000

“<” denotes minimum detection level of the methodology employed.

Non compliance with Category 2

**TECHNICAL REPORT FOR ADDITIONAL STUDIES OF THE
NATURAL ENVIRONMENT SURVEY OF THE
NEW PROJECT SITES
MORAGOLLA HYDROPOWER PROJECT**



NIPPON KOEI
Moragolla Hydropower Project
CEYLON ELECTRICITY BOARD
Sri Lanka

by
Centre for Environmental Studies (CES)
University of Peradeniya

October 2013

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EXECUTIVE SUMMARY

This report contains the physical, biotic and social status of the locations where the quarry, construction offices and spoil bank are located and possible impacts due to the construction and operation of activities in these sites.

The study found that the project does not lead to resettlement (only temporary evacuation of three houses), or the loss of any sensitive ecological resources. All three sites have been used and disturbed by human activity in the past.

Those who were affected did not oppose the project but expect reasonable compensation. The project needs to negotiate with the affected people regarding compensation.

The study found that several negative and positive impacts arising from the construction activities of the three sites.

Environmental Component	Positive or Negative	Impact
Physical	Negative	Soil Erosion
	Negative	Surface Water Pollution
	Negative	Air Pollution and Noise pollution and vibration
	Negative	Noise and Vibration due to Drilling and Blasting
Biological		No significant impacts except removal of some trees
Social	Positive	Increased employment to the local people who will be hired to work at the three sites
	Negative	Temporary evacuation of three houses near the quarry site
	Negative	Potential structural damages to the three buildings near the quarry site
	Negative	Loss of the Green houses at the spoil dump site and thus an income source to one family
	Positive	Reclamation of land to be economically more valuable at the spoil dump site upon completion of work
	Negative	Threat to the safety of the road users and the users of the access road

However all these impacts can be mitigated as can be seen from the table below.

Impact	Mitigation
Soil Erosion	Divert the stream running through the quarry to one of the adjacent stream Construction of appropriate drainage systems at all sites.
Surface Water and soil Pollution	Divert the stream running through the quarry to one of the adjacent stream Appropriate measures to be taken to avoid pollution of the ground due to spilling of oil and other liquid wastes etc. Construction of sedimentation/ settling ponds and discharge water to Mahaweli River
Air Pollution and Noise pollution	Use of efficient vehicles Controlled blasting Wetting using sprinklers to avoid dispersion of dust
Noise and Vibration due to Drilling and Blasting	Controlled blasting, Blasting to be limited to definite time gap, Avoid blasting during night time,
Removal of some trees	Initially unavoidable but reforestation and after reclaiming the quarry site. Maintain 50 m riverine buffer zone undisturbed
Increased employment to the local people who will be hired to work at	No mitigation needed
Temporary evacuation of three houses near the quarry site	Compensation during the temporary evacuation.
Potential structural damages to the three buildings near the quarry site	Temporary evacuation, Compensation or repair damages upon completion of the quarry operation (Crack survey to be carried out before commencing quarry operation)
Loss of the Green houses at the spoil dump site and thus an income source to one family	Compensation and assisting in rebuilding after completion of the reclamation.
Reclamation of land to be economically more valuable at the spoil dump site upon completion of work	No mitigation needed
Threat to the safety of the road users and the users of the access road	Controlled blasting, Sufficient warning to be issued to the traffic and the Users of the access road, Use piles of debris or excavated rock as a shield to minimize fly rock

If the above stated mitigation are complied with, the severity of the impacts can be avoided and or minimized.

1. INTRODUCTION

1.1 Background of the Project

The Ceylon Electricity Board (CEB) plans to develop a new 30.8 MW hydropower project at Moragolla in Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weli Ganga, to create a 38.5 ha, 1.98 MCM reservoir with a Full Supply Level (FSL) at 548 masl. Water will be diverted through a 3 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya.

A Feasibility Study for the project was conducted in 2009, and this included an Environmental Impact Assessment (EIA), which is expected to be approved by the Mahaweli Authority of Sri Lanka (MASL) in the near future. In 2012 CEB appointed Nippon Koei Co., Ltd. (NK) to review the Feasibility Study (FS) and prepare detailed designs and tender documents for project construction and to upgrade the EIA to comply with the Safeguard Policy of the Asian Development Bank, the principal funding agency.

To upgrade the EIA, surveys were conducted in certain key fields in 2013, to supplement existing baseline data and update the assessment of impacts. Some further study was needed to ensure properly planned and designed mitigation measures.

1.2 Rationale

The Technical Report describes the main physical, biological and social features of areas that will be directly affected by the project, assesses the impacts of activities to be conducted at each site, and proposes mitigation for negative impacts. This additional study includes three areas that were identified and under consideration as key project components namely;

- a) spoil dumping site for disposal of tunnel muck and other excavated spoil,
- b) quarry site,
- c) contractor's office and camp site.

These three sites have been identified during the FS review (by Nippon Koei Co., Ltd.) and the study of physical, biotic and social impacts of these sites and associated activities needed to be assessed.

1.3 Scope of Work

This work was conducted by the Centre for Environmental Studies (CES) of the University of Peradeniya, a nationally-recognised environmental consultancy arm of the University of Peradeniya. It has over 25 years of professional experience in environmental survey, analysis, data interpretation and report preparation, including extensive experience of assessing the physical, biological and social features of terrestrial sites.

The field survey work was led by three senior experts namely

- a. Dr. Jagath Gunatilake, Department of Geology (Team Leader and Geologist)
- b. Prof. Kithsiri Ranawana, Department of Zoology (Ecologist)
- c. Prof. Shantha Hennayake, Department of Geography (Social Scientist)

All of the three have over 20 years of research and consultancy experience in Sri Lanka in: a) field geology/topographic studies; b) terrestrial ecology (flora and fauna); and c) rural social studies. The senior experts and research assistants had several visits to each of the three sites and conducted sufficient qualitative site observations and investigations. The investigations included the following aspects:

- Physical: topography, drainage, geology, distance from Mahaweli Ganga and inflowing streams.
- Biological: flora, fauna, habitats and their importance, type and number of trees.
- Social: location and proximity of any houses, commercial or industrial buildings, other infrastructure, or locations or features of community importance at or near the site or alongside likely access routes.

The results of the surveys are presented in this report based on the format specified in the TOR (see the Attachment 1 for the TOR issued by the project)

2. APPROACH AND METHODOLOGY

Based on the potential impacts on a) physical features of locations of these sites including existing topography, drainage, geology, b) ecological features including existing fauna and flora, restricted areas etc. and c) social environment including existing settlements and the livelihood of the people, access roads, areas with religious concerns etc., 200m buffer zone is identified for the quarry site and 100 m buffer zones were selected as the impact areas of dumping site and campsite/office areas. Considering the impacts that may create due to quarry operations including site clearing, removing top soil and weathered rock, drilling, blasting, loading and hauling of rock as construction material for the dam and appurtenant structures, 200 m buffer zone was identified as the impact area for quarry site. However, identifying the potential impacts due to proposed access roads and the other construction sites are not included in the scope of this study.

Table 1-2 Methodology adopted in the study and report preparation

Item	Data Type	Data collection methods	Data analysis and Impact identification	Mitigation measures	Monitoring plan
Physical	topography, drainage, geology, distance from Mahaweli Ganga and inflowing streams	Secondary sources of GSMB Geological maps (1:100,000), NBRO Landslide Hazard Maps, and field observations, Other maps related to the project: 1:10,000-Sheet No.6113, Survey Plans; Satellite images (Google earth) In addition, GPS was devised to collect data on land use etc.	The data obtained from different sources and in different formats were integrated using GIS & RS technology. Maps, overlays, buffer generation, digital elevation model generation, preparation of slope maps were carried out by using GIS,	Based on consultants' experiences working in similar projects, mitigation measures have been given for each significant negative impacts	Environmental monitoring plan has been given on the internationally accepted format. This includes mitigation measures, relevant place or time, criteria, responsible institutions and personals who should carry out them.
Biology:	flora, fauna, habitats and their importance, type and number of trees	Field investigations			
Social:	location and proximity of any houses, commercial or industrial buildings, other infrastructure, or locations or features of community importance at or near the site or alongside likely access routes	Through maps, Key informant interviews, focus group discussion and direct observations, Land use maps, Satellite images (Google earth) etc. were used to collect data	Impact area was demarcated with the aid of geo-visualization method in GIS. Also significant impacts have been discussed in detail.		

2.1 Methodology of Impact Assessment for Physical Environment

There will certainly be drastic changes in the physical landscape and as a whole, physical environment within the project area in all three sites. Considering the potential impacts on the topography, existing surface and sub surface drainage in particular to the nearby Mahaweli Ganga, 200 m buffer zone was identified as the potential impact zone for the proposed quarry site. One hundred meter buffer zone surrounding the proposed camp/office site was identified as the potential impact zones for the physical features due to site clearing, construction and operation. Considering the site clearing, transportation of waste rock and soil, tunnel muck etc., 100 m buffer zone is identified as the potential impact zone for dumping site.

2.1.1 Topography

Topography of each of the three sites were studied including the desk study using the available large scale contour maps (survey maps provided by the client), topographic maps (1:10,000) as well as satellite images and aerial photographs. Aerial photographs were being used to study whether there are any significant structural features of lineaments or faults particularly within the quarry site.

Field investigations were carried out to identify the topographic features of the three sites under investigation. Topography and the general elevations at the spoil dumping site and the future scenarios during and after completion of the spoil dumping operation were assessed by comparing and analysing the information from contour maps, satellite images, survey maps and the field observations.

2.1.2 Drainage

Existing drainage ways within the sites and the demarcated impact areas were studied using the available maps, satellite images and aerial photographs combined with field investigations. All likely impacts on drainage systems at each site and also the nearby river banks are identified and necessary mitigation measures were proposed. GIS maps were generated using the available AutoCad drawings and the field observations made.

2.1.3 Geology and Slope Stability

All existing data on surface and sub-surface geology including bore hole data, rock samples and rock thin section studies etc. were used to identify any adverse conditions and impacts that may encounter during the operation of the quarry site, dumping site and camp site. In addition, field studies were carried out to compare the actual conditions at site. However, since the contractor's method statements were not being available, general operating conditions at similar projects were taken into consideration.

Slope stability conditions also were evaluated considering the future operations of the quarry site, camp/office site and spoil bank area. However, since the method statement of the quarry operation was not available, the slope stability conditions within the quarry site could not be evaluated. Diagrams indicating 3-D view of the quarry site and the surrounding area, dump site and the camp site etc. were generated using GIS and Remote Sensing. Landslide Hazard maps compiled by the National Building Research Organization was used to describe the potential of landslides within and the surrounding area. Necessary mitigation measures are suggested to minimize the potential impacts including the slope instability.

Data Analysis and interpretation were carried out for all available sites using the data obtained by GIS and remote sensing techniques as well as the field information collected during the field studies and the available bore hole data. Geological maps and profiles were compiled for quarry site and slope stability conditions were assessed and evaluated based on the actual field conditions during operations. Slope stability of the Contractor's area and spoil bank areas were also studied considering the progressive excavation and filling work proposed. Geological profiles/maps, photographs, etc. are being included in this report to illustrate the potential impacts on the physical environment and the proposed mitigation measures.

Several rock samples were obtained and analysed for the mineralogical composition. Thin sections made could confirm the type of rock and the mineralogy as well as strength properties of the rocks.

2.2 Methodology of Impact Assessment for Biological Environment

Direct sampling methods using transect surveys were adopted to identify the fauna and Flora to be affected due the project development.

Ecological study (Fauna and flora) has been carried out for three sites selected for different project activities. These include sites selected for quarrying, construction of workers camp and spoil disposal. The site selected for quarrying is derelict grassland dominated by the grass species *Panicum maximum*. Site allocated for the construction of workers camp is a broad strip of vegetation bordering the Mahaweli river below the Gampola – Kotmale road between 4- 5 km posts. Spoil dumping site mainly consists of Kandyan forest gardens.

Wherever possible, attempts have been made to compare the results obtained from the survey with the information presented in the Environmental Impact Assessment Report of the Moragolla Hydropower Project (CECB, 2012)

2.2.1 Sampling Terrestrial Habitats

Fauna and flora of impact areas was mainly studied through the field work. Villagers were also interviewed to get some additional information on certain faunal groups.

2.2.2 Vegetation Survey

The vegetation in three sites was studied using sampling plots representing all habitats types. Stratified Random Sampling method was used to locate the sampling points in the project area. Presence of different tree / plant species in the project area was recorded. Lists of plants giving their conservation status (such as endangered, threatened etc.), and ecological status (such as endemic, exotic, invasive etc.) was compiled for the three sites. Trees >20cm dbh was identified and counted. Accordingly number of trees to be removed in three sites was estimated. If there are any rare or endangered plant species within the study areas, methods for relocation of these species is proposed.

2.2.3 Faunal Sampling

Sampling method for each group is different. Looking at the time frame of the study, rapid sampling methods were used to evaluate the richness of key species in each faunal group.

i. Invertebrates

Two groups of invertebrates, namely, butterflies and land molluscs was selected for sampling. Butterflies in the sites were sampled using fixed survey routes within a single habitat type. A fixed survey route was of 100m in length. All the species encountered during the transect survey was identified.

ii. Vertebrates

Amphibians and Reptiles

Amphibians and Reptiles in the sites were sampled using a combination of three methods: visual encounter surveys along transect lines, quadrature searches, and specialized searches in select habitats known to be important to particular species.

Birds

Line transect method was used to count and gather data on birds. An experienced observer walk along the entire length of transect (500 m) identifying and counting birds seen within 20m distance to both sides of the transect. Transects spots were systematically positioned to represent each and every habitat type in the project area.

Mammals

Mammals were sampled using the line-transect method. The length of transect was determined suitable to the site specific characteristics. While walking along transect, direct observation of individual species as well as signs indicating their presence (dung piles, tracks, browse, etc.) was be recorded. Interviews were conducted with the villagers in the area to get an idea of the species inhabiting the area.

Species lists were prepared indicating their conservation and ecological status

2.3 Methodology of Social Impact Assessment

The Social Impact Area considered for the study is two folds.

1. The direct impact area consisting of the foot print of the three project sites and 100 meter buffer zone. However, for the quarry site this is extended to 200 m.
2. Indirect Impact area covering the Grama Niladari Divisions within which the project sites are located.

The social study and the assessment took into account the following variables.

1. Current pattern
2. Dwellings within the foot print and the impact area
3. Culturally significant places within foot print the impact area
4. Land that will be affected
5. Houses and other buildings that will be affected
6. Income sources and levels that will be affected
7. Accessibility that will be affected
8. Nature of compensation expected

The data collection techniques adopted include the following

1. Observation and collecting photographic evidence
2. Detailed discussions with the households in the impact area to collect the following information

Data Analysis was based on the following.

1. Total area that will be affected, the ownership and value
2. Value of structures that will be affected
3. Income losses
4. Social impacts and inconveniences due to increased traffic and noise

Mitigation measures will be proposed for the identified following major impacts

1. Loss of land
2. Loss of structures
3. Loss of income sources

3. SITE DESCRIPTIONS

A detailed description of each site is provided individually, dealing in each case with Physical Features, Ecology and Social Environment. Each section is dealt with the aspects specified in the TOR and any others that are considered relevant to this study. All important or sensitive features were identified and the reasons for their importance were explained. Discussions are illustrated with maps, Figures (including photographs) and Tables for each site and key features.

The entire study area belongs to the narrow strip of the Kandy District of the Central Province of Sri Lanka in between Kegalle District and Nuwera Eliya Districts. The site is adequately accessible through main road from Gamopola to Nuwera Eliya and then through secondary road running towards Ulapane (Map Nos. 3.1 & 3.2). The quarry site and the contractor's office/camp area are located in Galatha GND in Uda Palatha DSD and the disposal site is located in Gampola Wela GND in Ganga Ihala Korale DSD (Map No. 3.3).

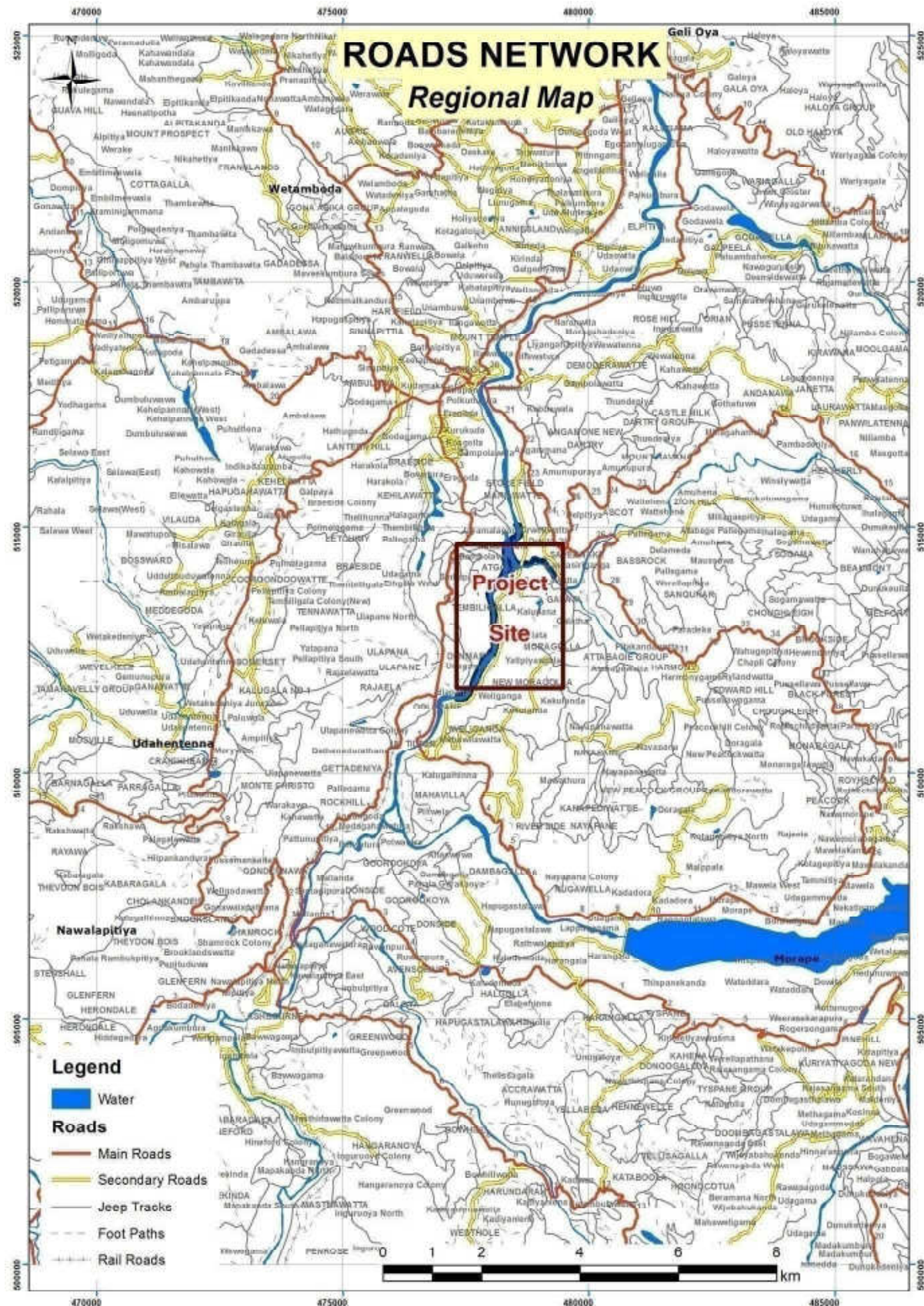
3.1. Proposed Quarry Site

3.1.1 Physical Environment

3.1.1.1 Landuse

General landuse of the area is illustrated as forest in Map No. 3.4 which is based on available 1:10,000 topographical maps prepared in 1987 by the Survey Department of Sri Lanka and subsequent field verification carried out by them in 1989. The topographic map (1:10,000) shows that the proposed quarry site is within forest area but field observations revealed that the forest area has been cleared for developing as residential areas as well as small scale agriculture.

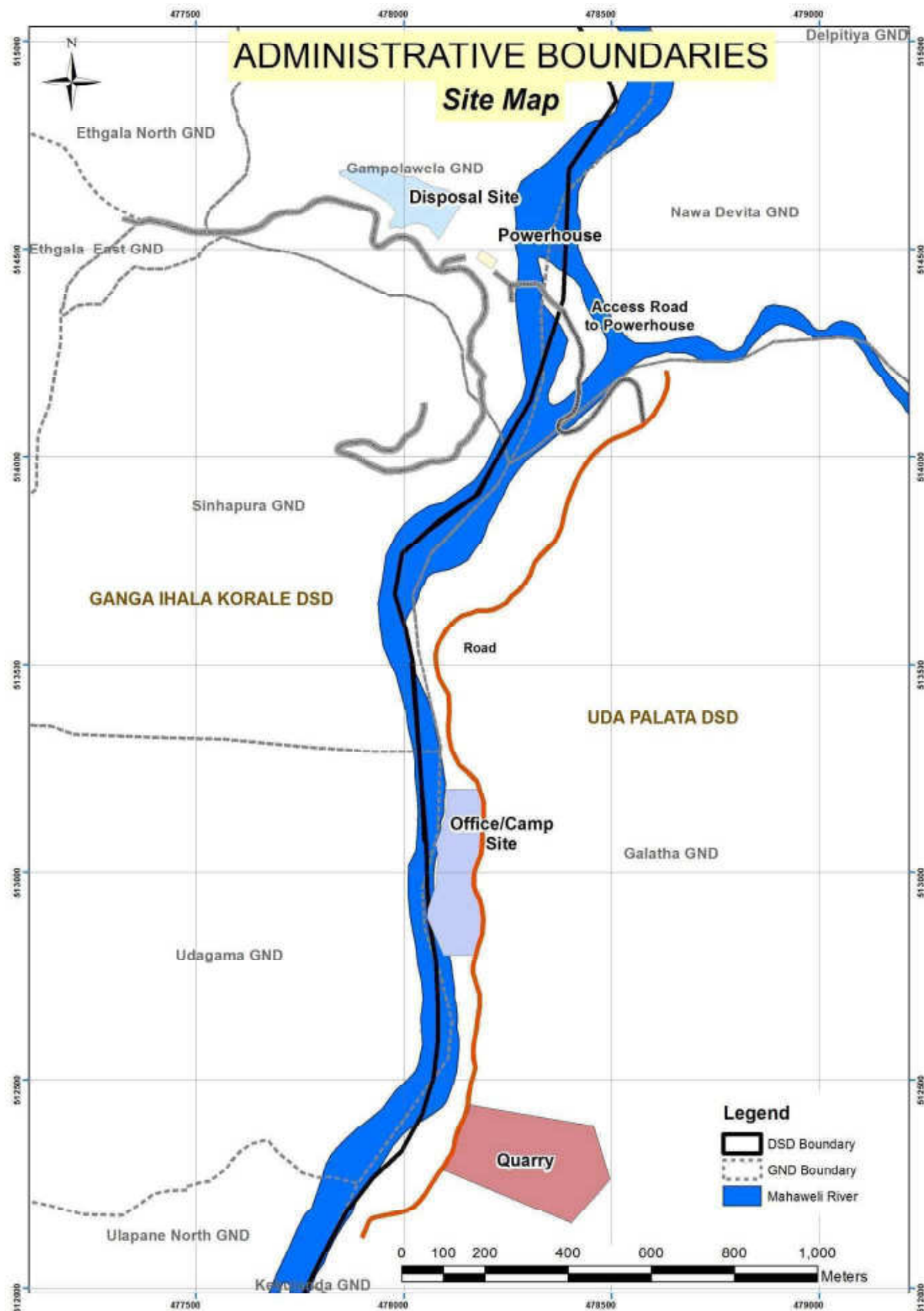
The land area has undergone a lot of developmental changes during the recent past and therefore some areas indicated as forest in the vicinity have been cleared and developed for residential purposes, small scale agriculture and housing schemes etc. The existing landuse observed during the current study is illustrated in the satellite image (Map Nos. 3.5, 3.6 and Figure 3.1)



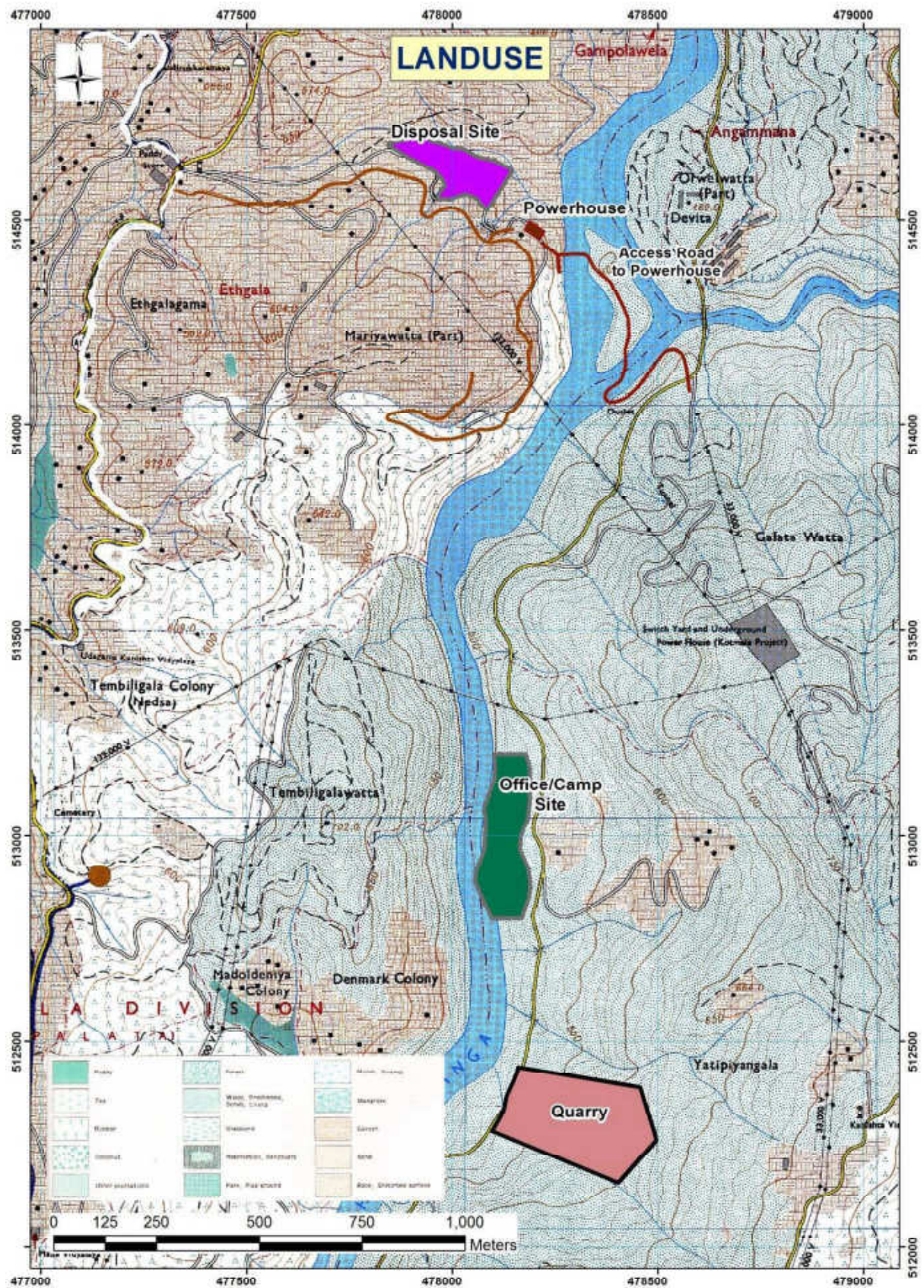
Map No. 3.1 General location of the Moragolla Project area and road network
Source; 1 : 50,000 ABMP Maps, Survey Department, Sri Lanka



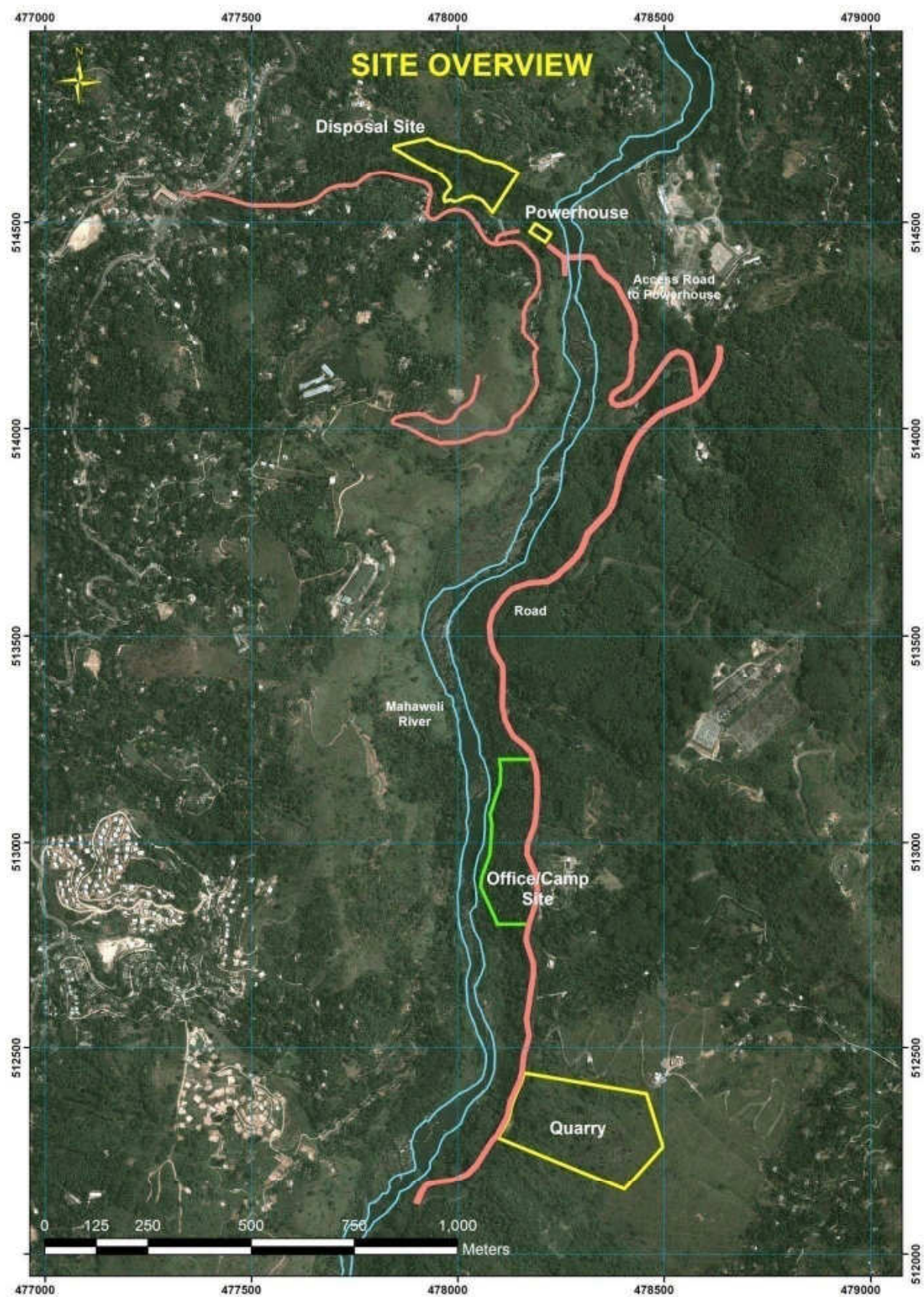
Map No. 3.2 Administrative Boundaries of the project area and the surrounding (Districts and DSD)
Source; 1 : 50,000 ABMP maps, Survey Department, Sri Lanka



Map No. 3.3 Administrative Boundaries of the project area (GN and DSD)
Source; 1: 10,000 ABMP maps, Survey Department, Sri Lanka



Map No. 3.4 Landuse map of the project area - Moragolla Hydropower Project
Source; 1: 10,000 ABMP maps, Survey Department, Sri Lanka



Map No. 3.5 Satellite Image of the project area and the surrounding
Source; Google Earth

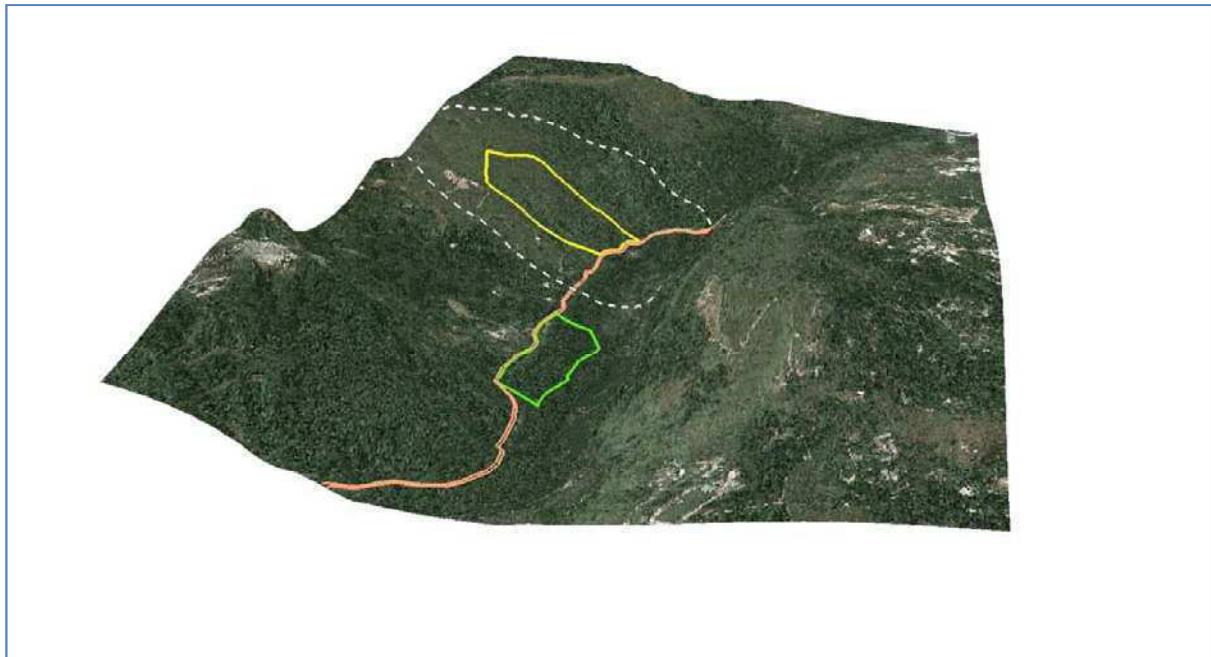
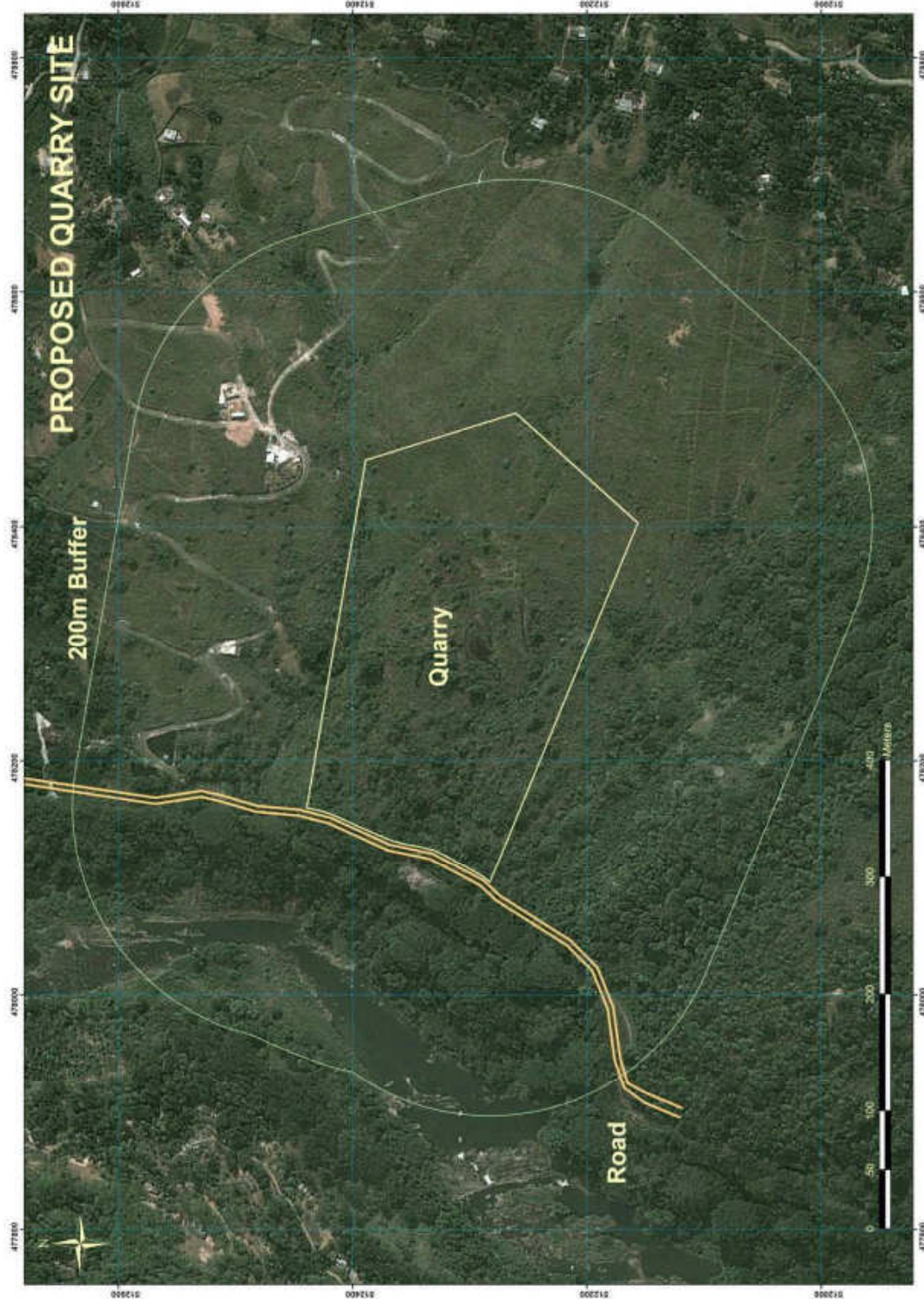


Figure 3.1 three-Dimensional views of the Quarry site and contractor's Office, Camp area; 200 m buffer zone is demarcated as the impact area of quarry operation.

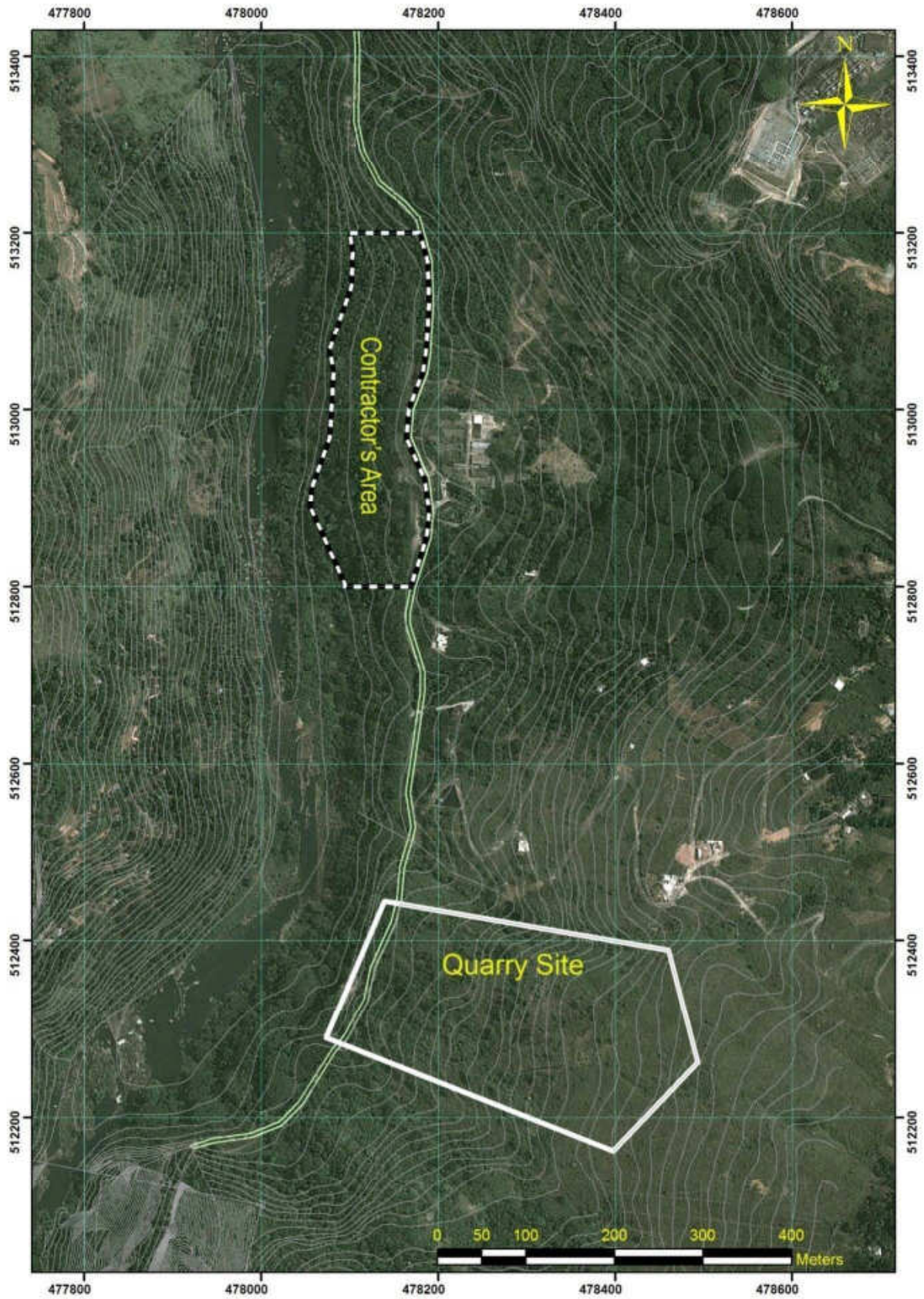
3.1.1.2 Topography and Drainage

The proposed quarry site is located within the Mahaweli drainage basin and belongs to wet climatic zone. Mahaweli River flows towards northeast direction and bend towards North near the proposed quarry site. The area consist of rugged topography(Figure 3.2) with an elevation ranging from 500m above mean sea level to about 700m within the narrow strip of Kandy District in between Kegalle and Nuwara Eliya Districts (Map Nos. 3.2 & 3.3). Satellite image (Map No. 3.7) and contour map (Map No. 3.8) indicate the general topography at the Quarry Site.

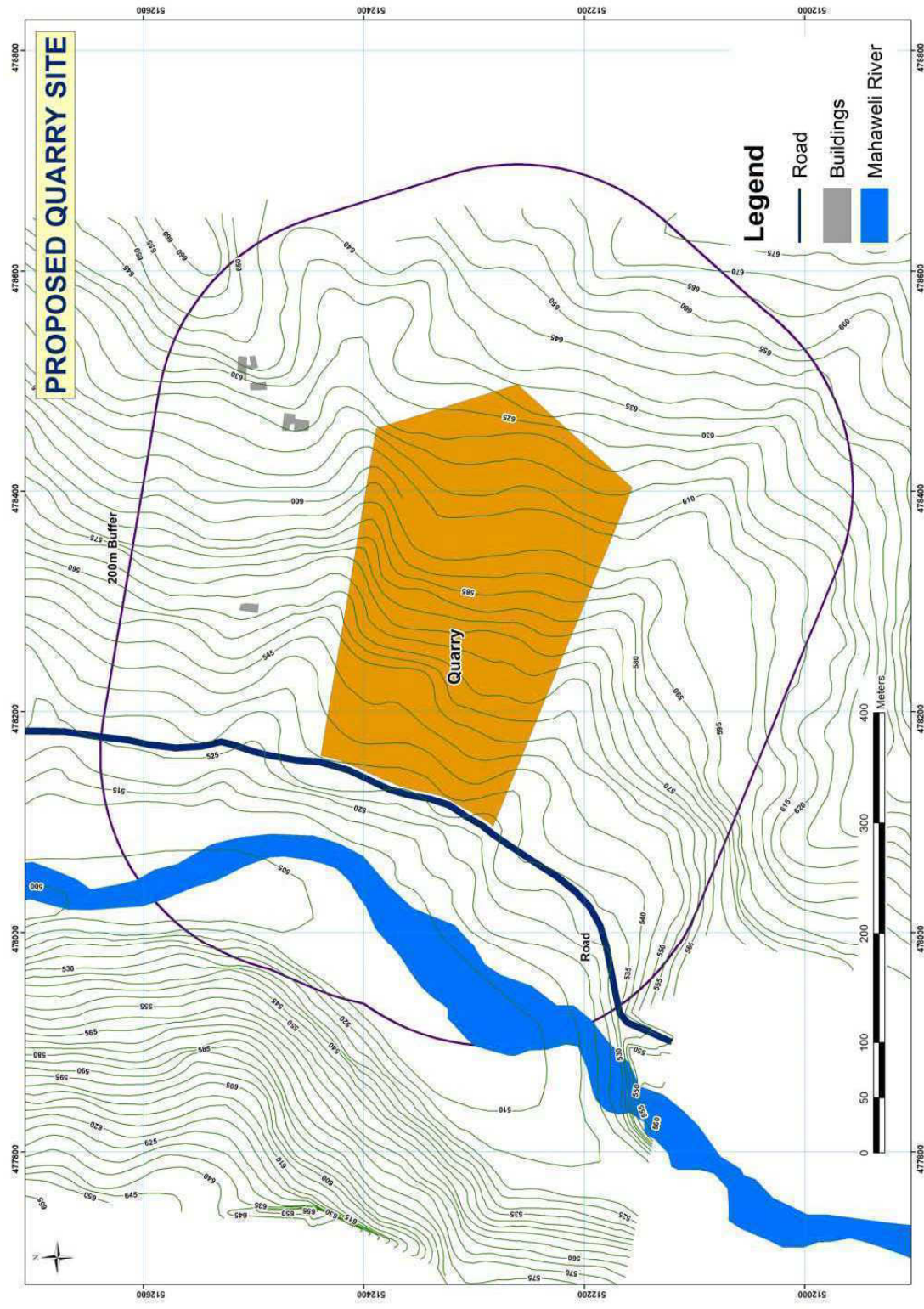
The elevation rises from the right bank of Mahaweli River towards Southeast direction beyond the upper boundary of the quarry site up to about 800 m. Map No. 3.7 shows the distribution of contours superimposed on a satellite image of the area. Gentle slope towards the west, follow the dip slope of the underlying basement rock. However, at certain locations, slope consists of colluviums of variable thickness. As per the slope map for the site (Map No. 3.9), it shows that slope of the entire area surrounding the proposed quarry site ranges from 10-30 degrees which can be categorized as gentle slope.



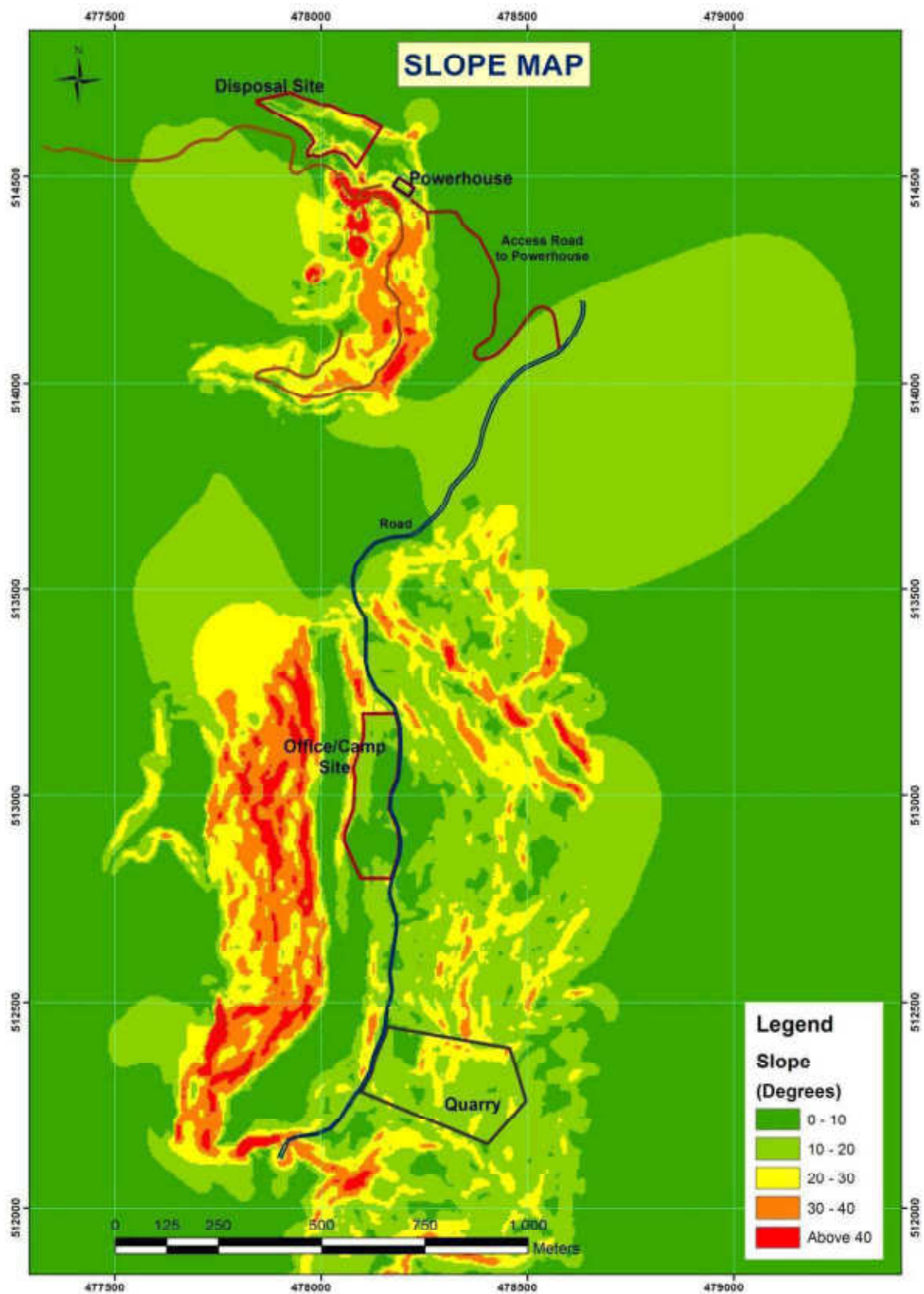
Map No. 3.6 Satellite Image of the proposed quarry site; 200 m buffer zone and the buildings/houses which are to be affected.
Source; Google Earth images, Survey Maps – Moragolla HEP



Map No. 3.7 Satellite Image of the quarry site, contractor's office/camp area and the surrounding Sources; Google earth, Survey Maps – Moragolla HEP



Map 3.8 Contour map of the proposed quarry site; 200 m buffer zone and the buildings/houses which are to be affected
Source; Google Earth images, Survey Maps – Moragolla HEP



Map No. 3.9 Slope Map of the project area - Generated using 1:10,000 scale elevation data
 Source; Survey Department, Sri Lanka

Some sections of the slopes adjacent to the stream valleys and right bank of Mahaweli River below the main road are as steep as 40 degrees and other regions have gentle slope. Left bank of the Mahaweli River consists of steep slope on bed rock.



Figure 3.2 Left; Rugged topography at the upper reaches of the quarry site; Right; relatively thick weathered overburden exists at the upper reaches of the quarry site.



Figure 3.3 Gentle slope of the valley and the stream traces follow the foliation of the charnockitic gneiss bed rock.

The western boundary of the proposed quarry site is the secondary road on the right bank of Mahaweli River where Northern and Southern boundaries are marked by small parallel tributaries fed by the upper reaches of the Mahaweli Right bank (Map No. 3.6 and 3.8 and Figure 3.4). As seen in Figure 3.4, the third stream is running right across quarry site along the small valley in the middle of the proposed quarry site. Approximately 100 m distance is there from the secondary road being the Western

boundary and the Mahaweli River. In case this site is selected as the quarry, it is anticipated that all these three streams are to be adversely affected unless proper mitigation measures are undertaken. The stream running across the quarry will have to be diverted from the upper reaches beyond the Eastern boundary of the proposed quarry site. However, facilitating appropriate drainage system within the quarry site including a settling pond (for sedimentation of quarry dust and soils to be washed along the slope during quarry operations) will be an essential requirement. In addition to that, the paths of existing two streams on either side should be kept intact. However, protecting the lower reaches of the streams by burying Hume pipes of appropriate diameter can also be considered as suitable mitigation measures.

Appropriate measures to be taken to remove colluviums overlaying the bed rock to avoid eroding them towards the Mahaweli River during the quarry operations. Since the thickness of overburden at the upper reaches at the Eastern most end, opening up of the quarry towards the upper reaches should be limited. Overburden material removed should be dumped at appropriate spoil banks without piling them in the vicinity of the quarry site in operation.

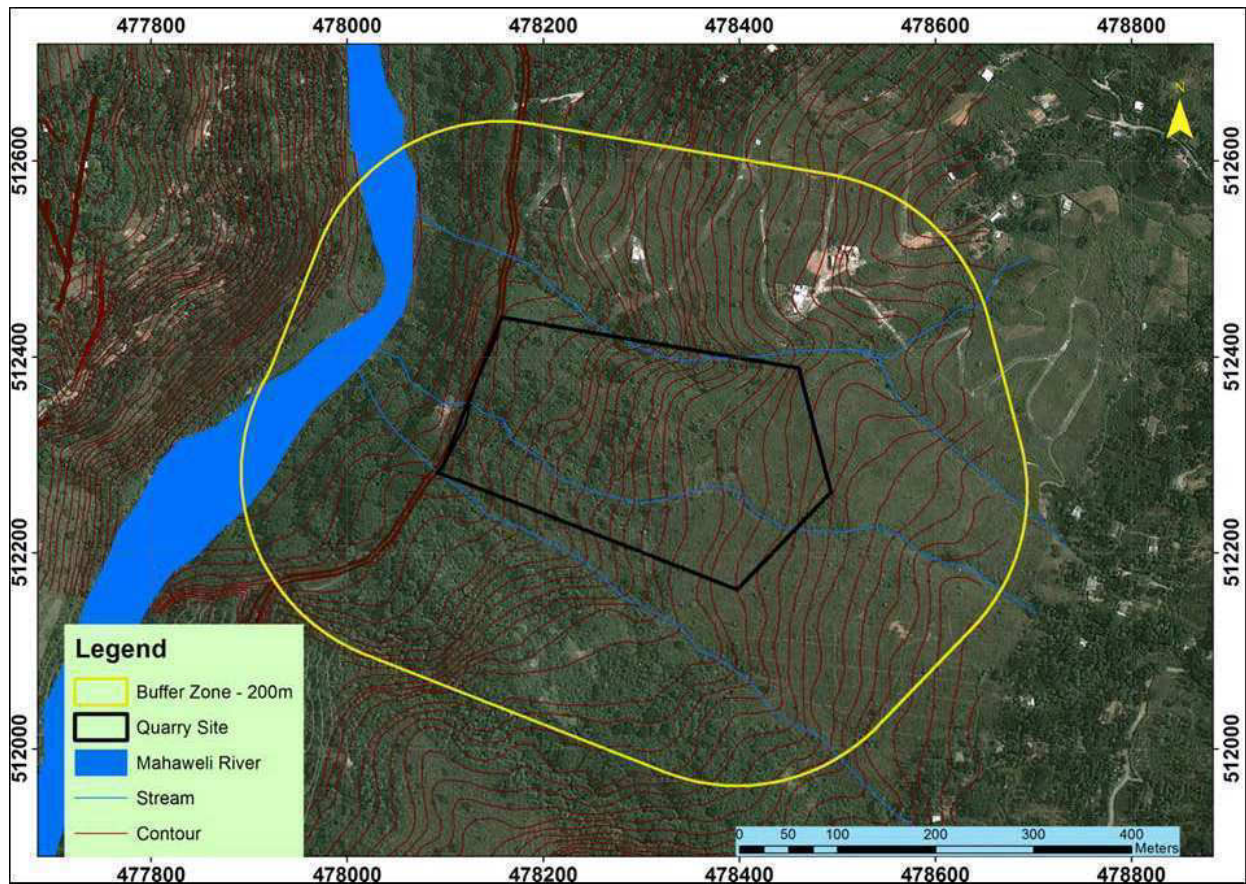
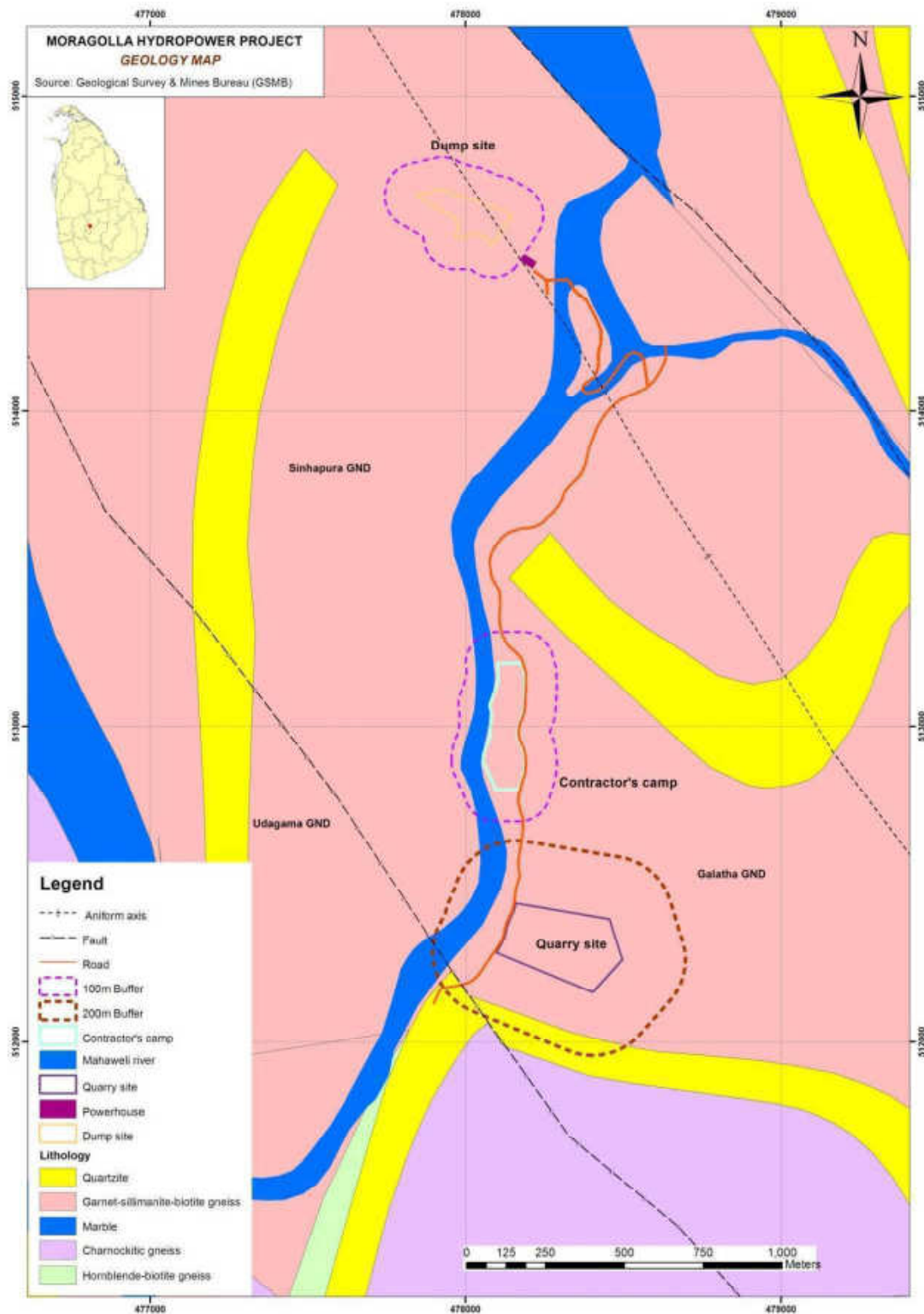


Figure 3.4 Satellite image showing the topography of the quarry site where three streams run parallel to each other on Northern and Southern boundary and right across the proposed quarry site

3.1.1.3 Geology and Structure of the Quarry Site;

Geologically, the area lies within the Highland Complex and composed of high grade metamorphic rocks namely charnockitic gneiss (Figure 3.5). Although the geological map by the Geological Survey & Mines Bureau indicate that the entire area consists of garnet sillimanite biotite gneiss (Map No. 3.10), field investigations indicated that predominantly charnockitic gneiss exist at the site. The stream valleys and Mahaweli main river valley are comprised with fresh charnockitic gneiss basement rock (Figures 3.3, 3.5 and 3.6) with occasionally thin bands of garnatiferous biotite gneiss. The garnatiferous biotite gneiss bands are either too thin to be mapped or too difficult to be distinguished at 1: 5,000 scale and hence entire area was mapped as one unit of charnockitic gneiss (Figure 3.5). However, the 5-8m thick garnatiferous biotite gneiss bands have been identified in drill core logs (attachment 1) as well as rock thin sections



Map No. 3.10 Geological map of the project area and the surrounding
Source; 1:10,000 scale Geological maps compiled by the GSMB

The figure is a geological map of the study area. It displays topographic contours, streams, roads, and a quarry site. The map includes a legend, a scale bar (0-400 meters), and a north arrow. The quarry site is outlined in black. The map shows various geological features including joints, streams, contours, roads, and the Mahaweli river. The quarry site is located in the central part of the map, surrounded by Charnockitic gneiss. The map also shows strike and dip directions for various joints.

30

The bed rock terrain is dissected by the two prominent conjugate joint systems (Figure 3.8) as major structural features in the area. These are ubiquitous in the project area. There are several different joint sets in the area with the major ones being vertical and trending N 250-300 E and N 550-600 W (Figure 3.8). These tend to intersect and create blocks of charnockitic gneiss varying in size from fractions of meter to several meters. Several open fractures exist and they are widened by weathering and erosion to create fissures and gullies.

The strike of the foliation in this charnockitic rock varies from N 42° W to N 18° E and dip direction varies from Southwest to Northwest direction. The bedrock of the proposed quarry site dips between 13 and 29 degrees mainly towards Mahaweli River. The irregular dip variations occur due to the physical and chemical weathering of the foliation plane and weathering along joints. Charnockitic gneiss rock is exposed mostly along the valley slopes and along the stream traces (Figures 3.6 and 3.7).



Figure 3.7 Large bedrock exposures in the proposed quarry site

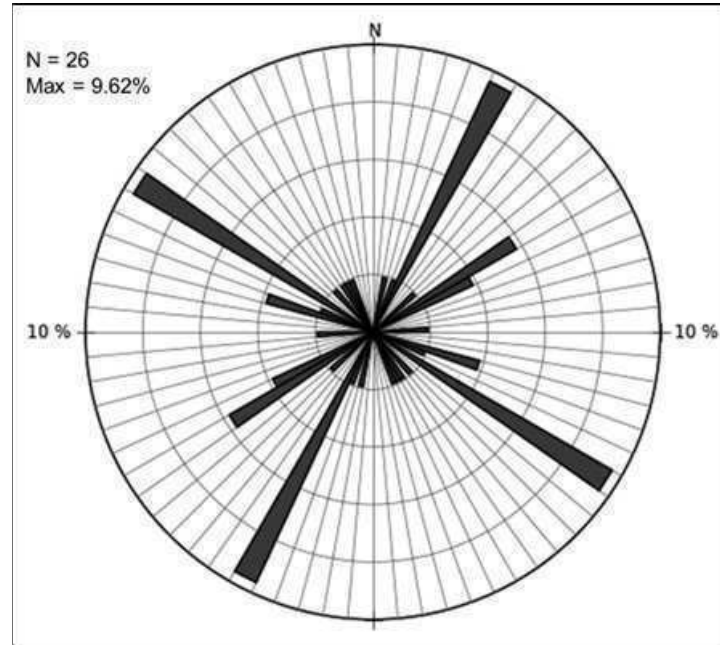


Figure 3.8 Rose diagram showing two conjugate joint sets in the study area

The most dominant subsurface soil type in the quarry site is colluviums with boulders ranging from 0.25 m to about 5m sizes and the thickness of the soil cover varies about 0.5 m to 8 m (Figures 3.9and 3.10).

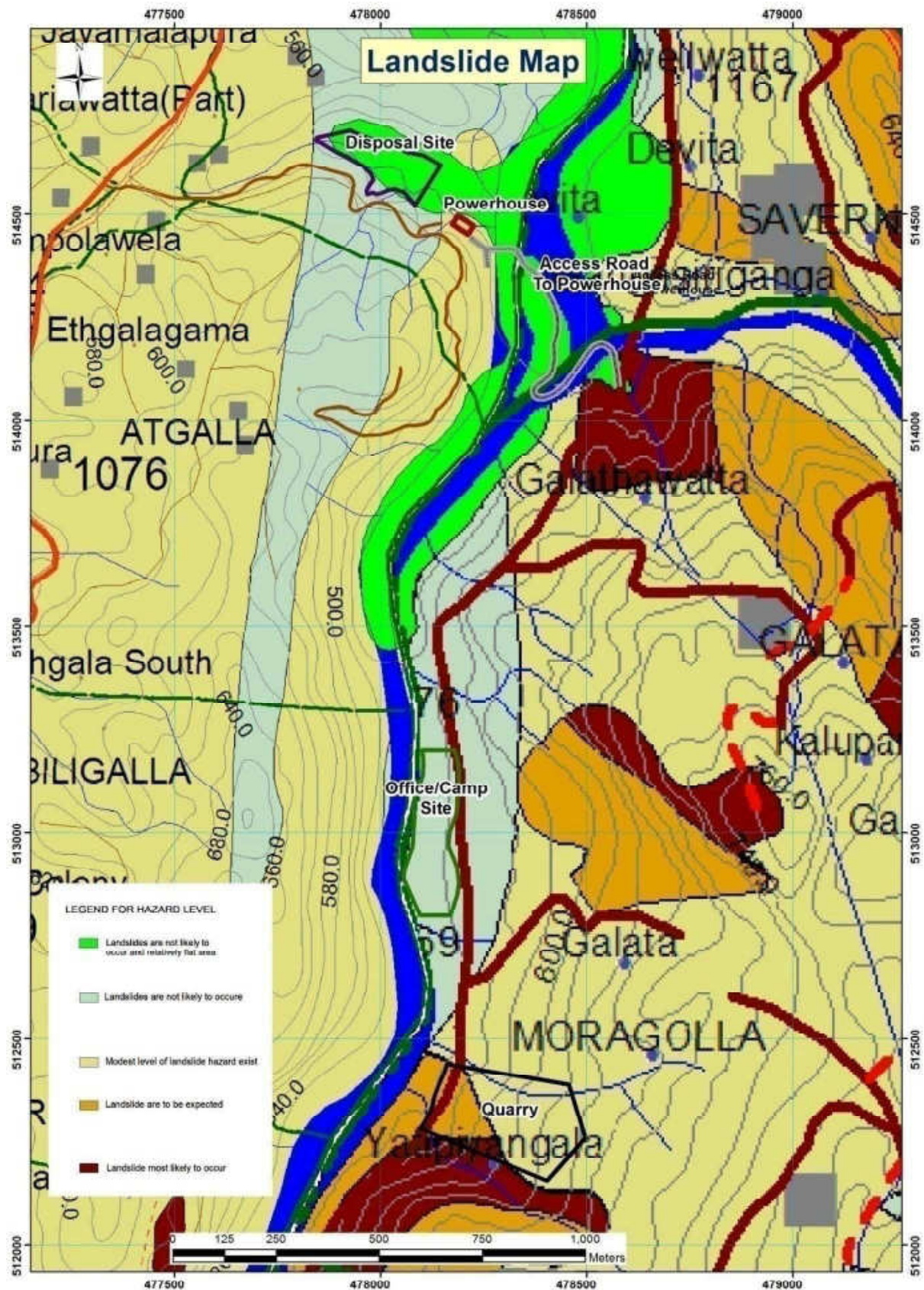


Figure 3.9 Colluviums at the lower reaches of the quarry site



Figure 3.10 Large boulders on the quarry site indicate the existence of colluviums

Except for the South western boundary of the proposed quarry site and few sections along the southern most streams, other areas are being categorised by NBRO landslide hazard map as modest level landslide hazard areas (Map 3.11).



3.1.2 Biological Environment

3.1.2.1 Site description

This site consists of a grassland dominated vegetation type with few scattered trees, shrubs and herbs. The soil layer in the site is very thin and hence does not support a growth of large trees forming a close canopy. *Dcranopterislinearis* (kekilli) forms the dominant ground cover of the site while patches of *Panicum maximum* (Mana) and *Cymbopogonnardus* (Pangirimana) are found in patches (Figure 3.11).



Figure 3.11 *Dcranopterislinearis* (kekilli), *Panicum maximum* (Mana) and *Cymbopogonnardus* (Pangirimana) dominant ground cover in the quarry site.

Few tree species such as *Symplocuscochinensis* (Bombu), *Tremnaorientalis* (Gadumba), *Acacia mangium*, *Macrangapeltata*, *Alstoniamacrophylla* (Hawerinnuga) are found near the road side and bordering the stream. Few herb species such as *Eupatorium inufifolium*, *E. Odoratum* were also found in the stream bank (Figure 3.12).



Figure 3.12 Tree cover near the stream bank of the quarry site

3.1.2.2 Current Status of Fauna and Flora

3.1.2.2.1 Fauna

Area selected for the quarry site is a species poor habitat. Only 41 species of animals in 25 families have been recorded from this site. Fauna recorded include two endemics, and one threatened species (Table 3.1).

Table 3.1. Summary of the fauna recorded from the quarry site

Animal group	Families	No. of Species		Conservation status* of the species recorded			
		Total	Endemics	CR	EN	VU	NT
<u>Invertebrates</u>							
Dragonflies	3	10	1	-	-	-	-
Butterflies	5	13	1	1	-	-	-
<u>Vertebrates</u>							
Amphibians	2	2	1	-	-	-	-
Reptiles	5	6	-	-	-	-	-
Birds	4	4	-	-	-	-	-
Mammals	6	6	-	-	-	-	-
Total	25	41	2	1	4	5	8

*Conservation status follows National Redlist 2012

CR- Critically endangered

EN-Endangered

VU-Vulnerable

NT – Near Threatened

} Threatened

Complete list of endemic and threatened fauna is given in Appendix II and the detailed list of fauna recorded is given in the Appendix III.

3.1.2.2.2 Flora

A total of 72 plant species (Table 3.2) including three endemics (Table 3.3) have been recorded in the sampling area. Majority of the species recorded are shrub and herbs.

Table 3.2. Summary of the flora recorded from the quarry site

Sites	Family	Species	Life form categories					
			Tree	Small tree	Shrub	Herb	Liana	Grass
Quarry site	42	72	26	8	10	19	5	4

Most of the plants recorded are characteristic species of disturbed sites. The plant species recorded in all three sites is given in the Appendix V.

Table 3.3 Ecological status of the flora recorded from the quarry site

	Family	Species	Ecological Status				
			Native	Endemic	Cultivated	Introduced	Ornamental
Quarry site	42	72	64	3	-	5	-

Endemicity of plants is very poor (only three endemics recorded) and no threatened plants were found in the site sampled.

3.1.3 Social Environment

The site is located in Galatha GND in Udapalatha DSD in Kandy District (see Map 3.3). Table 3.4 provides basic information of the two GN Divisions where the components of the project are located.

Table 3.4

Social Variable		Gampola Wela - 1077 (According to 2012 data)	Galatha -1185 (According to 2011 data)
Total Population		2469	3456
Total Families		668	662
House Holder (Families)	F	129	14
	M	539	648
Population	Female	1283	1676
	Male	1186	1780
	Total	2469	3456
Religious Composition of the population	Buddhist	1945	2040
	Hinduism	20	1377
	Islam	40	0
	Roman Catholic	464	39
	Other	0	0
Ethnic Composition of the population	Sinhala	1942	2043
	Sri Lankan Tamil	48	16
	Indian Tamil	0	1389
	Sri Lankan Muslims	476	0
	Burger	0	8

The current landuse in the area demarcated is characterized primarily by grassland (see Map 3.4) and remains in a state of abandonment. Occasionally stray neat cattle are seen grazing in the grassland. There are no houses or any other structures within the footprint of the quarry site. There are no culturally or religiously significant places within the footprint or within the 200 m buffer zone. There are no access roads through the site.



Figure 3.13 “a” and “b” Two Houses located within the buffer zone of the Quarry site

However, the land adjacent to the site on the south side has been auctioned for residential purposes a few years ago and three houses has been constructed as holiday homes (See Figure 3.13). The access to these roads runs along the southern perimeter of the site (See Map 3.7 and Figure 3.4).

3.1.4 Issues and Impacts

3.1.4.1 Physical Environment

The impacts identified due to quarry operation and mitigation measures proposed;

Soil Erosion

Soil erosion along the slope of the quarry site is anticipated during clearing the site and removal of the overburden. This may aggravate by the existing perennial stream which is running through the quarry site.

Leaving a stable slope cut at the boundary of the quarry site and diverting the stream to one of the adjacent streams on either sides of the quarry will help to mitigate the problem. Construction of appropriate drainage system and facilitating ponding areas for sedimentation is required.

Surface Water and Soil Pollution

Soil and surface water along the streams may get polluted due to oil spills, cleaning and washing of loaders, dump trucks or other machineries operating at the quarry site.

As a large fleet of heavy vehicles are to be deployed for quarry operation and haulage of rock material and spoil material, appropriate measures to be taken to avoid pollution of the ground due to spilling of oil and other liquid wastes etc. Special areas to be maintained for maintenance of such vehicles or machineries, cleaning and washing purposes. Construction of sediment settling ponds would be required to avoid the pollution of the surface water sources.

Turbidity of the water in the stream running through the middle of the quarry site will get increased by mixing with quarry dust and the spoil material.

The stream running through the quarry to be diverted to one of the adjacent stream and maintain the quarry without water flowing through it. However, water drained through the quarry site should be diverted through a sedimentation/ settling ponds before discharging water to Mahaweli River

Air Pollution and Noise pollution

Air pollution and noise pollution are anticipated during quarry operation.

Use of efficient vehicles for drilling, loading and hauling operations, controlled blasting, wetting using sprinklers to avoid dispersion of dust etc. would be appropriate as mitigation measures.

Noise and Vibration due to Drilling and Blasting

Encouraging the contractor to limit drilling and blasting to day time, Controlled blasting, and using noise barriers such as piles of spoil material or sand bags etc., would be appropriate. However, frequent monitoring of the buildings for the occurrence of cracks or widening of the existing cracks to be carried out. Duration of blasting and drilling operations must be clearly stated in the contractor's method statement and strict vigilance to be maintained to assure the safety and freedom of the people living in the area.

Potential structural damages to the three buildings near the quarry site within the 200m buffer zone

As indicated in Map No. 3.6, the three houses are under direct threat of the structural damages from the quarry operations.

Occupants are to be temporarily evacuated and compensation be paid for the duration. Compensation or repair damages upon completion of the quarry operation (Crack survey

to be carried out before commencing quarry operation to avoid future disputes). Upon completion of the project, proper damage assessment to be done for the buildings and either compensation be paid or necessary repairs be done up to the satisfaction of the owners.

Fly rock during blasting

Threat to the safety of the road users and the users of the access road leading to the village in the upper reaches are under threat due to fly rock during blasting.

Controlled blasting is to be encouraged. Appropriate and sufficient warning to be issued (alarm signals) to the traffic and the pedestrians of the Secondary road and access road to upper reaches above the quarry site.

Sand bags, piles of debris or excavated rock or any other form of barriers can be used as a shield to minimize fly rock problem. Controlled blasting to be encouraged and appropriate and sufficient warning to be issued to the traffic on the secondary road as well as the users of the access road. Appropriate measures to be taken to ensure the safety of the users of the access road or to provide an alternative access road for them away from the hazardous area.

3.1.4.2 Biological Environment

Removal of trees

A total of 71 trees belonging to 11 species will have to be removed from the site (Table 3.5).

Table 3.5. Trees to be removed from quarry site

Family	Species	Common name	No. of trees
Fabaceae	<i>Acacia mangium</i>	Accasia	36
Fabaceae	<i>Albizia lebbek</i>	Albezia	10
Anacardiaceae	<i>Spndiasmombin</i>	Ambalanga	1
Moraceae	<i>Ficus religiosa</i>	Bo	1
Euphorbiaceae	<i>Homalanthus populifolius</i>	Ginikanda	1
Lecythidaceae	<i>Careya arborea</i>	Kahata	7
Euphorbiaceae	<i>Macaranga peltata</i>	Kenda	2
Euphorbiaceae	<i>Bridelia retusa</i>	Ketakala	1
Fabaceae	<i>Delonix regia</i>	Mi Mara	10
Moraceae	<i>Ficus benghalensis</i>	Nuga	1
Apocynaceae	<i>Alstonia scholaris</i>	Rukattana	1
Total			71

All these species are not considered as high quality timber species. Species such as *Acacia mangium*, *Albizia lebbek*, *Macaranga peltata* are low grade timber species which are mainly used for making temporary structures in construction facilities.

3.1.4.3 Social Environment

Although no houses are located inside the land demarcated for the quarry site, the three houses located in the 200 meter buffer zone need special attention as the high explosives and blasts could damage these houses both aesthetically and structurally. The owners of the houses were not available at the time of field visits to get their comments.

It is suggested, subject to further discussions and negotiations that the following steps are adopted as mitigation measures.

1. Conduct a comprehensive crack survey prior to the commencement of blasting.
2. Value the house.

3. Request the occupants to leave the houses for the duration of operation of the quarry.
4. Through negotiations with the house owners, pay a monthly allowance commensurate with the going rate for a guest houses.
5. Upon closure of the quarry, to repeat the crack survey to assess any damages caused by blasting.
6. Offer to compensate for the damages or the contractors rebuild the houses free of charge for the owners.
7. If the damage is too severe, acquire the land and compensate the owners.

The large scale blasting could have impacts on the traffic along Gampola-Kotmale road bordering the site. Thus sufficient precautions should be taken to stop the traffic sufficiently away from the site during blasting times.

3.2 Proposed Site for Contractor's Office and Camp Area

3.2.1 Physical Environment

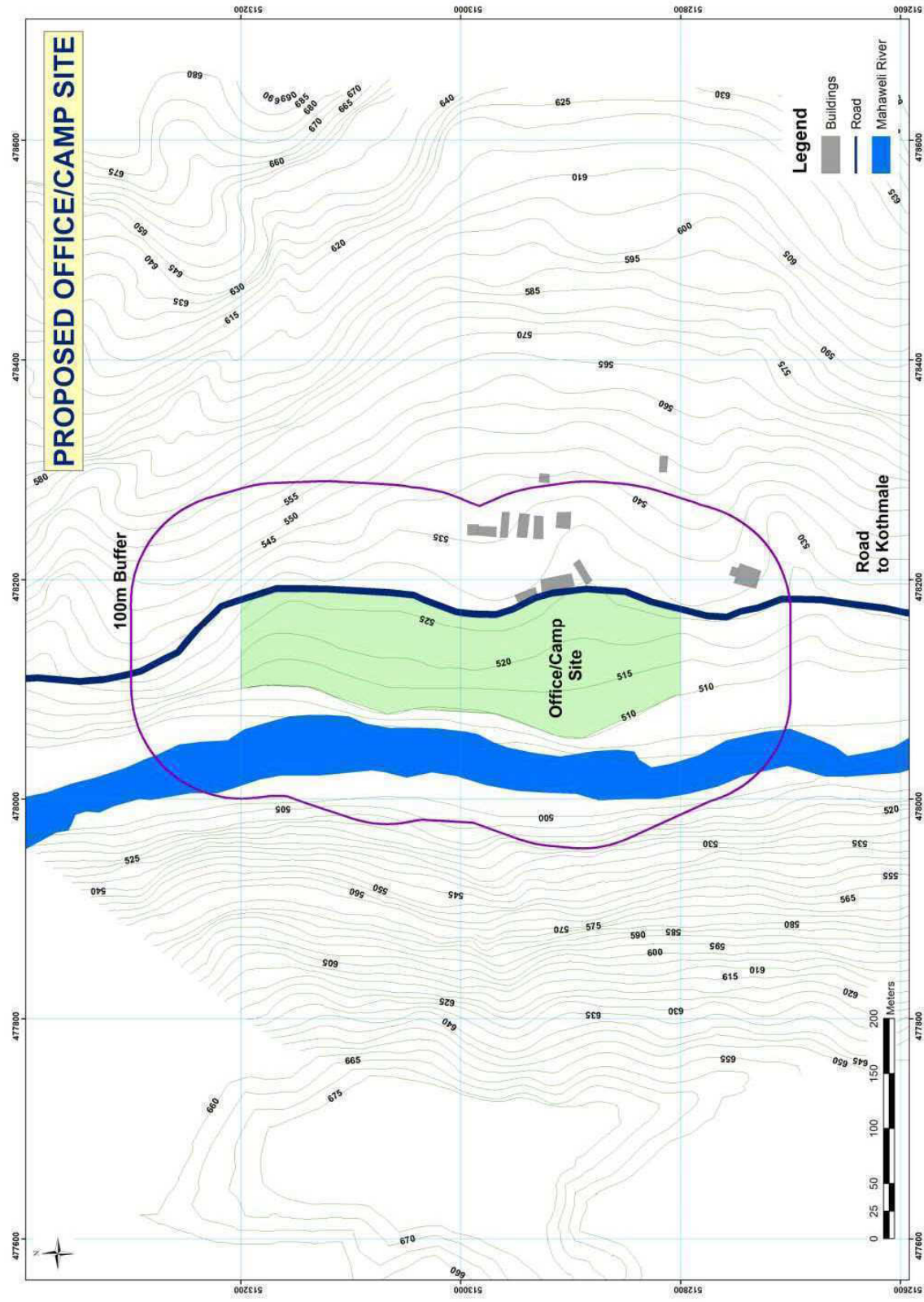
3.2.1.1 Landuse

General landuse of the area is illustrated as forest in Map No. 3.4 which is based on available 1:10,000 topographical maps prepared in 1987 by the Survey Department of Sri Lanka and subsequent field verification carried out by them in 1989. The field observations revealed that part of the forest area has been cleared for developing as religious location as well as small scale agriculture (Farm land). The existing landuse observed during the current study is illustrated in the satellite image (Map Nos. 3.7, 3.12 and 3.13) and Figure 3.14.

3.2.1.2 Topography and Drainage

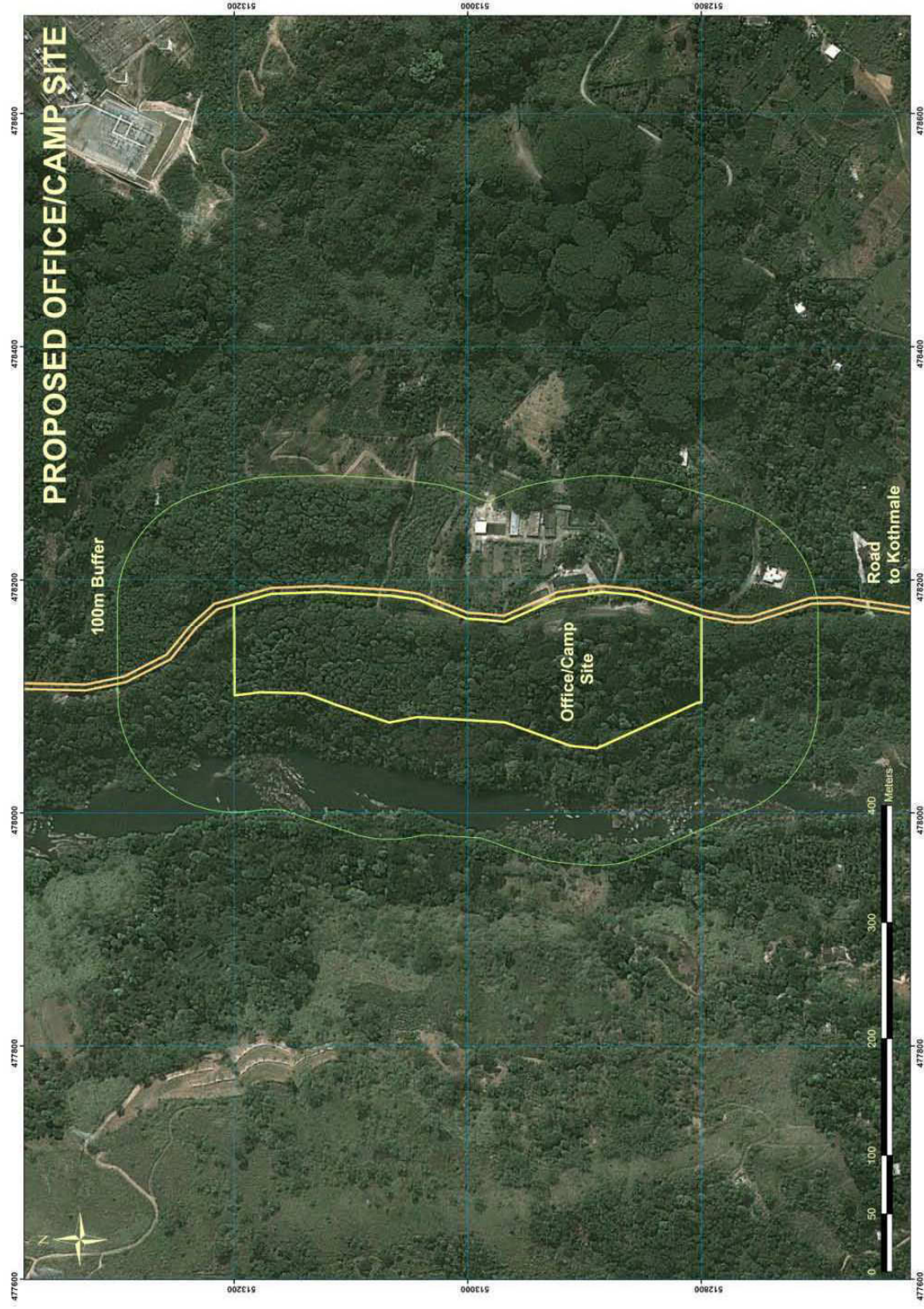
The proposed Office and camp site for Contractor is located within the immediate vicinity of the right bank of Mahaweli River at the upstream of the proposed quarry site (Figure 3.14). The designated area is generally having a flat topography (Map Nos. 3.7, 3.12 and 3.13) where elevation ranges from 510-525m above MSL except for the very steep river bank adjacent to the area. Slope map (Map No. 3.9) shows that the general gradient of the land is 0 – 10 Degrees. This area is former cultivated area and presently it is fully covered with thick vegetation. There are several small streams flowing across the camp site and join with the Mahaweli River.

This land area is formerly used for cultivation and presently fully covered with thick riverine vegetation. There are several small streams flowing across the proposed camp site and join with the Mahaweli River. Total area covered by this facility is about 0.04 km² (Map Nos. 3.12, 3.13 and Figure 3.15). A 50 m distance is to be maintained as the Reservation for Mahaweli River and, the riverine vegetation in the immediate vicinity of the river should not be disturbed (Map No. 3.13).



Map No. 3.12 Contour map of the proposed site for Contractor's Office/Camp area

Source: Survey Maps – Moragolla HEP



Map 3.13 Satellite Image of the proposed site for Contractor's Office/Camp site; 100 m buffer zone and the buildings/houses which are to be affected
Source; Google Earth Images, Survey Maps – Moragolla HEP

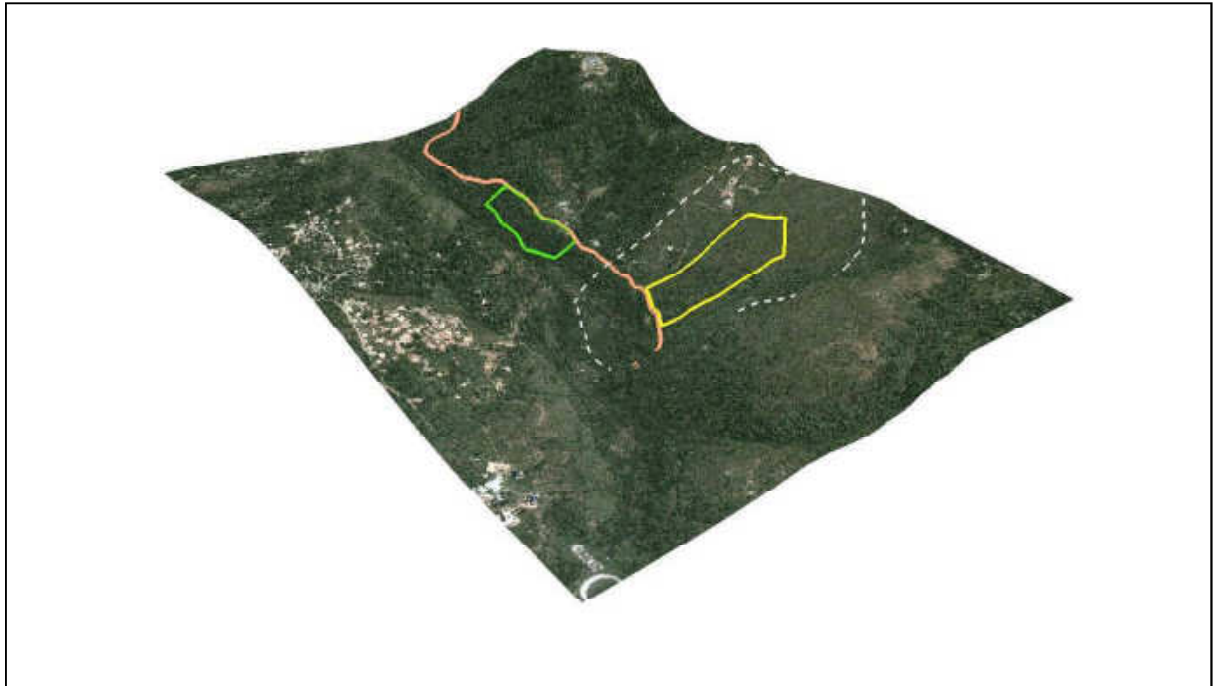


Figure 3.14 Topography at the general area for contractor's camp and office, and quarry site; 3-D perspective using 1:10,000 contour data and Google Earth Image

However, the adjacent Mahaweli River bank is very steep and appropriate precautions to be taken to avoid liquid wastes from the temporary installations, kitchens, wash rooms etc. Appropriate effluent treatment procedure to be adopted and required dilution process of 1:8 to be maintained. Suitable solid waste management plan is to be implemented to ensure that they are properly treated without dumping them in the near vicinity. Appropriate drainage facility to be maintained to divert the storm water and to avoid soil erosion upon site clearing etc.



Figure 3.15 General area for contractor's camp and office

3.2.1.3 *Geology, Structure and Slope Stability*

The entire site is underlain by thick colluviums and few outcrops of garnet biotite gneiss. Since there will not be significant excavations or blasting, there is no requirement for considering the slope stability conditions. However, according to NBRO Landslide hazard map (Map No. 3.11), the entire area lies within the area where landslides are not likely to occur and hence landslide free zone. As per the slope map for the site (Map No. 3.9), it shows that slope of the entire area surrounding the proposed site ranges from 0-10 degrees which can be categorized as almost flat terrain.

3.2.2 Biological Environment

3.2.2.1 *Site Description*

Area between the Mahaweli River and the Gampola-Kotmale road between 4 -5km post was sampled (Figure 3.16). However, sampling did not continue up to the river. A 50m wide stretch of vegetation along the river was not sampled as this region would be preserved as the river reservation.



Figure 3.16 Area selected for the construction of Office/camp site and workers quarters etc.

Macaranga peltata (Kenda) form the dominant tree canopy (cover) in the site (Figure 3.17). *Macaranga peltata* is an early colonizer of a disturbed site and hence it could be assumed that this site may have been subjected to anthropogenic disturbance sometimes back. The field survey team has noted scatted concrete rubbles across the sampling area. The villagers inform the survey team that this area was used as a spoil dumping site during the construction of Kotmale dam. *Alstonia macrophylla* (Havarinuga) and *Albizia falcataria* (Albizia) are the other dominant tree species in the site.



Figure 3.17 *Macaranga* dominant tree cover in the site selected for the construction of workers camp



Figure 3.18 *Clidemia hirta* (Katakalu bovitiya), dominant ground cover in the site

The ground cover of the site mainly consists of *Clidemia hirta* (Katakalu bovitiya), which is an alien invasive species (Figure 3.18).

3.2.2.2 Current Status of Fauna and flora

3.2.2.2.1 Fauna

A total of 71 faunal species in 40 families were recorded from the site selected for the construction of worker's camp. Fauna recorded include 20 endemics, two proposed endemics and six threatened species (Table 3.6). This site supports comparatively a higher faunal richness. The site has a good tree (canopy) cover and a moist forest floor which are favourable habitats for many species of animals. Species such as *Suncus zeylanicus* and *Ratufa macroura* have been recorded from this site. These two species have not been recorded during the EIA study for the project area. List of endemic and threatened fauna is given in Appendix II and the detailed list of fauna recorded is given in the Appendix III.

Table 3.6 Summary of the fauna recorded and their conservation status

Animal group	Families	No. of Species		Conservation status* of the species recorded			
		Total	Endemics	CR	EN	VU	NT
<u>Invertebrates</u>							
Land Molluscs	2	5	3	-	-	1	2
Dragonflies	2	6	-	-	-	-	-
Butterflies	4	11	1	-	1	1	-
<u>Vertebrates</u>							
Amphibians	2	5	5	-	1	-	-
Reptiles	5	10	4	-	-	-	-
Birds	16	24	5+2 [‡]	-	-	1	1
Mammals	9	10	2	-	1	1	-
Total	40	71	20+2	-	3	3	7

*Conservation status follows National Redlist 2012

CR- Critically endangered

EN-Endangered

VU-Vulnerable

NT – Near Threatened

‡ Proposed endemic

} Threatened

3.2.2.2.2 Flora

A total of 73 plant species including three endemics have been recorded in the sampling area (Table 3.7).

Table 3.7 Summary of the flora recorded from the camp site

Site	Family	Species	Life form categories					
			Tree	Small tree	Shrub	Herb	Liana	Grass
Camp site	41	73	32	10	9	15	7	1

Most of the plants recorded are characteristic species of disturbed sites (Table 3.8). List of plant species recorded in is given in the Appendix V.

Table 3.8 Ecological status of the flora recorded from the camp site

Site	Family	Species	Ecological Status				
			Native	Endemic	Cultivated	Introduced	Ornamental
Camp Site	41	73	60	3	2	6	2

Endemicity of plants is very poor (only three endemics recorded) and no threatened plants were found in the site sampled.

3.2.3 Social Environment

The site is located in Gampolawatte GND in Udapalatha DSD in Kandy District (see Map 3.3). Table 3.9 provides basic information of the two GN Divisions where the components of the project are located.

Table 3.9 Social variables in Gampola Wela and Galatha as per 2012 and 2011 data

Social Variable		Gampola Wela -1077 (According to 2012 data)	Galatha - 1185 (According to 2011 data)
Total Population		2469	3456
Total Families		668	662
House Holder (Families)	F	129	14
	M	539	648
Population	Female	1283	1676
	Male	1186	1780
	Total	2469	3456
Religious Composition of the population	Buddhist	1945	2040
	Hinduism	20	1377
	Islam	40	0
	Roman Catholic	464	39
	Other	0	0
Ethnic Composition of the population	Sinhala	1942	2043
	Sri Lankan Tamil	48	16
	Indian Tamil	0	1389
	Sri Lankan Muslims	476	0
	Burger	0	8

The site is located in a narrow stretch of land between the Mahaweli River and the Gampola-Kotmale road(see Map 3.4) and the land remains in a state of abandonment. There are no houses or any other structures within the foot print of the contractor's office and camp area.

A Buddhist Shrine and an old Bo tree (a tree sacred to the Buddhists) are located within the foot print bordering the main road. Although there are no permanent temples here, the land between the Bo Tree and Shrine room is paved and during the religiously sacred days, devotees come here to observe “*sil*” and to practice meditation. During

the interviews, the people did not object to the proposed construction but they insisted that the project develop the site and allow unhindered access to it at all times.

A government agricultural farm, popularly known as “Hadabima” is located within the 100 meter buffer zone on the eastern side of the site and the main road (see Map 3.4 and 3.7). However, as this complex is located on the other side of the main road, it is less likely to be affected by the construction work. The officers in the Hadabima complex also did not object to the project but they were concerned about the possible traffic congestion, especially at the entrance gate which is located almost in front the proposed site.

3.2.4 Issues and Impacts

3.2.4.1 Physical Environment

The impacts identified due to clearing the site, construction of temporary structures and operation period and mitigation measures proposed;

Soil Erosion

Soil erosion at the site is anticipated during clearing the site for contractor’s camp/Office area on the right bank of Mahaweli River along the narrow strip of land between the river and secondary road.

Carrying out this site clearing and excavations during dry period is encouraged to minimize soil erosion. Construction of appropriate drainage system to divert storm water and the water to be discharged from the facility can mitigate the problem.

Pollution of Groundwater and soil overburden

Groundwater and soil pollution due to effluents discharged from the sanitary facilities, liquid wastes from the temporary installations, kitchens, wash rooms, vehicle yards etc. Appropriate effluent treatment procedure should be adopted and required dilution process of 1:8 to be maintained for the discharging liquid wastes if any. Suitable solid waste management plan to be implemented to ensure that they are properly handled without dumping them in the near vicinity which may eventually be washed out to the Mahaweli River.

Surface Water and Soil Pollution

Soil and surface water along the streams may get polluted due to oil spills, cleaning and washing of machineries (loaders, dump trucks or other machineries) operating at the quarry site and other construction sites.

