TERMS OF REFERENCE (ToR)

CONSULTANCY SERVICE FOR PREPARATION OF FEASIBILITY REPORT

DEVELOPMENT OF SEDIMENT REMOVAL AND MANAGEMENT STRATEGY FOR SELECTED MAJOR RESERVOIRS UNDER MASL

Mahaweli Authority of Sri Lanka (MASL)

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1. Background

Mahaweli Ganga is the largest and longest river in Sri Lanka and is the river which benefits from both Southwest and Northeast monsoons. The headwaters of the Mahaweli Ganga originate on the Hatton Plateau and flows into the Bay of Bengal at Koddiyar Bay, south of Trincomalee district. It flows through the Central, North Central and Eastern Provinces. The catchment area of the basin is 10,268 km^2, representing about 16% of total land area of the island and the length of the river is 335 km.

Kala Oya basin has a catchment area of 2,866 km^2. The basin is located mainly in the Dry Zone of Sri Lanka with the rest of the basin area located in the Intermediate Zone. The main river is 148 km long. Kala Oya flows to the sea at the upper part of the Puttalam Lagoon near Gange Wadiya. The basin receives relatively low rainfall with high seasonal and spatial variations.

Under the Mahaweli Development Programme, number of large-scale multipurpose development projects has been executed to accomplish the forecasted national irrigation, agriculture and energy demands. All these projects are being operated nearly for a period of forty years since 1980. Expected irrigation target to supply water for around 200,000 ha and the plan to add 2,800 GWh annually to the national power grid, had been achieved with around 95 % of success. Dam- reservoir complexes with capacities can be classified into two. (Reservoirs in the two basins can be basically categorized into two groups based on their Capacities, location and the intended use ie. the reservoirs in the Mahaweli upper catchment with large Capacities coupled with hydropower stations, and other type of reservoirs that are having medium capacities located in downstream of the Mahaweli catchment, built or renovated, to regulate the irrigation supply, these reservoirs had been designed to optimise the storage to intercept the monsoonal flows drained from respective net catchments, maintaining the designed capacities in these reservoirs are vital, as the entire seasonal irrigation plans are fully depending on the diversions from these reservoirs).

Further, any reduction of capacity will negatively be impacted on targeted power generations too. The major Hydro power schemes operated in the upper Mahaweli catchment are Kotmale (177 MCM[1]), Polgolla (4 MCM[1]), Victoria (722 MCM[1]), Randenigala (860 MCM[1]), Rantembe (10 MCM[1]) and Bowatenna (34 MCM[1]) are storing the water, necessary to regulate to cater the seasonal irrigation demands in Mahaweli systems as well as to augment the tanks being operated under the Irrigation Department. The Figure 1 Shows the Mahaweli Systems, under MASL and the outlined circle areas in orange colour are the major reservoirs, which are selected to carry out the Feasibility study of desilting.

However, after nearly a four decades of time span, the observations revealed that capacities of these vital reservoirs have been decreasing day by day due to sitation, at an alarming rate. Reservoirs in main Mahaweli cascade, if filled with sediment, not only lose its capacity, but would also leads to very dreadful flood discharge complication, as all the spill way control discharge calculations are based on the available area - capacity curves.