As a large fleet of heavy vehicles are to be deployed, appropriate measures to be taken to avoid pollution of the soil and surface water due to spilling of oil and other liquid wastes etc. Special areas should be maintained for maintenance of such vehicles or machineries.

3.2.4.2 Biological Environment

Removal of trees

One hundred eighty seven (187) trees (in 18 species) will have to be removed from the site designated for the construction of camp site (Table 3.10).

Table 3.10. Trees to be removed from the camp site

Family	Species	Common name	No. of trees
Anacardiaceae	<i>Mangifera indica</i>	Amba	1
Apocynaceae	<i>Alstonia macrophylla</i>	Hawarinuga	25
Bignoniaceae	<i>Spathodea campanulata</i>	Spathodia	4
Combretaceae	<i>Terminalia catappa</i>	Bulu	8
Combretaceae	<i>Terminalia arjuna</i>	Kumbuk	3
Euphorbiaceae	<i>Mallotus tetracoccus</i>	Bu kanda	4
Euphorbiaceae	<i>Macaranga peltata</i>	Kenda	74
Fabaceae	<i>Acacia mangium</i>	Accasia	15
Fabaceae	<i>Albizia falcataria</i>	Albizea	28
Fabaceae	<i>Albizia lebbeck</i>	Hurimara	1
Fabaceae	<i>Delonix regia</i>	Mi Mara	9
Leguminoseae	<i>Gliricidia sepium</i>	Ginisiriya	4
Magnoliaceae	<i>Michelia champaca</i>	Sapu	2
Moraceae	<i>Ficus exasperata</i>	Budeliya	1
Moraceae	<i>Artocarpus nobilis</i>	Waldel	2
	<i>Petrospermum</i>		
Sterculiaceae	<i>suberifolium</i>	Welan	1
Tiliaceae	<i>Grewia damine</i>	Daminiya	3
Verbenaceae	<i>Vitex altissima</i>	Milla	2
Total			187

Of the species needs to be removed *Terminalia arjuna*, *Vitex altissima*, *Michelia champaca* are valuable timber species. *Terminalia arjuna* is a water lowering species and considered to be important in strengthening stream banks. It is legally prohibited to cut this species and hence approval from the Forest Department will be required to cut and remove this species. Few other species such as *Alstonia macrophylla*, *Macaranga peltata*, and *Acacia mangium* are low grade timber species.

Environmental Impact Assessment Report of the Moragolla Hydropower Project (CEB, 2012) indicates that 18 trees (>20 cm DBH) needs to be removed from the site originally identified for the construction of the camp site.

3.2.4.3 Social Environment

The Buddhist Shrine and the Bo Tree should not be disturbed as it is a culturally very sensitive. The following steps are suggested

1. Construct a wall separating the shrine and Bo tree from the contractors office and camp complex.
2. Discuss with the local civic leaders and the meditators and provide a better surface as the existing cement surface is heavily damaged.
3. Construct a small hall with a roof so that religious observers and meditators can practise even under bad weather.
4. Construct a modern toilet for the benefit of the devotees who come for religious observances and meditation.
5. The project should also ensure that the entrance to the Hadabima will not be obstructed during the construction period.

3.3 Proposed Site for Spoil Dumping

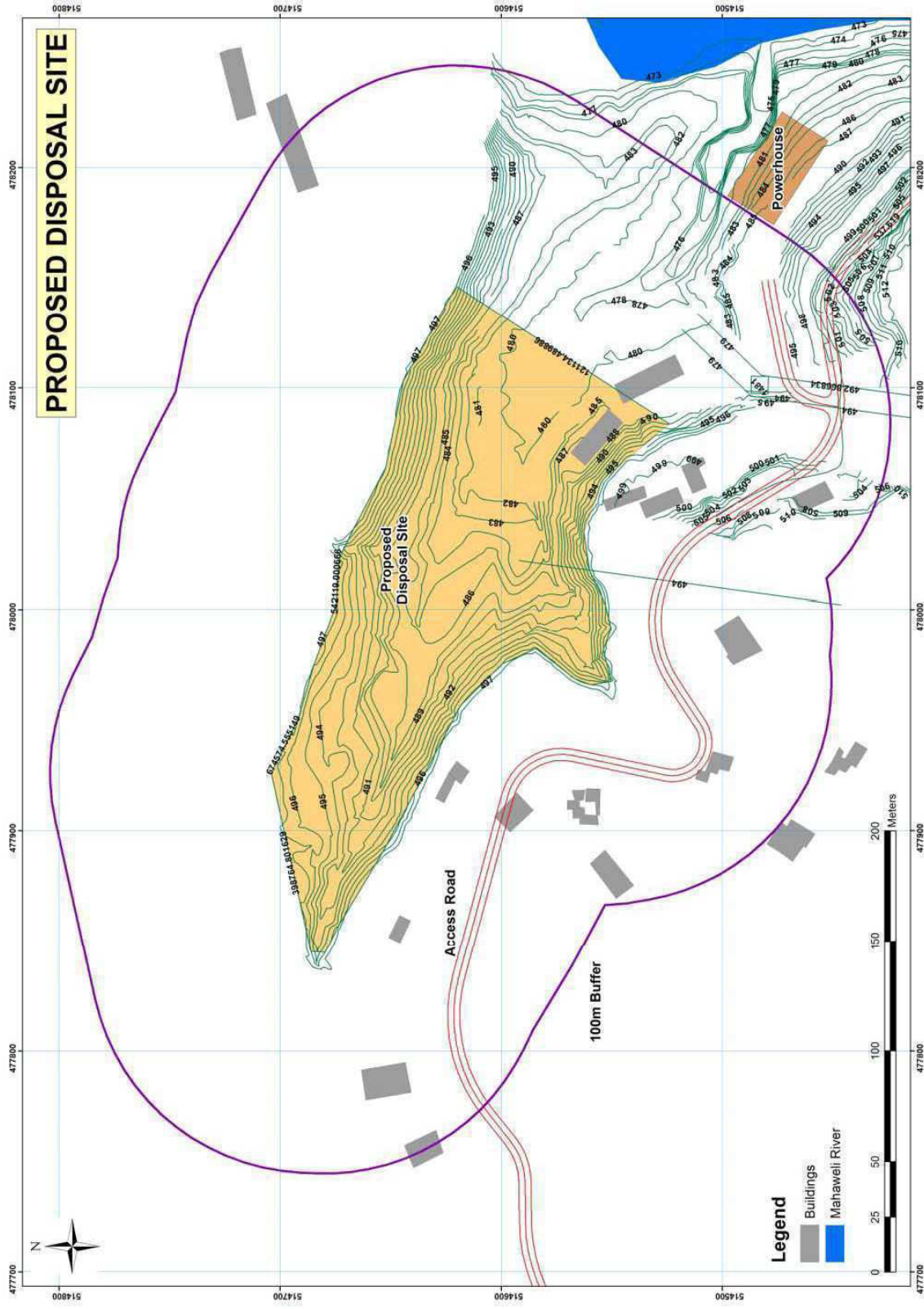
3.3.1 Physical Environment

3.3.1.1 *Topography and Drainage*

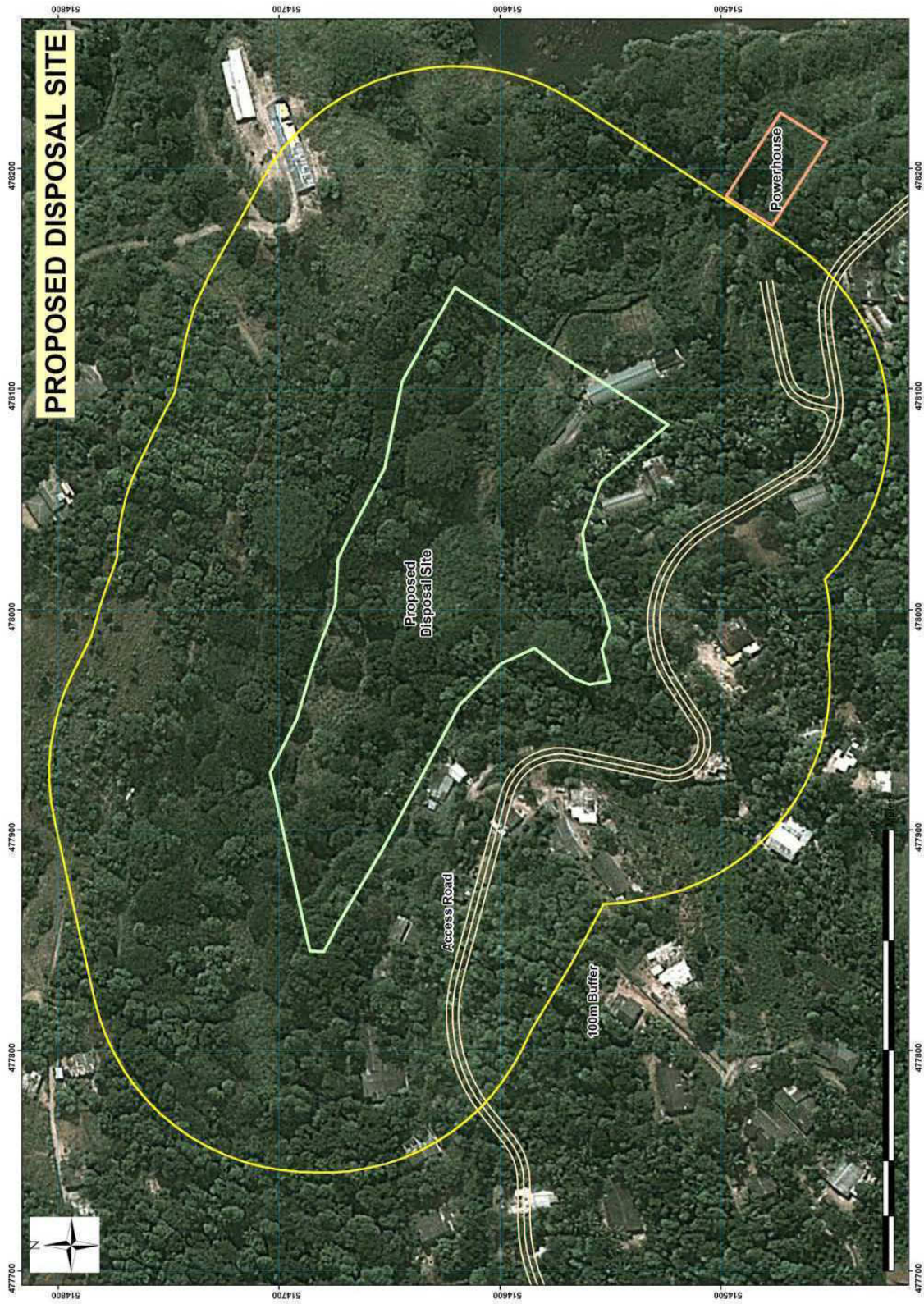
Proposed dumping site is located in a low land along a valley of the small stream just downstream of the power house at Ethgala. The area is surrounded by higher grounds where elevation of the area ranges from 475 m to 500 m above MSL showing a 25 m relief difference. Western side of the upstream part of the valley consists of gentle slope showing irregular patterns due to the colluviums of old landslides (Map No. 3.14 and 3.15).

As per the slope map for the site (Map No. 3.9), it shows that slope of the entire area surrounding the proposed quarry site ranges from 10-30 degrees which can be categorized as gentle slope. However, some sections of the slopes adjacent to the stream valley are as steep as 30-40 degrees.

Constructed irrigation channel follows the higher elevation contour line around the proposed dumping site. There are few streams flowing across the proposed dumping site and, gullies are developed due to the leakage flow of the irrigation channel around dump site (Figure 3.19). These are connected with main stream flowing towards southeast direction. Lowest part of the area consists of flood plain and stream shows irregular patterns in this region. The general topography is consisting valleys with steep slopes. Slopes in the area vary from gentle to steep slopes. Map No. 3.15 and Figure 3.20 shows the general topography of the area.



Map 3.14 Contour map of the proposed dumping/disposal site; 100 m buffer zone and the buildings/houses which are to be affected
Source; Survey Maps – Moragolla HEP



Map 3.15 Satellite image of the proposed dumping/disposal site Source; Google Earth Images, Survey Maps – Moragolla HE



Figure 3.19 Left; Irrigation cannel along the upper level of the spoil bank; Right; Area to be filled during dumping operation.

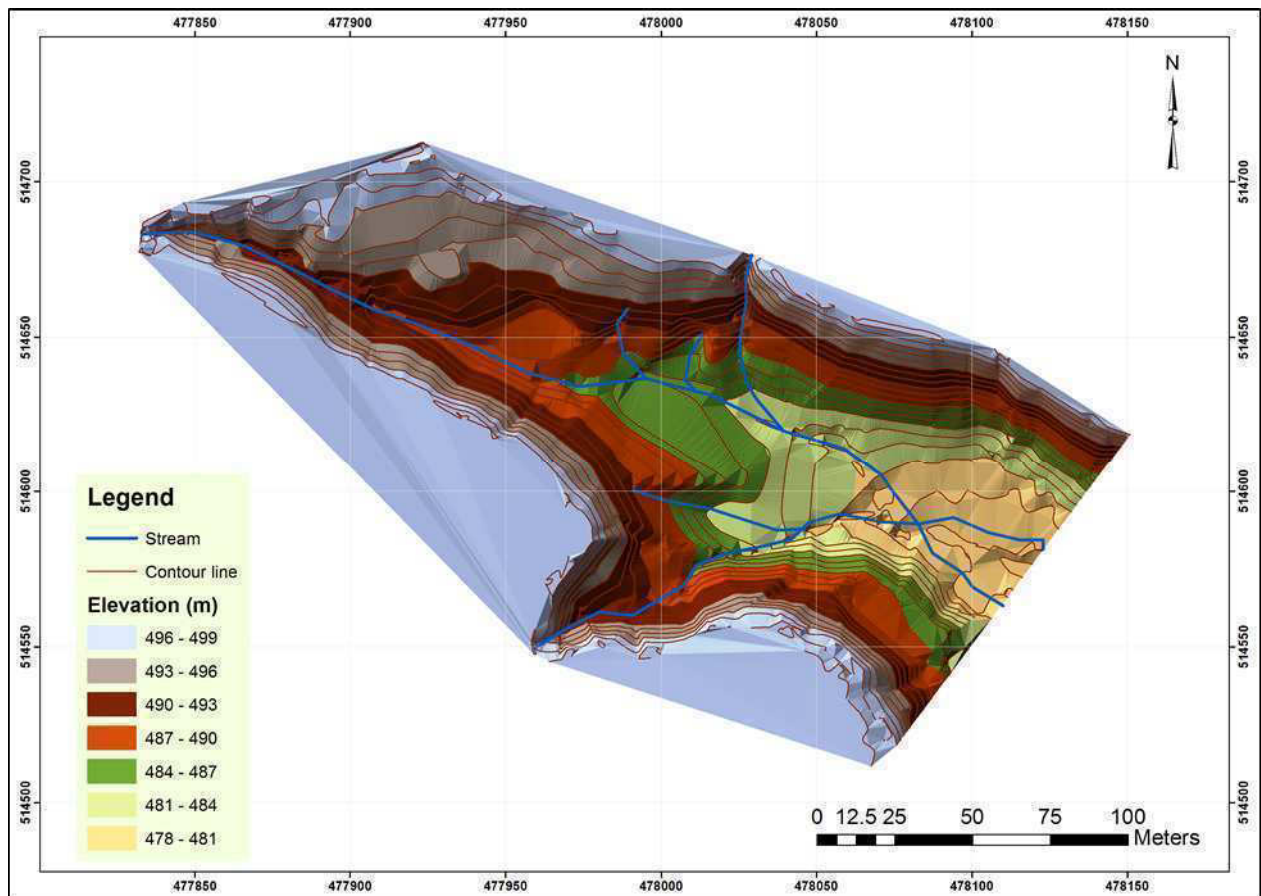


Figure 3.20 Digital Elevation Model for the proposed dumping site showing topography of the area

3.3.1.2 Geology, Structure and Slope Stability

Generally the area consists of two types of high grade metamorphic rocks namely charnockitic gneiss as lower rock formation and khondalite as upper formation. Charnockitic gneiss rock is exposed in the valley in the upstream (Figure 3.21). Khondalite exposure is observed in the escarpment slope on the left bank of irrigation channel (Figure 3.21). General strike of the Northwest region shows that the rocks dip towards Northwest and Northeast directions.

There are three types of subsurface soil in the proposed dumping site. They are alluvial soils transported into the lower flood plains, residual soil that is a product of weathering of underlain basement rock and colluviums soil transported by gravity. The alluvial deposit comprises of boulders, coarse gravels, sand and clay (Figures. 3.21 and 3.22).



Figure 3.21 Charnockitic gneiss exposure and the Khondalite exposure along the stream



Figure 3.22 Alluviums in the flood plain; Coarse gravel and boulders along the valley

According to the landslide hazard map of NBRO, the area is categorized as an area landslides are not likely to occur (map No. 3.9). However, prior to commence dumping operation, carefully laid subsurface drainage system to be introduced for this stream valley. Diameter and the sizes etc. will have to be determined considering the flow rates of this stream during heavy rain fall. The existing irrigation channel should be properly protected in order to avoid any damage, possibly replacing with a sub surface concrete channel.

3.3.2 Biological Environment

3.3.2.1 Site description

The site is located between the “Dunhinda Ela” (which is a part of the Gampola Wela Raja Ela Scehme” and the left bank of the Mahaweli River in Ethgala village (Figure 3.23). The area has been used in the past to cultivate *Piper nigrum* (Gammiris). Pepper cultivation in the area has been abandoned sometimes back. *Gliricidiasepium* (Giniseria) sticks planted as a support for the piper veins now have grown in to moderate size trees and dominate understory layer of the site.



Figure 3.23 Planted *Gliricidiasepium* (Giniseria) fence along the irrigation channel Gampolawela Raja Ela.

Macaranga peltata (Kanda) has established well in the site and form the dominant tree cover of the site. The other tree species found in considerable numbers in the site is *Swietenia mahagoni* (Mahogany) which has also colonized the abandon land. The ground cover of the land mainly consists of panicum grass (*Panicum maximum*) (Figure 3.24)



Figure 3.24 *Macaranga* dominant tree cover and the *Panicum* covered ground layer in the site

3.3.2.2. Current Status of Fauna and Flora

3.3.2.2.1 Fauna

A total of 64 faunal species in 41 families were recorded from the site. Fauna recorded include 10 endemics, 1 proposed endemic and four threatened species (Table 3.11). List of endemic and threatened fauna is given in Appendix II and the detailed list of fauna recorded is given in the Appendix III.

Table 3.11 Summary of the fauna recorded from the spoil dump site and their conservation status

Animal group	Families	No. of Species		Conservation status* of the species recorded			
		Total	Endemics	CR	EN	VU	NT
<u>Invertebrates</u>							
Land Molluscs	3	6	2	-	-	-	1
Dragonflies	3	8	1	-	-	-	-
Butterflies	4	10	1	-	1	-	-
<u>Vertebrates</u>							
Amphibians	3	4	2	-	1	-	-
Reptiles	6	10	2	-	-	1	1
Birds	16	20	2+1 [‡]	-	-	-	2
Mammals	6	6	-	-	-	-	-
Total	41	64	10+1 [‡]	1	2	1	4

*Conservation status follows National Redlist 2012

CR- Critically endangered
 EN-Endangered
 VU-Vulnerable

} Threatened

NT – Near Threatened

‡Proposed endemic

Summary of the fauna recorded in all three sites is given in Appendix IV.

3.3.2.2.2 *Flora*

A total of 80 plant species including two endemics have been recorded in the sampling area (Table 3.12).

Table 3.12 Summary of the flora recorded from the spoil dump site

Site	Family	Species	Life form categories					
			Tree	Small tree	Shrub	Herb	Liana	Grass
Dump site	42	80	33	11	15	12	7	2

Most of the plants recorded are characteristic species of Kandyan home gardens which also include some ornamental species. Spoil dump site harboured the highest number of cultivated, introduced and ornamental species (Table 3.13). The plant species recorded in is given in the Appendix V.

Table 3.13 Ecological status of the flora recorded from the spoil dump site

Site	Family	Species	Ecological Status				
			Native	Endemic	Cultivated	Introduced	Ornamental
Spoil dump site	42	80	59	2	9	6	4

Kandyan home gardens are known to support high plant diversity as they include both planted species (such as herbs, spices, ornamental plants as well as some economically important timber species as well as naturally occurring species). This site contain a combination of native species as well as cultivated and the introduced ornamental species. Endemicity of plants is very poor (only for endemics recorded) and no threatened plants were found in the sites sampled.

Summary of the flora recorded from all three sites is given in the Appendix VI and ecological status of the flora recorded from all three sites is summarized in Appendix VII.

3.3.3 Social Environment

The site is located in Gampola Wela GND in Ganga Ihala Korale DSD in Kandy District (see Map 3.3). Table 3.14 provides basic information of the two GN Divisions where the components of the project are located.

Table 3.14 Social variables at Gampola Wela and Galatha as per the 2012 and 2011 data

Social Variable		Gampola Wela 1077 (According to 2012 data)	Galatha -1185 (According to 2011 data)
Total Population		2469	3456
Total Families		668	662
House Holder (Families)	F	129	14
	M	539	648
Population	Female	1283	1676
	Male	1186	1780
	Total	2469	3456
Religious Composition of the population	Buddhist	1945	2040
	Hinduism	20	1377
	Islam	40	0
	Roman Catholic	464	39
	Other	0	0
Ethnic Composition of the population	Sinhala	1942	2043
	Sri Lankan Tamil	48	16
	Indian Tamil	0	1389
	Sri Lankan Muslims	476	0
	Burger	0	8

The current land use in the area demarcated is characterized primarily by thick home gardens (see Map 3.12). On the proposed site there is a complex of green houses growing vegetables for the local super markets and for export (see Figures 3.25 and 3.26).



Figure 3.25: Greenhouse that will be affected



Figure 3.26: Greenhouse that will be affected



Map 3.12: Home gardens in the Proposed Spoil Bank Site.

The owners of the land and the proprietor of the green houses were willing to allow the project to dump the spoil on their land located on a valley and in return, they expect the following

1. A reasonable compensation for the monthly loss of income. The compensation value is to be negotiated taking into account the current production levels.
 2. The spoil dumping should be done in such a way that upon completion, the utility and the value of the land should increase. Thus spoil dumping ground should be terraced and levelled for them to recommence their business.
 3. At least a few member of this family is to be provided with jobs in the project.
- There are no other houses or structures in the spoil dumping area.

The access road from Gampola-Nawalapitiya road through the spoil dump to the proposed powerhouse has already been dealt in the original EIA.

3.3.4 Issues and Impacts

3.3.4.1 Physical Environment

The impacts identified due to clearing the site and dumping operation and mitigation measures proposed;

Soil Erosion

Soil erosion is anticipated during clearing the site and dumping spoil material. Maintaining a stable slope at the boundary of the operation of dumping site and diverting the stream through sub surface Hume pipe (with appropriate diameter) beyond the designated dumping area will help to mitigate the problem to most extent.

3.3.4.2 Biological Environment

Removal of trees

One hundred sixty one (161) trees (in 21 species) need to be removed from the spoil dump site (Table 3.15).

Table 3.15 Trees to be removed from the spoil dump site

Family	Species	Common name	No of trees
Anacardiaceae	<i>Mangifer aindica</i>	Amba	1
Anacardiaceae	<i>Anacardium occidentale</i>	Kaju	1
Apocynaceae	<i>Alstonia macrophylla</i>	Hawarinuga	1
Bigoniaceae	<i>Spathodea campanulata</i>	Spathodia	5
Euphorbiaceae	<i>Mallotus tetracoccus</i>	Bukenda	3
Euphorbiaceae	<i>Macaranga peltata</i>	Kanda	59
Euphorbiaceae	<i>Hevea brasiliensis</i>	Rubber	2
Fabaceae	<i>Albizia falcataria</i>	Albezia	2
Fabaceae	<i>Erythrina sabumbrans</i>	Eramudu	3
Fabaceae	<i>Gliricidia sepium</i>	Ginisiriya	28
Lauraceae	<i>Persea americana</i>	Alipera	5
Lauraceae	<i>Neolitsea cassia</i>	Kududawula	2
Lauraceae	<i>Cinnamomum capparau</i>	Kurundu	2
Magnoliaceae	<i>Michelia champaca</i>	Sapu	2
Meliaceae	<i>Swietenia mahagoni</i>	Mahogany	27
Moraceae	<i>Ficus asperrima</i>	Budaliya	6
Moraceae	<i>Artocarpus nobilis</i>	Del	1
Moraceae	<i>Artocarpus heterophyllus</i>	Kos	2
Sapindaceae	<i>Filicium decipiens</i>	Pihimbiya	1
Tiliaceae	<i>Grewia damine</i>	Damanu	3
Ulmaceae	<i>Trema orientalis</i>	Gadumba	5

Species such as *Michelia champaka*, *Artocarpus heterophyllus*, and *Filicium decipiens* are naturally occurring valuable timber species in Kandyan home gardens.

Total number of trees to be removed from all three sites is summarized in Appendix VIII.

Environmental Impact Assessment (EIA) Report of the Moragolla Hydropower Project (CEB, 2012) states that 15 trees should be removed from five sites originally selected for spoil dumping.

The EIA report state that a total of 489 trees need to be removed due to various project activities. From the sites originally designated for camp site and spoil dumping, 33 trees were identified for removal. Since new sites have been identified for quarrying, workers camps and spoil dumping, the number of tree to be removed from the original list could be reduced to 456 (i.e. 489-33).

3.3.4.3 *Social Environment*

Although, spoil dumping activity, at first glance, seems to be a negative activity, at this location, it will be a positive activity as the filling up of a land that is currently underutilized will first increase its land value and second it opens up new opportunities to use the land.

Two issues that can arise by the spoil dump is the final decision on the compensation package to be given to the owners of the land of the dump site.

1. The project needs to get comprehensive and accurate details on the legal ownership of land. Most rural lands in the central highland have multiple owners although all of them may not occupy the land. However, when issues of compensation arise, these “hidden” owners may surface and could create legal hurdles.
2. The actual determination of the compensation package can also become an issue. Since there is no acquisition of lands involved, it is best that the project enters into an agreement with the affected party on a mutually acceptable basis.

4 CONCLUSIONS

This study assessed the physical, biotic and social status of the locations where the quarry, construction offices and spoil bank are located and possible impacts due to the construction and operation of activities in these sites.

The existing environment of all three sites has been used for various purposes in the past. The study found that the three activities will not lead to the loss of any sensitive ecological resources.

The study revealed several negative and positive impacts arising from the construction activities of the three sites.

Environmental Component	Positive or Negative	Impact
Physical	Negative	Soil Erosion
	Negative	Surface Water Pollution
	Negative	Air pollution and Noise pollution and vibration
	Negative	Noise and Vibration due to Drilling and Blasting
Biological		No significant impacts except removal of some trees
Social	Positive	Increased employment to the local people who will be hired to work at the three sites
	Negative	Temporary evacuation of three houses near the quarry site
	Negative	Potential structural damages to the three buildings near the quarry site
	Negative	Loss of the Green houses at the spoil dump site and thus an income source to one family
	Positive	Reclamation of land to be economically more valuable at the spoil dump site upon completion of work
	Negative	Threat to the safety of the road users and the users of the access road

However all these impacts can be mitigated to acceptable levels as can be seen from the table below.

Impact	Mitigation
Soil Erosion	Divert the stream running through the quarry to one of the adjacent stream Construction of appropriate drainage systems at all sites.
Surface Water and soil Pollution	Divert the stream running through the quarry to one of the adjacent stream Appropriate measures to be taken to avoid pollution of the ground due to spilling of oil and other liquid wastes etc. Construction of sedimentation/ settling ponds and discharge water to Mahaweli River
Air Pollution and Noise pollution	Use of efficient vehicles Controlled blasting Wetting using sprinklers to avoid dispersion of dust
Noise and Vibration due to Drilling and Blasting	Controlled blasting, Blasting to be limited to definite time gap, Avoid blasting during night time,
Removal of some trees	Initially unavoidable but reforestation and after reclaiming the quarry site. Maintain 50 m riverine buffer zone undisturbed
Increased employment to the local people who will be hired to work at the three sites	No mitigation needed
Temporary evacuation of three houses near the quarry site	Compensation during the temporary evacuation.
Potential structural damages to the three buildings near the quarry site	Temporary evacuation, Compensation or repair damages upon completion of the quarry operation (Crack survey to be carried out before commencing quarry operation)
Loss of the Green houses at the spoil dump site and thus an income source to one family	Compensation and assisting in rebuilding after completion of the reclamation.
Reclamation of land to be economically more valuable at the spoil dump site upon completion of work	No mitigation needed
Threat to the safety of the road users and the users of the access road	Controlled blasting, Sufficient warning to be issued to the traffic and the Users of the access road, Use piles of debris or excavated rock as a shield to minimize fly rock

The study found that the project does not lead to resettlement (only temporary evacuation of three houses) and thus preparation of a resettlement action plan is not necessary. Those who were affected did not oppose the project but expect reasonable compensation. The project needs to negotiate with the affected people regarding compensation.

If the above stated mitigation measures are complied with, the severity of the impacts can be avoided and or minimized.

APPENDICES

APPENDIX 1: TOR

MORAGOLLA HYDROPOWER PROJECT REVIEW OF FEASIBILITY STUDY AND PREPARATION OF DETAILED DESIGN & BIDDING DOCUMENTS TERMS OF REFERENCE FOR ADDITIONAL STUDIES IN THE NATURAL ENVIRONMENT SURVEY OF THE ENVIRONMENTAL FEATURES OF NEW PROJECT SITES

1. BACKGROUND

The Ceylon Electricity Board (CEB) plans to develop a new 30.8 MW hydropower project at Moragolla in Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha, 1.98 MCM reservoir with a Full Supply Level (FSL) at 548 masl. Water will be diverted through a 3 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya (see land-use map, Attachment 1).

A Feasibility Study (FS) for the project was conducted in 2009, and this included an Environmental Impact Assessment (EIA)¹, which is expected to be approved by the Mahaweli Authority of Sri Lanka (MASL) in the near future. In 2012 CEB appointed Nippon Koei Co., Ltd. (NK) to review the FS and prepare detailed designs and tender documents for project construction and to upgrade the EIA to comply with the Safeguard Policy² of the Asian Development Bank, the principal funding agency.

To upgrade the EIA, surveys were conducted in certain key fields in 2013, to supplement existing baseline data and update the assessment of impacts. Some further study is now needed, so that mitigation measures can be properly planned and designed.

¹ Ceylon Electricity Board (2012): *Moragolla Hydropower Project, Feasibility Study*. Final Report: Volume 3 Environmental Impact Assessment (Central Engineering Consultancy Bureau, Sri Lanka and Al-Habshi Consultants Office, Kuwait), November 2012.

² Asian Development Bank (2009) *Safeguard Policy Statement*. ADB, Manila, 90pp. (<http://www.adb.org/site/safeguards/policy-statement>).

2. RATIONALE

The EIA report describes the main physical, biological and social features of areas that will be directly affected by the project, assesses the impacts of activities to be conducted at each site, and proposes mitigation for negative impacts. This includes five areas that were under consideration at that time for the disposal of tunnel muck and other excavated spoil. Certain additional sites (for spoil dumping, quarrying and the Contractors' area) have been identified during the FS Review, so the impacts of these activities in these areas now need to be assessed. The surveys described in these ToR will provide baseline data for that assessment.

3. SCOPE OF WORK

1. This work will be conducted by a nationally-recognised environmental consultancy company, with 10 years or more of professional experience in environmental survey, analysis, data interpretation and report preparation, including extensive experience of assessing the physical, biological and social features of terrestrial sites.

2. The field survey work shall be led by three senior experts, who have 15 years or more of research and consultancy experience in Sri Lanka in: a) field geology/topographic studies; b) terrestrial ecology (flora and fauna); and c) rural social studies. Each expert should also have an appropriate record of academic publications in refereed journals.

3. The senior experts and any necessary support staff shall visit each of the areas shown on the attached maps (Attachment 2) and should conduct sufficient qualitative site observations and investigations to enable them to confidently describe the main features and importance of each site in each of these fields. The investigation should include but not be limited to:

Physical: topography, drainage, geology, distance from Mahaweli Ganga and inflowing streams.

Biology: flora, fauna, habitats and their importance, type and number of trees.

Social: location and proximity of any houses, commercial or industrial buildings, other infrastructure, or locations or features of community importance at or near the site or alongside likely access routes.

4. The results of the surveys shall be presented and discussed in a report, which shall be set out as shown in Box 1 below. The text should be divided into each of the main sections indicated (Executive Summary, Introduction, etc) and each section should be

further subdivided as necessary. The text in each section should cover at least the topics shown in the annotations, plus any other topics necessary to provide an informed discussion of the issues.

5. The report should be written in the style of an academic paper and should be concise and informative and written in grammatically correct, good quality English.
6. Significant statements should be substantiated by reference to the relevant literature where appropriate, and all references should be provided in full in the bibliography
7. Readers of the report will be professional persons, but not experts in geology, ecology or social studies, so any technical terms must be explained in footnotes or a glossary.
8. Species should be referred to in the text by their scientific name and common English name; local names may also be shown if species are listed in tables. All names must be spelled correctly whenever they are used.
9. The report should be illustrated by maps, photographs, graphs, tables of data, etc and other forms of presentation as appropriate.

4. PROGRAMME

The work will be conducted over a period of one month in August and September 2013. The draft report will be submitted to NK on or before 13 September 2013: 3 hard copies and 1 soft copy (in a single MS Word file). NK will review the report and provide their comments, which the contractor shall address in full within two weeks of receipt. The contractor shall then submit the final version of the report: 3 hard copies and 1 soft copy (in a single MS Word file).

Box 1: Layout and content of report on the Environmental Features of new sites being considered for spoil disposal, quarrying and other project activities.

EXECUTIVE SUMMARY	Concise summary of the report, key findings and recommendations.
INTRODUCTION	The project; reasons for this study; aims and objectives.
APPROACH	How this work was done. Full written descriptions of: site observations; sample collection and analysis; identification of species, rock samples; etc. With a map of the site locations(with boundaries plotted accurately).
SITE DESCRIPTIONS	A detailed description of each site individually, dealing in each case with: 1. Physical Features; 2. Ecology; and 3. Social Environment. Each section should deal with those aspects specified in Item 3 of the Scope of Work, plus any others that are relevant. Any important or sensitive features should be clearly identified, and the reasons for their importance should be explained. Discussions should be illustrated with photographs of each site and any key features, tables of data, etc.
CONCLUSION	Overall conclusions regarding the characteristics of each site and any important features.
APPENDICES	ToR; tables of all data collected; any other supporting material that is too large to include in the text.

Attachments:

1. Land use map of the area in the vicinity of the proposed Moragolla project (NBRO, 2013).
2. Maps showing the location and boundaries of all potential project sites introduced during the FS Review and Detailed Design, including: quarry; spoil disposal sites; potential Contractor's area; etc.

Appendix II. List of Endemic and Threatened Fauna

GROUP Family Species	English Name	Sinhala Name	NCS*	Sampling Sites		
				Quarry site	Camp site	Spoil disposal site
MOLUSCS						
Family: Ariophantidae						
Cryptozonachenui*			NT		+	+
Euplecta partita*			NT		+	
Ratnadvipiairradians*						+
Family: Coriillidae						
Corillacolletti*			VU		+	
DRAGONFLIES						
Family - Protoneuridae						
Elattoneuracentralis*	Dark-glittering Threadtail			+		+
BUTTERFLIES						
Family - Nymphalidae						
Phalanthaalcippe	Small leopard	Punchithith-thambiliya	CR			
Lethe daretis*	Ceylon treebrown	Lanka gas-dumburuwa	EN	+	+	+
Family - Hespertiidae						
Notocryptacurvifascia	Restricted Demon		VU		+	
AMPHIBIANS						
Family - Nyctibatrachidae						
Lankanectescorrugatus*	Corrugated water frog	Vakaralimadiya		+		+
Family - Dicroglossidae						
Fejervarvagreennii*	Sri Lanka paddy field frog	Lanka velmadiya	EN			+

Appendix II. ctd.

GROUP Family Species	English Name	Sinhala Name	NCS	Sampling Sites		
				Quarry site	Camp site	Spoil Disposal site
AMPHIBIANS ctd						
Family - Rhacophoridae						
<i>Pseudophilautus popularis</i> *	Common shrub frog	Sulabapadurumediya			+	
<i>Pseudophilautus</i> *	Kandyan shrub frog	Nuvarapadurumediya	NT		+	
<i>Polypedates cruciger</i> *	Common hour-glass tree frog	Sulabapahimbu gas madiya			+	
<i>Polypedates</i>	Mountain tree frog	Kandukaragamediya	EN		+	
Family - Ranidae						
<i>Hylarana temporalis</i> *	Common wood frog	Sulababandimadiya	NT		+	
REPTILES						
Family - Gekkonidae						
<i>Cnemaspis clivicola</i> *	Mountain day gecko	Kandukaradivasarihuna			+	
<i>Cnemaspis kandiana</i> *	Kandyan day gecko	Kandukaradivasarihuna	DD		+	
<i>Cnemaspis silvula</i> *	Forest day gecko	Vanadivasarihuna			+	
Family - Scincidae						
<i>Lankascincus fallax</i> *	Common lankaskink	Sulabalakhiraluva			+	+
Family - Colubridae						
<i>Ahaetullanusuta</i>	Green vine snake	Ahaetulla		+	+	
<i>Boigaceylonensis</i>	Sri Lanka cat snake	Nidimapila	VU			+
<i>Lycodonaulicus</i>	Wolf snake, house snake	Aluradanakaya			+	
<i>Ptyas mucosa</i>	Rat snake	Gerandiya				+
Family - Elapidae						
<i>Bungarus ceylonicus</i> * 1	Sri Lanka krait / Ceylon krait	Mudukarawala	NT			+

Appendix II. ctd.

GROUP Family <i>Species</i>	English Name	Sinhala Name	NCS	Sampling Sites		
				Quarry site	Camp site	Spoil Disposal site
REPTILES ctd						
Family - Viperidae Daboia russelii	Russell's viper	Tithpolonga				+
BIRDS						
Family - Phasianidae Gallus lafayetii*	Sri Lanka Jungle fowl	Sri Lanka Wali-kukula		+		
Family - Picidae Chrysocolaptes lucidus‡	Greater Flameback	LepitaMaha-karela	NT		+	+
Family - Ramphastidae Megalaimeflavifrons* Megalaimearubricapilla‡	Sri Lanka Yellow-fronted Barbet Crimson-fronted Barbet	Sri Lanka RannhunathaKottoruwa RathmhunathKottoruwa		+	+	
Family - Psittacidae Loriculusberyllinus* Psittaculacathropae* Graculaptilogenys*	Sri Lanka Hanging Parakeet Sri Lanka Layard's Parakeet Sri Lanka Myna	Sri Lanka Giramaliththa Sri Lanka AluGirawa Sri Lanka Salalihiniya		+	+	+
MAMMALS						
Family - Soricidae Suncuszeylanicus*	Sri Lanka jungle shrew	Sri Lanka KeleHik-miya	EN		+	
Family - Cercopithecidae Macacasinica*	Sri Lanka toque monkey	Sri Lanka Rilawa	NT		+	
Family - Sciuridae Ratufamacrourea	Giant squirrel	Dandu-leena	VU		+	

Appendix III. Fauna recorded from tree sampling sites

GROUP		English Name	Sinhala Name	NCS*	Sampling Sites		
Family	Scientific Name				Quarry site	Camp site	Spoil Disposal site
MOLUSCS							
Family: Ariophantidae							
	<i>Cryptozonabistrialis</i>				+	+	
	<i>Cryptozonachenui*</i>			NT	+	+	
	<i>Euplecta partita*</i>			NT	+		
	<i>Euplectatravancoricii</i>				+	+	
	<i>Ratnadvipiairradians*</i>					+	
Family: Achatinidae							
	<i>Achatinafulica</i>					+	
Family: Corillidae							
	<i>Corillacolletti*</i>			VU	+		
Family: Veronicellidae							
	<i>Laevicaulisalte</i>					+	
DRAGONFLIES							
Family - Coenagrionidae							
	<i>Onychargiaatrocyana</i>	Marsh Dancer			+	+	
Family - Protoneuridae							
	<i>Elatoneuracentralis*</i>	Dark-glittering Threadtail			+	+	
Family - Libellulidae							
	<i>Orthetrumglaucum</i>	Asian Skimmer			+	+	
	<i>Orthetrumluzonicum</i>	Marsh Skimmer			+	+	
	<i>Orthetrumprunosum</i>	Pink Skimmer			+	+	
	<i>Orthetrumsabina</i>	Green Skimmer			+	+	
	<i>Crocothemisservilia</i>	Oriental Scarlet			+	+	
	<i>Neurothemistullia</i>	Pied Parasol			+	+	

Appendix III ctd.

GROUP	NCS*			Sampling Sites		
Family	English Name	Sinhala Name	Quarry site	Camp site	Spoil Disposal site	
Family - Libellulidae						
<i>Trithemisfestiva</i>	Indigo Dropwing		+	+		
<i>Trithemis pallidinervis</i>	Dancing Dropwing		+	+		+
BUTTERFLIES						
Family - Papilionidae						
<i>Pachlioptaaristolochiae</i>	Common rose	Podurosapapilia		+		+
<i>Papiliopolytes</i>	Common mormon	Kalupapilia	+			
<i>Papiliopolymnestor</i>	Blue mormon	Mahanilaya	+	+		+
<i>Graphiumagamemnon</i>	Green jay / Tailed jay	Kola papilia				
Family - Pieridae						
<i>Leptostanina</i>	Psyche	Kalu-thithsudda	+			
<i>Delias eucharis</i>	Jezebel	PoduMaha-sudda				+
<i>Ceporanerissa</i>	Common gull	PoduPunduru-sudana	+			
<i>Euremahecabe</i>	Common grass yellow	Mahakahakolaya	+			
Family - Nymphalidae						
<i>Paranticaaglea</i>	Glassy tiger	Suduwan nil-kotithiya	+			+
<i>Euploea core</i>	Common crow	Podu kaka-kotithiyaya				+
<i>Phalanthaalcippe</i>	Small leopard	Punchithith-thambiliya	+			
<i>Junoniaiphita</i>	Chocolate soldier	Podualankarikya		+		
<i>Neptishylas</i>	Common sailor	Gomaraselaruwa	+	+		
		Thambilypanduru-boraluwa		+		
<i>Acraeaviolae</i>	Tawny costor	Lanka gas-dumburuwa		+		+
<i>Lethe daretis*</i>	Ceylon treebrown	Maha-iripanduru-dumburuwa	+	+		+
<i>Orsotriaenamedus</i>	Medus Brown / Nigger	Podupanduru-dumburuwa		+		+
<i>Mycalisperseus</i>	Common bushbrown	Poduheen-dumburuwa		+		+
<i>Ypthimaceylonica</i>	White four-ring		+	+		+

Appendix III ctd.

GROUP Family <i>Scientific Name</i>	English Name	Sinhala Name	NCS*	Sampling Sites		
				Quarry site	Camp site	Spoil Disposal site
Family - Lycæenidae <i>Castaliusrosimon</i>	Common Pierrot	Podu Mal-nilaya		+	+	+
Family - Hesperidae <i>Notocryptacurvifascia</i> <i>Oriensgoloides</i>	Restricted Demon Common Dartlet		VU		+	
AMPHIBIANS						
Family - Bufonidae <i>Duttaphrynusmelanostictus</i>	Common house toad	Sulabageaigemba				+
Family Nyctibatrachidae <i>Lankanectescorrugatus*</i>	- Corrugated water frog	Vakaralimadiya		+		+
Family - Dicroglossidae <i>Fejervaryagreenii*</i> <i>Fejervaryalimnocharis</i>	Sri Lanka paddy field frog Common paddy field frog	Lanka velmadiya Sulabavelmadiya	EN			+
				+		+
Family - Rhacophoridae <i>Psedophilautuspopularis*</i> <i>Psedophilautusrus*</i> <i>Polypedatescruciger*</i> <i>Polypedatesesques*</i>	Common shrub frog Kandiyan shrub frog Common hour-glass tree frog Mountain tree frog	Sulabapadurumediya Nuvarapadurumediya Sulabapahimbu gas madiya Kandukaragasmediya	NT NT EN		+	+
Family - Ranidae <i>Hylarana temporalis*</i>	Common wood frog	Sulababandimadiya	NT		+	

Appendix III ctd.

GROUP	NCS*			Sampling Sites		
Family	English Name	Sinhala Name	Quarry site	Camp site	Spoil Disposal site	
REPTILES						
Family - Agamidae						
<i>Calotes calotes</i>	Green garden lizard	Pala katussa	+	+		+
<i>Calotes versicolor</i>	Common garden lizard	Garakatussa	+	+		+
Family - Gekkonidae						
<i>Cnemaspis livicola</i> *	Mountain day gecko	Kandukaradivasarihuna		+		
<i>Cnemaspis kandiana</i> *	Kandyan day gecko	Kandukaradivasarihuna		+		
<i>Cnemaspis silvula</i> *	Forest day gecko	Vanadivasarihuna		+		
Family - Scincidae						
<i>Eutropiscarinata</i>	Common skink	Sulabahikanala	+	+		+
<i>Lankascincus fallax</i> *	Common lankaskink	Sulabalakhiraluva		+		+
Family - Varanidae						
<i>Varanus salvator</i>	Water monitor	Kabaragoya				+
Family - Colubridae						
<i>Ahaetullanasuta</i>	Green vine snake	Ahaetulla	+	+		
<i>Boigaceylonensis</i>	Sri Lanka cat snake	Nidimapila				+
<i>Lycodonaulicus</i>	Wolf snake, house snake	Aluradanakaya		+		
<i>Ptyas mucosa</i>	Rat snake	Gerandiya				+
Family - Elapidae						
<i>Bungarusceylonicus</i> * 1	Sri Lanka krait / Ceylon krait	Mudukarawala				+
<i>Najanaja</i>	Indian cobra	Naya				+
Family - Viperidae						
<i>Daboia russelii</i>	Russell's viper	Tithipolonga				+
Information received from villagers						

¹Information received from villagers

Appendix III ctd.

GROUP	NCS*			Sampling Sites		
Family	English Name	Sinhala Name		Quarry site	Camp site	Spoil Disposal site
Scientific Name						
BIRDS						
Family - Phasianidae						
<i>Gallus lafayetii</i> *	Sri Lanka Junglefowl	Sri Lanka Wali-kukula			+	
Family - Picidae						
<i>Chrysocolaptes lucidus</i> ‡	Greater Flameback	LepitaMaha-karela	NT		+	+
Family - Ramphastidae						
<i>Megalaimazeylanica</i>	Brown-headed Barbet	PolosKottoruwa			+	+
<i>Megalaimaflavifrons</i> *	Sri Lanka Yellow-fronted Barbet	Sri Lanka RannhunathaKottoruwa			+	
<i>Megalaimarubricapilla</i> ‡	Crimson-fronted Barbet	RathmhunathKottoruwa			+	
Family - Alcedinidae						
<i>Alcedoatthis</i>	Common Kingfisher	Mal Pilihuduwa			+	+
<i>Pelargopsiscapensis</i>	Stork-billed Kingfisher	ManathuduMadi-pilihuduwa			+	
<i>Halcyon smyrnensis</i>	White-throated Kingfisher	LayasuduMadi-pilihuduwa			+	+
Family - Cuculidae						
<i>Eudynamysscolopacea</i>	Asian Koel	Kowula			+	+
<i>Centropussinensis</i>	Greater Coucal	Ati-kukula			+	
Family - Psittacidae						
<i>Loriculusberyllinus</i> *	Sri Lanka Hanging Parakeet	Sri Lanka Giramalitha			+	+
<i>Psittaculacyanocephala</i>	Plum-headed Parakeet	PanduGirawa			+	
<i>Psittaculacalthropae</i> *	Sri Lanka Layard's Parakeet	Sri Lanka AluGirawa	NT		+	
Family - Apodidae						
<i>Cypsiurusbalasiensis</i>	Asian Palm Swift	AsiaaThal-thurithaya				+
Family - Strigidae						
<i>Ketupazeylonensis</i>	Brown Fish Owl	Bora Kewul-bakamoona			+	

Appendix III ctd.

GROUP Family <i>Scientific Name</i>	English Name	Sinhala Name	NCS*	Sampling Sites		
				Quarry site	Camp site	Spoil Disposal site
BIRDS Ctd						
Family - Columbidae						
<i>Streptopeliachinensis</i>	Spotted Dove	AluKobeiyya		+	+	+
<i>Chalcophapsindica</i>	Emerald Dove	Neela-Kobeiyya		+	+	
Family - Rallidae						
<i>Amaurornisphoenicurus</i>	White-breasted Waterhen	Laya-suduKorawakka				+
Family - Accipitridae						
<i>Spilornischeela</i>	Crested Serpent Eagle	SiluSarapakussa		+		
Family - Ardeidae						
<i>Ardeolagravii</i>	Indian Pond Heron	Kana-koka				+
Family - Chloropseidae						
<i>Chloropsisjerdoni</i>	Blue-winged Leafbird	NilpiyaKolarisiya		+		
Family - Oriolidae						
<i>Orioluschinensis</i>	Black-naped Oriole	Kalu-gelasiKahakurulla		+		+
Family - Dicruidae						
<i>Dicruruscaerulescens</i>	White-bellied Drongo	Kawuda		+		+
Family - Corvidae						
<i>Corvuslevaillantii</i>	Large-billed Crow	KaluKaputa				+
Family - Campephagidae						
<i>Pericrocotuscinnamomeus</i>	Small Minivet	PunchiMiniviththa		+		
Family - Muscicapidae						
<i>Copsychussaularis</i>	Oriental Magpie Robin	Polkichcha				+

Appendix III ctd.

GROUP Family Scientific Name	English Name	Sinhala Name	NCS*	Sampling Sites		
				Quarry site	Camp site	Spoil Disposal site
BIRDS Ctd						
Family - Sturnidae						
<i>Acridotherestrictis</i>	Common Myna	Mayna			+	+
<i>Graculaptilogenys*</i>	Sri Lanka Myna	Sri Lanka Salalihiniya	VU		+	
Family - Pycnonotidae						
<i>Pycnonotuscifer</i>	Red-vented Bulbul	Kondaya		+	+	+
Family - Cisticolidae						
<i>Priniasocialis</i>	Ashy Prinia	AluPriniya		+		
Family - Dicaeidae						
<i>Dicaeum agile</i>	Thick-billed Flowerpecker	MathuduPililichcha		+		
Family - Nectariniidae						
<i>Nectarinazeylonica</i>	Purple-rumped Sunbird	Nithamba Dam Sutikka			+	+
MAMMALS						
Family - Soricidae						
<i>Suncuszeylelanicus*</i>	Sri Lanka jungle shrew	Sri Lanka KeleHik-miya	EN		+	
Family - Cercopithecidae						
<i>Macacasinica*</i>	Sri Lanka toque monkey	Sri Lanka Rilawa	NT		+	
Family - Herpestidae						
<i>Herpestesbrachyurus</i>	Brown mongoose	Bora Mugatiya		+	+	+
Family - Viverridae						
<i>Viverriculaindica</i>	Ring-tailed civet	Urulewa			+	+

Appendix III ctd.

GROUP Family <i>Scientific Name</i>	English Name	Sinhala Name	NCS*	Sampling Sites		
				Quarry site	Camp site	Spoil Disposal site
MAMMALS ctd						
Family - Cervidae <i>Muntiacus muntjak</i> 1	Barking deer	OluMuwa / WeluMuwa		+	+	
Family - Suidae <i>Sus scrofa</i>	Wild boar	WalUra		+	+	+
Family - Hystricidae <i>Hystrix indica</i>	Porcupine	Ittewa		+	+	+
Family - Muridae <i>Bandicota indica</i>	Malabar bandicoot	Uru-miya				+
Family - Sciuridae <i>Funambulus palmarum</i> <i>Ratufamacroura</i>	Palm squirrel Giant squirrel	Leena Dandu-leena	VU	+	+	+
Family - Leporidae <i>Lepus nigricollis</i>	Black-naped hare	WalHawa		+	+	

*NCS – National Conservation Status

Appendix IV Summary of the fauna recorded and their conservation status

Animal group	Families	No. of Species		Conservation status of the species recorded			
		Total	Endemics	CR	EN	VU	NT
<u>Invertebrates</u>							
Land Molluscs	4	8	4	-	-	1	2
Dragonflies	3	10	1	-	-	-	-
Butterflies	5	21	1	1	1	1	-
<u>Vertebrates</u>							
Amphibians	5	9	7	-	2	-	2
Reptiles	7	1	5	-	-	1	1
Birds	23	32	5	-	-	1	2
Mammals	10	11	2	-	1	1	1
Total	57	106	25+2	1	4	5	8

*Conservation status follows National Redlist 2012

CR- Critically endangered
 EN-Endangered
 VU-Vulnerable
 NT – Near Threatened
 #Proposed endemic

Appendix V List of recorded flora from three sites

Family	Species	Common name	Life form	Quarry site	Camp site	Dump site
Acanthaceae	<i>Justiciabetonica</i>	Sudupuruk	Herb	+	+	+
Acaceae	<i>Pothosscandens</i>	Potawel	Liana	-	+	+
Anacardiaceae	<i>Mangiferaindica</i>	Amba	Tree	+	+	+
Apiaceae	<i>Centellaasiatica</i>	Gotukola	Herb	+	+	+
Apocynaceae	<i>Alstoniascholaris</i>	Rukattana	Tree	+	+	+
Araceae	<i>Cocosnucifera</i>	Pol	Tree	-	-	+
Arecaceae	<i>Areca catechu</i>	Puwak	Tree	-	-	+
Aristolochiaceae	<i>Aristolochiarings</i>	Tara mal	Liana	+	+	-
Astaraceae	<i>Centratherumpunctatum</i>		Herb	+	+	-
Astaraceae	<i>Vernoniazeylanica*</i>		Shrub	+	-	-
Astaraceae	<i>Tageteserecta</i>	Daspethiya	Herb	-	-	+
Asteraceae	<i>Ageratum conyzoides</i>	Hulantala	Herb	+	+	+
Asteraceae	<i>Eupatorium odoratum</i>	Podisinno	Shrub	+	-	+
Asteraceae	<i>Mikeniacordata</i>	Gahalawel	Liana	+	+	+
Asteraceae	<i>Tithoniadiversifolia</i>	Walsuriyacantha	Shrub	+	+	+
Bignoniaceae	<i>Tecomastans</i>	Kelanitissa	Small tree	-	+	+
Caesalpiniaceae	<i>Sennaspectabilis</i>	Kahakoona	Tree	-	+	+
Combretaceae	<i>Terminaliacatappa</i>	Kottamba	Tree	+	-	-
Euphorbiaceae	<i>Brideliaretusa</i>	Ketakela	Tree	+	+	+
Euphorbiaceae	<i>Heveabrsiliensis</i>	Rubber	Tree	-	-	+
Euphorbiaceae	<i>Macarangapeltata</i>	Kenda	Tree	+	+	+
Euphorbiaceae	<i>Mellotustetracoccus</i>	Bu kenda	Tree	+	+	+
Fabaceae	<i>Acacia mangium</i>		Tree	+	+	+
Fabaceae	<i>Albiziamoluccana</i>	Mara	Tree	+	+	+

*endemic species

Appendix V ctd.

Family	Species	Common name	Life form	Quarry site	Camp site	Dump site
Fabaceae	<i>Centrosemapubescens</i>		Liana	-	-	+
Fabaceae	<i>Crotalaria micans</i>		Herb	+	-	-
Fabaceae	<i>Crotalaria retusa</i>	Kahaandanahiriya	Shrub	+	-	+
Fabaceae	<i>Desmodiumtriflorum</i>	Udupiyaliya	Herb	+	+	+
Fabaceae	<i>Mimosa pudica</i>	Nidikumba	Herb	+	+	+
Fabaceae	<i>Pongamiapinnata</i>	Karanda	Tree	+	+	+
Fabaceae	<i>Sesbaniagrandiflora</i>	Kathurumurunga	Small tree	+	-	+
Fabaceae	<i>Delonixregia</i>	Mai mara	Tree	+	+	-
Flacourtiaceae	<i>Hydnocarpusvenenata</i>	Makulu	Tree	-	+	-
Gleicheniaceae	<i>Dicranopterislinearis</i>	Kakilla	Herb	+	+	-
Graminaeae	<i>Bambusaventricosa</i>	Una	Tree	-	+	-
Lauraceae	<i>Neolitsea cassia</i>	Kududawla	Tree	+	+	+
Lauraceae	<i>Persia americana</i>	Alipera	Tree	-	+	+
Lecythidaceae	<i>Careyaarborea</i>	Kahata	Tree	+	+	+
Leeaceae	<i>Leeaindica</i>	Burulla	Small tree	+	+	+
Leguminoseae	<i>Albizialebbeck</i>	Hurimara	Tree	+	+	+
Leguminoseae	<i>Gliricidiasepium</i>	Vetahira	Small Tree	+	+	+
Liliaceae	<i>Gloriosasuperba</i>	Niyagala	Liana	+	+	-
Lobeliaceae	<i>Laurentialongiflora</i>		Herb	+	+	+
Magnoliaceae	<i>Micheliachampaca</i>	Ginisapu	Tree	+	+	+
Malvaceae	<i>Hibiscus rosinensis</i>	Wada mal	Shrub	-	-	+
Malvaceae	<i>Malvaviscuspenduliflorus</i>		Shrub	-	+	+
Malvaceae	<i>Sidarthombifolia</i>		Herb	+	+	+
Malvaceae	<i>Urenalobata</i>	Pattaepala	Herb	+	+	+

Appendix V ctd.

Family	Species	Common name	Life form	Quarry site	Camp site	Dump site
Melastomataceae	<i>Clidemiahirta</i>	Katakalubovitiya	Shrub	+	+	+
Melastomataceae	<i>Osbeckiaoctandra*</i>	Heenbowitiya	Shrub	+	+	+
Meliaceae	<i>Meliaazedarach</i>	Lunumidella	Tree	-	-	+
Meliaceae	<i>Swieteniamacrophylla</i>	Mahogani	Tree	+	+	+
Meliaceae	<i>Toonaciliata</i>	Tuna	Tree	-	+	+
Menispermaceae	<i>Cycleapeltata</i>	Kehipithan	Liana	+	+	-
Mimosaceae	<i>Calliandracalothyrsus</i>		Small tree	+	+	+
Mimosaceae	<i>Mimosa invisa</i>		Liana	-	+	+
Moraceae	<i>Artocarpusheterophyllus</i>	Kos	Tree	+	+	+
Moraceae	<i>Artocarpusindicus</i>	Del	Tree	-	-	+
Moraceae	<i>Artocarpusnobilis*</i>	Waldel	Tree	-	+	+
Moraceae	<i>Ficusexasperata</i>	Budeliya	Tree	+	+	+
Moraceae	<i>Ficus hispida</i>	Kotadimbula	Small tree	+	+	+
Moraceae	<i>Ficusreligiosa</i>	Bo	Tree	+	+	-
Musaceae	<i>Musa paradisiaca</i>	Khel	Shrub	-	-	+
Myrtaceae	<i>Psidiumguajava</i>	Pera	Small tree	+	+	+
Myrtaceae	<i>Psidiumlittorale</i>	Cheenapera	Small Tree	+	+	-
Myrtaceae	<i>Syzygiumaromaticum</i>	Karabu	Tree	-	-	+
Myrtaceae	<i>Syzygiumsp</i>		Tree	-	+	-
Oxalidaceae	<i>Oxalis berrelieri</i>		Herb	+	+	-
Palmae	<i>Caryotaurens</i>	Kitul	Tree	+	+	+
Pandanaceae	<i>Pandanusamaeyllifolius</i>	Rampe	Shrub	-	-	+
Passifloraceae	<i>Passifloraedulis</i>	Passion fruit	Liana	-	-	+
Phyllanthaceae	<i>Phyllanthusamarus</i>	Pitawakka	Herb	+	-	-

Appendix V ctd.

Family	Species	Common name	Life form	Quarry site	Camp site	Dump site
Phytolaccaceae	<i>Rivinahumilis</i>		Herb	+	-	+
Piperaceae	<i>Piper nigrum</i>	Gammiris	Liana	-	-	+
Poaceae	<i>Cymbopogoncitratius</i>	Sera	Grass	+	-	-
Poaceae	<i>Cymbopogonnardus</i>	Pengirimana	Grass	+	-	-
Poaceae	<i>Heteropogoncontortus</i>	E thana	Grass	+	-	+
Poaceae	<i>Panicum maximum</i>	Rata tana	Grass	+	-	+
Polygonaceae	<i>Persicariacapitata</i>		Herb	+	+	-
Polygonaceae	<i>Persicariachinensis</i>		Herb	+	+	-
Proteaceae	<i>Grevillearobusta</i>	Sabukku	Tree	+	+	-
Rubiaceae	<i>Coffeaarabica</i>	Kopi	Small tree	-	+	+
Rubiaceae	<i>Mitracarpushirtus</i>		Herb	+	+	-
Rubiaceae	<i>Mussaendafrondosa</i>	Welbuthsarana	Shrub	+	+	+
Rubiaceae	<i>Wendlandiadicuspidade*</i>	Wanaidala	Tree	+	+	-
Rutaceae	<i>Cirtusgrandis</i>	Jambola	Tree	-	-	+
Rutaceae	<i>Thodaliaasiatica</i>	Kudu miris	Liana	+	+	+
Sapindaceae	<i>Filiciumdecipiens</i>	Pihimbiya	Tree	+	+	+
Sapotaceae	<i>pouteriacampechiana</i>	Rata lawulu	Tree	-	-	+
Solanaceae	<i>Solanumviolaceum</i>	Tibbtu	Shrub	-	-	+
Sterculiaceae	<i>Petrospermumsuberifolium</i>	Welan	Tree	+	+	+
Sterculiaceae	<i>Theobroma cacao</i>	Coco	Small tree	-	-	+
Symplocaceae	<i>Symplocoscochinchinensis</i>	Bomu	Small tree	+	+	+
Theaceae	<i>Camellia sinensis</i>	Te	Shrub	+	-	+
Theaceae	<i>Camellia sinensis</i>	Tea	Shrub	-	+	+
Tiliaceae	<i>Grewiadamine</i>	Daminiya	Tree	+	+	+

Appendix V ctd.

Family	Species	Common name	Life form	Quarry site	Camp site	Dump site
Tiliaceae	<i>Muntingiacalabura</i>	Jam	Small tree	-	+	+
Ulmaceae	<i>Tremaorientalis</i>	Gadumba	Tree	+	+	+
Urticaceae	<i>Laporteainterrupta</i>	Hahabiliya	Herb	+	-	+
Verbenaceae	<i>Clerodendrum serratum</i>	Kanhenda	Shrub	-	+	-
Verbenaceae	<i>Duranta repens</i>		Shrub	-	+	+
Verbenaceae	<i>Lantana camara</i>	Gandapana	Shrub	+	+	+
Verbenaceae	<i>Lantana trifolia</i>		Shrub	+	-	-
Verbenaceae	<i>Stachytarphetaurticaefolia</i>	Balunakuta	Herb	+	+	+
Verbenaceae	<i>Vitexaltissima</i>	Milla	Tree	+	+	+

Appendix VI Summary of the flora recorded and Their conservation status

Sites	Family	Species	Life form categories					
			Tree	Small tree	Shrub	Herb	Liana	Grass
Quarry site	42	72	26	8	10	19	5	4
Camp site	41	73	32	10	9	15	7	1
Spoil Dump site	42	80	33	11	15	12	7	2

Note:

Total number of plants recorded: 105 plant species

Total number of endemics recorded: Four (04)

Appendix VII Summary of ecological status of the flora recorded from the three sites

Site	Family	Species	Ecological Status				
			Native	Endemic	Cultivated	Introduced	Ornamental
Quarry site	42	72	64	3	-	5	-
Camp Site	41	73	60	3	2	6	2
Spoil dump site	42	80	59	2	9	6	4

Appendix VIII Number of trees to be removed from all three sites

Family	Species	Common name	No. of trees to be removed		
			Quarry site	Camp site	Spoil dump site
Anacardiaceae	<i>Mangifer aindica</i>	Amba	-	1	1
Anacardiaceae	<i>Anacardium occidentale</i>	Kaju	-	-	1
Anacardiaceae	<i>Spndias mombin</i>	Ambalanga	1	-	-
Apocynaceae	<i>Alstonia macrophylla</i>	Hawarinuga	-	25	1
Apocynaceae	<i>Alstonia scholaris</i>	Rukattana	1	-	-
Bigoniaceae	<i>Spathodea campanulata</i>	Spathodia	-	4	5
Combretaceae	<i>Terminalia catappa</i>	Bulu	-	8	-
Combretaceae	<i>Terminalia arjuna</i>	Kumbuk	-	3	-
Euphorbiaceae	<i>Mallotus tetracoccus</i>	Bukenda	-	4	3
Euphorbiaceae	<i>Macaranga peltata</i>	Kanda	2	74	59
Euphorbiaceae	<i>Hevea brasiliensis</i>	Rubber	-	-	2
Euphorbiaceae	<i>Homalanthus populifolius</i>	Ginikanda	1	-	-
Euphorbiaceae	<i>Bridelia retusa</i>	Ketakala	1	-	-
Fabaceae	<i>Albizia falcataria</i>	Albezia	10	28	2
Fabaceae	<i>Erythrina sabumbrans</i>	Eramudu	-	-	3
Fabaceae	<i>Gliricidia sepium</i>	Ginisiriya	-	4	28
Fabaceae	<i>Acacia mangium</i>	Accasia	36	15	-
Fabaceae	<i>Albizia lebbeck</i>	Hurimara	-	1	-
Fabaceae	<i>Delonix regia</i>	Mi Mara	10	9	-
Lauraceae	<i>Persea americana</i>	Alipera	-	-	5
Lauraceae	<i>Neolitsea cassia</i>	Kududawula	-	-	2
Lauraceae	<i>Cinnamomum capparum</i>	Kurundu	-	-	2
Lecythidaceae	<i>Careya arborea</i>	Kahata	7	-	-
Magnoliaceae	<i>Michelia champaca</i>	Sapu	-	-	2
Magnoliaceae	<i>Michelia champaca</i>	Sapu	-	2	-
Meliaceae	<i>Swietenia mahagoni</i>	Mahogany	-	-	27
Moraceae	<i>Ficus asperrima</i>	Budaliya	-	1	6
Moraceae	<i>Artocarpus nobilis</i>	Del	-	-	1
Moraceae	<i>Artocarpus heterophyllus</i>	Kos	-	-	2
Moraceae	<i>Artocarpus nobilis</i>	Waldel	-	2	-
Moraceae	<i>Ficus religiosa</i>	Bo	1	-	-
Moraceae	<i>Ficus benghalensis</i>	Nuga	1	-	-
Sapindaceae	<i>Filicium decipiens</i>	Pihimbiya	-	-	1
Sterculiaceae	<i>Petrospermum suberifolium</i>	Welan	-	1	-
Tiliaceae	<i>Grewia damine</i>	Damanu	-	-	3
Tiliaceae	<i>Grewia damine</i>	Daminiya	-	3	-
Ulmaceae	<i>Trema orientalis</i>	Gadumba	-	-	5
Verbenaceae	<i>Vitex altissima</i>	Milla	-	2	-
TOTAL			71	187	161

Note: Total number of trees to be removed: 419

MORAGOLLA HYDROPOWER PROJECT

ADDITIONAL STUDIES IN THE NATURAL ENVIRONMENT

**REPORT ON RIVER USERS DOWNSTREAM OF THE PROPOSED
MORAGOLLA DAM**



OCTOBER 2013

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ABBREVIATIONS

CEB	Ceylon Electricity Board
NWS & DB	National Water Supply and Drainage Board
WMS	Water Management Secretariat
FS	Feasibility Study
MASL	Mahaweli Authority of Sri Lanka
EIA	Environmental Impact Assessment
TOR	Terms of Reference
GN	Grama Niladhari

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INTRODUCTION

1. BACKGROUND

The Ceylon Electricity Board (CEB) plans to develop a new 30.8 MW hydropower project at Moragolla in Kandy District. The project involves construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli River at Weliganga, to construct a 38.5 ha, 1.98 MCM reservoir with a Full Supply Level (FSL) at 548 msl. Water will be diverted through a 3 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and the outfall is located opposite the confluence with the Atabage Oya (see land-use map, Attachment 1).

A Feasibility Study (FS) of the project was conducted in 2009, and this included an Environmental Impact Assessment (EIA), which has been approved by the Mahaweli Authority of Sri Lanka (MASL) in the near future. In 2012 CEB appointed Nippon Koei Co., Ltd. (NK) to review the FS and prepare detailed designs and tender documents for project construction; and to upgrade the EIA to comply with the Safeguard Policy of the Asian Development Bank, the principal funding agency.

To upgrade the EIA, surveys were conducted in certain key fields in 2013, to supplement existing baseline data and update the assessment of impacts. A further study is now needed, so that mitigation measures can be properly planned and designed.

2. OBJECTIVES

The EIA report examined human uses of the river in the immediate project area (between the predicted upstream end of the reservoir and the tailrace outfall) and identified the locations used for washing and bathing, sand mining, one water extraction and discharge point (Crysbro Poultry Processing) and the intake of the Dunhinda irrigation canal. The locations of these activities are shown on the attached land-use map, produced following a detailed field analysis by the National Building Research Organisation (NBRO) in March - July 2013. A further survey of river users between the tailrace outfall and Gampolla Bridge was conducted in 2013 as part of a socio-economic study.

CEB is committed to mitigate all negative impacts of the project including impacts on the river users whose socio-economic activities are affected by the project and compensating them via a favourable Resettlement Policy to be spelt out in the Resettlement Action Plan (RAP), currently under preparation. CEB will also take measures to ensure the safety of downstream river users who might be prone to risk due to fluctuations of the water level once the project starts operation. The additional survey, in keeping with the TOR, examined the users of the river in the downstream between the bridges at Gampola and the Peradeniya, to identify the numbers of people involved in each activity. The results of the additional survey were analyzed together with the findings of the original survey, so that appropriate measures can be designed and established to secure the safety of river users. An early warning system will be installed for the benefit of the river users of the downstream. Similar system has been installed in the already commissioned Upper Kotmale Hydropower Project.

3. METHODOLOGY AND APPROACH

The field surveys were led by a senior social studies expert, with more than 15 years of practical experience in design, implementation and analysis of data from social surveys. All members of the survey team possess previous experience of conducting field surveys.

- The survey covered the Mahaweli Ganga from Gampolla Bridge to Peradeniya Bridge, a stretch of 13 km approximately.
- The aim of the survey was to a) identify all users of the river along the surveyed stretch and the number of people involved in each activity; and b) geo-reference the location of each activity via GPS recorder and plot the locations accurately on a map.
- Information was obtained by a combination of: a) direct observation; b) interviews with river users and local communities; and c) collecting official data and information from Grama Niladharies and other local level government offices (eg sand mining licences, locations of irrigation scheme off-takes and users, industrial facilities, etc)
- Survey team travelled along both riverbanks over a period of two weeks, observing the river uses and their locations, visiting each area at different times on different days to ensure all users were recorded. Survey team interviewed people engaged in each activity to collect data on the numbers of people involved and their identity, and obtain information on other locations and different river users.
- Interviews properly structured, with answers entered into a data recording sheet (attached as an appendix).
- Results of the survey were analysed and compiled, together with the findings of the original survey so that it will facilitate designing a Resettlement Policy and an Entitlement Policy to be implemented by the project.

4. THE ADDITIONAL STUDIES IN THE NATURAL ENVIRONMENT- SURVEY ON THE DOWNSTREAM RIVER USES

The census survey which has already been completed (original survey) had studied the socio-economic impacts of five kilo metre (05km) stretch of the downstream of the proposed dam and the data collected at the survey has already been compiled. Therefore, this report will focus on the additional survey carried out in respect of river stretch up to the bridge at Peradeniya.

4.1 Impacts on Economic Activities

4.1.1 Sand Mining

The major economic activity along the 13 km stretch of the downstream of the river is sand mining. In the survey, twenty one (21) sand mining locations have been identified. According to the survey, the number of people engaged in sand mining is 83. In most cases sand mining is not a regular activity. There are only eleven (11) permit holders (permits are issued by respective Divisional Secretaries) who have gained the right to do sand mining along the river. Permits are given to extract sand only for 3 days per week. Majority are illicit miners. Some of the permit holders have abandoned extraction of sand.

Average volume of sand extracted by a sand mining labourer has been estimated as **1.42m³** per day. The market price of one meter cube (m³) of sand at mining location is Rs. **1060/=**

4.1.1.1 Impacts on the Sand Mining

It is observed that no negative impact will be caused to sand mining due to the proposed dam. There will be continuous environmental flow of 1.5 m³/s of water in the downstream. Also, water released after generation of power will accumulate in the downstream of the river. Besides, water carried by Atabage Oya, Nillambe Oya, Geli Oya and some other fairly large streams (See flow chart in appendix), is a major feeding source of the Mahaweli River in the downstream of the proposed Dam. There are also 19 streams flowing in to the Mahaweli River in the river stretch between the Atabage Oya and the bridge at Peradeniya. The sediments brought by these streams (See flow chart in appendix) into the downstream of the proposed dam quite substantial and thus formation of sand in this stretch is sufficient to carryout sand mining without disruptions. The Table-1 provides details of sand mining in the additional study area.

The Moragolla reservoir is not a storage type and hence according to the technical literature "Trap Efficiency Curves" by Brune and Churchill given in small dams, this reservoir is capable to retain 40% of sediment coming from the upstream due to its operation nature. Therefore, 60% of sediment from upstream of the dam and sediments from 19 streams confluence with Mahaweli River is available to downstream sand miners. Therefore, it is clear that the sand miners in the downstream to the Moragolla outfall will not be impacted significantly.

However, the project has taken measures to mitigate impact to sand mining livelihood within certain distance from the dam (3km upstream and 8km downstream) by providing assistance to acquire alternative sources of income opted by the affected sand miners. Furthermore, a payment of cash compensation will be made to them for loss of income for the period from the date on which sand mining will be disturbed and start of the new source of income.

TABLE 1 - DOWN STREAM RIVER USERS SURVEY - SAND MINING

Item No.	Location ID	Name of Mining Place	Name of Sand miner	Sand mine Labours	Volume Extracted per Day (Cubes)	Frequency of Mining days (Per Week)	Net Income per working Day (Rs)	Remarks
01	S1	Atuwewatta	M.T. M. Naleeze	3	1.50	3	4,500.00	-
02	S2	Ihalawela 2	M.T. M. Naleeze	4	2.00	3	6,000.00	-
03	S3	KapukotuwaThotupala	M.G. Dulip Kumara	5	3.50	3	10,500.00	-
04	S5	Iskolawatta	U.G. G. Manike	2	1.00	3	3,000.00	-
05	S6	Ganthotapitiya	D.K. Senevirathna	3	1.50	3	4,500.00	-
06	S7	Wellathota	M.P.C. Jayasundara	3	1.50	3	4,500.00	-
07	S8	Kotta Gas Handiya	AjithPadmasiri	4	3.00	3	9,000.00	-
08	S9	Walawwawatta	D. W. Gunathilake	2	0.75	3	2,250.00	-
09	S10	Hindagala 1	UpulChandralal	2	1.00	3	3,000.00	-
10	S11	Hindagala 2	UpulChandralal	3	1.00	3	3,000.00	-
11	S12	Kandy South Intake (NWS & DB)	H.M.A. Rathnayake	5	5.50	3	16,500.00	-
12	S13	Kurunduwatta	S.L.R.A. Senevirathna	3	2.00	3	6,000.00	-
13	S14	PahingamaThotupala 1	P.G. Jayarathna	2	1.25	3	3,750.00	-
14	S15	PahingamaThotupala 2	P.G. Jayarathna	0	-	0	-	Currently Abundant
15	S16	PahingamaThotupala 3	K. Nawarathna	2	1.00	3	3,000.00	-
16	S17	PahingamaThotupala 4	Hemalatha	2	0.50	3	1,500.00	-
17	S18	No.8 Thotupala	M.L.M. Haneefa	2	1.50	3	4,500.00	-
18	S19	KottunnaThotupala	O.L.M. Azam	2	1.00	3	3,000.00	-
19	S20	Wali-UllahPallithota	M. Irfam	3	1.25	3	3,750.00	-
20	S21	Pussathota	D. Dehideniya	2	1.00	3	3,000.00	-
21	S22	Pussangolla	P.D.A.B. Gunarathne	4	2.00	3	6,000.00	-
22	S23	ParuThota	K.G. Sriyani	5	3.50	3	10,500.00	-

Some scenes of sand mining activities in downstream



Atuwewatta (Location S1)



Atuwewatta (Location S1)



Ihalawela (Location S2)



Ihalawela (Location S2)



Kapukotuwa (Location S3)



Paruthota (Location S23)

4.1.2 Fishing

No commercial fishing has been observed in the downstream of the river up to the bridge at Peradeniy. Fishing for household consumption is also not very significant in this particular stretch of the river. Occasional fishing by a very few individuals has been observed. Even such isolated fishing will not be affected as depletion of fish will not be resulted due to lack of water in the downstream as large volumes of water are carried by 19 streams. The method of fishing is by using fishing rods. Fishing is not very popular as it takes long hours to catch a few fish. Therefore, people who are busy with other important work do not consider fishing as a profitable activity. A few species of fish such as Kaha Korali (*Orange Chromide*), Mal Korali (*Perl Spot*) Wala Poththa (*Butter Catfish*) are the most common fish caught by those go fishing in their leisure times.

4.1.3 Irrigation – Dunhinda Cana I(This has been already included in the original study)

Dunhinda irrigation canal which feeds about 200 acres of paddy lands is located one kilo metre (01 km) downstream of the proposed dam and irrigational water requirement is $0.28 \text{ m}^3/\text{s}$. The project management has consulted the farmers of three Farmer Organizations, namely, Mangalaketha, Maligapurana and Vewa and assured that this irrigation system will be improved by renovating already damaged canal at several places. Also, action will be taken to construct a weir at the present intake to make sure that no shortage of water will occur for irrigation.

Apart from Dunhinda irrigation scheme, utilization of river water for irrigation purposes along the stretch subjected to the additional study has not been observed.

***A scene of the
Dunhinda Canal***



4.1.4 Business activity

No business activities depend on river water are observed within the study area

4.1.5 Industry

Industries which use river water have not been observed within the study area, except for the Crysbro Chicken Processing Industry, details of which have been included in the original study

4.2 IMPACTS ON SOCIAL ACTIVITIES

4.2.1 Bathing and Washing

Along either side of the river within the stretch under study there are a fairly large number of bathing and washing places. The study revealed that there are 34 bathing and washing places within the stretch under survey. These bathing places are always busy with the people, mostly with the people of low income groups, who come for bathing and washing.

According to the inference of the downstream river user survey only one bathing place (location B34) has disclosed the awareness of river water level fluctuation by their self-judgment when Kotmale Plant is in operation. The water level fluctuation in the other locations covered by the survey is not significant even though Kotmale Plant releases $110.0 \text{ m}^3/\text{s}$ of flow to the river at full load operation.

The downstream river users may believe that the river water level fluctuation by the power plant operation is a normal occurrence of the river flow pattern as they have accustomed to such situation over last 30 years. This is further substantiated by not reporting any accident caused by the water level fluctuation in the river downstream, so far after commissioning of Kotmale Power Plant in 1983.

As per the present analysis, peak discharge of Kotmale Plant alone could influence to raise the downstream river water level by nearly 1.0m. This will increase further by 0.5m with the addition of Moragolla Plant. Based on that it is planned to organize public awareness programs on river water level rise in future with the operation of Moragolla plant as an initial precautionary measure.

To ensure safeguard of downstream users from the anticipated river water level fluctuations, it is proposed to introduce public awareness system through mass media and public warning system using sirens when both plants release more than $110.0 \text{ m}^3/\text{s}$ of flow to the river.

Some scenes of downstream Bathing and washing



Wellathota (Location B10)



Iskolawatta (Location B7)

It has been established that the proposed dam will not pose a threat to the bathing or washing activities along this particular stretch of river as large volume water is brought in by several large and small streams flowing from either side of the river. Also, the environmental flow released from the reservoir will supplement the above volume. The Table- 2 gives the details of bathing and washing places in the additional study area.

TABLE 2 - DOWN STREAM RIVER USERS SURVEY - BATHING & WASHING

Item No.	Location ID	Name of the Place	No. of User Families		Key Informant details	
			Wet Season	Dry Season	Name	Address
01	B1	Walkotuwa	10	50	JanakaAshoka	84, Pallewela, Millawatta, Gampola
02	B2	Palliyathota	15	50	Ajmaal	Atuwewatta, Gampola
03	B3	Daraande	10	15	H.M.L. Fowser	159C, Andiyakadawatha, Gampola
04	B4	Ihalawela 1	15	25	M.T. M. Naleeze	199B, Ihalawela, Polwatta, Gampola
05	B5	Ihalawela 2	15	25	M.T. M. Naleeze	199B, Ihalawela, Polwatta, Gampola
06	B6	Polwatta	3	10	N. Dasanayake	Polwatta, Naranvita
07	B7	Iskolawatta	6	25	U.G.G. Manike	IskolaWatta, Niyamgama, Gampola
08	B8	Ganthotapitiya	10	25	D.K. Senevirathna	Liyandeniya, Doluwa
09	B9	Walapēlawala	20	10	D.K. Senevirathna	Liyandeniya, Doluwa
10	B10	Wellathota	5	15	M.P.C. Jayasundara	Godawela, Doluwa
11	B11	Kotta Gas Handiya	5	15	AjithPadmasiri	132/4, MegogaKalugamuwa
12	B12	Pipe Bridge-Kalugamuwa	10	25	AjithPadmasiri	132/4, MegogaKalugamuwa
13	B13	Walawwawatta	5	5	D. W. Gunathilake	142, Doluwa Road, Hindagala
14	B14	PahingamaThotupala 1	2	5	P.G. Jayarathna	46/3, Pahingama, Gelioya
15	B15	PahingamaThotupala 3	1	2	K. Nawarathna	35, Pahingama, Gelioya
16	B16	Nape thota	10	10	T.M. Munnah	516/1A, Kalugamuwa Road, Gelioya
17	B17	Pallithota	30	40	A.N. Maujude	505/3, Kalugamuwa, Gelioya

Contd..

DOWN STREAM RIVER USERS SURVEY - BATHING & WASHING Contd..

Item No.	Location ID	Name of the Place	No. of User Families		Key Informant details	
			Wet Season	Dry Season	Name	Address
18	B18	No.8 Thotupala	40	60	M.L.M. Haneefa	479/3, Kalugamuwa, Gelioya
19	B19	BangalaThota	60	100	S.M. Waseem	454, Kalugamuwa, Gelioya
20	B20	Elpitiya 1	3	8	T.G.N. Bandara	391A, Elpitiya, Weligalla
21	B21	Elpitiya 2	2	5	T.G.N. Bandara	391A, Elpitiya, Weligalla
22	B22	Elpitiya 3	8	20	S.H.D Ruwankumara	280/48/1, Elpitiya, Weligalla
23	B23	Pussathota	5	10	D. Dehideniya	Elpitiya, Weligalla, Gampola
24	B24	Pussangolla	15	30	P.D.A.B. Gunarathne	"Asiri", Udowita, Weligalla
25	B25	ParuThota	2	10	K.G. Sriyani	21/51, Bothalapitiya, Gampola
26	B26	Illawathura - 1	3	10	M.J.M. Ashfer	79, Illawatura, Gampola
27	B27	Illawathura - 2	5	10	M. Amanulla	12/2B, Illawatura, Gampola
28	B28	Illawathura - 3	10	20	M. Amanulla	12/2B, Illawatura, Gampola
29	B29	Illawathura - 4	10	15	M.T.M. Ikbali	13/12, Illawatura, Gampola
30	B30	Illawathura - 5	7	18	M.T.M. Ikbali	13/12, Illawatura, Gampola
31	B31	Illawathura - 6	5	25	M. Nazeer	56/37, Illawatura, Gampola
32	B32	Illawathura - 7	10	30	M.N.M. Navaz	52, Illawatura, Gampola
33	B33	Illawathura - 8	5	15	M.S.M. Asvin	56/8, Illawatura, Gampola
34	B34	Illawathura - 9	5	15	J.A. Gafur	17/48, Illawatura, Gampola

4.2.2 Swimming

Swimming is a very remote recreation activity due to the risk factor and no safety measures are in place in this particular river stretch.

4.2.3 Domestic Water Supply Schemes

Kandy South Water Supply Scheme and the water supply scheme for University of Peradeniya are the only Domestic Water Supply Schemes implemented by the National Water Supply and Drainage Board (NWS&DB()) which harness Mahaweli Water, observed in the study area.

The Kandy South Water Supply Scheme has already given connections to 45,000 houses and it has the capacity to give 15,000 more connections. A small weir with gates is constructed across the river as intake structure and that is not obstructing the fish movements of the river.

Some scenes of the intake of the Kandy South Water Supply Scheme



Meewathura (Location P1+S12)

A scene of the water intake for water supply scheme for University of Peradeniya



Although the proposed Dam of the Moragolla Hydropower Project will restrict the flow of water in the downstream to a certain extent, it will not debilitate these two water supply schemes as there will be no shortage of water for the purpose as the water from the following sources will supplement the requirement.

- **Environmental flow to be released from the Moragolla Reservoir.**

It has been planned to release $1.5 \text{ m}^3/\text{s}$ of water from the Moragolla Reservoir, as an environmental flow.

- **Water carried to the river in the downstream of the proposed Dam by 19 streams including large streams such as Atabae Oya, Nillabe oya, Nanu Oya and Geli Oya**

In between Moragolla dam and Peradeniya Bridge there are 19 streams having different flow capacities confluence with the Mahaweli River. According to downstream survey of the river there are several large scale water users such as National Water Supply and Drainage Board (NWS&DB), University of Peradeniya and the Municipality of Kandy and they utilize large amounts of water in this river stretch. Beyond 1 km downstream of the Peradeniya Bridge in Getambe, certain studies are being carried out to build a weir across Mahaweli River to construct 10MW power plant. According to them, at this weir location the 95% exceedance flow would be $9.0 \text{ m}^3/\text{s}$. Conversely the 95% exceedance flow at Moragolla dam would be $3.6 \text{ m}^3/\text{s}$

Therefore, the 95% exceedance flow of all the streams confluence with Mahaweli River in between Moragolla dam and Getambe weir location would be $5.4 \text{ m}^3/\text{s}$ plus the river water required for all downstream river water users in between these two points. Based on them when Moragolla reservoir will be in operation, the 95% exceedance flow available at Getambe would be $6.9 \text{ m}^3/\text{s}$, i.e. $(5.4+1.5)$. It is equal to 77% of the 95% exceedance flow at Getambe before the operation of Moragolla reservoir.

Furthermore, Atabage Oya contributes around $2.0 \text{ m}^3/\text{s}$ as the 95% exceedance flow. Therefore, in lean flow period of the river at least 60% of the normal river flow is available in the river just downstream of the project.

A scene of the Atabage Oya



A Scene of Geli Oya



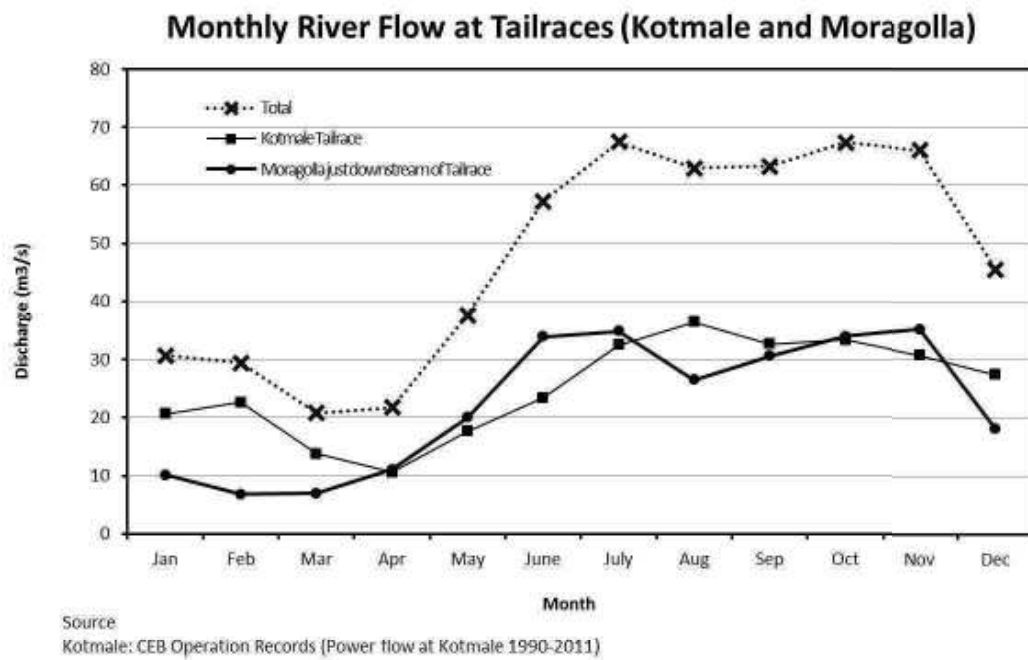
- **Release of water from the Kotmale Reservoir**

The Water Management Secretariat (WMS) functioning under the Ministry of Irrigation and Water Resources Development has the authority to allocate Mahaweli water for different purposes on priority basis. In the order of priority allocation of water for irrigation comes first. Next priority of allocation of water is for domestic water supply.

Meetings of the WMS are held weekly. Representatives from the Ceylon Electricity Board (CEB) and the National Water Supply and Drainage Board attend these meetings regularly. At these meetings water requirements of different agencies and for different purposes are discussed and decisions are made on allocation of water based on the priority. It has been confirmed that water requirements of NWS&DB for the above water supply schemes are guaranteed by the WMS and the decisions on the amount of water to be released are made at the weekly meetings. Therefore, operation of Kandy South Water Supply Scheme and the water supply scheme for University of Peradeniya will not be hampered because of the Moragolla Hydropower Project. In addition, when the operation of both Moragolla & Kothmale plants in future, river water flow just downstream location of tailraces is analysed and tabulated in Table-3 with a graphical output as follows,

Table 3 - Monthly river flow at tailrace downstream of Kothmale & Moragolla

Month	River Flow at Tailrace (m ³ /s)		
	Moragolla	Kotmale	Total
Jan	10.10	20.63	30.73
Feb	6.80	22.63	29.43
Mar	7.00	13.77	20.77
Apr	11.10	10.65	21.75
May	20.00	17.66	37.66
June	33.90	23.38	57.28
July	34.90	32.53	67.43
Aug	26.50	36.48	62.98
Sep	30.60	32.68	63.28
Oct	34.00	33.37	67.37
Nov	35.30	30.76	66.06
Dec	18.10	27.48	45.58



4.3 Cultural activity

No cultural activity linked to the river water has been observed in the study area.

APPENDICES

- MAJOR DOWNSTREAM CONFLUENCES – FLOW CHART
- GEO-REFERENCE MAP OF LOCATIONS
- SUMMARY TABLE OF COLLECTED DATA
- SURVEY DATA SHEETS OF DOWNSTREAM RIVER USERS

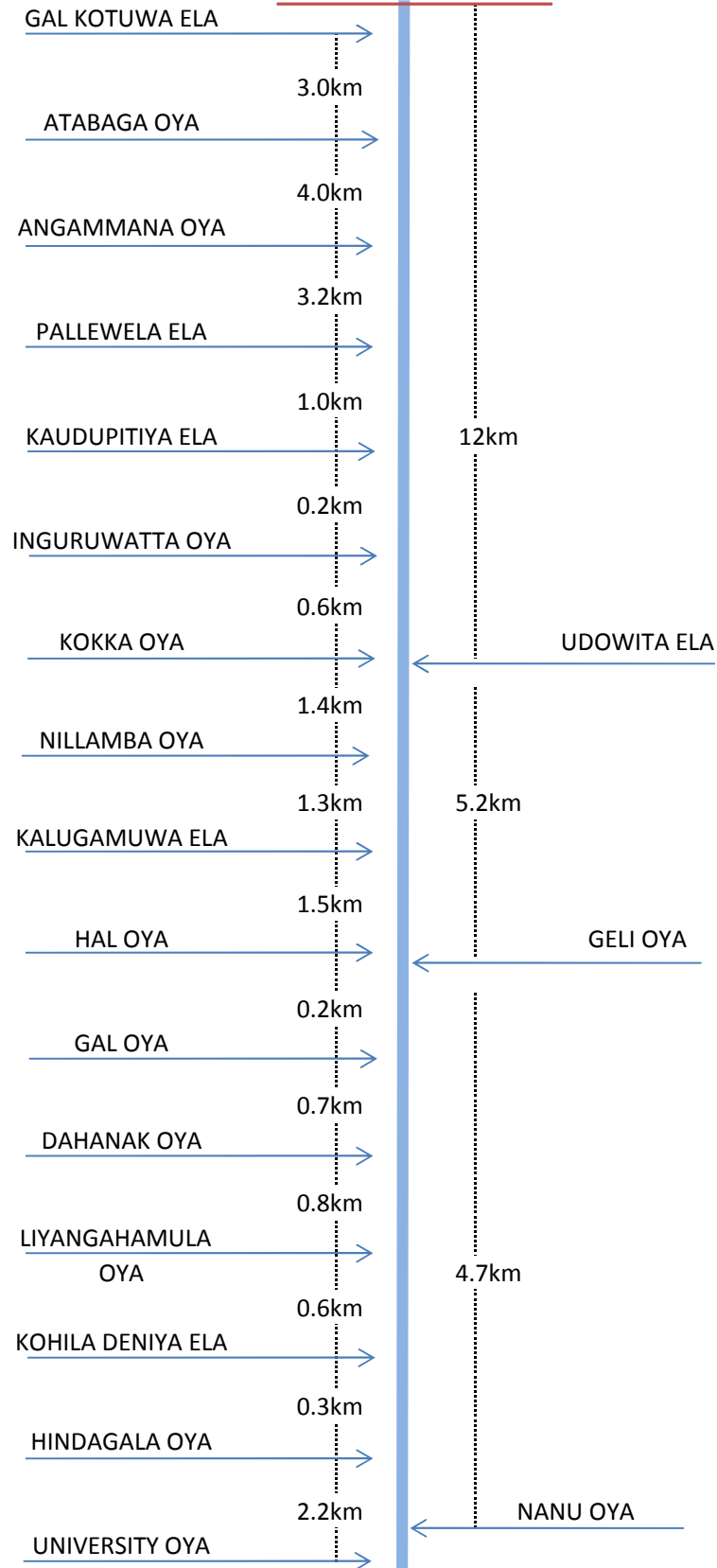
APPENDIX - I

- **MAJOR DOWNSTREAM CONFLUENCES – FLOW CHART**

RIGHT BANK

LEFT BANK

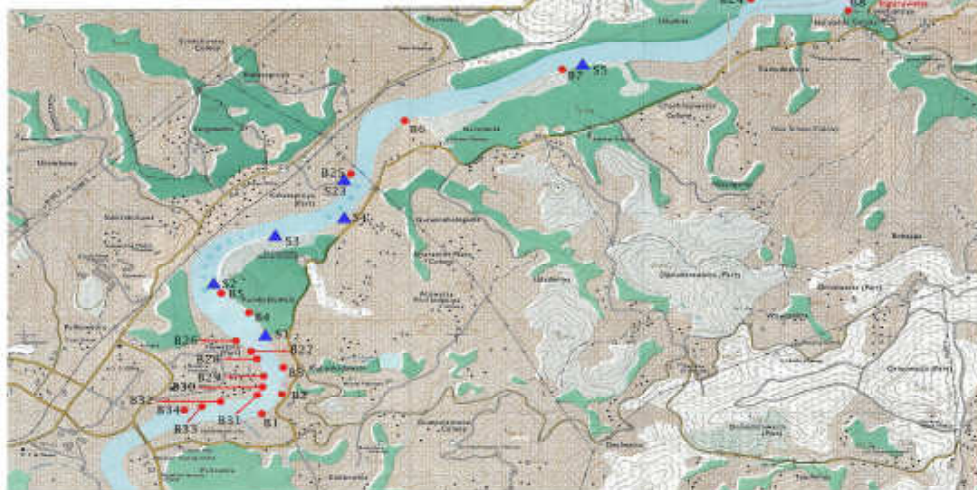
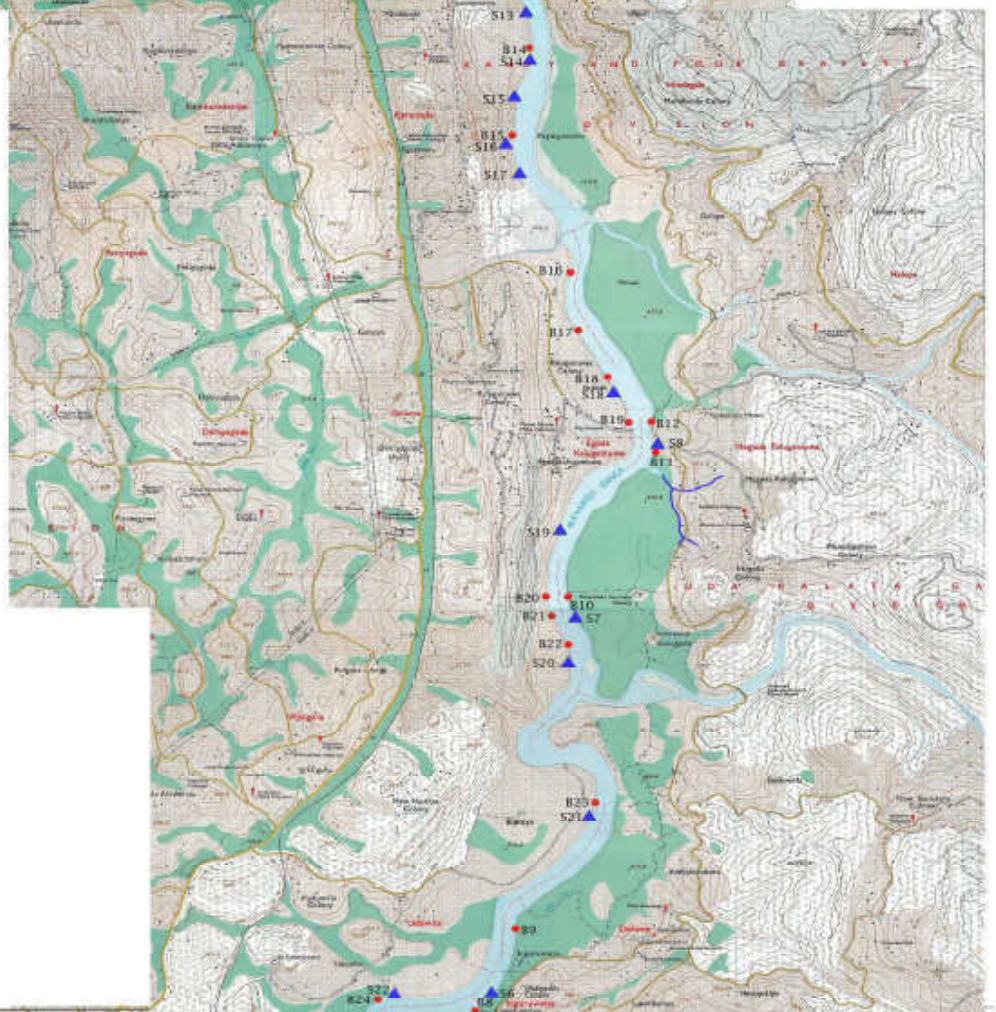
DAM AXIS OF MORAGOLLA



PERADENIYA BRIDGE

APPENDIX - II

- **GEO-REFERENCE MAP OF LOCATIONS**



APPENDIX - III

- **SUMMARY TABLE OF COLLECTED DATA**

DOWN STREAM RIVER USERS SURVEY – MORAGOLLA HYDROPOWER PROJECT

Location ID	Name of the Place	Village	GPS Coordinates		Washing /Bathing Families		Fishing	Sand mine workers	Key Informant details			GN Division	Remarks
			N	E	Wet	Dry			Name	Address	Contact No.		
B1	Walkotuwa	Andiya Kadawatha	218005	178297	10	50	No	-	Janaka Ashoka	84, Pallewela, Millawatta, Gampola	071 3354119	Naranvita	
B2	Pallyathota	Andiya Kadawatha	218139	178473	15	50	rare	-	Ajmaal	Atuwewatta, Gampola	077 0616747	Naranvita	
B3	Daraande	Andiya Kadawatha	218298	178424	10	15	No	-	H.M.L. Fowser	159C, Andiya kadawatha, Gampola	077 9811797	Naranvita	
S1	Atuwewatta	Ihalawela	218714	178146	-	-	No	9	M.T. M. Naleeze	199 B, Ihalawela, Polwatta, Gampola	077 9598782	Atuwewatta	
B4	Ihalawela 1	Ihalawela	218803	178165	15	25	rare	-	M.T. M. Naleeze	199 B, Ihalawela, Polwatta, Gampola	077 9598782	Atuwewatta	
B5 + S2	Ihalawela 2	Ihalawela	218845	178252	15	25	rare	4	M.T. M. Naleeze	199 B, Ihalawela, Polwatta, Gampola	077 9598782	Atuwewatta	
S3	Kapukotuwa Thotupala	Kapukotuwa	218917	178569	-	-	No	5	M.G. Dulip Kumara	17, Gampola watta, Gampola	077 9786937	Atuwewatta	
B6	Polwatta	Naranvita	219488	178958	3	10	rare	-	N. Dasanayake	Polwatta, Naranvita	081 5610454	Naranvita	
B7 + S5	Iskola watta	Iskola watta	219777	179884	6	25	rare	2	U.G.Gunaratne Manike	Iskola Watta, Niyamgama, Gampola	081 5733416	Inguruwatta	
B8 + S6	Ganthota pitiya	Kawudu pitiya	220073	180866	10	25	rare	3	D.K. Senevirathna	Liyandeniya, Doluwa	081 4927235	Inguruwatta	
B9	Wala pēla wala	Doluwa	220252	181004	20	10	No	-	D.K. Senevirathna	Liyandeniya, Doluwa	081 4927235	Doluwa	
B10 + S7	Wella thota	Doluwa	221308	181217	5	15	rare	3	M.P.C. Jayasundara	Godawela, Doluwa	077 6168464	Godawela	
B11 + S8	Kotta Gas Handiya	Megoda Kalugamuwa	222771	181631	5	15	No	4	Ajith Padmasiri	132/4, Megoda Kalugamuwa	077 6167570	Megoda Kalugamuwa	
B12	Pipe Bridge- Kalugamuwa	Megoda Kalugamuwa	222983	181641	5	10	rare	-	Ajith Padmasiri	132/4, Megoda Kalugamuwa	077 6167570	Megoda Kalugamuwa	
B13 + S9	Walawwa watta	Hindagala	225728	180759	5	5	No	2	D. W. Gunathilake	142, Doluwa Road, Hindagala	-	Hindagala	
S10	Hindagala 1	Hindagala	226565	180689	-	-	No	2	Upali Chandralal	"Musdale", Galaha road, Peradeniya	-	Palle – Peradeniya	
S11	Hindagala 2	Hindagala	226778	180592	-	-	No	3	Upali Chandralal	"Musdale", Galaha road, Peradeniya	-	Palle – Peradeniya	supply water for
P1 + S12	Kandy South Intake (NWS & DB)	Meewathura	227396	180262	-	-	No	6	H.M.A. Rathnayake	Kandy South NWS & DB office, Meewathura, Peradeniya	081 2385725	Angunawela East	45000 nos. of connection in area. 24hrs in operating. Plant Capacity 20000
P2	University Intake	Meewathura	227129	180285	-	-	No	-	H.M.A. Rathnayake	Kandy South NWS & DB office, Meewathura, Peradeniya	081 2385725	Angunawela East	Operating from 4am to 10pm hrs. Capacity 5500 m ³ /s
S13	Kurunduwatta	Kurunduwatta	225389	180906	-	-	No	3	S.L.R.A. Senevirathna	B/53, New Peradeniya, Kossinna, Galleiya	081 4980143	Godapala West	

Location ID	Name of the Place	Village	GPS Coordinates		Washing /Bathing Families		Fishing	Sand mine workers	Key Informant details			GN Division	Remarks
			N	E	Wet	Dry			Name	Address	Contact No.		
P3	Brick Manufacturing Place	Pahingama	225141	181027	-	-	No	-	K. Bandara	Pahingama, Gelloiya	-	New Peradeniya	Approx. 500 bricks per day
B14 + S14	Pahingama Thotupala 1	Pahingama	224706	181148	2	5	No	2	P.G. Jayarathna	46/3, Pahingama, Gelloiya	077 9914938	New Peradeniya	
S15	Pahingama Thotupala 2	Pahingama	224585	181084	-	-	No	-				New Peradeniya	Currently Abundant
B15 + S16	Pahingama Thotupala 3	Pahingama	224197	181087	1	2	No	2	Kanchana Nawarathna	35, Pahingama, Gelloiya	077 7030950	New Peradeniya	
S17	Pahingama Thotupala 4	Pahingama	224169	181101	-	-	No	2	Hemalatha	Pahingama, Gelloiya	-	New Peradeniya	
B16	Nape thota	Pol Mandiya	223783	181311	10	10	rare	-	T.M. Munnah	516/1A, Kalugamuwa Road, Gelloiya	075 6692427	Egoda Kalugamuwa	
B17	Pallithota	Egoda Kalugamuwa	223567	181284	30	40	rare	-	A.N. Maujude	505/3, Kalugamuwa, Gelloiya	-	Egoda Kalugamuwa	
B18 +S18	No.8 Thotupala	Egoda Kalugamuwa	223308	181402	40	60	rare	2	M.L.M. Haneefa	479/3, Kalugamuwa, Gelloiya	-	Egoda Kalugamuwa	
B19	Bangala Thota	Egoda Kalugamuwa	222935	181583	60	100	No	-	S.M. Waseem	454, Kalugamuwa, Gelloiya	-	Egoda Kalugamuwa	
S19	Kottunna Thotupala	Egoda Kalugamuwa	221521	181158	-	-	No	2	O.L.M. Azam	Elpitiya, Weliganga	-	Egoda Kalugamuwa	
B20	Elpitiya 1	Elpitiya	221247	181178	3	8	rare	-	T.G.N. Bandara	391A, Elpitiya, Weligalla	077 7963279	Udowita	
B21	Elpitiya 2	Elpitiya	221241	181228	2	5	rare	-	T.G.N. Bandara	391A, Elpitiya, Weligalla	077 7963279	Udowita	
B22	Elpitiya 3	Elpitiya	220905	181334	8	20	No	-	S.H.D Ruwankumara	280/48/1, Elpitiya, Weligalla	-	Udowita	
S20	Wall-Ullah	Elpitiya	220776	181259	-	-	rare	3	M. Irfam	380/2/1, Elpitiya, Weligalla	077 0501051	Udowita	
B23 +S21	Pussathota	Udowita	220595	181017	5	10	No	2	D. Dehideniya	Elpitiya, Weligalla, Gampola	-	Udowita	
B24+S22	Pussangolla	Udowita	219888	180279	15	30	No	4	P.D.A.B. Gunarathne	"Asiri", Udowita, Weligalla	-	Udowita	
B25+S23	Paru Thota	Javasengama	219141	178745	2	10	rare	5	K.G. Srivani	21/51, Bothalapitiya, Gampola	-	Bothalapitiya	
B26	Ilawathura - 1	Ilawathura	218437	178198	3	10	rare	-	M.J.M. Ashfer	79, Ilawathura, Gampola	-	Ilawathura	
B27	Ilawathura - 2	Ilawathura	218220	178392	5	10	No	-	M. Amanulla	12/2B, Ilawathura, Gampola	077 9196220	Ilawathura	
B28	Ilawathura - 3	Ilawathura	218280	178350	10	20	No	-	M. Amanulla	12/2B, Ilawathura, Gampola	077 9196220	Ilawathura	
B29	Ilawathura - 4	Ilawathura	218162	178387	10	15	No	-	M.T.M. Ikkal	13/12, Ilawathura, Gampola	-	Ilawathura	
B30	Ilawathura - 5	Ilawathura	218154	178375	7	18	No	-	M.T.M. Ikkal	13/12, Ilawathura, Gampola	-	Ilawathura	
B31	Ilawathura - 6	Ilawathura	218090	178301	5	25	No	-	M. Nazeer	56/37, Ilawathura, Gampola	-	Ilawathura	
B32	Ilawathura - 7	Ilawathura	218080	178250	10	30	No	-	M.N.M. Navaz	52, Ilawathura, Gampola	-	Ilawathura	
B33	Ilawathura - 8	Ilawathura	218053	178196	5	15	No	-	M.S.M. Asvin	56/8, Ilawathura, Gampola	-	Ilawathura	
B34	Ilawathura - 9	Ilawathura	218057	178117	5	15	No	-	J.A. Gafur	17/48, Ilawathura, Gampola	-	Ilawathura	

APPENDIX - IV

- **SURVEY DATA SHEETS OF DOWNSTREAM RIVER USERS**

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola.		Location ID	B1	
Surveyor	A.H. Dissanayake		Date	2013	08 26
DS Division	DOLUWA	GN Division	Naranwita	1149	
Location Name	WALKOTUWA				
GPS	N	218005			
	E	178297			

Type of activityBusinessSand mining ☐Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key Informant

Name JANAKA ASHOKA

Address 84, PALLEWELA, WĒLLA WATTA, GAMPOLA

Telephone +94713354119

Number of users

(Families)

Dry Season 50

Wet Season 10

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola			Location ID	B2		
Surveyor	A. H. DISSANAYAKE			Date	2013	08	26
DS Division	DOLUWA			GN Division	NARANWITA 1149		
Location Name	PALLI THOTA						
GPS	N	218139					
	E	178473					

Type of activityBusinessSand mining ☐Fishing ☒Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key InformantName Address Telephone Number of users

(Families)

Dry Season Wet Season Any effect of Kotmale HPP operation

Notes

Fishing - rare ; as a hobby

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola.			Location ID	B3		
Surveyor	A. H. DISSANAYAKE			Date	2013	08	26
DS Division	DOLUWA			GN Division	NARANWITA 1149		
Location Name	DARĀNDE NĀNA THOTA						
GPS	N	178424					
	E	218298					

Type of activityBusinessSand mining ☐Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key Informant

Name H. M. L. FOUZAR

Address 159C , ANDIYA KADAWATHA , GAMPOLA

Telephone +94779811797

Number of users

(Families)

Dry Season 15

Wet Season 10

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/68 Gampola			Location ID	S1		
Surveyor	A.H. DISSANAYAKE			Date	2013	08	26
DS Division	DOLUWA			GN Division	ATUWE WATTA 1151		
Location Name	ITHALA WELA, ATUWE WATTA						
GPS	N	218 714					
	E	178146					

Type of activityBusinessSand mining ☒Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☐Camping ☐Swimming ☐

Other :

Key Informant

Name M. T. M. NALIEZ

Address 199B, ITHALAWELA, POLWATTA, GAMPOLA

Telephone 0779598782

Number of users

(Families)

Dry Season Wet Season Any effect of Kotmale HPP operationNotes

No. of sand mining workers - 09

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	6/08 Gampola		Location ID	B5, S2	
Surveyor	A. H. DISSANAYAKE		Date	2013	08 26
DS Division	DOLUWA	GN Division	ATUWEWATTA	1151	
Location Name	IHALAWELA 2				
GPS	N	178252			
	E	218845			

Type of activityBusinessSand mining ☒Fishing ☒Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key Informant

Name M. T. M. NALIEZ

Address 199/B, IHALAWELA, POLWATTA, GAMPOLA

Telephone +94779598782

Number of users

(Families)

Dry Season 25

Wet Season 15

Any effect of Kotmale HPP operationNotes

No. of sand mining workers - 04

Fishing - rare

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola.			Location ID	B4		
Surveyor	A. H. DISSANAYAKE			Date	2013	08	26
DS Division	DOLUWA			GN Division	ATUWEWATTA 1151		
Location Name	IHALAWELA 1						
GPS	N	218803					
	E	178165					

Type of activityBusiness

Sand mining	<input type="checkbox"/>
Fishing	<input checked="" type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	M. T. M. Naieez
Address	199 B , IHALAWELA , POLWATTA , GAMPOLA
Telephone	077 959 8782

Number of users

(Families)

Dry Season	25
Wet Season	15

Any effect of Kotmale HPP operation

Notes

Fishing - rare

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number 61/08 Gampola. Location ID 83

Surveyor A. H. DISSANAYAKE Date 2013 08 26

DS Division DOLUNA GN Division ATUWENWATTA 1151

Location Name KAPUKOTUWA THOTUPALA

GPS
N 218917
E 178569

Type of activity

Business

Sand mining ☒

Fishing ☐

Irrigation ☐

Industry ☐

Other :

Cultural

Bathing & Washing ☐

Camping ☐

Swimming ☐

Other :

Key Informant

Name M. G. DULIP KUMARA

Address 17, GAMPOLA WATTA, GAMPOLA

Telephone 077 9786937

Number of users

(Families)

Dry Season

Wet Season

Any effect of Kotmale HPP operation

.....
.....
.....

Notes

No. of sand mining workers - 05
.....
.....

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola.			Location ID	B6		
Surveyor	A. H. DISSANAYAKE			Date	2013	08	26
DS Division	DOLUWA		GN Division	NARANWITA		1149	
Location Name	POLWATTA						
GPS	N	219488					
	E	178958					

Type of activityBusinessSand mining ☐Fishing ☒Irrigation ☐Industry ☐

Other :

CulturalBathing & ☒

Washing

Camping ☐Swimming ☐

Other :

Key Informant

Name N. DASANAYAKE (MRS.)

Address POLWATTA, NARANWITA

Telephone 0815610454

Number of users

(Families)

Dry Season 10

Wet Season 3

Any effect of Kotmale HPP operation

Notes

Fishing - rare

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola.			Location ID	B7, S5		
Surveyor	A. H. DISANAYAKE			Date	2013	08	26
DS Division	DOLUWA			GN Division	INGURUWATTA 1153		
Location Name	ISKOLAWATTA						
GPS	N	219717					
	E	179884					

Type of activityBusinessSand mining ☒Fishing ☒Irrigation ☐Industry ☐

Other :

CulturalBathing & ☒

Washing

Camping ☐Swimming ☐

Other :

Key Informant

Name U. A. GUNARATHNA MENIKE

Address ISKOLA WATTA , NIYAMGAMA , GAMPOLA

Telephone 081 5733416

Number of users

(Families)

Dry Season 25

Wet Season 6

Any effect of Kotmale HPP operation

Notes

Fishing - rarely

Sand mining workers - 02

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.			Location ID	S6, B8		
Surveyor	A. H. DISSANAYAKE			Date	2013	08	26
DS Division	DOLUWA			GN Division	INGURUWATTA		
Location Name	GANTHOTA PITIYA, KAWDU PITIYA						
GPS	N	220073					
	E	180866					

Type of activity

Business

Sand mining	<input checked="" type="checkbox"/>
Fishing	<input checked="" type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	D.K. SENEVIRATHNA
Address	LIYANDENIYA, DOLUWA
Telephone	081 49272 35

Number of users

(Families)

Dry Season	25
Wet Season	10

Any effect of Kotmale HPP operation

Notes

Fishing - rare

Sand mining workers - 03

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.		Location ID	B9	
Surveyor	A. H. DISSANAYKE		Date	2013	08 26
DS Division	DOLUWA	GN Division	DOLUWA	1155	
Location Name	WALA PĒLA WALA				
GPS	N	220252	E	181004	

Type of activityBusinessSand mining ☐Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key Informant

Name D. K. SENEVIRATHNA

Address LIYANDENIYA, DOLUWA

Telephone 081 492 72 35

Number of users

(Families)

Dry Season 20

Wet Season 10

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	<u>61/3 Gampola.</u>	Location ID	<u>S7, 810</u>				
Surveyor	<u>A. H. DISSANAYAKE</u>	Date	<u>2013</u> <u>08</u> <u>26</u>				
DS Division	<u>DOLUWA</u>	GN Division	<u>GODAWELA</u> <u>1156</u>				
Location Name	<u>WELLA THOTA</u>						
GPS	<table border="1"> <tr> <td>N</td> <td><u>221308</u></td> </tr> <tr> <td>E</td> <td><u>181217</u></td> </tr> </table>			N	<u>221308</u>	E	<u>181217</u>
N	<u>221308</u>						
E	<u>181217</u>						

Type of activity

<u>Business</u>		<u>Cultural</u>	
Sand mining	<input checked="" type="checkbox"/>	Bathing & Washing	<input checked="" type="checkbox"/>
Fishing	<input checked="" type="checkbox"/>	Camping	<input type="checkbox"/>
Irrigation	<input type="checkbox"/>	Swimming	<input type="checkbox"/>
Industry	<input type="checkbox"/>	Other :	Other :

Key Informant

Name	<u>M. P. C. JAYASUNDARA</u>
Address	<u>GODAWELA, DOLUWA</u>
Telephone	<u>077616 8464</u>

<u>Number of users</u>	Dry Season	<u>15</u>
<u>(Families)</u>	Wet Season	<u>5</u>

Any effect of Kotmale HPP operation

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.....

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Notes

Fishing - rare

Sand mining Workers - 03

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.....

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/36ampola.		Location ID	B11, S8	
Surveyor	A. H. DISSANAYAKE		Date	2013	08 26
DS Division	DOLUWA	GN Division	MEGODA KALUGAMUWA		1157
Location Name	KOTTA GAS HANDIYA				
GPS	N	222 771	E	181631	

Type of activityBusinessSand mining ☒Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key Informant

Name AJITH PADMASIRI

Address 132/4, MEGODA KALUGAMUWA, PERADENIYA

Telephone 0776167570

Number of users

(Families)

Dry Season 15

Wet Season 5

Any effect of Kotmale HPP operationNotes

No. of Sand mining workers - 04

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola			Location ID	B12		
Surveyor	A. H. DISSANAYAKE			Date	2013	08	26
DS Division	DOLUWA		GN Division	MEGODA KALUGAMUWA		1157	
Location Name	PIPE BRIDGE - KALUGAMUWA						
GPS	N	222983					
	E	181641					

Type of activityBusinessSand mining ☐Fishing ☒Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key InformantName **AJITH PATHMASIRI**Address **132/4 , MEGODA KALUGAMUWA**Telephone **0776167570**Number of users

(Families)

Dry Season **10**Wet Season **05**Any effect of Kotmale HPP operationNotes

Fishing - rarely

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	54/23 Kandy			Location ID	B13, S9		
Surveyor	A. H. DISSANAYAKE			Date	2013	08	27
DS Division	GANGAWATA KORALE			GN Division	HINDAGALA 267		
Location Name	WALAWWA WATTA						
GPS	N	225728					
	E	180759					

Type of activityBusinessSand mining ☒Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key Informant

Name D. W. GUNATHILAKE

Address 142, DOLUWA ROAD ROAD, HINDAGALA

Telephone

Number of users

(Families)

Dry Season 5

Wet Season 5

Any effect of Kotmale HPP operationNotes

No. of Sand mining workers - 02

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	54/23 Kandy		Location ID	S10	
Surveyor	A. H. DISSANAYAKE		Date	2013	08 27
DS Division	GANGAWATA KORALE	GN Division	PALLE PERADENIYA	248	
Location Name	HINDAGALA 1				
GPS	N	226565	E	180689	

Type of activityBusinessSand mining ☒Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☐Camping ☐Swimming ☐

Other :

Key Informant

Name UPALI CHANDRALAL

Address "MUSSDALE" , GALAHAROD , PERADENIYA

Telephone Number of users

(Families)

Dry Season Wet Season Any effect of Kotmale HPP operationNotes

No. of Sand mining workers - 02

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	54/23 Kandy		Location ID	S11	
Surveyor	A. H. DISANAYAKE		Date	2013	08 27
DS Division	GANGAWATA KORALE	GN Division	PALLE PERADENIYA	248	
Location Name	HINDAGALA 2				
GPS	N	226778	E	180592	

Type of activityBusiness

Sand mining	<input checked="" type="checkbox"/>
Fishing	<input type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	UPALI CHANDRALAL
Address	"MUSSDALE", GALAH ROAD, PERADENIYA
Telephone	

Number of users

(Families)

Dry Season	<input type="text"/>
Wet Season	<input type="text"/>

Any effect of Kotmale HPP operationNotes

No. of Sand mining workers - 03

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	54/23 Kandy			Location ID	P1 + S12		
Surveyor	A.H. DISSANAYAKE			Date	2013	08	27
DS Division	UDUNUWARA		GN Division	ANGUNAWELA EAST		0018	
Location Name	KANDY SOUTH INTAKE (NWS&DB)						
GPS	N	227396					
	E	180262					

Type of activityBusinessSand mining ☒Fishing ☐Irrigation ☐Industry ☐

Other : Water Supply Intake

CulturalBathing & Washing ☐Camping ☐Swimming ☐

Other :

Key Informant

Name PROJECT DIRECTOR

Address WATER SUPPLY AND DRAINAGE BOARD,
GAMPOLA ROAD, MEENATHURA, PERADENIYA

Telephone 081 2385725

ksouth@sltnet.lk

Number of users

(Families)

Dry Season Wet Season Contact Person :

H.M.A. Rathnayake

Any effect of Kotmale HPP operation

Notes

Sand mining workers - 06

Water supply for Kandy city - South area.

Max^m capacity 32000 m³/daypresent prod^m 20000 m³/day

Num of water connections 15,000

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	54/23 Kandy.		Location ID	P2	
Surveyor	A. H. DISANAYAKE		Date	2013	08 27
DS Division	UDUNUWARA	GN Division	ANGUNAWELA EAST 0018		
Location Name	UNIVERSITY INTAKE				
GPS	N	227129	E	180285	

Type of activityBusinessSand mining ☐Fishing ☐Irrigation ☐Industry ☐Other : Water supply
schemeCulturalBathing & Washing ☐Camping ☐Swimming ☐

Other :

Key InformantName PROJECT DIRECTORAddress NATIONAL WATER SUPPLY AND DRAINAGE BOARD
GAMPOLA ROAD, MEEWATHURA, PERADENIYATelephone 0812385725ksouth@sltnet.lkNumber of usersDry Season ☐Wet Season ☐Contact person :H.M.A. Rathnayake

Any effect of Kotmale HPP operation

NotesPlant Capacity 5500 m³/day

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola			Location ID	S13		
Surveyor	A. H. DISANAYAKE			Date	2013	08	28
DS Division	UDUNUWARA		GN Division	GODAPOLA WEST		0028	
Location Name	KURUNDUWATTA						
GPS	N	225329		E	180906		

Type of activity

Business

Sand mining	<input checked="" type="checkbox"/>
Fishing	<input type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	S. L. R. A. SENEVIRATHNA
Address	B/53, NEW PERADENIYA, KOSSINNA, GELIOYA
Telephone	0814980143

Number of users

Dry Season	<input type="text"/>
Wet Season	<input type="text"/>

Any effect of Kotmale HPP operation

Notes

No. of Sand mining workers - 03

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.			Location ID	P3		
Surveyor	A. H. DISSANAYAKE			Date	2013	08	28
DS Division	UDUNUWARA			GN Division	NEW PERADENIYA 0026		
Location Name	BRICK MANUFACTURING PLACE 1						
GPS	N	225141					
	E	181027					

Type of activityBusinessSand mining ☐Fishing ☐Irrigation ☐Industry ☒

Other :

CulturalBathing & Washing ☐Camping ☐Swimming ☐

Other :

Key InformantName Address Telephone Number of usersDry Season Wet Season Any effect of Kotmale HPP operation

Notes

Small scale brick manufacturing place, around 500 Nos of bricks a day.

Un-authorized water usage from river.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.		Location ID	B14, S14	
Surveyor	A. H. DISSANAYAKE		Date	2013	08 28
DS Division	UDUNUWARA	GN Division	NEW PERADENYA	0026	
Location Name	PAHINGAMA THOTUPALA 1				
GPS	N	224706	E	181148	

Type of activityBusiness

Sand mining	<input checked="" type="checkbox"/>
Fishing	<input type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	P. G. JAYARATHNA
Address	46/3, PAHINGAMA, GELIOYA
Telephone	077 99 14 938

Number of users

(Families)

Dry Season	5
Wet Season	2

Any effect of Kotmale HPP operationNotes

No. of sand mining workers - 02

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola		Location ID	S15	
Surveyor	A. H. DISSANAYAKE		Date	2013	08 28
DS Division	UDUNUWARA	GN Division	NEW PERADENIYA	0026	
Location Name	PAHINGAMA THOTUPALA 2				
GPS	N	224585	E	181084	

Type of activity**Business**Sand mining ☒Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☐Camping ☐Swimming ☐

Other :

Key InformantName Address Telephone **Number of users**Dry Season Wet Season **Any effect of Kotmale HPP operation**

Notes

Abandoned - no one available to collect information.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.		Location ID	B15+ S16	
Surveyor	C. Aberathne		Date	2013	08 28
DS Division	udu nuwara.	GN Division	New Peradeniya. 0026		
Location Name	Pahingama 3				
GPS	N	224169	E	181087	

Type of activityBusinessSand mining ☒Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key Informant

Name Kanchana Nawarathna.

Address 35, Paingamuwa, Geli oya

Telephone 077 7030950

Number of users

(Families)

Dry Season 02

Wet Season 01

Any effect of Kotmale HPP operationNotes

sand mining workers - 02 Nos. approx.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola		Location ID	S 17	
Surveyor	A. H. Dissanayake		Date	2013	08 28
DS Division	udu Nuwara.	GN Division	NEW PERADENIYA	0026	
Location Name	Paingamuwa thotupala 04				
GPS	N	224169			
	E	181101			

Type of activityBusinessSand mining ☒Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & ☐

Washing

Camping ☐Swimming ☐

Other :

Key Informant

Name Hemalatha

Address Paingamuwa, Gelioya.

Telephone -

Number of users

(Families)

Dry Season -

Wet Season -

Any effect of Kotmale HPP operation

Notes

Approx. 02 workers involved in sand mining.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola		Location ID	B 16	
Surveyor	A.H. Dissanayake		Date	2013	08 28
DS Division	Uda Palatha	GN Division	Egoda Kalugamuwa	1159	
Location Name	Nape thota, Polmandiya				
GPS	N	223783	E	181311	

Type of activity**Business**

Sand mining	<input type="checkbox"/>
Fishing	<input checked="" type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	T.M. Munnah
Address	516/1A, Kalugamuwa road Geli oya,
Telephone	075 6692427

Number of users

(Families)

Dry Season	10
Wet Season	10

Any effect of Kotmale HPP operation

Notes

Fishing is a rare activity in this place as a hobby.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	B17				
Surveyor	A.H. Dissanayake	Date	2013 08 28				
DS Division	Uda Palatha	GN Division	Egoda Kalugamuwa 1159				
Location Name	Pallithota						
GPS	<table border="1"> <tr> <td>N</td> <td>2 2 3 5 6 7</td> </tr> <tr> <td>E</td> <td>1 8 1 2 8 4</td> </tr> </table>			N	2 2 3 5 6 7	E	1 8 1 2 8 4
N	2 2 3 5 6 7						
E	1 8 1 2 8 4						

Type of activityBusiness

Sand mining	<input type="checkbox"/>
Fishing	<input checked="" type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	A.N. Maujude
Address	505/3, Kalugamuwa, Gelioya
Telephone	

Number of users

(Families)

Dry Season	40
Wet Season	30

Any effect of Kotmale HPP operationNotes

Fishing is a rare activity only for domestic purpose.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola		Location ID	B18+ S18	
Surveyor	A. H. Dissanayake		Date	2013	08 28
DS Division	uda Palatha	GN Division	Egoda Kalugamuwa	1159	
Location Name	No. 8. thotupala				
GPS	N	223308	E	181402	

Type of activityBusiness

Sand mining	<input checked="" type="checkbox"/>
Fishing	<input checked="" type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	M. L. M. Haneefa
Address	479/3, kalugamuwa, Gelioya.
Telephone	-

Number of users

(Families)

Dry Season	60
Wet Season	40

Any effect of Kotmale HPP operation

Notes

sand mining workers - 02 Nos.
Fishing is very rare activity.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola		Location ID	B19	
Surveyor	C. Aberathne		Date	2013	08 28
DS Division	uda palatha	GN Division	Egoda kalugamuwa	1159	
Location Name	Bangalathota (near pipe bridge)				
GPS	N	222935	E	181583	

Type of activityBusinessSand mining ☐Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key InformantName Address Telephone Number of users

(Families)

Dry Season Wet Season Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	<u>61/3 Gampola</u>	Location ID	<u>S 19</u>				
Surveyor	<u>A. H. Dissanayake</u>	Date	<u>2013</u> <u>09</u> <u>13</u>				
DS Division	<u>uda Palatha</u>	GN Division	<u>Egoda kalugamuwa</u> <u>1159</u>				
Location Name	<u>Kottunna thotupala</u>						
GPS	<table border="1"> <tr> <td>N</td> <td><u>2 2 1 5 2 1</u></td> </tr> <tr> <td>E</td> <td><u>1 8 1 1 5 8</u></td> </tr> </table>			N	<u>2 2 1 5 2 1</u>	E	<u>1 8 1 1 5 8</u>
N	<u>2 2 1 5 2 1</u>						
E	<u>1 8 1 1 5 8</u>						

Type of activity

Business

Sand mining	<input checked="" type="checkbox"/>
Fishing	<input type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	<u>O. L. M. AZAM</u>
Address	<u>Elpitiya, weligalla</u>
Telephone	<u>-</u>

Number of users

(Families)

Dry Season	<u>-</u>
Wet Season	<u>-</u>

Any effect of Kotmale HPP operation

Notes

sand mining workers - 02 Nos. approx.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola		Location ID	B 20	
Surveyor	A.H. Dissanayake		Date	2013	09 13
DS Division	uda Palatha	GN Division	udo wita	11 25	
Location Name	Elpitiya - 01				
GPS	N	2 2 1 2 4 7			
	E	1 8 1 1 7 8			

Type of activityBusinessSand mining ☐Fishing ☒Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key Informant

Name T. G. N. Bandara

Address 391 A, Elpitiya, weligalla

Telephone 077 796 3279

Number of users

(Families)

Dry Season 08

Wet Season 03

Any effect of Kotmale HPP operation

Notes

Fishing is rare activity in this place in minor scale.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola		Location ID	B 21	
Surveyor	C. Aberathne		Date	2013	09 13
DS Division	uda Palatha.	GN Division	udowita	1125	
Location Name	Elpitiya-02				
GPS	N	2 2 1 2 4 1			
	E	1 8 1 2 2 8			

Type of activityBusiness

Sand mining	<input type="checkbox"/>
Fishing	<input checked="" type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	T. G. N. Bandara
Address	391A, Elpitiya, Weligalla.
Telephone	077 7963279

Number of users

(Families)

Dry Season	5
Wet Season	2

Any effect of Kotmale HPP operation

Notes

very occasional fishing activity.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.		Location ID	B 22	
Surveyor	A.H. Dissanayake		Date	2013	09 13
DS Division	Uda Palatha	GN Division	Udowita	11 25	
Location Name	Elpitiya -03				
GPS	N	220905	E	181334	

Type of activityBusinessSand mining ☐Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key InformantName Address Telephone Number of users

(Families)

Dry Season Wet Season Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola		Location ID	S 20	
Surveyor	A. H. Dissanayake		Date	2013	09 13
DS Division	Uda Palatha	GN Division	Udowita	1125	
Location Name	wali ullah Pallithota, Elpitiya				
GPS	N	220776	E	181259	

Type of activityBusiness

Sand mining	<input checked="" type="checkbox"/>
Fishing	<input checked="" type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	M. Irfam
Address	380/2/1, Elpitiya, Weligalla.
Telephone	077 0501051

Number of users

(Families)

Dry Season	-
Wet Season	-

Any effect of Kotmale HPP operation

Notes

Fishing is done as hobby and rarely. 03 workes involved in sand mining.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola		Location ID	B23 + S21	
Surveyor	C. Aberathne		Date	2013	09 13
DS Division	uda palatha	GN Division	udowita	1125	
Location Name	Pussathota, udowita.				
GPS	N	220595	E	181017	

Type of activityBusinessSand mining ☒Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key Informant

Name D. Dehideniya.

Address Elpitiya, Weligalla, Gampola.

Telephone -

Number of users

(Families)

Dry Season 10

Wet Season 05

Any effect of Kotmale HPP operation

Notes

Sand mining workers - 02 NOS. approx.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	<u>61/3 Gampola</u>	Location ID	<u>B24+522</u>				
Surveyor	<u>C. Aberathna</u>	Date	<u>2013</u> <u>09</u> <u>13</u>				
DS Division	<u>Uda Palatha</u>	GN Division	<u>Udowita</u> <u>1125</u>				
Location Name	<u>Pussangolla</u>						
GPS	<table border="1"><tr><td>N</td><td><u>219 8 88</u></td></tr><tr><td>E</td><td><u>180 2 79</u></td></tr></table>			N	<u>219 8 88</u>	E	<u>180 2 79</u>
N	<u>219 8 88</u>						
E	<u>180 2 79</u>						

Type of activity

Business

Sand mining	<input checked="" type="checkbox"/>
Fishing	<input type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	<u>P.D.A.B. Gunarathne</u>
Address	<u>"Asiri", Udowita, Weligalla.</u>
Telephone	<u> </u>

Number of users

(Families)

Dry Season	<u>30</u>
Wet Season	<u>15</u>

Any effect of Kotmale HPP operation

Notes

Approx. 04 workers involved in sand mining activity.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	<u>61/8 Gampola</u>	Location ID	<u>B25 + S23</u>				
Surveyor	<u>A.H. Dissanayake</u>	Date	<u>2013</u> <u>09</u> <u>13</u>				
DS Division	<u>UDA PALATHA</u>	GN Division	<u>Bothalapitiya</u> <u>1109</u>				
Location Name	<u>Jayasengama, Paruthota</u>						
GPS	<table border="1"> <tr> <td>N</td> <td><u>219 141</u></td> </tr> <tr> <td>E</td> <td><u>178 745</u></td> </tr> </table>			N	<u>219 141</u>	E	<u>178 745</u>
N	<u>219 141</u>						
E	<u>178 745</u>						

Type of activityBusiness

Sand mining	<input checked="" type="checkbox"/>
Fishing	<input checked="" type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	<u>MS. K.G. Sriyani</u>
Address	<u>21/51, Bothalapitiya, Gampola.</u>
Telephone	<u>-</u>

Number of users*(Families)*

Dry Season	<u>10</u>
Wet Season	<u>02</u>

Any effect of Kotmale HPP operation

Notes

Fishing is a rare activity in this place done as a hobby. Approximately 5 workers involve in sand mining.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola		Location ID	B 26	
Surveyor	C. Abenathne.		Date	2013	09/13
DS Division	VDA PALATHA	GN Division	ILLAWATURA	1110	
Location Name	ILLAWATURA . . . 01				
GPS	N	218437	E	178198	

Type of activityBusinessSand mining ☐Fishing ☒Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key Informant

Name

M.J.M. ASHFER

Address

79, ILLAWATURA, GAMPOLA

Telephone

-

Number of users

(Families)

Dry Season

10

Wet Season

3

Any effect of Kotmale HPP operation

Notes

Fishing is rare activity only as a hobby who done for individual use.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola		Location ID	B 27	
Surveyor	A.H. Dissanayake		Date	2013	09/13
DS Division	VDA PALATHA	GN Division	ILLAWATURA	1110	
Location Name	ILLAWATURA - 02				
GPS	N	218 220			
	E	178 392			

Type of activityBusinessSand mining ☐Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & ☒

Washing

Camping ☐Swimming ☐

Other :

Key InformantName

Address

Telephone

Number of users

(Families)

Dry Season

Wet Season

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	<u>61/8 Gampola</u>	Location ID	<u>B 28</u>				
Surveyor	<u>C. Aberathne</u>	Date	<u>2013</u> <u>09</u> <u>13</u>				
DS Division	<u>UDA PALATHA</u>	GN Division	<u>ILLAWATURA</u> <u>1110</u>				
Location Name	<u>ILLAWATURA - 03</u>						
GPS	<table border="1"> <tr> <td>N</td> <td><u>2 1 8 2 8 0</u></td> </tr> <tr> <td>E</td> <td><u>1 7 8 3 5 0</u></td> </tr> </table>			N	<u>2 1 8 2 8 0</u>	E	<u>1 7 8 3 5 0</u>
N	<u>2 1 8 2 8 0</u>						
E	<u>1 7 8 3 5 0</u>						

Type of activity

Business

Sand mining	<input type="checkbox"/>
Fishing	<input type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	<u>A. Amanulla.</u>
Address	<u>12/2B, ILLAWATURA</u> <u>GAMPOLA</u>
Telephone	<u>077 919 6220</u>

Number of users

(Families)

Dry Season	<u>20</u>
Wet Season	<u>10</u>

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola		Location ID	B 29	
Surveyor	A.H. Dissanayake		Date	2013	09 13
DS Division	UDA PALATHA	GN Division	ILLAWATURA	1110	
Location Name	ILLAWATURA - 4				
GPS	N	218162	E	178387	

Type of activityBusiness

Sand mining	<input type="checkbox"/>
Fishing	<input type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	MTM IKBAL
Address	13/12, ILLAWATURA, GAMPOLA
Telephone	-

Number of users

(Families)

Dry Season	15
Wet Season	10

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number 61/8 Gampola Location ID B 30

Surveyor C. Aberathne Date 2013 09 13

DS Division UDA PALATHA GN Division ILLAWATURA 1110

Location Name ILLAWATURA-5

GPS

N	218 154
E	178 375

Type of activity

Business

Sand mining

Fishing

Irrigation

Industry

Other :

Cultural

Bathing & Washing ✓

Camping

Swimming

Other :

Key Informant

Name M.T.M. IKBAL

Address 13/12, ILLAWATURA, GAMPOLA

Telephone —

Number of users

(Families)

Dry Season 18

Wet Season 07

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	<u>61/8 Gampola.</u>	Location ID	<u>B 31</u>				
Surveyor	<u>A.H. DISSANAYAKE</u>	Date	<u>2013</u> <u>09</u> <u>13</u>				
DS Division	<u>UDA PALATHA</u>	GN Division	<u>ILLAWATURA</u> <u>1110</u>				
Location Name	<u>ILLAWATURA - 6</u>						
GPS	<table border="1"> <tr> <td>N</td> <td><u>218090</u></td> </tr> <tr> <td>E</td> <td><u>178301</u></td> </tr> </table>			N	<u>218090</u>	E	<u>178301</u>
N	<u>218090</u>						
E	<u>178301</u>						

Type of activity

Business

Sand mining	<input type="checkbox"/>
Fishing	<input type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	<u>M. NAZEER</u>
Address	<u>56/37, ILLAWATURA, GAMPOLA</u>
Telephone	<u>-</u>

Number of users

(Families)

Dry Season	<u>25</u>
Wet Season	<u>05</u>

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola		Location ID	B-32	
Surveyor	A.H. Dissanayake.		Date	2013	09 13
DS Division	UDA PALATHA	GN Division	ILLAWATURA	1110	
Location Name	ILLAWATURA - 07				
GPS	N	218 080	E	178 250	

Type of activityBusinessSand mining ☐Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & Washing ☒Camping ☐Swimming ☐

Other :

Key InformantName Address Telephone Number of users

(Families)

Dry Season Wet Season Any effect of Kotmale HPP operation

People have the feeling of water level fluctuations with times. In extreme case relevant authorities & institutions disseminate the message of warning.

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola		Location ID	B 33	
Surveyor	C. Aberathne		Date	2013	09 13
DS Division	UDA PALATHA	GN Division	ILLAWATURA	1110	
Location Name	ILLAWATURA - 08				
GPS	N	218053	E	178196	

Type of activityBusinessSand mining ☐Fishing ☐Irrigation ☐Industry ☐

Other :

CulturalBathing & ☒

Washing

Camping ☐Swimming ☐

Other :

Key Informant

Name

M.S.M. ASVIN

Address

56/8, ILLAWATURA, GAMPOLA

Telephone

-

Number of users

(Families)

Dry Season

15

Wet Season

05

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola	Location ID	B 34				
Surveyor	A. H. Dissanayake	Date	2013 09 13				
DS Division	UDA PALATHA	GN Division	ILLAWATURA 1110				
Location Name	ILLA WATURA - 9						
GPS	<table border="1"> <tr> <td>N</td> <td>218 057</td> </tr> <tr> <td>E</td> <td>178 117</td> </tr> </table>			N	218 057	E	178 117
N	218 057						
E	178 117						

Type of activityBusiness

Sand mining	<input type="checkbox"/>
Fishing	<input type="checkbox"/>
Irrigation	<input type="checkbox"/>
Industry	<input type="checkbox"/>

Other :

Cultural

Bathing & Washing	<input checked="" type="checkbox"/>
Camping	<input type="checkbox"/>
Swimming	<input type="checkbox"/>

Other :

Key Informant

Name	J. A. GAFUR
Address	17/48, ILLAWATURA, GAMPOLA
Telephone	-

Number of users

Families.

Dry Season	15
Wet Season	05

Any effect of Kotmale HPP operation

with the long term experience, people know the water level fluctuations well.

Notes

All houses nearby to this place have water connections from NWS & DB.



Moragolla Hydropower Project

Additional Studies in the Natural Environment: Expert Report on Mitigating the Impacts of the Moragolla Hydropower Project on Fish

FINAL REPORT



August 2013

Study team

Professor Devaka Weerakoon (Team Leader)

Naalin Perera (Fish expert)

Sampath de A. Goonatilake (Fish expert)

Technical oversight and coordination

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GIS mapping

Darshani Wijesinghe

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We are grateful to Nippon Koei Co. Ltd. for providing us with the opportunity to undertake this interesting study. In particular, we would like to thank Mr. Makoto Nakagawa (Team Leader) and Mr. Upul Gunasekera (Deputy Team Leader) for their assistance and the provision of the materials necessary to complete the study successfully.

We are also immensely grateful to Mr. W. A. D. D. Wijesuriya, who accompanied the IUCN team in the field for his assistance and guidance.

ABBREVIATIONS

CEB	–	Ceylon Electricity Board
CR	–	Critically Endangered
DWC	–	Department of Wildlife Conservation
EIA	–	Environmental Impact Assessment
EN	–	Endangered
FD	–	Forest Department
IUCN	–	International Union for Conservation of Nature
LC	–	Least Concern
MASL	–	Mahaweli Authority of Sri Lanka
MHP	–	Moragolla Hydropower Project
NBRO	–	National Building Research Organization
NK	–	Nippon Koei Co. Ltd
NT	–	Near Threatened
VU	–	Vulnerable

EXECUTIVE SUMMARY

The proposed Moragolla Hydropower Project (MHP) involves the construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha, reservoir with a Full Supply Level (FSL) of 548 m asl. Water will be diverted through a conveyance system to the powerhouse, while the outfall is located opposite the confluence with Atabage Oya.

The main objective of the study is to identify the critical freshwater species that occur in project area and to propose a plan to mitigate the impacts of the MHP on the fish fauna of the area. The EIA report for the MHP reported a total of 12 fish species from the project area. Additional studies on the aquatic ecology of the area indicate the existence of a total of 47 fish species from Moragolla downstream up to the Polgolla dam near Katugasthota (NBRO, 2013). According to these reports, 14 endemic fish species are found in the area.

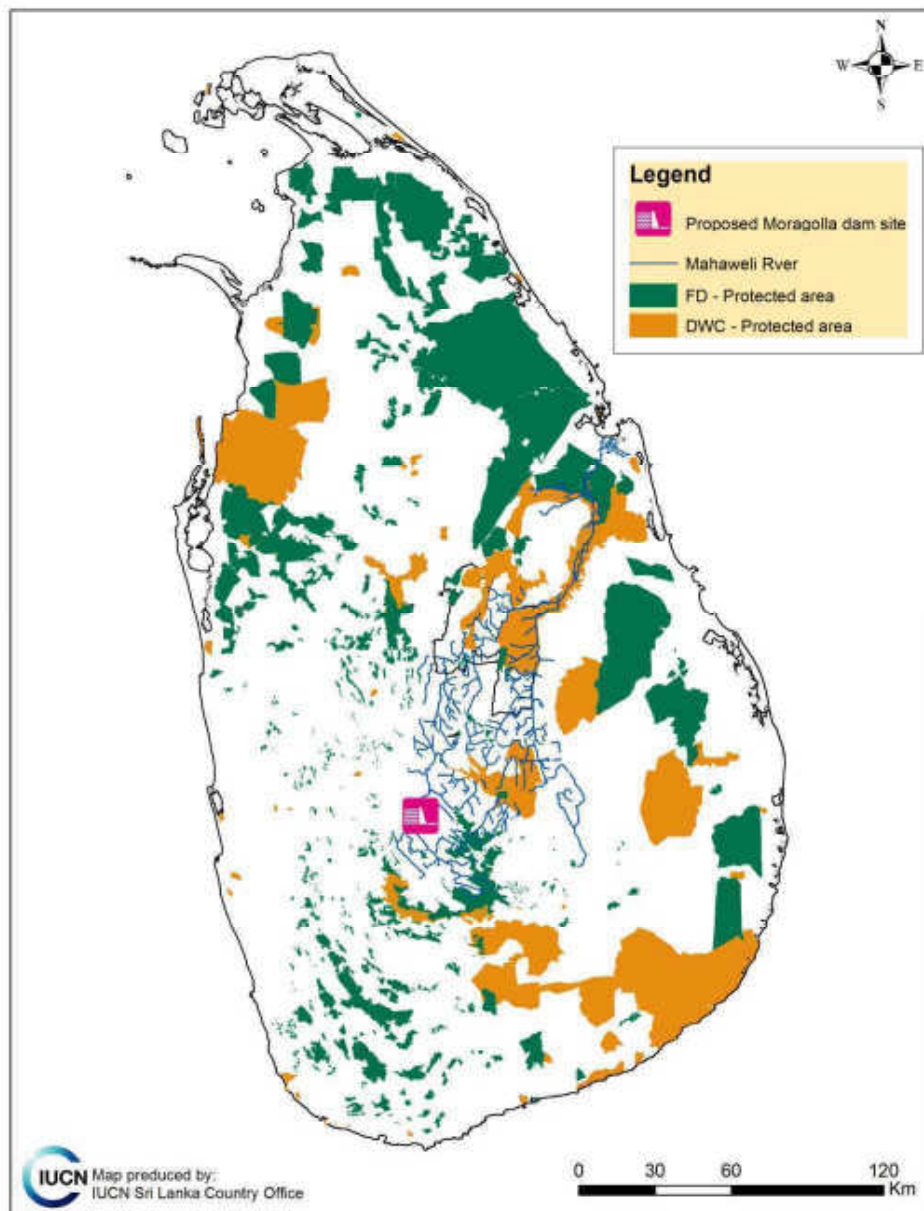
A points-based system was developed to identify critical fish species that will be impacted by the project. As part of this activity indigenous fish were categorized into three groups - low priority, moderate priority and high priority. *Labeo fisheri* (Mountain labeo) is categorized as a high priority species that can be affected significantly due to the project. A mitigation plan highlighting the importance of translocating the Moragolla population of *L. fisheri* to the Kelani River basin has been proposed. Although two catadromous fish species - *Anguilla bicolour* (Level-finned eel) and *Anguilla nebulosa* (Long-finned eel) - have been recorded by NBRO (2013), a recovery plan was not proposed for these species after careful consideration of relevant factors.

The impacts of the MHP on the fish fauna of the area have been identified, while a mitigation plan has been developed in order to facilitate minimization of these impacts. Some of the mitigation measures proposed in the Terms of Reference (ToR) for the assignment have been rejected after careful consideration of the relevant ground realities. A habitat management plan for the upper catchment of the Mahaweli River, up to Nawalapitiya, is proposed in order to provide offset habitat protection.

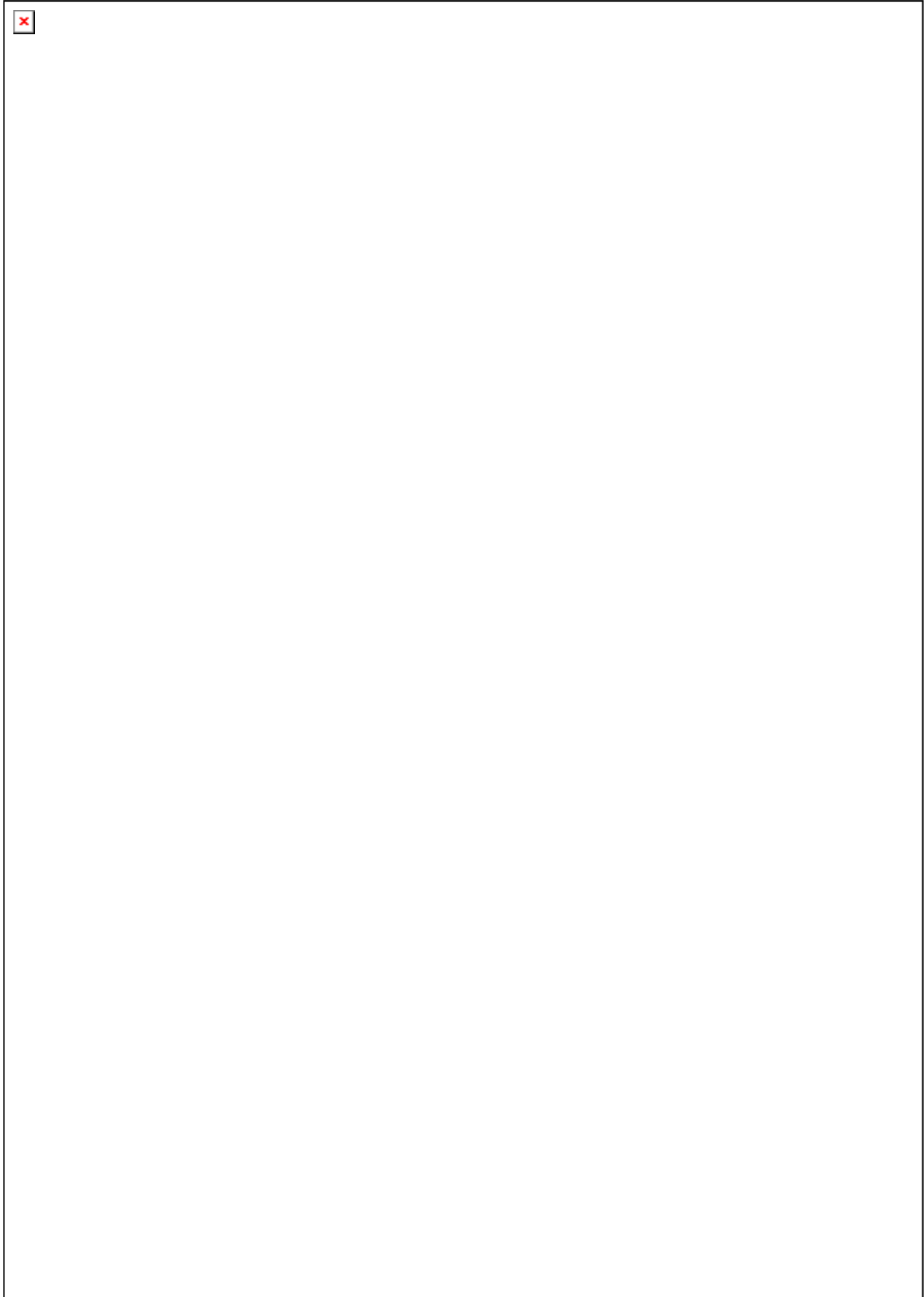
1. INTRODUCTION

1.1 Background

The Ceylon Electricity Board (CEB) is planning to develop a 30.8 MW hydropower project in Moragolla, Sri Lanka. The proposed Moragolla Hydropower Project (MHP) is located in the Kandy District of the Central Province. The project involves the construction of a 35 m high concrete dam across the Mahaweli River at Weliganga, resulting in the formation of a 38.5 ha reservoir with a Full Supply Level (FSL) of 548 m asl.



Map 1. Location of the Moragolla Hydropower Project



Map 2. Land use map of the project area.

The water diverted from this reservoir will be transported through a conveyance system to the power house, which is located three and a half kilometres downstream of the proposed dam. The water discharge point is located near Ethgala and the Atabage sub-catchment of the Mahaweli River. The Kotmale power station using water diverted from Kotmale Oya, one of the main sub-catchments of the Mahaweli River, also discharges in to the main river system very close to the tailrace outlet of the proposed power station.

The Mahaweli River (known locally as Mahaweli Ganga) is the longest river in Sri Lanka, and consists of a catchment that is 10, 448 km² in area, draining almost 16 percent of the total land area of Sri Lanka, and discharging 4, 009 million cubic meters of water per year (Survey Department of Sri Lanka, 2012). The Mahaweli River is also the most important river in Sri Lanka from an economic perspective. The largest integrated agricultural, hydro-electricity and rural development programme ever undertaken in Sri Lanka is based on the water resources of the Mahaweli River basin. According to the 2010 Annual Report of the Ceylon Electricity Board, the Mahaweli complex contributed 22.8 percent of the total power generation of the network. Water from the Mahaweli River has fed many thousands of hectares of agricultural land in many districts in northern Dry Zone of the country since the diversion of the Mahaweli River at Polgalla in 1976.

In addition to its social and economic significance, the Mahaweli River basin is of great environmental and ecological significance. The Mahaweli River crosses the entire central mountain area with its unique drainage pattern, and flows through many protected areas spanning from Horton Plains National Park located in the third peneplain to Flood Plains National Park located in the first peneplain, passing number of other protected areas, such as the Knuckles Conservation Forest of the Central Highlands World Heritage Site, the Hakgala Strict Nature Reserve, Somawathiya National Park, the Victoria-Randenigala-Rantambe Sanctuary and the Wasgamuwa National Park on its way to the discharge point located in Trincomalee. Further, the Mahaweli River supports some of the unique faunal species of Sri Lanka, including several species of freshwater fish, such as *Dawkinsia srilankensis*¹ (Sri Lanka blotched filamented barb), *Systemus martenstyni*¹ (Martenstynis barb), *Labeo fisheri* (Mountain labeo), *Labuca insularis* (Knuckles labuca) and *Devario aequipinnatus* (Knuckles danio), that are found only in the Mahaweli River and its tributaries. Likewise, the endemic freshwater crab, *Ceylonthelphusa durrelli* is also restricted to the tributaries of the Mahaweli River that flow through Cobert's Gap. Further, several terrestrial faunal species endemic to Sri Lanka, such as *Ceratophora tennentii* (Leaf-nosed lizard), *Cophotis dumbara* (Knuckles pygmy lizard) and *Nannophrys marmorata* (Kirtisinghe's rock frog), are found only within the Mahaweli River basin.

As such, it was necessary to conduct an environmental Feasibility Study, including an Environmental Impact Assessment (EIA), for the proposed project – which is based within the Mahaweli River basin – in 2009. This was followed by a supplementary assessment of the aquatic ecology of the area in 2013 by the National Building Research Organization (NBRO) in order to investigate the aquatic species and habitats present in the site, and the ways in which they would be impacted by the project. Given that these studies indicated the presence of some threatened fish species in the project area, an additional study on the mitigation of the impacts of the project on the fish fauna of the area has been deemed necessary in order to assist Nippon Koei Co. Ltd. (NK) in planning such mitigation measures, as well as to provide the CEB with information necessary for key decision making processes. The present study has been designed to address this need.

¹ Formally considered to belong to the Genus *Puntius*.

1.2 Objectives

The overall objective of the study is to propose a plan for the mitigation of ecological impacts of the Moragolla Hydropower Project on the fish fauna of the area.

The specific objectives of the study are:

- To provide an overview of the fish fauna of the Mahaweli River and the impacts of hydropower and other development projects on these species;
- To provide data on the fish species found in the project area and their importance both locally, and from national and global conservation perspectives;
- To provide information on the natural history, ecology, distribution and *ex-situ* conservation of all Critically Endangered (CR), Endangered (EN), Vulnerable (VU) and Near Threatened (NT) fish species recorded in the project area;
- To analyse the potential impact of the MHP on the fish fauna of the area during the construction period, as well as the operational period, of the MHP; and
- To propose recommendations for the mitigation of impacts on fish due to the MHP.

2. METHODOLOGY AND APPROACH

This report is based primarily on the findings of the Moragolla Hydropower Project Feasibility Study: Volume 3 - Environmental Impact Assessment (EIA) compiled by the CECB and ACO (2012), and the report on the Aquatic Ecology of the Mahaweli River (NBRO, 2013). The list of fish species recorded in the area (see Annex 2 and 3) has been obtained from these two reports, and it is assumed that all species listed in these reports occur within project site.

A brief field visit was also undertaken by the IUCN team between 21 and 22 August, 2013, in order to ascertain the ground situation in the area, and gain better insights into the relevant technical reports. Further this short field visit helped to gain a better understanding of the impact of the project on the fish fauna of the area. This has aided the development of the proposed impact mitigation plan and the translocation plan.

In addition, a comprehensive literature survey was carried out to gather necessary information and analyse these technical reports, in order to compile the present report on the impacts of the project on fish and to develop and provide suitable recommendations for the mitigation of impacts of the MHP on the fish fauna of the area.

The Terms of Reference (ToR) for the study (see Annex 6), states that all threatened – Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species - and Near Threatened (NT) species should be considered as critical species for the purpose of the study. However it should be noted that each of these species will be affected by the construction of the Moragolla dam differently. As such, the priority species that will be impacted by project activities should be identified and mitigation measures should be developed for these species, in order to better utilize the limited funds available for environmental impact mitigation.

As such, a set of criteria were developed in order to identify priority species relevant to the MHP. Six critical factors were considered in the development of these criteria, and a points-based system was developed in order to rank and select priority species objectively. It should be noted that only native species were considered during this analysis. The criteria used and details of the scoring system are as follows:

1. **Status of the species:** native but recent introduction to area (0), Indigenous (+1), Endemic (+2);
2. **Distribution:** Island wide (0), Mahaweli basin and Dry Zone (+1), Mahaweli basin and Wet Zone (+2), Mahaweli basin only (+3);
3. **Impact to species due to the proposed reservoir/dam:** Positive (-3), Low negative (+3), High negative (+5); no impact (0);
4. **Conservation status (based on the National Red List 2012 of Sri Lanka):** LC (0), NT (+1), DD (+2), VU (+2), EN (+4), CR (+6);
5. **Generalist or specialist** with respect to reproduction, habitat and feeding habits: generalist (0), specialist (+1); and
6. **Captive breeding:** successfully bred species (0), hard to breed (+1), captive breeding not successful (+2).

Two of the criteria used to identify priority species – conservation status and impact to the species due to construction – were identified as the most crucial factors that should be considered in the evaluation of species. Conservation status was identified as a most important factor when considering the concept of a critical habitat, as defined in the ADB Safeguard Policy. Similarly, the impact of the project on each species is also identified as significant with regard to the concept of a critical habitat as defined by the ADB (2009). Therefore, relatively high scores were given to threatened species, and species that are likely to be impacted negatively as a result of the project.

According to this points-based system, each species could, potentially, get a maximum score of 18 points. Therefore, scores were grouped into three categories by dividing the maximum score (18) by three, and allocating each species to a group based on its score. These groups are: (i) High priority group (12 to 18 points), (ii) moderate priority group (6 to 11.9 points) and (iii) low priority group (0 to 5.9 points).

Based on this evaluation the native fish fauna of the MHP area were classified under three groups

- (i) High priority group;
- (ii) Moderate priority group; and
- (iii) Low priority group.

The cut off points used to assign fish into these three groups is presented in the table below.

Table 1. The cut of points used in the prioritization process.

Priority group	Points
High priority	12 to 18
Moderately priority	6 to 11.99
Low priority	0 to 5.99

Detailed profiles of the priority species identified using these criteria, including information on their conservation status, distribution, ecology, breeding season and captive breeding, along with distribution maps, were then prepared.

Similarly, the major potential impacts of the construction and operational elements of the MHP were identified, with management recommendations for the mitigation of these impacts, and the conservation and recovery of these species, being developed for these priority species.

Nomenclature and classification of freshwater fish was based on Goonatilake (2012), Pethiyagoda *et al.* (2012), Pethiyagoda *et al.* (2008), Deraniyagala (1952), Senanayake (1980) and Pethiyagoda (2001) for the purpose of the study. These sources were also used to compile data and information on the distribution, ecology, habitat, reproduction and captive breeding of each fish species. Critical habitats for each species were analysed based on the ADB (2009) Safeguard Policy Statement. The mitigation and conservation management plan was developed based on previous relevant experience (IUCN, 2007), and other relevant sources (Cowx and Welcomme, 1998). Information on the conservation status and endemism of fish was based on Goonatilake (2012).

3. DISCUSSION

3.1 Ecology

3.1.1 Fish fauna of the Mahaweli River basin

A total of 47 species of freshwater fish have been recorded from the entire Mahaweli River basin (Senanayake 1981; Pethiyagoda, 1991). A total of 23 of these species are considered to be endemic to Sri Lanka, while five of these species - *Labeo fisheri* (Sri Lanka mountain labeo), *Dawkinsia srilankensis*² (Sri Lanka blotched filamented barb), *Systomus martensytyni* (Sri Lanka Martensyn's barb)², *Laubuca insularis* (Sri Lanka Knuckles laubuca) and *Devario cf. aequipinatus* (Sri Lanka Knuckles danio) - are endemic to the Mahaweli River basin, specifically (see Annex 1). These species - apart from *Labeo fisheri* - are restricted to the Knuckles sub-catchment (Kalu Ganga Valley) of Mahaweli River. Due to the significance of the fish distribution pattern and endemism, the Mahaweli River basin is considered to be a discrete ichthyological province within Sri Lanka (Senanayake, 1980). The Mahaweli basin is further sub-divided in to three zones from an ichthyological perspective (see Map 3):

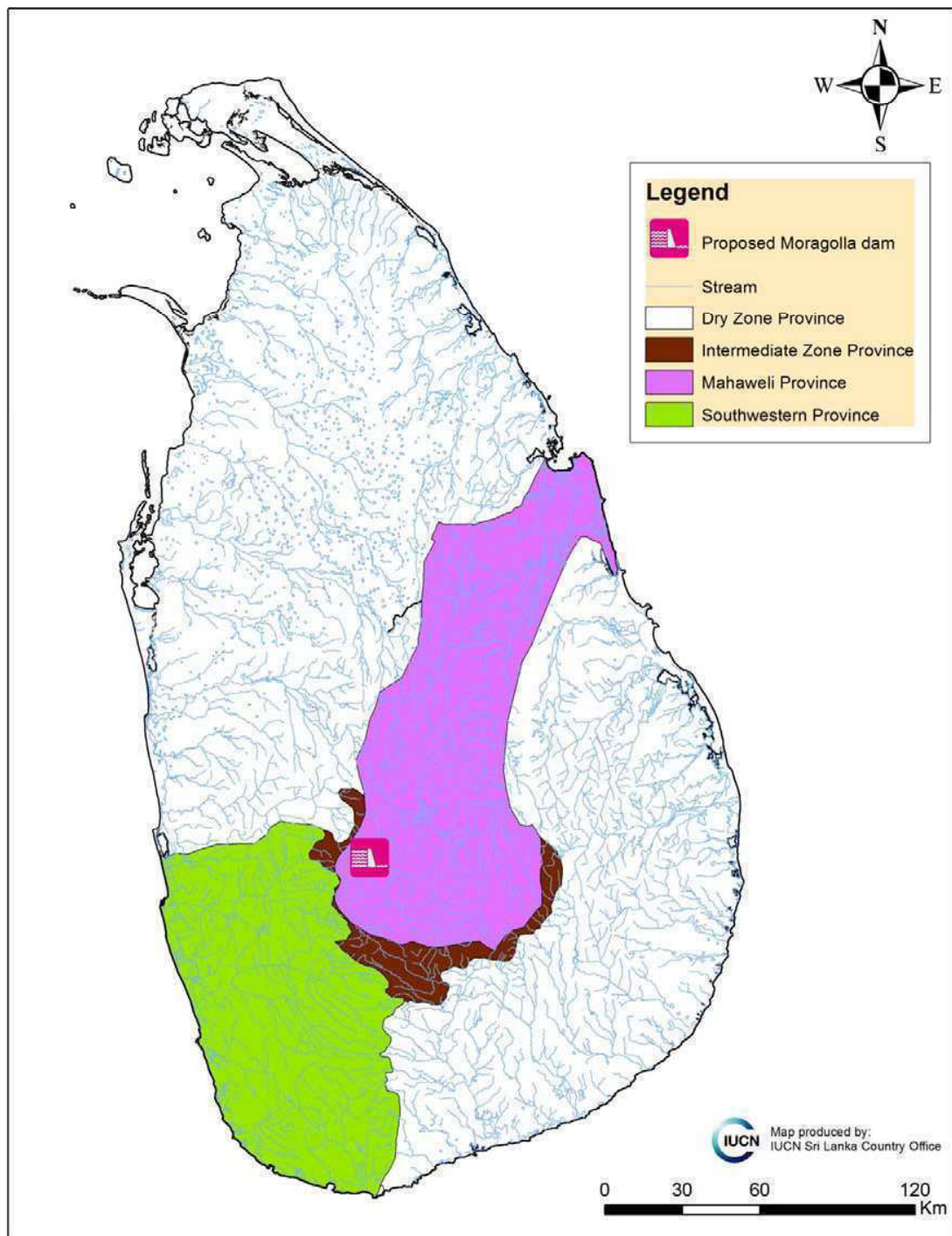
1. The wet part of the Mahaweli River, which flows through the second and third Peneplains;
2. The dry part of the Mahaweli River, which flows through the first peneplain; and
3. The Knuckles sub-catchment, which consists of tributaries of Amban Ganga and Kalu Ganga.

The taxonomy of freshwater fish in Sri Lanka has changed significantly over the last few years (Goonatilake, 2012) and it is likely that there will be further taxonomic changes in the near future. It is likely that these changes will result in revisions to present knowledge on the distribution and endemism of some species, and may include additions to the list of freshwater fish species found in the Mahaweli River basin.

In addition to these fish species, four endemic freshwater fish species, *Pethia nigrofasciata*³ (Sri Lanka black ruby barb), *Pethia reval*³ (Sri Lanka red-finned barb), *Rasboroides vaterifloris* (Sri Lanka golden rasbora) and *Puntius titteya* (Sri Lanka cherry barb), which were restricted to the southwestern ichthyological province were introduced to the Mahaweli River basin near Ginigathhena, which is located upstream of Moragolla, by Senanayake and Moyle in 1982. These introductions were made in an effort to conserve these species.

² Formally considered to belong to the Genus *Puntius*.

³ Formally considered to belong to the Genus *Puntius*.



Map 3: Ichthyological zones within Sri Lanka

3.1.2 A general overview of the impacts of hydropower and other development activities on the fish of the Mahaweli River

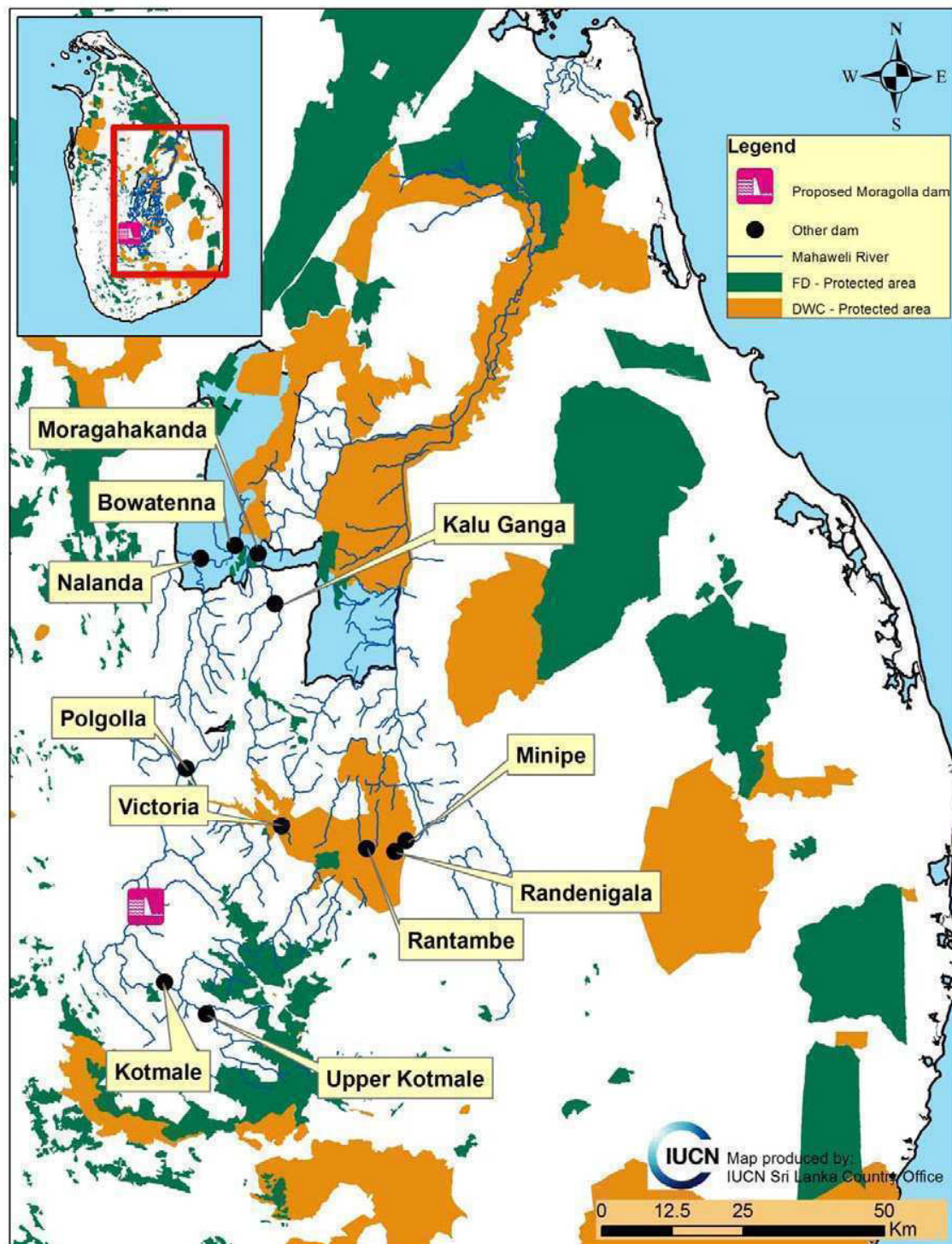
Among the vertebrate taxa of Sri Lanka, freshwater fish are one of the most severely affected vertebrate taxa with respect to past, and ongoing, development projects (Pethiyagoda, 1999; Senanayake and Moyle, 1982). Most of the endemic and threatened freshwater fish in Sri Lanka occur in the southwestern ichthyological zone and the wet part of the Mahaweli River basin. The population densities of these areas are considered to be immensely high, with less than two percent of the land area of the wet zone having natural forest, which can be considered as prime habitat for most of endemic fish species (Pethiyagoda, 1999). Further, many sub-populations of endemic and threatened freshwater fish are found outside the protected area network. The fish of the Mahaweli River have also been impacted due to various factors, including Mahaweli hydropower and agricultural extension projects, and other infrastructure developments in the area.

Dams, reservoirs and water diversion

Dams and reservoirs are irreversible physical changes, which can affect some fish species adversely, but can also benefit some species. Dams block the natural flow of river systems, which impacts migratory fish species, such as *Anguilla bicolor* (Level-finned eel) and *Anguilla nebulosa* (Long-finned eel), significantly. Further, dams affect the local movements of fish, and subsequently stop the free exchange of genes among populations, resulting in the fragmentation of populations (see Annex 5 for a full list of possible impacts resulting from dams). The Mahaweli River has been blocked in such ways at many points in the past, and further blockages can be expected in future, including the MHP.

Many authors have highlighted the links between the decline of *Labeo fisheri* and the dams found within the Mahaweli River basin (Wikramanayake, 1990, Pethiyagoda, 1999 Shirantha 2012). The proposed Kalu Ganga and Moragahakanda reservoirs are also being constructed at present, with direct implications for other endemic species, such as *Dawkinsia srilankensis*³ (Sri Lanka blotched filamented barb), *Systomus martensytyni*³ (Sri Lanka Martensytynis barb), *Laubuca insularis* (Sri Lanka Knuckles laubuca), in addition to *Labeo fisheri* (Sri Lanka mountain labeo).

Constructing dams for river diversion also results in low flows in the river downstream of the dam site, making the habitat unsuitable for many species. Further changes in the flow regime of the river due to river diversion may also impact the life cycles of some aquatic species such as aquatic insects and some freshwater fish species, including *Labeo fisheri* (Sri Lanka mountain labeo), that require seasonal floods to trigger some aspects of their life cycles such as moulting or breeding (triggering flows). Further, low flows will also result in changes in the river geomorphology and the resultant changes in the channel structure will result in changes to the aquatic habitats in the areas where such low flows occur (absence of channel maintenance flows). Therefore, it has become compulsory for river diversion projects to release an environmental flow to meet such ecological demands. However, in practice, most development products fail to release adequate flows or comply with even the flows prescribed by the project approving agencies.



Map 4. Dams and reservoirs within the Mahaweli River system, including the proposed Moragolla, Kalu Ganga and Moragahakanda dams.

Deforestation

Deforestation affects fish – both directly and indirectly - in numerous ways. The removal of natural vegetation leads to soil erosion and siltation, which result in changes to the physical and chemical conditions of rivers. Biological changes associated with these physical and chemical changes are then often observed. For instance, silt accumulates in rivers following deforestation, resulting in rocks and other substrate being covered in a layer of silt. As a consequence, the algae found usually on this substrate are lost, which has a profound impact on species, such as *Labeo fisheri* (Sri Lanka mountain labeo) and *Garra ceylonensis* (Sri Lanka stone sucker), that feed exclusively on the algae found on the substrate. Many of the freshwater fish species found in Sri Lanka, especially the endemic species, live in clear water, and rapid declines of the populations of these species are expected due to excessive siltation (Pethiyagoda, 1999; Senanayake, 1980). The clearance of river bank vegetation also impacts shade-loving species, such as *Pethia nigrofasciata*⁴ (Sri Lanka black ruby barb) and *Belontia signata* (Sri Lanka combtail), directly, through the loss of suitable shade conditions.

Agricultural extensions projects and agro-chemicals

The entire upper Mahaweli catchment, with only a few exceptions such as Horton Plains National Park, is occupied by agricultural lands. These agricultural lands include tea estates and highland vegetable plots, which require large amounts of agro-chemicals (Pethiyagoda, 1999). Although the impacts of agrochemicals on the freshwater fish of Sri Lanka have not been documented at present, a number of major impacts – both direct and indirect – are expected. Further, agriculture also contributes to soil erosion, which impacts river systems and fish directly.

Introduction of exotic fishes in to reservoirs within the Mahaweli system

According to Petr.(ed) 1985 3,538.7 ton per annum were estimated Mahaweli reservoirs and this catch totally depends on exotic species. Exotic fish species, such as *Labeo rohita* (Rohu), *Catla catla* (Indian carp), *Oreochromis* spp. (Tilapia) and *Cyprinus carpio* (Common carp), have been introduced to several reservoirs within the Mahaweli system in order to develop the inland freshwater industry in these areas. Some of these species, including *Labeo rohita* (Rohu) and *Cyprinus carpio* (Common carp), are direct competitors of indigenous species such as *Labeo fisheri* (Sri Lanka mountain labeo), *Labeo dussumieri* (Common labeo) and *Labeo lanke* (Sri Lanka orange fin labeo). Although almost all the exotic fish species introduced to these reservoirs are either herbivorous or omnivorous, studies have shown that the introduction of such species has impacted native fish species negatively (Pethiyagoda, 1999). For example, tilapia is a resilient species that breeds throughout the year. Their breeding success is very high compared to that of native species, and as such, this species has become dominant in a diverse range of habitats, including tanks, slow flowing rivers and reservoirs, depriving native species of the resources they require. Intensive fishing practices introduced with the introduction with exotic species have also resulted in increased fishing pressure on native species in the Mahaweli basin, leading to a decline of these native species (Pethiyagoda, 1999).

⁴ Formally considered to belong to the Genus *Puntius*.

3.1.3 Fish fauna of the project area

A total of 12 fish species are reported from the Moragolla project area in the EIA report for the MHP. In contrast to the EIA report, additional studies on aquatic ecology of the project site conducted by the NARA has listed a total of 47 fish species within the project area and downstream areas up to Polgolla dam near Katugasthota. Out of these 47 species, only 14 are recorded in the Moragolla project area are considered to be endemic to Sri Lanka. In addition, a total of eight exotic fish species are also reported from the project site.

A summary of the threatened and Near Threatened (NT) fish species recorded within the Moragolla project area is presented in the table below.

Table 2. Summary of the threatened and Near Threatened (NT) fish species recorded within the Moragolla project area.

(CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened)

Red List	Number of species found under each conservation status			
	CR	EN	VU	NT
National Red List 2012 of Sri Lanka	1	4*	3	4
Global Red list	0	2	0	1

*Including introduced *Pethia reval*⁵ and *Pethia nigrofasciata*⁵.

The list of threatened and Near Threatened (NT) fish species recorded within the project area are presented in the table below.

Table 3. Threatened, Near Threatened (NT) and Data Deficient (DD) Species recorded within the project area.

(Endemic species are indicated in **bold** text; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; DD – Data Deficient; NT – Near Threatened)

No.	Family	Species	Common name	Conservation status (MOE, 2012)
1	Balitoridae	<i>Schistura notostigma</i>	Banded mountain loach	NT
2	Belontiidae	<i>Belontia signata</i>	Comb-tail	NT
3	Channidae	<i>Channa ara</i>	Giant snakehead	EN
4		<i>Channa orientalis</i>	Smooth-breasted snakehead	VU
5	Clariidae	<i>Clarias brachysoma</i>	Marble catfish	NT
6	Cyprinidae	<i>Garra ceylonensis</i>	Ceylon stone-sucker	VU
7		<i>Labeo fisheri</i>	Mountain/ Green labeo	CR
8		<i>Pethia melanomaculata</i>	Fire fin barb	VU

⁵ Formally listed under the Genus *Puntius*.

No.	Family	Species	Common name	Conservation status (MOE, 2012)
9		<i>Pethia reval</i>	Red fin barb	EN
10		<i>Pethia nigrofasciata</i>	Black ruby barb	EN
11		<i>Systomus spilurus</i>	Sri Lanka olive barb	DD
12		<i>Tor khudree</i>	Mahseer	NT
13	Siluridae	<i>Wallago attu</i>	Shark Catfish	EN

A total of seven nationally threatened species, including one Critically Endangered (CR) species, four Endangered (EN) species and two Vulnerable (VU) species, have been recorded from the Moragolla project site.

In addition, two globally Endangered (EN) freshwater fish species, *Labeo fisheri* (Sri Lanka mountain labeo) and *Tor khudree* (Mahseer) and one globally Near Threatened (NT) species, *Wallago attu* (Shark catfish), have been recorded from the site. *Tor khudree* and *Wallago attu* are not endemic to Sri Lanka, but are listed as globally threatened species due to global decline of their populations.

3.1.4 Priority fish species recorded within the MHP area

Details of points allocated to each of the native fish species recorded within the MHP area using the criteria described (see methodology and approach) are provided in the table below.

Table 4. Points allocated to native fish species within the MHP area based on identified criteria.

Species	Points allocated for each criterion						Total points	Priority category
	Criteria 1 (Species status)	Criteria 2 (Distribution)	Criteria 3 (Impact of the project)	Criteria 4 (Conservation status)	Criteria 5 (Generalist or specialist)	Criteria 6 (Success of captive breeding)		
<i>Labeo fisheri</i>	+2	+2	+5	+6	+1	+2	+18	High priority
<i>Pethia reval</i>	0	+1	+3	+4	+1	0	+9	Moderate priority
<i>Channa ara</i>	+2	0	0	+4	+1	+1	+8	Moderate priority
<i>Garra ceylonensis</i>	+2	0	+3	+2	+1	+1	+8	Moderate priority
<i>Schistura notostigma</i>	+2	0	+3	+1	+1	+1	+8	Moderate priority
<i>Channa orientalis</i>	+2	0	+3	+2	+1	0	+8	Moderate priority
<i>Belontia signata</i>	+2	0	+3	+1	+1	0	+7	Moderate priority
<i>Pethia melanomaculata</i>	+2	0	+3	+1	0	0	+6	Moderate priority
<i>Pethia nigrofasciata</i>	0	+1	0	+4	+1	0	+6	Moderate priority
<i>Tor khudree</i>	+1	0	+3	+1	0	+1	+6	Moderate priority
<i>Anguilla bicolor</i>	+1	0	+3	0	+1	0	+5	Low priority

Species	Points allocated for each criterion						Total points	Priority category
	Criteria 1 (Species status)	Criteria 2 (Distribution)	Criteria 3 (Impact of the project)	Criteria 4 (Conservation status)	Criteria 5 (Generalist or specialist)	Criteria 6 (Success of captive breeding)		
<i>Anguilla nebulosa</i>	+1	0	+3	0	+1	0	+5	Low priority
<i>Clarias brachysoma</i>	+2	0	0	+1	0	0	+3	Low priority
<i>Puntius thermalis</i>	+2	0	0	0	0	0	+2	Low priority
<i>Anabas testudineus</i>	+1	0	0	0	0	0	+1	Low priority
<i>Mystus seengi</i>	+1	0	0	0	0	0	+1	Low priority
<i>Mystus vittatus</i>	+1	0	0	0	0	0	+1	Low priority
<i>Channa gachua</i>	+1	0	0	0	0	0	+1	Low priority
<i>Channa punctata</i>	+1	0	0	0	0	0	+1	Low priority
<i>Channa striata</i>	+1	0	0	0	0	0	+1	Low priority
<i>Lepidocephalichthys thermalis</i>	+1	0	0	0	0	0	+1	Low priority
<i>Amblypharyngodon melettinus</i>	+1	0	0	0	0	0	+1	Low priority
<i>Dawkinsia singhala</i>	+2	0	-1	0	0	0	+1	Low priority
<i>Esomus thermoicos</i>	+2	0	-1	0	0	0	+1	Low priority
<i>Puntius bimaculatus</i>	+1	0	0	0	0	0	+1	Low priority
<i>Puntius dorsalis</i>	+1	0	0	0	0	0	+1	Low priority
<i>Puntius vittatus</i>	+1	0	0	0	0	0	+1	Low priority

Species	Points allocated for each criterion						Total points	Priority category
	Criteria 1 (Species status)	Criteria 2 (Distribution)	Criteria 3 (Impact of the project)	Criteria 4 (Conservation status)	Criteria 5 (Generalist or specialist)	Criteria 6 (Success of captive breeding)		
<i>Rasbora dandia</i>	+1	0	0	0	0	0	+1	Low priority
<i>Awaous melanocephalus</i>	+1	0	0	0	0	0	+1	Low priority
<i>Glossogobius giurnis</i>	+1	0	0	0	0	0	+1	Low priority
<i>Heteropneustes fossilis</i>	+1	0	0	0	0	0	+1	Low priority
<i>Mastacembelus armatus</i>	+1	0	0	0	0	0	+1	Low priority
<i>Ompok bimaculatus</i>	+1	0	0	0	0	0	+1	Low priority
<i>Aplocheilichthys parvus</i>	+1	0	-1	0	0	0	0	Low priority
<i>Etroplus maculatus</i>	+1	0	-1	0	0	0	0	Low priority
<i>Etroplus suratensis</i>	+1	0	-1	0	0	0	0	Low priority
<i>Devario malabaricus</i>	+1	0	-1	0	0	0	0	Low priority

Only one species, *Labeo fisheri* (Sri Lanka mountain labeo), was identified as a high priority species. Nine species - *Schistura notostigma* (Sri Lanka banded mountain loach), *Belontia signata* (Sri Lanka combtail), *Channa ara* (Sri Lanka giant snakehead), *Channa orientalis* (Smooth-breasted snakehead), *Garra ceylonensis* (Sri Lanka stone sucker), *Pethia reval*⁶ (Sri Lanka red-finned barb), *Pethia nigrofasciata*⁶ (Sri Lanka black ruby barb), *Systomus spilurus*⁶ (Sri Lanka olive barb) and *Wallago attu* (Shark catfish) were identified as moderate priority species. The remaining 30 species are considered as low priority species as they have wider distribution, and therefore, only a small proportion of their populations will be impacted by the MHP. Based on this analysis, *Labeo fisheri* (Sri Lanka mountain labeo) is the only fish species that can be considered as a fish species that will be critically affected by the proposed MHP.

Therefore, a species recovery plan is proposed for *Labeo fisheri* (Sri Lanka mountain labeo/ Green labeo) in order to minimize the impacts of the MHP on this species, while general guidelines for the mitigation of impacts of the MHP are provided for moderate priority species.

The study on the aquatic ecology of the MHP area conducted by the NBRO (2013), indicates the existence of two catadromous (migrate from freshwater to the sea or downstream in freshwater to spawn) eel species - *Anguilla bicolor* (Level-finned eel) and *Anguilla nebulosa* (Long-finned eel) within the MHP area. This report has not considered these two species as priority species for two reasons. First, both *Anguilla* species were categorised as Least Concern (LC) species in the National Red List 2012 of Sri Lanka (MOE, 2013), as well as in the global Red List. Secondly, and more importantly, there are at least four major dams between the Mahaweli estuary and the proposed Moragolla dam site. The first of these large dams, Polgolla, was commissioned in 1977 (approximately 35 years ago), and is followed by other large dams including Victoria, Randenigala and Rantambe. As a result, the major impacts and conservation needs relevant to these species have been overlooked.

3.2 Potential impacts of the project

3.2.1 Impact of the MHP on fish fauna during the construction period

The period of construction of the dam and other structures is crucial for many species that occur in close proximity to, and downstream of, the project area. Fish, as well as other aquatic fauna and flora, are more vulnerable than many other terrestrial animals due to limitations of their mobility. Therefore, anything destructive or damaging associated with the water can be harmful to aquatic fauna and flora. The possible impacts of the MHP on the fish fauna of the area, during the construction phase are discussed below. Although this section focuses on native fresh water fish, many of these impacts are also likely to affect other aquatic species as well.

Habitat destruction and removal of natural vegetation

It can be anticipated that habitat destruction, and the removal of natural vegetation, top soil and riverine rocks, will occur during the construction period. Such impacts will result in numerous direct, and indirect, as well as short, and long, term impacts on fish fauna. The removal of natural vegetation will lead to sudden heavy soil erosion, especially during the rainy season. Consequently, this silt will cover the rocky substrate of the river, affecting the specific critical

⁶ Formally listed under the Genus *Puntius*.

micro-habitat conditions required by *Labeo fisherii* (Mountain labeo). Pethiyagoda (1999) and Senanayake (1980) have discussed the adverse effects of sudden heavy siltation on freshwater fish in detail. Senanayake (1980) observed heavy siltation as a result of gem mining in Kalu Ganga in the Knuckles area, and concluded that this may cause the extinction of some sensitive freshwater fish species.

Release of fuel, cement, machine oils and other chemicals in to the main river system and its tributaries during the construction period

Large amounts of fuel, machine oils, cement and other chemicals will be transported to the construction site. There is a high possibility that such materials can be released accidentally into the water during the construction period. The release of such harmful substances, even in small quantities, can be harmful to aquatic fauna, including fish, over a period of time.

Temporary blocking and diversion of the main river

Temporary blocking and diversion of the main river can be expected during the construction period. Such changes may result in sudden decreases of the water level, exposing previously submerged habitats. Large fish, such as *Labeo fisherii* (Mountain labeo), *Tor kudree* (Mahseer), *Wallago attu* (Shark catfish) and *Ompok bimaculatus* (Butter catfish), are the most vulnerable in such situations.

Impact of blasting in and around the river during the construction period

It is anticipated that blasting will take place in the dam axis, as well as other areas such as quarry sites, during the construction period. Fish that inhabit the main river will be directly affected by any blasting activities carried out at the dam axis, particularly those involving submerged areas or adjacent rocks. Further, all fish, from juveniles to breeding adults, that inhabit the direct impact zone of these blasts will be killed as they will be affected by the resulting vibrations as has been demonstrated in other such sites (e.g. rock blasting for the construction of the weir of the Getambe Mini-hydro project resulted in such fish deaths). Further, an illegal form of fishing called blast fishing that uses an explosion inside the water to catch fish also shows that a large vibration created under water will result in the death of all fish in the direct impact zone. In addition, fish that occur away from the direct impact zone will be forced to move away from their habitats, spawning grounds and hiding places, due to weak shock waves resulting from the blast.

Opportunistic fishing by construction workers and villagers

Illegal and destructive exploitation of wild animals and fish by construction workers has been reported in other similar projects. Given that the fish inhabiting the construction area will be disturbed and their movements are restricted by temporary structures built for water diversion during the construction period, they will be more vulnerable to opportunistic and destructive fishing. Locally developed blast methods to catch large fish in the main rivers of Sri Lanka have been recorded in the past. Construction related blasting activities may trigger, or encourage, such destructive practices further.

3.2.2 Impacts of the MHP on fish fauna during the operational period

The operational impacts of the MHP consist of long term irreversible impacts, long term reversible impacts, short term impacts and seasonal impacts.

Long term irreversible impacts

Transverse blocking of the river channel

This can have a major impact on many aquatic species, particularly migratory species. Two catadromous migratory fish species - *Anguilla bicolor* (Level-finned eel) and *Anguilla nebulosa* (Long-finned eel) have been reported from the project area (NBRO, 2013). Further, freshwater fish species, such as *Labeo fisherii* (Mountain labeo), *Garra ceylonensis* (Stone sucker) and *Tor khudree* (Mahseer), are known to show local movements during the breeding season (Pethiyagoda 1991; Shirantha, 2012). The permanent blockage of the river may disturb the upstream movement of such species. Further, large fish species, such as *Wallago attu* (Shark catfish) and *Channa ara* (Giant Snakehead), may require a larger area of the river to maintain a minimum viable population. Fragmentation of such populations may affect the genetic diversity of these large and territorial fish species adversely. The free flow of river water, and the longitudinal connectivity between mountains and the ocean, are important to most aquatic species, particularly when the availability of nutrients in downstream areas is considered (Cox and Welcomme, 1998). Therefore, changes and restrictions to this flow will affect access to these nutrients.

Formation of the reservoir upstream

The majority of Sri Lankan freshwater fish species are either stream dwellers (*Pethia reval*) or river dwellers (*Wallago attu* and *Labeo fisherii*). There are no records of natural lake dwelling fish in Sri Lanka apart from relatively common and opportunistic species such as *Dawkinsia singhala* (Sri Lanka filamented barb). Therefore, the formation of a reservoir is not favourable to the majority of native freshwater fish species found in the area, particularly critical species such as *Labeo fisherii* (Mountain labeo).

Long term reversible impacts

Change of downstream flow pattern

Naturally, almost all Sri Lankan rivers are subject to seasonal changes of river flow. Rains and dry seasons are the main drivers of such seasonal changes, and most native aquatic faunal and floral species have become adapted to these seasonal changes that are triggered by rainfall (Pethiyagoda, 1991; Senanayake 1980). Local movements, spawning periods and other behaviours are often linked closely with these changes.

Therefore, the daily changes and irregular flow patterns that are anticipated as a result of the project can have significant impacts on the fish fauna of the area. Although such a change is long term, it is categorised as a reversible impact, as the maintenance of a minimum e-flow, as outlined in the EIA report for the MHP, can minimise the impact of such changes.

Impact of exotic species and intensive fishing practices on native species

Given that there are no specialised lake fish among the native fish fauna of Sri Lanka, the prospect of introducing exotic fish suited to such conditions is always an attractive one. Some exotic fish species have been introduced to reservoirs accidentally (e.g. *Xiphophorus helleri* – Green swordtail), while others have been introduced deliberately for fisheries (e.g. *Labeo rohita* - Rohu). It has been observed that the introduction of such species has affected native species adversely (Pethiyagoda, 1999; Senanayake and Moyle, 1982). These exotic fish can exert further pressure on native species that are already stressed due to the impacts arising as a result of changes in the flow regime of the river. Further, the introduction of exotic species for fisheries may encourage intensive fishing practices. Although native species are not targeted in reservoir fisheries, increasing and intensive fishing practices can result in an unintentional decline of these species.

Short term and occasional impacts

Gas bubble trauma disease and heavy flooding downstream

Juvenile fish are the most vulnerable to gas bubble trauma disease, which is caused by super-saturation of atmospheric gases in river water due to the heavy mobility of water during power generation (Williams, 2008). Although there is no published evidence of such incidents in Sri Lanka, it is important that this phenomenon is considered in the context of the MHP, as the tail race of both Kotmale hydropower generation tunnel and the proposed Moragolla hydropower tunnel will discharge their waters into the main river in very close proximity to one other. This may increase super-saturation of atmospheric gas immediately downstream of the discharge points, and thereby, affect the fish of the area. The discharge of water from both Kotmale and Moragolla simultaneously may also cause sudden and heavy floods in downstream areas. This can be identified as a potential adverse impact of the MHP, as it can impact fish and other aquatic fauna downstream of the Mahaweli River, significantly.

Impact of MHP on *Labeo fisheri* (Green labeo)

The following impacts on *Labeo fisheri* (Mountain labeo or green labeo) can be expected as a result of construction activities associated with the project:

- Removal of natural vegetation and subsequent soil erosion at the construction site will cause sedimentation, altering the substrate, and affecting the feeding habits of this species;
- The accidental release of cements, machinery oils and fuels, and other hazardous chemicals during the construction period will affect the *Labeo fisheri* population in Moragolla project area; and
- Temporary blocking of the main river during the construction period will reduce the flow of water downstream, and as a result, may disturb the habitats of this species in project area.

The *Labeo fisheri* (Green labeo) population within the project area will become fragmented permanently due to the construction of the Moragolla dam and reservoir, affecting this Critically Endangered (CR) species in several ways. *Labeo fisheri* (Green labeo) is not a common fish species in the Mahaweli River system, and according to Shirantha (2012), the population density of this species is limited to 0.5 per km². Therefore, this fragmentation will affect the free flow of genes within the existing population due to the isolation of certain individuals and the difficulties of finding mating partners during the breeding season. It can also be anticipated that the permanent drying of the area downstream of the dam up to powerhouse will result in the depletion of habitats that are important to *Labeo fisheri* (Green labeo) in Moragolla project area.

3.3 Mitigation of impacts

The appropriateness of the possible measures for mitigating the impacts of the MHP mentioned in the ToR (see Annex 6) were explored as part of the study, and our findings are discussed in the mitigation plan presented below. Additional measures that can be taken to minimize or mitigate the impacts of the project are also discussed as part of this plan.

Hatchery

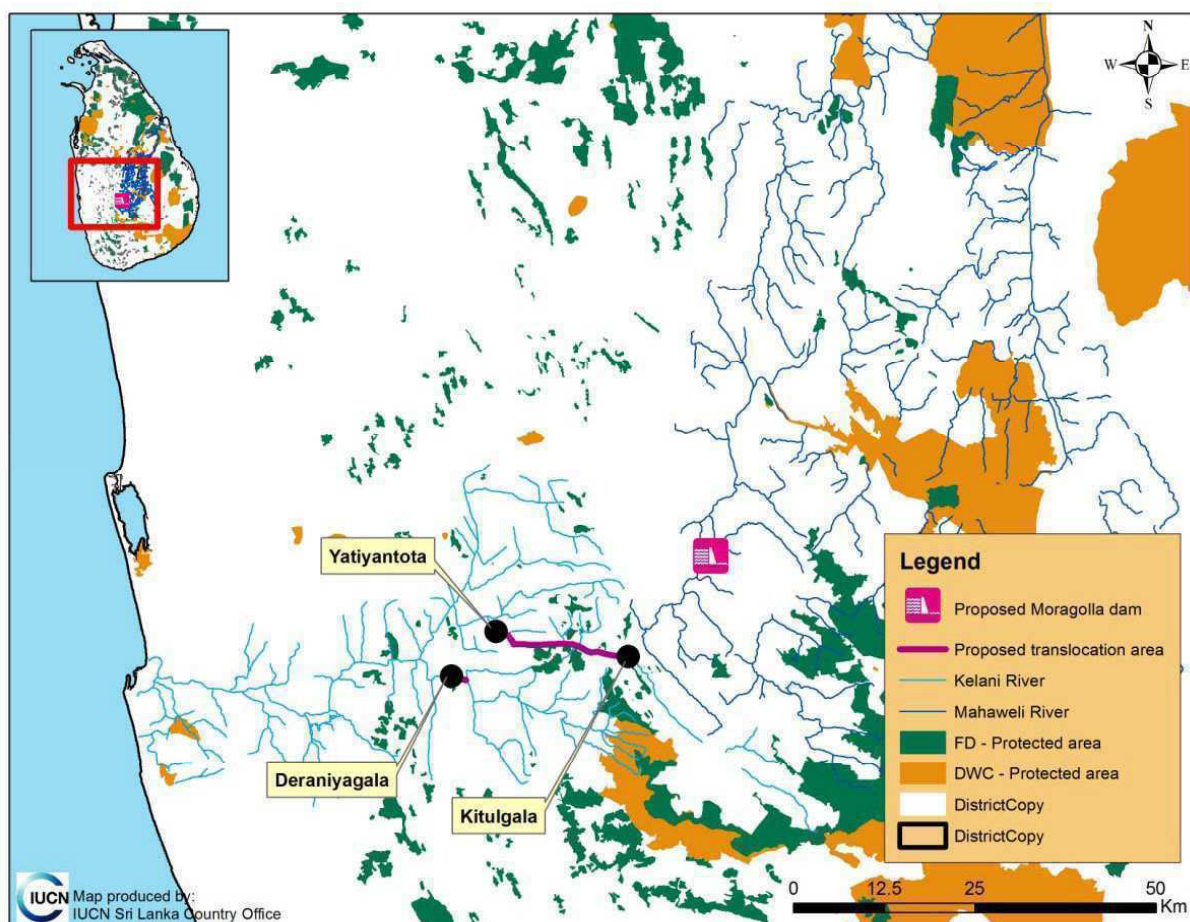
Although captive breeding coupled with reintroduction is a popular conservation action with respect to protecting threatened fish species by boosting their population size, it is not recommended in the context of the MHP as a mitigation or conservation action. The proposed MHP area is not considered to be a critical habitat for the majority of fish species found in the area, with the exception of the sole high priority species identified during the study - *Labeo fisherii* (Mountain labeo).

All other populations of moderate priority species - *Schistura notostigma* (Banded mountain loach), *Belontia signata* (Combtail), *Channa ara* (Giant snakehead), *Channa orientalis* (Smooth-breasted snakehead), *Garra ceylonensis* (Stone sucker), *Pethia reval* (Red-fin barb), *Pethia nigrofasciata* (Sri Lanka black ruby barb), *Systomus spilurus* (Sri Lanka olive barb) and *Wallago attu* (Shark catfish) – which are considered to be nationally threatened or Near Threatened (NT), are not likely to be impacted directly by this project. Although, it has been observed that there is a need for captive breeding and *ex-situ* conservation of some of these species, including *Wallago attu* (Shark catfish) and *Channa ara* (Giant snakehead), these activities should be undertaken on a national scale, giving consideration to the national status of these species and the involvement of relevant stakeholders.

There is an urgent need for *in-situ* and *ex-situ* conservation of *Labeo fisheri* (Mountain labeo), which can be considered as the only critical high priority species with respect to the MHP. However, as reported in Shirantha (2012), Pethiyagoda (1991), Senanayake (1980) and Deraniyagala (1952), there is a lack of information with respect to captive breeding of *L. fisheri* (Mountain labeo). Therefore, it is not possible to breed this specialized *Labeo* species in captivity successfully, at present. As such, captive breeding will not be a viable action for the mitigation of the impacts of the MHP on this species.

Catch-and-haul

Catch-and-haul activities have not been documented or reported as a mitigation measure for dam construction in Sri Lanka in the past (pers. com. R. Pethiyagoda), with the exception of fish rescue operations implemented jointly by IUCN and the Mahaweli Authority of Sri Lanka (MASL) for the MASL Moragahakanda and Kalu Ganga projects. This translocation programme has yielded positive results, and has resulted in the rescue of several sub-populations that inhabit the inundation and downstream areas of the proposed dam sites. As part of this translocation work, it was been possible to translocate critical fish species, including *Systemus martenstyni* (Martenstyn's barb), *Dawkinsia srilankensis* (Blotched filamented barb) and *Laboe lanke* (Sri Lanka orange-finned labeo) to the upper catchment of the Amban Ganga and Kalu Ganga sub-basins during the construction period. Based on IUCN's experience with this programme, it is recommended that a similar programme is implemented to rescue and translocate less mobile and cryptic fish species reported in the EIA report for the MHP and the study carried out by the NBRO (2013) (see Annex 6 for details of the proposed translocation programme). It is recommended that all translocation activities are carried out by in accordance with the Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC, 2013).



Map 5. Proposed translocation sites (from Kitulgala to Yatiyantota stretch and Deraniyagala area) of *Labeo fisheri* in the Kelani River basin.

Offset habitat protection

The Mahaweli River upper catchment of the Moragolla proposed reservoir is identified as a key area for habitat protection with respect to the conservation of critical and moderate priority fish of the area. Given that the Moragolla upper catchment of Kotmale Oya up to the Kotmale dam remains relatively dry, except at spillage time, only the Mahaweli upper catchment provides suitable habitats for species such as *Labeo fisheri* (Mountain labeo), *Wallago attu* (Shark catfish), *Channa ara* (Giant snakehead) and *Tor khudree* (Mahseer). Preliminary observations show that the area between the upper catchment of the Moragolla reservoir up to Nawalapitiya is the most suitable area for the species that are likely to move upstream, including *Tor khudree* (Mahseer), *Labeo fisheri* (Mountain labeo) and *Wallago attu* (Shark catfish). The removal of river bank vegetation up to Nawalapitiya and the depletion of the upper catchment due to encroachment have been observed. Therefore, it is recommended that the upper catchment of MHP, spanning from Moragolla up to Nawalapitiya, is protected and strict conservation measures are implemented to improve the quality of natural habitats present in this region (see Annex7).

Fish pass or ladder

Although fish passes and ladders are suitable for the facilitation of the migration and local movement of fish species in general (Cowx and Welcomme, 1998), they cannot be considered as a viable options in the context of mitigating the impacts of the MHP. There are at least four major dams between the Moragolla proposed dam site and the Mahaweli estuary, and there are two more large dams - Kotmale and Upper Kotmale - upstream of Kotmale Oya (see Map 4). Given that these dams were constructed without fish passes or ladders, the establishment of a fish pass or fish ladder in the Moragolla project area would be futile. As such, the establishment of such structures is not recommended in the context of the MHP.

Prohibition of the introduction of competitive exotic species to the Moragolla reservoir

Large reservoirs tend to be attractive to the fisheries industry. However, given that there are no natural lakes in Sri Lanka, large reservoir conditions are not suitable for majority of the native fish species. As a result, many exotic species have been introduced to the reservoirs of Sri Lanka. Some of these exotic species are similar to native species, and as such, compete with these indigenous species for resources. For instance, the introduced species *Labeo rohu* is considered a direct competitor of the threatened native species *Labeo fisheri* and *Labeo lankae*. Therefore, a ban on the introduction of competitive fish species, such as *Labeo rohu*, in to the Moragolla reservoir is recommended.

Further, some researchers have observed that the introduction of fast growing exotic species leads to intensive fishing efforts, which also impacts native fish species negatively (Pethiyagoda, 1999). Therefore, this should be considered during the development of current or future fisheries development plans for the Moragolla reservoir.

4. CONCLUSIONS AND RECOMMENDATIONS

The MHP area is identified as critical area only for one fish species - *Labeo fisheri* (Mountain labeo). This species only occurs in the middle catchment of the Mahaweli basin, including the Knuckles sub-catchment area. According to Senanayake (1980), *L. fisheri* (Mountain labeo) was not a rare species in its distribution range, but decades later Pethiyagoda (1991) reported *L. fisheri* as a rare species. Further, he indicated the rapid decline of fish populations with local extinction. The declining period is overlapped by the period during which the major dams of the Mahaweli system were commissioned. Therefore, many researchers have observed a direct link between the Mahaweli reservoirs and the rapid decline of *L. fisheri* (Pethiyagoda, 1991). The depletion of feeding grounds due to heavy siltation in the upper and middle Mahaweli catchment, the heavy use of agrochemicals, fishing and competition from exotic species are identified as the other factors that have contributed to the sharp decline of the population of this species. As such, a recovery plan for this species in relation to the MHP is provided. A trans-river basin relocation programme can be introduced to save this species from extinction. *L. fisheri* is the most sensitive faunal species with regard to the MHP and its impacts. Therefore, it is recommended that a national level recovery plan is developed (Annex 9), involving the relevant authorities and experts. It is recommended that the CEB facilitates such a recovery plan, although this initiative will extend beyond the Moragolla area.

Although all other species were not identified as critical species with regard to the impacts of the Moragolla project, it is recommended that less mobile and cryptic fish species are rescued and translocated during the construction period. Further, the conservation and enrichment of the upper catchment of Mahaweli River up to the Nawalapitiya area is recommended in order to preserve the habitat of fish that move upstream or are translocated to these areas. An estimated budget (Annex 8) for the translocation programme of *Labeo fisheri* and other moderately priority species is provided. This estimated budget is based on the translocation plan (Annex 6) and the offset habitat protection plan (Annex 7). Given that the latter is included in the afforestation and watershed management plan, it was not given a separate budget in this report.

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ANNEXES

Annex 1. List of fish species found in the Mahaweli River basin (after Pethiyagoda 1991, Senanayake 1981, Pethiyagoda et al 2012, Pethiyagoda 2008 and Goonatilake 2012).

Note: Bold text indicates endemics.

No.	Family	Species	Common name	Conservation status (MOE, 2012)
01	Cyprinidae	<i>Amblypharyngodon melettinus</i>	Silver carplet	LC
02		<i>Dawkinsia srilankensis</i>	Sri Lanka blotched filamented barb	CR
03		<i>Dawkinsia singhala</i>	Sri Lanka filamented barb	LC
04		<i>Devario malabaricus</i>	Giant danio	LC
05		<i>Devario cf. aequipinnatus</i>	Sri Lanka Knuckles danio	CR
06		<i>Esomus thermoicos</i>	Sri Lanka flying barb	LC
07		<i>Garra ceylonensis</i>	Sri Lanka stone sucker	VU
08		<i>Labeo dussumieri</i>	Common labeo	LC
09		<i>Labeo fisheri</i>	Sri Lanka mountain labeo	CR
10		<i>Labeo lankae</i>	Sri Lanka orange-fin labeo	CR
11		<i>Laubuca insularis</i>	Sri Lanka Knuckles laubuca	CR
12		<i>Laubuca lankensis</i>	Sri Lanka blue laubuca	VU
13		<i>Pethia melanomaculata</i>	Sri Lanka tic tac barb	VU
14		<i>Pethia nigrofasciata</i>	Sri Lanka black ruby barb	EN
15		<i>Pethia reval</i>	Sri Lanka red-fined barb	EN
16		<i>Puntius bimaculatus</i>	Redside barb	LC
17		<i>Puntius dorsalis</i>	Long-snouted barb	LC
18		<i>Puntius thermalis</i>	Swamp barb	LC
19		<i>Puntius vittatus</i>	Silver barb	LC
20		<i>Rasbora dandiya</i>	Broad line strip rasbora	LC
21		<i>Rasbora microcephalus</i>	Narrow line rasbora	LC
22		<i>Systomus spilurus</i>	Sri Lanka olive barb	DD
23		<i>Tor khudree</i>	Mahseer	NT

No.	Family	Species	Common name	Conservation status (MOE, 2012)
24	Balitoridae	<i>Schistura notostigma</i>	Banded mountain loach	NT
25	Cobitidae	<i>Lepidocephalichthys thermalis</i>	Common spiny loach	LC
26	Bagridae	<i>Mystus gulio</i>	Long-whiskered catfish	LC
27		<i>Mystus vittatus</i>	Striped dwarf catfish	LC
28		<i>Mystus seengtee</i>	Yellow catfish	LC
29	Claridae	<i>Clarias brachysoma</i>	Sri Lanka walking catfish	NT
30	Siluridae	<i>Ompok bimaculatus</i>	Butter catfish	LC
31		<i>Wallago attu</i>	Shark catfish	EN
32	Heteropneustidae	<i>Heteropneustes fossilis</i>	Stinging catfish	LC
33	Gobiidae	<i>Awaous melanocephalus</i>	Scribbled goby	LC
34		<i>Glossogobius giuris</i>	Bar-Eyed goby	LC
35	Anguillidae	<i>Anguilla bicolor</i>	Level-finned eel	LC
36		<i>Anguilla nebulosa</i>	Long-finned eel	LC
37	Mastacembelidae	<i>Mastacembelus armatus</i>	Marbled spiny eel	LC
38	Channidae	<i>Channa ara</i>	Sri Lanka giant snakehead	EN
39		<i>Channa gachua</i>	Brown snakehead	LC
40		<i>Channa punctata</i>	Spotted snakehead	LC
41		<i>Channa striata</i>	Murrel	LC
42	Aplocheilidae	<i>Aplocheilus parvus</i>	Dwarf panchax	LC
43	Cichlidae	<i>Etroplus suratensis</i>	Green chromide	LC
44		<i>Etroplus maculatus</i>	Orange chromide	LC
45	Belontiidae	<i>Belontia signata</i>	Sri Lanka combtail	NT
46	Anabantidae	<i>Anabas testudineus</i>	Climbing perch	LC

Annex 2: Fish species recorded from the project area (as reported in the EIA)

Note: **Bold** text indicates endemism and Ex. Indicates exotic species.

No.	Family	Species	Common name	Conservation status (MOE, 2012)
1	Balitoridae	<i>Schistura notostigma</i>	Banded mountain loach	NT
2	Belontiidae	<i>Belontia signata</i>	Combtail	NT
3	Channidae	<i>Channa gachua</i>	Brown snakehead	LC
4	Cobitidae	<i>Lepidocephalichthys thermalis</i>	Common spiny loach	LC
5	Cyprinidae	<i>Dawkinsia singhala</i>	Sri Lanka filamented barb	LC
6		<i>Devario cf. aequipinatus</i>	Giant danio	CR
7		<i>Garra ceylonensis</i>	Ceylon stone-sucker	VU
8		<i>Pethia reval</i>	Red fin barb	EN
9		<i>Pethia nigrofasciata</i>	Black ruby barb	EN
10		<i>Puntius bimaculatus</i>	Redside barb	LC
11		<i>Puntius dorsalis</i>	Long snouted barb	LC
13		<i>Rasbora dandiya</i>	Striped rasbora	LC
14		<i>Systemus spilurus</i>	Sri Lanka olive barb	DD
15		<i>Tor khudree</i>	Mahseer	NT
16	Poeciliidae	<i>Poecilia reticulata</i> Ex.	Guppy	

Annex 3: Fish species recorded from the project area (as reported in NBRO, 2013).

Note: **Bold** text indicates endemism and Ex. Indicates exotic species.

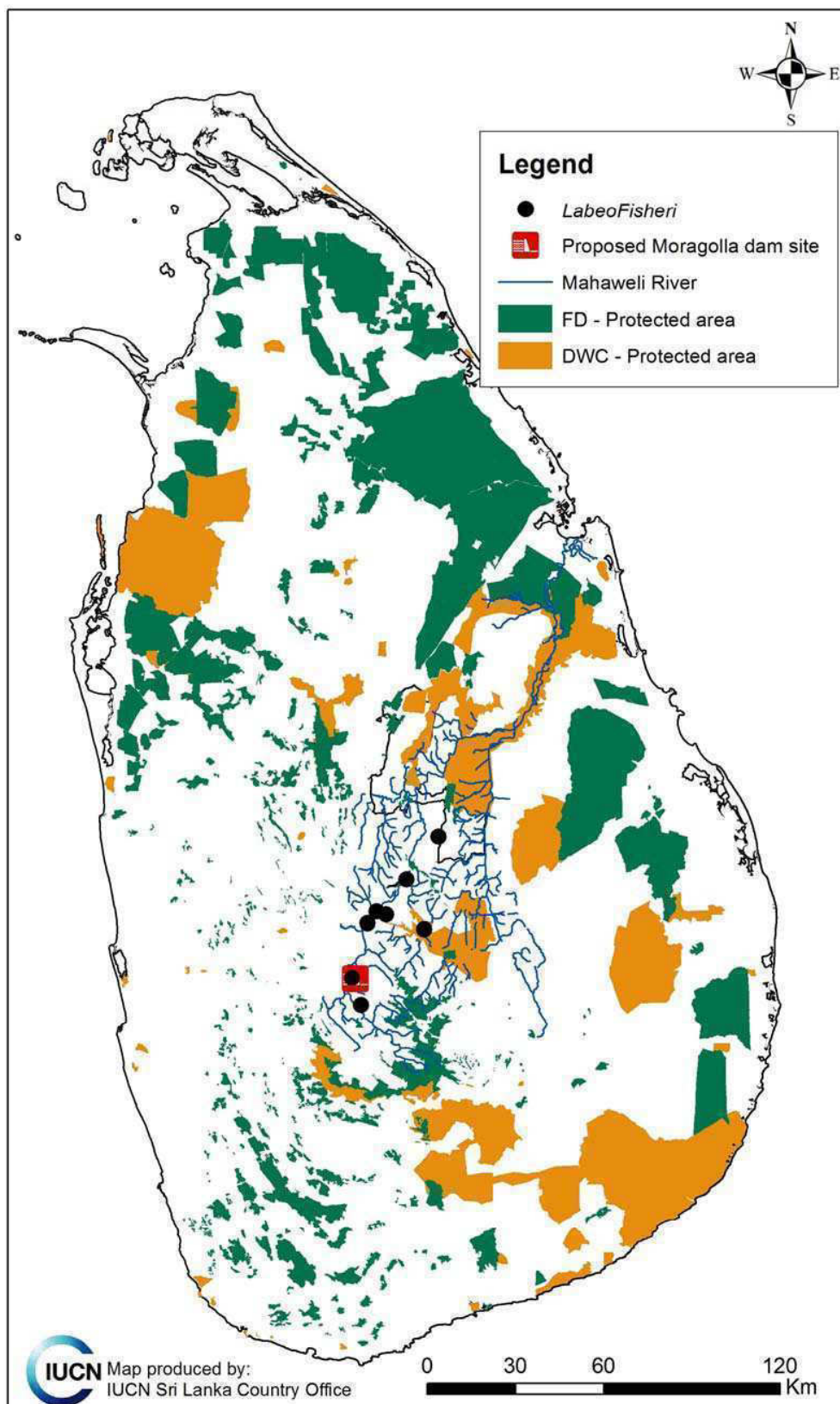
No.	Family	Species	Common Name	Conservation status (MOE, 2012)
1	Anabantidae	<i>Anabas testudineus</i>	Climbing perch	LC
2	Anguillidae	<i>Anguilla bicolor</i>	Level finned eel	LC
3		<i>Anguilla nebulosa</i>	Long finned eel	LC
4	Aplocheilidae	<i>Aplocheilichthys parvus</i>	Dwarf panchax	LC
5	Bagridae	<i>Mystus seengtee</i>	Yellow catfish	LC
6		<i>Mystus vittatus</i>	Striped dwarf catfish	LC
7	Balitoridae	<i>Schistura notostigma</i>	Banded mountain loach	NT
8	Belontiidae	<i>Belontia signata</i>	Comb-tail	NT
9	Channidae	<i>Channa ara</i>	Giant snakehead	EN
10		<i>Channa gachua</i>	Brown snakehead	LC
11		<i>Channa orientalis</i>	Smooth-breasted snakehead	VU
12		<i>Channa punctata</i>	Spotted snakehead	LC
13		<i>Channa striata</i>	Murrel	LC
14	Cichlidae	<i>Etroplus maculatus</i>	Orange chromide	LC
15		<i>Etroplus suratensis</i>	Pearl spot	LC
16		<i>Oreochromis mossambicus</i> Ex.	Mozambique tilapia	
17		<i>Oreochromis niloticus</i> Ex.	Nile tilapia	
18	Clariidae	<i>Clarias batrachus</i> Ex.	Marble catfish	
19		<i>Clarias brachysoma</i>	Walking catfish	NT
20	Cobitidae	<i>Lepidocephalichthys thermalis</i>	Common spiny loach	LC
21	Cyprinidae	<i>Amblypharyngodon meletinus</i>	Silver carplet	LC
22		<i>Cyprinus carpio</i> Ex.	Common carp	
23		<i>Dawkinsia singhala</i>	Sri Lanka filamented barb	LC
24		<i>Devario malabaricus</i>	Giant Danio	LC
25		<i>Esomus thermoicos</i>	Flying barb	LC
26		<i>Garra ceylonensis</i>	Ceylon stone-sucker	VU
27		<i>Labeo fisheri</i>	Mountain/ Green Labeo	CR
28		<i>Labeo rohita</i> Ex.	Rohu	
29		<i>Pethia melanomaculata</i>	Fire fin barb	VU
30		<i>Pethia reval</i>	Red fin barb	EN
31		<i>Pethia nigrofasciata</i>	Black ruby barb	EN
32		<i>Puntius bimaculatus</i>	Redside barb	LC
33		<i>Puntius dorsalis</i>	Long snouted barb	LC
34		<i>Puntius thermalis</i>	Swamp barb	LC

No.	Family	Species	Common Name	Conservation status (MOE, 2012)
35		<i>Puntius vittatus</i>	Silver barb	LC
36		<i>Rasbora dandia</i>	Striped rasbora	
37		<i>Systomus spilurus</i>	Sri Lanka olive barb	DD
38		<i>Tor khudree</i>	Mahseer	NT
39	Gobiidae	<i>Glossogobius giuris</i>	Scribbled goby	LC
40		<i>Awaous melanocephalus</i>	Bar eyed goby	LC
41	Heteropneustidae	<i>Heteropneustes fossilis</i>	Stinging catfish	LC
42	Loricaridae	<i>Pterygoplichthyes multiradiatus</i> Ex.	Sail fin catfish	
43	Mastacembelidae	<i>Mastacembelus armatus</i>	Marbled spiny eel	LC
44	Osphronemidae	<i>Osphronemus goramy</i> Ex.	Giant gourami	
45	Poeciliidae	<i>Poecilia reticulata</i> Ex.	Guppy	
46	Siluridae	<i>Ompok bimaculatus</i>	Butter catfish	LC
47		<i>Wallago attu</i>	Shark catfish	EN

Annex 4: Profiles of threatened (CR, EN and VU) species and Near Threatened (NT) species found in the project area.

***Labeo fisheri* (Sri Lanka mountain labeo)**

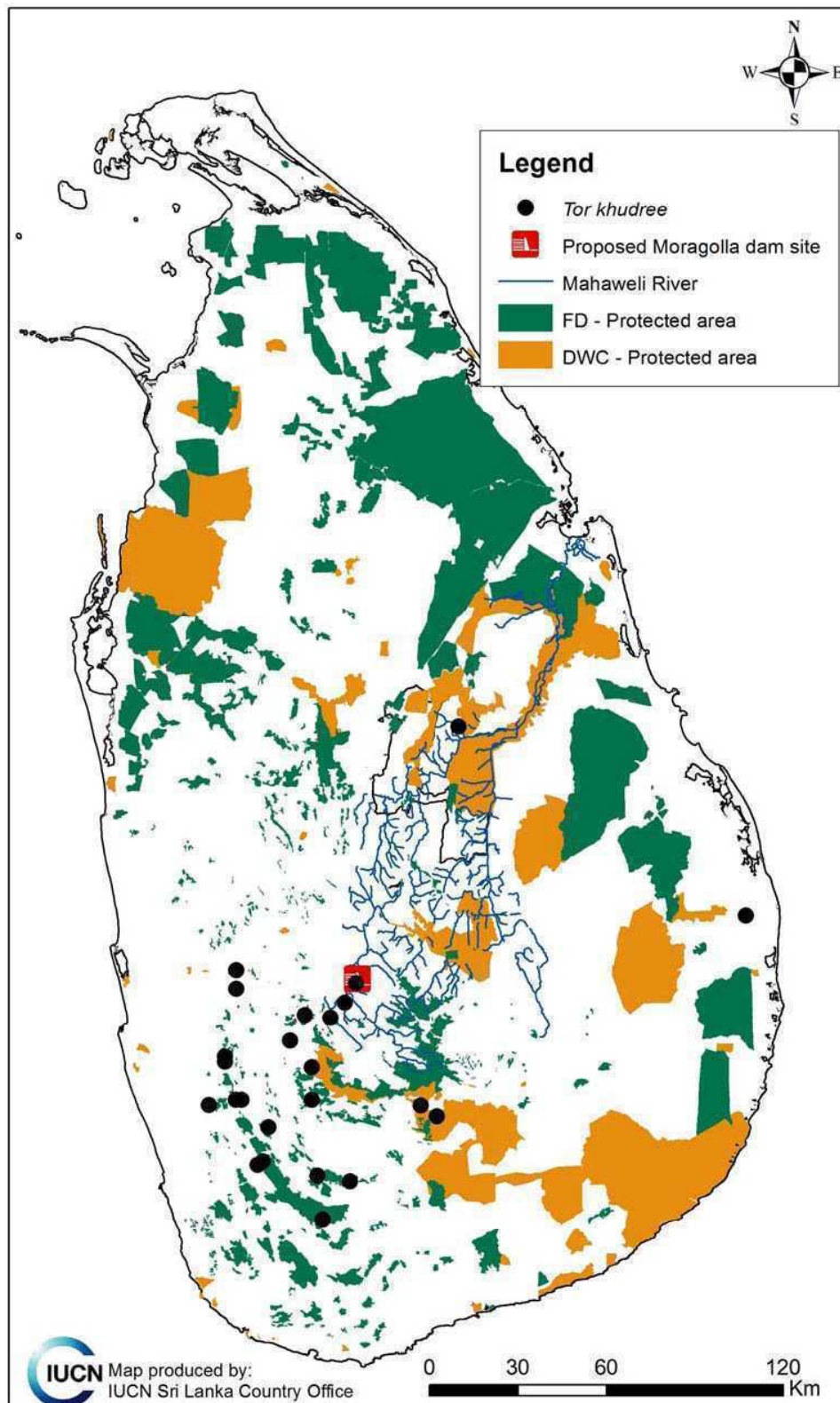
Scientific name	<i>Labeo fisheri</i>
Common names	Green labeo, Mountain labeo, Kalu gadeya, Gadeya
Synonyms	<i>Labeo gadeya</i> , <i>Morulus gadeya</i>
Conservation status	Endangered (Global Red List, 2009), Critically Endangered (National Red List 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka and restricted to the Mahaweli River basin.
Distribution within the Mahaweli River system	The distribution of <i>Labeo fisheri</i> is restricted to the upper and middle reaches of the Mahaweli River basin, including tributaries that originate from the Knuckles mountain area. <i>Labeo fisheri</i> was a common edible fish species in middle reaches of the Mahaweli River until the late 1970s.
Feeding, habitat preference, life cycle and population density	Pethiyagoda (1991) reports that the juvenile of <i>Labeo fisheri</i> feed on algae that grows on rocky surfaces. The external morphology of the fish also indicates bottom dwelling and grazing feeding habits. The preferred habitat of this mysterious fish is clear, fast flowing water, and rocky mountainous pools in the main river system (Pethiyagoda, 1991; Shirantha, 2012). Breeding has not been recorded, but Shirantha (2012) suggests an upstream movement for spawning. In 1990, Wickramanayake reported the possible extinction of this fish. However, Pethiyagoda (1991) recorded this species from a few locations within the Mahaweli basin. A recent study on the distribution of <i>L. fisheri</i> shows that the population density of this species in middle reaches of the Mahaweli River is 1 per 0.5 km ² (Shirantha, 2012).
Reproduction	Not recorded (Pethiyagoda, 1991; Shirantha, 2012).
Captive breeding and ex-situ conservation	According to the available data, this is one of the most difficult fish to breed in captivity. Pethiyagoda (1991) stated that there is no record of aquarium kept <i>L. fisherii</i> . Further, Shirantha (2012) reported that all efforts to keep this species in captivity were unsuccessful. It can, therefore, be concluded that the likelihood of breeding this species in captivity successfully is extremely low.
Critical habitats	The project area can be considered as a critical habitat area for the survival of <i>Labeo fisheri</i> . Although the historical distribution of this species ranges from the project area to the Victoria–Randenigala area, and the Kalu Ganga sub-catchment in the Knuckles area, this species has become extinct locally from many areas. Therefore, the Moragolla project area is critical for the existing sub-population of <i>L. fisheri</i> .



Distribution map of *Labeo fisheri*

***Tor khudree* (Mahseer)**

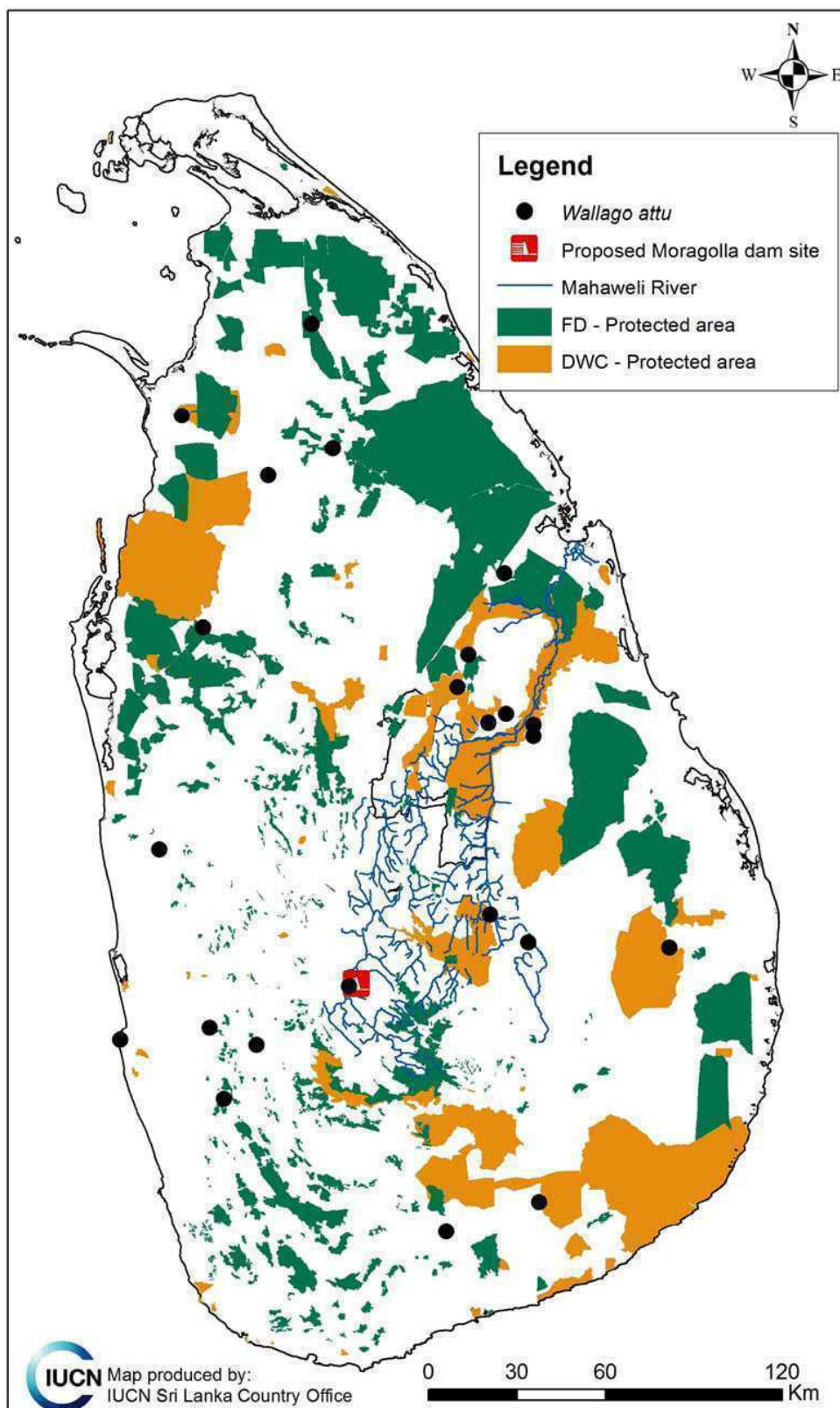
Scientific name	<i>Tor khudree</i>
Common names	Mahseer
Synonyms	<i>Barbus khudree</i>
Conservation status	Near Threatened (National Red List 2012).
Distribution within Sri Lanka	<i>Tor khudree</i> occurs in streams, rivers and tanks up to an elevation of 1, 000 m. It is restricted to the mid hills in the second penepplain.
Distribution within the Mahaweli River system	Distributed commonly within the Mahaweli River system, including in the Knuckles range.
Feeding, habitat preference, life cycle and population density	Omnivorous. Feeds on many type of plant material including leaves, flowers and substrate algae. Lies in fast flowing clear water, with large individuals living in major rivers and large water bodies, while juveniles live in streams. Pethiyagoda (1991) observes that breeding adults move up small streams after the rains begin for spawning. <i>Tor khudree</i> is locally common and schools with other individuals in deep areas of rivers.
Reproduction	According to published sources (Pethiyagoda, 1991) <i>Tor khudree</i> moves up small tributaries to breed, although it lives usually in large deep areas.
Captive breeding and <i>ex-situ</i> conservation	Not recorded, but adapt easily to aquarium conditions.
Critical habitats	<i>Tor khudree</i> is a widely distributed species. Healthy populations of this species even occur within protected areas in Sri Lanka. Therefore, the project area is not considered to be a critical habitat area for <i>Tor khudree</i> .



Distribution map of *Tor khudree*

***Wallago attu* (Shark catfish)**

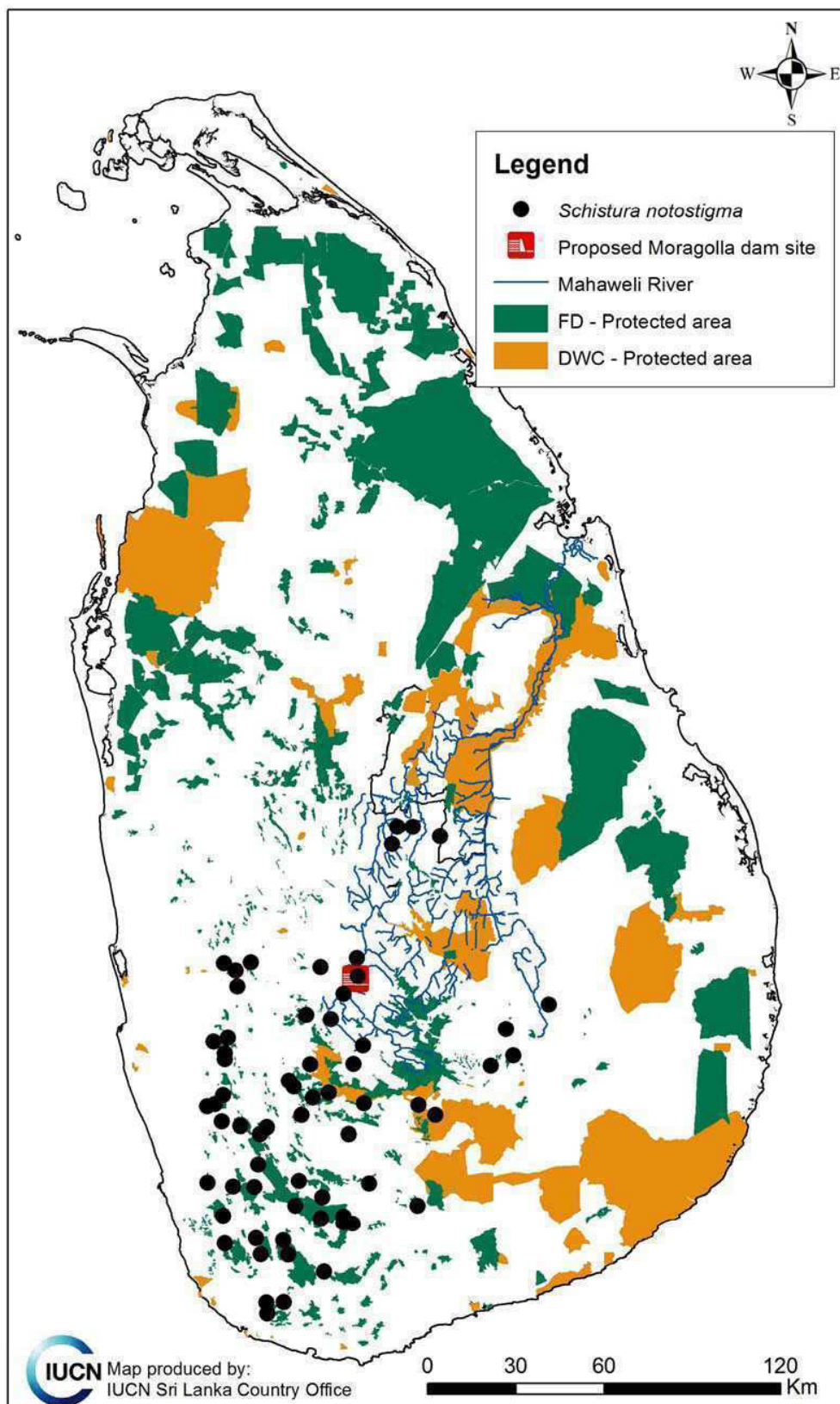
Scientific name	<i>Wallago attu</i>
Common names	Shark catfish
Synonyms	<i>Silurus attu</i>
Conservation status	Endangered (National Red List 2012)
Distribution within Sri Lanka	According to Senanayake (1982) <i>W. attu</i> was a common food fish and was recorded in many places within the Dry Zone, including tanks and rivers, as well as at several sites in Wet Zone rivers. Pethiyagoda (1991) observed the local extinction of this species in many places, as well as the fact that the species was becoming rare at sites in which it has been common previously.
Distribution within the Mahaweli River system	Both Pethiyagoda (1991) and Senanayake (1982) did not record <i>W. attu</i> in the wet part of the Mahaweli river, but did record it from the dry part of Mahaweli River from Mahiyanganaya to Polonnaruwa. The study conducted by NBRO (2013) reported this species from the Moragolla project area. However, there are discrepancies between the record of this species in the area, and the historical distribution of this species.
Feeding, habitat preference, life cycle and population density	Primarily carnivorous, and feeds on fish and small crustaceans. Naturally Occurs naturally in deep areas of large rivers and tanks. Nocturnal. Senanayake (1982) reports that <i>W. attu</i> prefers quiet waters with tree roots and vegetation. There is no record of the life cycle of this species in Sri Lanka. Drastic declines of populations have been recorded during past few decades.
Reproduction	No published information available.
Captive breeding and <i>ex-situ</i> conservation	Although there is no record of successful captive breeding of <i>W. attu</i> in Sri Lanka, this species has been bred in captivity as part of the aquaculture industry in some other Asian countries.
Critical habitats	<i>Wallago attu</i> is a widely distributed species. Further, the project area does not fall within the historical distribution range of this species. Therefore, the Moragolla project area is not considered to be a critical habitat area for <i>Wallago attu</i> .



Distribution map for *Wallago attu*

***Schistura notostigma* (Banded mountain loach)**

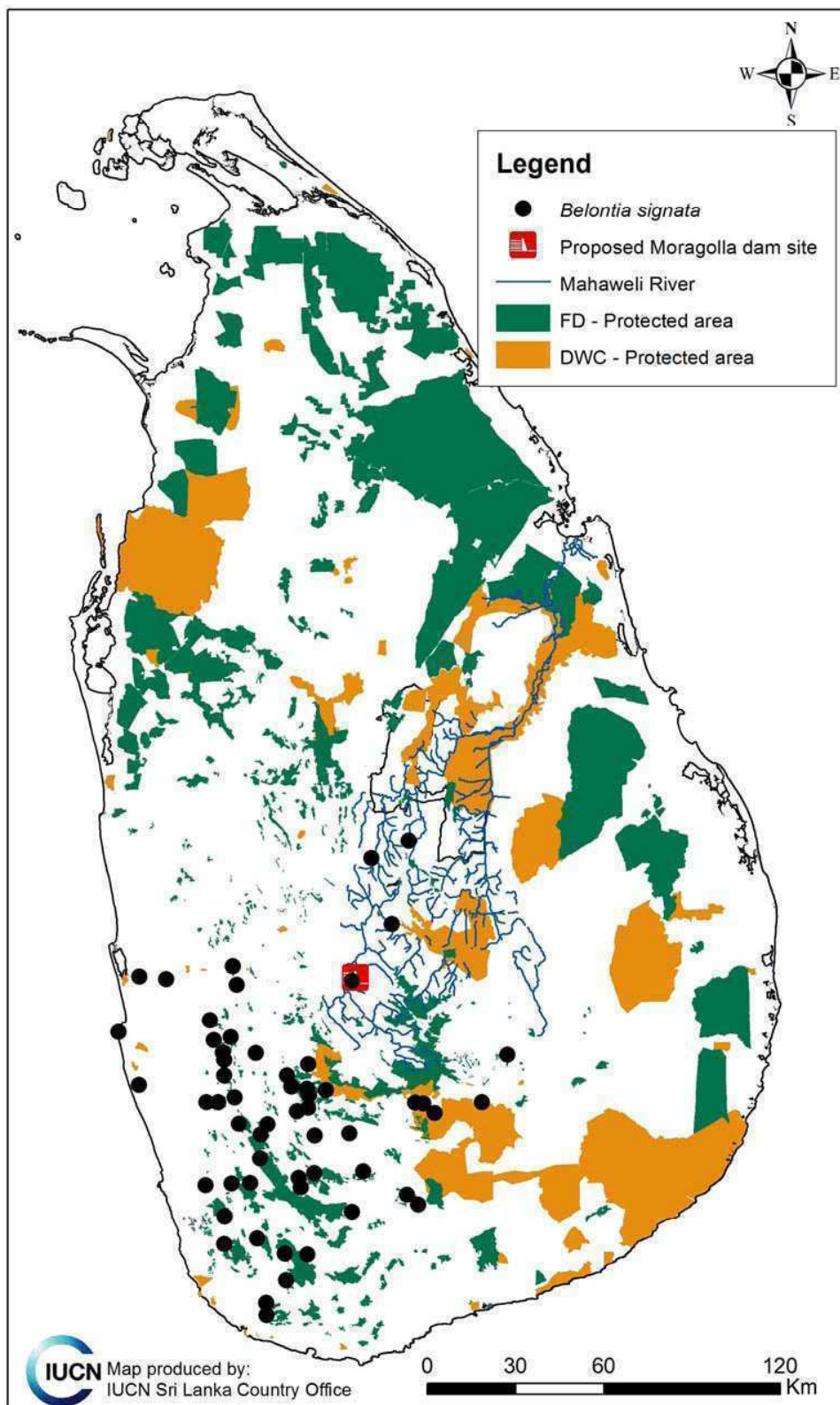
Scientific name	<i>Schistura notostigma</i>
Common names	Banded mountain loach
Synonyms	<i>Nemacheilus notostigma</i>
Conservation status	Near Threatened (National Red List 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka. Common in small tributaries in southwestern ichthyological zone of the country and also recorded from other areas up to an elevation of 1, 500 m.
Distribution within the Mahaweli River system	There are records of this species from the Knuckles area and main Mahaweli system, including the project area.
Feeding, habitat preference, life cycle and population density	Feeds primarily on benthic foods. <i>S. notostigma</i> prefers fast flowing and clear water, and is always associated with rocky substrates. This species is common locally in small to medium sized streams from the Kelani River basin to the Nilwala River basin. <i>S. notostigma</i> shows a restricted population size within the Mahaweli basin.
Reproduction	Not recorded.
Captive breeding and <i>ex-situ</i> conservation	An easily adaptable fish species that is exported by aquarium fish traders.
Critical habitats	The natural habitat of <i>Schistura notostigma</i> is small and moderate sized streams, and the species is not normally recorded from major rivers. The proposed Moragolla project is unlikely to impact the small streams of the area severely. Further, this species shows a wide distribution and even occurs in protected areas. Therefore, the Moragolla project area is not considered to be a critical habitat area for <i>Schistura notostigma</i> .



Distribution map for *Schistura notostigma*

***Belontia signata* (Combtail)**

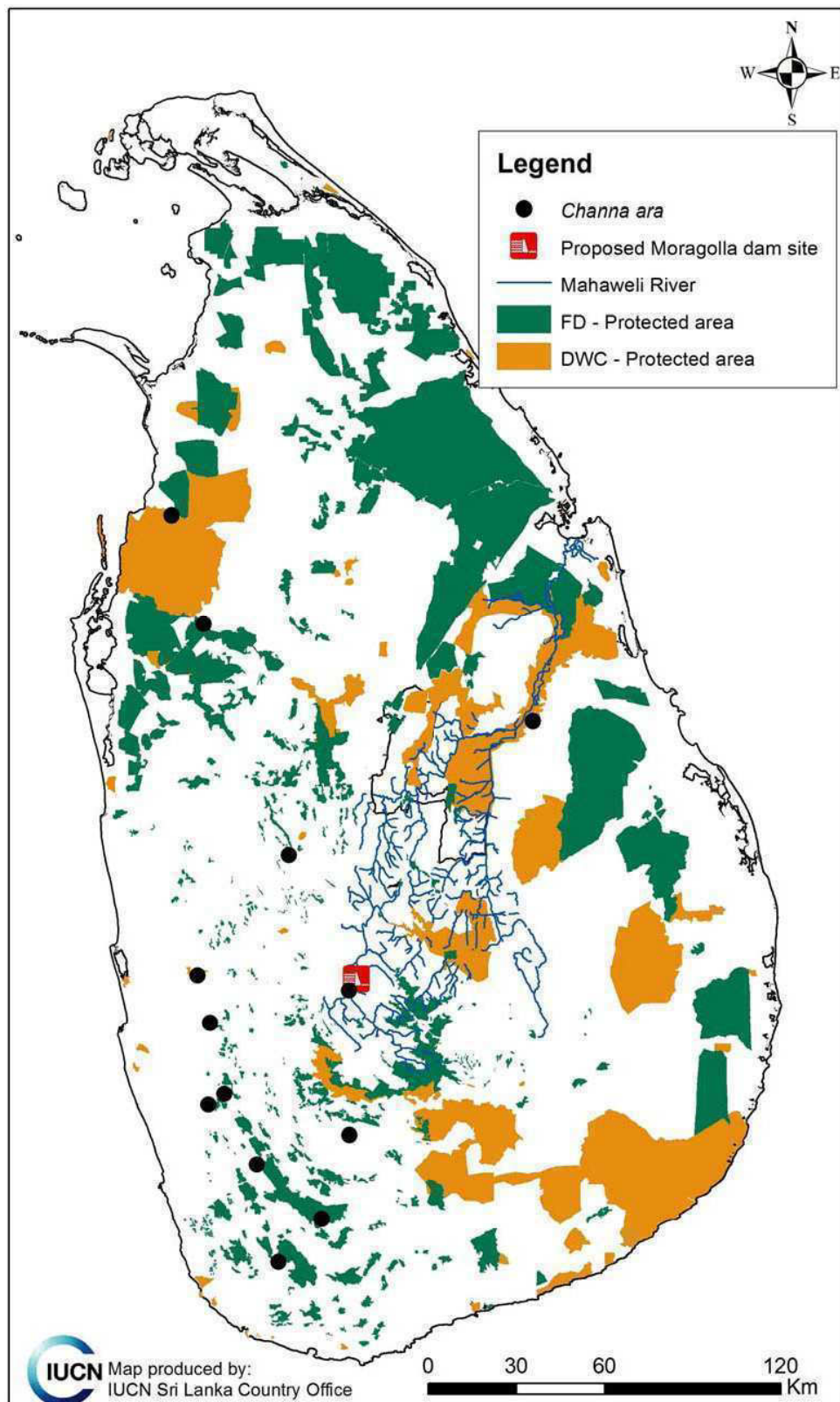
Scientific name	<i>Belontia signata</i>
Common names	Combtail
Synonyms	<i>Polycanthus signatus</i>
Conservation status	Near Threatened (National Red List 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka. Recorded in many places in the southwest of the country from the Kelani River to the Nilwala River basin. There are also some records from the Intermediate Zone of Sri Lanka.
Distribution within the Mahaweli River system	Not common in the Mahaweli basin, and restricted to the Knuckles range and a few other sites within the main river system, including project area.
Feeding, habitat preference, life cycle and population density	Carnivorous. <i>Belontia signata</i> lives usually in shady, clear, slow flowing shallow streams. Although it is considered to a hardy species in general, it is not recorded outside its preferred habitat. Usually, this species is found associated with submerged roots, branches and leaves. It is not a rare species, and although adults are territorial, it can relatively common within its distribution range in southwestern ichthyological zone of Sri Lanka.
Reproduction	This species makes bubble nests. Males guard the nests, while both parents protect juveniles in the first few weeks.
Captive breeding and <i>ex-situ</i> conservation	This is a very hardy species that is easy to keep under aquarium conditions. Captive breeding of <i>Belontia signata</i> is well documented, and individuals are observed to defend their territories.
Critical habitats	This species shows a wide distribution and even occurs in protected areas. As such, the Moragolla project area is not considered to be a critical habitat area for <i>Belontia signata</i> .



Distribution map for *Belontia signata*

***Channa ara* (Giant snakehead)**

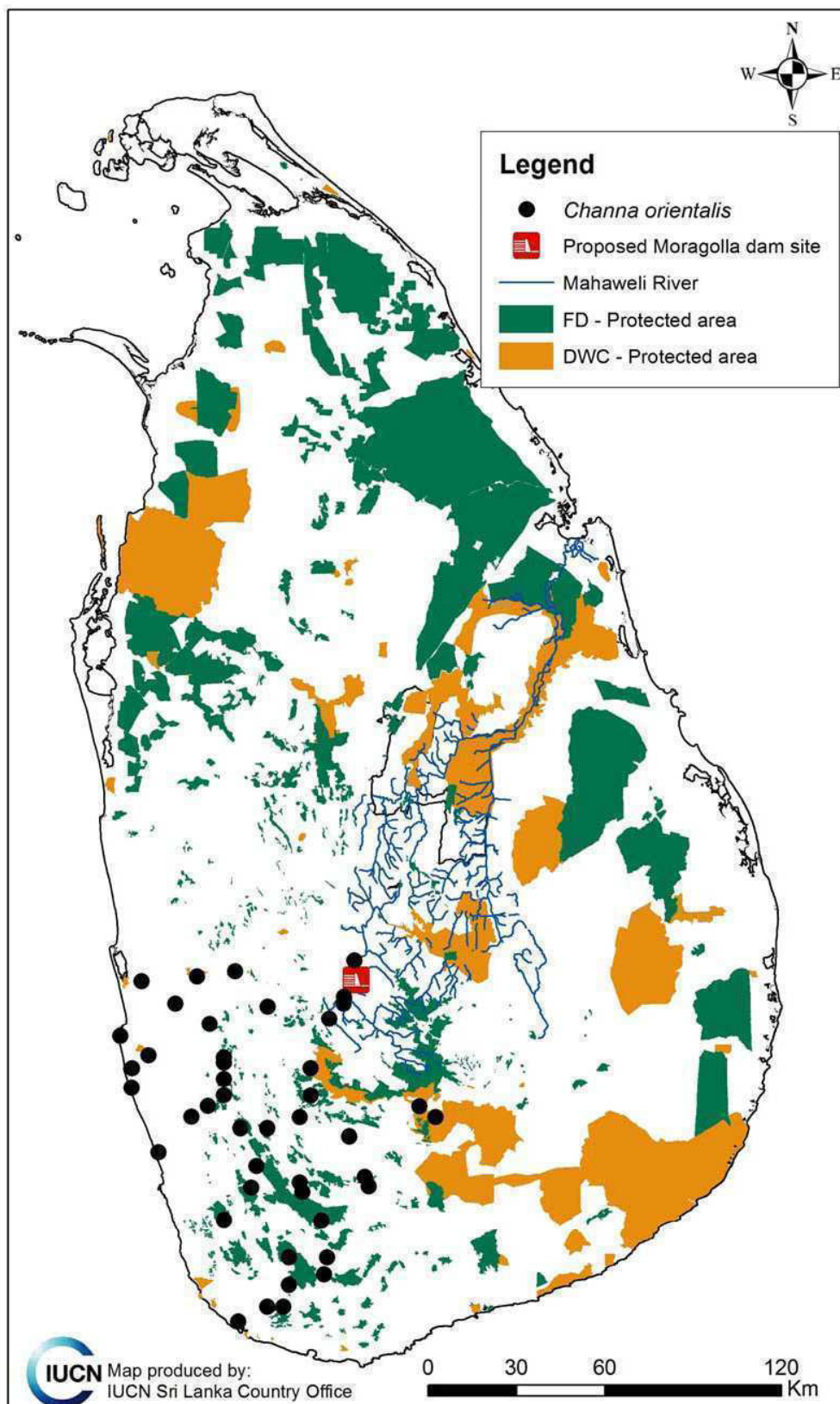
Scientific name	<i>Channa ara</i>
Common names	Giant snakehead
Synonyms	<i>Channa marulius</i>
Conservation status	Endangered (National Red List 2012)
Distribution within Sri Lanka	Endemic to Sri Lanka. According to Pethiyagoda (1991) and Senanayake (1982) this species is widely distributed in low country areas up to 500 m, but current records show a rapid decline of <i>Channa ara</i> from many areas.
Distribution within the Mahaweli River system	<i>Channa ara</i> occurs in the lower and middle part of the Mahaweli basin up to Kandy (Pethiyagoda, 1991). Sennayake (1982) also observes that the distribution of <i>Channa ara</i> in the Mahaweli basin is restricted to dry lowland part of the river. Records of <i>Channa ara</i> from project site represent an extension of the range of this species to a higher altitude.
Feeding, habitat preference, life cycle and population density	Carnivorous. Occupies deep pools in rivers, and is found occasionally in lakes (Pethiyagoda, 1991).
Reproduction	This species builds a nest of aquatic weeds, within which its eggs are laid. Both parents guard the eggs and the young, and are highly territorial during the breeding season, attacking possible predators of their hatchlings.
Captive breeding and <i>ex-situ</i> conservation	They are considered to be hardy fish, and it is possible to keep them captivity. However, a large space is required to rear this species. Although there are no reports available on captive breeding of <i>Channa ara</i> , international attempts to breed similar species, such as <i>Channa striata</i> , indicate that it is possible to breed this species in captivity.
Critical habitats	<i>Channa ara</i> is a widely distributed species in Sri Lanka. Therefore, the Moragolla project area is not considered to be a critical habitat area for this species.



Distribution map for *Channa ara*

***Channa orientalis* (Smooth-breasted snakehead)**

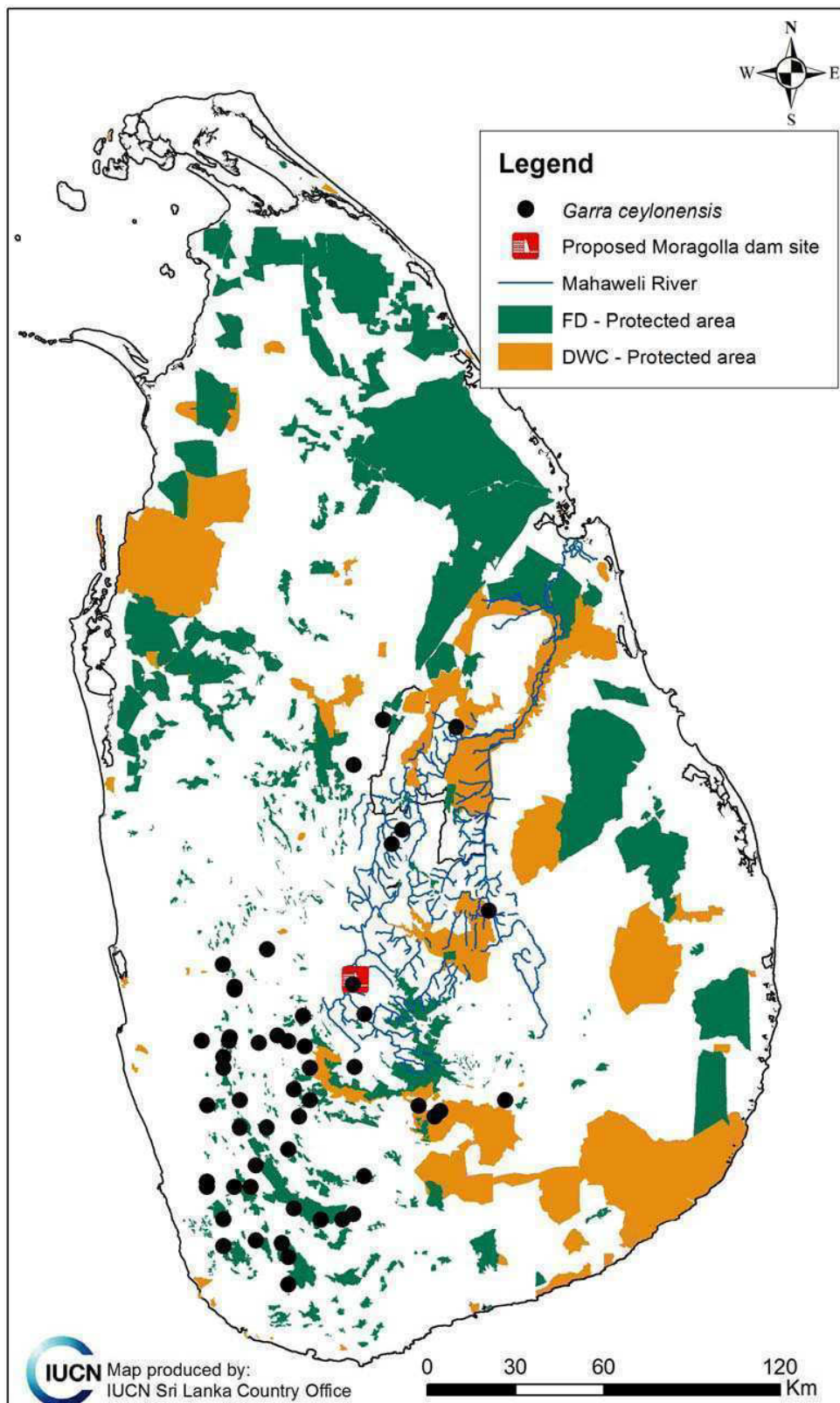
Scientific name	<i>Channa orientalis</i>
Common names	Smooth-breasted snakehead
Conservation status	Vulnerable (National Red List 2012)
Distribution within Sri Lanka	Endemic to Sri Lanka. According to Pethiyagoda (1991), this species is restricted to the southwestern ichthyological zone of the country from the Attanagalu River basin to the Nilwala River basin. Deraniyagala (1952) also reports this distribution pattern.
Distribution within the Mahaweli River system	According to the majority of past studies, this species has not been recorded from the Mahaweli River basin (Pethiyagoda, 1991; Deraniyagala, 1952). Only Senanayake (1980) reported a single record near Ginigathena. However, this species was recorded from the Amban Ganga and Kalu Ganga tributaries, during recent studies in the Knuckles area.
Feeding, habitat preference, life cycle and population density	Carnivorous. Feeds on terrestrial insects, small crustaceans and fish. Usually found in slow flowing, shady, clear streams. <i>Channa orientalis</i> is considered to be a mouth breeder, and eggs are hatched in mouth of the male. Either the male or female may keep the brood in its mouth for protection after hatching (Pethiyagoda, 1991). <i>Channa orientalis</i> is widely distributed in the low country Wet Zone and is locally common.
Reproduction	Both parents protect eggs and hatchlings.
Captive breeding and <i>ex-situ</i> conservation	Captive breeding of <i>Channa orientalis</i> has not been reported in literature. However, it is likely that it is possible to breed this species in captivity, as other <i>Channa</i> species are bred widely in captivity for the aquarium trade.
Critical habitats	<i>Channa orientalis</i> is a widely distributed species and occurs in many protected area. Therefore, the Moragolla project area is not considered to be a critical habitat area for this species.



Distribution map for *Channa orientalis*

***Garra ceylonensis* (Stone sucker)**

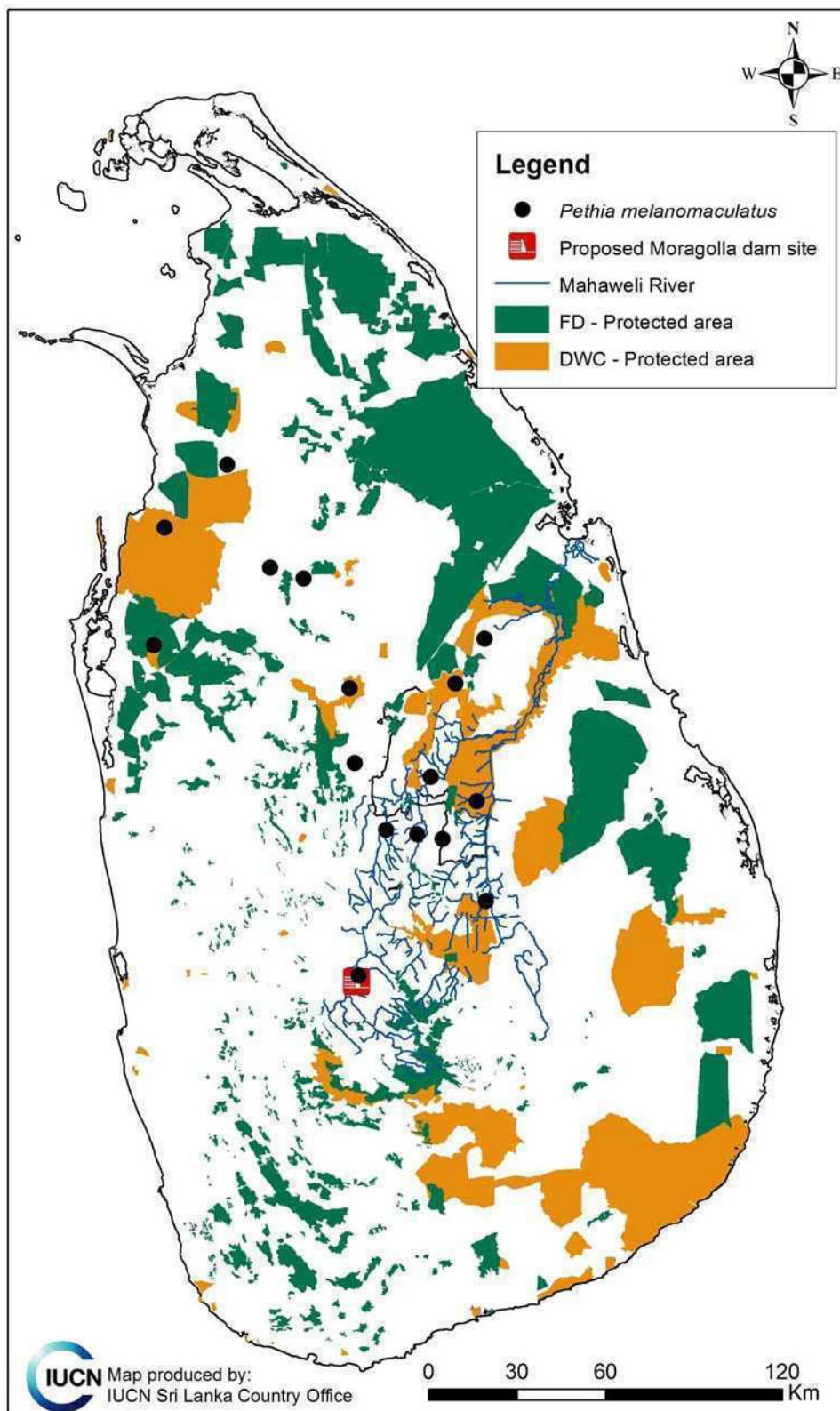
Scientific name	<i>Garra ceylonensis</i>
Common names	Stone sucker
Synonyms	<i>Discognathus lamta</i>
Conservation status	Vulnerable (National Red List 2012)
Distribution within Sri Lanka	Endemic to Sri Lanka. Widely distributed throughout the island. It is the one of the species that has been recorded at very high altitudes.
Distribution within the Mahaweli River system	<i>Garra ceylonensis</i> is distributed throughout the Mahaweli basin, except in its lower reaches (Pethiyagoda, 1991). Occurs commonly in the main river system, as well as rivulets of the Mahaweli basin.
Feeding, habitat preference, life cycle and population density	Feeds primarily on substrate algae. This species is mainly restricted to fast flowing and clear water, with rocky substrate. Adults tend to live associated with rocky substrates, while juveniles are free swimmers. Adults live in rivers and larger rivulets, while juveniles have been recorded from small streams and stagnant area on the periphery of the main river. <i>Garra ceylonensis</i> is not a rare species and common within its core distribution areas.
Reproduction	According to published information, this species shows upstream movement for spawning (Pethiyagoda, 1991). Juveniles also live in slow flowing streams in the first stages of their lives, and come down to the main river gradually. Records of <i>Garra</i> juveniles from outskirt pools of the main river areas indicate that possibility of spawning in such areas.
Captive breeding and ex-situ conservation	There are some records of captive rearing of this species under aquarium conditions (Pethiyagoda, 1991). However, literature on the captive breeding of this species is not available.
Critical habitats	<i>Garra ceylonensis</i> shows a wide distribution in the second peneplain, and most of the major river basins in Sri Lanka. It also occurs in protected areas. Therefore, the Moragolla project area is not considered to be a critical habitat area for this species.



Distribution map for *Garra ceylonensis*

***Pethia melanomaculata* (Tic-tac barb)**

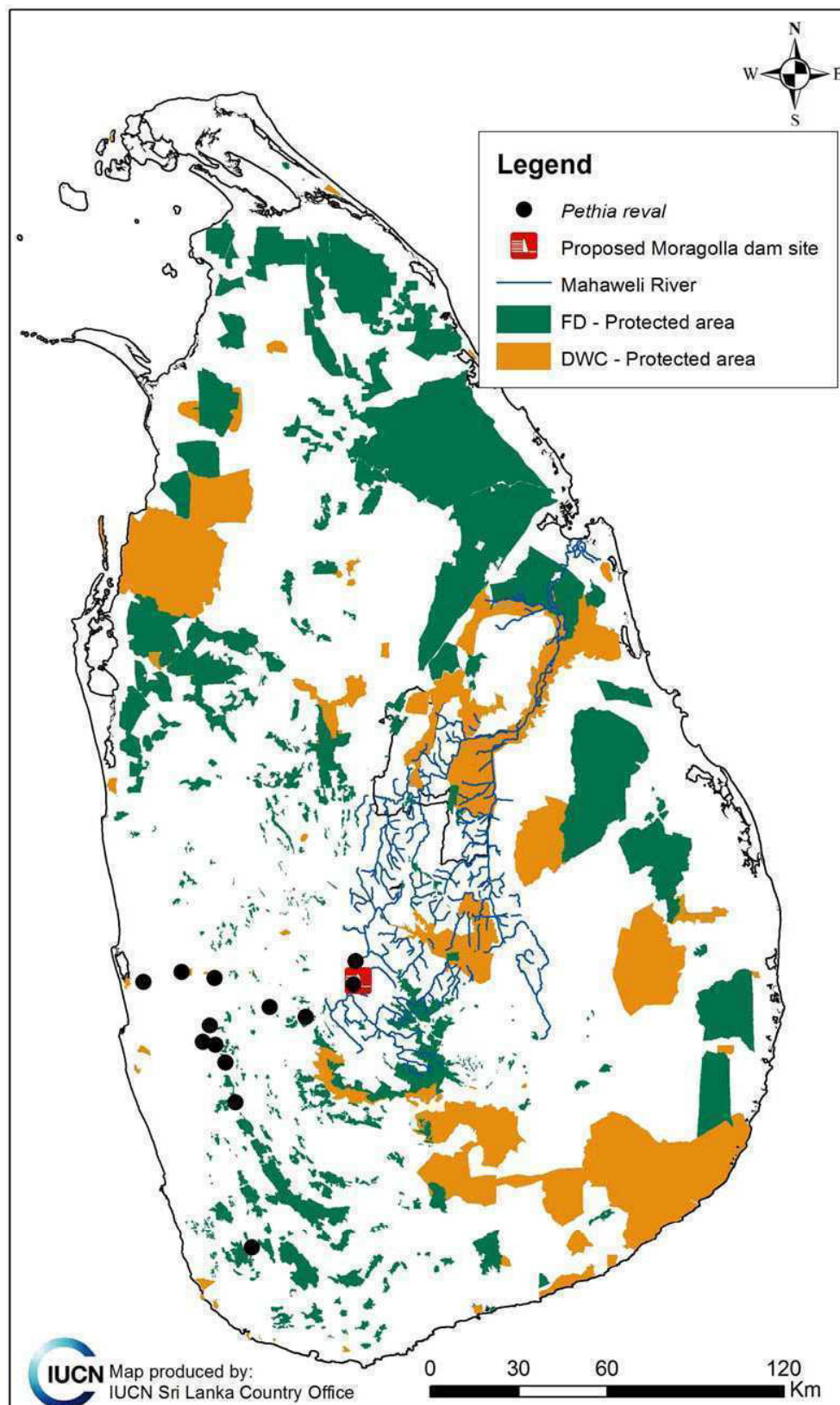
Scientific name	<i>Pethia melanomaculata</i>
Common names	Tic-tac Barb
Synonyms	<i>Puntius ticto</i>
Conservation status	Vulnerable (National Red List 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka. Considered to be a Dry Zone species. According to Pethiyagoda (1991) and Senanayake (1982), this species is confined to the Dry Zone lowland and the Mahaweli Dry Zone lowland.
Distribution within the Mahaweli River system	This species is recorded in the dry lowland part of the Mahaweli River basin. There are some records from below the Victoria dam site, and the lower part of the Knuckles region, which are not in close proximity to Moragolla project area. Therefore, there are discrepancies between the known distribution of this species, and the record reported from the Moragolla project area in NBRO (2013).
Feeding, habitat preference, life cycle and population density	Feeds primarily on plant materials, as well as on zooplankton and phytoplankton (Pethiyagoda, 1991). Found in smaller tanks or small, clear, rocky rivers in the Dry Zone. Not considered to be rare.
Reproduction	Reproduction in this species is similar to that of other barb species, and is well documented (Pethiyagoda, 1991).
Captive breeding and <i>ex-situ</i> conservation	According to the published information, breeding of <i>P. melanomaculata</i> is possible under captive conditions (Pethiyagoda, 1991).
Critical habitats	<i>Pethia melanomaculata</i> shows a wide distribution in the northern low country Dry Zone. Therefore, the Moragolla Project area is not considered to be a critical habitat area for this species.



Distribution map for *Pethia melanomaculata*

***Pethia reval* (Red-fin barb)**

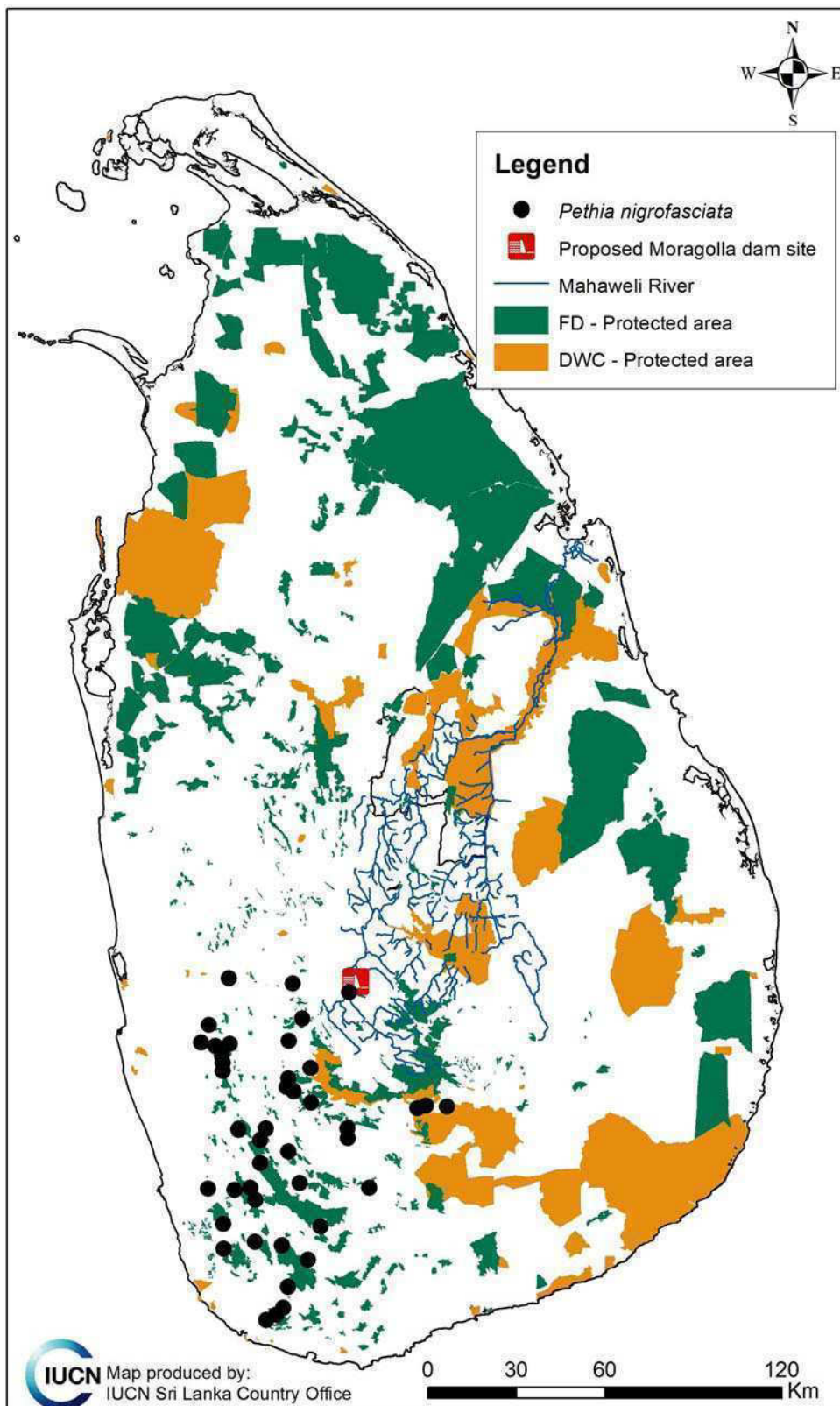
Scientific name	<i>Pethia reval</i>
Common names	Red-fin barb
Synonyms	<i>Puntius cumingi</i>
Conservation status	Endangered (National Red List 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka, and confined to the Attanagalu and Kelani River basins.
Distribution within the Mahaweli River system	Senanayake and Moyle (1982) introduced this species into the Mahaweli River near the Ginigathhena area for conservation purpose. The existing population of <i>P. reval</i> (<i>Puntius cumingii</i>) in project area are direct decedents from that translocated population, which is currently distributed in Gampola, Nawalapitiya and Ginigathhena within the Mahaweli river basin.
Critical habitats	The natural distribution range of <i>Pethia reval</i> is restricted from the Attanagalu River to the Kelani River in the Western Province, and the introduced population in the Mahaweli basin is not considered in the Red Listing process. Therefore, the Moragolla project area is not considered to be a critical habitat area for this species.



Distribution map for *Pethia reval*

***Pethia nigrofasciata* (Sri Lanka black ruby barb)**

Scientific name	<i>Pethia nigrofasciata</i>
Common names	Sri Lanka black ruby barb
Synonyms	<i>Puntius nigrofasciatus</i>
Conservation status	Endangered (National Red List 2012)
Distribution within Sri Lanka	Endemic to Sri Lanka, and confined from the Attanagalu River basin to the Nilwala River basin.
Distribution within the Mahaweli River system	Senanayake and Moyle (1982) introduced this species into the Mahaweli River near the Ginigathhena area for conservation purposes. The existing population of <i>P. nigrofasciata</i> in project area are direct decedents from this translocated population, which is currently distributed in Gampola, Nawalapitiya and Ginigathhena in the Mahaweli River basin.
Critical habitats	The natural distribution of <i>Pethia nigrofasciata</i> ranges from the Attanagalu River to the Nilwala River, and the introduced population in the Mahaweli basin is not considered during the Red Listing process. Therefore, the Moragolla project area is not considered to be a critical habitat area for this species.



Distribution map for *Pethia nigrofasciata*

Note: A species profile has not been prepared for *Systomus spilurus* (Olive barb) as there is some taxonomic uncertainty surrounding this species, and as it is considered to be a Data Deficient (DD) species.

Annex 5: Impacts of dams and mini-hydro power projects on freshwater biodiversity (Adapted partly from McAllister *et al.*, 2001).

Dams and associated reservoirs impact freshwater biodiversity in the following ways:

- Blockage and restriction of the movement of migratory species up and down rivers, causing extirpation or extinction of genetically distinct stocks or species.
- Changes to the turbidity or sediment levels of rivers, the natural levels of which species and ecosystems have become adapted to. Trapping of silt in reservoirs deprives downstream deltas and estuaries of the materials and nutrients necessary for their maintenance as productive ecosystems.
- Filtering out of woody debris, which would otherwise contribute to creating habitats and sustaining food webs.
- Changes to the conditions of rivers flooded by reservoirs, with running water becoming still, silt being deposited, deepwater zones being created, and new temperature and oxygen conditions being created. These conditions are unfavourable to the riverine species adapted to occupy these areas in the past.
- The provision of new habitats for waterfowl, in particular for overwintering, or in arid regions, which may increase their populations.
- The increased possibility of fostering exotic species, and the likelihood that these exotic species will tend to displace the indigenous biodiversity.
- Colonization of reservoirs by species that are considered to be vectors of human and animal disease agents.
- Management of the dam may alter or prevent normal flooding conditions, which will impact the maintenance of surrounding flood plains that support a rich diversity of species during high water periods. This will have implications for the biodiversity of the area, and well as on fisheries resources.
- Changes to the normal seasonal estuarine discharge, which can reduce the supply of entrained nutrients, impacting the food chains that sustain fisheries in inland and estuarine deltas.
- Modification of the water quality and flow patterns in downstream areas.
- Cumulative effects of a series of dams, especially where the impact footprint of one dam overlaps with that of the next downstream dam, can exacerbate the impacts on biodiversity.
- Other human activities, including agriculture, forestry, urbanization and fishing, that increase with the development of the area, can impact the biodiversity associated with these systems despite the fact that these activities are primarily land-based.

As such, dams are considered to be a significant threat to freshwater diversity. The impacts associated with such development activity occur largely through the frequent loss of habitat, modifications to the natural flow regime and blockage of migrations.

Annex 6: Proposed translocation action plan

All the translocation activities should be implemented according to the Guidelines for Reintroduction and Other Conservation Translocations (IUCN/SSC, 2013).

A technical committee including representatives from the Ceylon Electricity Board (CEB), the Department of Wildlife Conservation (DWC), the Forest Department (FD), the National Zoological Gardens (NZG), IUCN and other experts, should be established in order to oversee and evaluate the implementation of this programme.

Species name	Common name	Proposed area for collection	Proposed translocation destination site	Proposed period of implementation
<i>Labeo fisheri</i>	Mountain labeo	Inundation area and downstream areas (up to the proposed power house) of proposed Moragolla dam axis.	Suitable from Kitulgala to Yatiyanthota in the Kelani River or Sitawake River*.	During the construction period.
<i>Belontia signata</i>	Combtail	Inundation area of the proposed MHP.	Atabage Oya and Ulapone Oya.	During the construction period.
<i>Schistura notostigma</i>	Banded mountain loach	Inundation area of the proposed MHP.	Atabage Oya and Ulapone Oya.	During the construction period.
Species of the Family Bagridae		Inundation area of the proposed MHP.	Atabage Oya and Ulapone Oya.	During the construction period.
<i>Tor kudree</i>	Marsheer	Downstream areas (up to the proposed power house) of the proposed Moragolla dam axis.	Atabage Oya or the upper catchment of Moragolla up to Nawalapitiya.	During the construction period.
<i>Channa ara</i>	Giant snakehead	Downstream areas (up to the proposed power house) of proposed the Moragolla dam axis.	The upper catchment of the Moragolla reservoir up to Nawalapitiya.	During the construction period.
<i>Channa orientalis</i>	Smooth-breasted snakehead	Inundation area and downstream areas (up to the proposed power house) of the proposed Moragolla dam axis.	Atabage Oya and Ulapone Oya.	During the construction period.

Species name	Common name	Proposed area for collection	Proposed translocation destination site	Proposed period of implementation
<i>Wallago attu</i>	Shark catfish	Downstream areas (up to the proposed power house) of the proposed Moragolla dam axis.	The upper catchment of the Moragolla reservoir up to Nawalapitiya.	During the construction period.
<i>Ompoc bimaculatus</i>	Butter catfish	Downstream areas (up to the proposed power house) of the proposed Moragolla dam axis.	The upper catchment of the Moragolla reservoir up to Nawalapitiya.	During the construction period.

*Translocation of *Labeo fisheri*.

Labeo fisheri (Mountain labeo) is the only critical fish species that is present in the Moragolla project area that was identified as a high priority fish species according to points-based analysis carried out in order to identify priority species. *Labeo fisheri* is restricted to the middle part of the Mahaweli River, including the Amban Ganga and Kalu Ganga sub-catchments of the Mahaweli basin. All known primary habitats of *Labeo fisheri* (Mountain labeo) are being affected severely due to dams and reservoirs in the Mahaweli River system. Therefore, the translocation of this species to another river basin, - in this case the Kelani River basin - after analysing all factors regarding the survival of this critical endemic fish species, is recommended. This trans-river basin translocation should be carried out after thorough assessments of the existing population of *Labeo fisheri* (Mountain labeo), and the habitat conditions and species composition of both the source site (Mahaweli River) and the destination site (Kelani River) have been conducted and considered.

Annex 7: Offset habitat protection plan for the upper catchment of Moragolla up to Nawalapitiya*

No.	Action	Resources required	Potential implementing agency / agencies	Outcome / output	Monitoring
1	Identification of critical areas for fish in order to facilitate natural movement and relocation – this action is linked with translocation plan presented in Annex 6.	GIS expert and fauna expert.	Technical experts with relevant experience.	Map of the critical and suitable areas in the Mahaweli River system for natural upstream relocation and facilitation of natural upstream movement of fish in the proposed Moragolla project area.	A period of six months is necessary for monitoring and mapping - this action is linked with translocation plan presented in Annex 6.
2	Identification of the most depleted areas in the upper catchment and preparation of suitable habitat improvement plans.	GIS expert and flora expert.	Forest Department and technical experts with relevant experience.	Map of the upper catchment up to Nawalapitiya prepared along with habitat improvement plans.	
3	Implementing an afforestation programme in the identified locations. This action can be linked with the afforestation and watershed management plans of the MHP.	Forestry expert and labourers.	Forest Department.	Suitable areas in the upper watershed are replanted.	Monitoring of the progress of growth.
4	Community awareness programme - this action can be linked with other awareness programmes related to the mitigation of impacts on the terrestrial fauna of the area, and the afforestation and watershed management plan.	Community mobilizers and environmental communicators.	Forest Department and technical experts with relevant experience.	Communities are educated about the importance of upper watershed management for the conservation of the native fish of the area.	Re-visiting relevant sites to evaluate the impacts of the awareness programmes.

*Note: Most of these activities are a part of the afforestation and watershed management activities of the MHP and are not, therefore, not budgeted separately.

Annex 8: Estimated budget for the fish translocation programme for the Moragolla hydropower project

No	Description	Amount (LKR)
01	Project staff	900, 000.00
02	Transport (Field Team/Fish)	350, 000.00
03	Equipment purchase and Hire	200, 000.00
04	Awareness programme for relocated sites	100, 000.00
05	Allowance for Government staffs (DWC,)	40, 000.00
06	Communication and Stationeries	50, 000.00
07	Surveying and selection of translocation sites	400, 000.00
	Total cost	1, 940, 000.00

Annex 9: National level recovery Plan for *Labeo fisheri* (Green Labeo)

Justification

Labeo fisheri is a Critically Endangered (CR) endemic freshwater fish species and occurs only in the Mahaweli River basin. According to published information, *L. fisheri* is restricted to fast flowing, clear and rocky areas of main river and the adjacent main branches (Senanayake 1980, Deraniyagala 1952, Pethiyagoda 1991, Shirantha 2012). All known localities of *Labeo fisheri* overlap with existing or proposed dams and reservoirs and such altered habitats are not suitable for *L. fisheri* (Pethiyagoda 1991, Senanayake and Moyle 1982). According to the Shirantha (2012), attempts to breed this species in captivity have failed and according to the Pethiyagoda (1991) there is no records of captive rearing of *L. fisheri*. *L. fisheri* is one of the freshwater fish species that is on the brink of extinction due to the above reasons and habitat deterioration due to heavy siltation of the upper Mahaweli catchment, large scale use of agrochemicals and destructive fishing activities (Wikramanayake 1990, Pethiyagoda 1991, Shirantha 2012).

Therefore, it is recommended that a national level recovery plan is developed and implemented for this species. It is not expected that this will be done through the MHP alone, but some activities are relevant to the MHP.

Conservation status of *Labeo fisheri*

According to the National Red List 2012, *Labeo fisheri* is categorized as a Critically Endangered freshwater fish and is included in Schedule VI of the Fauna and Flora protection Ordinance (Amended act No. 22 of 2009) as a protected species (Gunasekara, 2011).

Proposed activities and responsible organization/s

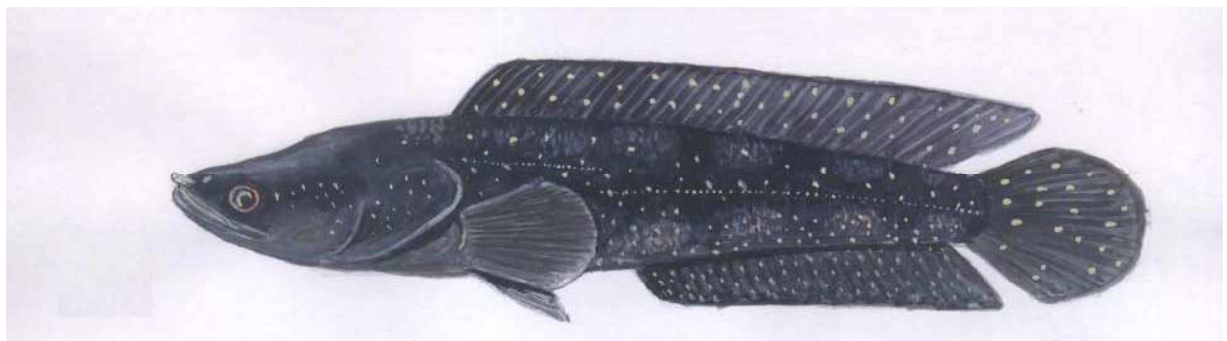
No.	Activity	Organization/s
01	Habitat assessment of <i>L. fisheri</i> historical range in the Mahaweli basin	Mahaweli Authority of Sri Lanka (MASL), CEB, DWC, IUCN, University of Peradeniya
02	Implementing research on captive breeding and ex-situ conservation of <i>L.fisheri</i>	University of Peradeniya, DWC, National Zoological Gardens
03	Recovery and translocation of Moragolla subpopulation of <i>L.fisheri</i> to new location/s	MHP, IUCN
04	Habitat protection and watershed management of critical habitats which will identify by Activity 1 and 3	DWC, Mahaweli Authority, MHP
05	Community awareness programmes to improve the sustainable use of upper watershed management and reduce destructive fishing activities	DWC, Mahaweli Authority, MHP
06	Reintroduce captive bred individuals into natural habitats	University of Peradeniya, DWC
07	Study the impact of competitive exotic fish species such as <i>Labeo rohita</i> on <i>Labeo fisheri</i> .	University of Peradeniya, IUCN,DWC

Annex 10: Illustrations of important fish of the Moragolla Project Area

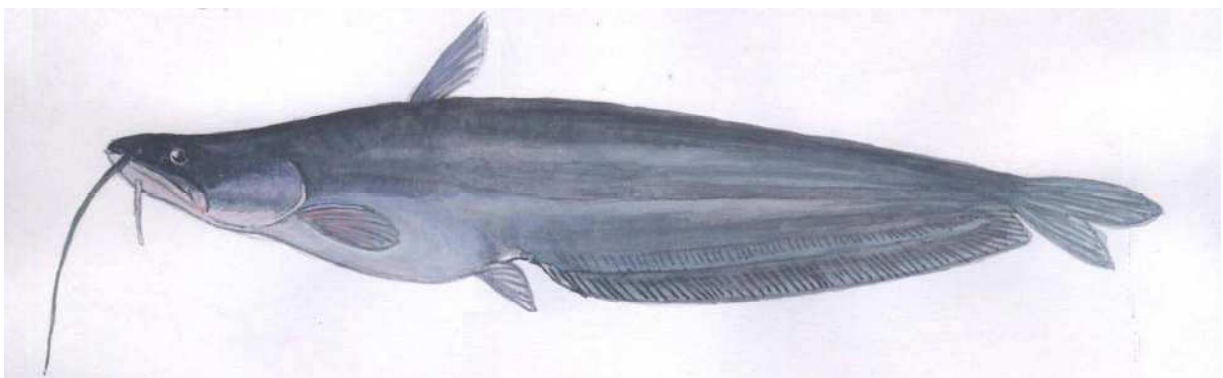
(All illustrations by Sampath A. de Goonatillake)



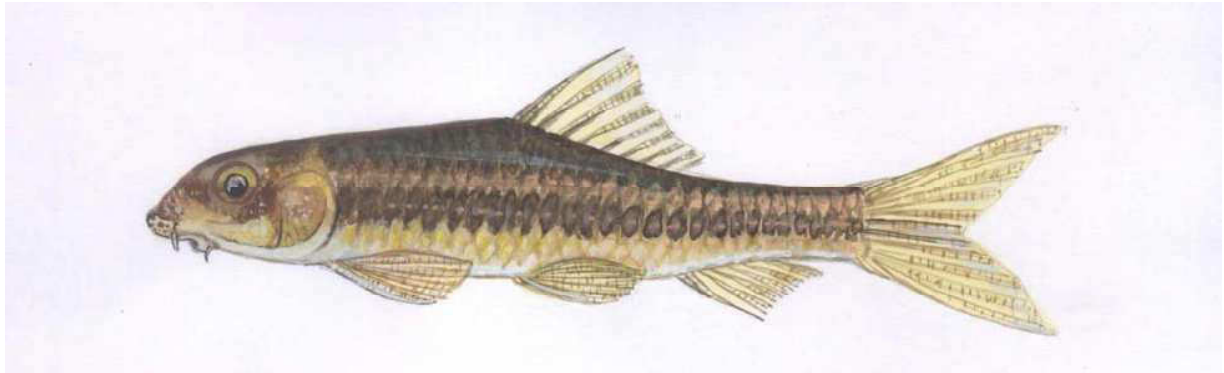
***Labeo fisheri* (Green Labeo)**



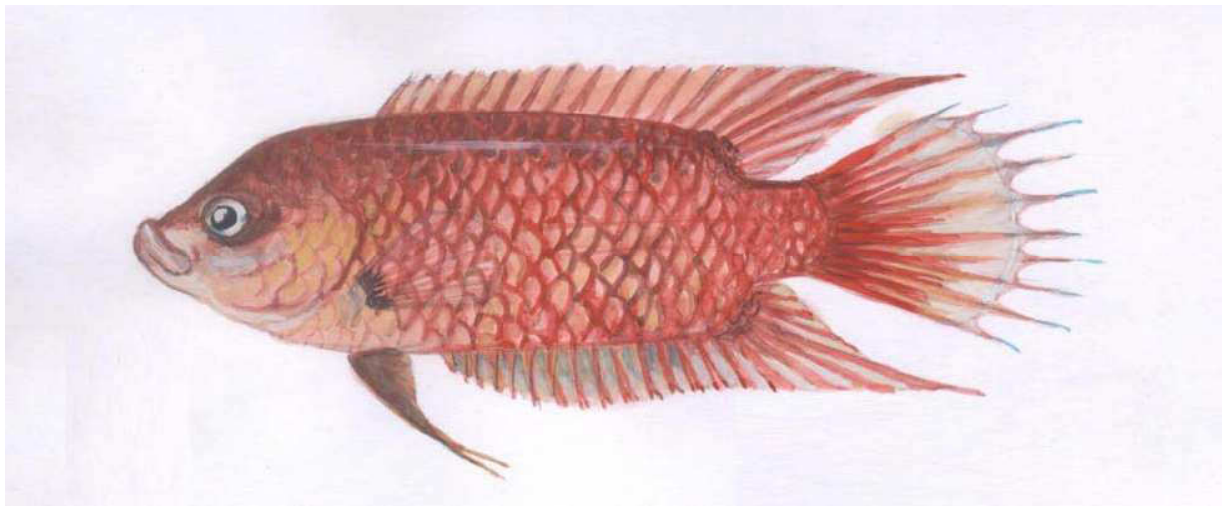
***Channa ara* (Giant Snakehead)**



***Wallago attu* (Shark Catfish)**



Garra ceylonensis (Stone Sucker)



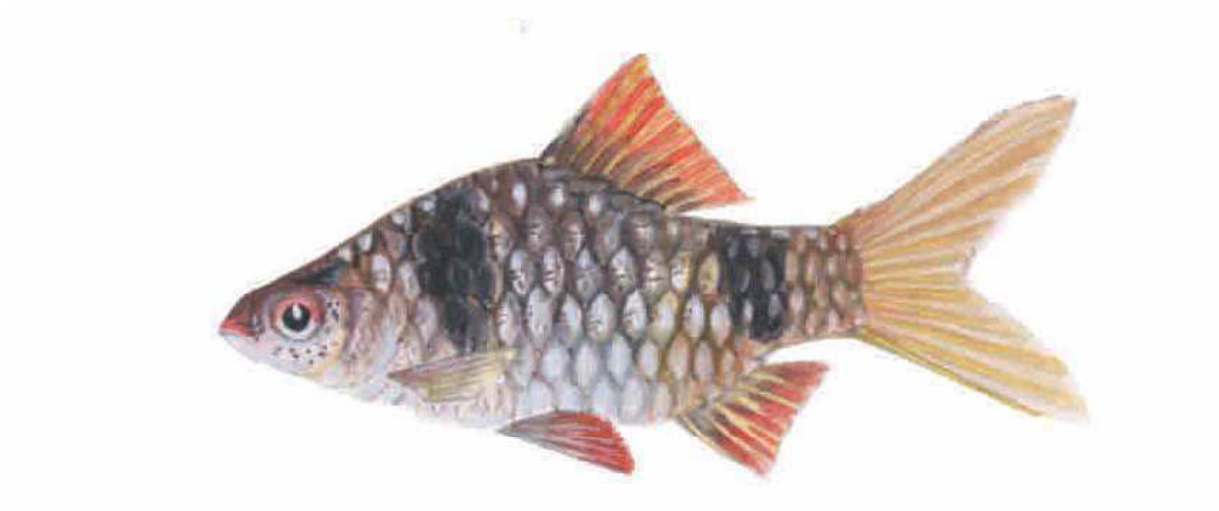
Belontia signata (Comb tail)



Schistura notostigma (Banded mountain loach)



Pethia nigrofasciata (Black-ruby barb)



Pethia reval (Red fin barb)

IUCN, International Union for Conservation of Nature

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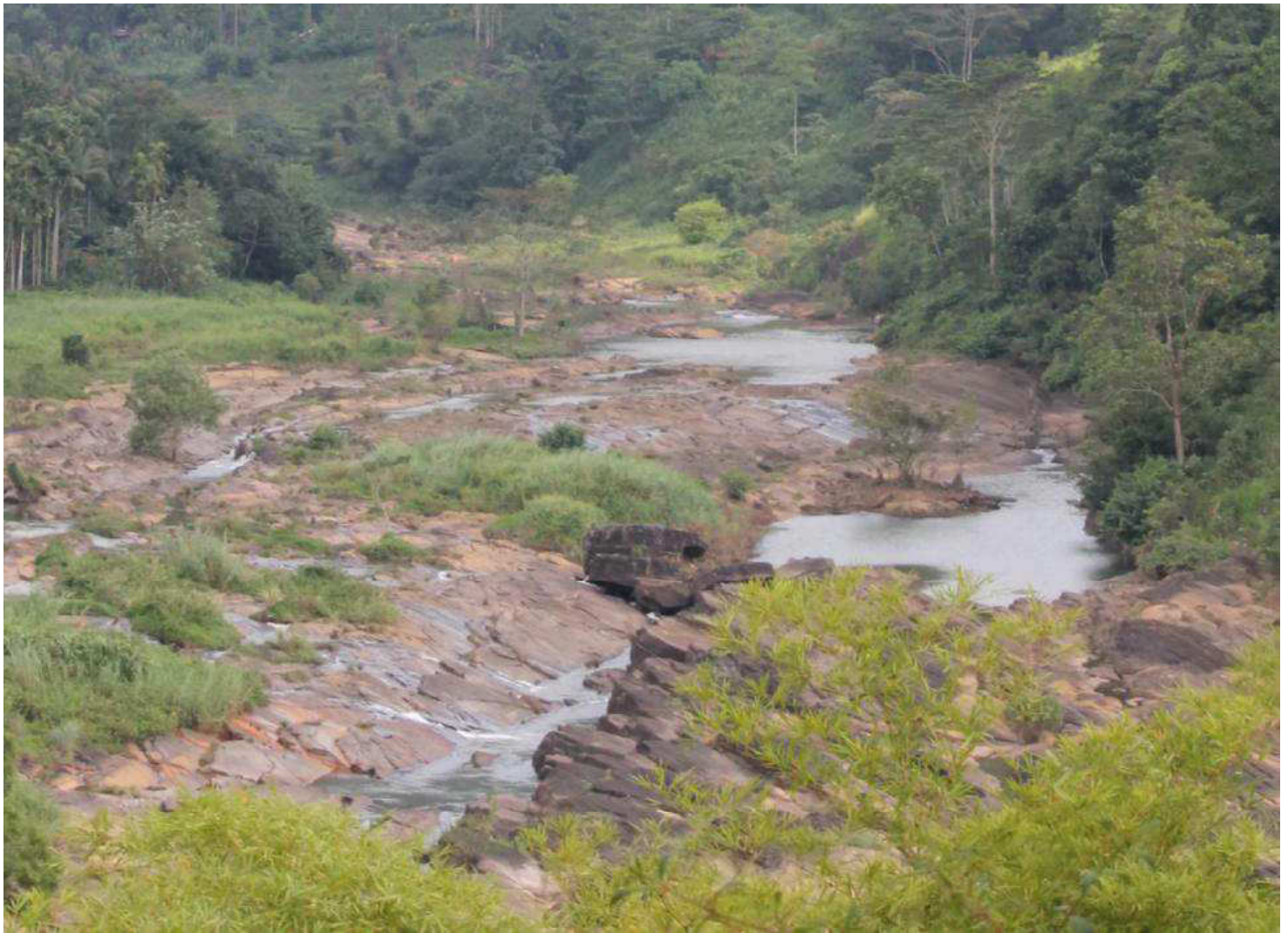
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Moragolla Hydropower Project

Additional Studies in the Natural Environment: Expert Report on Habitat Creation and Management to enhance Terrestrial Biodiversity

FINAL REPORT



August 2013

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We are also immensely grateful to Mr. W. A. D. D. Wijesuriya, who accompanied the IUCN team in the field for his assistance and guidance.

ABBREVIATIONS

CEA	–	Central Environmental Authority
CEB	–	Ceylon Electricity Board
CR	–	Critically Endangered
DWC	–	Department of Wildlife Conservation
EIA	–	Environmental Impact Assessment
EN	–	Endangered
EPA	–	Environmental Protection Area
FD	–	Forest Department
IUCN	–	International Union for Conservation of Nature
LC	–	Least Concern
MASL	–	Mahaweli Authority of Sri Lanka
MHP	–	Moragolla Hydropower Project
NBRO	–	National Building Research Organization
NK	–	Nippon Koei Co. Ltd
NT	–	Near Threatened
VU	–	Vulnerable

EXECUTIVE SUMMARY

The Ceylon Electricity Board (CEB) plans to develop a new 30MW hydropower project at Moragolla in the Kandy District. The involves the construction of a 35 m high concrete gravity dam across the Mahaweli Ganga, in order to form a 38.5 ha reservoir with a Full Supply Level (FSL) of 548 m asl. Water will be diverted through a conveyance system to a powerhouse and with the outfall located opposite the confluence with the Atabage Oya.

As the project will be located in the middle catchment of the Mahaweli river - which is the longest river in Sri Lanka, and supports a wide variety of habitats inhabited by a number of endemic and threatened fauna - an Environment Impact Assessment (EIA) has been carried out to ascertain the impact of the project on biodiversity of the area, as well as on the biodiversity of Sri Lanka as a whole. This assessment has been supplemented by additional studies for further analysis of the impacts of the project on local biodiversity. The present study has been undertaken with the objective of identifying and prioritizing terrestrial faunal species that require mitigation measures in order to minimize the impacts of the proposed Moragolla Hydropower Project (MHP), and to propose mitigation measures to reduce the negative impacts of the proposed project on identified priority species.

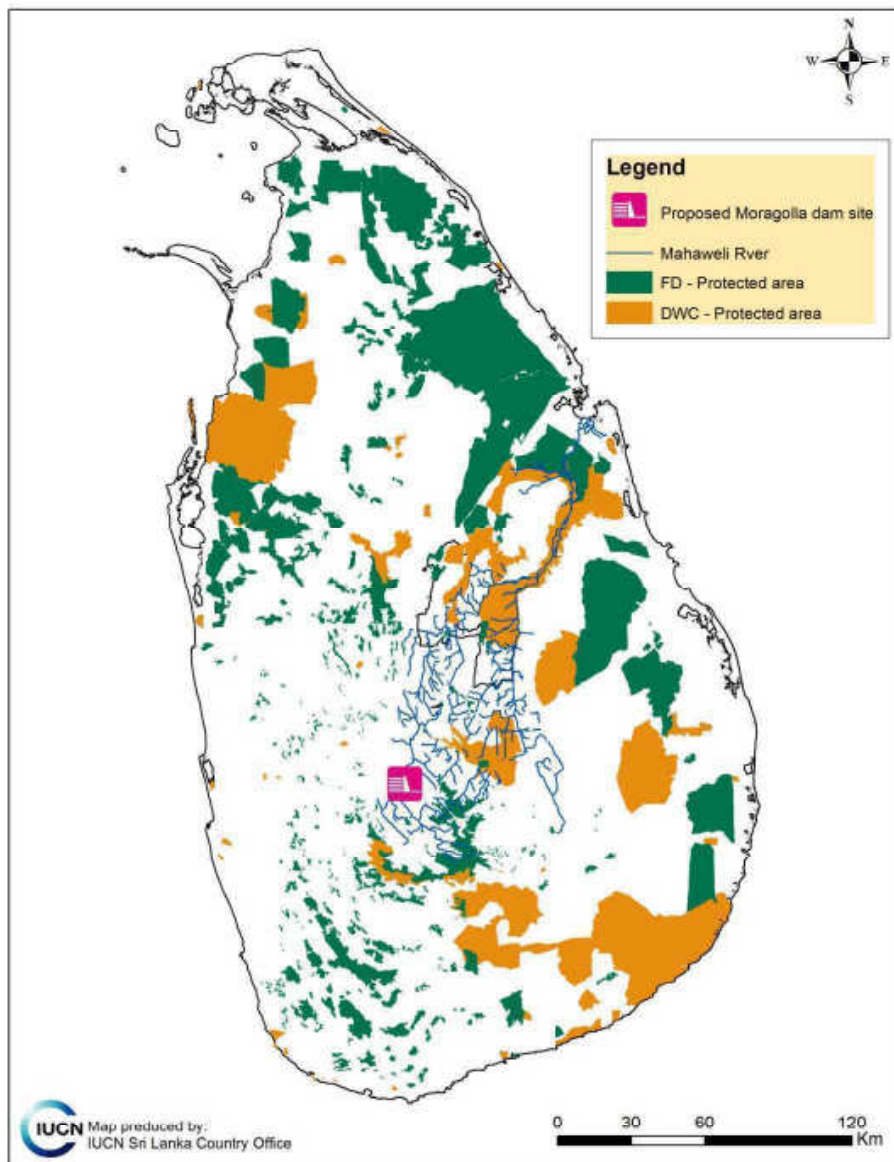
Based on direct and indirect observations (evidence such as scats and tracks) made during the EIA study (CECB and ACO, 2012), and the Additional Study (NBRO, 2013) , a total of 173 species of terrestrial fauna have been recorded in the area that is directly impacted by the proposed project. A total of 23 of these species are endemic to Sri Lanka, while 16 are listed as threatened species and 12 are listed as Near Threatened (NT) species. Further, ten of the 23 species of endemic species are listed as threatened or Near Threatened (NT) species. Therefore, overall, a total of 41 species that were recorded in the area were considered as critical species. These species were evaluated using an impact index developed in order to determine how these species will be affected by the proposed project during the present study. Other species were not evaluated as they show a wide distribution in Sri Lanka, as well as outside Sri Lanka, and therefore, the proportions of their populations impacted by the project will be insignificant.

Based on the evaluations carried out, none of the 41 identified threatened and endemic species will be significantly affected by the proposed project. Five species have been identified as moderately affected due to loss of habitat as a result of the project, and the impact of the project on these species can be mitigated by creating suitable habitats within the reservation of the proposed reservoir that will act as a refuge for the species that become displaced as a result of project activities. Further, the site will become colonized by species showing high mobility such as birds, mammals and butterflies. The ideal example for such colonization is the establishment of a butterfly garden in Lady Ridgeway Hospital in the city of Colombo as this garden was colonized by rare butterfly species that do not occur in any of the urban habitats within a radius of about 25 km around the hospital. As this reserve is in close proximity to natural habitats compared to the above scenario, the probability of colonization is expected to be much higher.

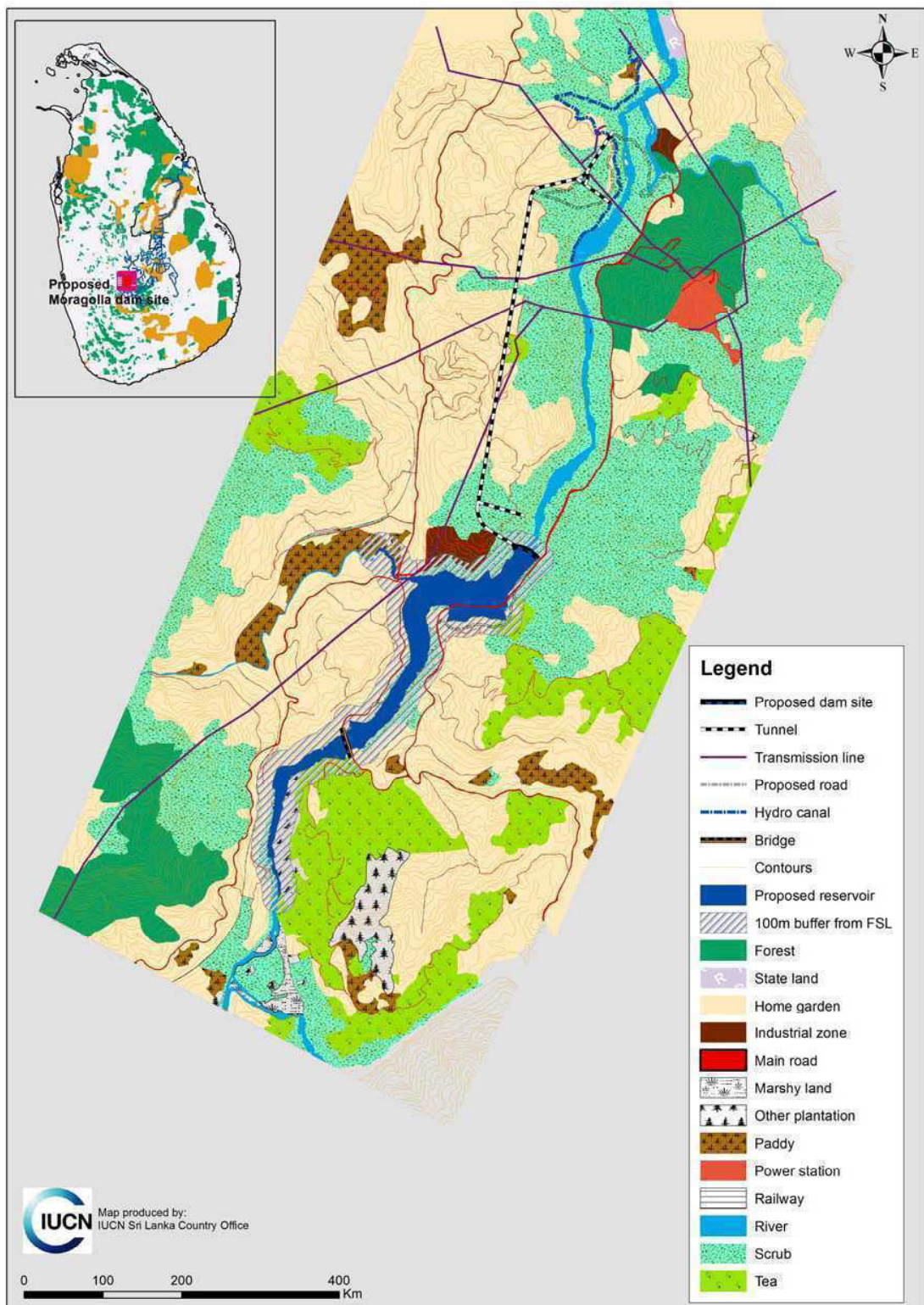
1. INTRODUCTION

1.1 Background

The Ceylon Electricity Board (CEB) is planning to develop a 30.8 MW hydropower project in Moragolla, Sri Lanka. The proposed Moragolla Hydropower Project (MHP) is located in the Kandy District of the Central Province. The project involves the construction of a 35 m high concrete dam across the Mahaweli River at Weliganga, resulting in the formation of a 38.5 ha reservoir with a Full Supply Level (FSL) of 548 m asl.



Map 1. Location of the Moragolla Hydropower Project

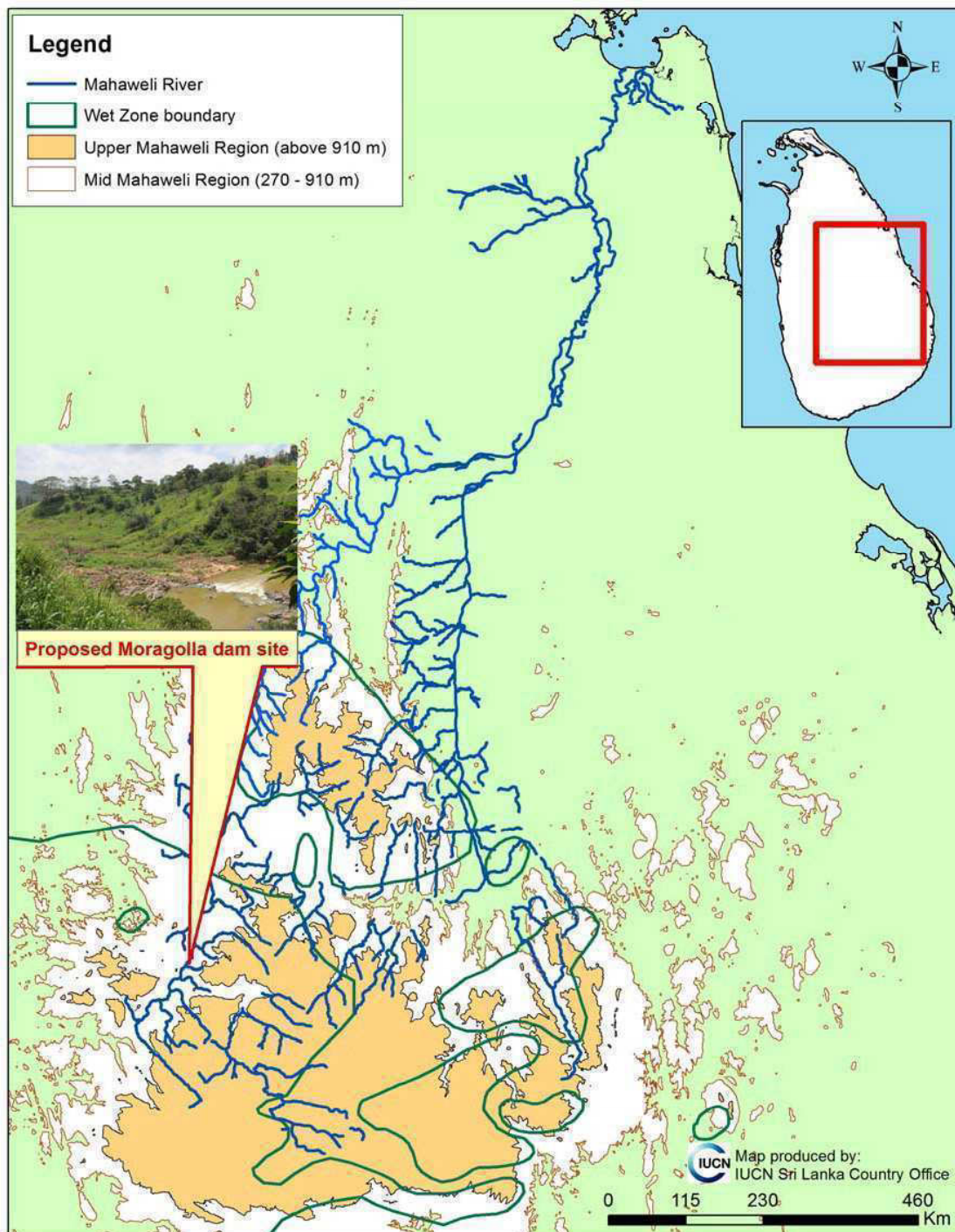


Map 2. The project area including land uses.

The Mahaweli River (known locally as Mahaweli Ganga) is the longest river in Sri Lanka, and is of great economic and social importance. It is also an ecologically important system, supporting a large number of endemic and threatened species, including several terrestrial faunal species, such as *Ceratophora tennentii* (Leaf-nosed lizard), *Cophotis dumbara* (Knuckles pygmy lizard) and *Nannophrys marmorata* (Kirtisinghe's rock frog), that are found only within the Mahaweli River basin.

An environmental Feasibility Study, including an Environmental Impact Assessment (EIA) (CECB and ACO, 2012), was conducted for the proposed Moragolla Hydropower Project – which is based within the Mahaweli River basin – in 2009. Another additional study (NBRO, 2013) was undertaken in 2013 to upgrade the EIA and to supplement existing data.

The Proposed Moragolla Hydropower project area lies within the second peneplain of the Wet Zone of the Sri Lanka. Overall, the Mahaweli basin can be divided into three major parts based on peneplains. The Upper Mahaweli area lies within the third peneplain (above 910 m from mean sea level), while the mid-Mahaweli region lies within the second peneplain (270 – 919 m from mean sea level) and the lower Mahaweli region lies mainly within the third peneplain in the Dry Zone of the island (up to 210 m from mean sea level). The project area belongs to mid-Mahaweli region, where the rivers flow fast and feature rocky substrate (See Map 3 and Figure 1).



Map 3. Mahaweli basin showing the upper, mid and lower Mahaweli regions.

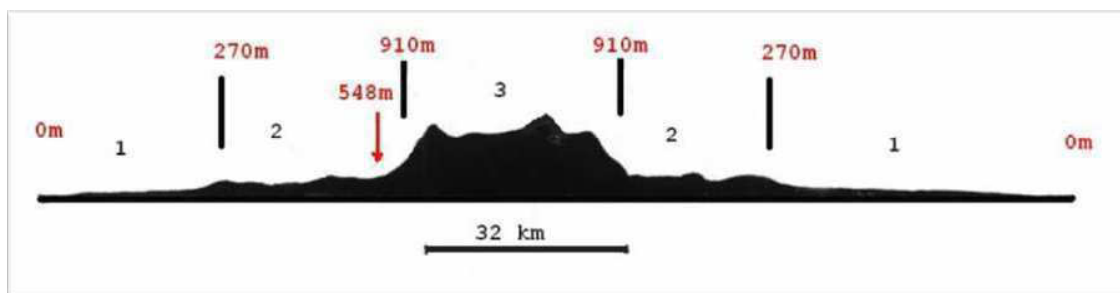


Figure 1. Diagrammatic cross-section of Sri Lanka showing the three peneplains (after Wadia, 1942).

(1 - first peneplain; 2 - second peneplain; 3 - third peneplain; red arrow - project area)

The EIA report (CECB and ACO, 2012) and additional study (NBRO, 2013) indicate that the project area – which consists primarily of degraded habitats - has been selected with consideration to avoiding and minimizing the environmental impacts of the hydropower project to the greatest extent possible. The terrestrial area that will be impacted directly due to project activities consists primarily of secondary vegetation, and is subject to a number of anthropogenic pressures, including farming. Therefore, the project is not expected to have significant impacts on terrestrial species and their habitats, as none of these species are restricted to the project area, and can be observed in other parts of the lowland Wet Zone, the Intermediate Zone or in similar habitats throughout the country. Nevertheless, a number of potential impacts of the project, including the loss of habitats and disturbances to habitats during construction, have been identified in the EIA report (CECB and ACO, 2012). Therefore, habitat creation and management activities will result in a positive contribution to the conservation of biodiversity in the area.

The EIA study, and subsequent supplementary surveys (CECB and ACO, 2012; NBRO, 2013) have identified a total of 41 terrestrial and aquatic associate faunal species that are endemic, threatened or Near Threatened within the direct impact zone of the project. Therefore, a further study has been deemed necessary to facilitate the planning and design of suitable measures to mitigate the impacts of the MHP on these terrestrial faunal species.

1.2 Objectives

The overall objective of the study is to identify suitable measures necessary to mitigate the impacts of the MHP on priority faunal species found in the area.

The specific objectives of the project are as follows:

- To identify priority species and their habitats within the project area;
- To assess the impacts of the project on priority species, as well as the need for any mitigation measures or management actions; and
- To prepare specific protection, mitigation, management and monitoring plans for the sustainability of each priority species.

2. METHODOLOGY AND APPROACH

The priority species list provided in Annex 1 of the Terms of Reference (ToR) for the study does not include the updated taxonomic and species status information. As such, it was necessary to update this list in order to identify priority species for which mitigation measures are necessary.

The study is based primarily on information from the EIA report for the MHP (CECB and ACO, 2012), as well as information from additional biodiversity assessments (NBRO, 2013). According to these two reports, the species documented within the project area were observed at the project site through direct sightings or indirect evidence, such as footprints or dung analysis. Therefore, the word “recorded”, in this document, refers to species that have actually been encountered – either directly or indirectly – within the site. A brief field visit was also undertaken by the IUCN team between 21 and 22 August, 2013, in order to ascertain the ground situation in the area, and gain better insights into the findings of these two reports.

The initial listing of species was based on the 2007 Red List of Threatened Species of Sri Lanka (IUCN and MENR, 2007)¹. Given that the National Red List of Sri Lanka was updated recently (MOE, 2012), the total list of terrestrial and aquatic associate fauna recorded from the project area was updated based on the new taxonomic nomenclature given in the updated Red List. Further, the conservation statuses of the species has been updated according to the National Red List 2012 of Sri Lanka (MOE, 2012) and the Global IUCN Red List², in order to gain better insights into the current conservation status of each species (see Annex 2). Distribution maps for the identified critical species – including endemic, threatened (CR, EN or VU) and Near Threatened (NT) species were developed using data from the Red List database housed at the Ministry of Environment and Renewable Energy.

¹ http://www.environmentmin.gov.lk/web/pdf/Red_List.pdf

² <http://www.iucnredlist.org/>

3. DISCUSSION

3.1 Existing ecology and biodiversity

3.1.1 Terrestrial ecology and biodiversity of the Mahaweli River and the impact of hydropower and other development activities

The Mahaweli River is the longest river in Sri Lanka. It is 355 km long and drains an area of approximately 10, 448 km² (16 percent of the land area of Sri Lanka). The Mahaweli basin is spread across three types of bio-climatic zones – the dry zone, the low and mid-country intermediate zone and the montane zone), due to its geographical variations (IUCN Sri Lanka, 2007). Further, the Mahaweli River flows through a number of unique floral zones, such as tropical wet evergreen forests, humid zone dry patana grasslands, central mountains, northern intermediate lowlands, and dry and arid lowlands (Gunatilleke and Gunatilleke, 1990). Due to this high variation of geographical features and floristic regions, the Mahaweli basin harbours a rich faunal diversity.

The upper montane region of the Mahaweli basin (see Map 3) has been shown to be an important region for the *in-situ* conservation of many localized endemic faunal species recently. Manamendra-Arachchi and Pethiyagoda (2006) discovered 29 amphibian species, including 23 rhacophorids³ of the genus *Pseudophilautus*, that are confined to the Mahaweli basin. Some of these species are confined to the central montane range (CMR), while the others are confined to the Knuckles mountain range (KMR). Further, Dutta and Manamendra-Arachchi (1996) have observed that the endemic frog species *Microhyla zeylanica* (Sri Lanka narrow mouthed frog) and *Nannophrys marmorata* (Kirtisinghe's rock frog) that are found only in the central and Knuckles massif up to approximately 2, 000 m in altitude. Likewise, several species of endemic reptiles are also restricted to the upper montane region of the Mahaweli basin. For instance, two species belonging to the endemic genus *Ceratophora* (horned lizards) – *Ceratophora stoddartii* (Rhino horn lizard) and *Ceratophora tennentii* (Leaf-nosed lizard)- and two species belonging to the endemic genus *Cophotis* (pygmy lizards) - *Cophotis dumbara* (Knuckles pygmy lizard) and *Cophotis zeylanica* (Pygmy lizard) - are restricted to this region.

An endemic bird species - *Myophonus blighi* (Sri Lanka Whistling Thrush) and three indigenous birds - *Saxicola caprata* (Pied Bush Chat), *Aviceda jerdoni* (Jerdon's Baza) and *Turdus merula* (Eurasian Blackbird)- are also confined mainly to the upper montane region of the Mahaweli basin. A number of endemic mammals, including *Solisorex pearsoni* (Sri Lanka Pearson's long-clawed shrew), *Suncus fellowes-gordoni* (Sri Lanka pygmy shrew) and *Rattus montanus* (Nelu rat), are also restricted to the montane region of the Mahaweli basin. Considering their high species diversity and endemism, Peak Wilderness Sanctuary, Horton Plains National Park and Knuckles Conservation Forest were declared, collectively, as natural World Heritage Site serial property – know as the Central Highlands World Heritage Site - by UNESCO in 2012. The upper Mahaweli basin, despite its high biodiversity value, is under heavy pressure. Most of the upper catchment of the Mahaweli basin has been converted to tea plantations and vegetable cultivation land since the eighteenth century. This has led to heavy deforestation in the upper catchment. Further, it has increased the rate of soil erosion, as well as contamination of the river with fertilizers. All

³ Amphibian species belonging to Family Rhacophoridae. In Sri Lanka, this family is represented by the genera *Pseudophilautus*, *Taruga* and *Polypodates*.

these activities have contributed to a reduction of the biodiversity of the upper Mahaweli basin.

In 1979, under the Mahaweli accelerated development project, the Mahaweli basin has subjected to a number of water diversion projects, which have affected the whole ecology of the river and its natural environments. Apart from the main river, small tributaries of the Mahaweli River at the borders of the upper and mid-Mahaweli regions have also been blocked off for mini-hydro power generation. Such diversions have resulted in low flows downstream of the diversion point. When the flow is restricted due to the diversion of water, the water retained in downstream areas tends to become stagnated, and the quality of the water deteriorates rapidly making it unsuitable for most fish. Further, low flows downstream of the dam, and conversion of the river upstream of the dam into a reservoir, has impacted the ecology of the fish species found in these areas, resulting in a marked reduction in the population sizes of some native riverine fish species, such as *Labeo lankae* (Sri Lanka orange fin labeo) and *Labeo fisheri* (Mountain labeo), and causing them to be listed as Critically Endangered (CR) species.

Further, the construction of large dams across the Mahaweli River at several sites has resulted in the blockage of the river, preventing free movement of aquatic organisms. This is particularly relevant to migratory fish species, as it has disrupted their breeding ecology. Even populations of non-migratory fish have become fragmented due to the establishment of dams. In addition, the inundation of large areas due to the establishment of large reservoirs has resulted in a loss of habitat for many terrestrial species that inhabited these areas previously.

3.1.2 Terrestrial fauna of the project area and their conservation importance (IUCN and Sri Lanka Red List)

As reported in the EIA report and relevant supplementary studies, a total of 173 terrestrial faunal species have been recorded in the direct impact zone of the MHP area. This includes 23 dragonfly species, 32 butterfly species, seven amphibian species, ten reptile species, 88 bird species and 14 mammal species. The recorded species include 28 endemic species, 11 species of migratory birds and one species of domestic mammal. An overview of the faunal species richness of the project area is given in Table 1.

A complete list of faunal species recorded from the project area, including species status and conservation status information, is presented in Annex 3.

Table 1. Overview of the terrestrial faunal diversity recorded within the project area

Taxon	Number of species							
	Total	Species status			National conservation status			
		Endemic	Exotic	Migrant	Nationally Threatened ⁴			NT
Butterflies	32	3	0	0	CR	EN	VU	NT
Dragonflies	23	6	0	0	0	4	4	4
Amphibians	7	3	0	0	0	0	1	1
Reptiles	10	2	0	0	0	0	0	0
Birds	88	7	0	11	0	0	0	5

⁴ According to the National Red List 2012 of Sri Lanka (MOE, 2012).

Taxon	Number of species							
	Total	Species status			National conservation status			
		Endemic	Exotic	Migrant	Nationally Threatened ⁴			NT
					CR	EN	VU	
Mammals	14	2	1	0	0	2	2	0
Total	173	23	1	11	1	6	9	12

As described in the methodology and approach section, the conservation statuses of species listed in the EIA report are based on the 2007 Red List of threatened fauna and flora. Therefore, as the first step, the conservation statuses of the species listed in the EIA study and supplementary studies were reevaluated according to the National Red List 2012 of Sri Lanka. An updated detailed list of the threatened and Near Threatened (NT) species – based on the National Red List 2012 of Sri Lanka and the Global Red List 2013 - is given in Annex 2.

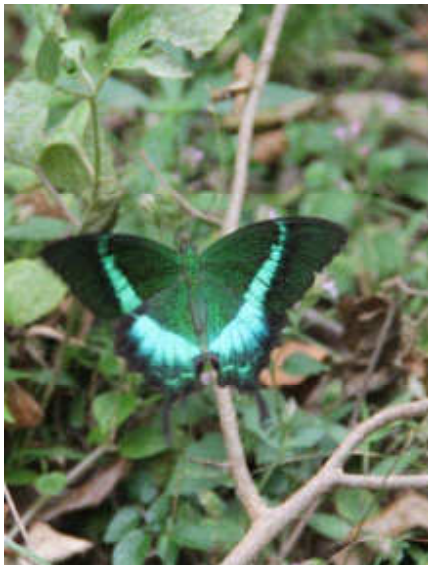
According to this evaluation, a total of 16 species have been identified as nationally threatened species have been recorded from the MHP area. This includes one nationally Critically Endangered (CR) species - *Cepora nadina* (Lesser gull) - six nationally Endangered (EN) species - *Libellago greeni* (Green's gem), *Paragomphus henryi* (Brook hooktail), *Orthetrum triangulare* (Triangle skimmer), Red-veined Darter - *Sympetrum fonscolombii* (Red-veined darter), *Prionailurus rubiginosus* (Rusty spotted cat) and *Prionailurus viverrinus* (Fishing cat) - and nine nationally Vulnerable (VU) species - *Papilio crino* (Banded peacock), *Eurema andersoni* (One spot grass yellow), *Libellago adami* (Adam's gem), *Libellago finalis* (Ultima gem), *Indolestes gracilis* (Mountain reedling), *Trithemis festiva* (Indigo dropwing), Corrugated water frog - *Lankanectes corrugates* (Corrugated water frog), *Lutra lutra* (Otter) and *Moschiola kathygre* (Sri Lanka pygmy mouse-deer). In addition, 12 Near Threatened (NT) species have also been recorded from the MHP area.

Species profiles for all threatened – Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) – species and all Near Threatened (NT) terrestrial faunal species recorded from the project area are presented below.

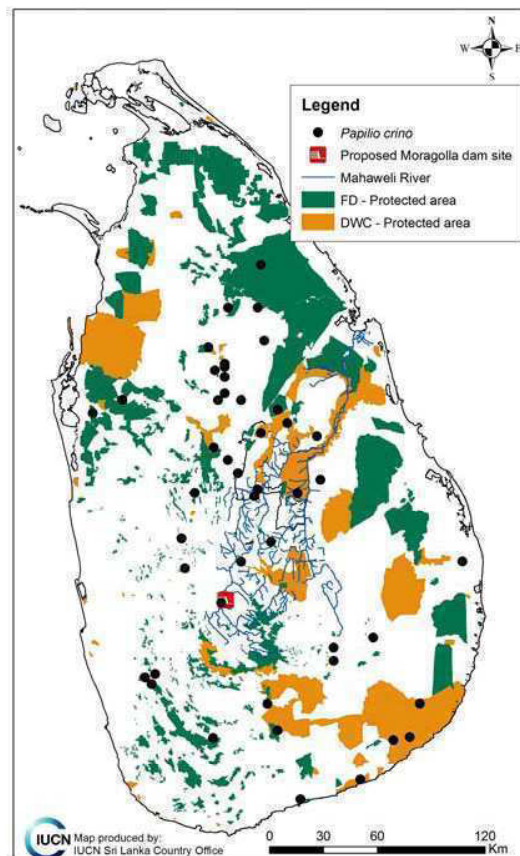
Butterflies

Papilio crino (Banded peacock)

Scientific name	<i>Papilio crino</i>
English name	Banded peacock
Sinhala name	Monara papilia
Family	Papilionidae
Species status	Indigenous
National conservation status	Vulnerable (VU)
Ecology	This species can be found throughout the island in forested areas, as well as open area, in both wet and drier areas, but is common in the dry part of the island. Its larvae feed on <i>Chloroxylon swietenia</i> (Satinwood) leaves.
Geographical distribution	This species has an island wide distribution up to 1, 800 ft from sea level. It can be found in Sri Lanka and southern India up to Kolkota.
Critical habitat	As this species shows a wide distribution, the project area does not function as one of its critical habitats. The host plant of this species - <i>Chloroxylon swietenia</i> (Satinwood) - can be planted in the reservation of the reservoir to increase its population.



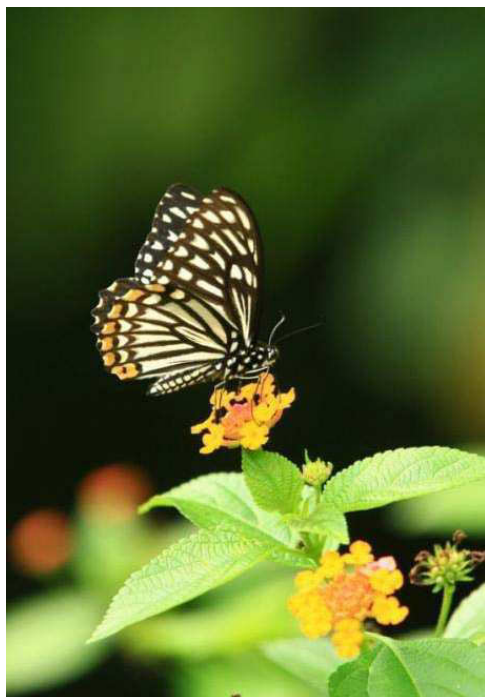
Source: © Sampath de A Goonatilake



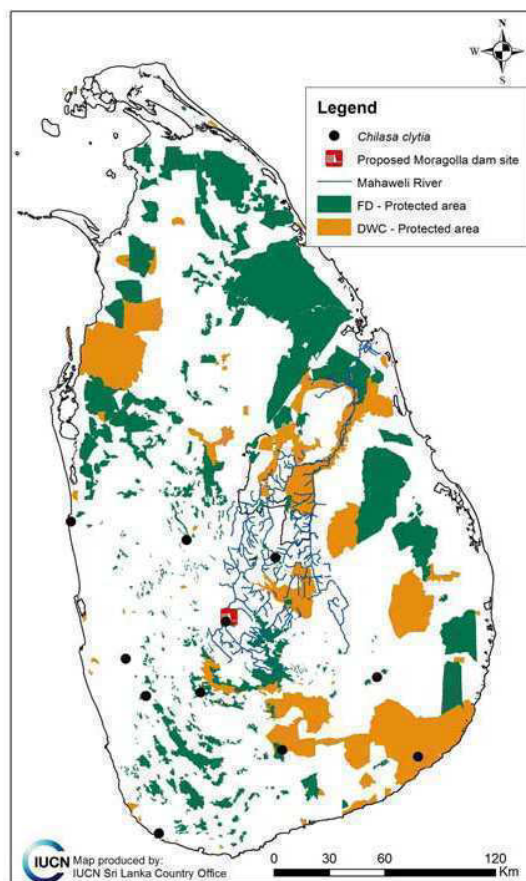
Distribution map (developed based on the 2007 Red List database)

***Chilasa clytia* (Mime)**

Scientific name	<i>Chilasa clytia</i>
English name	Mime
Sinhala name	Rawana papilia
Family	Papilionidae
Species status	Indigenous
National conservation status	Near Threatened (NT).
Ecology	This species shows an island wide distribution as its host plants – species belonging to Family Lauracea, especially Camphor laurel and Cinnamon – are available island wide.
Geographical distribution	This species shows a distribution up to 2, 800 ft from sea level. It can be found in Sri Lanka and in the oriental region ⁵ .
Critical habitat	As this species shows a wide distribution, the project area does not function as one of its critical habitats. Its host plants (species belonging to Family Lauracea) can be planted in the reservation of the reservoir to increase its population.



Source: <http://butterflyclub.greenpower.org.hk/>



Distribution map (developed based on the 2007 Red List database)

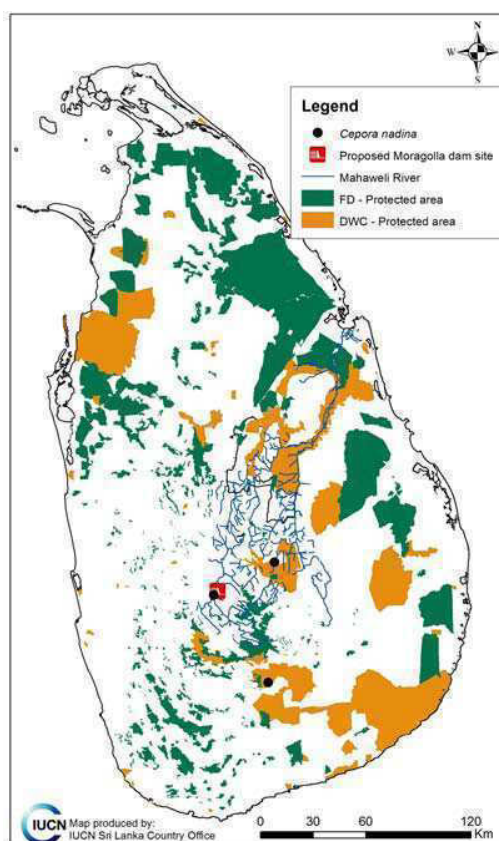
⁵ The South Asia and Malaysian region.

***Cepora nadina* (Lesser gull)**

Scientific name	<i>Cepora nadina</i>
English name	Lesser gull
Sinhala name	Heen punduru-sudana
Family	Pieridae
Species status	Indigenous
National conservation status	Critically Endangered (CR)
Ecology	Exact habitat unknown. Shows low flight closer to the ground and settles among the under growth.
Geographical distribution	It is distributed from 600 m to 1, 800 m from sea level in high rain fall areas. According to museum records, it has been recorded from Madugoda in the Knuckles area in the Central Province, and Gallelletota in Sabaragamuwa Province. It can be found in Sri Lanka and in the oriental region.
Critical habitat	Its habitat has not been recorded as yet. However, the project area is situated between its known locations. Therefore, it may have wider distribution and the project area may not function as one of its critical habitats.



Source: © Adrian Hoskins



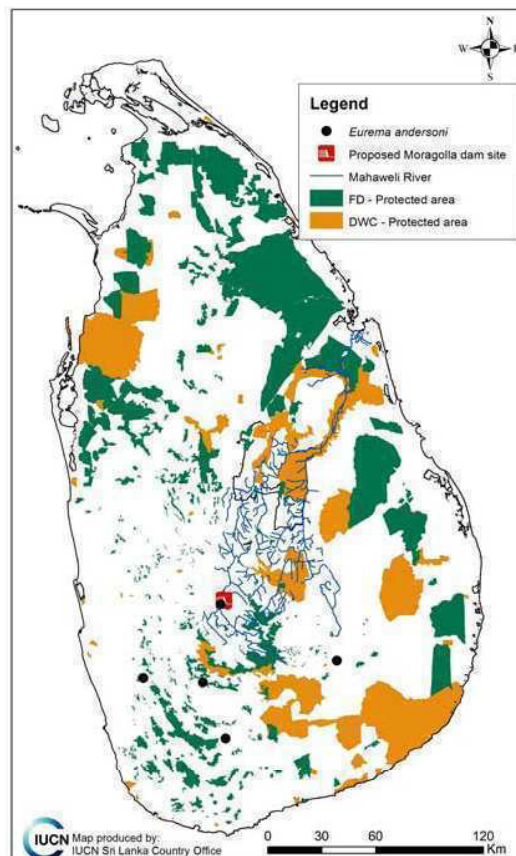
Distribution map (developed based on the 2007 Red List database)

***Eurema andersoni* (One-spot grass yellow)**

Scientific name	<i>Eurema andersoni</i>
English name	One-spot grass yellow
Sinhala name	Kela kahakolaya
Family	Pieridae
Species status	Endemic
National conservation status	Vulnerable (VU)
Ecology	Exact habitat unknown. Recorded in the wettest areas of the island.
Geographical distribution	This species is found up to 3,500ft from sea level in the Wet Zone. It has been recorded in the Kandy, Ratnapura, Deniyaya and Wellawaya areas of the Central, Southern and Sabaragamuwa Provinces. This species is endemic to Sri Lanka.
Critical habitat	Its habitat has not been recorded as yet. However, the project area is situated between its known locations. Therefore, it may have wider distribution and the project area may not function as a critical habitat for this species.



Source: © Peter Eeles



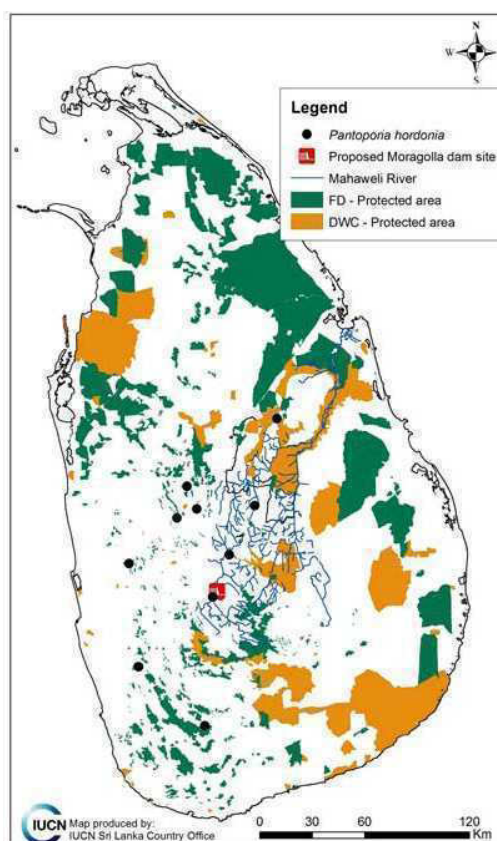
Distribution map (developed based on the 2007 Red List)

***Pantoporia hordonia* (Common lasker)**

Scientific name	<i>Pantoporia hordonia</i>
English name	Common lasker
Sinhala name	Kaha selaruwa
Family	Nymphalidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Ecology	The exact habitat of this species is unknown. It is found in the wettest areas of the island. The larval host plants are species belonging to the genera <i>Acacia</i> and <i>Albizzia</i> .
Geographical distribution	This species has been recorded from the coastal belt up to 4,500 ft in the central mountains. It can be found Sri Lanka, as well as all over the oriental region.
Critical habitat	The feeding plants of this species have a wide distribution in Sri Lanka. Therefore, it is likely that this species may also have a wider distribution. As such, the project area may not function as a critical habitat for this species.



Source: © Kai-Wing Leung



Distribution map (developed based on the 2007 Red List database)

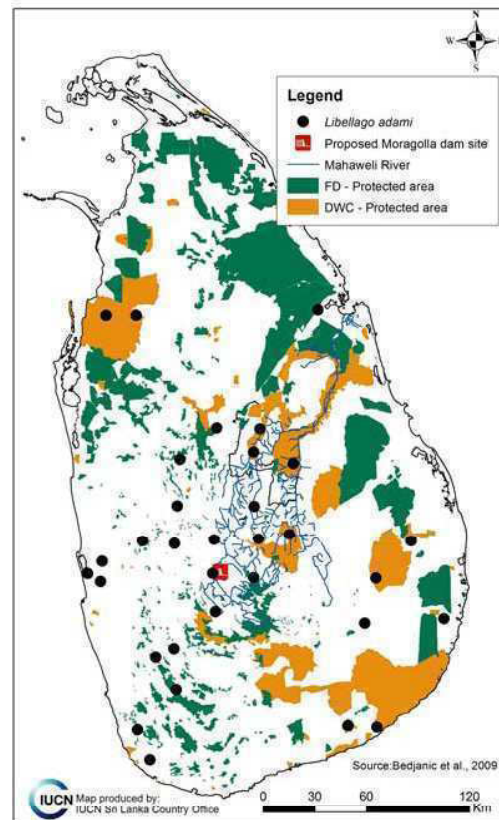
Dragonflies

Libellago adami (Adam's gem)

Scientific name	<i>Libellago adami</i>
English name	Adam's gem
Family	Cholorocyphidae
Species status	Endemic
National conservation status	Vulnerable (VU)
Ecology	Occurs around both fast and slow moving Rivers, canals and streams from low wetland areas to the lower hill areas.
Geographical distribution	This species has been recorded recently from the lowland wet zone, and wet montane and intermediate zones. Historically, it has been recorded in both the Wet and Dry zones of the island. This species is endemic to Sri Lanka.
Critical habitat	This species has been recorded from riverine and stream side habitats. Due to project activities, the existing riverine habitats will be lost. However, at the same time, new habitats will be created along the edge of the reservoir. Therefore, the habitat of this species will not be affected significantly due to the proposed MHP.



Source: © Gehan de Silva Wijeyratne



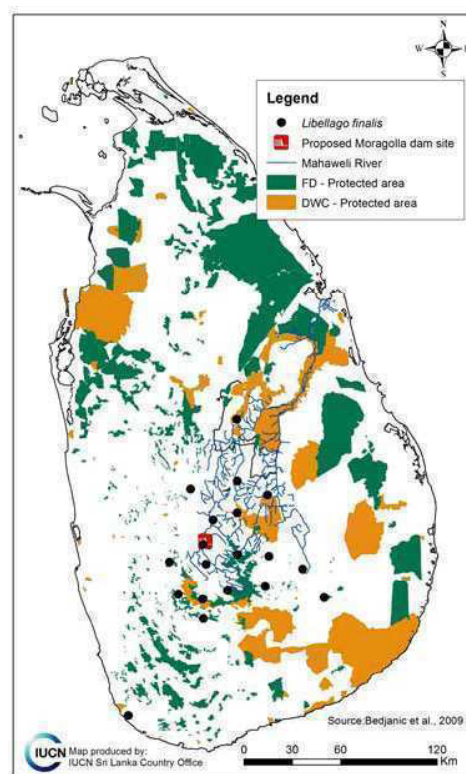
Distribution map (based on Bedjanic *et al.*, 2009)

Libellago finalis (Ultima gem)

Scientific name	<i>Libellago finalis</i>
English name	Ultima gem
Family	Cholorocyphidae
Species status	Endemic
National conservation status	Vulnerable (VU)
Ecology	Occurs in shaded rivers and small streams from the mid hills to mountain areas.
Geographical distribution	Most of the previous records are from both wet montane and dry montane areas. It has also been recorded from the southern tip of the wet lowland zone. This species is endemic to Sri Lanka.
Critical habitat	Given that it is found along stream side habitats, the project activities will not affect its habitat critically. In fact, the shallow areas of the edge of the reservoir will function as a new habitat for this species.



Source: © Imesh Nuwan Bandara



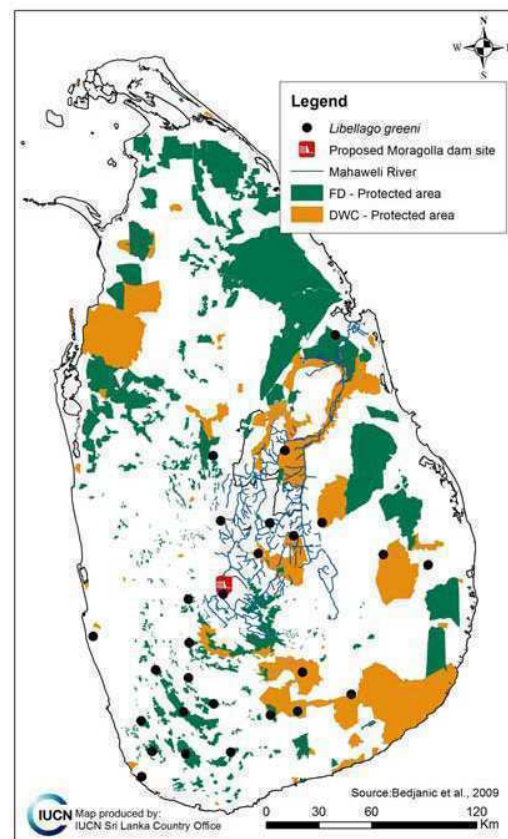
Distribution map (based on Bedjanic *et al.*, 2009)

Libellago greeni (Green's gem)

Scientific name	<i>Libellago greeni</i>
English name	Green's gem
Family	Cholorocyphidae
Species status	Endemic
National conservation status	Endangered (EN)
Ecology	Shaded rivers and streams.
Geographical distribution	This species has been recorded from the lowland wet zone, and the wet montane (low and mid hills to higher elevations) and intermediate zones. It is endemic to Sri Lanka.
Critical habitat	Given that it is found along stream side habitats, this species and its habitats will not be affected critically due to the proposed MHP. In fact, the shallow areas at the edge of the reservoir will function as new habitats for this species.



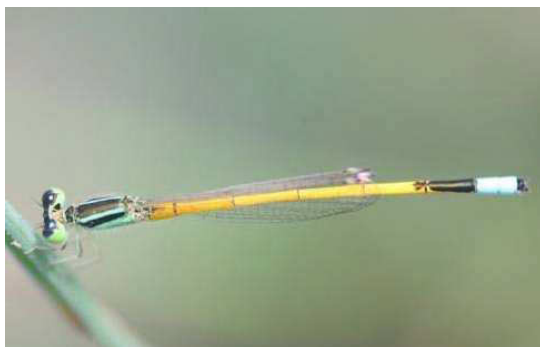
Source: © Niluka Herath



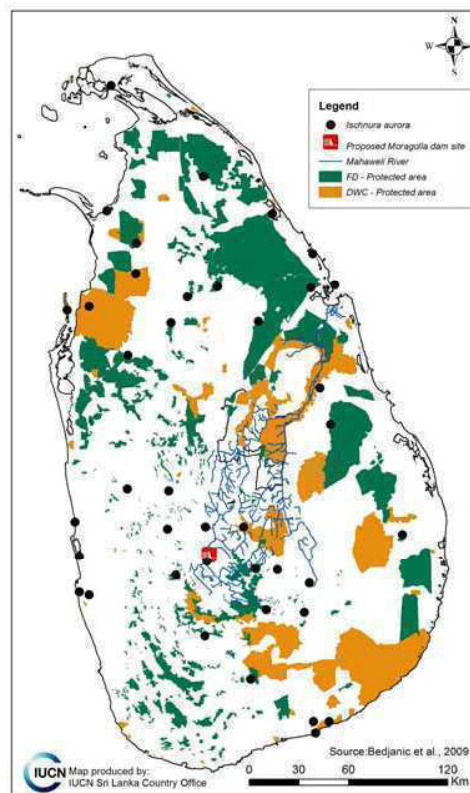
Distribution map (based on Bedjanic *et al.*, 2009)

Ischnura aurora (Dawn bluetail)

Scientific name	<i>Ischnura aurora</i>
English name	Dawn bluetail
Family	Coenagrionidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	In vegetation next to a wide range of slow moving and stagnant water habitats from the coast to the mountains.
Geographical distribution	This species has been recorded all over the island throughout the lowland wet zone, the wet and dry montane zone (low and mid hills to higher elevations), the Dry Zone, the Arid Zone and the Intermediate Zone. It is also found in India.
Critical habitat	Given that this species is found along stream side habitats as well as stagnant water edges, its habitats will not be critically affected due to the proposed MHP. The hallow areas of the reservoir will function as a new habitats for this species.



Source: © Dennis Farrell



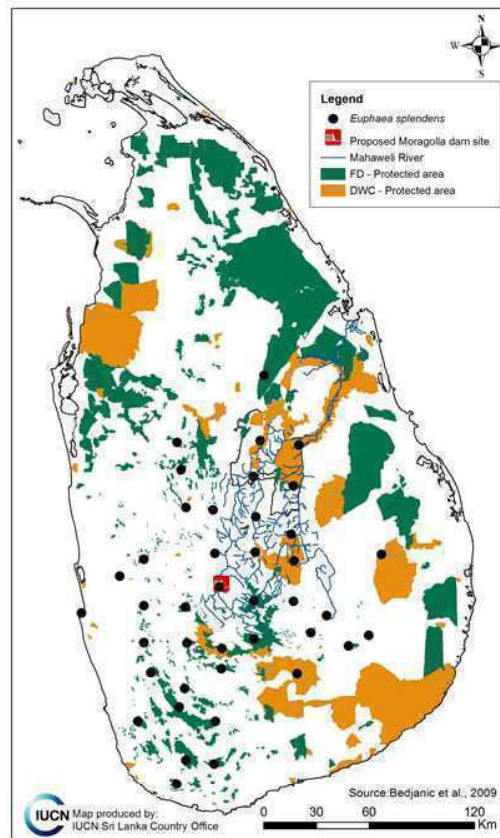
Distribution map (based on Bedjanic *et al.*, 2009)

***Euphaea splendens* (Shining gossamerwing)**

Scientific name	<i>Euphaea splendens</i>
English name	Shining gossamerwing
Family	Euphaeidae
Species status	Endemic
National conservation status	Near Threatened (NT)
Ecology	All types of moderate to fast flowing streams and rivers surrounded by mixed vegetation in hilly areas.
Geographical distribution	This species has been recorded from the lowland wet zone, the wet and dry montane zone (low and mid hills to higher elevations) and the intermediate zone. It is endemic to Sri Lanka.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.



Source: © David Cook



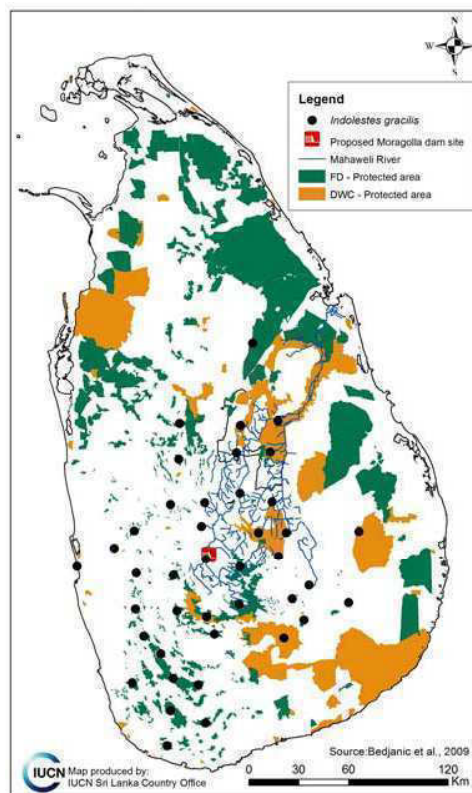
Distribution map (based on Bedjanic *et al.*, 2009)

***Indolestes gracilis* (Mountain reedling)**

Scientific name	<i>Indolestes gracilis</i>
English name	Mountain reedling
Family	Lestidae
Species status	Indigenous
National conservation status	Vulnerable (VU)
Global conservation status	Least Concern (LC)
Ecology	All types of moderate to fast flowing streams and rivers surrounded by mixed vegetation in hilly areas.
Geographical distribution	This species has been recorded from the lowland wet zone, the wet and dry montane zone (low and mid hills to higher elevations) and the intermediate zone. It is also found in India.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.



Source: © Karen Conniff



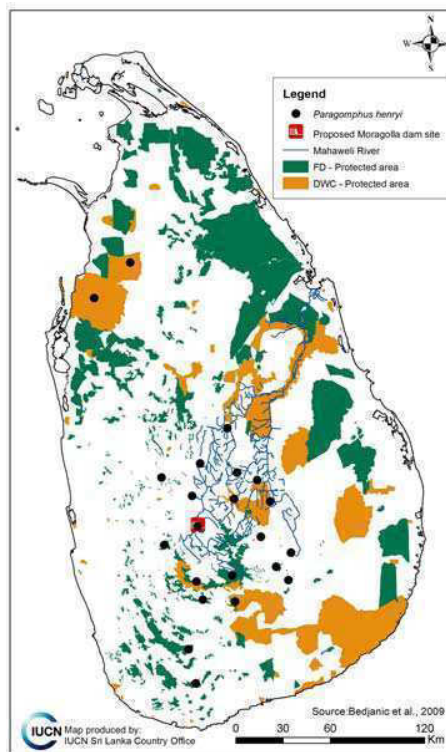
Distribution map (based on Bedjanic *et al.*, 2009)

***Paragomphus henryi* (Brook hooktail)**

Scientific name	<i>Paragomphus henryi</i>
English name	Brook hooktail
Family	Gomphidae
Species status	Endemic
National conservation status	Endangered (EN)
Global conservation status	Near Threatened (NT)
Ecology	Occurs in moderate to fast flowing streams and rivers in the hilly and montane regions.
Geographical distribution	This species has been recorded from the lowland wet zone, and the wet and dry montane zone (low and mid hills to higher elevations). However, there are also some historical records from the northern arid zone. It is endemic to Sri Lanka.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.



Source: © Karen Conniff



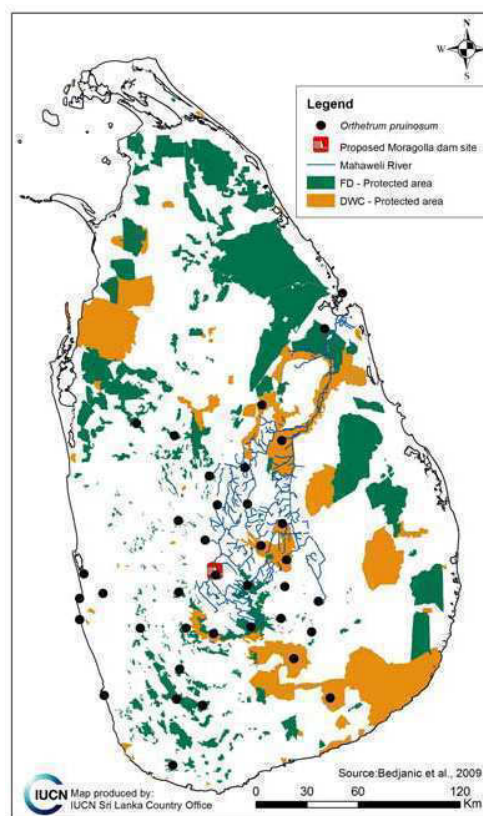
Distribution map (based on Bedjanic *et al.*, 2009)

Orthetrum pruinosum (Pink skimmer)

Scientific name	<i>Orthetrum pruinosum</i>
English name	Pink skimmer
Family	Libellulidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	Occurs in weedy tanks, ponds, marshes, paddy fields and shallow slow flowing streams in the lowlands. Also found in India.
Geographical distribution	This species has been recorded from the lowland wet zone, the wet and dry montane zone (low and mid hills to higher elevations) and the intermediate zone. However, there are also two historical records from the eastern coast.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.



Source: © Sampath de A Goonatilake



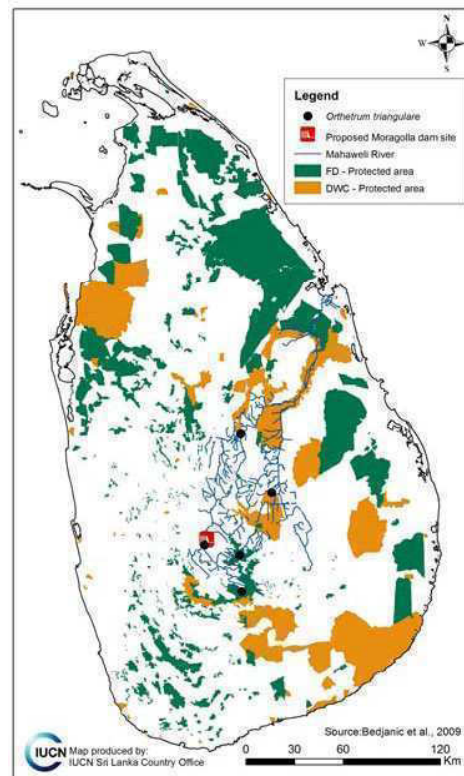
Distribution map (based on Bedjanic *et al.*, 2009)

***Orthetrum triangulare* (Triangle skimmer)**

Scientific name	<i>Orthetrum triangulare</i>
English name	Triangle skimmer
Family	Libellulidae
Species status	Indigenous
National conservation status	Endangered (EN)
Global conservation status	Least Concern (LC)
Ecology	Small tanks and puddles in the montane and hilly regions.
Geographical distribution	This species has been recorded from the wet montane to the central mountains and the Knuckles range. It is also found in India.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.



Source: © Gary Feulner and Narayan Karki



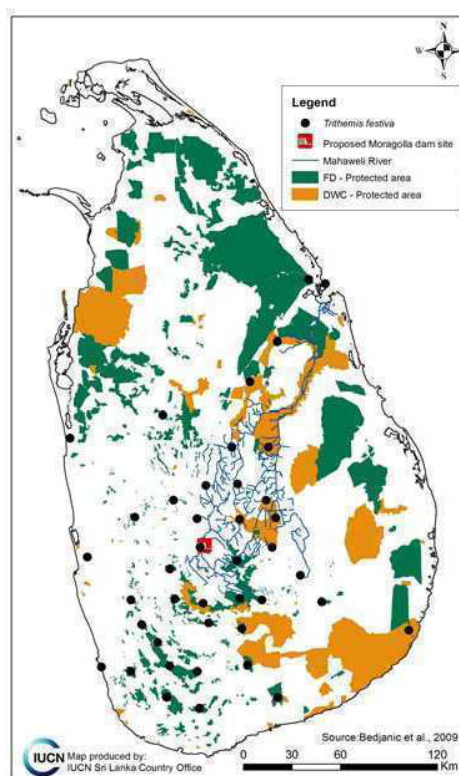
Distribution map (based on Bedjanic *et al.*, 2009)

***Trithemis festiva* (Indigo dropwing)**

Scientific name	<i>Trithemis festiva</i>
English name	Indigo dropwing
Family	Libellulidae
Species status	Indigenous
National conservation status	Vulnerable (VU)
Global conservation status	Least Concern (LC)
Ecology	Occurs in moderate to fast flowing streams and rivers in the mid-hills to montane areas.
Geographical distribution	This species has been recorded from the lowland wet zone, the wet and dry montane zone (low and mid hills to higher elevations) and the intermediate zone. However, there are also a few historical records from the Dry Zone. It is also found in India.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.



Source: © Sampath de A Goonatillake



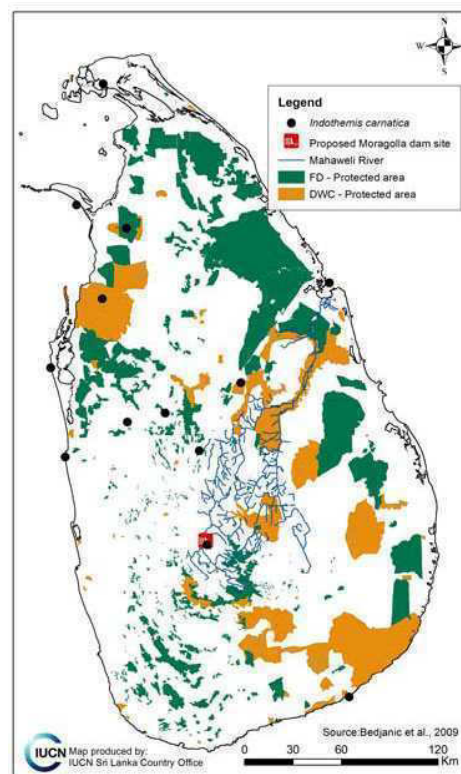
Distribution map (based on Bedjanic *et al.*, 2009)

Indothemis carnatica (Light tipped demon)

Scientific name	<i>Indothemis carnatica</i>
English name	Light tipped demon
Family	Libellulidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Near Threatened (NT)
Ecology	Occurs in tanks and ponds in the lowlands
Geographical distribution	This species has been recorded in the northern and southern arid zones. It is also found in India.
Critical habitat	This species was recorded during the supplementary study carried out in the MHP area. However, this species is unlikely to be present in the Kotmale area based on its known current distribution. Therefore, this is likely to be a misidentification as this species is similar to <i>Trithemis festiva</i> which has a similar colour pattern, and it is unlikely that the MHP area is one of its critical habitats.



Source: © Oleg Kosterin



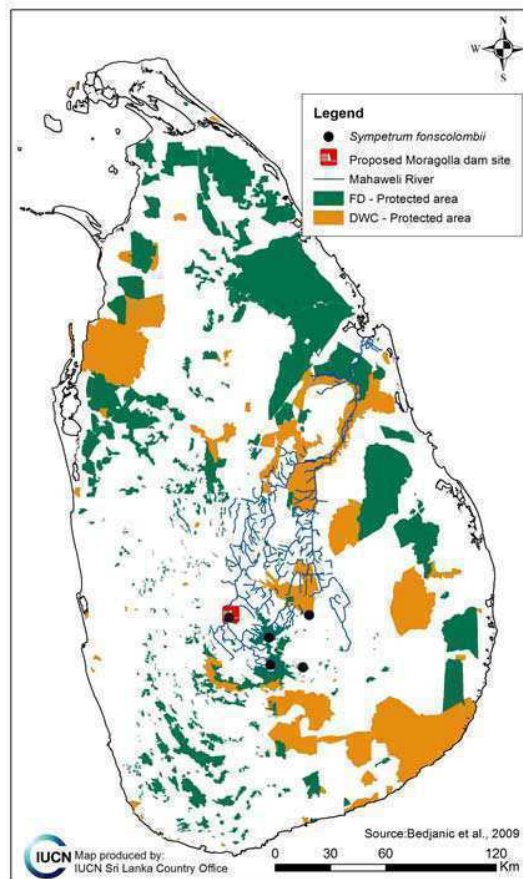
Distribution map (based on Bedjanic *et al.*, 2009)

***Sympetrum fonscolombii* (Red veined darter)**

Scientific name	<i>Sympetrum fonscolombii</i>
English name	Red veined darter
Family	Libellulidae
Species status	Indigenous
National conservation status	Endangered (EN)
Ecology	Occurs in ponds, lakes and marshes in the montane region.
Geographical distribution	This species has been recorded only from the wet and dry montane zone (especially in the Nuwara Eliya area) within Sri Lanka. It is also found in India.
Critical habitat	Given that this species has been recorded around ponds and lakes, the reservoir will create suitable habitats it. Therefore, its habitats will not be critically affected due to the proposed MHP.



Source: © Robert Thomas



Distribution map (based on Bedjanic *et al.*, 2009)

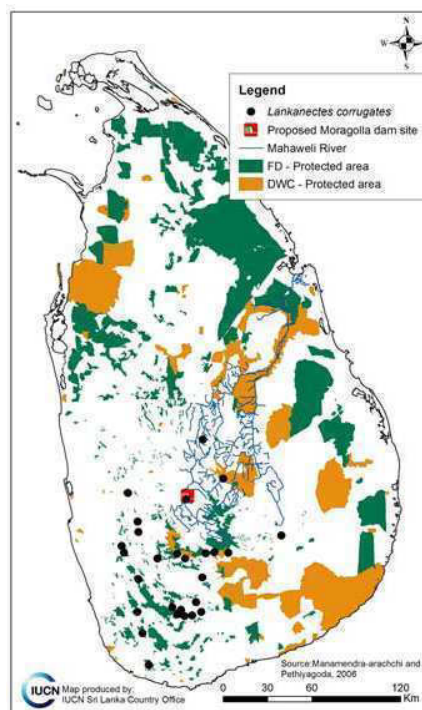
Amphibians

Lankanectes corrugates (Corrugated water frog)

Scientific name	<i>Lankanectes corrugates</i>
English name	Corrugated water frog
Sinhala name	Vakarali madiya
Family	Nyctibatrachidae
Species status	Endemic
National conservation status	Vulnerable (VU)
Ecology	Entirely aquatic and appears to be a sub-montane species, having been recorded between elevations of approximately 60 to 1,525 m. It prefers shaded, narrow, shallow and slow flowing streams, and also occurs under grass tussocks in marshes.
Geographical distribution	Entirely aquatic and appears to be a sub-montane (foot hills to central highlands) species being recorded between elevations of approximately 60 to 1,525 m in the lowland wet zone, the wet and dry montane zone and the intermediate zone. This species is endemic to Sri Lanka.
Critical habitat	This species has been recorded in ponds and marshes. Therefore, the reservoir will create new habitats for this species. Therefore, its habitats will not be critically affected due to the MHP.



Source: © Sampath de A Goonatillake



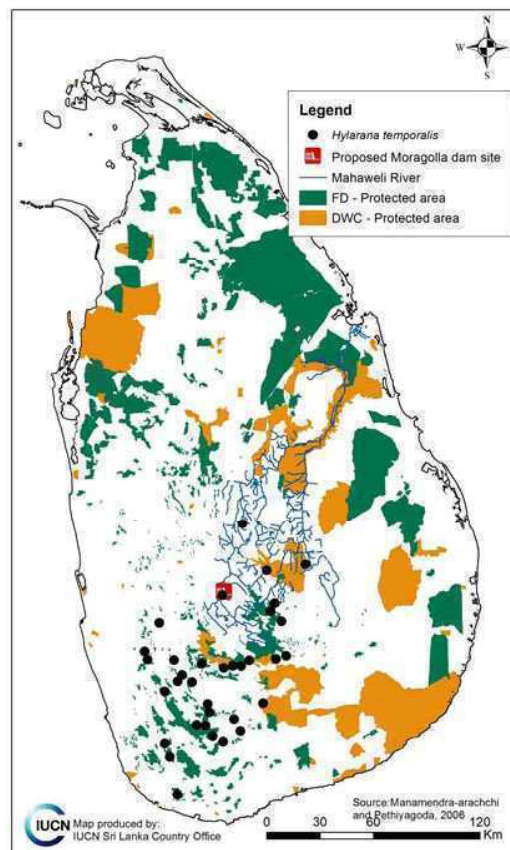
Distribution map (based on Manamendra-arachchi and Pethiyagoda, 2006)

Hylarana temporalis (Common wood frog)

Scientific name	<i>Hylarana temporalis</i>
English name	Common wood frog or bronze frog
Sinhala name	Sulaba bandi madiya
Family	Ranidae
Species status	Endemic
National conservation status	Near Threatened (NT)
Ecology	This species prefers rocky and shaded streams in rainforests. It has been observed mainly on wet boulders in streams, rather than in the water itself.
Geographical distribution	This species is common in the foot hills and montane region up to 1,830 m. It is endemic to Sri Lanka.
Critical habitat	This species prefers rocky and shaded streams, and as such suitable habitats will be created in the area downstream of the dam axis. Therefore, its habitats will not be critically affected due to the proposed MHP.



Source: © Sampath de A Goonatillake



Distribution map (based on Manamendra-arachchi and Pethiyagoda, 2006)

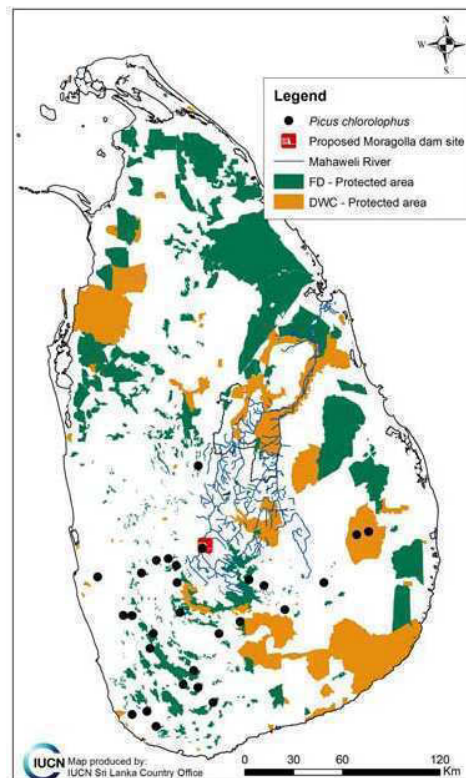
Birds

Picus chlorolophus (Lesser yellow-naped woodpecker)

Scientific name	<i>Picus chlorolophus</i>
English name	Lesser yellow-naped woodpecker
Sinhala name	Heen Kaha-gelasi Karela
Family	Picidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	This species prefers well wooded forests and home gardens.
Geographical distribution	Restricted to the lowland wet zone up to 1, 800 m from sea level. It is also found in India.
Critical habitat	This is a widely distributed species and therefore its habitat will not be affected critically due to the proposed MHP.



Source: <http://lananhbirds.com>



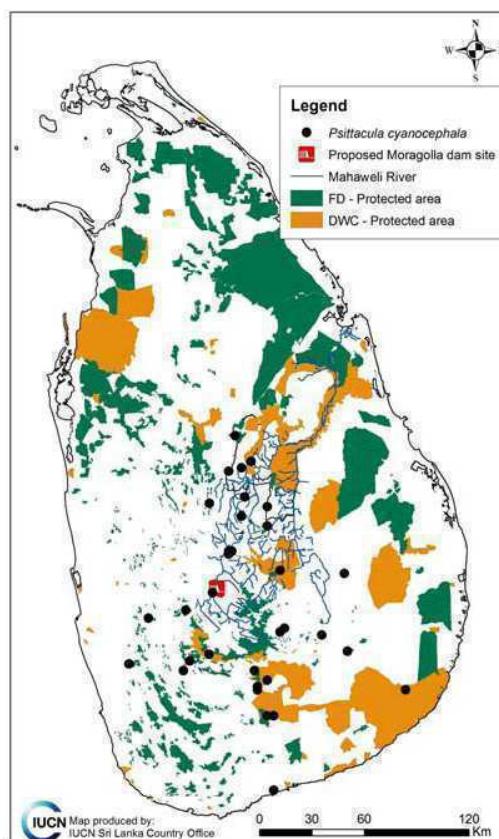
Distribution map (developed based on the 2007 Red List database)

***Psittacula cyanocephala* (Plum-headed parakeet)**

Scientific name	<i>Psittacula cyanocephala</i>
English name	Plum-headed parakeet
Sinhala name	Pandu Girawa
Family	Psittacidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	Occurs in primary forests and secondary forests. It also occurs in home gardens and tea plantations with tall trees.
Geographical distribution	Occurs in mid hill areas of both the wet and intermediate zone. This species is also found in South India.
Critical habitat	This species shows a wide distribution within the home gardens of the area, and the project area does not function as a critical habitat of this species.



Source: <http://lananhbirds.com>



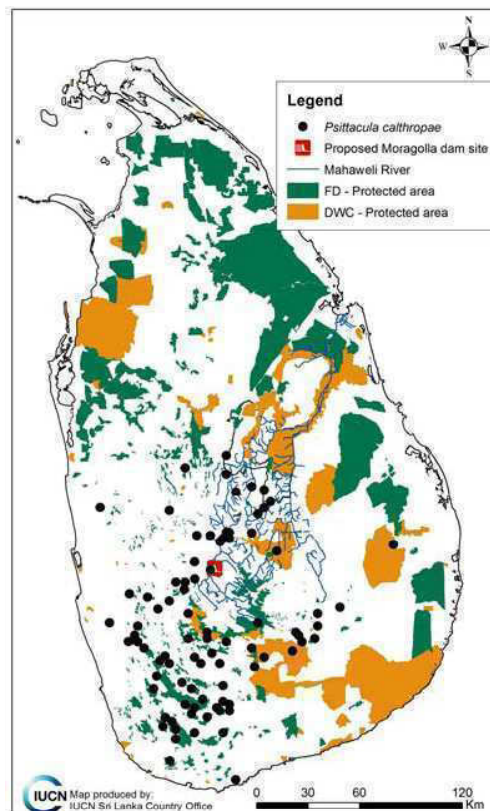
Distribution map (developed based on the 2007 Red List database)

Psittacula calthropae (Sri Lanka Layard's parakeet)

Scientific name	<i>Psittacula calthropae</i>
English name	Sri Lanka Layard's parakeet
Sinhala name	Sri Lanka alu girawa
Family	Psittacidae
Species status	Endemic
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	Occurs in primary forest and secondary forest areas. It also occurs in home gardens and tea plantations with tall trees.
Geographical distribution	An inhabitant of the lowland wet zone and the intermediate zone up to the mid mountain area. This species is endemic to Sri Lanka.
Critical habitat	This species is widely distributed within home gardens in the area, and therefore, the project area does not function as a critical habitat for this species.



Source: © Pathmanath Samaraweera



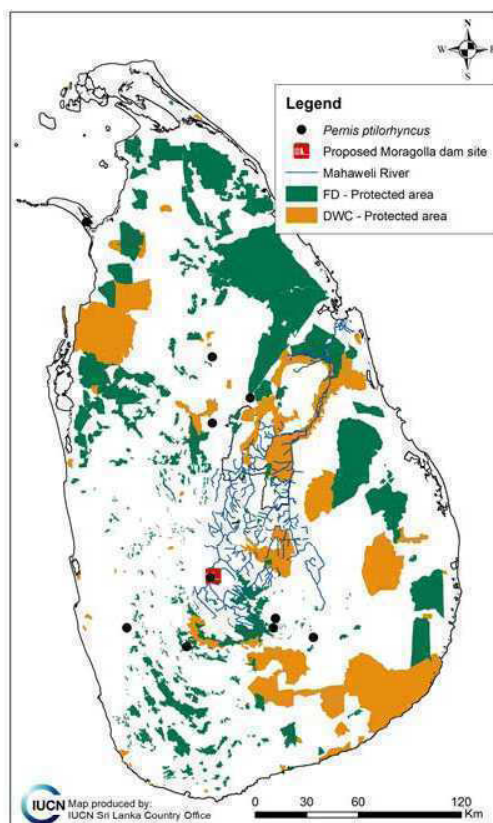
Distribution map (developed based on the 2007 Red List database)

***Pernis ptilorhyncus* (Oriental honey-buzzard)**

Scientific name	<i>Pernis ptilorhyncus</i>
English name	Oriental honey-buzzard
Sinhala name	Silu Bambarakussa
Family	Accipitridae
Species status	Breeding resident/ winter visitor/ vagrant
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	Occurs in forested areas.
Geographical distribution	This species has both a resident and migrant population in Sri Lanka. Apart from Sri Lanka, this species can be found in Borneo, Java and Philippines, within the Asian region.
Critical habitat	The habitat in the project area is only important as feeding ground for this species. Therefore, the project area does not function as a critical habitat for this species.



Source: © P. J. Vasanthan



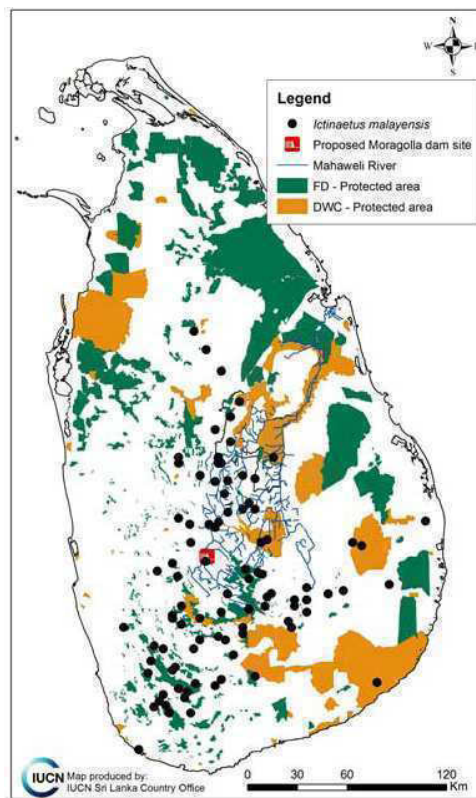
Distribution map (developed based on the 2007 Red List database)

***Ictinaetus malayensis* (Black eagle)**

Scientific name	<i>Ictinaetus malayensis</i>
English name	Black eagle
Sinhala name	Kalukussa
Family	Accipitridae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	Prefers forested and hilly areas with high slopes.
Geographical distribution	This species can be found in forested and hilly areas in both the wet and dry zone up to the montane region. Apart from Sri Lanka, it can be found in India, South China and South East Asia.
Critical habitat	The habitat in the project area is only important as a feeding ground for this species. Therefore, the project area does not function as a critical habitat for this species.



Source: © K. Arul



Distribution map (developed based on the 2007 Red List database)

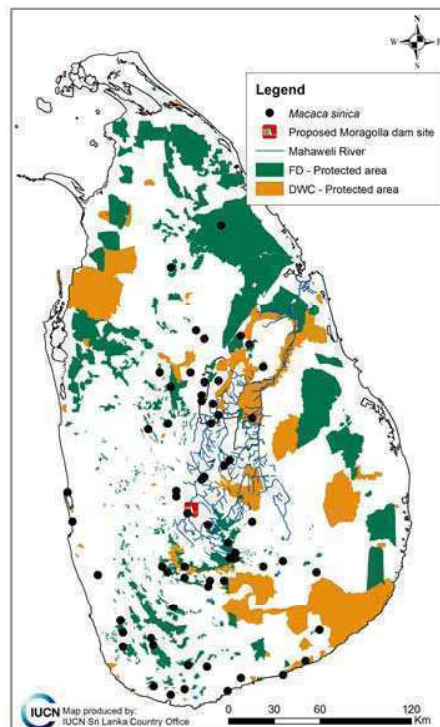
Mammals

Macaca sinica (Sri Lanka toque monkey)

Scientific name	<i>Macaca sinica</i>
English name	Sri Lanka toque monkey
Sinhala name	Rilawa
Family	Cercopithecidae
Species status	Endemic
National conservation status	Least Concern (LC)
Global conservation status	Endangered (EN)
Ecology	This species prefers secondary forest and scrub forest to thick primary forest. In wet zone forests, it prefers to live at the edges of the forest edges rather than in deep forest. This species enters home gardens and vegetable plots frequently. It is more common in the dry zone.
Geographical distribution	This species occurs throughout the island, except in northern most part. It is restricted to the island.
Critical habitat	It is generalized species that can live in forest areas, as well as human modified landscapes. Only a very small area of forest where this species occurs will be cleared due to the MHP. Therefore, it cannot be considered as a critical habitat for this species. Further, reforestation along the edges of the reservoir will create new habitats for this species.



Source: © Sampath de A. Goonatillake



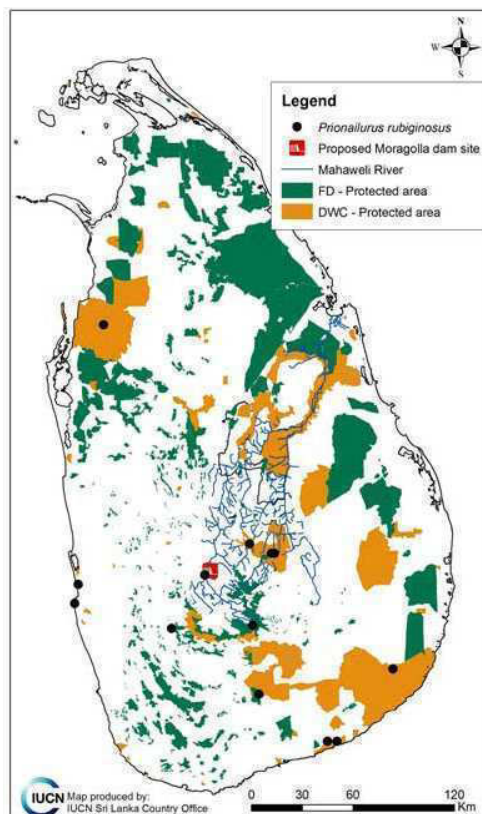
Distribution map (based on 2007 Red List database)

***Prionailurus rubiginosus* (Rusty spotted cat)**

Scientific name	<i>Prionailurus rubiginosus</i>
English name	Rusty spotted cat
Sinhala name	Kola diviya / Balal diviya
Family	Felidae
Species status	Indigenous
National conservation status	Endangered (EN)
Global conservation status	Vulnerable (VU)
Ecology	This species occupies shrub lands, grasslands and forested areas throughout the island.
Geographical distribution	It has been recorded throughout the island in all the bio-climatic zones. It has also been recorded within South Asia and South East Asia.
Critical habitat	This species prefers to live in the forested areas and shrub lands around the project area. Due to project activities Only a very small area of forest inhabited by this species will be cleared due to project activities. Therefore, it cannot be considered as a critical habitat for this species. Further, reforestation along the edges of the reservoir will create new habitats for this species.



Source: © Terry Whittaker



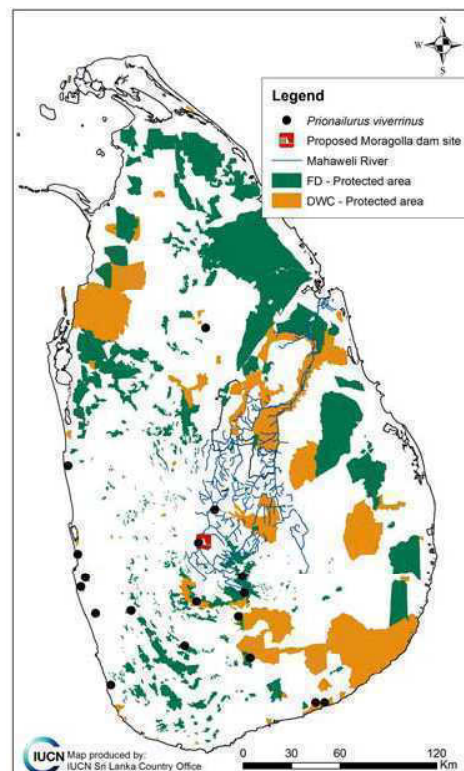
Distribution map (based on 2007 Red List database)

***Prionailurus viverrinus* (Fishing cat)**

Scientific name	<i>Prionailurus viverrinus</i>
English name	Fishing cat
Sinhala name	Handun diviya
Family	Felidae
Species status	Indigenous
National conservation status	Endangered (EN)
Global conservation status	Endangered (EN)
Ecology	This species occurs in marshy areas and riverine forests throughout the island.
Geographical distribution	It has been recorded throughout the island in all the bio-climatic zones. It is also found within South Asia and South East Asia.
Critical habitat	This species prefers riverine habitats around the Mahaweli river bank. Due to the project activities Only a very small riverine forest patch will be lost as a result of the MHP. Therefore, the project area cannot be considered as a critical habitat for this species. Further, reforestation along the edge of the reservoir will create new habitats for this species.



Source: <http://www.kattengedoe.nl>



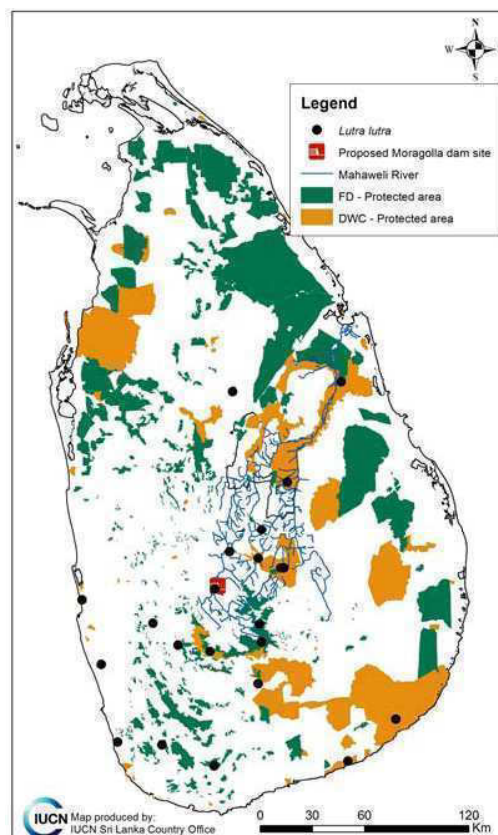
Distribution map (based on 2007 Red List database)

Lutra lutra (Otter)

Scientific name	<i>Lutra lutra</i>
English name	Otter
Sinhala name	Diya balla
Family	Mustelidae
Species status	Indigenous
National conservation status	Vulnerable (VU)
Global conservation status	Near Threatened (NT)
Ecology	This species occurs in marshy areas and riverine forests throughout the island.
Geographical distribution	It has been recorded throughout the island in all bio-climatic zones. Apart from Sri Lanka, it is found throughout Asia.
Critical habitat	Otters prefer the riverine habitats around the Mahaweli river bank. Only a very small patch of riverine forest will be lost due to the MHP. Therefore, the project area cannot be considered as a critical habitat for this species. Further, reforestation along the edge of the reservoir will create new habitats for this species.



Source: © Bild Jiri Bohdal



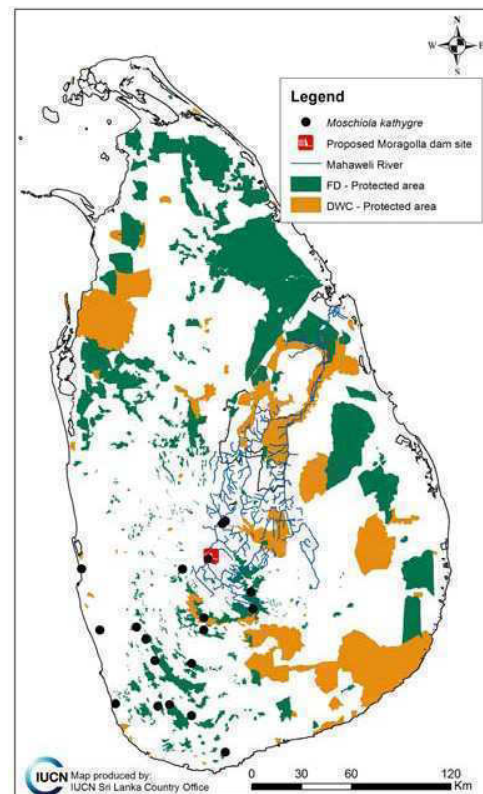
Distribution map (based on 2007 Red List database)

***Moschiola kathygre* (Sri Lanka pygmy mouse-deer)**

Scientific name	<i>Moschiola kathygre</i>
English name	Sri Lanka pygmy mouse-deer
Sinhala name	Sri Lanka kuru meeminna
Family	Tragulidae
Species status	Endemic
National conservation status	Vulnerable (VU)
Global conservation status	Vulnerable (LC)
Ecology	This species prefers secondary forests that have dense shrub vegetation, rather than primary forests. This species has also been recorded from well wooded home gardens.
Geographical distribution	This species is restricted to wet zone lowland areas up to mid mountain areas. It is restricted to island (endemic).
Critical habitat	This species prefers to live in the forested both secondary and riverine areas and shrub lands around the project area. Only a very small area of forest inhabited by this species will be cleared due to the MHP. Therefore, the project area cannot be considered as a critical habitat for this species. Further, reforestation along the edge of the reservoir will create new habitats for this species.



Source: <http://valueofnature.blog.com>



Distribution map (based on 2007 Red List database)

3.2 Project impacts

3.2.1 Context

Assessment of project impacts on critical habitats

According to the ADB Safeguard policy statement, a critical habitat includes areas with high biodiversity value, including habitats required for the survival of Critically Endangered (CR) or Endangered (EN) species, areas of special significance for endemic or restricted-range species, sites that are critical for the survival of migratory species, areas that support globally significant concentrations or numbers of individuals of congregatory species, areas with unique assemblages of species, that are associated with key evolutionary processes or provide key ecosystem services, and areas with biodiversity of significant social, economic, or cultural importance to local communities. Critical habitats include those areas either legally protected or officially proposed for protection, such as areas that meet the criteria of the World Conservation Union classification, the Ramsar List of Wetlands of International Importance, and the United Nations Educational, Scientific, and Cultural Organization's Natural World Heritage Sites (ADB, 2009).

As such, it is necessary first to identify whether the project affected area qualifies as a critical habitat. Therefore, it is pertinent that the project site is analyzed against the criteria that are detailed above. The list of threatened and Near Threatened species found in the project area is presented in Annex 2. Therefore, it is necessary to ensure that the project, is aligned with ADB's Safeguard Policy Statement (2009), and that the CEB should identify measures to avoid, minimize, or mitigate potentially adverse impacts and risks and, as a last alternative, propose compensatory measures, such as biodiversity offsets, to achieve no net loss or net gain of the affected biodiversity. Therefore, the project area was evaluated against the ADB definition of critical habitats. Simultaneously, species prioritization was done to evaluate species that have a high risk of becoming threatened or extinct due to project activities.

An area with high biodiversity value

An area with high biodiversity value is defined based on a broad set of attributes, such as the relative size of the area, the condition of the area, whether it supports threatened, endemic or restricted range species, or whether it provides crucial connectivity across the landscape. However, as reported in the EIA report, the project impacted area is less than 38.5 ha in extent. This area is too small to be considered as an ecologically significant landscape. The forest that exists in the area cannot be considered as primary forest as these areas have been remodelled and modified extensively over the last few centuries. Therefore, these habitats support a much smaller proportion of threatened and endemic species when compared to some of the high biodiversity habitats of the wet zone, such as Peak Wilderness Nature Reserve or Knuckles Conservation Forest. Further, the site does not function as a critical habitat for any of the threatened or endemic species that have been recorded from the project affected area (see species profiles above). Additionally, none of the species recorded in the project affected area are restricted to the area. Similarly, the area does not function as a habitat that supports range-restricted species. Finally, the project affected area does not function as a crucial corridor connecting important habitats or landscapes. Therefore, even though the site selected for the project supports a diverse species assemblage, it cannot be considered as an area of high biodiversity value.

Habitat required for the survival of critical species

A total of 173 terrestrial and aquatic associated faunal species have been recorded in the project area. This includes 23 endemic fauna (ten of which are listed as threatened or Near Threatened), one Critically Endangered (CR) species, six Endangered (EN) species, nine Vulnerable (VU) species and 12 Near Threatened (NT) species.

The 41 endemic, threatened or Near Threatened (NT) species are considered to be the critical species that inhabit the project area. All other species recorded from the area are considered to be common species that show a wide distribution within, and in some cases, outside, Sri Lanka. Therefore, the proportions of their populations impacted by the project are insignificant.

An assessment was carried out to evaluate whether the project area functions as a critical habitat that is necessary for the survival of the 41 species identified critical species (endemic, threatened or Near Threatened) that inhabit the project area.

The key parameter that can be used to ascertain the importance of a given habitat or area for the long term survival of a critical species, is to determine the proportion of the population of that critical species that occupies the habitat. However, information on the overall population sizes of these 41 critical species is not available, and therefore, such a determination was not possible in the present context. However, in the absence of population data, alternate proxies can be used to make such an assessment. Therefore, in this study an index (impact score) using the conservation status of the species, as well as their distribution data, was developed as a proxy to determine the importance of the habitat affected by the project for the survival of the recorded 41 threatened (CR, EN or VU), Near Threatened (NT) or endemic species.

Species prioritization

A list of priority species that require special conservation attention in order to mitigate the impacts of the MHP was developed in order to ensure that available conservation resources can be allocated and spent in the most effective and efficient ways possible.

An index (impact score) was developed in order to identify priority species found within the project area. This index was developed taking into consideration the four factors described below. A suitable marking scheme was also developed for each of these criteria.

Species status: This indicates the overall status of the species. Species status was scored as follows:

- (i) Indigenous (1 point);
- (ii) Endemic (3 points); and
- (iii) Possible new species (3 points)

Distribution: A species that shows a wider distribution within a country across several bioclimatic zones is less likely to be affected by a single catastrophic event that might result in large scale mortality of members of that species. Distribution was scored as follows:

- (i) Island wide (0 points) ;
- (ii) Mahaweli basin and Dry Zone (1 point);
- (iii) Mahaweli basin and Wet Zone (2 points);
- (iv) Mahaweli basin only (3 points); and
- (v) Restricted to the project area (4 points).

Habitat impact: Some species can be affected negatively, while others may benefit, through that habitat changes that take place as a result of the project. Habitat impact was scored as follows:

- (i) Positive impact (-2 points);
- (ii) No impact (0 points); and
- (iii) Negative impact (+ 2 points).

For all terrestrial faunal species the project is considered to have a net negative impact, as the project will result in the conversion of the terrestrial habitats of the area in to aquatic habitats, causing loss of suitable habitats. However, the project is expected to impact aquatic associate species positively due to the creation of more aquatic habitats (See Annex 2 for details regarding scoring for each of the 41 critical species).

Conservation status: This indicates the long term survival potential of the species, and has been determined based on overall population trends, as well as threats that are operating on the species at a national scale. Conservation status was scored as follows:

- (i) Not evaluated (2 points, as this indicates species that have been described after 2012);
- (ii) Least Concern (LC) (0 points);
- (iii) Near Threatened (NT) (1 point);
- (iv) Data Deficient (DD) (2 points, as Data Deficient species may be extremely rare species);
- (v) Vulnerable (VU) (3 points);
- (vi) Endangered (EN) (4 points); and
- (vii) Critically Endangered (CR) (5 points).

Based on this marking scheme the maximum possible score is 14, and the cut-off point was taken to be seven points (the mid-point). A species that obtains a score above the cut-off point was considered as moderately or significantly affected by the proposed project.

The scores obtained by each of the 41 critical species evaluated using this index are presented in Figure 1.

The level of impact of the MHP on these species can be ascertained based on the scoring system as shown in the table below.

Table 2. The level of impact of the MHP on endemic, threatened and Near Threatened (NT) species based on the scoring system.

Group	Score
Low impact on the survival of the species	7 points or below
Moderate impact on the survival of the species	8 to 12 points
Significant impact on the survival of the species	13 to 17 points

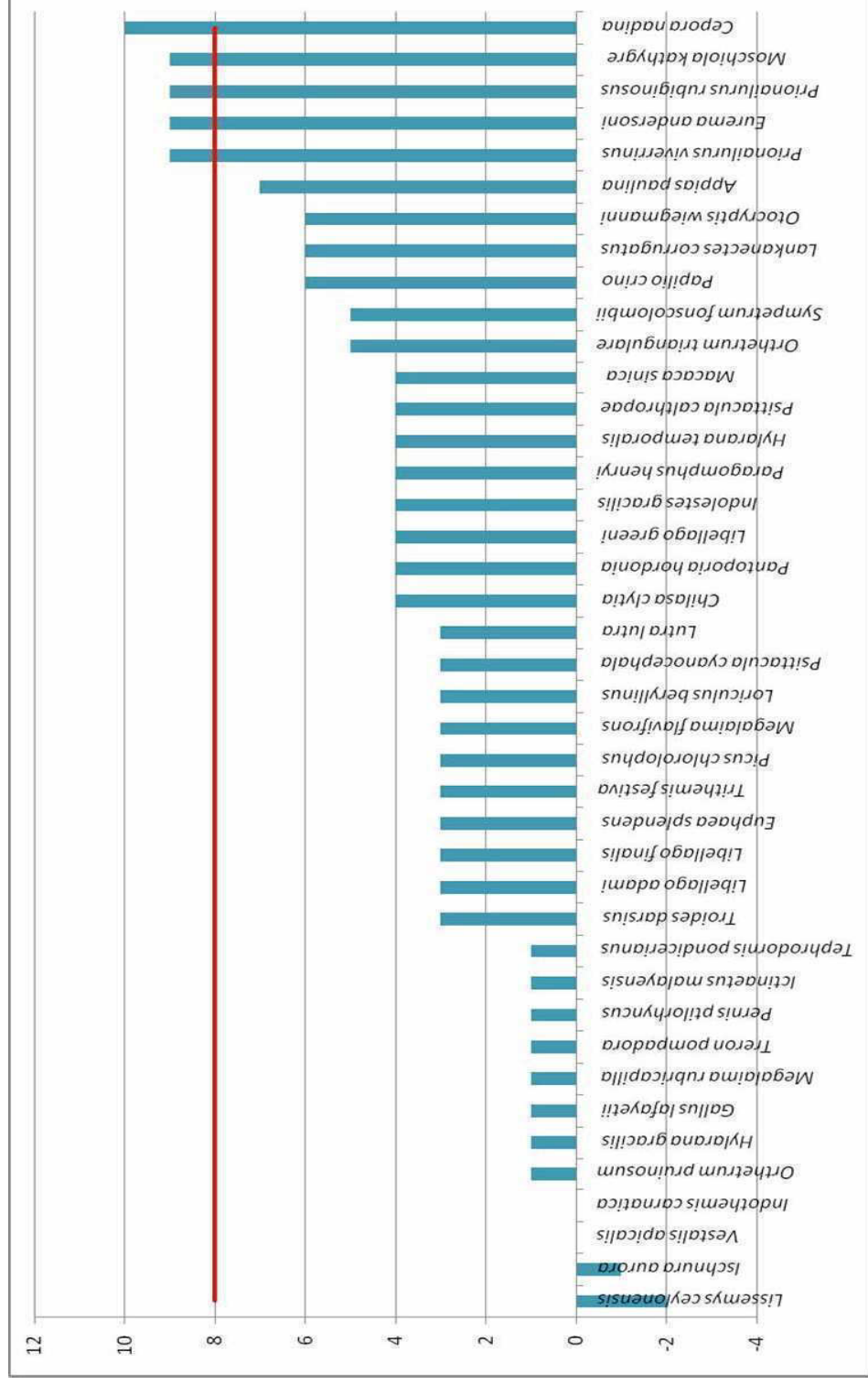


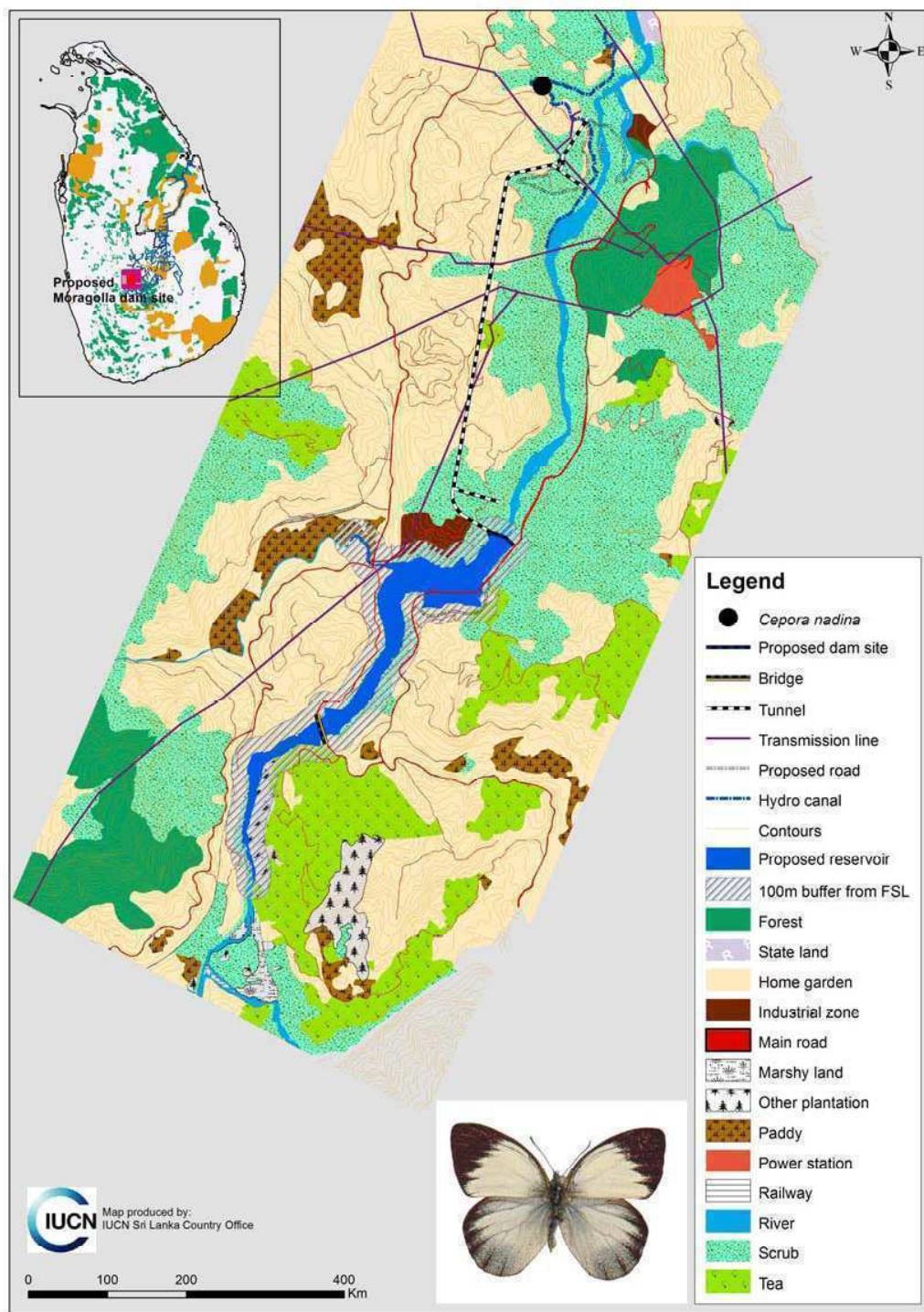
Figure 1. The impact score received by each of the 41 species that were evaluated and the cut-off mark.

According to scores attributed to the 41 critical species that have been recorded from the project area, none of the species will be impacted significantly due to the proposed project. Five species were identified as being moderately affected by the project, while the impact on the remaining 36 species was found to be low. Therefore, mitigation measures are proposed only for the five species that will be moderately affected by the project. These species are listed in the table below.

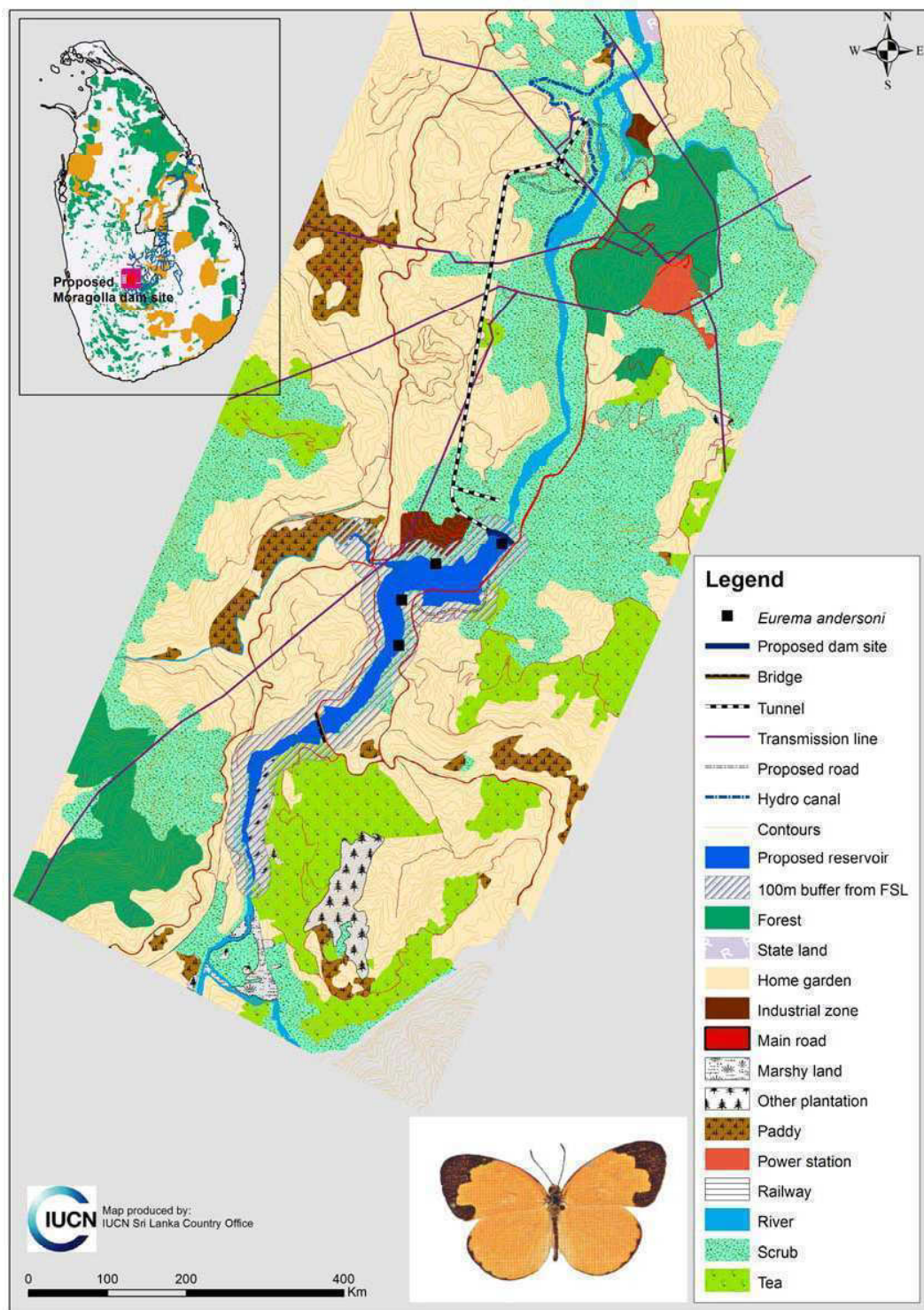
Table 3. Priority species that are likely to be impacted the most due to the MHP.

Family	Species	Common name	Species status	Conservation status		Nature of the Impacts
				National	Global	
Butterflies						
Pieridae						Habitat destruction (reduction of feeding plants and nectar plants).
	<i>Cepora nadina</i>	Lesser gull	Indigenous	CR		
	<i>Eurema andersoni</i>	One-spot grass yellow	Endemic	VU		Habitat destruction (reduction of feeding plants and nectar plants).
Mammals						
Felidae						Habitat destruction (reduction of hiding places and hunting grounds).
	<i>Prionailurus rubiginosus</i>	Rusty-spotted cat	Indigenous	EN	VU	
	<i>Prionailurus viverrinus</i>	Fishing cat	Indigenous	EN	EN	Habitat destruction (reduction of hiding places and hunting grounds).
Tragulidae	<i>Moschiola kathygre</i>	Sri Lanka pygmy mouse-deer	Endemic	VU	LC	Habitat destruction (reduction of hiding places and feeding grounds).

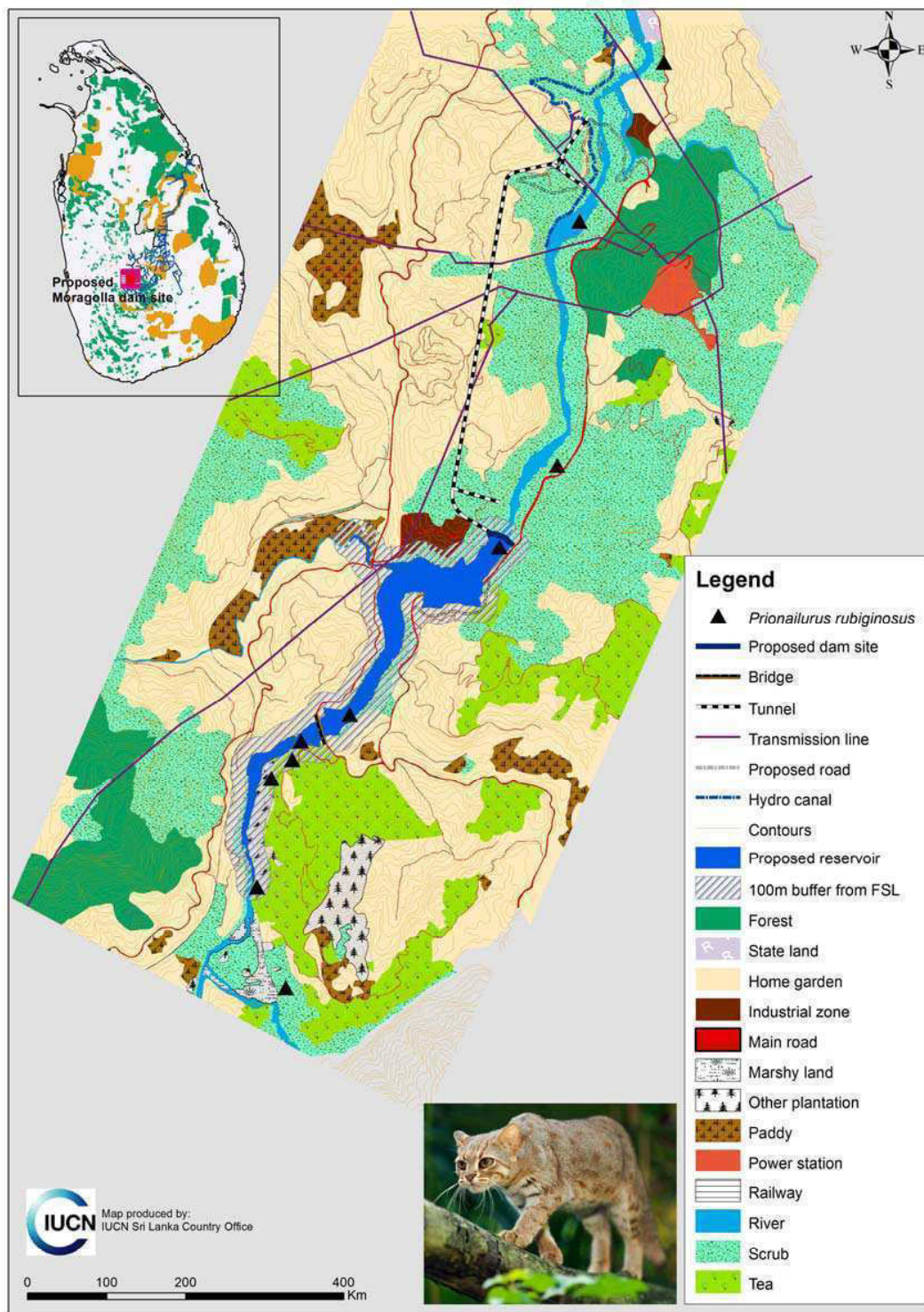
The distribution of these five species within the project is illustrated in the maps below.



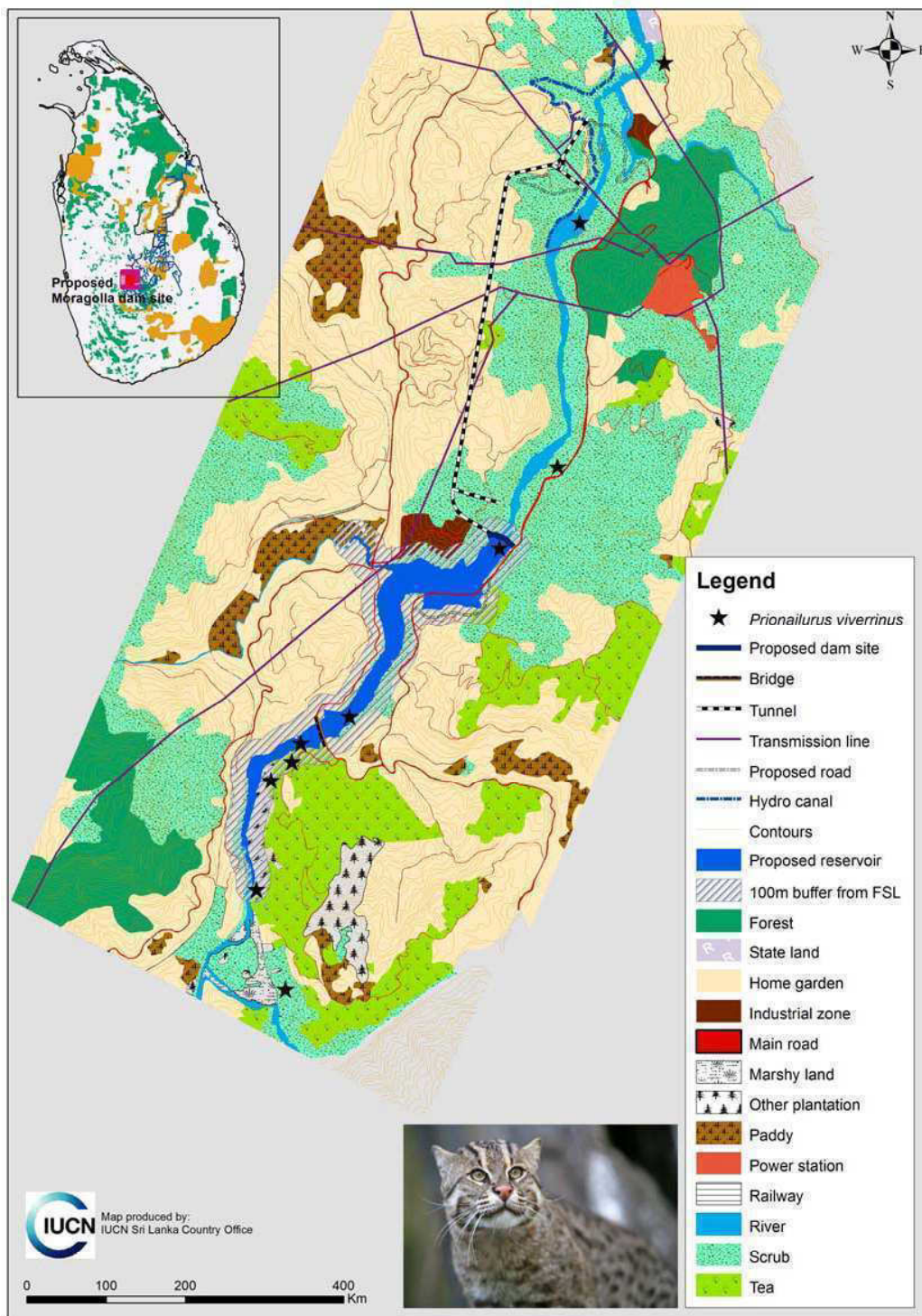
Map 4. Distribution of *Cepora nadina* (Lesser gull) within the project area.



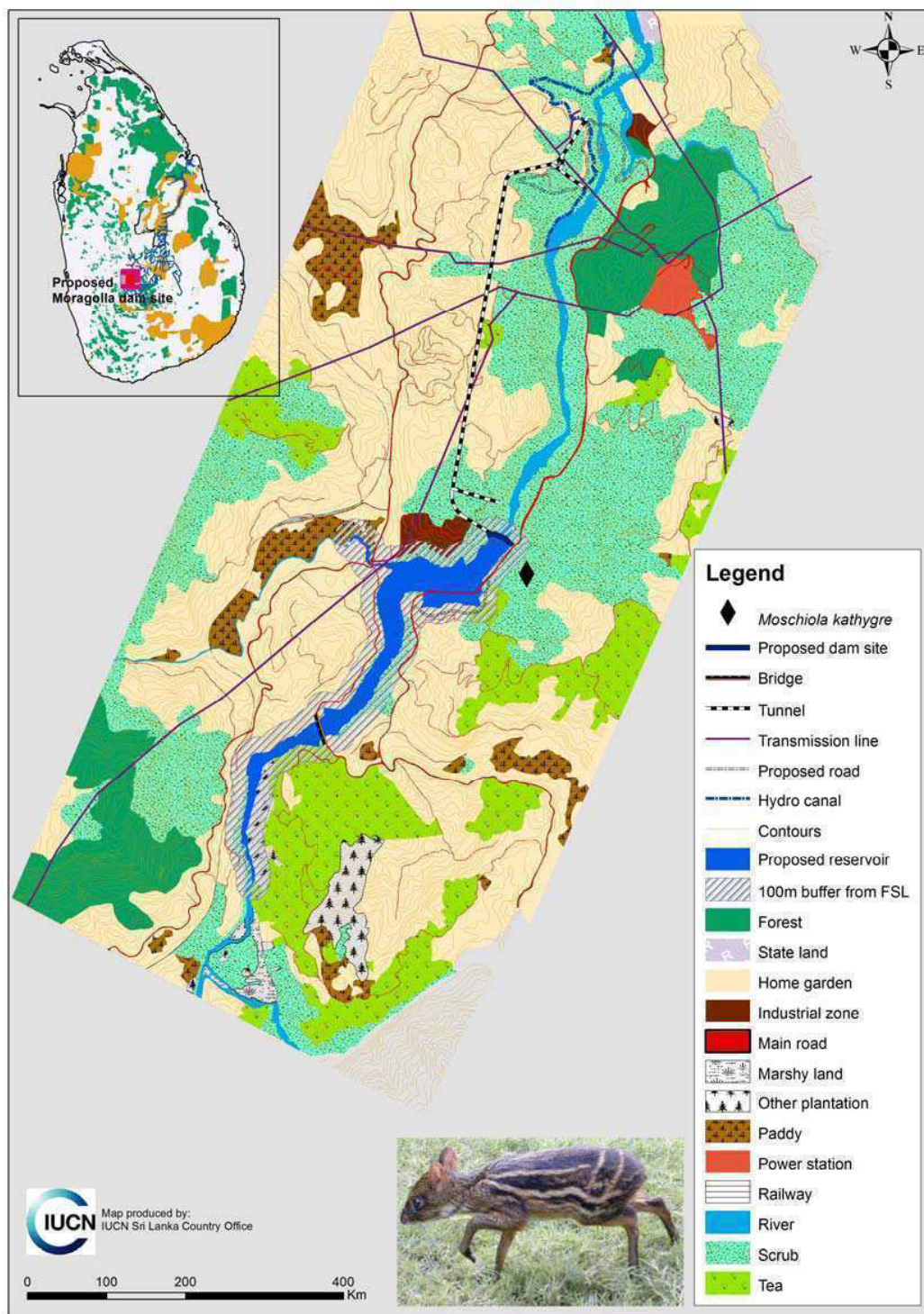
Map 5. Distribution of *Eurema andersoni* (One-spot grass yellow) within the project area.



Map 6. Distribution of *Prionailurus rubiginosus* (Rusty-spotted cat) within the project area.



Map 7. Distribution of *Prionailurus viverrinus* (Fishing cat) within the project area.



Map 8. Distribution of *Moschiola kathygre* (Sri Lanka pygmy mouse deer) within the project area.

3.2.2 Potential impacts during construction

The direct impacts of the proposed project on the identified priority faunal species include habitat loss due to the removal of trees and disturbance of ground cover. As such, construction work will result in the temporary or permanent loss of habitat for priority species, as well as a number of other endemic and threatened species that inhabit the direct impact zone of the project.

During the construction period, the five priority species identified above are expected to be impacted as follows:

- Death or injury of individuals;
- Loss or disturbance of limited foraging resources;
- Loss or disturbance of limited breeding resources;
- Disturbance due to noise and vibrations;
- Loss of habitat quality due to the emission of dust; and
- Loss of hiding places.

Limited resources are specialized habitat components that species are dependent on for their ongoing survival. Such resources include specialized breeding habitats - including tree hollows or suitable nest or maternity roost sites - that occur at low densities, with high levels of competition from a range of species. Further, for some species, limiting resources include specialized foraging or breeding habitats that have a restricted distribution.

3.2.3 Potential impacts during operation

During the operational period, the level the impact on the terrestrial fauna is less compared to that of the construction phase. At present, both banks of the river exist in a degraded state. Therefore, if afforestation of the reservation along the periphery of the reservoir is implemented properly, with consideration of recommended species, the terrestrial fauna of the area will stand to benefit from the project due to the creation of new habitats, as well as the enhancement of the carrying capacity of the project area. Further, given that access to the reservation will be regulated by the CEB, this area will function as a protected area, providing additional protection to the species that inhabit the area.

3.3 Mitigation of impacts

The following key recommendations can be proposed for the mitigation of the impacts resulting from the MHP.

- Relocation of species at risk- Less mobile species such as small amphibians, reptiles and mammals may be directly, or indirectly, at risk. Therefore, the relocation of such species is recommended.
- **Habitat creation and management** - to mitigate habitat loss, restore habitats in degraded areas and manage the restored reservation area. This includes:

- Declaration of the catchment, and the wider landscape, as a protected area, such as an Environmental Protection Area (EPA) by the Central Environmental Authority; and
 - Law enforcement and creation of awareness among the general public on environmental conservation.
- **Collection of voucher specimens of flora and fauna from the inundation area.**
- **Strict adherence to environmental guidelines pertaining to construction activities** – It is possible that unexpected mass-scale erosion may occur during the construction phase, and that explosions may lead to habitat destruction. Therefore, it is imperative that environmental guidelines are applied strictly during the construction phase. This includes:
 - Creation of awareness regarding environmental guidelines among relevant stakeholders, including construction workers and engineers;
 - Allocation of dedicated staff for project related environmental matters;
 - Introduction of biodiversity-friendly livelihood strategies, including eco-agriculture and eco-tourism; and
 - Incorporation of biodiversity concerns into human settlement policies.
- **Ensuring that Invasive Alien Species (IAS) do not proliferate in the project area** – There is a possibility that invasive species may spread rapidly due to clearing of natural vegetation during the construction period. Therefore, suitable controls for invasive species must be put in place.
- **Maintenance of an environmental flow by releasing water from the main dam.-** The downstream area - between the main dam and proposed power house - will dry out due to the physical barrier effect of the dam. Therefore, the proposed e-flow must be maintained in order to facilitate the maintenance and support of the biodiversity of the area. This will involve regulation of the release of water.
- **Introduce appropriate local area development policies for likely industries to minimize impacts on biodiversity** - At present, the left bank of the proposed dam area is declared for the industrial area. Therefore, a plan should be developed to manage the industrial activities in this area.

Details of the impacts of the MHP and the relevant mitigatory measures proposed, are presented in the table below.

Table 4. Mitigation plan for the MHP.

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan				Periodicity	Cost in LKR	Responsibility of implementation and monitoring
				General approach	Experience in Sri Lanka and elsewhere	Likely suitability in the context of the MHP				
Construction phase	Upstream	Total disappearance of some habitats (riparian forests), causing a loss of habitat for some of the terrestrial species observed in the project area and resulting in reduction of their populations.	Relocate species at risk.	Animal rescue programme immediately prior to and during the construction period along the dam axis, the powerhouse and all quarry areas.	1. Upper Kotmale – translocation of <i>Ravana polticima</i> monitored by the CEB. 2. Moragahakanda Project – Translocation of multiple critical species by IUCN Sri Lanka and monitored by MASL. 3. Vavuniya Water Project – translocation of multiple critical species by the Water Board. 4. HOLCIM Aruwakkalu Quarry site by IUCN.	Animal rescue programme.	This process should be initiated just before construction work has started and continued during the ground clearance and excavation period.	1, 000, 000	Ceylon electricity Board (CEB).	
				Reforestation within the reservation of the proposed reservoir and upper catchment.	Moragahakanda (MASL).	Creation of riparian forests along the full flood level.	This activity can be started before the start of construction.	Will be addressed by the reforestation programme.	CEB, Mahaweli Authority of Sri Lanka (MASL), Forest Department (FD) and local villagers.	
			Habitat creation and management.	Planting host plants associated with identified endemic and		This activity can be started before the start of	CEB, Mahaweli Authority of Sri Lanka (MASL),			

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					
				General approach	Experience in Sri Lanka and elsewhere	Likely suitability in the context of the MHP	Periodicity	Cost in LKR	Responsibility of implementation and monitoring
				threatened fauna (see Table 3 and the relevant species profiles) in the reservation of the proposed reservoir.			construction.		Forest Department (FD) and local villagers.
				Creating hiding places for faunal species by placing logs and boulders along the upper water level.		Applicable.	This activity can be started before the start of construction.		CEB.
		Collection of voucher specimens of flora and fauna from the inundation area.	Placing a collection of specimens in the National Herbarium, National Museum and Plant Genetic Resource Centre for future reference and research.	Moragahakanda (MASL) This also involved the following National Agencies: <ul style="list-style-type: none">o National Herbariumo National Botanic Gardenso National Museumo Plant Genetic Resource Centero National Zoological Gardens. IUCN facilitated the involvement of these	Applicable.	This activity can be started before the start of construction.	200, 000	CEB with technical facilitation by IUCN.	

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					Responsibility of implementation and monitoring
				General approach	Experience in Sri Lanka and elsewhere	Likely suitability in the context of the MHP	Periodicity	Cost in LKR	
		Destructive land use practices outside the proposed protected area.	Declaration of the catchment, and the wider landscape as a protected area.	Initiate a dialogue with the FD and CEA, together with IUCN to discuss plans to declare the Moragolla reservoir area as an Environmental Protection Area (EPA).	Moragahakanda (MASL).	To reduce destructive activities in the surrounding habitats in future.	After the commission of project.	50, 000	CEB, with technical support from IUCN. Declaration of the protected area through relevant authorities such as the Central Environment al Authority (CEA).
			Law enforcement, and restoration of degraded habitats.					The cost is included in the reforestation.	CEA, FD and DWC.
		Habitat destruction and deterioration, and disturbance to wildlife due to construction activities (including quarrying, dumping, clearing of habitats, camp sites, temporary road network and transmission	Strict adherence to environmental guidelines pertaining to construction activities. Awareness of relevant stakeholders.	This can be implemented by the CEB through awareness of, and compliance with, the conditions laid down by the CEA throughout the project period.	Moragahakanda (MASL) by IUCN.	Applicable.	During the whole of the construction period until the end of commission.	The cost is included in the contract sum for implementation of the EMP. 100, 000	CEB, CEA and construction company.

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					
				General approach	Experience in Sri Lanka and elsewhere	Likely suitability in the context of the MHP	Periodicity	Cost in LKR	Responsibility of implementation and monitoring
		lines)	Employ dedicated staff for project related environmental matters.	<p>This can be implemented by the CEA and suitable technical experts through awareness campaigns targeting relevant stakeholders at regular intervals throughout the project.</p> <p>This can be done by the CEA through the appointment of an environmental officer to monitor environmental activities relating to the project.</p>				Cost included in the contractors payment .	
		Proliferation of IAS and suppression of native biodiversity	Ensure that IAS ⁶ do not proliferate in the project area (see	The CEA and suitable technical experts can conduct	Moragahakanda (MASL) IUCN has provided the guidelines.	Applicable.		200, 000	CEB, CEA and construction company. Technical

⁶ Alien Invasive Species.

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					
				General approach	Experience in Sri Lanka and elsewhere	Likely suitability in the context of the MHP	Periodicity	Cost in LKR	Responsibility of implementation and monitoring
			Annex 5).	awareness campaigns addressing this issue at regular intervals for relevant stakeholders throughout the project. Appointment of a CEB environmental officer to monitor the environmental activities.					support can be provided by IUCN.
	Downstream	Deterioration of the quality of the downstream riverine habitats and species.	Maintain an environmental flow by releasing water from the main dam.	Recreate annual flooding events to ensure water requirements and habitat creation for terrestrial fauna. Flash flush flow has to be maintained during the early rainy season.			After the commission of the project. During the wet season	No cost	CEB and CEA.
	Upstream	Land based human activities such as land clearing, agriculture,	Introduce biodiversity friendly livelihood strategies	These activities can be implemented by agencies	Moragahakanda (MASL)		Can be started during the construction phase	500, 000	CEB and community-based organizations (CBOs),

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					Responsibility of implementation and monitoring
				General approach	Experience in Sri Lanka and elsewhere	Likely suitability in the context of the MHP	Periodicity	Cost in LKR	
		industries, expansion of settlements and soil waste will have devastating impacts on species and habitats.	including eco-agriculture and eco-tourism. Incorporate biodiversity concerns into human settlement policies. Introduce appropriate local area development policies for likely industries to minimize impacts on biodiversity.	such as the CEB, the Department of Agriculture, the CEA and the Tourist Board, through training programmes and pilot projects throughout the project and beyond.			and continued.	200, 000	
	Downstream	Degradation and deterioration of downstream riverine habitats.	Maintain a sustainable e-flow and recreate annual flash flood events to maintain riverine habitats.	The CEB can arrange for the minimum water flow to be released annually during the rainy season.		After the commission of the project. During the wet season.		No cost	CEB and CEA.
		Unregulated sudden opening of the sluice gates of the reservoir, affecting downstream wildlife and communities.	Regulate the release of water.	The CEB can regulate the release of water daily so that it is released gradually.	In Amban Ganga, the recent floods affected the Ukuwela sluice gates, which in turn impacted downstream habitats and faunal species.	After the commission of the project. During the wet season.		No cost	CEB and CEA.

3.4 Habitat creation and management plan

Based on the findings and analyses carried out as part of the present study, none of the 41 critical species (endemic, threatened or Near Threatened species) that have been recorded within the study area will be impacted significantly as a result of the MHP. Five species were found to be moderately affected by the project (see Table 3), while the impact on the remaining 36 species was found to be low. Therefore, mitigation measures are proposed only for the five species that will be affected moderately as a result of the project.

The impact of the project on the five moderately impacted species can be mitigated through habitat creation in the reservation of the reservoir area and the upper catchment of the reservoir. This aspect will be addressed in detail in the 'Preparation of an afforestation and watershed management plan' assignment also undertaken by IUCN. Therefore, it will not be discussed in detail here. The recommended list of floral species for reforestation, considering species that are important for terrestrial fauna, is presented in Annex 4.

Additionally, it is strongly recommended that the invasive floral species found within the project area are removed. A list of identified invasive plant species is given in Annex 5.

Habitat requirements for target species during the restoration phase are given in the Table 5.

Table 5. Habitat requirements for target species.

Family	Species	Common name	Impact	Restoration measure
Butterflies				
Pieridae	<i>Cepora nadina</i>	Lesser gull	Habitat destruction (reduction of feeding plants and nectar plants).	Planting of larval feeding plants and nectar plants along the reservation and home gardens around the proposed reservoir.
	<i>Eurema andersoni</i>	One-spot grass yellow	Habitat destruction (reduction of feeding plants and nectar plants).	
Mammals				
Felidae	<i>Prionailurus rubiginosus</i>	Rusty-spotted cat	Habitat destruction (reduction of hiding places and hunting grounds).	Replanting of thick riverine habitat along the reservoir bank to create hiding places as well as food sources.
	<i>Prionailurus viverrinus</i>	Fishing cat	Habitat destruction (reduction of hiding places and hunting grounds).	
Tragulidae	<i>Moschiola kathygre</i>	Sri Lanka pygmy mouse deer	Habitat destruction (reduction of hiding places and feeding grounds).	

It is not necessary to translocate these five species from the immediate impact area. If habitat creation activities are initiated in the buffer zone and surrounding areas prior to construction, these species will begin to move into the new and restored habitats, gradually, with the inundation of affected areas.

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the EIA study (CECB and ACO, 2012), and relevant additional studies (NBRO, 2013), a total of 173 species of terrestrial fauna have been recorded in the area that is to be impacted directly due to the MHP. A total of 23 of these species are endemic to Sri Lanka, while 16 species are considered to be threatened species, and 12 species considered to be Near Threatened (NT) species. Further, ten of the 23 endemic species found in the area are considered to be threatened or Near Threatened (NT) species. Therefore, a total of 41 species recorded from the area were considered to be threatened and endemic species. These species have been evaluated using an impact index developed in order to identify the species that will be most affected by the proposed project. Other species were not evaluated as they show a wide distribution in Sri Lanka, as well as outside Sri Lanka, and therefore, the proportion of their population impacted by the project will be insignificant. Based on the evaluations carried out as part of the study, none of the 41 identified threatened and endemic species were identified as being affected by the proposed project significantly. However, five species have been identified as moderately impacted species. The impacts of the project on these species can be mitigated by creating suitable habitats for these species in the reservation of the proposed reservoir.

In addition to this activity, the following recommendations are proposed in order to ensure the sustainability of the project:

- Avoid the introduction and transportation of alien invasive weeds, particularly into areas that currently have relatively low incidences of weeds, such as areas of woodland and open forest within the project area and within the vegetation surrounding the dam construction site. Measures that can be implemented to minimize the transportation of weeds include, cleaning the heavy vehicles used for construction activities before bringing them to the site, and periodic monitoring of the construction site, especially temporary soil storage areas and vehicle wash down areas, to ensure that there are no new infestations occurring in the project area.
- Avoid the removal of hollow-bearing trees and branches to the greatest extent possible in areas above the flood zone. Where the removal of such trees and branches is found to be unavoidable, this work should be undertaken by an appropriately qualified arborist under the observation of qualified ecologist or zoologist. Hollows should be inspected for resident fauna by a qualified ecologist prior to felling or trimming. If resident fauna are found, the appropriate action to follow should be determined in consultation with the qualified ecologist or zoologist.
- Habitat creation within the reservation area of the proposed reservoir should be done in a way that will benefit the prioritized threatened species.
- Construction of a dam over the Mahaweli River would result in the clearing of 2-3 ha of vegetation and faunal habitats. The proposed action would incur a low level impact on the habitats of prioritized threatened species considered in this assessment, given the small area of impact, and the large area of remaining habitat in the locality. Furthermore, it is recommended that any species rescue mission should be carried out immediately prior to undertaking land clearing work in order to prevent the cleared areas being re-colonized.

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ANNEXES

Annex 1: Endemic, threatened and Near Threatened (NT) fauna recorded from the project site, as provided in the ToR for the assignment.

Notes: Moragolla Hydropower Project EIA - Table 3.18

IUCN Conservation Status added in 2013

abbreviations used: CR - Critically Endangered, EN – Endangered, VU – Vulnerable, NT - Near Threatened,

LC - Least Concern, NE - Not Evaluated.

Moragolla Hydropower EIA (2012)					IUCN 2013 ⁷
Group	Species	Common Name	Endemic	Threatened	
Butterflies	<i>Troides darsius</i>	Sri Lankan birdwing	+	NT	NE
	<i>Chilasa (Papilio) clytia</i>	Common mime		NT	NE
	<i>Cepora nadina</i>	Lesser gull		CR	NE
	<i>Eurema andersonii</i>	One-spot grass yellow		EN	NE
	<i>Pantoporia hordonia</i>	Common Lascar		NT	NE
Dragonflies	<i>Vestalis apicalis</i>	Black-tipped forest glory			LC
	<i>Libellago greeni</i>	Green's Gem	+		NE
Fish	<i>Devario cf aequipinnatus</i>	Giant danio			LC
	<i>Puntius (Pethia) nigrofasciata</i>	Black ruby barb	+	VU	NE
	<i>Puntius (Pethia) reval</i>	Redfin two-banded carplet	+		NE
	<i>Puntius (Dawkinsia) singhala</i>	Filamented barb	+		NE
	<i>Belontia signata</i>	Combtail	+	NT	LC
Amphibians	<i>Hylarana gracilis</i>	Gravenhorst's frog	+		LC
	<i>Hylarana temporalis</i>	Bronzed frog		NT	NT
	<i>Lankanectes corrugates</i>	Corrugated water frog	+		LC

⁷ <http://www.iucnredlist.org/>

Moragolla Hydropower EIA (2012)					IUCN 2013 ⁷
Group	Species	Common Name	Endemic	Threatened	
Reptiles	<i>Otocryptis wiegmanni</i>	Sri Lankan kangaroo lizard	+	NT	NE
	<i>Xenochrophis cf piscator</i>	Checkered keelback			NE
Birds	<i>Dendrocopos nanus</i>	Brown-capped woodpecker		NT	LC
	<i>Celeus brachyurus</i>	Rufous woodpecker		NT	LC
	<i>Picus chlorolophus</i>	Yellow-naped woodpecker		NT	LC
	<i>Megalaima flavifrons</i>	Sri Lanka yellow-fronted barbet	+		LC
	<i>Megalaima rubricapilla</i>	Crimson-fronted barbet	+		LC
	<i>Loriculus beryllinus</i>	Sri Lanka hanging parrot	+		LC
	<i>Psittacula calthropae</i>	Sri Lanka Layard's parakeet	+	NT	LC
	<i>Collocalia unicolor</i>	Indian swiftlet		NT	LC
	<i>Sitta frontalis</i>	Velvet-fronted nuthatch		NT	LC
	<i>Hirundo daurica</i>	Red-rumped swallow		NT	LC
	<i>Iole indica</i>	Yellow-browed bulbul		NT	LC
	<i>Pellorneum fuscicapillum</i>	Sri Lanka brown-capped babbler	+	NT	LC
	<i>Pomatorhinus melanurus</i>	Sri Lanka scimitar babbler	+	NT	LC
	<i>Dumetia hypertyra</i>	Tawny-bellied babbler		NT	LC
Mammals	<i>Macaca sinica</i>	Sri Lanka toque macaque	+	NT	EN
	<i>Prionailurus viverrinus</i>	Fishing cat		VU	EN
	<i>Lutra lutra</i>	European otter		VU	NT
	<i>Moschiola kathygre</i>	Yellow-striped chevrotain	+	NT	LC

Annex 2: Updated list of endemic, threatened and Near Threatened (NT) fauna recorded from the project site with impact scores.

Note: **NRL** – National Red List (MOE, 2012) and **GRL** - Global Red List (IUCN, 2013)

Abbreviations used: CR - Critically Endangered, EN – Endangered, VU – Vulnerable, NT - Near Threatened, LC - Least Concern, NE - Not Evaluated.

	Species name	English name	Species status	Conservation status		Selection criteria (with scoring in parentheses)					
						1. Status of species: indigenous (0), endemic/ possibly new species (2).					
				2. Distribution: island wide (0), Mahaweli basin and dry zone (1), Mahaweli basin and wet zone (2), Mahaweli basin only (3), restricted to project area (4).							
3. Impact: positive impact (-3), no impact (0), low negative impact (-3) high negative impact (+5).											
4. Conservation status: LC (0), NT (1), DD/NE (2), VU (3), EN (4), CR(5), both nationally and globally threatened (6).											
BUTTERFLIES											
Family – Papilionidae											
1	<i>Troides darsius</i>	Ceylon birdwing	Endemic	LC	NE	0	0	3	0	3	3
2	<i>Papilio crino</i>	Banded peacock	Indigenous	VU	NE	0	0	3	3	6	3
3	<i>Chilasa clytia</i>	Mime	Indigenous	NT	NE	0	0	3	1	4	4
Family – Pieridae											
4	<i>Cepora nadina</i>	Lesser gull	Indigenous	CR	NE	0	2	3	5	10	10
5	<i>Appias paulina</i>	Lesser albatross	Endemic	LC	NE	1	0	3	3	7	7
6	<i>Eurema andersoni</i>	One-spot grass yellow	Endemic	VU	NE	1	2	3	3	9	9
Family - Nymphalidae											
7	<i>Pantoporia hordonia</i>	Common lasker	Indigenous	NT	NE	0	0	3	1	4	4
DRAGONFLIES											
Family – Calopterygidae											
1	<i>Vestalis apicalis</i>	Black-tipped flashwing	Endemic	LC	LC	1	2	-3	0	0	0
Family - Cholorocypidae											
2	<i>Libellago adami</i>	Adam's Gem	Endemic	VU	NE	1	2	-3	3	3	3
3	<i>Libellago finalis</i>	Ultima Gem	Endemic	VU	NE	1	2	-3	3	3	3
4	<i>Libellago greeni</i>	Green's Gem	Endemic	EN	NE	1	2	-3	4	4	4
Family - Coenagrionidae											
5	<i>Ischnura aurora</i>	Dawn Bluetail	Indigenous	NT	LC	1	0	-3	1	-1	-1
Family - Euphaeidae											

6	<i>Euphaea splendens</i>	Shining Gossamerwing	Endemic	NT		3	2	-3	1	3
Family – Lestidae										
7	<i>Indolestes gracilis</i>	Mountain Reedling	Indigenous	VU	LC	1	3	-3	3	4
Family – Gomphidae										
8	<i>Paragomphus henryi</i>	Brook Hooktail	Endemic	EN	NT	1	2	-3	4	4
Family – Libellulidae										
9	<i>Orthetrum pruinatum</i>	Pink Skimmer	Indigenous	NT	LC	1	2	-3	1	1
10	<i>Orthetrum triangulare</i>	Triangle Skimmer	Indigenous	EN	LC	1	3	-3	4	5
11	<i>Trithemis festiva</i>	Indigo Dropwing	Indigenous	VU	LC	1	2	-3	3	3
12	<i>Indothemis camatica</i>	Light tipped Demon	Indigenous	NT	NT	1	1	-3	1	0
13	<i>Sympetrum fonscolombii</i>	Red-veined Darter	Indigenous	EN	LC	1	3	-3	4	5
AMPHIBIANS										
Family – Nyctibatrachidae										
1	<i>Lankanectes corrugatus</i>	Corrugated water frog	Endemic	VU	LC	1	2	0	3	6
Family - Ranidae										
2	<i>Hylarana gracilis</i>	Sri Lanka wood frog	Endemic	LC	LC	1	0	0	0	1
3	<i>Hylarana temporalis</i>	Common wood frog	Endemic	NT	LC	1	2	0	1	4
REPTILES										
Family – Trionychidae										
1	<i>Lissemys ceylonensis</i>	Flapshell turtle	Endemic	LC	NE	1	0	-3	0	-2
Family – Agamidae										
2	<i>Otocryptis wiegmanni</i>	Sri Lankan kangaroo lizard	Endemic	LC	NE	1	2	3	0	6
BIRDS										
Family – Phasianidae										
1	<i>Gallus lafayetii</i>	Sri Lanka Junglefowl	Endemic	LC	LC	1	0	0	0	1
Family – Picidae										
2	<i>Picus chlorolophus</i>	Lesser Yellow-naped Woodpecker	Indigenous	NT	LC	0	2	0	1	3
Family – Ramphastidae										

3	<i>Megalaima flavifrons</i>	Sri Lanka Yellow-fronted Barbet	Endemic	LC	LC	1	2	0	0	3
4	<i>Megalaima rubricapilla</i>	Crimson-fronted Barbet	Endemic	LC	LC	1	0	0	0	1
Family – Psittacidae										
5	<i>Loriculus beryllinus</i>	Sri Lanka Hanging Parakeet	Endemic	LC	LC	1	2	0	0	3
6	<i>Psittacula cyanocephala</i>	Plum-headed Parakeet	Indigenous	NT	LC	0	2	0	1	3
7	<i>Psittacula calthiopae</i>	Sri Lanka Layard's Parakeet	Endemic	NT	LC	1	2	0	1	4
Family – Columbidae										
8	<i>Treron pompadora</i>	Pompadour Green-pigeon	Endemic	LC	LC	1	0	0	0	1
Family – Accipitridae										
9	<i>Pernis ptilorhynchus</i>	Oriental Honey-buzzard	Indigenous/ Migrant	NT	LC	0	0	0	1	1
10	<i>Ictinaetus malayensis</i>	Black Eagle	Indigenous	NT	LC	0	0	0	1	1
Family – Campephagidae										
11	<i>Tephrodornis pondicerianus</i>	Common Woodshrike	Endemic	LC	LC	1	0	0	0	1
MAMMALS										
Family - Cercopithecidae										
1	<i>Macaca sinica</i>	Sri Lanka toque monkey	Endemic	LC	EN	1	0	3	0	4
Family – Felidae										
2	<i>Prionailurus rubiginosus</i>	Rusty-spotted cat	Indigenous	EN	VU	0	0	3	6	9
3	<i>Prionailurus viverrinus</i>	Fishing cat	Indigenous	EN	EN	0	0	3	6	9
Family - Mustelidae										
4	<i>Lutra lutra</i>	Otter	Indigenous	VU	NT	0	0	0	3	3
Family – Tragulidae										
5	<i>Moschiola kathygre</i>	Sri Lanka pygmy mouse-deer	Endemic	VU	LC	1	2	3	3	9

Annex 3: Detailed list of species recorded in the project area by CECB and ACO (2012) and NBRO (2013) (conservation statuses as given in the 2012 National Red List and Global Red List 2013)

Butterflies

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family - Papilionidae						
1	<i>Troides darsius</i>	Common birdwing / Ceylon birdwing	Maha kurulu piya papiliya	Endemic	LC	
2	<i>Pachliopta hector</i>	Crimson rose	Maha rosa papilia	Indigenous	LC	
3	<i>Pachliopta aristolochiae</i>	Common rose	Podu rosa papilia	Indigenous	LC	
4	<i>Papilio crino</i>	Banded peacock	Monara papilia	Indigenous	VU	
5	<i>Papilio polytes</i>	Common mormon	Kalu papilia	Indigenous	LC	
6	<i>Papilio polymnestor</i>	Blue mormon	Maha nilaya	Indigenous	LC	
7	<i>Graphium sarpedon</i>	Blue bottle	Nil papilia	Indigenous	LC	
8	<i>Graphium agamemnon</i>	Tailed jay	Kola papilia	Indigenous	LC	
9	<i>Chilasa clytia</i>	Mime	Rawana papilia	Indigenous	NT	
Family - Pieridae						
10	<i>Leptosia nina</i>	Psyche	Kalu-thith sudda	Indigenous	LC	
11	<i>Delias eucharis</i>	Jezebel	Podu Maha-sudda	Indigenous	LC	
12	<i>Cepora nadina</i>	Lesser gull	Heen Punduru-sudana	Indigenous	CR	
13	<i>Appias paulina</i>	Lesser albatross	Kuda sudana	Endemic	LC	
14	<i>Catopsilia pyranthe</i>	Mottled emigrant / African emigrant	Thith-piya piyasariya	Indigenous	LC	
15	<i>Catopsilia pomona</i>	Lemon emigrant	Kaha piyasariya	Indigenous	LC	
16	<i>Eurema hecabe</i>	Common grass yellow	Maha kahakolaya	Indigenous	LC	
17	<i>Eurema andersoni</i>	One-spot grass yellow	Kela kahakolaya	Endemic	VU	
Family - Nymphalidae						
18	<i>Parantica aglea</i>	Glassy tiger	Suduwan nil-kotithiya	Indigenous	LC	
19	<i>Danaus chrysippus</i>	Plain tiger	Podu koti-thambiliya	Indigenous	LC	
20	<i>Junonia lemonias</i>	Lemon pansy	Dumburuwan alankarikya	Indigenous	LC	
21	<i>Junonia atlites</i>	Grey pansy	Aluwan alankarikya	Indigenous	LC	

22	<i>Junonia iphita</i>	Chocolate soldier	Podu alankarikya	Indigenous	LC	
23	<i>Junonia almana</i>	Peacock pansy	Monera alankarikya	Indigenous	LC	
24	<i>Pantoporia hordonia</i>	Common lasker	Kaha selaruwa	Indigenous	NT	
25	<i>Neptis hylas</i>	Common sailor	Gomara selaruwa	Indigenous	LC	
26	<i>Acraea violae</i>	Tawny costor	Thambily panduru-boraluwa	Indigenous	LC	
27	<i>Melanitis leda</i>	Common evening brown	Podu dumburuwa	Indigenous	LC	
28	<i>Orsotriaena medus</i>	Nigger	Maha-iri panduru-dumburuwa	Indigenous	LC	
29	<i>Mycalesis perseus</i>	Common bushbrown	Podu panduru-dumburuwa	Indigenous	LC	
30	<i>Ypthima ceylonica</i>	White four-ring	Podu heen-dumburuwa	Indigenous	LC	
Family - Lycaenidae						
31	<i>Castalius rosimon</i>	Common Pierrot	Podu Mal-nilaya	Indigenous	LC	
32	<i>Jamides celeno</i>	Common Cerulean	Podu Seru-nilaya	Indigenous	LC	

Dragonflies

	Species name	Common name	Species status	Conservation status	
				NRL 2012	GRL 2013
1	<i>Neurobasis chinensis</i>	Oriental green-wing	Indigenous	LC	LC
2	<i>Vestalis apicalis</i>	Black-tipped flashwing	Endemic	LC	LC
Family - Chlorocyphidae					
3	<i>Libellago adami</i>	Adam's Gem	Endemic	VU	
4	<i>Libellago finalis</i>	Ultima Gem	Endemic	VU	
5	<i>Libellago greeni</i>	Green's Gem	Endemic	EN	
Family - Coenagrionidae					
6	<i>Agriocnemis pygmaea</i>	Wandering Wisp	Indigenous	LC	LC
7	<i>Pseudagrion rubriceps</i>	Red-headed Sprite	Indigenous	LC	
8	<i>Ischnura aurora</i>	Dawn Bluetail	Indigenous	NT	LC
9	<i>Ischnura senegalensis</i>	Common Bluetail	Indigenous	LC	LC
Family - Euphaeidae					
10	<i>Euphaea splendens</i>	Shining	Endemic	NT	

		Gossamerwing		
Family – Lestidae				
11	<i>Indolestes gracilis</i>	Mountain Reedling	Indigenous	VU
Family – Gomphidae				
12	<i>Paragomphus henryi</i>	Brook Hooktail	Endemic	EN
Family - Libellulidae				
13	<i>Orthetrum pruinosum</i>	Pink Skimmer	Indigenous	NT
14	<i>Orthetrum sabina</i>	Green Skimmer	Indigenous	LC
15	<i>Orthetrum triangulare</i>	Triangle Skimmer	Indigenous	EN
16	<i>Crocothemis servilla</i>	Oriental Scarlet	Indigenous	LC
17	<i>Crocothemis servilla</i>	Oriental Scarlet	Indigenous	LC
18	<i>Neurothemis tullia</i>	Pied parasol	Indigenous	LC
19	<i>Trithemis festiva</i>	Indigo Dropwing	Indigenous	VU
20	<i>Indothemis carnatica</i>	Light tipped Demon	Indigenous	NT
21	<i>Sympetrum fonscolombii</i>	Red-veined Darter	Indigenous	EN
22	<i>Trithemis aurora</i>	Crimson Dropwing	Indigenous	LC

Amphibians

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family – Bufonidae						
1	<i>Duttaphrynus melanostictus</i>	Common house toad	Sulaba geai gamba	Indigenous	LC	
Family – Microhylidae						
2	<i>Ramanella variegata</i>	White-bellied pugsnout frog	Bada-sudu motahombu madiyas	Indigenous	LC	
Family – Nyctibatrachidae						
3	<i>Lankanectes corrugatus</i>	Corrugated water frog	Vakarali madiya	Endemic	VU	
Family – Dicroglossidae						
4	<i>Euphyctis cyanophlyctis</i>	Skipper frog	Utpatana madiya	Indigenous	LC	
5	<i>Fejervarya shyadrensis</i>	Common paddy field frog	Sulaba vel madiya	Indigenous	LC	
Family - Ranidae						

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
6	<i>Hylarana gracilis</i>	Sri Lanka wood frog	Lanka bandi madiya	Endemic	LC	
7	<i>Hylarana temporalis</i>	Common wood frog	Sulaba bandi madiya	Endemic	NT	

Reptiles

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family - Trionychidae						
1	<i>Lissemys ceylonensis</i>	Flapshell turtle	Kiri ibba	Endemic	LC	
Family - Agamidae						
2	<i>Calotes calotes</i>	Green garden lizard	Pala katussa	Indigenous	LC	
3	<i>Calotes versicolor</i>	Common garden lizard	Gara katussa	Indigenous	LC	
4	<i>Otocryptis wiegmanni</i>	Sri Lankan kangaroo lizard	Gomu talikatussa	Endemic	LC	
Family - Gekkonidae						
5	<i>Hemidactylus parvimaculatus</i>	Spotted housegecko	Pulli gehuna	Indigenous	LC	
Family - Varanidae						
6	<i>Varanus salvator</i>	Water monitor	Kabaragoya	Indigenous	LC	
Family – Colubridae						
7	<i>Ahaetulla nasuta</i>	Green vine snake	Ahaetulla	Indigenous	LC	
8	<i>Ptyas mucosa</i>	Rat snake	Gerandiya.	Indigenous	LC	
Family – Natricidae						
9	<i>Xenochrophis cf. piscator</i>	Checkered Keelback	Diya bariya	Endemic	LC	
10	<i>Xenochrophis asperimus</i>	The checkered keelback	Diya polonga / Diya bariya	Endemic	LC	

Birds

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family - Phasianidae						
1	<i>Gallus lafayetii</i>	Sri Lanka Junglefowl	Sri Lanka Wali-kukula	Endemic	LC	LC
Family – Picidae						
2	<i>Dendrocopus nanus</i>	Brown-capped Pygmy Woodpecker	Bora Esasi Gomara-karela	BrR	LC	LC
3	<i>Celeus brachyurus</i>	Rufous Woodpecker	Borath Koda-karela	BrR	LC	LC
4	<i>Picus chlorolophus</i>	Lesser Yellow-naped Woodpecker	Heen Kaha-gelasi Karela	BrR	NT	LC
5	<i>Dinopium benghalense</i>	Black-rumped Flameback	Rath-karela	BrR	LC	LC
Family – Ramphastidae						
6	<i>Megalaima zeylanica</i>	Brown-headed Barbet	Polos Kottoruwa	BrR	LC	LC
7	<i>Megalaima flavifrons</i>	Sri Lanka Yellow-fronted Barbet	Sri Lanka Rannhunatha Kottoruwa	Endemic	LC	LC
8	<i>Megalaima rubricapilla</i>	Crimson-fronted Barbet	Rathmhunath Kottoruwa	Proposed Endemic	LC	LC
Family – Alcedinidae						
9	<i>Alcedo atthis</i>	Common Kingfisher	Mal Pilihuduwa	BrR	LC	LC
10	<i>Pelargopsis capensis</i>	Stork-billed Kingfisher	Manathudu Madi-pilihuduwa	BrR	LC	LC
11	<i>Halcyon smyrnensis</i>	White-throated Kingfisher	Layasudu Madi-pilihuduwa	BrR	LC	LC
12	<i>Ceryle rudis</i>	Pied Kingfisher	Gomara-pilihuduwa	BrR	LC	LC
Family - Meropidae						
12	<i>Merops philippinus</i>	Blue-tailed Bee-eater	Nilpenda Binguharaya	WV	NE	LC
14	<i>Merops leschenaulti</i>	Chestnut-headed Bee-eater	Thambala-hisa Binguharaya	BrR	LC	LC
Family – Cuculidae						
15	<i>Eudynamys scolopacea</i>	Asian Koel	Kowula	BrR	LC	LC
16	<i>Centropus sinensis</i>	Greater Coucal	Ati-kukula	BrR	LC	LC
Family – Psittacidae						

Species name	Common name	Local name	Species status	Conservation status	
				NRL 2012	GRL 2013
17 <i>Loriculus beryllinus</i>	Sri Lanka Hanging Parakeet	Sri Lanka Giramaliththa	Endemic	LC	LC
18 <i>Psittacula krameri</i>	Rose-ringed Parakeet	Rana Girawa	BrR	LC	LC
19 <i>Psittacula cyanocephala</i>	Plum-headed Parakeet	Pandu Girawa	BrR	NT	LC
20 <i>Psittacula calthropae</i>	Sri Lanka Layard's Parakeet	Sri Lanka Alu Girawa	Endemic	NT	LC
Family – Apodidae					
21 <i>Collocalia unicolor</i>	Indian Swiftlet	Indu Upa-thurithaya	BrR	LC	LC
22 <i>Cypsiurus balasiensis</i>	Asian Palm Swift	Asiaa Thal-thurithaya	BrR	LC	LC
Family – Columbidae					
23 <i>Streptopelia chinensis</i>	Spotted Dove	Alu Kobeiyya	BrR	LC	LC
24 <i>Chalcophaps indica</i>	Emerald Dove	Neela-Kobeiyya	BrR	LC	LC
25 <i>Treron pompadora</i>	Pompador Green-pigeon	Pompadoru Batagoya	Proposed Endemic	LC	LC
26 <i>Ducula aenea</i>	Green Imperial Pigeon	Neela Mahagoya	BrR	LC	LC
Family – Rallidae					
27 <i>Amauromis phoenicurus</i>	White-breasted Waterhen	Laya-sudu Korawakka	BrR	LC	LC
Family - Accipitridae					
28 <i>Pernis ptilorhynchus</i>	Oriental Honey-buzzard	Silu Bambarakussa	BrRWV/Va	NT	LC
29 <i>Haliastur indus</i>	Brahminy Kite	Bamunu Piyakussa	BrR	LC	LC
30 <i>Haliaeetus leucogaster</i>	White-bellied Sea-eagle	Kusa-ali Sayurukussa	BrR	LC	LC
31 <i>Spilornis cheela</i>	Crested Serpent Eagle	Silu Sarapakussa	BrR	LC	LC
32 <i>Accipiter badius</i>	Shikra	Ukussa	BrR	LC	LC
33 <i>Ictinaetus malayensis</i>	Black Eagle	Kalukussa	BrR	NT	LC
Family – Phalacrocoracidae					
34 <i>Phalacrocorax niger</i>	Little Cormorant	Punchi Diyakava	BrR	LC	LC
Family - Ardeidae					
35 <i>Egretta garzetta</i>	Little Egret	Punchi Ali-koka	BrR	LC	LC
36 <i>Bubulcus ibis</i>	Cattle Egret	Gava-koka	BrR	LC	LC
37 <i>Ardeola grayii</i>	Pond Heron	Kana-koka	BrR	LC	LC
Family – Ciconiidae					
38 <i>Anastomus oscitans</i>	Asian Openbill	Asia V'varathuduwa	BrR	LC	LC
Family - Pittidae					
39 <i>Pitta brachyura</i>	Indian Pitta	Avichchiya	WV	NE	LC

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family – Chloropseidae						
40	<i>Chloropsis jerdoni</i>	Blue-winged Leafbird	Nilpiya Kolarisiya	BrR	LC	LC
Family – Laniidae						
41	<i>Lanius cristatus</i>	Brown Shrike	Bora Sabariththa	WV	NE	LC
Family – Artamidae						
42	<i>Artamus fuscus</i>	Ashy Woodswallow	Alu Wanalihiniya	BrR	LC	LC
Family – Oriolidae						
43	<i>Oriolus xanthornus</i>	Black-hooded Oriole	Kahakurulla	BrR	LC	LC
Family – Dicruidae						
44	<i>Dicrurus caerulescens</i>	White-bellied Drongo	Kawuda	BrR	LC	LC
Family - Monarchidae						
45	<i>Terpsiphone paradisi</i>	Asian Paradise- flycatcher	Asia Rahanmara	BrR/WV	LC	LC
Family – Corvidae						
46	<i>Corvus splendens</i>	House Crow	Kolamba Kaputa	BrR	LC	LC
47	<i>Corvus levaillantii</i>	Large-billed Crow	Kalu Kaputa	BrR	LC	LC
Family – Campephagidae						
48	<i>Coracina melanoptera</i>	Black-headed Cuckooshrike	Kalu-his Kovul-saratiththa	BrR	LC	LC
49	<i>Pericrocotus cinnamomeus</i>	Small Minivet	Punchi Miniviththa	BrR	LC	LC
50	<i>Pericrocotus flammeus</i>	Scarlet Minivet	Dilirath Miniviththa	BrR	LC	LC
51	<i>Coracina macei</i>	Large Cuckooshrike	Maha Kovul-saratiththa	BrR	LC	LC
52	<i>Tephrodornis pondicerianus</i>	Common Woodshrike	Podu Wana-saratiththa	Proposed Endemic	LC	LC
53	<i>Hemipus picatus</i>	Bar-winged Flycatcher-shrike	Wairapiya Masi-saratiththa	BrR	LC	LC
Family – Aegithinidae						
54	<i>Aegithina tiphia</i>	Common Iora	Podu Iorawa	BrR	LC	LC
Family – Muscicapidae						
55	<i>Muscicapa dauirica</i>	Asian Brown Flycatcher	Asia Bora Masimara	WV	NE	LC
56	<i>Cyornis tickelliae</i>	Tickell's Blue Flycatcher	Tickel Nil-masimara	BrR	LC	LC
57	<i>Copsychus saularis</i>	Oriental Magpie Robin	Polkichcha	BrR	LC	LC
58	<i>Saxicoloides fulicata</i>	Indian Robin	Indu Kalukichcha	BrR	LC	LC
Family - Sturnidae						
59	<i>Acridotheres tristis</i>	Common Myna	Mayna	BrR	LC	LC

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
60	<i>Gracula religiosa</i>	Hill Myna	Salalihiniya	BrR	LC	LC
Family - Sittidae						
61	<i>Sitta frontalis</i>	Velvet-fronted Nuthatch	Villuda Nalal Yatikuriththa	BrR	LC	LC
Family – Paridae						
62	<i>Parus major</i>	Great Tit	Maha Tikiriththa	BrR	LC	LC
Family - Hirundinidae						
63	<i>Hirundo rustica</i>	Barn Swallow	Atu Wahilithiniya	BrR	NE	LC
64	<i>Hirundo daurica</i>	Red-rumped Swallow	Nithamba rathu Wahilithiniya	Proposed Endemic	LC	LC
Family – Pycnonotidae						
65	<i>Pycnonotus cafer</i>	Red-vented Bulbul	Kondaya	BrR	LC	LC
66	<i>Iole indica</i>	Yellow-browed Bulbul	Bamakaha Guluguduwa	BrR	LC	LC
67	<i>Pycnonotus luteolus</i>	White-browed Bulbul	Bamasudu Kondaya	BrR	LC	LC
68	<i>Pycnonotus melanicterus</i>	Black-crested Bulbul	Kalu Hisasi Kondaya	BrR	LC	LC
Family – Cisticolidae						
69	<i>Prinia socialis</i>	Ashy Prinia	Alu Priniya	BrR	LC	LC
70	<i>Prinia inornata</i>	Plain Prinia	Sarala Priniya	BrR	LC	LC
Family - Zosteropidae						
71	<i>Zosterops palpebrosus</i>	Oriental White-eye	Peradigu Sithasiya	BrR	LC	LC
Family – Sylviidae						
72	<i>Acrocephalus dumetorum</i>	Blyth's Reed Warbler	Blyths Panraviya	WV	NE	LC
73	<i>Orthotomus sutorius</i>	Common Tailorbird	Battichcha	BrR	LC	LC
74	<i>Phylloscopus trochiloides</i>	Greenish Warbler	Kola Gassraviya	WV	NE	LC
75	<i>Phylloscopus magnirostris</i>	Large-billed Leaf Warbler	Mathusu Gassraviya	WV	NE	LC
Family – Timalidae						
76	<i>Pellorneum fuscicapillum</i>	Sri Lanka Brown-capped Babbler	Sri Lanka Boraga-demalichcha	Endemic	LC	LC
77	<i>Pomatorhinus melanurus</i>	Sri Lanka Scimitar Babbler	Da-demalichcha	Endemic	LC	LC
78	<i>Rhopocichla atriceps</i>	Dark-fronted Babbler	Wathanduru Panduru-demalichcha	BrR	LC	LC
79	<i>Dumetia hyperythra</i>	Tawny-bellied Babbler	Kusakaha Landu-demalichcha	BrR	LC	LC
80	<i>Turdoides affinis</i>	Yellow-billed Babbler	Demalichcha	BrR	LC	LC

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family – Dicaeidae						
81	<i>Dicaeum erythrorhynchos</i>	Pale-billed Flowerpecker	Lathudu Pillichcha	BrR	LC	LC
Family – Nectariniidae						
82	<i>Nectarina zeylonica</i>	Purple-rumped Sunbird	Nithamba Dam Sutikka	BrR	LC	LC
83	<i>Nectarina lotenia</i>	Loten's Sunbird	Lotenge Sutikka	BrR	LC	LC
Family – Passeridae						
84	<i>Passer domesticus</i>	House Sparrow	Gekurulla	BrR	LC	LC
Family – Motacillidae						
85	<i>Dendronanthus indicus</i>	Forest Wagtail	Wana-halapenda	WV	NE	LC
86	<i>Motacilla cinerea</i>	Grey Wagtail	Alu Halapenda	WV	NE	LC
Family – Estrididae						
87	<i>Lonchura striata</i>	White-rumped Munia	Nithamba Sudu Weekurulla	BrR	LC	LC
88	<i>Lonchura punctulata</i>	Scaly-breasted Munia	Laya Kayuru Weekurulla	BrR	LC	LC

Mammals

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family - Pteropodidae						
1	<i>Pteropus giganteus</i>	Flying fox	Ma-vavula	Indigenous	LC	LC
Family – Rhinolophidae						
2	<i>Rhinolophus rouxii</i>	Rufous horse-shoe bat	Borath Ashladan-vavula	Indigenous	LC	LC
Family – Cercopithecidae						
3	<i>Macaca sinica</i>	Sri Lanka toque monkey	Sri Lanka Rilawa	Endemic		EN
Family – Felidae						
4	<i>Prionailurus rubiginosus</i>	Rusty-spotted cat	Kola Diviya / Balal Diviya	Indigenous	EN	VU
5	<i>Prionailurus viverrinus</i>	Fishing cat	Handun Diviya	Indigenous	EN	EN
Family - Herpestidae						
6	<i>Herpestes fuscus</i>	Brown mongoose	Bora Mugatiya	Indigenous	LC	
Family – Mustelidae						
7	<i>Lutra lutra</i>	Otter	Diya-balla	Indigenous	VU	NT
Family – Canidae						
8	<i>Canis aureus</i>	Jackal	Nariya / Hiwala	Indigenous	LC	LC
Family – Bovidae						
9	<i>Bos indicus</i>	Domestic hump-backed cattle	Sinhala Elaharaka	domestic	NE	NE
Family – Tragulidae						
10	<i>Moschiola kathygre</i>	Sri Lanka pygmy mouse-deer	Sri Lanka Kuru Meminna	Endemic	VU	LC
Family – Suidae						
11	<i>Sus scrofa</i>	Wild boar	Wal Ura	Indigenous	LC	LC
Family – Hystricidae						
12	<i>Hystrix indica</i>	Porcupine	Ittewa	Indigenous	LC	LC
Family – Sciuridae						
13	<i>Funambulus palmarum</i>	Palm squirrel	Leena	Indigenous	LC	LC
Family – Leporidae						
14	<i>Lepus nigricollis</i>	Black-naped hare	Wal Hawa	Indigenous	LC	LC

Annex 4: List of floral species proposed for planting river-side and in reservation areas within the project site.

Planting the species listed as follows in dense patch will help to create the habitats necessary for the three mammal species and two butterfly species that are likely to be impacted moderately due to project activities. A mixed-species planting approach (polyculture) – whereby a range of species are planted in the buffer zone - should be used in order to create suitable habitat conditions.

Further details are provided in the afforestation and watershed management plan for the Moragolla project area.

	Plant species	Common name	Beneficiary species
1	<i>Trema orientalis</i>	Gedumba	Insect eating birds
2	<i>Macaranga peltata</i>	Kenda	Fruit eating birds
3	<i>Macaranga indica</i>	Kenda	Fruit eating birds
4	<i>Mallotus tetracoccus</i>	Bu Kenda	Fruit eating birds
5	<i>Ficus</i> sp.	Nuga	Fruit eating birds, <i>Moschiola kathygre</i> (Sri Lanka pygmy mouse deer) and <i>Macaca sinica</i> (Toque monkey).
6	<i>Ficus racemosa</i>	Attikka	Insect eating birds and mammals (e.g. <i>Macaca sinica</i> and <i>Moschiola kathygre</i>), and butterflies for which this species is a host plant.
7	<i>Acacia</i> sp.		Insect eating birds and species for which it is a host plant.
8	<i>Albizia lebbeck</i>	Kabal mara	<i>Pantoporia hordonia</i> (Common lasker) (as a host plant).
9	<i>Madhuca neriifolia</i>	Gam Mi	Fruit eating birds and mammals (e.g. <i>Macaca sinica</i> and <i>Moschiola kathygre</i>).
10	<i>Symplocos cochinchinensis</i>	Bombu	Butterflies for which it is a feeding plant.
11	<i>Artocarpus nobilis</i>	Wal del	Fruit eating birds and mammals (e.g. <i>Macaca sinica</i>).
12	<i>Chloroxylon swietenia</i>	Satinwood	<i>Papilio crino</i> (Banded peacock) (as a host plant).
13	Plant species belonging to Family Lauracea ⁸	Wal enasal	<i>Papilio clytia</i> (Mime) (as a host plant) and <i>Prionailurus rubiginosus</i> (Rusty-spotted cat), <i>Prionailurus viverrinus</i> (Fishing cat) and <i>Moschiola kathygre</i> (Sri Lanka pygmy mouse deer) as a hiding place.
14	<i>Erythrina subumbrans</i>	Erabadu	Shade loving flora and fauna.

⁸ Camphor laurel and Cinnamon.

	Plant species	Common name	Beneficiary species
15	<i>Delonix regia</i>	Mara	Insect eating birds and species for which it is a host plant.
16	<i>Mangifera indica</i>	Amba	Fruit eating birds and mammals (e.g. <i>Macaca sinica</i>).
17	<i>Artocarpus heterophyllus</i>	Kos	Fruit eating birds and mammals (e.g. <i>Macaca sinica</i> and <i>Moschiola kathygre</i>).
18	<i>Capparis</i> sp.	Wellangiriya	Gulls (as a host plant) and <i>Prionailurus rubiginosus</i> (Rusty-spotted cat), <i>Prionailurus viverrinus</i> (Fishing cat) and <i>Moschiola kathygre</i> (Sri Lanka pygmy mouse deer) as a hiding place.
19	<i>Spathodea campanulata</i>	African tulip tree	Small mammals, birds and butterflies that feed on these plants.
20	<i>Ochlandra</i> sp.	Bata	Larval feeding plant for Butterflies as larval feeding plants and <i>Prionailurus rubiginosus</i> (Rusty-spotted cat), <i>Prionailurus viverrinus</i> (Fishing cat) and <i>Moschiola kathygre</i> (Sri Lanka pygmy mouse deer) as a hiding place.
21	<i>Cassia</i> sp.	Thora	Grass yellow butterfly larvae as a feeding plant.



Figure 1. A *Pinus* plantation – an example of monoculture planting, which is not recommended.

Monoculture planting, as in the images above, is not recommended. Instead, a mixed-species planting approach should be used. Habitats developed through planting

activities must be diverse and should resemble existing riverine habitats. A series of photographs at different sites along the river within the project area are given below in Figure 2.



Figure 2. The existing riverine habitats within the project area.

Although some of the existing riverine habitats within the project area are somewhat degraded, they support mammalian species including *Prionailurus rubiginosus* (Rusty-spotted cat), *Prionailurus viverrinus* (Fishing cat) and *Moschiola kathygre* (Sri Lanka pygmy mouse deer). Therefore, efforts should be made to create riverine habitats such as those shown in Figure 2. An example of mixed species planting is also illustrated in the image below.



Figure 3. An example of mixed species planting, an approach that should be used for habitat creation.

Once the recommended planting activities have been carried out using the species listed above, and a mixed species approach, habitats around the reservoir should resemble that illustrated in Figure 4 below.



Figure 4. An example of mixed species planting around the Kotmale reservoir.

Annex 5: Invasive plant species that should be eradicated or removed due to dominance in the existing natural vegetation

- *Lantana camara* (Gandapana)
- *Eupatorium odoratum*
- *Mimosa pigra* (Yodha Nidi kumba)
- *Alstonia macrophylla* (Hawari Nuga)
- *Ludwigia peruviana*
- *Clusia rosea* (Gal Goraka)

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Moragolla Hydropower Project

Additional Studies in the Natural Environment: Afforestation and Watershed Management Plan

FINAL REPORT



August 2013

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ABBREVIATIONS

ADB	Asian Development Bank
AusAID	Australian Agency of International Development
AWMP	Afforestation and Watershed Management Plan
CBD	Convention on Biological Diversity
CC	Climate Change
CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CR	Critically Endangered
DAU	Department of Ayurveda
DOA	Department of Agriculture
DWLC	Department of Wildlife Conservation
EIA	Environmental Impact Assessment
EN	Endangered species
FD	Forest Department
FFPO	Fauna and Flora Protection Ordinance
FO	Forest Ordinance
FR	Forest Reserve
FS	Feasibility Study
GOSL	Government of Sri Lanka
ha	Hectares
IUCN	International Union for Conservation of Nature
LKR	Sri Lankan Rupee
MASL	Mahaweli Authority of Sri Lanka
MCM	Million Cubic Meters
NK	Nippon Koei Co. Ltd
NTFP	Non Timber Forest Product
OSF	Other State Forest
PA	Protected Area
PR	Proposed Reserve
STC	State Timber Corporation
UMC	Upper Mahaweli Catchment
UMW	Upper Mahaweli Watershed
USAID	United States Agency of International Development

EXECUTIVE SUMMARY

At present nearly 60 percent of the annual electricity demand of the country is met by various hydropower plants. The demand for electricity in Sri Lanka is growing at an annual rate of about 7-8 percent and this trend is expected to continue in the foreseeable future. As a contribution to meet this growing electricity demand, the Ceylon Electricity Board (CEB) plans to develop a new 30.8 MW hydropower project at Moragolla in the Kandy District by constructing a concrete gravity dam across the Mahaweli Ganga at Weliganga. The proposed reservoir is expected to be 38.5 ha in extent with a capacity of 1.98 MCM at Full Supply Level (FSL) at 548 m MSL. The Feasibility Study (FS) for this project was conducted in 2009, and included an Environmental Impact Assessment (EIA). Later it was decided to upgrade this EIA, and surveys were conducted in 2013 covering some key fields, to supplement existing baseline data and update the assessment of impacts. However, further studies were deemed necessary in order to plan and design mitigation measures to minimize the adverse impacts of the project. The preparation of an Afforestation and Watershed Management Plan (AWMP) is one such study identified for the mitigation of the adverse impacts of the Moragolla Hydropower Project (MHP).

The study consists of two components - afforestation and watershed management.

Afforestation plan: This section includes details of the forest cover of Sri Lanka, forest cover in the upper Mahaweli watershed, Protected Areas (PAs) in the upper Mahaweli catchment, the importance of protected areas, the impact of the Moragolla project on forests, the rationale for the reservoir buffer zone and AWMP, forestry and afforestation in Sri Lanka, legal requirements for afforestation in Sri Lanka and an afforestation/reforestation plan for the Moragolla watershed. The afforestation/reforestation plan includes proposed sites for afforestation, recommended tree species for planting, a brief description on each species, planning and preparation for afforestation/reforestation programme, afforestation/reforestation techniques, establishment of nurseries, post-planting maintenance and management, relevant cost estimates, implementation of the afforestation programme, and a schedule of activities and timeframe for the afforestation/reforestation programme. The proposed afforestation/reforestation sites for Moragolla project consist of riparian sites, degraded forest sites, abandoned lands, pine plantations and privately owned home gardens. Twenty nine tree species have been recommended for the afforestation/reforestation programme. Suitable tree species should be selected from this species list after conducting a site-species matching exercise. The nursery establishment and planting techniques are described within this section. The total area to be afforested (planted) is approximately 130 ha, and includes afforestation and planting of riparian sites, degraded forest sites, abandoned lands, pine plantations and privately owned home gardens. A total of 78, 000 plants are estimated to be required for the entire afforestation programme. The cost estimate for the total afforestation programme is LKR 25 million for a period of five years, including planning during the first year.

Watershed management plan: This section includes details of the topography and the land uses of the immediate watershed of the proposed Moragolla reservoir, the existing conditions of sections of the immediate watershed of the Moragolla reservoir, environmental and watershed-related issues in the Moragolla catchment, problems associated with the land use patterns of the watershed, and problems related to specific land uses in the area. The proposed management strategies for the Moragolla reservoir watershed include the construction of lock and spill drains, the construction of bunds and stone walls, small check

dams along tributaries, cover crops, mulching, grass strips, reforestation, home garden improvement, establishment of wetlands, an awareness programme and monitoring. The cost estimate for the entire watershed management programme is LKR 3.7 million for two years.

1. INTRODUCTION

1.1 Context

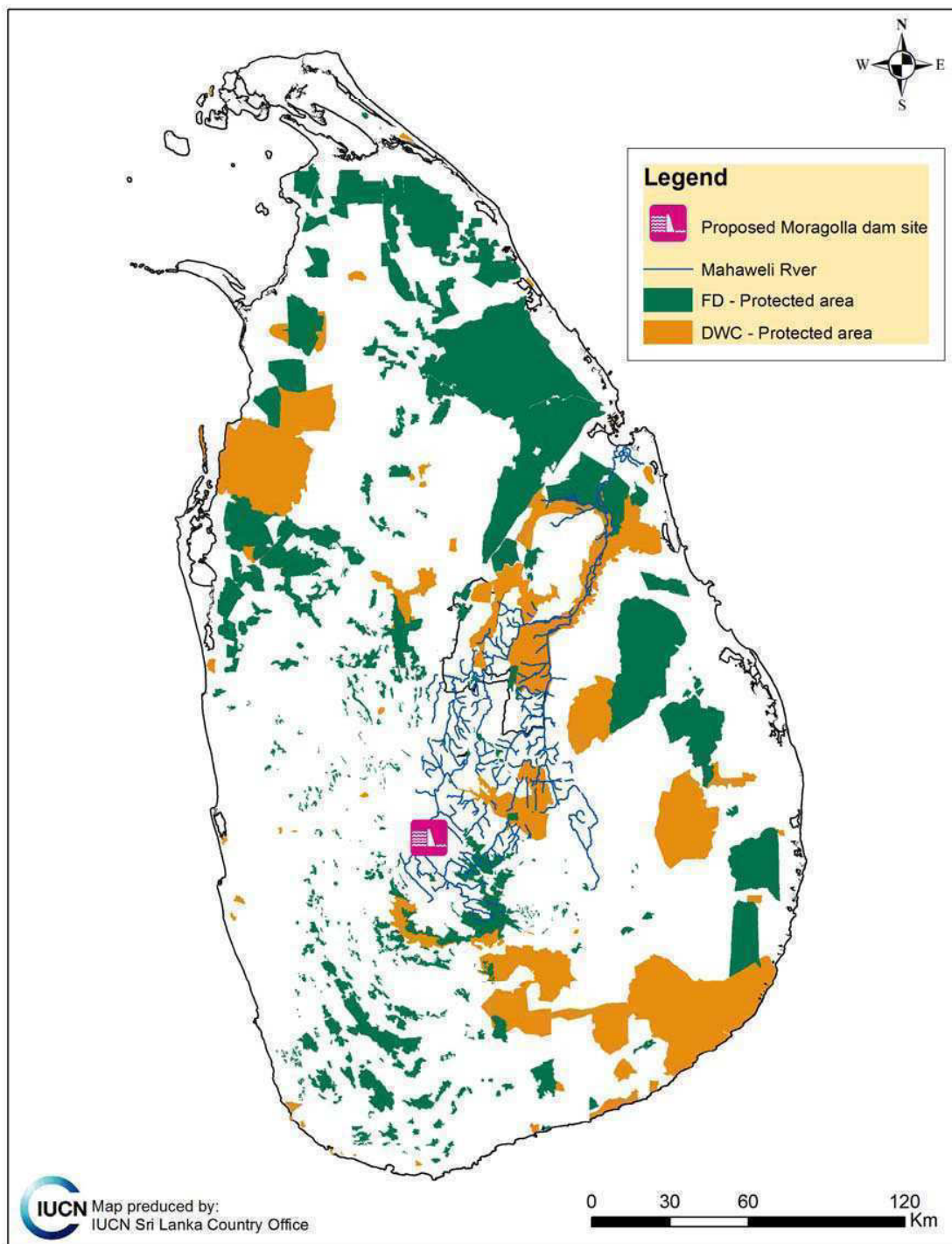
The demand for electricity in Sri Lanka has been growing at an annual rate of 7-8 percent, and this trend is expected to continue for the foreseeable future. As such, increased generating capacity is necessary in order to meet this growth in demand. At present, approximately some 60 percent of the annual demand is met by various hydropower plants (CEB, 2004). This is possible due to the large number of streams and rivers in the southwestern highlands, which are fed by the southwestern monsoon rains and the two inter-monsoon seasons. The Moragolla Hydropower Project (MHP) is likely to be the last medium scale hydropower scheme to be developed in Sri Lanka, aside from a few sites with potential for the development of mini-hydropower plants. In the future, additional power supply is likely to be provided from conventional fossil fuel based power plants, and to a small extent, by renewable energy sources. Therefore, the power system in Sri Lanka, which has been predominantly hydropower based in the past, will have to be transformed in to a thermal based system in the future. However, the National Energy Policy promotes the development of indigenous energy to minimize Sri Lanka's dependence on non-indigenous resources. Hence, realizing the remaining hydropower potential of country - even if it is through small or medium scale initiatives - is fast gaining attention from the CEB (CECB, 2012).

The growth in the demand for electricity has been linked closely with the growth in the economy in recent years closely, illustrating the need for a reliable and uninterrupted supply of electricity provided at a reasonable price if the current trend of economic growth is to continue. The 30.8 MW expected to be provided by the MHP would therefore, be a significant asset to the country.

As a contribution to meet this electricity demand, the Ceylon Electricity Board (CEB) plans to develop a new 30.8 MW hydropower project in Moragolla in the Kandy District. The proposed Moragolla Hydropower Project (MHP), and the area that will be impacted through associated development, are located around the southern slopes of the Central Highlands of Sri Lanka. Administratively, this area falls under the Uda Palatha and Ganga Ihala Korale Divisional Secretariat Divisions (DSDs) in the Kandy District of the Central Province.

1.2 The project

The proposed Moragolla Hydropower Project involves the construction of a 35 m high concrete gravity dam across the Mahaweli River at Weliganga. As part of this project, water will be diverted through a conveyance system to a powerhouse and outfall located opposite the confluence with the Atabage Oya. The proposed reservoir that will form as a result of the dam is expected to be 38.5 ha in extent, with a capacity of 1.98 MCM at a Full Supply Level (FSL) of 548 m asl.



Map 1. Location of the Moragolla Hydropower Project.

The Feasibility Study (FS) for the project – including an Environmental Impact Assessment (EIA) - was conducted in 2009. In 2012, Nippon Koei Co. Ltd (NK) was appointed by the CEB to review these reports, and prepare detailed designs and tender documents for project, as well as to upgrade the EIA in order to comply with the Safeguard Policy of the Asian Development Bank (ADB), the principal funding agency. A number of additional surveys were conducted in 2013 to supplement existing baseline data and update the assessment of impacts, in order to upgrade the EIA. However, a further study is now been

deemed necessary needed, so that mitigation measures can be properly planned and designed.

1.3 Reasons for the study

The topography of the project area is mountainous with a striking landscape of deep river valleys running beneath high cliffs and escarpments. The establishment of tea plantations in the hill country of Sri Lanka began in the 1850s. At present, the plantations cover a considerable land area in Kandy District. Most of the catchment area of the proposed project is covered by tea plantations and forest. The higher slopes and the tops of the hills remain forested with most of the forested areas designated as forest reserves. The project area is predominantly rural in character, with the majority of the population living in small rural communities. In general, most of the population is scattered over the area in traditional villages and tea estate worker communities. The dominant economic activities of the area are tea plantations and cultivation of other crops.

A detailed field analysis of land uses in the area conducted by the National Building Research Organization (NBRO) during the period March-July 2013, showed that approximately 133 ha of “forest” (6.3 percent of the total land area), which comprises primarily of secondary vegetation, is located within the project area. The forest area is degraded in nature at present due to human activities and anthropogenic pressures and can be categorized as a scrub jungle. Administratively, the forest area belongs to the category of Other State Forest (OSF), and falls under the purview of the Mahaweli Authority of Sri Lanka (MASL). According to the findings of the EIA, the most prominent tree species in the forest are *Albizia* spp. (*Albizia*), *Swietenia macrophylla* (Broadleaf Mahogany) and *Artocarpus heterophyllus* (Jak). A small proportion of this forest is expected to be affected by the proposed project due to activities including land clearance for inundation, quarrying and spoil disposal.

According to the EIA carried out for the proposed project, approximately 489 trees over 20 cm in Diameter at Breast Height (DBH) are expected to be removed from the site. The species likely to be most affected will be *Mangifera indica* (27 trees), *Alstonia macrophylla* (32 trees), *Albizia falcataria* (48 trees), *Peltophorum pterocarpum* (25 trees), *Swietenia macrophylla* (60 trees) and *Artocarpus heterophyllus* (77 trees). A complete list of tree species (over 20 cm DBH) identified for removal is given in Annex 1.

The CEB is committed to mitigating all negative impacts associated with the project and compensating for the loss of trees. Therefore, an Afforestation and Watershed Management Plan (AWMP) has been deemed necessary in order to facilitate the mitigation of the negative impacts of the proposed project, including forest clearing and habitat disturbances. The present document has been prepared for this purpose.

1.4 Objectives

The general goal of the study is to ensure that the watershed of the Moragolla reservoir that provides water for the Moragolla Hydropower project is managed effectively and protected as natural asset of the highest importance in order to ensure its sustainable contribution to the electricity generation in Sri Lanka.

The specific objectives of the study are as follows:

1. To rehabilitate and restore ecologically the degraded forests and adjoining areas of the Moragolla catchment as a watershed;
2. To improve native forest diversity in the area by planting native tree species in the Moragolla catchment;
3. To control or prevent the establishment of invasive floral species that disrupt forest ecosystem process;
4. To provide a suitable habitat for fauna in the reservoir buffer zone and minimize the loss of flora and fauna belonging to species of high conservation significance during the construction phase of the project due to the clearing of vegetation and alteration of habitats.
5. To reduction soil erosion from the Moragolla catchment and minimize sedimentation within the proposed reservoir through the adoption of eco-friendly cultivation systems on privately owned lands within the catchment; and
6. To increase public awareness on the need to adopt soil conservation measures and environment-friendly land-use options in order to protect and maintain the Moragolla reservoir.

2. APPROACH

The methodology adopted for the development of the Afforestation and Watershed Plan is described briefly below.

The study consisted of an extensive survey of relevant literature, information and maps, and a brief field visit conducted between 21 and 22 August, 2013, in order to gain an understanding of the current ground situation at the project site.

Literature survey and office based work

- The EIA report and maps provided by Nippon Koei Co. Ltd (NK) were studied in order to obtain basic information necessary for the preparation of the plan.
- The environmental base maps were provided for the study area detailing types of land use, the terrain in the project area and important forest vegetation types.
- The presence of threatened floral species in the Upper Mahaweli watershed was investigated. Those species or communities that are considered to be of conservation significance were identified.
- A literature survey was carried out to identify the possible floral species present in the area, as well as information on their species statuses (endemic or introduced), and conservation statuses.

Field surveys

- A field survey was carried out in the proposed project area between 21 and 22 August, 2013, in order to investigate the land use types, land ownership, vegetation types, the status of forest vegetation present in the area, the status of private lands in the area and relevant development trends.
- A rapid survey was carried out to identify the species found in the remaining forests in the reservoir area, and plants or plant communities of conservation significance that have the potential to be impacted by the project.
- Consultations were held with representatives of the CEB and the Forest Department in the project area to clarify information on land use and land ownership. Forest Department officers provided the information on administrative and legal status of protection of forests in the project area.
- Public consultations were held with private land owners in the area to gather more information on land uses and crops grown in their lands including home gardens.
- Observations were made on the land uses in the Ulapane Industrial Park located in the immediate catchment area (left bank) of the proposed Moragolla reservoir.

3. BACKGROUND

The island of Sri Lanka has a land area of approximately 6.5 million hectares. Topographically, the country consists of a highland area in the south central part of the island, which rises to approximately 2,500 meters, and the lowland plains that surround it. The climate of Sri Lanka is generally tropical and maritime. Three major climatic zones can be recognized based on their rainfall patterns. They are the Wet Zone (over 2,500 mm per year), the Intermediate Zone (1,900 to 2,500 mm per year) and the Dry Zone where dry conditions prevail from May to September (below 1,900 mm per year). The natural vegetation follows the pattern of the climatic zones of the country. In the wet zone, lowland rainforests form the climax vegetation type. From the southwestern lowlands, the vegetation gradually changes as it reaches the central mountains. At elevations of 1,000 to 1,500 m, the natural vegetation is classified as sub-montane forest, and at even higher elevations, as montane forests. The characteristic natural vegetation of the dry zone is dry monsoon forest. The natural vegetation of the intermediate zone is moist monsoon forest.

The 207 mile long Mahaweli River traverses from the Wet Zone to the Dry Zone and has been augmented by dams, canals and tunnels from over 2,000 years ago. Of the annual precipitation in the Mahaweli River basin of 28,000 MCM, 9,000 MCM is discharged to the sea. The accelerated Mahaweli project, which was carried out during the 1980s, was the largest development project in Sri Lanka involving the generation of hydroelectricity, irrigation in the Dry Zone, land settlement, generation of employment opportunities and infrastructure development. This project resulted in the development of a hydropower generation capacity of 470 MW, and irrigation of an additional 365,000 ha of land in the Dry Zone. Its catchment spans 10,448 km² and feeds 1,003 tanks. Subsequent to the associated construction, attention has shifted to watershed management, water management, crop diversification, participatory management and enterprise development. Similarly, there have been concerted efforts to manage the watershed in the upper reaches of the Mahaweli system.

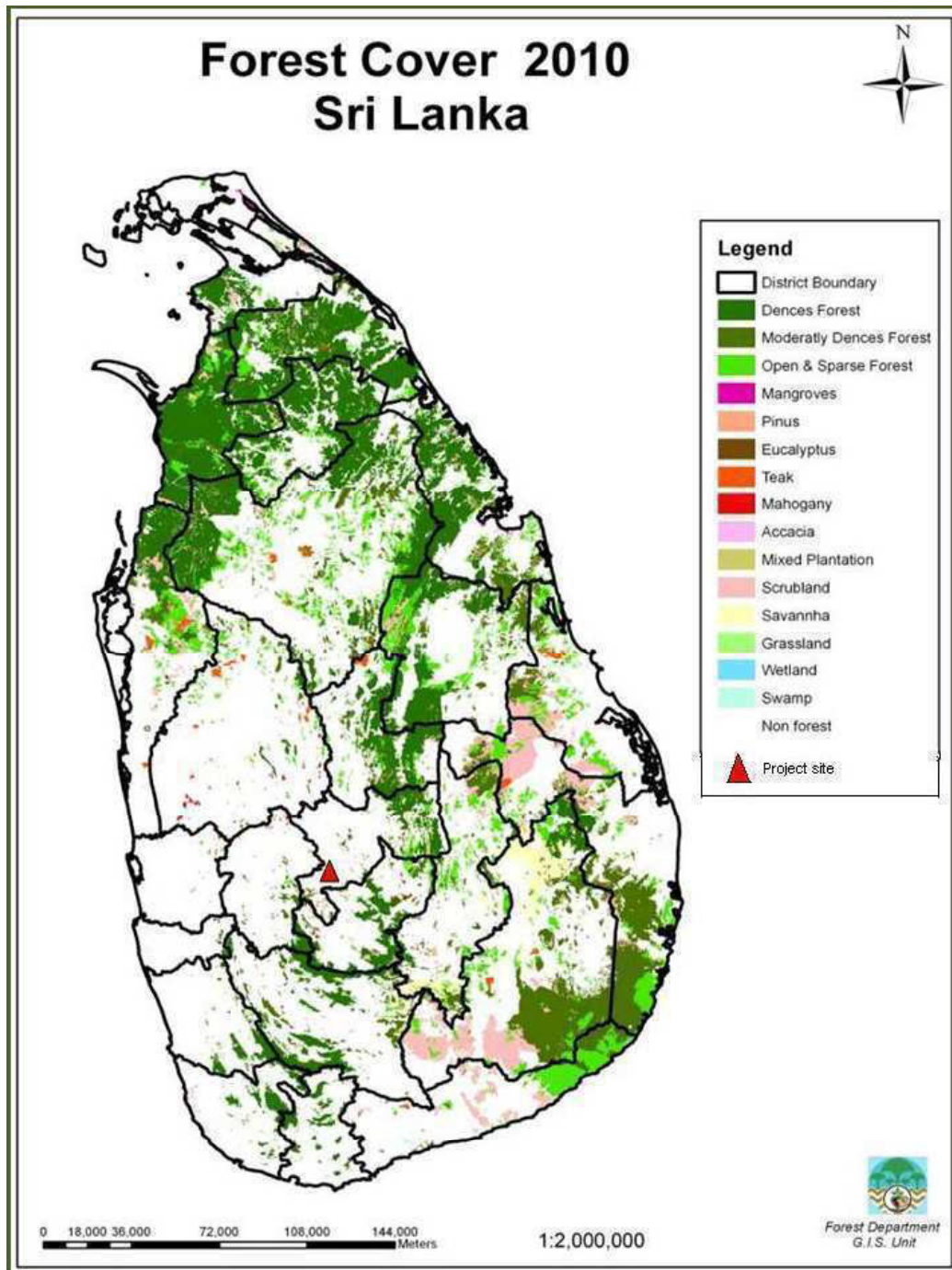
The natural forest cover of the upper Mahaweli catchment (UMC) has been decreasing gradually over the last two centuries due to the large-scale deforestation for plantation agriculture. Subsequently, the forest cover of the hill country has been reduced further to a few isolated patches, in order to meet the demand for land for agriculture, developmental activities and human settlements. At present, vegetables are grown extensively on the steep slopes of the UMC without proper land management practices. Consequently, this agriculturally active land is exposed to severe soil erosion and landslides, in parallel with the rapid rate of deforestation.

The major portion of land in the UMC is under tea cultivation, which is known to result in severe soil erosion, at present. With population growth in the hill country, settlements and farming have expanded rapidly, even to steep slopes, thereby exacerbating existing erosion issues. Estimates of the rate of soil loss on these hill slopes and the associated sediment yields in the fluvial system of the UMC, indicate that human-mediated activities in the UMC have increased rates of ongoing erosion by over 100 times above the background rates of natural erosion (Hewawasam, 2010). Thus, the Mahaweli River and its tributaries carry enormous amounts of sediment during the rainy seasons, both as bed and suspension loads downstream, with large amounts of sediment deposited in multi-purpose reservoirs within this system, leading to reduction of their storage capacity. Siltation is a major issue in hydropower reservoirs, and can lead to reduced hydropower generation. If this is allowed to

continue unabated, it can be anticipated that the situation will become worse in the future. Therefore, proper management of land by minimizing *in-situ* erosion and preserving the detached soil within the catchments through effective conservation measures is necessary in order to maintain and ensure a steady and continuous supply of power from the hydropower resources of the country.

3.1 Forest cover in Sri Lanka

According to the forest cover survey carried out by the Forest Department in 2010 based on the satellite images from 2008, the dense natural forest cover in Sri Lanka was 1.46 million ha (22.2 percent of the land area of the country). However, when all forests, including "sparse natural forests", which cover 6.5 percent of the land area, are also considered, the total forest cover of the country, excluding forest plantations and other forms of tree vegetation, is estimated to be 1.88 million ha (28.7 percent of the total land area) (MoAL&F, 1995). The total extent of forest plantations established for commercial or protective purposes amounts to 93, 000 ha (approximately 1.4 percent of the total land area). Therefore, the the total forest cover of Sri Lanka, including forest plantations, amounts to 1.975 million ha (30 percent of the total land area of the country), as illustrated in Map 2 (Forest Department, 2010).



Map 2. Forest cover of Sri Lanka (Forest Department, 2010).

In addition to these natural forests and forest plantations, a wide range of non-forest tree resources are available in the form of home gardens, rubber plantations, coconut plantations, ashade trees in tea plantations and trees on farmlands. These non-forest tree resources provide more than 70 percent of the industrial timber requirement of the country (MoAL&F, 1995).

As a result of its spatial variation in rainfall, altitude and soil, Sri Lanka features a striking variety of forest types. The forests that support much of the biodiversity of Sri Lanka include tropical wet lowland evergreen forests (lowland rainforests) in the Wet Zone, to tropical moist evergreen forests (moist monsoon forests) in the Intermediate Zone and tropical dry mixed evergreen forests (dry monsoon forests) in the Dry Zone (at elevations below 1, 000 m), tropical sub-montane forests (at elevations between 1, 000-1, 500 m in the Wet Zone), tropical montane forests (at elevations of 1, 500-2, 500 m in the Wet Zone); riverine forest (along river banks), tropical thorn forests (in the arid areas) and mangrove swamps in the coastal areas (Forest Department, 1995). The main forest types of Sri Lanka as a percentage of total forest cover in 2010 are shown in Table 1 below.

Table 1. Summary of natural forests in Sri Lanka in 2010
(based on Forest Department, 2011)
*included under sparse forest

Forest type	Total forest area (ha)	Percentage of total land area
Montane forest	44, 787	0.68
Sub-montane forest	29, 022	0.44
Lowland wet evergreen forest	124, 032	1.89
Moist evergreen forest	117, 674	1.79
Dry mixed evergreen forest	1, 121, 438	17.09
Riverine dry forest	2, 446	0.04
Mangroves	16, 037	0.24
Scrubland*	317, 708	4.84
Savannah*	68, 044	1.04
Montane grassland*	40, 927	0.72
Total dense Forest	1, 455, 436	22.17
Total sparse forest	426, 679	6.5
Total forest cover	1, 882, 115	28.68

3.2 Forest cover in the upper Mahaweli watershed

The upper Mahaweli watershed (UMW) is the upper portion of the Mahaweli watershed area, above the Rantambe dam, and extends into the Kandy, Nuwara Eliya, Badulla and Matale Districts, covering an area of approximately 3, 110 km² (Attygalle, 1998). The five reservoirs located within this catchment – Upper Kotmale, Kotmale, Victoria, Randenigala and Rantambe - contribute over 60 percent of the electricity supply in Sri Lanka through hydropower, as well as irrigation water for rice cultivation in lowland areas. Therefore, this watershed area is vital to national economy.

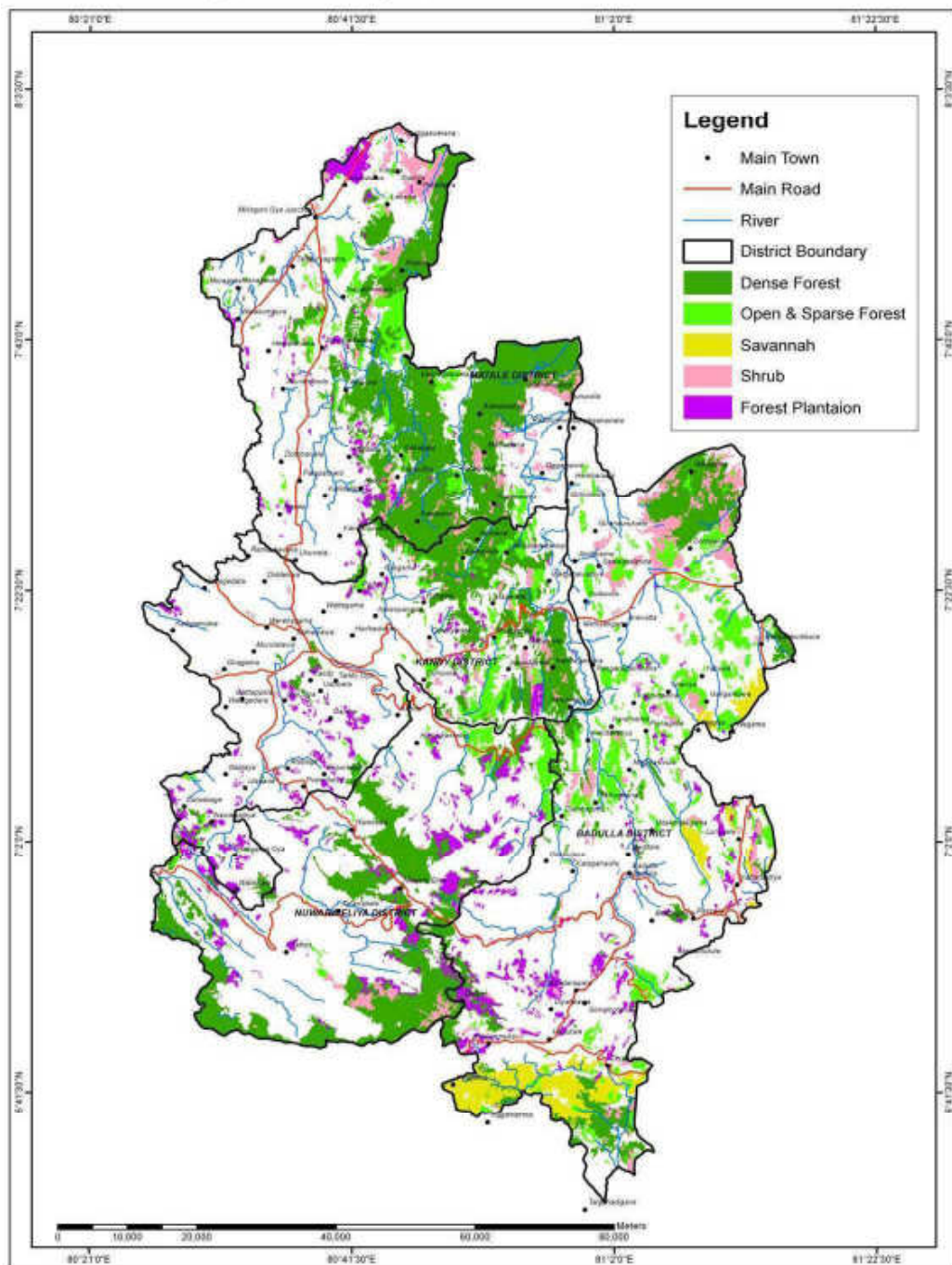
The natural forest cover of the Mahaweli watershed has decreased gradually over the last two centuries due to the large-scale deforestation for plantation agriculture. As in the national scenario, subsequently, the forest cover in this region has reduced further to a few isolated patches in order to meet the demand for land due to agriculture, developmental activities and human settlements. At present, vegetables are grown extensively on the steep slopes of the Mahaweli catchment without consideration of proper land management practices. Consequently, this agriculturally active land is exposed to severe soil erosion and landslides, in addition to rapid deforestation.

Six natural forest types – (i) montane forests, (ii) sub-montane forests, (iii) lowland rainforests, (iv) moist monsoon forests, (v) dry monsoon forests and (vi) savannah forests - can be observed in the upper Mahaweli watershed (Badulla, Kandy, Nuwara Eliya and Matale Districts). Natural forests are divided into two categories - dense natural forests (canopy density over 80 percent) and sparse forests. The overall average forest cover in the Mahaweli watershed (Badulla, Kandy, Nuwara Eliya and Matale Districts) was estimated to be approximately 29.6 percent in 2010 (Forest Department, 2010). Information on the natural forest types and forest plantations (over five years old) in the Mahaweli catchment (Badulla, Kandy, Nuwara Eliya and Matale Districts) is provided in Table 2. A forest cover map of the upper Mahaweli watershed is provided in Map 3.

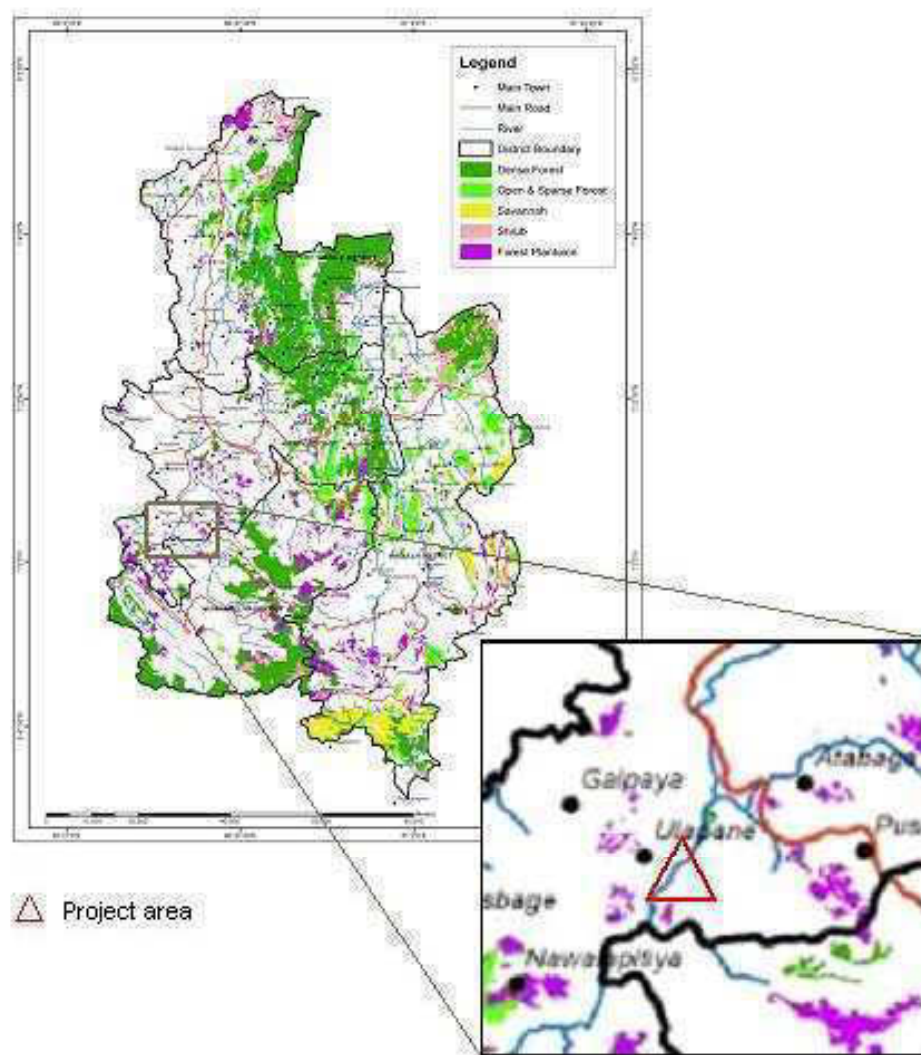
Table 2. Summary of the forests in the upper Mahaweli watershed

Forest type	Forest cover (ha) by district				
	Badulla	Kandy	Nuwara Eliya	Matale	Total
Montane forest	4,897	1,917	32,992	559	39,806
Sub-montane forest	576	6,204	2,065	4,323	8,845
Lowland rainforest	199	7,379	3,550	11,965	11,128
Moist monsoon forest	15,302	12,539	1,745	28,646	29,586
Dry monsoon forest	3,685	333	-	15,702	4,018
Total dense forest	24,659	28,372	40,352	61,195	93,383
Open sparse forest	27,832	9,001	5,483	11,453	42,316
Savannah forest	16,240	-	-	-	16,240
Forest plantation	5,833	5,408	7,203	3,186	18,444
Total forest	74,564	42,781	53,038	75,834	170,383
Forest cover (%)	26.4	22.3	31.1	38.8	29.6

Forest Cover in the Mahaweli Upper Catchment - Kandy, Nuwara Eliya ,Matale and Badulla Districts.



Map 3. Forest cover in the Mahaweli upper catchment, covering the Kandy, Nuwara Eliya, Matale and Badulla Districts (Forest Department, 2010).



Map 4. Forest cover in the project area adopted from the Forest Department map (Forest Department, 2010).

Details of the different natural forest types observed in the Upper Mahaweli watershed area are provided below. The enlarged map above shows that there are dense forests within the project area.

Montane forests

The montane forests of the area are restricted to the uppermost elevations of (> 1500 m) the Nuwara Eliya and Badulla Districts (above 1, 500 m), and a small extent in the Knuckles area of the Kandy District. The average annual rainfall in this area is over 1, 800 mm, and is received predominantly during the southwest and northeast monsoon periods. These forests are dominated by Clusiaceae, Myrtaceae, Lauraceae, Symplocaceae and Rubiaceae species. Common tree species found within this forest type include *Calophyllum walker* (Keena), *Calophyllum trapezifolium* (Keena), *Garcinia echinocarpa* (Madol), *Syzygium revolutum*, *Syzygium rotundifolium*, *Syzygium umbrosum* (Heen damba), *Symplocos cochinchinensis* (Wal bombu), *Strobilanthes sexennis* (Nelu), *Semecarpus nigro-viridis*

(*Badulla*), *Neolitsea fuscata*, *Cinnamomum ovalifolium*, *Litsea ovalifolia* and *Actinodaphne speciosa* (Elephant's ears). Some of the shrub species present found montane forests include *Strobilanthes sexennis* (Nelu), *Gaertnera walker* and *Lasianthus oliganthus*. The forest floor of this habitat type harbours many species of ferns. In most areas, the understory of the forest is dense and dominated by *Strobilanthes* spp., bamboes and *Coleus* spp. These forests are characterized by trees that are approximately 8-10 m tall, and short in stature, with gnarled twisted branches an abundance of epiphytes dominated by mosses, leafy liverworts, ferns and orchids, colourful young foliage, relatively small, thick, leathery leaves and an absence of drip tips a. With an increase in elevation and windy conditions, the canopy species become quite stunted, giving way to pygmy forests.

Some of the endemic and threatened faunal species associated with montane forests are as follows:

Butterflies - Ceylon Tiger (*Parantica taprobana*), Blue Oakleaf (*Kallima philarchus*), Common Birdwing (*Troides darsius*) and Ceylon Palmfly (*Elymnias singhala*).

Amphibians - Sri Lanka Wood Frog (*Hylarana gracillis*), Montane Paddyfield Frog (*Fejervarya kirtisinghei*), Corrugated Water Frog (*Lankanectes corrugatus*), Hour-glass Tree-Frog (*Polypedates cruciger*), Small-eared Shrub Frog (*Pseudophilautus microtympanum*) and Ferguson's Shrub Frog (*Pseudophilautus fergusonianus*).

Reptiles - Kangaroo Lizard (*Otocryptis wiegmanni*), Crestless Lizard (*Calotes liocephalus*), Whistling Lizard (*Calotes liolepis*), Great Forest Gecko (*Cyrtodactylus fraenatus*), Common Lanka Skink (*Lankascincus fallax*), Smooth Lanka Skink (*Lankascincus taprobanensis*) and Green Pit Viper (*Trimeresurus trigonocephalus*).

Birds - Sri Lanka Spur Fowl (*Galloperdix bicalcarata*), Sri Lanka Wood Pigeon (*Columba torringtoniae*), Sri Lanka Jungle Fowl (*Gallus lafayetti*) and Mountain Hawk Eagle (*Spizaetus nipalensis*).

Sub-montane forests

The natural vegetation type of tropical sub-montane forests represents a transitional biological belt between the highlands and the lowlands. Tropical sub-montane forests are distributed in the middle elevations (1, 000–1, 500 m) in the Kandy and Nuwara Eliya Districts. The canopies of sub-montane forests are approximately 20–25 m high, and are dominated by the Dipterocarpaceae, Clusiaceae and Myrtaceae families. The soft and medium hardwood species dominant within this habitat include *Shorea gardneri*, *Calophyllum* spp. *Cryptocarya wightiana* (Gal mora), *Eleocarpus gladulifer* (Malveralu), *Myristica dactyloides* (Malaboda) and *Syzygium* spp., *Symplocos cochinchinensis* (Bombu), *Turpinia malabarica* (Gurenda). Some of the shrub species present in this forest type include *Strobilanthes* spp. (Nelu), *Hortonia floribunda* (Wawiya), *Lasianthus oliganthus*, *Rauvolfia densiflora*, *Rubus indicus* (Vel batu), *Stemonurus coriaceus*. Approximately, 50 percent of the species observed in sub-montane forests are considered to be endemic to Sri Lanka. Most species of the endemic genus *Stemonoporus* show a localized distribution in these montane forests. The major forest areas of this category include Peak Wilderness Sanctuary, Knuckles Conservation Forest (Dumbara hills) and Namunukula mountain range.

Some of the endemic and threatened faunal species associated with sub-montane forests are as follows:

Butterflies - Ceylon Palmfly (*Elymnias singhala*), Ceylon Tree Nymph (*Idea iasonia*), Ceylon Tiger (*Parantica taprobana*), Blue Oakleaf (*Kallima philarchus*), Clipper (*Parthenos sylvia*) and Common Birdwing (*Troides darsius*).

Freshwater fish - Stone Sucker (*Garra ceylonensis*), Mountain Labeo (*Labeo fisheri*), Banded Mountain Loach (*Schistura notostigma*) and Walking Catfish (*Clarias brachysoma*).

Amphibians: Kelaart's Dwarf Toad (*Adenomus kelaartii*), Sri Lanka Wood Frog (*Hylarana gracillis*), Montane Paddyfield Frog (*Fejervarya kirtisinghe*), Marbled Rock Frog (*Nannophrys marmorata*), Hour-glass Tree-Frog (*Polypedates cruciger*), Small-eared Shrub Frog (*Pseudophilautus microtympanum*), Grey-Brown Pug-snouted Frog (*Ramanella obscura*), and Corrugated Water Frog (*Lankanectes corrugates*).

Reptiles: Kangaroo Lizard (*Otocryptis wiegmanni*), Crestless Lizard (*Calotes liocephalus*), Whistling Lizard (*Calotes liolepis*), Humpnose Lizard (*Lyriocephalus scutatus*), Great Forest Gecko (*Cyrtodactylus fraenatus*), Spotted Bowfinger Gecko (*Cyrtodactylus triedra*), Kandyan Gecko (*Hemidactylus depressus*), Smooth Lanka Skink (*Lankascincus taprobanensis*), Sri Lanka Flying Snake (*Chrysopelea taprobanica*) and Pipe Snake (*Cylindrophis maculata*).

Birds: Sri Lanka Spur Fowl (*Galloperdix bicalcarata*), Sri Lanka Jungle Fowl (*Gallus lafayetti*), Sri Lanka Wood Pigeon (*Columba torringtoniae*), Sri Lanka Hanging Parakeet (*Loriculus beryllinus*), Sri Lanka Emerald Collared Parakeet (*Psittacula calthropae*), Yellow-fronted Barbet (*Megalaima flavifrons*), Sri Lanka Yellow-eared Bulbul (*Pycnonotus penicillatus*), Spot-winged Thrush (*Zoothera spiloptera*), Sri Lanka Whistling Thrush / Arrenga (*Myophonus blighi*), Sri Lanka Dusky Blue Flycatcher (*Eumyias sordid*) and Blue Magpie (*Urocissa ornate*).

Mammals: Red slender Loris (*Loris tardigradus*), Purple-faced Leaf Monkey (*Semnopithecus vetulus*), Sri Lanka Bi-coloured Rat (*Srilankamys ohienensis*) and Golden Palm Civet (*Paradoxurus aureus*), Sri Lankan Toque Monkey (*Macaca sinica*) and Fishing Cat (*Prionailurus viverrinus*).

Of the bird and mammal species present in the sub-montane forests the following species have been recorded in the EIA study carried out in Moragolla project site (November 2012):

Birds: Sri Lanka Jungle Fowl (*Gallus lafayetti*), Yellow-fronted Barbet (*Megalaima flavifrons*), Sri Lanka Hanging Parakeet (*Loriculus beryllinus*) and Sri Lanka Emerald Collared Parakeet (*Psittacula calthropae*).

Mammals: Sri Lankan Toque Monkey (*Macaca sinica*) and Fishing Cat (*Prionailurus viverrinus*).

Lowland rainforests or lowland wet evergreen forests

Tropical lowland wet evergreen forests represent 6.4 percent of the natural forest cover of the country. This forest type is restricted to the Wet Zone in the southwest of the island, up to a mean elevation of 1,000 m, and is, at present, highly fragmented. These forests are now represented primarily by isolated and very fragmented forest patches scattered over the Wet Zone. In the Mahaweli catchment area, these forests are located mainly in the Kandy and Nuwara Eliya Districts.

These forests are of particular importance as they constitute the last remnants of the once widespread mid-miocene tropical rainforests of Sri Lanka. They are exceptionally rich in biodiversity and high in endemism (approximately 60–75 percent of the tree species found in lowland rainforests are endemic to Sri Lanka), especially among the Dipterocarps, which constitute the characteristic tree flora and dominate the structural and floristic composition of this habitat type. Lowland wet evergreen forests harbour nearly all the woody endemic floral species found in Sri Lanka, as well as approximately 75 percent of the endemic fauna and all endemic genera. The level of endemism in these forests ranges from 37-64 percent for woody plants, and 14-52 percent for fauna, compared with 10-16 percent for species in Dry Zone forests. All endemic genera and over 90 percent of the woody endemic floral species and approximately 75 percent of the endemic fauna occur in these forests. In the lower slopes and valleys, these forests are characterized by a dense canopy of tree species reaching 30-40 m in height, with emergents rising to approximately 45 m, and woody lianas that form an intricate network (Gunatilleke *et al.* 2008).

Lowland wet evergreen forests are dominated by the families Dipterocarpaceae, Clusiaceae, Sapotaceae, Bombacaceae and Myrtaceae. At lower elevations (less than 100 m), *Dipterocarpus zeylanicus* (Hora) and *Dipterocarpus hispidus* (Bu hora) dominates the canopy within these forests, while *Mesua ferrea* (Na) and *Shorea trapezifolia*, dominate the canopy of these forests at higher elevations (above 100 m). Common species in the sub-canopy include *Cullenia rosayroana* (Katu boda), *Cullenia Ceylanica* (Katu boda) and *Myristica dactyloides* (Mala boda), while common species in the understorey include *Xylopia championii* (Dat ketiya) and *Garcinia hermonii* (Madol). Some of the other tree species present in this forest type include *Dimocarpus longan* (Mora), *Diospyros ebenoides* (Yabara), *Pleurostyliya opposite* (Panakka), *Semecarpus nigro-viridis* (Badulla) and *Vitex altissima* (Milla). Some of the shrub species present in this forest type include *Dimorphocalyx glabellus* (Weliwarana), *Glycosmis mauritiana* (Dodanpana), *Memecylon umbellatum* (Korakaha), *Miliusa indica* (Kekili messa) and *Streblus asper* (Kolapollan). Large leaves, drip tips on leaves, buttresses, cauliflory (fruiting and flowering from main stems), drooping young twigs, colourful young leaves and fewer lianas and epiphytes characterize this vegetation type (Gunatilleke, 2008).

Some of the endemic and threatened faunal species associated with lowland rainforests are as follows:

Butterflies: Ceylon Palm fly (*Elymnias singhala*), Ceylon Tree Nymph (*Idea iasonia*), Ceylon Tiger (*Parantica taprobana*), Blue Oakleaf (*Kallima philarchus*) and Common Birdwing (*Troides darsius*).

Amphibians: Kelaart's Dwarf Toad (*Adenomus kelaartii*), Sri Lanka Wood Frog (*Hylarana gracillis*), Corrugated Water Frog (*Lankanectes corrugatus*), Marbled Rock Frog (*Nannophyrus marmorata*), Ferguson's Shrub Frog (*Pseudophilautus fergusonianus*), Grey-Brown Pug-snouted Frog (*Ramanella obscur*), Sri Lanka Narrow-mouthed Frog (*Microhyla zeylanica*) and Bigfoot Shrub-Frog (*Pseudophilautus macropus*).

Reptiles: Leaf-nose Lizard (*Ceratophora tennentii*), Crestless Lizard (*Calotes liocephalus*), Whistling Lizard (*Calotes liolepis*), Great Forest Gecko (*Cyrtodactylus fraenatus*), Dwarf day Gecko (*Cnemaspis podihuna*), Kandyan Gecko (*Hemidactylus depressus*), Common Lanka Skink (*Lankascincus fallax*), Toeless Snake Skink (*Nessia monodactylus*), Dumeril's Kukri Snake (*Oligodon sublineatus*), Blyth's Earth Snake (*Rhinophis blythii*) and Green Pit Viper (*Trimeresurus trigonocephalus*).

Birds: Sri Lanka Spurfowl (*Galloperdix bicalcarata*), Sri Lanka Wood Pigeon (*Columba torringtoniae*), Sri Lanka Hanging Parrot (*Loriculus beryllinus*), Sri Lanka Emerald Collared Parakeet (*Psittacula calthropae*), Sri Lanka Yellow-eared Bulbul (*Pycnonotus penicillatus*), Spot-winged Thrush (*Zoothera spiloptera*), Sri Lanka Warbler (*Bradypterus palliseri*), Sri Lanka Hill Myna (*Gracula religiosa*) and Blue Magpie (*Urocissa ornata*).

Mammals: Red Slender Loris (*Loris tardigradus*), Purple-faced Leaf Monkey Toque (*Semnopithecus vetulus*), Sri Lanka Bi-coloured Rat (*Srilankamys ohienensis*) and Golden Palm Civet (*Paradoxurus aureus*).

Moist monsoon forests or tropical moist evergreen forests

Tropical moist evergreen forests represent 11.4 percent of the natural forest cover of the country. Tropical moist evergreen forests constitute a distinct group in the lowland Intermediate Zone (below 1,000 m). In the Mahaweli catchment, this forest type is located in the Badulla and Kandy Districts, as well as a small extent in the lower elevations of the Nuwara Eliya District. Trees in these forests are typically approximately 25-30 m tall, and represent the transition or ecotone between forests in aseasonal and seasonal climates. They bear similarities in species composition to both tropical lowland wet evergreen forests and tropical dry mixed evergreen forests, but also support some species of their own. The dominant floral families found within this forest type include Anacardiaceae, Sapindaceae, Euphorbiaceae and Moraceae. The dominant floral species observed in moist monsoon forests include *Mangifera zeylanica* (Etamba), *Canarium zeylanicum* (Dik kakuna), *Filicium decipiens* (Pehimbiya), *Dimocarpus longan* (Mora), *Nothopodia beddomei* (Andum telageddi), *Gironniera parvifolia* (Akmediya) and *Vitex altissima* (Milla). Some other tree species present include *Actinodaphne stenophylla* (Metidavula), *Drypetes gardneri* (Etaweera), *Gomphia serrata* (Rathgo), *Mallotus philippensis* (Molabe) and *Psychotria gardneri* (Labutharana). Lianas are also abundant in this forest type. Only approximately 17 percent of the tree species in these forests are endemic to Sri Lanka.

Some of the endemic and threatened faunal species associated with moist monsoon forests are as follows:

Butterflies: Ceylon Tree Nymph (*Idea iasonia*), Ceylon Tiger (*Parantica taprobana*) and Common Birdwing (*Troides darsius*).

Freshwater fish: Stone Sucker (*Garra ceylonensis*), Phillips' Garra (*Garra phillipsi*), Blotched Filamented Barb (*Dawkinsia srilankensis*), Martenstyn's Barb (*Systomus martenstyni*) and Banded Mountain Loach (*Schistura notostigma*).

Amphibians: Kelaart's Dwarf Toad (*Adenomus kelaartii*), Sri Lanka Wood Frog (*Hylarana gracilis*), Corrugated Water Frog (*Lankanectes corrugatus*), Hour-glass Tree-Frog (*Polypedates cruciger*), Small-eared Shrub Frog (*Pseudophilautus microtypanum*) and Grey-Brown Pug-snouted Frog (*Ramanella obscura*).

Reptiles: Kangaroo Lizard (*Otocryptis wiegmanni*), Leaf-nose Lizard (*Ceratophora tennentii*), Crestless Lizard (*Calotes liocephalus*), Whistling Lizard (*Calotes liolepis*), Spotted Bowfinger Gecko (*Cyrtodactylus triedra*), Fourtoe Snake Skink (*Chalcidoseps thwaitesii*), Dumeril's Kukri Snake (*Oligodon sublineatus*), Pipe Snake (*Cylindrophis maculata*) and Green Pit Viper (*Trimeresurus trigonocephalus*).

Birds: Sri Lanka Spurfowl (*Galloperdix bicalcarata*), Sri Lanka Wood Pigeon (*Columba torringtoniae*), Sri Lanka Hanging Parrot (*Loriculus beryllinus*), Sri Lanka Emerald Collared

Parakeet (*Psittacula calthropae*), Yellow-fronted Barbet (*Megalaima flavifrons*), Brown-capped Babbler (*Pellorneum fuscicapillus*), Sri Lanka Dusky Blue Flycatcher (*Eumyias sordidus*) and Sri Lanka Hill Mynah (*Gracula religiosa*).

Mammals: Red Slender Loris (*Loris tardigradus*) and Purple-faced Leaf Monkey (*Semnopithecus vetulus*).

Dry monsoon forests or tropical dry mixed evergreen forests

Tropical dry mixed evergreen forests represent 53 percentage of the natural forest cover of country. These forests are the characteristic vegetation type of the Dry Zone. In the Mahaweli catchment, these forests are located in drier parts of the Badulla District. Generally, the trees within this habitat type are approximately 25 m tall, and shorter in towards the Arid Zone. Approximately 13 percent of the tree species in these forests are endemic to Sri Lanka (MoENR/EML, 2006).

The families Euphorbiaceae, Sapindaceae, Ebenaceae, Sapotaceae and Rutaceae dominate this forest type. The dominant canopy species include *Manilkara hexandra* (Palu), *Chloroxylon swietenia* (Satinwood), *Schleichera oleosa* (Ceylon Oak) and *Pleurostyliia opposita* (Panakka), while species observed in the understorey are *Pterospermum suberifolium* (Welang), *Drypetes sepiaria* and *Dimorphocalyx glabellus* (Weli wenna) (MoENR/EML, 2006). These forests comprise of a mixture of evergreen and deciduous canopy species. In general, the latter are found in the canopy, shedding their leaves during the late dry period, allowing light to filter to the forest floor. This enables grasses and herbaceous species to flourish at the onset of the rainy season, before new foliage emerges on denuded canopy trees.

Although Dry Zone forests are considered to be less diverse than Wet Zone forests floristically, they are important as habitats for large mammals including leopards (*Panthera pardus*), elephants (*Elephas maximus*), spotted deer (*Axis axis*), sambhur (*Rusa unicolor*), and wild boar (*Sus scrofa*), as well as primate species, with faunal groups, such as carnivores, ungulates and primates, showing their highest species diversity in tropical dry mixed evergreen forests within Sri Lanka.

Savannah forests

The savannah forest type has evolved due to frequent fires related to human activities in the area. Typical savannah forests can be found in the Haldumulla area of the Badulla District. These savannah forests have a very simple structure, with isolated trees scattered over a vast expanse of grassland. An important characteristic feature of the tree species present in savannah forests is that they are well adapted to survive fires. This may be attributed to the thick bark covering their stems, which protects the internal tissues from heat. The annual occurrence of fires during the dry season between May and August is a common incidence almost every year. While all the grasses and herbaceous vegetation are destroyed by fire, but the underground parts of these species remain alive to produce new shoots with the onset of the rains. Lemon grass is the typical dominant grass species found in this community. The exotic species *Panicum maximum* (Guinea grass) also grows quite aggressively in savannah forests. This species is a good fodder plant for herbivorous mammals, and young grass shoots appear after the burning season, making the savannah a good feeding ground for wild herbivores.

Some of the tree species common to savannah forests include *Albizia odoratissima* (Panimara), *Alstonia scholaris* (Ruk attana), *Bridelia retusa* (Ketakela), *Chukrasia tabularis* (Barawahik), *Grewia damine* (Damunu), *Phyllanthus embilica* (Nelli), *Semecarpus nigro-viridis* (Badulla) and *Trema orientalis* (Gedumba).

3.3 Forest types in the Moragolla project area

The Moragolla project area falls within the wet climatic zone. Two types of natural forests were typical in this area - (i) sub-montane forests or tropical sub-montane forests (1,000 – 1,500 m) and (ii) lowland rainforests or lowland wet evergreen forests (<1000 m) - prior to the 1830s, before the clearing of forests for plantation agriculture such as coffee and tea. These forest formations occur in the project area primarily due to its rainfall and altitude. Deforestation in the last two centuries has resulted in the removal of a large part of natural forest cover for agricultural usage, including plantation agriculture (e.g. coffee and tea). At present, natural forest patches have been persevered only in very small areas on hilltops, especially in higher elevations. Generally, almost all the forests in the Moragolla project area at present are degraded secondary forests of original sub-montane and lowland rainforest types. Apart from these two forest types, other forest types, such as montane forests, moist monsoon forests, dry monsoon forests and savannah forests, present in the Upper Mahaweli catchment, are not found in the Moragolla project area. Further details regarding the forest cover and tree species present in the project area are presented in a separate section below.

3.4 The importance of protected areas

Protected areas (PAs) are designated with the objective of conserving nature and biodiversity, along with associated ecosystem services and cultural values. In addition to the conservation of the fauna and flora of a site, PAs provide many important ecosystem services, as well as several localized goods and services, including watershed protection, the provision of drinking water, the prevention of floods and soil erosion, carbon storage, water conservation and soil stabilization, eco-tourism, the regulation of rainfall, limiting the prevalence of disease and the provision of livelihoods for local people. In addition, PAs also hold important gene reservoirs that are of value in a variety of sectors including medicine, agriculture and forestry.

In the face of climate change, these roles become even more critical with regard to the enhancement of the adaptive capacity of local people to cope with climate change. PAs can contribute considerably to physical protection against major disasters, such as earth slips and landslides, by helping to maintain natural ecosystems, as the maintenance of ecosystems and protection of forests protection can reduce such impacts of climate change.

PAs can also provide a direct means of enhancing revenue, particularly through Non Timber Forest Products (NTFP) and nature tourism, as well as through the valuable services they provide. In addition, PA management can help to empower marginalized populations and communities through approaches such as community forest management.

a. The role of Protected Areas in the maintenance of watershed protection functions

Protected forest areas play an important role in the conservation of soil and water resources. Natural forest vegetation protects the soil from splash erosion by intercepting rainfall,

dissipating droplet energy and protecting the surface of the land with a covering of leaf litter. As a result of the presence of forest vegetation, rainfall infiltration is increased, while surface runoff and soil erosion are reduced. In addition, natural forests stabilize groundwater levels and stream flows. The relative importance of forests in watershed protection, soil and water conservation and minimizing flood hazards, differs between the Dry and Wet Zones of Sri Lanka due to differences in the intensity of rainfall and the steepness of the terrain.

There are several hydropower reservoirs within the Mahaweli basin in the hill country of the Wet Zone, including Victoria, Randenigala, Rantambe, Minipe, Kotmale and Upper Kotmale. The watersheds of these reservoirs are under severe population pressure, which has already resulted in severe deforestation and forest degradation. In the long term, if the forests in the catchment areas are not protected adequately, the sedimentation of reservoirs associated with excessive soil erosion may reduce their capacity to store water for hydropower and irrigation substantially, jeopardizing the agro-industrial base of the economy.

b. The role of Protected Areas in the conservation of biodiversity

It is believed that tropical rainforests support over half of the world's floral and faunal species. As such, these systems are considered to be some of the most biodiverse terrestrial systems to have evolved.

Sri Lanka is one of the smallest, but most biodiverse, countries in Asia. Hence, the economic value of its biodiversity is inestimable. There are many products harvested from forests that provide food and livelihood necessities to local communities, often at little to no cost. Some of these products enter more formal markets, while other items, including some items, such as yams, fruits, nuts, spices, leaf vegetables, medicinal herbs, rattan, bamboo, gums, resins and *kitul* (*Caryota urens*) products, are used by local communities on a domestic basis. Almost all the medicinal plants used in the traditional Ayurvedic medicinal practices are forest products that form a significant component of forest biodiversity. Similarly, the cottage industry developed through the manufacture of traditional crafts from rattan and bamboo extracted from forests is an important income source for some villagers in Sri Lanka.

c. The role of Protected Areas in nature tourism

Nature based tourism is considered to be rapidly growing component of the tourism industry world-wide. Nature based tourism focuses primarily around Protected Areas (PAs). In Sri Lanka, eco-tourism has been recognized as a high priority area capable of driving the country's economic development effectively. Accordingly, the national target for tourist arrivals in Sri Lanka is two million tourists by 2016, with tourism becoming a major foreign exchange earner for the country. Sri Lanka, with its rich biodiversity and high rate of endemism, holds very high potential for the development of nature based tourism, as promoted in current tourism development policies and plans.

3.5 Protected areas in the Mahaweli catchment

Protected Areas (PAs) are locations that receive protection due to their recognized natural, ecological and cultural values. The definition for PAs that has been accepted widely across regional and global frameworks has been provided by the International Union for Conservation of Nature (IUCN). The IUCN definition for a Protected Area is "*A clearly defined geographical space, recognized, dedicated and managed, through legal or other*

effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values” (IUCN, 2008). In practice, PAs are managed for a wide variety of purposes, including for scientific research, wilderness protection, preservation of species and ecosystems, maintenance of environmental services, protection of specific natural and cultural features, tourism and recreation, education, sustainable use of resources from natural ecosystems and maintenance of cultural and traditional attributes (MoENR/EML, 2006).

In Sri Lanka, the forest sector falls under the jurisdiction of the Forest Department (FD), the Department of Wildlife Conservation (DWC) and the State Timber Corporation (STC). In addition, a small fraction of forest areas (approximately two percent) falls under the jurisdiction of several other state sector institutions, as well as under private ownership. However, forest PAs within the country are managed by the Forest Department (FD) and the Department of Wildlife Conservation (DWC). The STC does not have any forest management authority and is only a commercial organization dealing with the extraction and sale of state timber. In the case of Forest Department PAs, Forest Reserves (FRs), Proposed Reserves (PRs) and Other State Forests (OSFs) (with protected forest vegetation), which are predominantly in a natural condition (at least two-thirds) and managed long-term protection of biodiversity, meet the criteria of IUCN Category VI – Managed Resource Protected Area (*Protected Area with Sustainable Use of Natural Resources*). Commercial forest plantations do not qualify under the criteria for PA categories of IUCN (MoALF, 1995). All forest areas under the jurisdiction of the DWC are recognized as PAs, and are protected legally under the *Fauna and Flora Protection Ordinance*. The legal protection for PAs under the FD is provided under the *National Heritage and Wilderness Areas Act*, as well as different sections of the *Forest Ordinance*.

In addition, based on a policy decision taken in 1990, all the natural forests in Sri Lanka have been withdrawn from commercial logging through the imposition of a logging ban since 1990, as a strategy for achieving forest conservation. Therefore, since 1990, all the natural forests of the country, including natural forests in the Mahaweli catchment, are managed based on conservation objectives.

The PAs network within the Mahaweli catchment includes six PAs under the jurisdiction of DWC, and 57 PAs under the FD. The most prominent of all the PAs within the Mahaweli catchment is the Central Highlands serial property World Heritage Site, which consists of the Knuckles Conservation Forest, Horton Plains National Park and the Peak Wilderness Protected Area (excluding the Peak itself and associated pathways). The Central Highlands of Sri Lanka was inscribed as a World Heritage Site in 2010, on account of its outstanding universal value as a Natural World Heritage Site. Of the three PAs included in the Central Highlands World Heritage Site, the Knuckles Conservation Forest falls under the jurisdiction of FD, while the other two PAs – the Horton Plains National Park and Peak Wilderness Protected Area - fall under the jurisdiction of the DWC. The aerial distance from the Moragolla project area to the Knuckles Conservation Forest of the Central Highlands World Heritage Site is approximately 35 km.

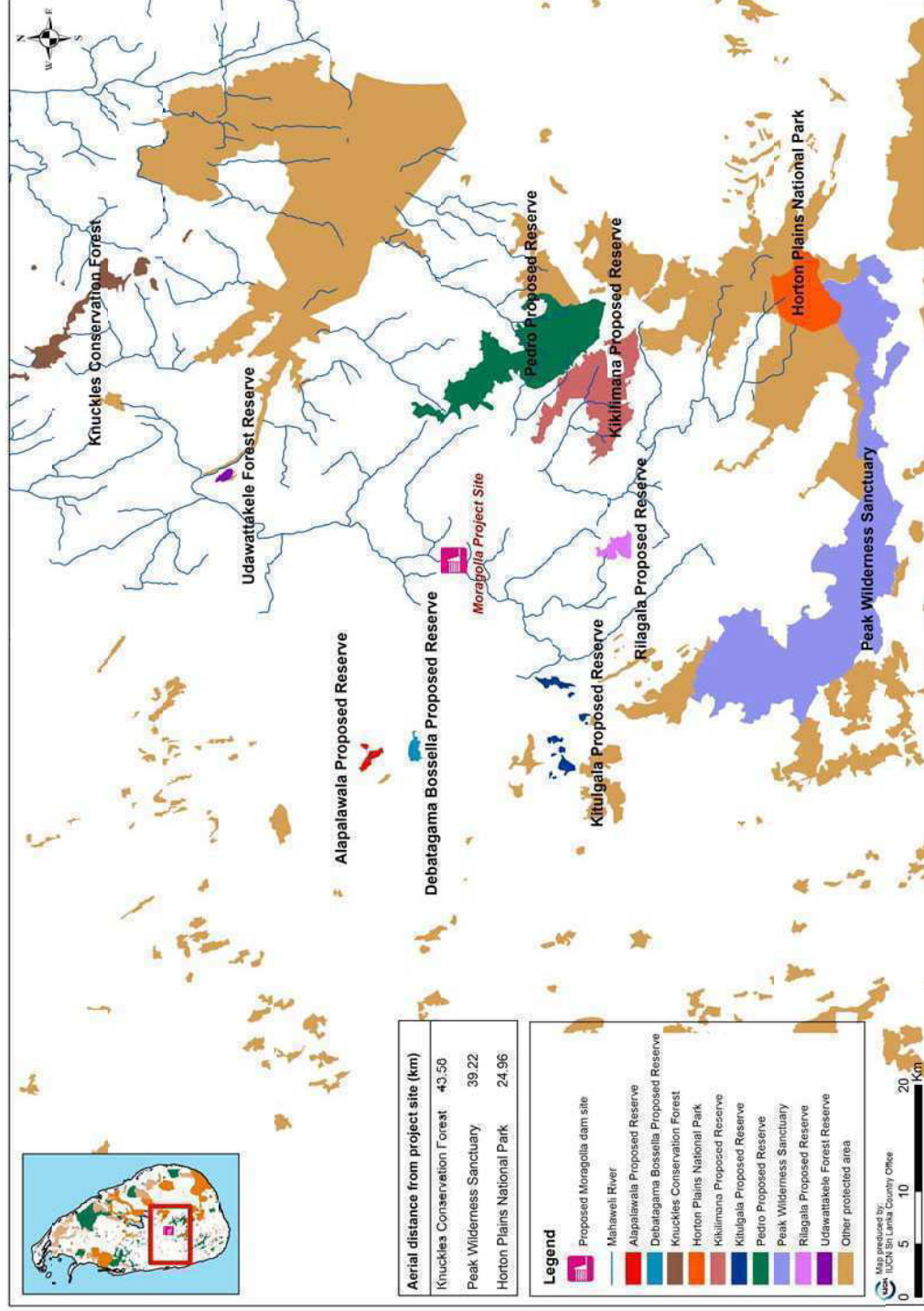
Individual PAs within the Mahaweli system under the jurisdiction of DWC include the Peak Wilderness Sanctuary (22, 380 ha), the Victoria-Randenigala-Rantambe Sanctuary (42, 087 ha), the Udawattakele Sanctuary (104 ha), the Horton Plains National Park (3, 160 ha), Galway's Land National Park (27 ha) and the Hakgala Strict Nature Reserve (1, 142 ha). The PAs within this area that fall under the jurisdiction of the FD consist of 17 Conservation

Forests including Knuckles, and 49 Forest Reserves. Udawattakele has been gazetted as both a Sanctuary (under the DWC) and a Forest Reserve (under the FD).

Details of Protected Areas within the Mahaweli catchment (Kandy, Nuwara Eliya and Badulla Districts) are provided in Table 3.

Table 3. Protected Areas within the Mahaweli catchment

Protected area	Management	Number	Location/District	Extent (ha)
World Heritage Site	DWC and FD	1	Kandy and Nuwara Eliya	42, 539
Strict Nature Reserve	DWC	1	Nuwara Eliya	1, 142
National Park	DWC	2	Nuwara Eliya	3,1 87
Sanctuary	DWC	2	Kandy	42, 191
Conservation Forest	FD	16	Kandy and Nuwara Eliya	
Forest Reserve	FD	49	Kandy and Nuwara Eliya	
Total		71		



Map 5. Key protected areas in close proximity to the Moragolla project area

3.6 The impact of the project on forests

The present status of the forest cover within the MHP area is discussed briefly below.

3.6.1 Forest cover within the project area

The proposed Moragolla reservoir area extends to approximately 3 km upstream of the proposed dam along the river, and will cover a surface area of approximately 36.5 ha, with a perimeter of 7, 100 m. The proposed elevation of the reservoir, once filled, will be 548 m MSL. The water level will increase by approximately 25-30 m, and as a result, the banks of the first 500 m upstream from the dam are likely to become inundated. Approximately 90 percent of the land area near the dam that will get inundated due to the proposed reservoir, will be the river bed and reservation area, which consists of degraded forest vegetation. The remaining ten percent of the land that will be inundated consists of residential lands with home gardens and mixed crops. These lands are owned by private parties.

Relatively undulating topography with mixed vegetation is prominent in the proposed project area at present, with tea lands, abandoned tea lands, home gardens and shrubs being the dominant land uses observed in the area.

In the right bank the river close to the dam site, A stretch of degraded secondary forest can be observed on the right bank of the river, in close proximity to the proposed dam site, between the road and the Mahaweli River. . Abandoned lands under different serial stages of regeneration are also found in patches within the area. Further, degraded grasslands are present on the slopes of hill tops (see photocatalogue for images).

The MHP is likely to impact the forests of the area due to establishment of permanent and temporary structures such as the dam, tunnel power house, switch yard, transmission lines, the development of new roads and widening of old roads, and the formation of the reservoir. In addition, the establishment of temporary structures such as labour camps, quarry sites, waste disposal sites and vehicle service areas, may also result in temporary impacts on the forest vegetation of the area. The impact of the proposed project on forest vegetation is due primarily to forest clearing in the inundation and construction areas, and disturbances to the forests in the vicinity of the construction areas. As such, it is anticipated that forest areas will be affected at the following sites:

- The inundation area;
- The dam site and surrounding area;
- The power house and surrounding area;
- Areas associated with the transmission line; and
- Areas where roads are constructed or widened.

Details of the vegetation present in these areas are presented in the tables below.

a) The inundation area

The vegetation in the inundation area includes grass and shrub dominated vegetation with a few scattered trees. The main species found in this area are presented in the following table.

Table 4. Grass, shrub and tree species found in the inundation area

No.	Species	Local name	Nature of vegetation
1.	<i>Panicum maximum</i>	Rata tana or Guinea grass	Grass
2.	<i>Arundo donax</i>	Giant cane	Shrub
3.	<i>Mimosa pigra</i>	Giant (Yoda) nidikumba	Shrub
4.	<i>Trema orientalis</i>	Gedumba	Tree
5.	<i>Symplocos cochinchinensis</i>	Bombu	Tree
6.	<i>Macaranga peltata</i>	Kenda	Tree
7.	<i>Macaranga indica</i>	Kenda	Tree
8.	<i>Cipadessa baccifera</i>	Hal bambiya	Tree
9.	<i>Syzygium caryophyllum</i>	Dan	Tree
10.	<i>Alstonia macrophylla</i>	Hawari nuga	Tree
11.	<i>Acacia mangium</i>	Acacia	Tree
12.	<i>Syzygium jambos</i>	Seeni Jambu	Tree
13.	<i>Madhuca nerifolia</i>	Gam mi	Tree
14.	<i>Albizia falcataria</i>	Mara	Tree
15.	<i>Mallotus tetracoccus</i>	Bu-kenda	Tree
16.	<i>Homonoia riparia</i>		Tree
17.	<i>Aporosa lanceolata</i>	Heen kebella	Tree
18.	<i>Clusia rosea</i>	Gal goraka	Tree
19.	<i>Ficus spp.</i>	Nuga	Tree
20.	<i>Artocarpus nobilis</i>	Wal Del	Tree
21.	<i>Actinodaphne elegans</i>		Tree
22.	<i>Ficus racemosa</i>	Attikka	Tree

b) The dam site and surrounding area

The vegetation found in the proposed dam site and its surrounding area is highly disturbed as a result of human activities, with grasses, shrubs and pioneer tree species being reported from the proposed dam site. The main species found in this area are given in the table below.

Table 5. Vegetation found in the dam site and surrounding area

No.	Species	Local name	Nature of vegetation
1.	<i>Panicum maximum</i>	Rata tana or Guinea grass	Grass
2.	<i>Mimosa pigra</i>	Giant (Yoda) nidikumba	Shrub
3.	<i>Trema orientalis</i>	Gedumba	Tree
4.	<i>Macaranga peltata</i>	Kenda	Tree
5.	<i>Symplocos cochinchinensis</i>	Bombu	Tree
6.	<i>Eupatorium odoratum</i>	Podisinnomaran	Tree
7.	<i>Acacia mangium</i>	Acacia	Tree

c) The power house and surrounding area

The power house will be located in the abandon land near the river. The vegetation in this area is dominated by grasses and shrubs, with a few scattered trees. The main species found in this area are given in the table below.

Table 6. Vegetation in the power house and surrounding area

No	Species	Local name	Nature of vegetation
1.	<i>Panicum maximum</i>	Rata tana or Guinea grass	Grass
2.	<i>Mimosa pigra</i>	Giant (Yoda) nidikumba	Shrub
3.	<i>Lantana camara</i>	Gandapana	Shrub
4.	<i>Trema orientalis</i>	Gedumba	Tree
5.	<i>Macaranga peltata</i>	Kenda	Tree
6.	<i>Alstonia macrophylla</i>	Hawari nuga	Tree
7.	<i>Eupatorium odoratum</i>	Podisinnomaran	Tree
8.	<i>Makania cordata</i>	Watu palu	Tree
9.	<i>Ipomoea cairiea</i>		Tree
10.	<i>Gliricidia sepium</i>	Weta mara	Tree
11.	<i>Hyptis suaveolens</i>	Maduruthala	Tree
12.	<i>Stachylarpheta jamaicensis</i>	Balu nkuta	Shrub

d) Areas associated with the transmission line

About 80 percent of the length of the transmission line traverses above home gardens, while the rest passes over abandoned lands. The vegetation in the home gardens are given below. The abandoned lands are covered mostly by a secondary growth dominated by pioneering herbaceous and shrub species. The most significant species in these lands are given in the table below.

Table 7. Vegetation in the areas associated with the transmission line

No.	Species	Local name	Nature of vegetation
1.	<i>Panicum maximum</i>	Rata tana or Guinea grass	Grass
2.	<i>Lantana camara</i>	Gandapana	Shrub
3.	<i>Eupatorium odoratum</i>	Podisinnomaran	Tree
4.	<i>Ageratum conyzoides</i>	Hulan tala	Shrub
5.	<i>Blechnus orientais</i>	Pattara werella	Tree
6.	<i>Crotalaria spp</i>		Tree
7.	<i>Dicranopteris linearis</i>	Kekilla	Shrub

e) Areas where roads are constructed or widened

Homegardens, abandoned lands and tea lands are the main land use types affected by proposed new road and road expansion areas. The main species found in this area are given in the table below.

Table 8. Vegetation in the areas where roads are constructed or widened

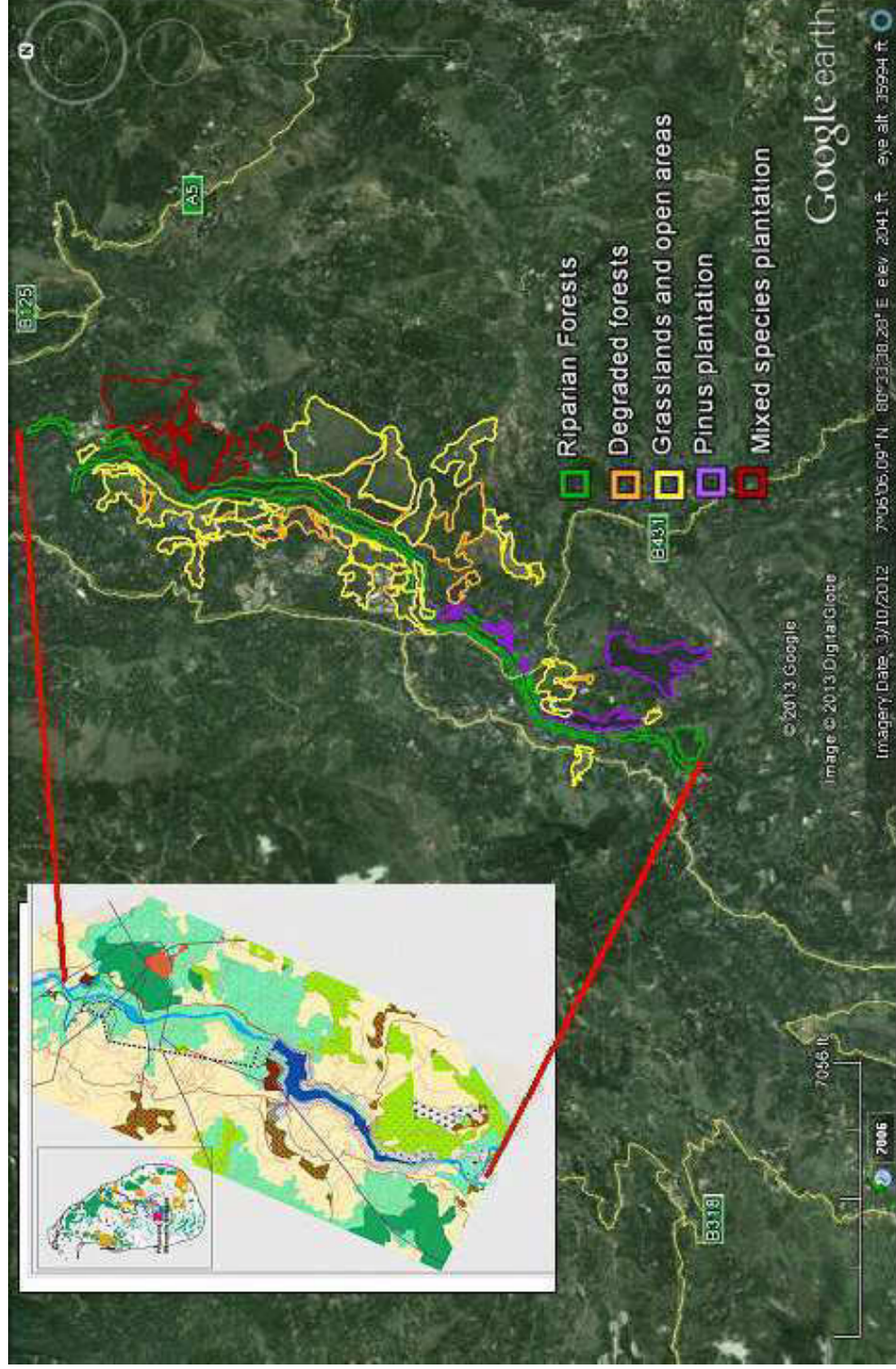
No.	Species	Local name	Nature of vegetation
1.	<i>Panicum maximum</i>	Rata tana or Guinea grass	Grass
2.	<i>Trema orientalis</i>	Gedumba	Tree
3.	<i>Macaranga peltata</i>	Kenda	Tree
4.	<i>Alstonia macrophylla</i>	Hawari nuga	Tree
5.	<i>Mangifera indica</i>	Amba	Tree
6.	<i>Artocarpus heterophyllus</i>	Kos	Tree
7.	<i>Persea americana</i>	Ali pera	Tree
8.	<i>Michelia champaca</i>	Sapu	Tree
9.	<i>Switenia macrophylla</i>	Mahogany	Tree
10.	<i>Cocos nucifera</i>	Pol	Tree
11.	<i>Areca catechu</i>	Puwak	Tree
12.	<i>Syzygium aromaticum</i>	Karabu	Tree
13.	<i>Melastoma malabathricum</i>	Maha bovitia	Tree
14.	<i>Cymbopogon nardus</i>	Pangirimana	Grass
15.	<i>Lantana camara</i>	Gandapana	Shrub
16.	<i>Dicranopteris linearis</i>	Kekilla	Shrub

g) Home garden vegetation

Home garden vegetation in this area is dominated by cultivated plant species. The following are the main species in home gardens.

Table 9. Main species found in home gardens

No.	Species	Local name	Nature of vegetation
1.	<i>Macaranga peltata</i>	Kenda	Tree
2.	<i>Alstonia macrophylla</i>	Hawari nuga	Tree
3.	<i>Mangifera indica</i>	Amba (Mango)	Tree
4.	<i>Artocarpus heterophyllus</i>	Kos (Jak)	Tree
5.	<i>Persea americana</i>	Ali pera	Tree
6.	<i>Michelia champaca</i>	Sapu	Tree
7.	<i>Switenia macrophylla</i>	Mahogany	Tree
8.	<i>Cocos nucifera</i>	Pol (Coconut)	Tree
9.	<i>Areca catechu</i>	Puwak	Tree
10.	<i>Syzygium aromaticum</i>	Karabu	Tree
11.	<i>Nephelium lappaceum</i>	Rambutan	Tree
12.	<i>Albizia falcataria</i>	Mara	Tree



Map 6. Forest cover within the project area
(Based on a satellite image obtained from Google Earth)

3.6.2 Removal of trees due to project activities

The removal of trees from the project area due to various project activities is discussed below.

a. Road construction: According to the EIA Report for the proposed MHP (CECB, 2012), a total of 489 trees with Diameter at Breast Height (DBH) of more than 20 cm will be removed or impacted due to various activities planned under the project. The construction of new roads and widening of existing roads will account for the removal of more than 48 percent of these trees. According to estimates, approximately 231 trees, belonging to 28 species, with DBH over 20 cm will be affected as a result. The species that will be affected the most due to road construction are *Artocarpus heterophyllus* (Jak) (58 trees) and *Swietenia macrophylla* (Mahogany) (53 trees). The area in which these activities will take place consist primarily of abandoned lands and home gardens located near the dam site and power house. As the affected area is spread over a large area, the magnitude of the impact on the area due to the removal of trees for road construction is expected to be minimal (CECB, 2012).

b. Establishment of the reservoir: An estimated 179 trees, belonging to 26 species, with DBH over 20 cm will be affected due to the establishment of the reservoir. This activity will have the second highest impact on trees as nearly 38 percent of the trees that will be lost due to the project will be lost as a result of reservoir construction. The species affected the most by the establishment of the reservoir are *Albizia falcataria* (Mara) (34 trees) and *Peltophorum pterocarpum* (23 trees). The river-side vegetation consists primarily of grasses and herbs with a few scattered trees. Given that the impact is spread over a large area, the magnitude of the impact is expected to be minimal.

c. Construction of the transmission line: A total of 28 individual trees, belonging to nine species, with DBH over 20 cm will be affected due to the construction of the transmission line. Four of the species affected are exotic, while the remaining five species are indigenous to Sri Lanka. No endemic or nationally threatened plant species will be removed as a result of the construction of the transmission line.

d. Other construction activities: According to the EIA study carried out by CECB and ACO in 2012, removal of trees due to other construction activities is insignificant; as most of these activities are carried out in abandoned lands or on private lands that has no natural habitats and only a few trees will be lost due to rest of the activities¹.

3.7 Rationale for the reservoir buffer zone and AWMP

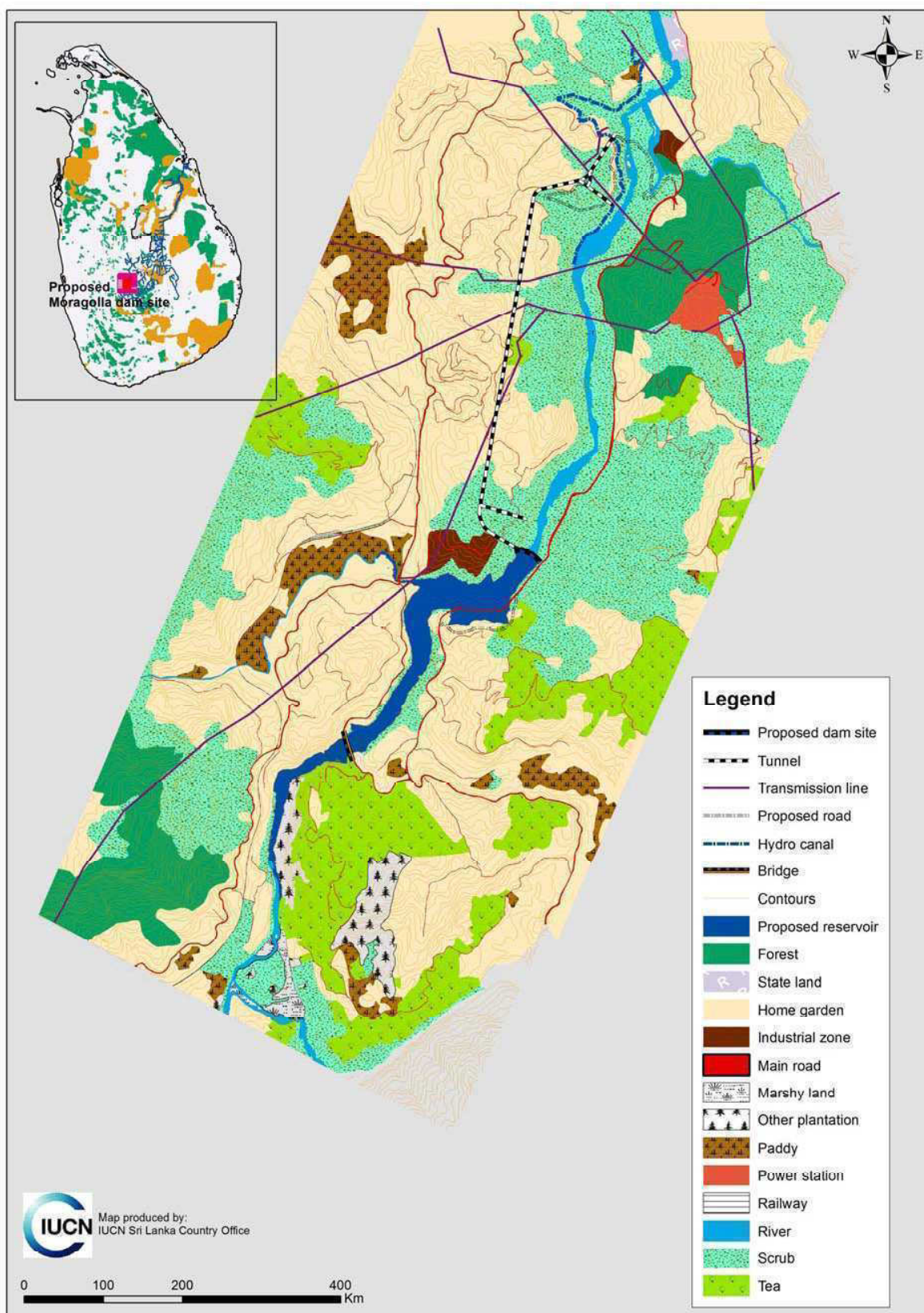
The project location has been selected to avoid and minimize the environmental impacts of the MHP to as great an extent as possible. The terrestrial area within the project site is already degraded due to human activities, including farming. The remaining forest area is highly degraded, and its vegetation is secondary in nature, with many pioneer species and introduced (exotic) tree species. However, the reforestation of an area approximately 100 ha in extent around the proposed reservoir has been planned in order to mitigate the negative impacts of the project, and to compensate for the loss of trees, by providing new habitats and creating a buffer zone, in which human activities are to be prohibited. This proposal serves the following purposes:

¹ CECB and ACO (2012) Environmental Impact Assessment Study, Final Report, Vol. 3, (Page 106).

- This proposed new forested buffer zone around the reservoir will provide effective protection for the immediate catchment of the reservoir against soil erosion and potential siltation of the proposed reservoir.
- The proposed reservoir buffer zone will serve as a refuge to fauna displaced due to project activities. The most suitable tree and shrub species for this purpose will be planted in this area at the time of planting. Suitable tree and shrub species and methods of planting to be decided at the stage of site-specific selection of suitable species (refer to section on Planning and Preparation for Afforestation/Reforestation programme).
- A section of the new buffer zone may be used for the conservation of threatened and endangered floral species by planting and protecting such species within the buffer zone.

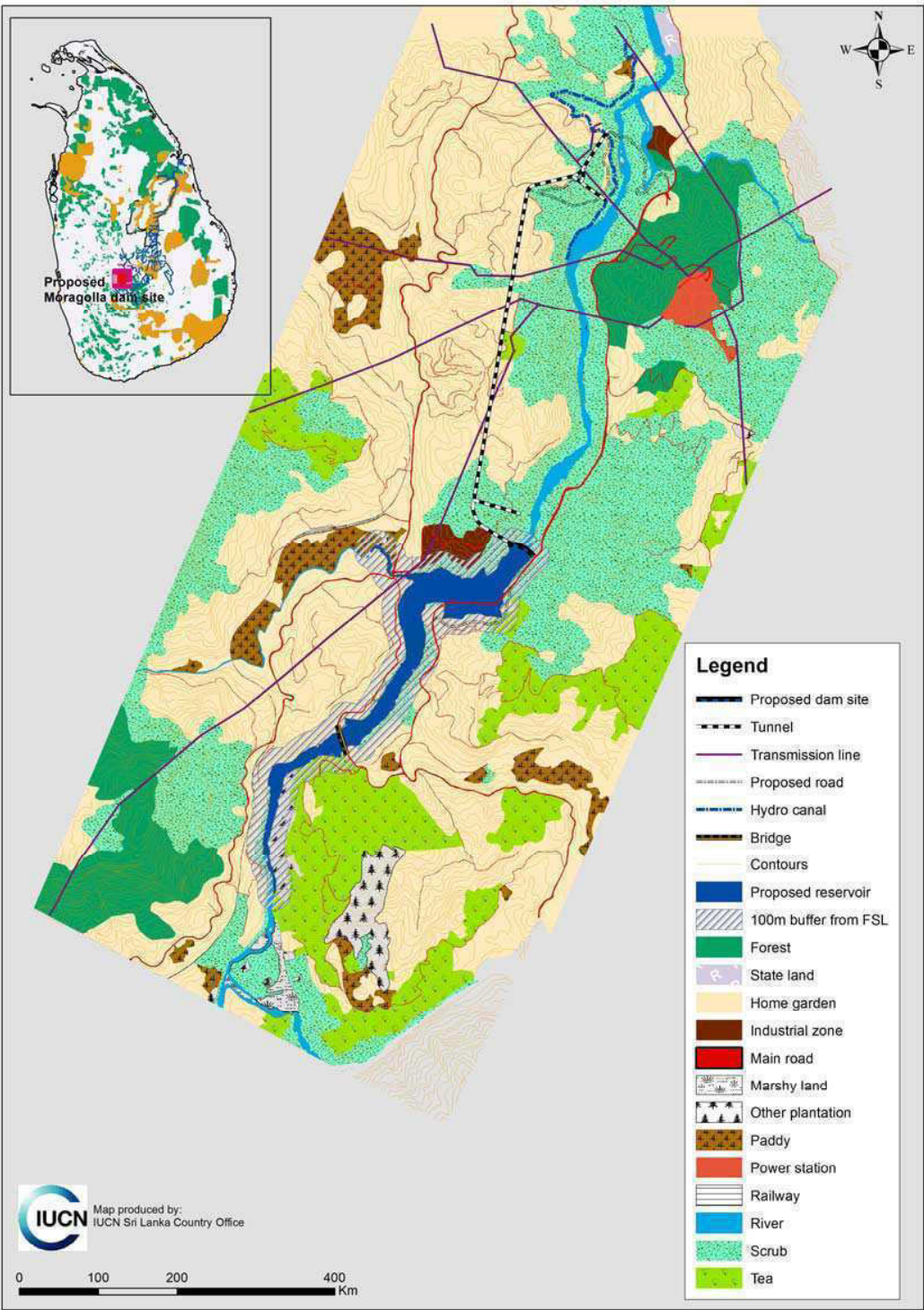
The present land use types observed within the project area included degraded and abandoned tea lands, abandoned lands, residential areas, home gardens, small scale agricultural areas, paddy lands, degraded forests and an industrial estate. Tea lands that lack adequate soil conservation measures occupy a large extent of land within the proposed Moragolla reservoir catchment area. Additionally, most of other land use systems within the area, including the industrial estate, do not provide adequate vegetative cover to protect against soil erosion and prevent siltation of the reservoir.

A land use map of the Moragolla Project given below.



Map 7. Land use map of the Moragolla project area.

A land use map of the area showing the proposed buffer zone is presented in Map 8 below.



Map 8. Land use map showing the proposed 100 m buffer zone around the reservoir.

With consideration of the land use types within the catchment, and the associated soil erosion issues, the Natural Resources Management Center of the Department of Agriculture has recommended the following:

- Implementation of soil conservation activities within the immediate catchment of the reservoir without delay;
- Initiation of conservation measures from the crest of the immediate catchment and downwards; and
- Taking steps to create awareness among local communities on the need for soil conservation.

Therefore, in order to prevent siltation and ensure the sustainability of the proposed Moragolla reservoir, it is necessary to develop a suitable plan to control soil erosion in the catchment area. Hence, one of the key purposes of the Afforestation and Watershed Management Plan (AWMP) for the Moragolla reservoir area, is to provide effective protection against soil erosion from the catchment and siltation of reservoir.

According to the present land use in the area, the 100 m buffer zone includes state lands (reservations with degraded forests), private home gardens, cultivated lands, tea lands and RDA lands (road reservations). New legislation is required to regulate land use activities in these areas in order to ensure legal protection of the buffer zone. The most appropriate action would be to declare the buffer zone as an “Environmental Protection Area” under the National Environment Act. The Central Environmental Authority (CEA) is the authority for the administration of the National Environment Act. No one is authorized to carry out prohibited actions in “Environmental Protection Areas”.

3.8 Forestry and afforestation in Sri Lanka: history and current programmes

The history of afforestation in Sri Lanka

The Forest Department (FD), the State Timber Corporation (STC) and the Department of Wildlife Conservation (DWC), are the three main institutions active within the forestry sector in Sri Lanka. The FD manages approximately 55 percent of the natural forests in the country, as well as approximately 90, 000 ha of forest plantations, including teak, mahogany, *Eucalyptus*, *Pinus* and other local species, which account for nearly 1 percent of the land area of the country. The remaining areas of natural forest (approximately 43 percent) are managed by the DWC and other government institutions, as well as by the private sector (approximately two percent).

All the forests managed by the DWC fall under the category of Protected Areas (PAs). The natural forests under the jurisdiction of the FD include both PAs and Multiple Use Management Forests. The STC has a monopoly on harvesting and marketing timber from state owned forests and forest plantations. The FD is the state agency that is responsible for the afforestation of state owned lands. However, there is no restriction to or prohibition of afforestation by other state parties or private institutions, as long as they have the required technical capability for conducting such work.

The Forest Department of Sri Lanka was established in 1887, during the colonial administration period. It has engaged in afforestation and reforestation activities in Sri Lanka since the beginning of the twentieth century. Teak is the oldest species planted in the country, and was introduced by the Dutch during the seventeenth century. The FD engaged

in cooperative reforestation through the Burmese 'Taungya System' in the Dry Zone between the 1960s and 1980s. The main tree species planted under this programme was teak. This was later expanded to other parts of the country, including the Intermediate Zone.

The planting tropical pines, including the Caribbean pine – an exotic species - on a large scale commenced in the early 1970s in the hill country, as well as in lowlands of the Wet Zone. However, the planting of pines ceased during the mid-1990s. The extraction of oleoresins from pines has been a lucrative business in Sri Lanka, but is being practiced only on a minor scale at present.

The planting of *Eucalyptus* in Sri Lanka was first reported in 1915. Several *Eucalyptus* species are now grown extensively in the hill country.

The establishment of *Artocarpus heterophyllus* (Jak) and *Swietenia macrophylla* (Mahogany) mixed plantations in the Intermediate Zone commenced during 1930s. These uneven aged plantations are managed on a selection system. The last decade is characterized by the increasing trend to plant *Khaya senegalensis* (African mahogany) in the second rotation areas of the Dry and Intermediate Zones.

In addition, many other native and exotic tree species are planted on a minor scale by the Forest Department. This includes species such as *Dipterocarpus zeylanicum* (Hora), Halmilla (*Berrya cordifolia* (Halmilla), *Azadirachta indica* (Margosa), *Artocarpus integrifolia* (Jak) and a few *Acacia* species, such as *Acacia mangium* and *Acacia auriculiformis*.

The FD introduced community forestry programmes to Sri Lanka around the mid 1980s. A more enhanced version of community participation established through the Participatory Forestry Project (1993-2000) implemented by the FD with the financial assistance from the Asian Development Bank (ADB). Each farmer was given a land of 0.4 ha on lease for 25 years, along with 400 utility timber seedlings. They were planted at a wider spacing of 2 x 5 m, while intercropping was practiced. As part of this programme, the beneficiaries were entitled to the entire timber yield raised by them. In addition to these woodlots, the project also consisted of three other components - planting trees in home gardens, establishing protective woodlots and miscellaneous planting, such as planting along roads, avenues and alleys. At present, the same programme is being implemented on a benefit sharing basis, through which 80 percent of the timber yield goes to the beneficiary, while 20 percent goes to the state.

The afforestation programmes carried out by the FD during the last three decades were financed by mainly by donor agencies. The key donors that provided funding for these programmes include USAID, the World Bank, ADB and AusAID. In addition, small-scale afforestation programmes were carried out with funding from the General Treasury. These donor assisted afforestation programmes include the Reforestation and Watershed Management Project (USAID), the Forest Resources Development Project (World Bank), the Forestry Sector Development Project (World Bank), the Community Forestry Project (ADB), the Participatory Forestry Project (ADB), the Forest Resources Management Project (ADB) and the Sri Lanka Australia Natural Resources Management Project (AusAID).

A summary of the key forestry projects and programmes implemented during the last 30 years in Sri Lanka is presented in Table 10 below.

Table 10. Key forestry projects and programmes implemented in Sri Lanka during the last 30 years.

(Developed based on information from the Forest Department)

No	Project and funding source	Period and implementation agency	Objective
1.	Reforestation and Watershed Management Project (USAID)	1980-1987 (FD)	Reforestation and watershed management in the Mahaweli basin.
2.	Community Forestry Project (CFP) (ADB)	1985-1989 (FD)	Community forestry development.
3.	Forestry Sector Development Project (FSDP) (World Bank)	1989-2004 (FD)	Development of the forestry sector in Sri Lanka.
4.	Participatory Forestry Project (PFP) (ADB)	1994–1998 (FD)	Participatory forestry development.
5.	Conservation and Sustainable Use of Medicinal Plants Project (World Bank/GEF)	1998-2004 (DAU/FD/DWC)	Conservation and sustainable use of medicinal plants, including <i>in-situ</i> and (In-situ & Ex-situ Conservation)
6.	Southwest Rainforest Conservation Project (UNEP/GEF and GEF/UNDP)	2000-2006 (FD)	Participatory forest conservation.
7.	Forest Resources Management Project (FRMP) (World Bank/GEF/DFID)	2000-2006 (FD)	Forest resource management in Sri Lanka.
8.	The Protected Area Management and Wildlife Conservation Project (ABD/GEF)	2001-2008 (DWC)	Protected area management and wildlife conservation.
9.	Sri Lanka Australia Natural Resources Management Project (AusAID)	2003-2008 (FD)	Poverty reduction through improved natural resource management.
10.	Sri Lanka Community Forestry Programme (SLCFP and AusAID)	2012 – 2015 (FD)	Community forestry.

Currently, only one donor assisted programme is implemented for afforestation in Sri Lanka. It is the Sri Lanka Community Forestry Programme funded by AusAID. This programme is implemented in 17 administrative districts in Sri Lanka.

The main objectives of afforestation programmes implemented by the Forest Department have been production of timber in order to meet the requirements of the country, and conservation and stabilization of soil associated with steep slopes and stream reservations.

Large-scale forest tree planting in Sri Lanka commenced in late 1950's. An estimated extent of approximately 105, 000 ha of forest plantations exist within the country at present. Of this, approximately 96, 000 ha belong to the FD, while the remaining area falls under private ownership particularly, in the plantation sector. The main plantation species are teak (*Tectona grandis*), eucalyptus for timber (mainly *Eucalyptus grandis* and *Eucalyptus myrcorrhiza*), pine (*Pinus caribaea*), mahogany (*Swietenia macrophylla*), acacias (*Acacia mangium* and *Acacia auriculiformis*) for timber and fuel wood, and mixed species of *Albizia*, *Khaya* (*Khaya senegalensis*), and indigenous species such as Kohomba (*Azadirachta indica*), Halmilla (*Berrya cordifolia*), Lunumidella (*Melia dubia*) and Godakirilla (*Holoptelea integrifolia*) for timber. Some of these forest plantations (approximately five percent) are protective plantations that are located in steep slopes with gradients over 30 percent. These forest plantations are maintained for soil conservation purposes, and are not harvested due to conservation reasons.

The FD has prepared Forest Plantation Management Plans for key forest plantation species such as teak, *Eucalyptus*, *Pinus* and mahogany, in order to ensure sustainable management of these resources. These plans provide the guidelines necessary for management operations, including the harvesting of timber by the STC. Forest plantations with these species are managed according to the management guidelines provided in the management plans. A summary of the forest plantations established by the FD until 2009 is provided in Table 11 below.

**Table 11. Forest plantations established by the Forest Department
(Forest Department, 2010)**

Species	Extent (ha)
Teak	30, 277
Eucalyptus (up country)	9, 338
Eucalyptus (dry zone)	15, 008
Pine	17, 240
Mahogany	5, 325
Acacia	8, 830
Albizia	405
Kohomba	1, 040
Alstonia	390
Kaya	293
Jak	90
Hora	72
Indigenous species	7, 942
Total	96, 250

3.9 Legal requirements for afforestation in Sri Lanka: laws, responsible agencies, approval procedure and requirements

As discussed, there are no specific legal requirements related to implementing afforestation work in Sri Lanka. Usually, afforestation in state owned lands is carried out by the FD. However, there are no prohibitions or restrictions preventing other state or private institutions from performing afforestation work, provided that they have the land and technical capability required.

Although there are no legal requirements related to afforestation, legal requirements exist where forest clearing is involved. Clearing of forests over one hectare for reforestation or any other purpose requires an Environmental Impact Assessment (EIA) to be carried out according to the legal provisions of the National Environment Act. It is also necessary for approval to be obtained from the project approving agency. Furthermore, legal provisions are available under the Forest Ordinance for the protection of forests, including afforested areas, such as that proposed for the MHP area. The FD is the authority responsible for implementing this law. Unauthorized clearing or felling of trees in forests or forest plantations is prohibited under the Forest Ordinance and legal action can be taken against violation of this law.

4 AFFORESTATION/REFORESTATION² PLAN

4.1 Rationale and guiding principles

The growth of the demand for electricity in Sri Lanka has followed the growth in the economy closely in recent years, illustrating the need for a reliable and uninterrupted supply of electricity provided at a reasonable price if the current trend of economic growth is to continue. The proposed MHP, which is expected to produce 30.8 MW, will, therefore, make a significant contribution to the electricity generating capacity of the country, as well as the economy. The proposed project involves the construction of a dam, forming a reservoir with a storage capacity of 4.23 MCM at full supply level, covering a surface area of 36.5 ha, with a perimeter of 7, 100 m.

4.1.1 Justification for the proposed afforestation programme

Both banks of the proposed reservoir consist of steep to very steep (30-50°) slopes. According to the soil conservation plan for the Moragolla catchment prepared by the Natural Resources Management Center of the Agriculture Department, approximately 14 percent of the reservoir catchment is on a slope of over 45 percent. Such areas are vulnerable to severe soil erosion, which ultimately results in siltation of the reservoir. These lands in the immediate catchment of the reservoir should be kept as undisturbed forest vegetation, which provides the best protection against such erosion.

The forests in the project area are currently degraded in nature due to various anthropogenic activities and pressures. In addition, there are abandoned lands in the catchment area that consist of grass dominated vegetation and a few scattered trees. These land uses are also vulnerable to the risk of erosion, and as such, protective forest vegetation is the ideal soil cover for these areas. Degraded forest areas may be enriched to improve forest cover, while abandoned areas should be afforested with suitable tree species.

Similarly, the establishment of a refuge - a protected area that can support key species including endemic and threatened species - of adequate size is necessary within the afforestation area in order to provide suitable habitats for terrestrial species that are displaced due to the construction of the dam, the development of the reservoir and other proposed project activities. Such sites are important for the minimization of the negative impacts of the MHP, as well as the conservation of threatened and endemic species found within the project area. It is important to identify such areas within the afforestation area, and to plant suitable tree species within such a refuge, so as to create a suitable environment. It is also necessary to ensure that these areas are protected adequately from anthropogenic and natural pressures, including fires.

4.2 Proposed afforestation/reforestation sites for Moragolla project

Potential sites for the implementation of an afforestation/reforestation programme include areas belonging to the following land categories:

a. Riparian sites: This includes afforestation on the banks and shoulder lands of the Mahaweli River. Riverine vegetation can be observed around the reservation of the river, particularly on the right bank, as well as in steep areas adjacent to the river. Riverine

² Afforestation refers to the planting of trees on areas that were not covered with forests, while reforestation refers to the re-planting of trees on areas that were once covered with forests.

vegetation is disturbed or absent towards the Ulapane area, where settlers have encroached on the reservation area.

b. Degraded forest sites: This habitat is highly disturbed and is only restricted to isolated patches of forest in certain areas of the immediate catchment, for example at the ridges of the watershed. The vegetation in such areas consists of degraded secondary wet evergreen forests, at present. Such sections are very limited and fragmented. In between these fragments of degraded forest, the vegetation has regenerated as grasslands and shrub lands.

c. Abandoned lands: These lands are predominantly abandoned tea lands, or lands that have been cleared for other cultivations. These areas are dominated by grasslands with some scattered trees, shrubs and herbs.

d. Pine plantations: There are a few blocks of pine plantations in the catchment area. There is a pine plantation of approximately 9 ha in extent around 2 km upstream on the left bank of the proposed reservoir. This plantation is estimated to be over 25 years, and is suitable for felling. It has been used for resin tapping, and is now in a bad condition. Hence, this over-aged pine plantation can be felled in strips, and re-planted with suitable local species.

e. Home gardens: Kandyan type home gardens are the other major land use in the catchment area. These home gardens are dominated with fruit trees, trees with timber value and multi-purpose trees. However, these lands are managed poorly in terms of soil and water conservation. The average size of a homestead ranges from 0.2 to 0.4 ha.

4.3 Species recommended for the afforestation/reforestation programme

A list of species that are recommended for the afforestation programme in the Moragolla catchment is presented in Table 12 below.

Table 12. Species recommended for the afforestation programme

Species	Local name	Occurrence of species at present
<i>Albizia lebbbeck</i>	Albizia (Sooriya Mara)	Yes
<i>Albizia odoratissima</i>	Albizia (Mara)	Yes
<i>Anacardium occidentale</i>	Cashew (Kaju)	Yes
<i>Annona muricata</i>	Anoda	Yes
<i>Artocarpus nobilis</i>	Waldel	Yes
<i>Artocarpus altilis</i>	Breadfruit (Del)	Yes
<i>Artocarpus heterophyllus</i>	Jakfruit (Kos)	Yes
<i>Azadirachta indica</i>	Margosa, Neem (Kohomba)	Yes
<i>Bamboo spp (Bambusa vulgaris)</i>	Bamboo (Bata)	Yes
<i>Capparis sp.</i>	Wellangiriya	No
<i>Caryota urens</i>	Kithul	Yes
<i>Carallia brachiata</i>	Dawata	No
<i>Cassia siamea</i>	Waa	No
<i>Cassia sp.</i>	Thora	Yes
<i>Chloroxylon swietenia</i>	Satinwood (Burutha)	No
<i>Cinamoum mooniana</i>	Kududaula	No

Species	Local name	Occurrence of species at present
<i>Dendrocalamus</i> spp.	Una	Yes
<i>Dipterocapus zeylanicus</i>	Hora	No
<i>Elaeocarpus serratus</i>	Veralu	Yes
<i>Erythrina subumbrans</i>	Erabadu	Yes
<i>Ficus</i> sp.	Nuga	Yes
<i>Ficus racemosa</i>	Attikka	Yes
<i>Filicium decipiens</i>	Pihimbiya	Yes
<i>Gliricidia sepium</i>	Gliricidia	Yes
<i>Macaranga indica</i>	Kenda	Yes
<i>Macaranga peltata</i>	Kenda	Yes
<i>Madhuca longifolia</i>	Mee	No
<i>Madhuca nerifolia</i>	Gam Mee	Yes
<i>Mallotus tetracoccus</i>	Bu Kenda	Yes
<i>Mangifera indica</i>	Amba	Yes
<i>Mangifera zeylanicus</i>	Atamba	Yes
<i>Michelia champaca</i>	Gini sapu	Yes
<i>Ochlandra</i> sp.	Bata	No
<i>Paraserianthes falcata</i>	Albizia (Rata Mara)	Yes
<i>Phyllanthus emblica</i>	Nelli	Yes
<i>Spathodea campanulata</i>	African tulip tree	No
<i>Strobilanthus</i> sp.	Nelu	Yes
<i>Swietenia macrophylla</i>	Broadleaf Mahogany	Yes
<i>Symplocos cochinchinensis</i>	Bombu	Yes
<i>Tamarindus indica</i>	Tamarind (Siyambala)	Yes
<i>Terminalia arjuna</i>	Kumbuk	Yes
<i>Trema orientalis</i>	Gedumba	Yes
<i>Toona sinensis</i>	Toona	Yes
<i>Vateria copallifera</i>	Hal	No
Species belonging to Family Lauracea	Wal enasal	Yes

***Albizia lebbeck* (Sooriya mara)**

Albizia lebbeck (Sooriya Mara) can attain a height of 30 m and a diameter of 1 m. More often, it is 15-20 m tall with a diameter of 50 cm. It has a grey-violet bark with rusty brown breathing pores, and is rough and fissured. *Albizia lebbeck* is a dominant species in semi-evergreen forests (monsoon forest) in areas with a mean annual rainfall of 1, 300-1, 500 mm. It is also found on the banks of riverine sites.

Albizia lebbeck coppices well, responds to pollarding, pruning and lopping, and will produce root suckers if the roots are exposed. However, these trees are vulnerable to strong winds and fires. Due to its extensive, fairly shallow root system, *A. lebbeck* is a good soil binder, and is recommended for erosion control on eroded lands. This species is commonly grown as a shade tree in pastures, and tea, coffee and cardamom plantations, as well as along avenues. The nitrogen-rich leaves of this species are also valuable as mulch and green manure.

This species also is important as a host plant for butterflies.

***Anacardium occidentale* (Cashew)**

Anacardium occidentale (Cashew) is a medium-sized tree, that is spreading, evergreen, and heavily branched. It grows to a height of 12 m, with a smaller crown diameter (4-6 m). The root system of mature cashew trees, when grown from the seed, consist of a very prominent taproot, and a well-developed and extensive network of lateral and sinker roots. The nut, which is the true fruit, dries and does not split open. Inside the poisonous shell is a large curved seed, nearly 2.5 cm long, that is the edible cashew nut. As the nut matures, the stalk (receptacle) at the base enlarges rapidly within a few days into a fleshy fruitlike structure, broadest at the apex, popularly known as the fruit. This thin-skinned edible cashew fruit has light yellow spongy flesh, which is very juicy, pleasantly acidic, and slightly astringent when eaten raw and highly astringent when green.

Cashew plants requires high temperatures and the distribution of rainfall is more important to this species than the amount of rain. The tree fruits well if rains are not abundant during flowering, and if nuts mature in a dry period. Given its extreme tolerance of external conditions, it can be planted in poor soils to control erosion.

***Annona muricata* (Anoda)**

Annona muricata (Anoda) is a slender, evergreen tree that is 5-10 m in height and 15 cm in diameter. Its root system extensive and superficial, and spreads beyond the diameter of the crown. Fruit from this species can be 14-40 x 10-18 cm, and can weigh up to 7 kg. It is ovoid and heart shaped, and has an oblong syncarp composed of numerous united pistils, which end in a fleshy spine.

A. muricata survives in the humid tropical and subtropical lowlands. The species is cultivated commonly in home gardens. This tree species can tolerate dry soil conditions, but the sheds its leaves if it experiences a prolonged drought. *A. muricata* fruits can be consumed fresh when fully ripe. The wood of this tree is soft and light (specific gravity of 0.4), and is not durable. Therefore, it is rarely used as timber. In addition, the leaves of this species have a good medicinal value. This species may be planted as an intercrop between larger fruit trees such as *Mangifera indica* (Mango) and *Persea americana* (Avocado).

***Artocarpus altilis* (Breadfruit)**

Artocarpus altilis (Breadfruit) is a large, attractive, evergreen tree, reaching heights of 15-20 m. Its bark is smooth and light in colour. Its trunk grows up to 1.2 m in diameter, and the tree may reach a height of 4 m before branching. It is a crop for the hot, humid, tropical lowlands. Rain stimulates extension growth, flowering and the rate of growth of the fruit. It prefers rainfall of fairly equal distribution, but is quite tolerant of short dry periods.

Breadfruit is versatile and can be cooked and eaten at all stages of its development. It can be eaten raw, boiled, steamed or roasted. *A. altilis* is a long-lived, perennial tree crop that provides beneficial shade and cooler micro-climates for humans, plants and animals beneath its canopy. It is an important component of traditional agro-forestry systems.

***Artocarpus heterophyllus* (Jakfruit)**

Artocarpus heterophyllus reaches 8-25 m in height, and is straight stemmed, branching near the base at an angle of 32-88 degrees. Its canopy is dense, dome shaped or rarely pyramidal, and its diameter varies with age. In 5-year-old trees it ranges from 3.5 to 6.7 m. *A. heterophyllus* grows in tropical, near tropical and sub-tropical regions. The tree will not

tolerate drought or flooding, and for optimum production requires a warm, humid climate and evenly distributed rainfall. Its wood is classified as medium hardwood. It is resistant to termite attack, as well as fungal and bacterial decay and is easy to season and polish.

***Artocarpus nobilis* (Waldel)**

Artocarpus nobilis (Waldel) is a large, attractive, evergreen tree, reaching heights of 15-20 m. Its leaves are thick, leathery, dark green in colour on top, and often glossy. *A. altilis* is a crop for the hot, humid, tropical lowlands. Rain stimulates extension growth, flowering and the rate of growth of the fruit. This species prefers rainfall of fairly equal distribution, but is quite tolerant of short dry periods. It is known to grow and fruit well without irrigation, even in areas with a distinct dry season. Regardless of the methods used for propagation, young plants do best under shade, but trees require full sun once established. It should be noted that seeds lose viability within a few weeks. The fruit is versatile and can be cooked and eaten at all stages of its development. It can be eaten raw, boiled, steamed or roasted. The seeds are a good source of protein and are low in fat. This species is important as a feeding resource to frugivorous birds and mammals, including *Macaca sinica* (Sri Lanka toque monkey).

***Azadirachta indica* (Margosa or Neem)**

Azadirachta indica is a small to medium-sized tree, usually evergreen, up to 15 m (30 m maximum) tall, with a round, large crown up to 10 m (20 m maximum) in diameter. *A. indica* is said to grow 'almost anywhere' in the lowland tropics. It requires large amounts of light, but tolerates fairly heavy shade during its first few years. Weeding of *A. indica* plantations in dry areas is essential, as the tree cannot withstand competition from weeds. These trees coppice freely, and early growth from coppice is faster than growth from seedlings. The *A. indica* fruit is an important source of food for some wildlife, especially birds and bats, although they digest only the pulp, and not the seed.

Bamboo species (Bata bamboo)

Bamboo is one of the fastest-growing plants on earth. However, its growth rate is dependent on local soil and climatic conditions, as well as species. This rapid growth can be attributed to the fact that bamboo is a form of grass. It is a woody plant that is usually hollow, erect and straight, and has smooth culms with internodes. Some species are up to 30 m tall with a 25 cm culm diameter. Branches and culms arise from internodes. The culm sheaths, which usually fall off when the culm matures, often have irritant hairs on the outside. Each branchlet bears 8 -18 leaves. Most species have lance shaped, thin leaves with a parallel pattern and leafstalk. New culm shoots are produced every year from the rhizomes (underground stems).

***Capparis zeylanica* (Wellangiriya)**

Capparis zeylanica is a climbing shrub that is common within the forest habitats of the country. This species is mainly used for its fruit, which is rich in micronutrients, and is considered important for its medicinal and nutritional values. It is useful in minimizing soil erosion and preserving agricultural lands. It is a climbing shrub with curved thorns, elliptical leaves and simple flowers, while its fruits form as clusters.

***Caryota urens* (Kitul)**

Caryota urens (Kithul) is a medium-sized palm up to 20 m tall. Its bole is straight, unbranched, and obscured at first by persistent fibrous leaf bases and sheaths. The species naturally inhabits the understorey tree stratum in moist lowland and sub-montane forests. Ecologically, it is found in monsoon climates and humid regions. It prefers moist, shady and cool places. *C. urens* is a slow-growing, shade-tolerant or shade-demanding species. The daily yield per tree of sap for wine and sugar from *C. urens* is 20-27 litres. Its trunk also yields 100-150 kg of starch. At room temperature, the seeds remain viable for 30-90 days, depending on storage conditions.

A primary product of *C. urens* in rural communities is the sugar substitute called known as kitul honey or jaggary. The leaves of *C. urens* are traditionally used as a 'delicacy fodder' for domesticated elephants. In areas where the trees are not tapped, they are cut down to feed elephants.

In addition, this species is an important feeding resource for frugivorous birds and mammals, and is also a good source of nesting materials.

***Chloroxylon swietenia* (Satinwood/Burutha)**

Chloroxylon swietenia is a hardwood tree, that is native to Sri Lanka. It is a medium-sized deciduous tree, growing to about 15-20 m tall with a thick, fissured, and slightly corky bark. Its leaves are 15-22 cm long, and are arranged alternately. They are pinnately divided into 10-20 pairs of oblong, blunt leaflets. The flowers of this species are small, and creamy-white in colour. The buds are round, while the fruit is oblong and consists of a three segmented capsule (2.5-4.5 cm). Each of these segments contains 1-4 seeds. The wood is often golden in colour and has a reflective sheen. It is used for small luxury items and as a veneer in wooden furniture. It is one of the best known woods in Sri Lanka. This species is important as the host plant of the butterfly species *Papilio crino* (Banded peacock).

***Cinamoum mooniana* (Kududaula)**

Cinnamomum mooniana is a small, glabrous tree, up to 40 m tall with a diameter of up to 3 m. The bark is yellow or brown with vertical fissures. Although yields of *C. mooniana* are greater for old trees, leaves and woody material can be harvested regularly from plants over five years of age, which are kept in a bushy form by coppicing. Propagation by seed is the normal practice. Germination can be rather slow and may continue up to one year after sowing.

***Cinnamom zeylanicum* (Wal kurundu)**

Cinnamomum zeylanicum – known as "true cinnamon" or "Sri Lanka cinnamon" - is a small evergreen tree belonging to the family Lauraceae. It is native to Sri Lanka. These trees are 10–15 m tall, with ovate-oblong leaves that are 7–18 cm long. Its flowers are arranged in panicles, and are greenish in colour, with a distinct odor. Its fruit (1 cm) is purple, and contains a single seed. This species is a leafy canopy species, and also exists as under storey trees or shrubs in lowland rainforest and high elevation wet evergreen montane tropical rainforests. Cinnamon is a spice obtained from the inner bark of several trees from the genus *Cinnamomum* that is used in both sweet and savoury foods. It is harvested by growing the tree for two years, and then coppicing it. The next year, about a dozen shoots will form from the roots. It has a very thin, smooth bark that is light-yellowish brown in colour and has a highly fragrant aroma. Cinnamon is also used in traditional medicine.

***Dipterocarpus zeylanicus* (Hora)**

Dipterocarpus zeylanicus is a medium sized to large tree up to 43 m tall. It requires partial shade in its early stages of development. Seeds are observed to have a short viability (3-5 days), and as such, must be sown as soon as possible. This species improves soil conditions through its fast rate of litter deposition and organic matter decomposition.

***Erythrina subumbrans* (Erabadu)**

A deciduous, medium-sized tree, that is 5-25 m tall, with a trunk reaching 60 cm in diameter. Its crown is spreading, while its bark is whitish in colour. Its trunk and branches have stout prickles. Its leaves are alternate and trifoliate, while its rachis is 10-21 cm long, and its petiole is up to 7 mm long. Its inflorescence is racemose, brownish and tomentose. It has many flowers that are arranged in groups of three. The flower has five petals that are red in colour. *E. subumbrans* – also known as 'dadap' - is planted widely. The necklace-shaped pods of this species are highly characteristic and can be used to identify this species. It is used as a shade tree in tea and cacao plantations. These trees are considered to be support trees for climbing crops, and are also valued as a nitrogen fixing trees. It also provides suitable shade conditions for faunal species.

***Ficus benghalensis* (Nuga)**

Ficus benghalensis is a large tree that grows throughout the Indian subcontinent. It produces propagating roots that grow downwards as aerial roots. Once these roots reach the ground, they grow into woody trunks that can become indistinguishable from the main trunk. The figs of this tree are eaten by birds and mammals, while its seeds are dispersed by frugivorous birds. It has been noted that the seeds that pass through the digestive systems of the birds are more likely to germinate and sprout relatively early. This species also plays a major role in the provision of shelter. Propagation of this species is conducted through seeds, transplanting and stem-cutting.

***Ficus racemosa* (Attikka)**

Ficus racemosa is a popular medicinal plant that has long been used in Ayurveda medicinal system for the treatment of various ailments including diabetes, liver disease, diarrhea, inflammatory conditions, hemorrhoids, respiratory problems and urinary diseases. A wide range of phyto-chemical constituents have been identified and isolated from various parts of *F. racemosa*. Its fruit is eaten by wild animals and frugivorous birds, and is valuable as a host plant for butterflies.

***Gliricidia sepium* (Gliricidia)**

Gliricidia sepium grows to a height of 2-15 m, has a medium crown and may be single or multi-stemmed. The tree has deep roots when mature, and establishes well on steep slopes. Pruning and pollarding are the main management activities related to this species. Pruning at 0.3-1.5 m will stimulate leaf production. Pollarding at 2 m or above is recommended for optimal wood biomass production.

Gliricidia is propagated most commonly through cuttings. *G. sepium* has been planted to reclaim denuded land or land infested with *Imperata cylindrica*. Hedgerows in alley cropping serve to suppress weed growth and control erosion. It is also used as a nurse tree for shade-loving species. The tree is capable of fixing atmospheric nitrogen, and its leaves are rich in protein and are highly digestible, while they are low in fibre and tannin. There is evidence of

improved animal production (both milk and meat) in large and small ruminants when *G. sepium* is used as a supplement.

Its fast growth, ease of propagation, nitrogen-fixing ability and light canopy make it ideal as green manure. *G. sepium* increases soil organic matter, and aids in the recycling of soil nutrients as it produces much litter. It also improves soil aeration and reduces soil temperature. It is a drought-resistant and valuable water-conserving species, as in the dry season, it sheds most of its leaves, reducing water loss through transpiration.

***Macaranga indica* (Kenda)**

This species is found in degraded forest areas. Trees are usually approximately 16 m tall. They are gregarious trees, with grey, smooth bark. Its exudation is red and watery. The leaves of this species are simple. *Macaranga* species are used as food plants by the larvae of some Lepidoptera species, and while their hollow stems serve as nesting sites for some ant species. They also provide nectar to these species occasionally. Macaranga gum - a crimson resin – is obtained from this species. In addition, it is a feeding resource for frugivorous birds.

***Macaranga peltata* (Kenda)**

This is one of the most common early successional woody species found in Sri Lanka, especially in the low country Wet Zone. It is a resinous tree, up to 10 m tall. The young parts of this tree are velvety and hairy. Its leaves are 20 to 50 cm, while its flowers are yellow-green in colour and occur in the long panicles of leaf axils between January and February. Kenda leaves are used commonly for flavouring in Sri Lanka. Halapa dough is often flattened on a kenda leaf to soak in the flavour. Kenda leaves are also used to wrap jaggery and other sweetmeats. This tree is a useful feeding resource for frugivorous birds.

***Madhuca longifolia* (Mee)**

Madhuca longifolia (Mee) is a large, much branched deciduous tree up to 18 m high and 80 cm DBH. Its bole is short, while its crown rounded and its bark is grey to black with vertical cracks. Fire tracing and fencing of plantations are essential in the early stages, along with clean weeding and soil working around seedlings. The tree is a light demander, and is also drought resistant and frost hardy. It coppices well if felled in the hot season. *Madhuca longifolia* has a large spreading superficial root system that holds the soil together.

***Madhuca neriifolia* (Gam Mi)**

This species is endemic to the forests of southwest Sri Lanka. It is a rare species that was only found in four localities during the comprehensive forest surveys conducted for the National Conservation Review in 1997. This tree provides food for frugivorous birds and mammals, such as *Macaca sinica* (Sri Lanka toque monkey).

***Mallotus tetracoccus* (Bu Kenda)**

The trees of this species grow up to 12 m tall. Its bark is brown while its blaze is cream in colour. Its young branchlets are flat, while its leaves are simple, alternate and spiral. Its petiole is 3-12.5 cm long. This species is found along the margins of evergreen forests up to 1,600 m. It is a pioneer species that can be found in disturbed forests, along roadsides, in

thickets in cultivated areas, at the boundaries of gardens and in secondary forests. This tree provides valuable food resources for frugivorous birds.

***Paraserianthes falcataria* (Rata Mara)**

Paraserianthes falcataria is a fairly large tree, up to 40 m tall. Its bole is branchless for up to 20 m. It grows to 100 cm or sometimes more in diameter, with a spreading flat crown. Its fruit is a flat, and found in a straight pod (10-13 x 2 cm) and is not segmented. *P. falcataria* occurs in primary, but more characteristically in secondary, lowland rainforests. It is adapted to semi-humid and monsoonal climates with a dry season of up to 2 months. It is sensitive to fire and damaged easily by strong winds. *P. falcataria* grows so fast that it is sometimes called the 'miracle tree'. Within good suitable sites, it can attain a height of 7 m in just over a year. *P. falcataria* is commonly used in agro-forestry systems. When planted, it can grow in comparatively poor sites and survive without fertilizer. However, it does not thrive in poorly drained, flooded or waterlogged soils.

P. falcataria requires great amounts of light and regenerates naturally. It provides a good protective cover to prevent erosion on slopes. It also coppices fairly well.

In addition, its nodules and fixes atmospheric nitrogen. The natural drop of leaves and small branches contributes nitrogen, organic matter and minerals to upper layers of soil. The extensive root system of this species further improves soil conditions by breaking up soils to provide channels for drainage and aeration.

***Strobilanthes* spp. (Nelu)**

Strobilanthes species are tropical soft-wood shrubs growing to approximately 1.2 m in height. They are important as food plants by the larvae of some Lepidoptera species. Similarly, it provides hiding places for small mammalian species.

***Swietenia macrophylla* (Broadleaf Mahogany)**

Swietenia macrophylla (Broadleaf Mahogany) is a very large tree, reaching a height of 30-40 m and a girth of 3-4 m. In favourable conditions, it can reach 60 m high and 9 m in girth. Its trunk is straight, cylindrical, with a buttressed base. Its bark is rough, flaking off in small patches. Young trees are fairly tolerant of shade, but conditions for optimum growth require full overhead light combined with side protection. Mahogany is planted extensively in Sri Lanka. The high value attached to *S. macrophylla* wood in the international markets is also well known.

***Symplocos cochinchinensis* (Bambu)**

These are evergreen trees that grow to a height of approximately 15 m. Its bark is light grey in colour and is thin and smooth, while its blaze is creamy white. Its leaves are simple, alternate and stipulate. Its petiole is 0.4-2.5 cm, while its leaf blade (6-27 x 0.9-10 cm) is narrowly elliptic, elliptic or obovate-elliptic in shape. This species is used in ayurvedic medicine. The plant can be grown from seeds or from stem cuttings.

***Tamarindus indica* (Tamarind)**

Tamarindus indica (Tamarind) is a large evergreen tree up to 30 m tall. Its bole is usually 1-2 m up to 2 m diameter. Its crown is dense, widely spreading and rounded. Its bark is rough, fissured, and grayish-brown. Its fruit consists of a pod (10-18 x 4 cm), and is indehiscent, sub-cylindrical, straight or curved, velvety and rusty-brown. The shell of the pod is brittle,

while the seeds are embedded in a sticky edible pulp. *T. indica* grows well over a wide range of soil and climatic conditions, occurring in low-altitude woodlands. This species prefers semi-arid areas and wooded grasslands, and can also be found growing along stream and riverbanks. Its extensive root system contributes to its resistance to drought and wind. The fruit pulp, mixed with a little salt, is a favourite ingredient of the curries and chutneys and is popular throughout the country.

***Terminalia arjuna* (Kumbuk)**

Terminalia arjuna (Kumbuk) is a deciduous large-sized fluted tree that grows to 30 m tall and 2-2.5 m DBH, with an often buttressed trunk. Its superficial, shallow root system spreads radially along stream banks. The large, spreading crown produces drooping branches. It occurs naturally along the banks of streams and rivers, and seasonally dry water courses at low elevations. The species is a characteristic component of dry tropical riverine forests, and tropical moist and dry deciduous forests. It is an initial slow-grower, that later grows very fast to attain 2–3 m in height in approximately three years.

The species is commonly found and planted along the banks of rivers, streams, old irrigation channels, the edges of tank bunds and alluvial bars in seasonally dry water courses, helping to reduce soil erosion on the banks of these water bodies through its root-mass.

***Toona sinensis* (Toona)**

Toona sinensis is a large deciduous tree with a spreading crown, and commonly attains a height of 20-30 m and a girth of 1.8-3 m. Its bark is dark grey or reddish-brown, and smooth up to middle age, while it becomes rough after this time. It is a tree of subtropical climates and grows in moist localities such as ravines, banks of streams and even swamps. It grows best in fire-protected savannah habitats, abandoned cultivation and in small gaps in forests.

Toona is a moderate light demander. However, young plants require some side protection from the direct sun. Trees growing in such situations develop a tall, clean bole up to a height of 9-12 m. In the open, they tend to have a large, spreading crown and short, clean bole 3.6-4.2 m. This species has a spreading superficial root system. Natural regeneration of this species is profuse, even in areas outside its natural range.

***Trema orientalis* (Gedumba)**

This tree is a fast-growing species that is found in previously disturbed areas and on forest margins. It is a pioneer species that can grow on poor soil and can be used to regenerate forest areas by providing shade and protection to the saplings of forest hardwoods. It is also a nitrogen fixing species, and can, thereby, improve soil fertility for other plant species. It grows up to approximately 10-15 m, and is immensely important ecologically, as a larval food plant for several butterfly species. In addition, several species of birds eat its fruit or feed on the insects that live in these trees. Similarly, it provides nesting material to birds such as pigeons and doves. Browsing animals feed on its leaves, which along with its pods and seeds, are also used as fodder for cattle.

4.4 Planning and Preparation for Afforestation/Reforestation programme

Afforestation or reforestation and forest restoration in the degraded habitats are important environmental restoration programmes under the proposed MHP. The chronological sequence of recommended afforestation or reforestation measures is presented below.

1. Selection of afforestation/reforestation sites

Afforestation and reforestation sites should be identified precisely by the organization or agency responsible for carrying out this work (see Chapter 6 for details of implementation). The land owning agency and private land owners (in the case of private lands) should be consulted, with their consent regarding the proposed planting programme obtained. A brief feasibility survey, and other relevant studies, may be necessary, while conditions such as soil and land types, water logging if any, and soil depth should be assessed in order to make informed decisions regarding the final site-specific suitability of species, and appropriate species combinations to be planted. Such feasibility surveys should also ascertain the estimated numbers of plants required from each species for the planting scheme.

The refuge – a protected area selected specifically to harbour priority species, including threatened species - should be of adequate size within the afforestation area in order to facilitate the successful translocation of priority fauna and flora displaced due to construction of the dam, the formation of the reservoir and other project activities.

2. Survey and demarcation of planting areas

The periphery of the selected afforestation and reforestation sites, and various blocks within those sites, need to be surveyed. Then, these blocks and the periphery of these sites, should be demarcated by fixing concrete posts at approximately 5 m intervals, in order to prevent encroachment and unauthorized expansion of cultivation lands into the afforested and reforested areas. This will also allow for easy identification of the boundaries of these blocks.

3. Final site-specific selection of suitable species

The growth and vigor response of a tree species planted at a given site depends largely on the soil type, soil depth and nutrient status, as well as water logging conditions, that the species is subject to. If the site and species are not matched appropriately, afforestation and reforestation efforts are likely to fail. Therefore, the suitability of species for different land types and situations (blocks) should be evaluated carefully. In consideration of the conditions described above, suitable tree species should be selected from the species list provided in Table 12. In addition, site specific species selection should be done carefully in order to develop appropriate habitats for faunal species.

The refuge area should be planted with species that are suitable for displaced fauna and flora, including fruit bearing species such as *Annona muricata* (Anoda), *Artocarpus nobilis* (Waldel), *Artocarpus heterophyllus* (Jakfruit), *Caryota urens* (Kitul), *Mangifera zeylanicus* (Atamba) and *Phyllanthus emblica* (Nelli).

4. Preparation of the detailed afforestation and reforestation plan

The next step is to prepare a detailed planting plan which should include the species name and number of the tree species proposed to be planted in each block, as well as the extent of the proposed reforestation area and block (ha). This can be done fairly accurately once the feasibility survey has been carried out.

5. Preparation of detailed planting maps.

Detailed planting maps should be prepared as the next step. This includes marking of tree species that need to be planted in each block. The area set aside for the establishment of the refuge site within the afforestation area should also be marked on this map.

6. Supply of planting material

All the tree species recommended for use in the afforestation and reforestation programme should be raised in Forest Department (FD) nurseries. The FD has vast experience in raising the species recommended for the programme. In order to avoid transport costs and damage to plants during transport, a nursery should be established by the FD within the project area. The seedlings should be raised in poly bags that are 9×6 inches (23 × 15 cm), and need to be raised to an appropriate size in the nursery for approximately 8-10 months before planting when approximately 15-20" tall.

7. Planting and maintenance

Planting should be carried out by an agency with extensive experience agency in such programmes, such as the FD or other suitable organizations (see Chapter 6). Planting should involve employing under the supervision of FD officers. After planting, maintenance (weeding) is required for three years. Fire protection programmes also need to be implemented simultaneously, in order to protect young seedlings against the risk of fire.

4.5 Afforestation and reforestation techniques

Afforestation and reforestation activities in the Moragolla catchment should involve the following programmes:

- (i) Enrichment planting
- (ii) Afforestation/reforestation; and
- (iii) Home garden improvement.

The techniques associated with these programmes are described below.

(i) Enrichment planting

Enrichment planting (EP) refers to the planting of trees to increase the tree density (number of trees per hectare) in already established degraded forests. It is recommended for riparian sites and degraded forest sites in the immediate catchment area of the Moragolla reservoir.

In enrichment planting, existing trees are not removed and new seedlings are not planted near existing trees. This technique has been recognized as an afforestation method that provides an opportunity to introduce valuable tree species in existing, but degraded, secondary forests. It can be used to increase the value of secondary forests successfully, as well as to prevent their conversion to other land uses. This technique has also been recognized as a land-use alternative to reduce emissions from deforestation and forest degradation (Dalle *et al.*, 2006).

Site preparation for enrichment planting:

Planting should be done in lines in a systematic manner. Each planting line should be marked along the contour on a straight line using a rope. Positions of planting holes should

be marked on a straight line along the contour in the planting line. Weeding should be done in strips to a width of 1.5 m, and should not involve clean weeding to expose the bare soil. Instead only grasses and shrubs need to be removed up to the ground level. This will prevent possible soil erosion due to exposing bare soil.

Planting holes should then be marked by placing sticks where seedlings need to be planted. This is done at a spacing of approximately 6–8 m, depending on the existing tree cover. The distance between two planting rows needs to be approximately 5 m (250 trees/ha). The size of each planting hole should be 1×1×1" (30 × 30 × 30 cm).

Planting: Seedlings should be placed in planting holes, seedlings should be treated carefully, so that their fine roots do not break. The topsoil should be used first to fill the bottom of the hole, as it is more fertile, and fertility is needed at this depth for the development of roots. Full advantage should be taken of this naturally fertile soil during reforestation and afforestation efforts. The land should be planted at a density of approximately 250 trees per ha (8 × 5 m spacing) with a mixture of naturalized and indigenous tree species that form the upper canopy of nearby areas. Compost may be applied to the planting hole at the time of planting.

(ii) Afforestation/reforestation

Site preparation for afforestation and reforestation:

Normal afforestation and reforestation should be carried out in abandoned lands, as well as in conversion of pine plantations to areas that support local tree species. Planting should be done in lines in a systematic manner as mixed species, and not as monoculture. The plant-to-plant distance in a given line, as well as the distance between two adjacent lines, is important. In this case, land preparation should be done by low slashing of the existing vegetation (grasses, herbs and shrubs) and patch weeding around the planting hole to approximately three feet in diameter. Positions of planting holes should be marked on a straight line along the contour in the planting line or in a straight line if it is a flat land. Planting should be done with a spacing of approximately 3 × 3 m (1, 110 seedlings/ha). The size of the planting hole should be 1×1×1" (30 × 30 × 30 cm) (Forest Department, 2009; PRP, 1997).

Planting: Seedlings should be placed in planting holes and treated carefully so the fine roots do not break. The topsoil should be used first to fill the bottom of the hole, as it is more fertile, and fertility is needed at this depth for the development of roots. As there is no existing tree cover on the land, planting spacing for afforestation and reforestation should be approximately 3 × 3 m. Compost may be applied to the planting hole at the time of planting.

(iii) Home garden improvement

Home gardens constitute a traditional system of perennial cropping for a wide range of valuable crops, such as food, fruits, timber, medicinal and spice crops, and are considered important sites for *in-situ* conservation of crop germplasm. Kandyan home gardens are essentially a luxuriant system of mixed cropping with a variety of economically valuable tree crops, and form an essential component of land use. These home gardens are like forests in many respects. They provide shelter to birds and other wildlife, and conserve soil and water, almost as well as the natural forest. In addition, they produce timber, fuelwood and non-wood forest products. However, some of the home gardens in the Moragolla catchment are managed poorly in terms of soil conservation. Therefore, a home garden improvement programme is critical component of the Afforestation and Watershed Management

Programme. Plants required for the homegarden improvement programme can be raised in the nurseries developed under the afforestation programme.

The average size of a home garden is approximately 0.2–0.4 ha. Twenty (20) seedlings should be provided for each home garden free of charge, for planting on their land. On that basis, the seedling requirement will be 50 seedling/ha. The choice of tree species should be based on the choices of the home garden owner.

4.6 Establishment of nurseries (based on Forest Department, 2007)

Important aspects of the establishment of a semi-permanent nursery for the afforestation programme are described briefly below.

Planning and site selection for the nursery

In order to avoid transport costs and damage during transport of plants, a semi-permanent nursery may be established in a suitable site within the project area. Identification of nursery sites needs to be done in consultation with the CEB. The following aspects should be considered in selecting a site for this semi-permanent nursery:

- To reduce the transport cost of seedlings, the nursery should be closer to the afforestation site; and
- The nursery site should be located with easy access to tractors and trucks transporting seedlings and other nursery material.

Required nursery area

The space required to raise approximately 80, 000 plants is approximately 0.4 ha (nearly 1 acre). This land should be provided to the relevant agency responsible for the afforestation programme.

Source of water for the nursery

A permanent water source should be available in the close proximity. The nursery should be supplied with water of good quality throughout the year. Generally, 3, 000 liters (3 m³) of water are required daily to water 50, 000 seedlings.

Layout and construction

Generally, a semi-permanent nursery requires the following:

- External fencing;
- Seed germination and nursery beds;
- An access road to the nursery;
- A nursery hut (shed) for seed germination and composting;
- A semi-permanent building for stores, workers facilities and accommodation; and
- A drainage system.

The layout of these features should be planned prior to the construction of the nursery.

Shade

Shade is essential to seedlings in seed beds and in stand-out beds after transplanting. Shade is necessary to maintain humidity, temperature and adequate light conditions, especially those required for seed germination and better growth of seedlings.

Nursery schedule

The planting season commences with the onset of the northeast monsoon in November, and therefore, all nursery activities should be well planned in advance to produce good quality seedlings in order to meet the target planting period. Preferably, nursery activities should commence at the beginning of the year in January or February.

Seed sources

Seeds stocks required for raising in nurseries should be collected well in advance from suitable seed sources. The best seeds come from strong healthy parent trees. Fully ripened fruits should be collected directly from trees. Seeds should be collected as soon as they are ripe. If not, many of them may be eaten or damaged by birds, animals or insects.

Seed storage

The two most important factors in good seed storage are keeping the seeds dry and cool. Wet seeds spoil and rot in storage, and so must be dried in air first. Then they can be stored in dry containers. Care should be taken to keep containers off floors and away from walls, as this practice helps to keep insects and dampness away from the seed containers. The containers should be stored in such a way that air can circulate around them. This helps to keep the seeds drier and cooler.

4.7 Production of nursery stock

Seedlings are grown commonly in poly bags. First, seeds are sown in seed beds and then sticking out of poly bags when the seedling is approximately 8-10 cm in size. Poly bags are filled with a mixture of top soil, sand and compost in the ratio 2:1:1. Poly bags used for this purpose should be 9 × 6" (23 × 15 cm). Medium or large size seeds that have good germination (over 40 percent) can be sown directly in poly bags. Young seedlings usually require some shade during their first two weeks, especially when they have just been transplanted from germination beds into poly bags.

In addition, regular watering, weeding, fertilizing and control of pests and diseases are important aspects in the production of a good nursery stock. Seedlings need to grow in the nursery for approximately 8-10 months (until they reach approximately 12– 15 " in height) before planting in the field.

4.8 Post-planting maintenance and management

Weeding

Intensive caretaking is required for a minimum period of three years for the successful establishment of an afforestation site. Weeding is one of the most important operations that needs to be carried during this time. In general, weeding should be done two times a year or whenever weeds are noticed around the feet of the planted saplings during the first two years. The frequency of weeding will vary based on different factors, including rainfall and

the nature of undergrowth vegetation. However, weeding two times a year is sufficient for the first two years following planting, while once or twice a year is sufficient in the third year.

In general, no weeding is required subsequently until approximately four years after planting. However, if the weed competition is very high after four years, another two or three rounds of weeding may be required.

The ideal weeding technique for this programme is strip weeding along the planting line to a width of about 1.5 m.

Fire protection

Ground fire during drought periods is a common problem encountered in the project area. In addition to continuous surveillance during the dry periods, other required preventive measures include opening and maintenance of fire lines in the periphery of the afforestation site. For large afforestation sites, internal fire lines may also be established in addition to external fire lines. The width of each external fire line should be approximately 10 m, while internal fire line should be approximately 5 m in width. Cutting and clearing of fire lines should be carried out for three years.

Application of fertilizer

If the parent soil is poor and quick growth of the seedlings is desired, chemical fertilizer may be applied as a top dressing. Mixed fertilizer comprised of equal proportions of NPK (at 13:9:9 formula) should be applied at 25-30 g per plant per application. Fertilizer should be applied during the growing season. The first dose should be applied a month after the actual date of planting. This should be done before the end of the rainy season. Fertilizer, if required, should be applied for three consecutive years after planting.

Climber/creeper cutting

In some situations climbers and creepers invade high grounds and grow on plants. Plants soon bend under the weight of the creeper, sometimes being brought to the ground. When that happens, such plants never stand erect or grow upright again. Therefore, cutting down of creepers and climbers should be done regularly in infested stands, as necessary. Creepers are so fast growing that fresh tendrils can develop just a few weeks after cutting. Therefore, they will have to be cut frequently in order to avoid such issues.

Only the climbers or creepers suppressing the growth of other plants should be removed. The need for some of these species as a habitat for fauna needs to be considered at the time of cutting climbers and creepers. Climber and creeper species that are beneficial to fauna should not be removed.

Pest control

The incidence of pests and diseases should be observed constantly and assessed carefully, with outbreaks being detected quickly. Usually, at a young stage, tree saplings are attacked by leaf eating insects. If any incidence of pests or diseases is noticed, the advice of local FD officers or local agricultural officers should be sought, with recommended remedial measures implemented swiftly.

Vacancy planting

Vacancy planting or filling up of gaps should be undertaken during the following planting season. As such, adequate amounts of seedlings need to be raised in the nursery for this vacancy planting operation in year following planting.

4.9 Monitoring of the afforestation programme

Monitoring activities are important components of the afforestation programme. Monitoring of these aspects on a regularly basis is very important in order to ensure the success of the afforestation programme. These activities are as follows:

- Regular monitoring of the progress of the afforestation programme;
- Survival counts approximately two months after planting (if the survival rate is below 85 percent necessary steps should be taken to fill the vacancies or gaps);
- Regular surveillance of pests and diseases;
- Careful monitoring of invasive species;
- Monitoring of changes in the floral and faunal composition of the area;
- Monitoring of significant soil erosion in the afforestation sites; and
- Monitoring of encroachments or unauthorized activities in the afforestation area.

4.10 Cost estimate

The cost estimate for the afforestation programme for the Moragolla watershed has been developed based on the following assumptions:

- (i) The area for enrichment planting is approximately 40 ha in extent;
- (ii) The area for afforestation/ reforestation (bare-land planting) is approximately 30 ha in extent;
- (iii) The area for home garden improvement is approximately 60 ha in extent; and
- (iv) The total area in which planting activities will take place is approximately 130 ha in extent.

Based on these assumptions, the numbers of plants required for each component programme based on the density of planting are given in Table 13.

Table 13. Estimated number of plants required

Purpose	Number of plants
Enrichment planting programme	10, 000
Afforestation/reforestation programme (bare-land planting)	33, 300
Home garden improvement	15, 000
Total required for programmes	58, 300
Total number of plants required for initial planting activities, including additional plants to compensate for damages and other issues (10%)	65, 000
Total number of plants required for the entire programme, including plants required for vacancy filling during the year following initial planting (20%)	78, 000

The total number of plants required will be 58,300, with additional 10 percent to compensate for damages in the nursery and transport. As such, the number of plants required for initial planting activities (first year) will be approximately 65,000 plants for the afforestation programme. An additional 20 percent of plants are expected to be required for vacancy filling in the year following initial planting. Including these plants, the total number of plants required for the entire afforestation programme will be approximately 78,000 plants. These plants should be raised in the nursery to be established at the Moragolla project site. The area required for the proposed nursery is approximately 0.4 ha (about 1 acre).

Based on these calculations, the total cost estimate for the afforestation programme is presented in Table 14 below.

Survey and demarcation will be done only in enrichment planting and afforestation or reforestation (bare-land planting) areas (40 ha + 30 ha = 70 ha). The home garden improvement programme will be done on private lands, while survey and demarcation activities will not be done on private lands.

The transport of plants to planting sites is based on the number of plants. (Enrichment planting 250 trees per ha; other afforestation (ie, bare land) 1, 110 plants per ha; and 50 seedlings per ha for home gardens). 85 ha is the average figure for calculating the transport costs.

Table 14. Estimated costs associated with the afforestation programme (covering a period of five years).

Item no.	Activity	Unit cost (LKR)	Number of units	Estimated cost (LKR)
1.	Selection of afforestation/reforestation sites	-	130 ha	60, 000
2.	Survey and demarcation of planting sites	14, 000 per ha	70 ha	980, 000
3.	Preparation of afforestation plan	-	-	50, 000
4.	Preparation of detailed planting maps	-	-	100, 000
5.	Establishment of nurseries and production of plants	20 per plant	78, 000 plants	1, 560, 000
6.	Transport of plants to planting sites, including loading and unloading	6,000 per ha	85 ha	510, 000
7.	Holing and planting	32 per plant	78, 000 plants	2, 425, 000
8.	Weeding	41, 400 per ha (calculated at two weeding events per year)	70 (for three years)	8, 694, 000
9.	Fire protection	22,500 per ha (for three years)	70	1, 575, 000
10.	Application of fertilizer	18, 000 per ha (two times)	70	900, 000
11.	Cutting of climbers and creepers	10,000 per ha (two times)	70	700, 000
12.	Pest control (including at the nursery stage)	Lump-sum amount	For three years	800, 000
13.	Vacancy planting	20 percent of planting cost		485, 000
14.	Monitoring	10,000 per ha	130 ha	1, 300, 000
Total estimated cost of activities				20, 139, 000
Contingencies (10 percent)				2, 014, 000
Total				22, 153, 000
Administrative and supervision cost (13 percent)				2, 880, 000
Grand total (for five years)				25, 033, 000

As such, the total cost for the afforestation programme would be approximately LKR 25 million (US Dollars (USD) 191.000)³.

³ USD = SLR 131.00

4.11. Implementation of the afforestation programme

Details on the implementation of the afforestation programme, including activities, descriptions of activities and the scheduled timeframe, are provided in Table 15 below. The total programme is planned for five years, including planning, implementation, post planting maintenance and management, and monitoring of progress and impacts.

Table 15. Summary of activities and tentative time frame for the afforestation/reforestation programme

No.	Activity	Description	Time frame
1.	Selection of afforestation/reforestation sites.	Afforestation sites should be more precisely identified by the organization responsible for carrying out this work.	Year 1 - February
2.	Survey and demarcation of planting sites.	The periphery of the selected afforestation sites and various blocks within those sites should be surveyed and demarcated.	Year 1 - April
3.	Final site-specific selection of tree species	Final selection of tree species and matching with suitable sites.	Year 1 - June
4.	Preparation of detailed afforestation plan.	Preparation of a detailed planting plan, including the species names and numbers to be planted in each block.	Year 1 - July
5.	Preparation of detailed planting maps.	Detailed planting maps, including tree species that should be planted in each block.	Year 1 - August
6.	Establishment and maintenance of nurseries	Establishment of a semi-permanent nursery for the afforestation programme.	Year 2 - January
7.	Land preparation for planting.	Preparation of the planting sites for planting including holing.	Year 2 - September
8.	Supply of planting material.	All tree species recommended for use in the afforestation programme should be supplied from nurseries.	Year 2 - October
9.	Afforestation planting.	Planting should be carried out by an experienced agency or organization.	Year 2 – October to December
10.	Post-planting maintenance and management	Post-planting maintenance and management activities are essential.	Years 3, 4 and 5 (March – October)
11.	Weeding	Weeding is one of the most important operations that needs to be carried during the first three years after planting.	Years 3 and 4 (March – August)
12.	Fire protection	Maintenance of fire lines in the afforestation sites.	Year 3, 4 & 5 – July to August
13.	Application of fertilizer	Chemical fertilizer may be applied as a top dressing, if required.	Years 2 and 3 – October
14.	Cutting of climbers and creepers	Creeper/climber cutting should be a regular operation in infested stands, as necessary.	Years 3, 4 and 5 (May – June)
15.	Pest and disease control	If incidence of pests or diseases is noticed, appropriate action should be taken.	When the need arises.
16.	Vacancy planting	Filling up of vacancies should be undertaken in the year following initial planting.	Year 3 (October – November)

No.	Activity	Description	Time frame
17.	Monitoring	Monitoring activities are an essential component of the afforestation programme. It should be done on regularly basis.	On a regular basis after the second year.

The schedule of activities planned for the afforestation programme for the Moragolla area is presented in Table 16 below.

Table 16. Schedule of activities planned for the afforestation programme for the Moragolla area.

No	Activity	Time frame															
		Year 1				Year 2				Year 3				Year 4			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1.	Selection of afforestation sites																
2.	Survey and demarcation of planting sites																
3.	Final site-specific selection of species																
4.	Preparation of detailed afforestation plan																
5.	Preparation of detailed planting maps																
6.	Establishment and maintenance of nurseries																
7.	Land preparation for planting																
8.	Supply of planting material																
9.	Afforestation planting																
10.	Post-planting maintenance and																

No	Activity	Time frame															
		Year 1				Year 2				Year 3				Year 4			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	management																
11.	Weeding																
12.	Fire protection																
13.	Application of fertilizer																
14.	Cutting of climbers and creepers																
15.	Pest and diseases control																
16.	Vacancy planting																
17.	Monitoring																
Q1- 1 st Quarter, Q2 – 2 nd Quarter, Q3 – 3 rd Quarter, Q4 – 4 th Quarter		As and when required															
		To be done on a regular basis															

5 WATERSHED MANAGEMENT

5.1 Overview

Topography and land uses of the immediate watershed of the proposed Moragolla reservoir

The immediate watershed of the Moragolla reservoir can be identified as the left and right banks of the Mahaweli River from the confluence of Kotmale Oya with the Mahaweli River up to the proposed dam site of the Moragolla reservoir. The general topography of the watershed area can be described as a steep valley with the river flowing at the bottom of the narrow valley. The slope of the left bank is steeper (30° to 35°) and appears to be more rocky compared to that of the right bank, which has a slope of approximately 18° (CEB, 2012). The slopes of both banks are very high at the proposed dam site and its immediate upstream area, up to the confluence of Ulapane Oya. The topography indicates that a large number of seasonal streams and temporary waterways flow through the slopes to join the main stream at the bottom of the valley (see photo-catalogue for photographs).

The watershed comprises of mixed vegetation, and a number of land use types can be observed within the area. Riverside vegetation, scrublands, grasslands, cultivated and abandoned tea lands, homesteads, plantation forests and degraded forest patches are the major types of vegetation found in the immediate watershed of the Moragolla reservoir. In addition, paddy cultivation areas are found on the left bank of the Moragolla reservoir, in the Ulapane area. Some marshlands are located in the upper most area of the immediate catchment, where the Kotmale Oya tributary confluences with the Mahaweli River. Apart from these land uses, industrial areas, new settlements and traditional villages are also present within the watershed.

Ownership and existing conditions of sections of the immediate watershed of the Moragolla reservoir

Apart from the stream reservation, the land area on the left bank consists predominantly of private lands. Immediately upstream of the proposed dam, the steep slope of the left bank bears grasslands, scrublands and some tea cultivation. Natural vegetation that has been disturbed by anthropogenic activities has regenerated as grasslands on the steep slopes of the river banks.

The Ulapane Industrial Estate is situated on the ridge of this landscape. From the point where the Ulapane Oya joins the reservoir up to the steel bridge at the Ulapane-Pussallawa road, the left bank of the reservoir is occupied heavily by settlements. Typical Kandyan home gardens containing woody perennial trees, fruit trees, multi-purpose trees and some annual crops, can be identified as the major land use type of this area. The average size of an individual land block is approximately half to one acre. Although the tenants have occupied these settlements for long periods - even for generations - they do not have legal ownership of certain blocks of land within this area of the watershed. The upstream area of the left bank from the Ulapane steel bridge, up to the point where the Kotmale Oya confluences with the reservoir, bears a relatively narrow strip of land in between the stream and the steep left bank slope. This area is

also occupied by settlements with home gardens. In addition, some areas are cultivated with tea, while abandoned tea lands can also be observed in this area.

The land on the right bank can be divided primarily into two categories. The land strip between the stream and the road comprises of the stream and road reservation. The land masses above the road are private blocks of land. Some of these lands are been set aside for sale, while others consist of scrublands with a lack of anthropogenic development, settlements, home gardens, cultivated and abandoned tea lands, and degraded forest patches at higher elevation, mainly at the uppermost parts of the watershed.

5.2 Environmental and watershed-related issues

Environmental and watershed related issues associated with the land use patterns of the Moragolla watershed and approaches recommended for their management

The identified immediate catchment area of the proposed Moragolla reservoir has undergone high levels of anthropogenic activities, mainly for settlements and cultivation. Unplanned and unsustainable land development activities in the area have led to a number of soil and water related environmental problems. Habitat and land degradation, quick loss of runoff, poor soil water retention, soil erosion and sedimentation of the bottom of the valley are some such problems. In addition, water pollution caused by domestic and industrial effluents, occasional fires in grasslands and scrublands, encroachment of the riparian reservation and illegal sand mining, have been described as issues associated with the watershed (CEB, 2012).

The environmental and watershed-related issues associated with each of the major land use types are detailed below.

a. Riparian vegetation

Riverine vegetation can be observed in the stream reservation, particularly on the right bank and also in the steep sloped areas adjacent to the stream. This riverine vegetation is disturbed towards the Ulapane area, where more settlements are found. Some sections of the stream reservation have been encroached. During an informal discussion with CEB officers in the area, it was understood that the stream-side strip of land extending from the Ulapane Industrial Zone up to the steel bridge at the Ulapane-Pussallawa road has been encroached, although the tenants occupying these lands have been doing so for long periods of time.

Properly planned replanting programmes are recommended to be carried out for the restoration of this degraded riparian vegetation. A variety of native plants should be selected for replanting. During the selection of plant species for replanting, consideration must be given to their ability to protect the stream bank, their capacity for preventing erosion, their ability to conserve water, their resistance to fluctuations in the water level, and their ability to provide habitats for other species.

b. Wet evergreen forests

This habitat is highly disturbed and only restricted to isolated patches of forest in certain areas of the watershed, particularly at the ridges of the watershed. Such forest areas are highly fragmented. Other sections of wet evergreen forests have become highly degraded secondary

forests (e.g. the strip of forest between the reservoir and main road on the right bank of the reservoir). Inbetween these degraded sections, the vegetation has regenerated as grasslands and scrublands. The establishment of forest vegetation in the upper catchment helps to sustain the soil water, as well as recharge groundwater, which will benefit the reservoir directly through the maintenance of the dry weather flow in the stream. Furthermore, it will reduce soil erosion and the risk of siltation. Establishment of this vegetation also creates habitats for numerous animals and other plant species. However, the main constraint for re-establishment of this vegetation is the availability of land for reforestation. As discussed, the strips of land that are most suitable for reforestation fall under private ownerships, with only very limited amounts of land being held under state ownership.

c. Abandoned land

These lands are predominantly abandoned tea lands or lands that have been cleared for other cultivations. These areas are dominated by grasslands with some scattered trees, shrubs and herbs. In areas with grass cover, the topsoil layer is well protected and less prone to erosion. However, the major problem associated with these grasslands is annual burning of the grasses by local communities just before the onset of rainfall. This exposes the bare soil to the intense rains, causing large-scale soil erosion and siltation.

As a watershed management intervention, these degraded lands can be replanted under the afforestation programme recommended by the CEB. However, the plants used for replanting have to be fire resistant species. Fire belts should be established to prevent the spreading of fire. Raising public awareness also is essential to minimizing the impacts of the burning of the grasslands. It is recommended that the FD takes responsibility in implementing relevant regulations and protecting the grasslands from such burning events.

d. Tea plantations

Tea plantations are one of the two major land uses of the catchment of the proposed Moragolla reservoir. However, most of these cultivation areas do not have any soil conservation measures, and gullies and waterways across the tea fields are not maintained properly. Tea cultivation does not have a good ground cover, as the tea bushes are scattered with gaps inbetween them. The bare ground lacks undergrowth or organic matter, and therefore, the soil is prone to erosion. The steep slopes facilitate quick surface runoff, increasing the vulnerability of the top soil of these areas to erosion.

Establishing lock and spill drains, stone bunds and terraces, and maintaining proper drainage, are some of the possible interventions for soil and water conservation within the tea lands.

e. Home gardens

Kandyan home gardens are the other major land use type within the catchment area. These home gardens are dominated by fruit trees, trees with timber value and multi-purpose trees. However, these lands are managed poorly in terms of soil and water conservation. The average size of a home garden ranges from 0.2 to 0.4 ha. A lack of space within the land was found to be a major obstacle for the development of these lands. The management of solid waste and wastewater is recommended in order to reduce soil and water pollution in homesteads.

f. Ulapane Industrial Park

A lack of soil conservation measures around the industrial premises and improper waste disposal are causing soil and water pollution issues that have to be addressed.

5.3 Management strategies proposed for the Moragolla reservoir watershed

Considering the land use patterns and related problems associated with the immediate watershed of the proposed Moragolla reservoir, the watershed management plan the area was developed focusing on the board land categories shown in Figure 1.

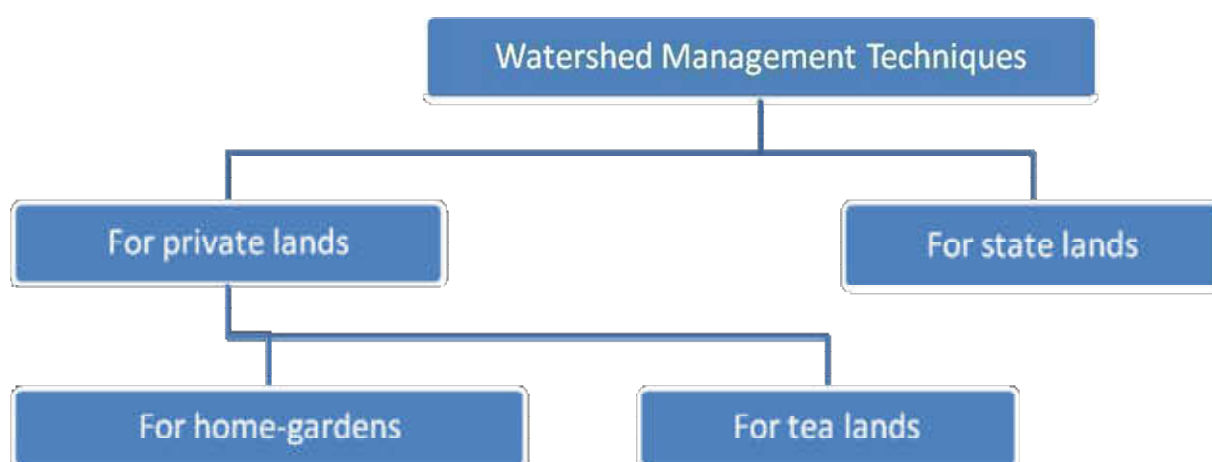


Figure 1. Land use categorization for watershed management of the Moragolla reservoir area

The techniques that can be adopted for watershed management in the Moragolla watershed area are presented in Table 17 below.

Table 17. Summary of the watershed management techniques that can be applied to the Moragolla area

Technique	Description	Purpose(s)	Applicable land uses
Lock and spill drains	Specific type of drains along contours that capture runoff in small stilling ponds.	Slowing down of runoff, temporary storage of runoff water, promotion of infiltration and thereby groundwater recharge, and trapping of silt.	Tea cultivation areas.
Bunds and stone	Embankments along contours that intercept	Slowing down of runoff, trapping of sediments, and	Cultivated lands

Technique	Description	Purpose(s)	Applicable land uses
walls	runoff and sediments, and lead runoff to exit the land.	disposal of runoff water from the fields.	and home gardens.
Small check dams along tributaries	Small scale embankments across tributaries to create ponds along these tributaries.	Slowing down of storm water, prevention of flash flooding, trapping of silt, and temporary holding of water allowing groundwater recharge through the banks.	Streams.
Cover crops	Crops that provide either continuous ground cover or a multi-layer canopy to intercept rainfall.	Reduction of soil detachment and transport (soil erosion), reduction of runoff velocity, possible provision of additional income depending on the type of cover crop used.	Tea cultivation areas and home gardens.
Mulching	Covering the ground with organic matter.	Reduction of soil detachment and transport (soil erosion), reduction of runoff velocity, provision of fertilizers to crops and thereby increasing yields and income, and increasing of the water holding capacity of the soil.	Tea cultivation areas.
Grass strips	Establishing vegetative barriers along the contour lines at a relatively low cost, with little labour and maintenance.	Slowing down runoff, settling sediments, provision of a good quality and quantity of runoff to streams and reservoirs.	Tea cultivation areas, stream reservations, home gardens and abandoned lands.
Reforestation (see the afforestation plan for details)	Replanting blocks of lands with suitable tree species, particularly those that are consistent with the natural vegetation of	Provision of canopy cover to intercept rainfall, provision of litter layer on the ground further reducing the runoff velocity and allowing	Stream banks, degraded forest areas and other reservations owned by the state.

Technique	Description	Purpose(s)	Applicable land uses
	the area.	infiltration, improvement of soil texture, support of cover crops, interception of with fog and thereby provision of additional precipitation, and creation of habitats.	
Home garden improvement (see the afforestation plan for details)	To establish a suitable vegetative cover in private home gardens to provide effective protection against soil erosion.	Minimization of soil erosion.	Home gardens.
Establishment of wetlands	To establish and maintain areas that are inundated seasonally and feature aquatic and semi-aquatic vegetation.	Trapping of silt, allowing groundwater recharge, purification of water and creation of habitats.	Suitable places within the stream reservation.
Awareness raising	To carry out public awareness programmes in order to raise the awareness of local communities on the importance of protecting the watershed.	Encouragement of the local community - particularly the private land owners - to adopt environmentally friendly land use options.	Tea cultivation areas, cultivated lands and home gardens.

Details of these watershed management techniques are provided below. Specific locations for applying these soil conservation measures should be identified after a detailed survey.

a. Lock and spill drains

Lock and spill drains are constructed along the contour lines and across slopes for the purpose to intercepting surface runoff and sediment load. The lock and spill drains slow down the speed of runoff water, and thereby reduce soil erosion. Advantages of lock and spill drains include protection of cultivated lands from hillside runoff, control of gully erosion and slowing down of the erosive power of runoff.

b. Bunds and stone walls

These artificial embankments are constructed and graded so as to intercept rainfall and sediments, and lead runoff away from the cultivated land. Stone walls are usually constructed along contours in fields or at road sides, and provide an irregular form of terracing.

c. Small check dams along tributaries

Small check dams can be constructed in order to prevent gully erosion. Check dams are barriers erected across seasonal waterways, such as gullies, to decelerate the flow of water, allowing soil particles to sediment. The excess water will spill over the barrier once the check dam is filled. They can be constructed as concrete, masonry, earthen or loose stone check dams. For small gullies, check dams can be constructed using branch wood. The recent trend is to construct check dams using Gabion cages filled with stones collected locally. It is necessary to observe the erosion in progress in major gullies and to construct at least a loose stone check dam as a preventive measure. Advantages of these structures include control of gully erosion, slowing down of the erosive power of runoff, and increasing retention time to facilitate groundwater recharge.

d. Cover crops

Cover crops are grown to protect the soil from erosion and to improve soil through green manuring. These are usually short rotation crops (less than two years), planted in fields or under trees, during fallow periods. Some of the advantages of cover crop planting include improvement of soil fertility, reduction of soil erosion and water loss, suppression of weeds, reduction of the need for fertilizers and herbicides, and an increase of soil organic matter.



Figure 2. Check dams constructed by IUCN during a previous project (Kumudu Herath @ IUCN)

e. Mulching

Mulching is a soil and water conservation practice in which a covering of cut grass, crop residues or other organic material is spread over the ground, between rows of crops or around the trunks of trees. This practice helps to retain soil moisture, prevents weed growth and enhances the structure of the soil. Advantages of mulching include interception of rain, reducing the direct impact of raindrops on bare soil, reducing surface runoff and soil loss, suppression of weeds and reduction of the labour cost of weeding, increased soil organic matter and increased moisture holding capacity of the soil.

f. Grass strips

Planting grass along contour lines creates barriers to minimize soil erosion and runoff. It includes a process of natural terracing on slopes as soil collects behind the grass barrier, even in the first year. Grass can be planted along the bottom and sides of ditches to stabilize them, and to prevent erosion of the upper slope. Grasses can also be planted on the ridges of bench terraces to prevent erosion and maintain the stability of the benches. Advantages of grass cover include control of soil erosion and runoff (i.e. the root systems of vetivera grass acts as a natural barrier to bind soils), and provision of fodder.

g. Reforestation

Forest cover with a good canopy and well developed litter on the forest floor can reduce or prevent soil erosion. Vegetation is the primary factor that changes the rate of soil erosion most radically within a given site. Forest vegetation, along with other factors such as the nature of the canopy, understorey vegetation, ground vegetation and ground cover by leaf litter, provides the best possible protection against soil erosion. Apart from reducing soil erosion, forest cover can reduce nutrient losses from the soil, and can build up the nutrient status and fertility of the soil. Forest vegetation also increases soil organic matter, as well as the moisture holding capacity of the soil. The details of the afforestation/reforestation programme of the project have been discussed in the previous section of the report.

h. Home garden improvement

As discussed previously, home gardens constitute a traditional system of perennial cropping for a wide range of valuable crops providing commodities such as food, fruits, timber, medicines and spices, and are considered important sites for the *in-situ* conservation of crop germplasm. Kandyan home gardens are essentially a luxuriant system of mixed cropping with a variety of economically valuable tree crops and form an essential component of the land use. These home gardens are like forests in many respects. They provide shelter to birds and other wildlife, and conserve soil and water almost as well as the natural forest. They also provide a range of products including timber, fuelwood and non-wood forest products. However, some of the home gardens in the Moragolla catchment are managed poorly in terms of soil conservation. Therefore, a home garden improvement programme is an essential component of the watershed management programme. This component has been incorporated in to the afforestation programme of this report.

i. Establishment of wetlands

Wetlands affect the landscape by virtue of their capability to retain water and decrease its velocity, controlling erosion. They also provide valuable habitats for wildlife and enhance water quality. Hydrological functions of wetlands include flood buffering, water storage, groundwater discharge and recharge, surface flow augmentation, and removal of pollutants, such as nutrients and heavy metals. Therefore, in addition to biodiversity conservation, the establishment of wetlands in the Moragolla watershed will also facilitate these hydrological functions.

j. Awareness raising

The objective of the public awareness programme will be to promote public awareness on the conservation and management of soil and water resources in the Moragolla project area, in order to emphasize the need to protect these resources among local communities. Such a public awareness programme will enhance and facilitate the other soil and water conservation and management activities implemented in the Moragolla reservoir area.

5.4 Implementation of the watershed management programme

The activities to be implemented under the watershed management programme are as follows:

1. Detailed field survey to identify specific locations to establish proposed soil conservation structures and measures appropriately;
2. Design of mechanical structures required, including lock and spill drains, bunds and stone walls, and small check dams;
3. A brief feasibility study on establishment of wetlands;
4. Preparation of a detailed programme on awareness raising, including identification of different target groups;
5. Provision of inputs to the afforestation programme for implementation of home garden improvement activities;
6. Preparation of an implementation plan; (see Chapter 6)
7. Establishment of lock and spill drains, bunds and stone walls and small check dams, as necessary.
8. Establishment of cover crops, mulching and grass strips, as well as implementation of home garden improvement programmes;
9. Establishment of wetlands, as necessary;
10. Implementation of the awareness programme; and

11. Monitoring.

The schedule for the implementation of activities related to watershed management is presented in Table 18 below.

Table 18. Schedule for the implementation of activities related to watershed management in the Moragolla Project area.

	Activity	Timeframe							
		Year 1				Year 2			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1.	Detailed field survey to identify specific locations for the implementation of proposed soil conservation measures								
2.	Design of mechanical structures required, including lock and spill drains, bunds and stone walls, and small check dams								
3.	A brief feasibility study on establishment of wetlands								
4.	Preparation of a detailed awareness programme on awareness								
5.	Provision of inputs to the afforestation programme for the implementation of the home garden improvement component								
6.	Preparation of an implementation plan								
7.	Establishment of lock and spill drains, bunds and stone walls and small check dams.								
8.	Establishment of cover crops, mulching and grass strips, and implementation of home garden improvement programmes								
9.	Establishment of wetlands								
10.	Implementation of awareness programme								
11.	Monitoring								
Q1- 1 st Quarter, Q2 – 2 nd Quarter, Q3 – 3 rd Quarter, Q4 – 4 th Quarter									

5.5. Cost estimate

The cost estimate for activities proposed as part of the watershed management programme are presented in the table below.

Table 19. Cost estimate for activities proposed as part of the watershed management programme.

No	Activity/technique	Unit cost (LKR)	Total length /area	Estimated cost (LKR)
1.	Detailed field survey to identify specific locations to establish proposed soil conservation measures	Lump sum	-	30,000
2.	Design of proposed mechanical measures	Lump sum	-	45,000
3.	Brief feasibility study on the establishment of wetlands	Lump sum	-	15,000
4.	Preparation of a detailed awareness programme	Lump sum	-	45,000
5.	Provision of inputs for the implementation of the home garden improvement component	Lump sum	-	15,000
6.	Preparation of implementation plan	Lump sum	-	30,000
7.	Construction of lock and spill drains.	LKR 225 per metre	2, 000 m	450,000
8.	Construction of earthen bunds	LKR 225 per metre	1, 700 m	382,500
9.	Construction of stone walls	LKR 360 per metre	1, 200 m	432,000
10.	Construction of small check dams	LKR 1200 per m ³	24 m ³	28,800
11.	Cover crops and mulching	LKR 15,000 per ha	20 ha	300,000
12.	Grass strips	LKR 450 per metre (2 m width)	1, 400 m	630,000
14.	Establishment of wetlands	LKR 15,000 per ha	1 ha	15,000
15.	Implementation of the awareness programme	1 year		375, 000
16.	Monitoring	Lump sum		450,000
Total estimated cost of activities				2,973,300
Contingencies (10%)				297,330
Total including contingencies				3,270,630
Administrative and supervision Cost (13%)				425,182
Grand total				3,695,812

As such, the total cost for the watershed management programme would be approximately LKR 3.7 million (US Dollars 28,212).

The assumptions and estimates used to calculate the costs are as follows:

- i. Lock and spill drains - Approximately 30 m of lock and spill drains to be constructed for each hectare of tea lands in 63 ha of tea in the immediate catchment;
- ii. Earthen dams - Approximately 20 m of earthen dams for each hectare of land in the 31-60% slope category (83 ha) of tea in the immediate catchment;
- iii. Stone walls - Approximately 14 m of stone walls for each hectare of land in 31-60% slope category (83 ha) of tea in the immediate catchment;
- iv. Small check dams - Ten (10) cubic meters for each hectare of 10 percent of the total land area (24 ha) of immediate catchment occupied by water bodies;
- v. Mulching and cover crops - Eight percent (8%) of the total extent (about 100 ha) of tea and 5% of the total extent (about 230 ha) of home-gardens/degraded tea lands in the immediate catchment up to a distance of 100 m from the FSL around the reservoir periphery ;
- vi. Grass strips - in twenty percent (20%) of the total periphery of the reservoir up to 100 m from the FSL in the immediate catchment ; and
- vii. Wetlands - Roughly 5% of the total land area of the immediate catchment is occupied by water bodies.

6 IMPLEMENTATION AND MONITORING

The most feasible option for implementing the proposed AWMP successfully is to have it implemented through professional organizations in Sri Lanka with adequate experience in planning and implementing such activities. It is recommended that the following government institutions are involved in this activity.

6.1 Programme implementation

Forest Department (FD)

The FD has a vast amount of experience in the implementation of afforestation and biodiversity conservation programmes in Sri Lanka. While the headquarters of this agency is located in Battaramulla, it has a well distributed district office network throughout the country. It also has many experienced professional staff in the field of forestry. The Moragolla project area comes under the authority of Divisional Forest Officer of the Kandy District. The field-level authority for the Moragolla project area is Range Forest Officer located at Nawalapitiya. The Beat Forest Officer of the Gampola Beat operates under the Divisional Forest Officer. In addition, a number of Field Assistants are also stationed in the project area. Considering this field-based structure, and the experience of the FD in afforestation work, the involvement of the FD in the implementation of the afforestation component of the AWMP is highly recommended.

Natural Resources Management Center (NRMC)

The Natural Resources Management Center of the Department of Agriculture is a professional organization with much experience in handling watershed management related activities. It has experienced professional staff in the field of soil conservation and watershed management. The NRMC is located in Peradeniya, and can be recommended for the implementation of watershed management related work within the AWMP.

6.2 Monitoring

Programme implementation should be monitored by a monitoring committee comprising of the CEB, implementing partners (see Chapter 6) and community organizations in the area. This programme monitoring committee should meet once each quarter to monitor the progress of implementation. If there are any issues adversely affecting the progress of the programme, immediate action should be taken to resolve such issues.

7 CONCLUSIONS AND RECOMMENDATIONS

A. Objectives of the programme

1. Rehabilitation and ecological restoration of degraded forests and adjoining areas of Moragolla catchment on watershed basis;
2. Improvement of native forest diversity by planting native tree species in the Moragolla catchment;
3. Prevention of the establishment or control of the spread of invasive plants species that disrupt forest ecosystem process;
4. Minimization of the loss of floral and faunal species of conservation significance during the construction phase of the project due to vegetation clearing and alteration of habitats;
5. Reduction of soil erosion from the Moragolla catchment and minimization of sedimentation of the proposed reservoir by adopting eco-friendly cultivation systems in privately owned lands within the catchment; and
6. Increased public awareness on the importance of protecting the Moragolla reservoir by adopting soil conservation measures and sediment-friendly land-use options.

The programme activities have been designed to meet these objectives. Objectives 1-4 are met through the afforestation component of the AWMP, while objectives 5 and 6 are met through the watershed management component of the programme.

B. Expected outcomes of the Afforestation programme

1. The forests in the Moragolla catchment and adjoining areas are highly productive in terms of forest products and services. There are no abandoned lands and degraded areas that are prone to soil erosion in the immediate catchment of the Moragolla reservoir. Forests in the catchment area provide good habitats for fauna and flora living in the area. Forest services such as the conservation of soil and water, the provision of good quality water, reduction of soil erosion and conservation of biodiversity are provided to satisfactory level. These forests provide Non-Timber Forest Products (NTFP) that are extremely valuable.
2. The species composition of forests in the immediate catchment of Moragolla shows a high proportion of native species, which is favourable for faunal species living in these forests.
3. Alien and invasive plant species are not present in the forest areas in the catchment. Native tree species are growing at a healthy rate as there is no competition from invasive plants.

4. Flora and fauna species of conservation significance are not lost due to construction activities. Suitable flora and fauna are rescued and translocated to the refuge established for the conservation of these species.

C. Expected outcomes of the watershed management programme:

1. All privately owned lands within the Moragolla catchment, particularly poorly managed tea lands and home gardens, are properly managed with adequate soil conservation measures and vegetative cover. Soil erosion from these lands and sedimentation of the reservoir is minimized. The sustainability of the reservoir is ensured due to good land management in privately owned lands in the catchment.
2. The local people in the Moragolla project area are fully aware of the importance of adopting soil conservation measures and environment-friendly land-use options for protecting the Moragolla reservoir. Private land owners in the area are adopting soil conservation measures in their tea lands and home gardens in the catchment area, and these areas are well protected with a good vegetative cover.

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ANNEXURES

Annex 1: Trees (>20 cm DBH) likely to be removed or affected due to the Moragolla Hydropower Project, as provided in the ToR
(Source: Moragolla Hydropower Project EIA, 2012)

Moragolla Hydropower EIA (2012)															
Family	Species	Common Name	BG	D	R	P	PH	C	NR	R1	R2	DS	TL	CS ⁴	
Anacardiaceae	Anacardiumoccidentale	Cashew	I							1			1	NE	
	Lanneacoromandelica		N					1						NE	
	Mangiferaindica	Mango	I		10			1	9	6	1			DD	
Apocynaceae	Alstonia macrophylla	Hard milk wood	I		12				3	8	3	2	4	LC	
	Alstonia scholaris	Milkwood pine	N		2								1	LC	
Arecaceae	Areca catechu	Betel palm	N										2	NE	
	Caryota urens	Jaggery palm	N		6			2						NE	
	Cocos nucifera	Coconut palm	N		7					6	1			NE	
Bignoniaceae	Spathodeacampanulata	Fountain tree	I						3	2	7			NE	
	Tabebuiarosea	Savannah oak	I		4				1					NE	
Malvaceae	Bombaxceiba	Cotton tree	N											NE	
	Ceibapentandra	Java cotton	I							1	2			NE	
	Duriozibethinus	Durian	I		1									NE	
Combretaceae	Terminaliaarjuna	Arjun tree	N		4									NE	
Tetramelaceae	Tetramelesnudiflora		N		1									LC	
Elaeocarpaceae	Elaeocarpus serratus	Ceylon olive	N						2	1				NE	
Euphorbiaceae	Hevea brasiliensis	Rubber	I							2	1			NE	
	Macarangapeltata	Kenda	N	1	4	2				3	9	4	8	NE	
	Mallotustetracoccus		N		2							3		NE	
Fabaceae	Acacia mangium	Black wattle	I	3	14			3	1				4	NE	
	Acacia melanoxylon	Hickory	I		3										
	Albizia falcataria	Silk tree	I		34			1	7		1	5		NE	
	Albizia odoratissima		N						1	2	1		5	NE	
	Cassia (Senna) spectabilis		I							1				LC	
	Delonixregia	Flame tree	I		5					1				VU	
	Gliricidia sepium	Gliricidia	I				2							NE	
	Peltophorumpterocarpum	Yellow flame tree	N		23			1	1					NE	
	Pterocarpusmarsupium	Indian kino tree	N					1						VU	
Lauraceae	Neolitsea cassia	Sri Lanka laurel	N		1	2		1		2	4			NE	
Magnoliaceae	Michelia (Magnolia) champaca	Magnolia	N		5	1		1	10		1			NE	
Meliaceae	Meliaazedarach	Indian lilac	N								1			NE	
	Swietenia macrophylla	Big-leaf mahogany	I		5					42	11		2	VU	

⁴ CS = IUCN Conservation Status 2013 (<http://www.iucnredlist.org/>)

Moragolla Hydropower EIA (2012)															CS ⁴
Family	Species	Common Name	BG	D	R	P	PH	C	NR	R1	R2	DS	TL		
	Toona sp.	Mahogany	I					1	2						
Moraceae	Artocarpus heterophyllus	Jackfruit	I		1			5	3	1	1	1		NE	
	Artocarpus nobilis		E		3						2			VU	
	Ficusexasperata	Fig tree	N							1	2			NE	
	Ficus racemosa	Cluster fig tree	N		6									NE	
	Ficus sp.	Fig	N		6										
Myrtaceae	Eucalyptus (Corymbia) torelliana	Eucalypt	I		3		PH							NE	
	Eucalyptus sp.	Eucalyptus	I						1	1					
Protaceae	Grevillea robusta	Silky oak	I						1					NE	
Rhizophoraceae	Carallia brachiata	Corkwood	N							3				NE	
Sapindaceae	Nephelium lappaceum	Rambutan	I		1									LC	
Malvaceae	Grewia damine		N										1	NE	
Cannabaceae	Trema orientalis	Indian charcoal	N	3	4	2	2		1					NE	
Sub Total				7	17	7	4	1	7	9	5	1	2		
Total					9			8	5	7	9	5	8		
489															

Key to Appendix I

BG = Biogeographic status: E = Endemic; N = Native; I = Introduced

D = Dam Site; **R** = Reservoir; **P** = Penstock; **PH** = Power House; **C** = Camp

NR = New Road; **R1**, **R2** = Expansion Road 1 and 2; **DS** = Dumping Sites; **TL** = Transmission Line

CS = IUCN Conservation Status: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; NE = Not Evaluated (From: <http://www.iucnredlist.org/>)

Source: CECB, 2012, Environmental Impact Assessment, Moragolla Hydropower Feasibility Study

PHOTO CATALOGUE

(Photographs by Avanti Wadugodapitiya @ IUCN)



Figure 1. The valley seen from the Ulapane industrial zone.



Figure 2. Stream at the proposed dam site.



Figure 3. Shrubs on the steep slope of the left bank of the valley at the proposed dam site.



Figure 4. Riparian vegetation at the stream reservation of the right bank at the proposed dam site – consists of shrubs and a grassy undergrowth.



Figure 5. Riparian vegetation of the stream upstream of the proposed dam site at the area where the existing road is to be submerged.

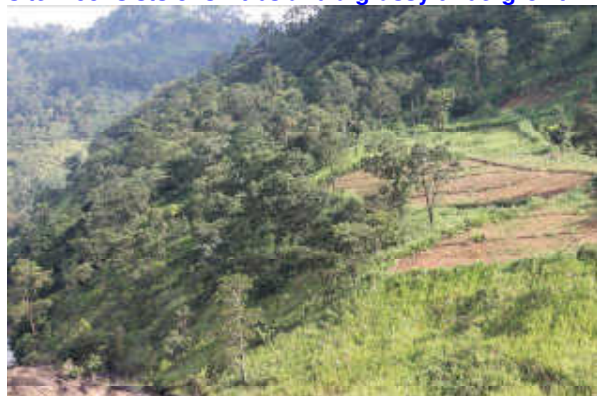


Figure 6. Cultivation lands without soil conservation located close to the riparian vegetation.



Figure 8. Degraded grasslands with patches of land cleared for cultivation.



Figure 9. Bare land prone to soil erosion.



Figure 10. Degraded forest area with patches of land cultivated with tea.



Figure 11. Remaining forest patches at the ridges of the watershed.



Figure 12. Degraded forest area with cultivated land.



Figure 13. Forest merged with home gardens at the ridge of the valley



Figure 14. Forest merged with home gardens provide habitats.



Figure 15. Home gardens consisting of trees such as kitul, jak, coconut, arecanut and banana.



Figure 16. Home gardens on the right bank of the proposed reservoir at the upper section of the immediate catchment.



Figure 17. Home gardens with poor soil conservation.



Figure 18. Tea cultivated area adjacent to the Ulapane industrial zone – no soil conservation measures have been adopted.



Figure 19. Grasslands cleared for cultivation – stone walls are established for soil conservation.



Figure 20. A wetland area close to the quarry site on the right bank of the stream.



Figure 21. Home gardens at the banks of the stream at the upper section of the immediate catchment.

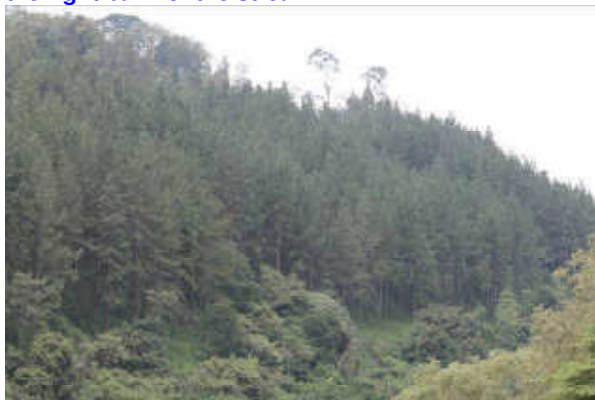


Figure 22. Pine plantations managed by the Forest Department at the right bank of the upper section of the immediate catchment. Monoculture planting such as that shown in this plantation is not recommended during afforestation.



Figure 23. Discussion with local people to collect information.

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MORAGOLLA HYDROPOWER PROJECT

**ADDITIONAL STUDIES IN THE NATURAL
ENVIRONMENT**

**PART A
SLOPE STABILITY IN THE RESERVOIR AREA**

**PART B
RESULT OF DAM BREAK ANALYSIS**

NOVEMBER 2013

Nippon Koei Co., LTD.

in joint Venture with

Nippon Koei India PVT. LTD.

PART A

SLOPE STABILITY IN THE RESERVOIR AREA

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Table

Table 1 Types of Landslides

Figure

Figure 1 Major types of Landslide

Figure 2 Location map of Unstable Rock Mass (1)

Figure 3 Location map of unstable Rock Mass (2)

1. General

This report explains the study results on slope stability in the reservoir area of Moragolla Hydropower Project. For the purpose of evaluation of the slope stability, topographic analysis and ground mapping of the reservoir area was carried out from 9th-21st Sep. 2013 by Mr. MOMOSE (Sr. Geologist) and Mr. YOKOYAMA (Geologist). The following items were identified through the study, and geological map of the reservoir area was prepared.

Data collection

- Existing geological map, landslide analysis data

Topographic Analysis:

- Landslide scar, talus, terrace, plain, cliff

Ground mapping:

- Geological components, locations of outcrops;
- Rock condition, weathering, the structure of the strata, joints, fracture zone;
- Distribution of unconsolidated deposits, such as talus deposits, terrace deposits and river sand; and
- Location and water flow of spring, and tributary

2. Previous Study

Landslide hazard investigation was carried out in 2009 by NBRO for the preparation of EIA report. On the basis of the results of site reconnaissance and review of the existing data, the Report of the Landslide Hazard Investigation for the Proposed Moragolla Hydropower Project (August 2009) was prepared. According to the report, there are no landslide except for gully or some bank failures and it has concluded that the Project is feasible without provoking landslides, if suitable measures are given during construction. In the report, the following recommendations are listed to prevent/mitigate landslide.

- Prevention measures of soil erosion surrounding the reservoir area;
- Evacuation of several houses on steep soil slopes of the right bank whose toes will be inundated (left bank?);
- Protection measures for unstable rock mass about 500 m upstream of dam site;
- Dispatching a super visor during construction stage
- Minimizing heavy blasting and deep excavations, and installation of suitable measures; and
- Minimizing removal of vegetation for erosion control.

In previous study, the slopes stability in the dam reservoir was not evaluated. Although some unstable rock masses were identified, locations and sizes of unstable rock masses and their condition were not mentioned. Therefore, in this study, the landslide-prone slopes including unstable rock mass were identified based on the ground mapping in the reservoir area, and their slope stability was evaluated.

3. Geology of the Reservoir Area

The project area is located in the Central Highlands underlain by the Precambrian metamorphic rocks belonging to the Highland series. The bedrock of the project area is composed mainly of Precambrian garnetiferous gneiss/charnockitic gneiss, intercalated with thin bands of quartzite.

3.1. Geological Component

(1) Garnetiferous gneiss/charnockitic gneiss

Inter bedded bands of dark grey fine to medium grained charnockitic gneiss and pale grey medium grained garnetiferous gneiss. Fresh rocks are solid and dense. Bedrocks are exposed along riverbed, forming cliffs particularly on the left bank downstream of the dam site.

(2) Quartzite

White color, generally several meters layers. Due to the brittleness of the rock, weathering along the joints sometimes reaches several ten meters in depth. Relatively thick quartzite layers are extending north to south on the left bank of the dam site.

(3) Terrace deposits

Small terraces are distributed along the Mahaweli River, of about 20-30 m and 5 m above the river floor. Gravely silt and clay, very stiff-stiff, including sub-rounded gravels of 10-50 cm in diameter.

(4) Alluvial deposits

A small amount of river sand, boulders of 2-3 m diameters are found on the river floor. Bedrocks are exposed on most of locations along the river.

3.2. Geological Structure

The project area lies on the rim of a NW-SE trending broad anticline. The gneissosity 10-30 degrees dips to the southwest at the dam site, while to the north/northwest at the powerhouse site.

Geological The Mahaweli River runs to the north and northeast in the project area. Rock masses on the right bank are likely to induce plane failures sliding on the foliation of the foundation rocks, because the structures of the foundation rocks

gently dip to the west.

4. Slope Stability in the Reservoir Area

4.1. Type of Landslide

The term of landslide describes a wide variety of processes that results in the downward and outward movement of slope-forming materials. Table 1 and Figure 1 shows a classification of landslides based on materials and mode of movement.

Table 1 Types of landslides.

Abbreviated version of Varnes' classification of slope movements (Varnes, 1978).

Type of Movement		Type of Material	
		Bedrock	Engineering soil
			Predominantly coarse Predominantly fine
Falls		Rock fall	Debris fall Earth fall
Topples		Rock topple	
Slides	Rotational	Rock slide	Debris slide Earth slide
	Translational		
Lateral Spreads		Rock spread	Debris spread Earth spread
Flows		Rock flow (deep creep)	Debris flow Earth flow (soil creep)
Complex: combination of two or more principal types of movement			

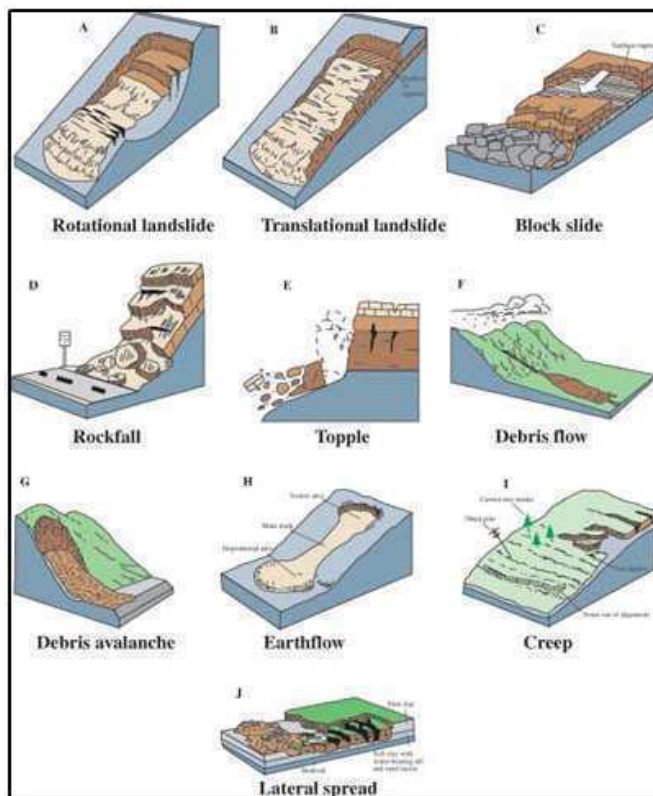


Figure 1 Major types of Landslide

Source: USGS Homepage
(<http://pubs.usgs.gov/fs/2004/3072/fs-2004-3072.html>)

In addition to the these typical landslides, deep weathering and thick unconsolidated deposits such as talus deposits etc. need to be identified, because landslide might be induced consequently if these materials are strongly affected by dam impoundment and fluctuation of dam reservoir level.

4.2. Slope Stability in the Reservoir Area

Results of the ground mapping revealed that:

- There are no large scale landslide in the reservoir area;
- On the left bank of the Mahaweli River, structures of bed rocks are suitable in slope stability, gneissosity dipping to the mountain side;
- On the other hand, on the right bank, gneissosity dipping to the river, two locations of rock slide area on right bank of Mahaweli River approximately 1.0 km and 1.35 km upstream of dam site are identified (See Figure 2 and Figure 3 location Map); and
- Erosion of the coastal area caused by the fluctuation of the dam reservoir level will not be significant, because bedrocks crops out at most of toes of the steep slopes of the left bank, and thick vegetation covers both bank slopes in the reservoir area.

(1) Rock slide (Loc.1)

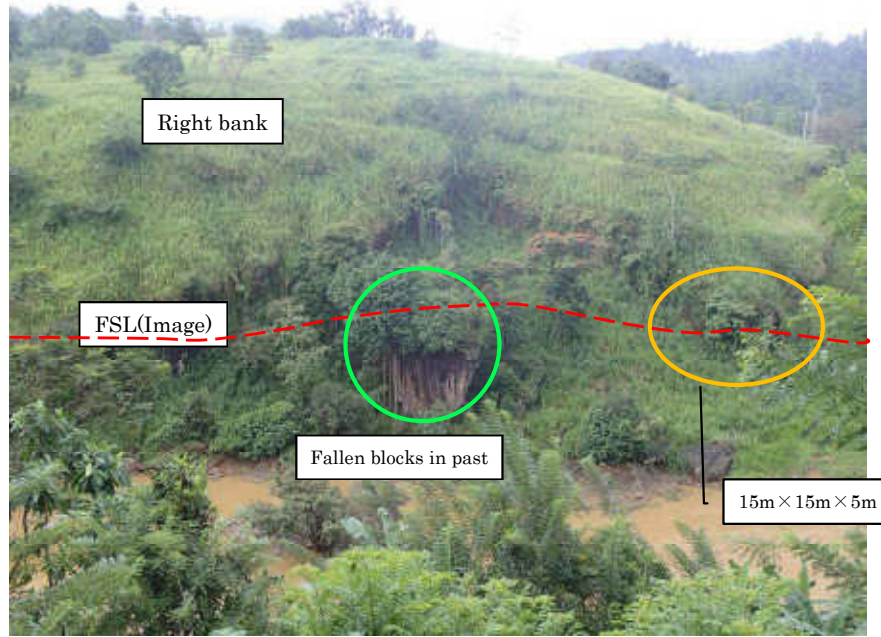
Location:	Right bank approximately 1.0 km upstream of dam site
Assumed unstable rock mass:	15 m (long) x 20 m (wide) x 5 m (thick) and 10 m (long) x 10 m (wide) x 5 m (thick)
Failure:	Blocks will be separated by two almost vertical joint systems striking N46E and N30W respectively, and slide on a plane of gneissosity to the river side.
Engineering assessment:	The greater part of unstable rock mass bodies are below MOL=542 m. This location is far from dam site. Even if these rock mass slides into the dam reservoir, the impact of landslide-generated waves will be negligible at dam site.



Picture 1 Unstable Rock mass Loc.1

(2) Rock slide (Loc.2)

Location:	Right bank approximately 1.35 km upstream of dam site
Assumed unstable rock mass:	15 m (long) x 15 m (wide) x 5 m (thick)
Failure:	Blocks will be separated by two almost vertical joint systems striking N70E and N10W respectively, and slide on a plane of gneissosity to the river side
Engineering assessment:	The greater part of unstable rock mass bodies are below MOL=542 m. This location is far from dam site. Even if these rock mass slides into the dam reservoir, the impact of landslide-generated waves will be negligible at dam site



Picture 2 Unstable Rock Mass Loc.2

5. Conclusion

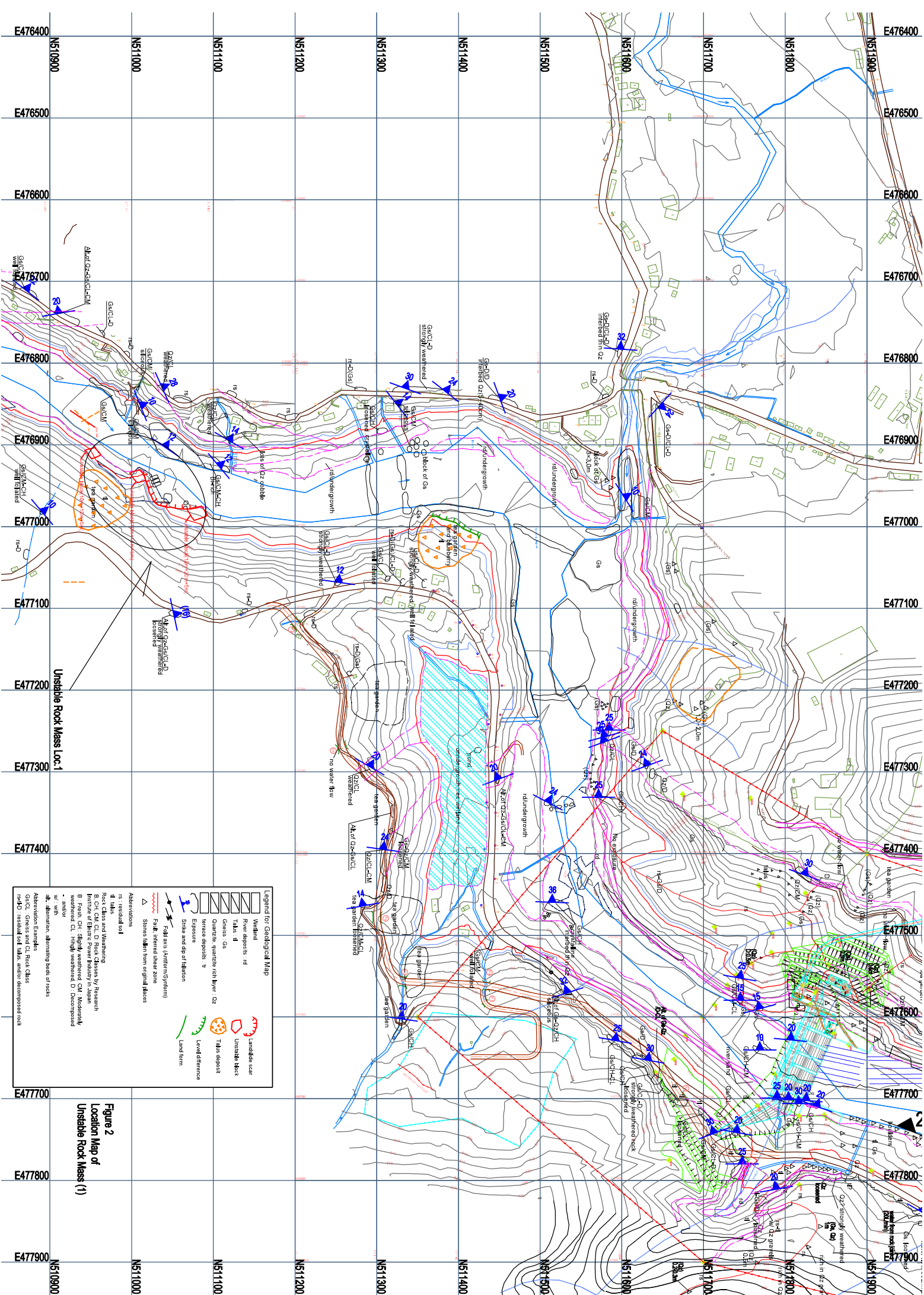
There are no large scale landslides in the reservoir area.

On the left bank of the Mahaweli River, structures of bed rocks are suitable in slope stability, gneissosity dipping to the mountain side.

On the other hand, on the right bank, gneissosity dipping to the river side, two locations of rock slide area on right bank of Mahaweli River approximately 1.0 km and 1.35 km upstream of dam site are identified in this study. However, the greater part of unstable rock mass bodies these unstable rock masses are located below LWL=523 m. Even if these rock mass slides into the dam reservoir, the impact of landslide-generated waves will be negligible at dam site.

Erosion of the coastal area caused by the fluctuation of the dam reservoir level will not be significant, because bedrocks crop out along most of toes of the steep slopes of the both banks, and thick vegetation covers relatively gentle slopes of the both banks in the reservoir area.

This report concludes that there are no landslides which make significant impact on the dam. However, monitoring of the slopes in the reservoir area is recommended during dam impoundment, because all potential of small scale landslides cannot be identified and small scale landslide might trigger larger landslides.





PART B

DAM SAFETY

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- 1. Safety of Moragolla Dam - 1 -
- 2. Failure of Maragolla Dam - 1 -

Figure

Figure 1 Discharge and Stage Hydrographs at Dam Failure

Figure 2 Inundation Area at Gampola at Dam Failure, below EL.488m

Figure 3 Inundation Area at Peradeniya at Dam Failure, below EL482m

1. Safety of Moragolla Dam

Moragolla dam is a concrete gravity dam.

In most cases of dam failure, foundation quality or large floods are the main cause. Foundation rocks of Moragolla dam are garnetiferous gneiss and charnockitic gneiss which are fresh and sound. The foundation has the safety factor more than 4 against share force even in the cases of the 10,000-year flood and the maximum credible earthquake with a seismic coefficient of 0.10. The dam is designed to meet the safety requirements in accordance with modern technical standards. The possibility that the dam will fail due to foundation failure or earthquake is remote.

The spillway has a capacity to pass the peak discharge of 10,000-year flood (6,700m³/s) with the reservoir level at FSL 548m, 2m below the top of dam. Even if one gate is completely blocked, the spillway is able to release the peak discharge of 10,000-year flood at the reservoir water level El.550, the top elevation of dam. The possibility of the dam being overtopped is remote. Even if the dam is overtopped, it is able to stand against water pressure with massive concrete body on sound rock foundation.

There is no possibility that the dam will cause catastrophic failure. Over 1% of concrete gravity dams built before 1930 but none of the 2500 more recent ones have failed (ICOLD Bulleting 117, “The Gravity Dam: a dam for the future-Review and recommendations, 2000”).

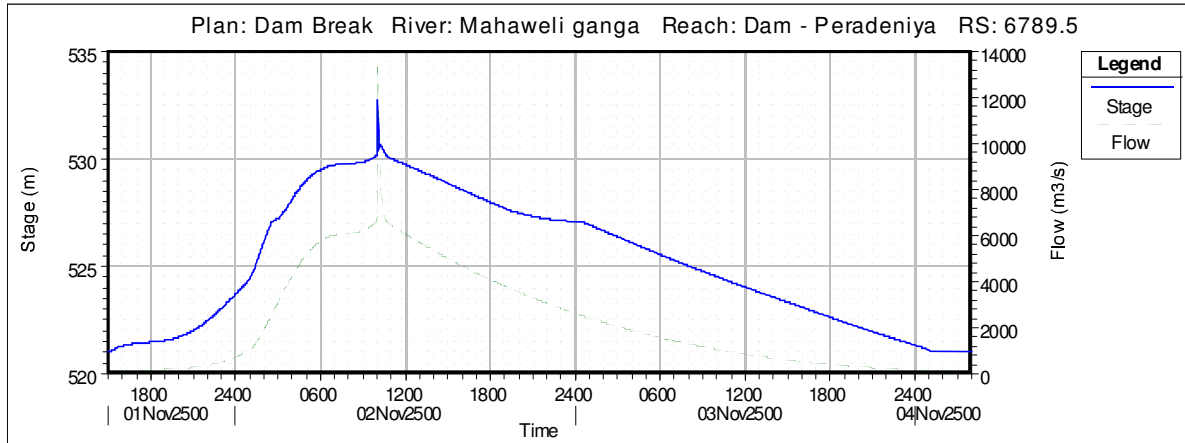
2. Failure of Maragolla Dam

Assuming that a 60m wide section of the dam above El. 520m could disappear instantaneously when the 10,000-year flood reaches the peak, it is estimated that a flood of 13,300m³/s would pass down from the dam site. Discharge hydrographs and stage hydrographs at the dam site, Gampola and Peradeniya calculated using HEC RAS are shown in Figure 1 and summarized below.

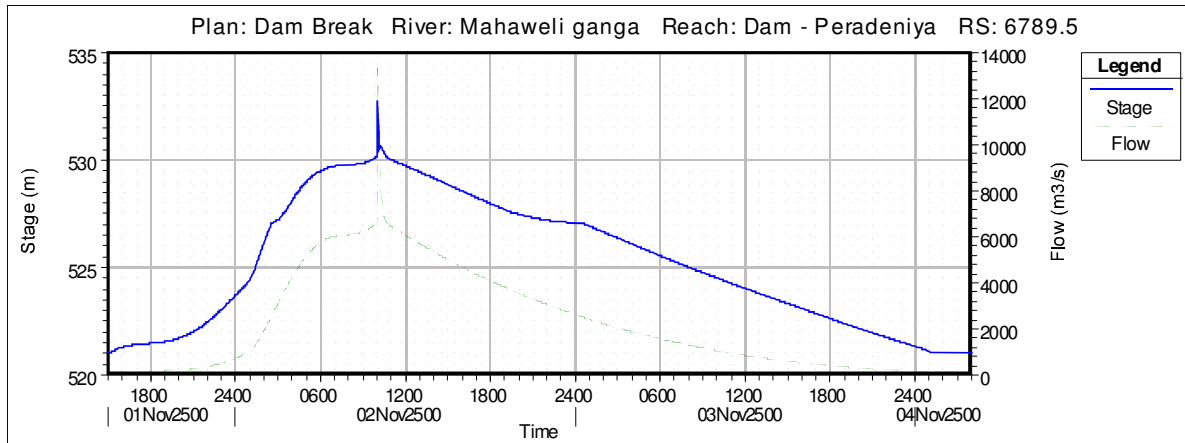
	Max. Discharge (m ³ /s)	Max. Stage (El.m)
Dam Site	13,300	534
Gampola	8,800	488
Peradeniya	7,000	482

This would raise the water levels to El.488m at Gampola and El. 482m at

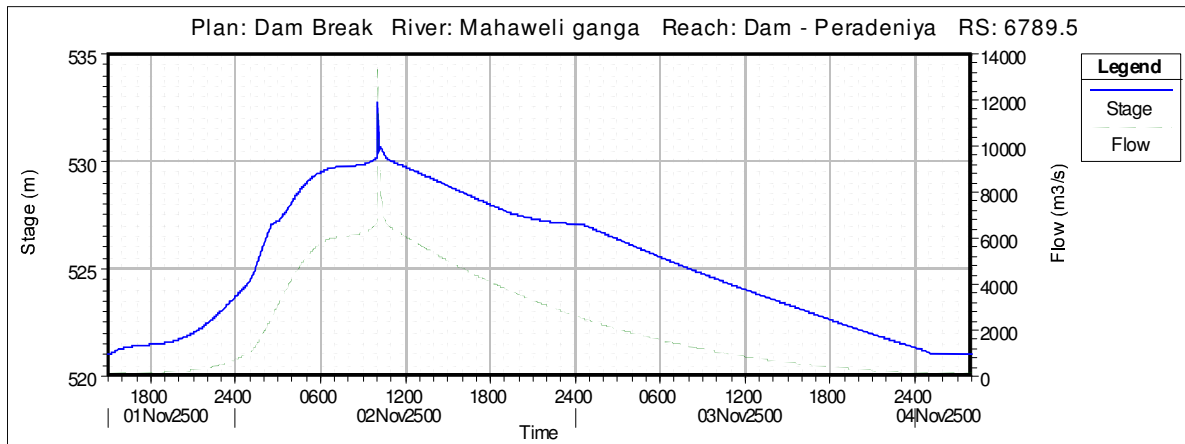
Peradeniya as shown in Figure 2 and Figure 3.



Dam Site



Gampola



Peradeniya

Figure 1 Discharge and Stage Hydrographs

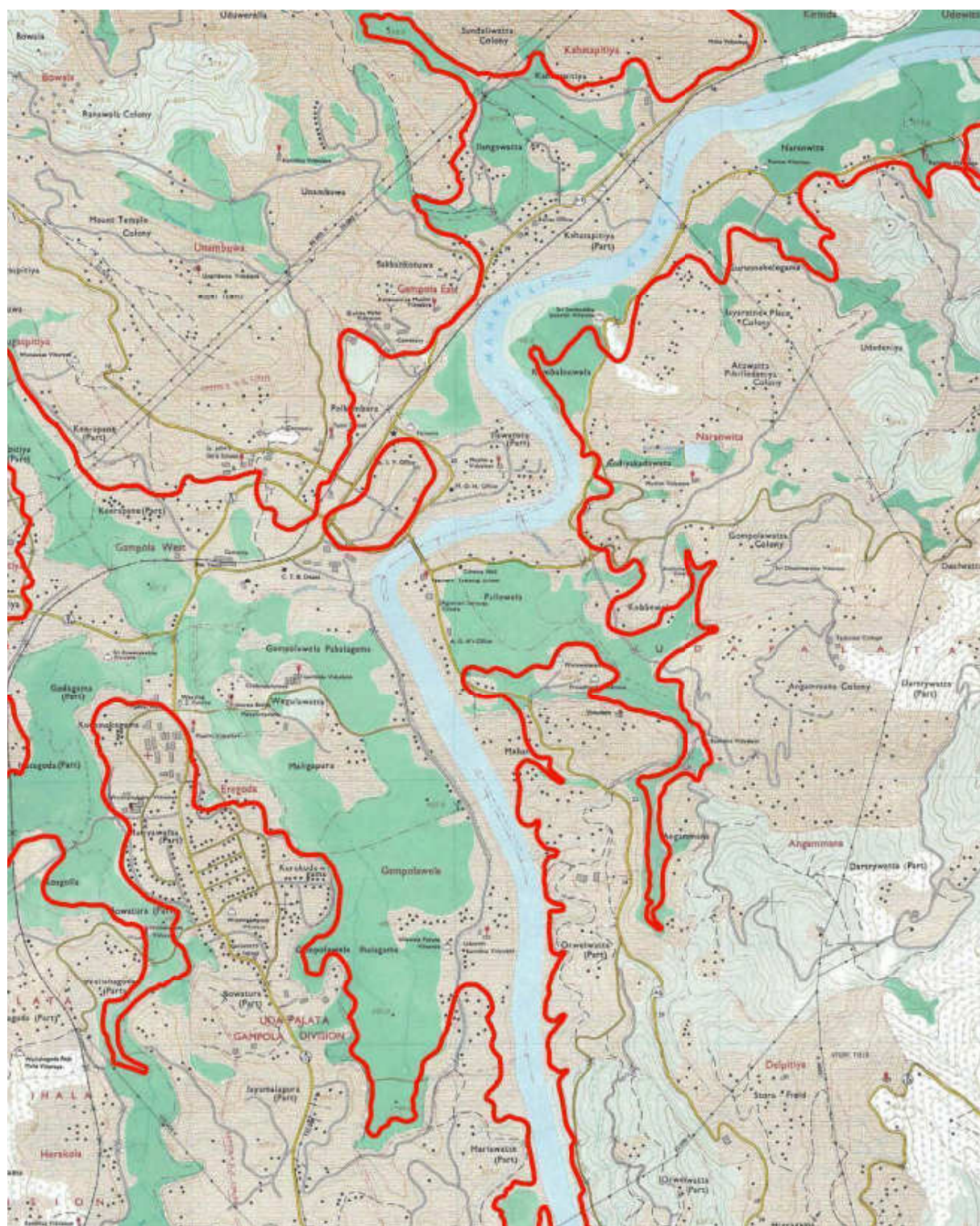


Figure 2 Inundation Area at Gampola at Dam Failure, below El. 488m

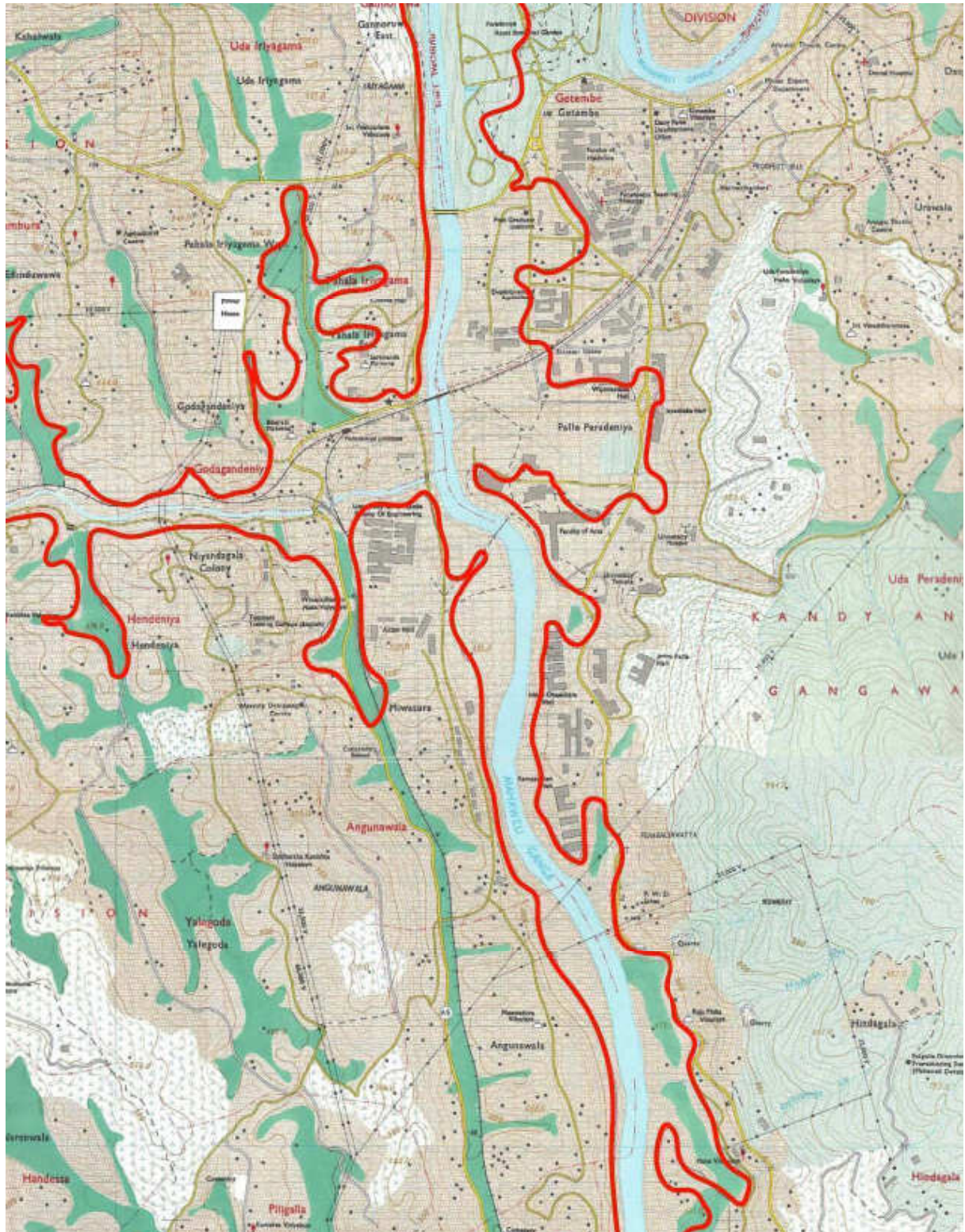


Figure 3 Inundation Area at Peradeniya at Dam Failure, below EL.482m