[1] Original design capacity

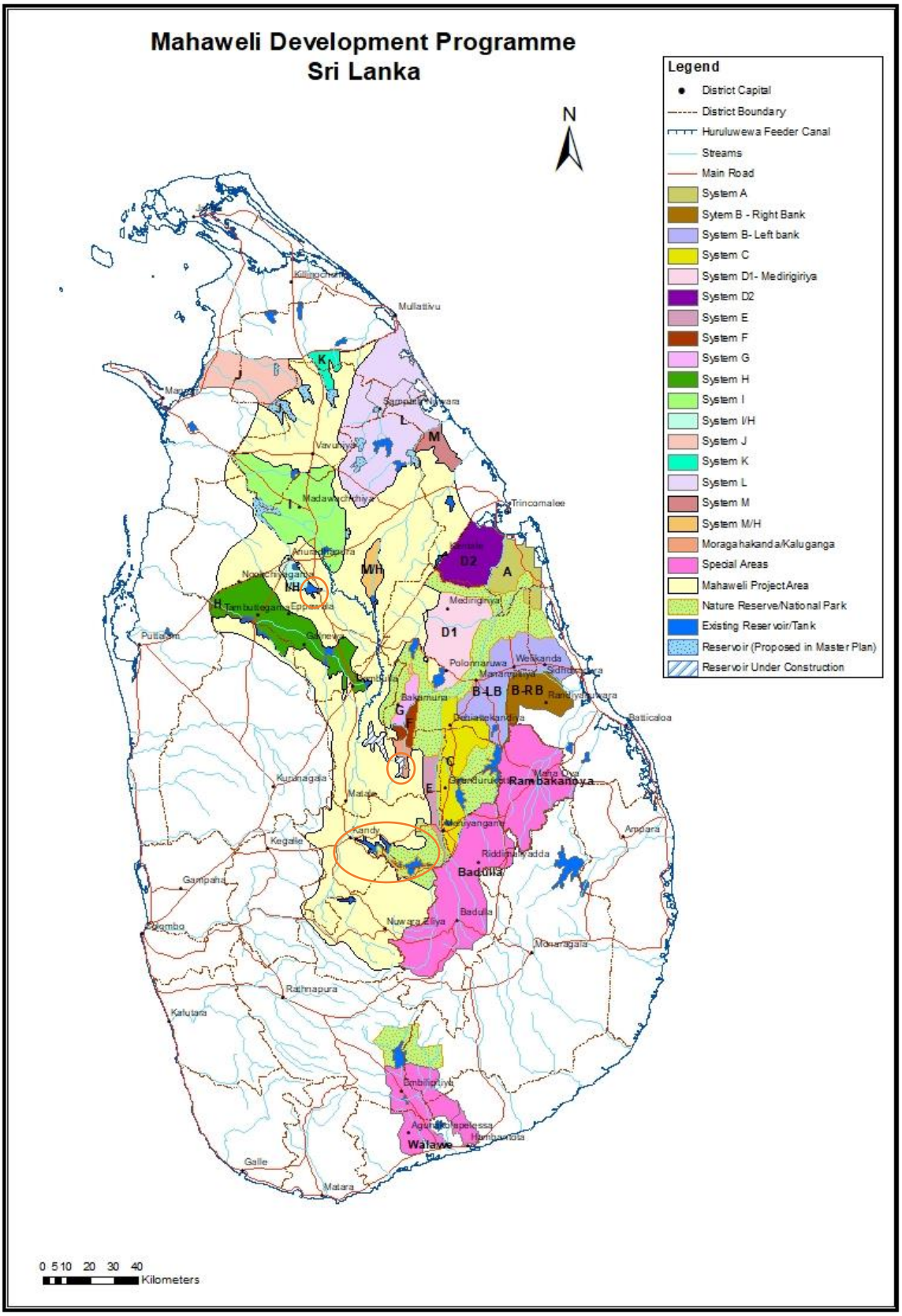

Figure 1-1 Mahaweli Areas

After four decades, the catchment degradation in Mahaweli basin has been severely increased in an uncontrolled rate, as a result of fast urbanization, decreasing of forest cover, changing the landuse

patterns and mismanaged constructions projects, etc that increased the deposition of sediment and other solid wastes to streams leading to reservoirs in Mahaweli River. Moreover, with the climate change the occurrence of a few storms of rainfall sufficient duration or intensity, can be related to activates of local landslides and earth slips, washing large masses of sediments to the river than predicted in 1980/85 by NEDECO and in 1990 /1995 by HR Wallingford, UK. (Note : Landslides occur basically due to the saturation of the soil mass. In recent years, intense short- and long-duration rainfall has triggered numerous shallow landslides (Jemec & Komac, 2013)).

2. Objectives

To carry out feasibility study on the Development of Sediment Removal & Management Strategy for Selected Major Reservoirs named Polgolla, Victoria, Randenigala, Rantambe, Bowathenna and Kala Wewa to increase the productivity of reservoirs, which are operated by the Mahaweli Authority of Sri Lanka. This study shall be addressed the following requirements, but shall not be limited. The Report shall further be enhanced with the own experience of the consultant.

2.1 Specific Objectives

The specific objectives shall be as follows

- Conduct hydrographic and bathymetric survey in reservoirs up to Full Supply Level (FSL) to identify the bathymetry and sedimentation volume of the reservoir to show the Longitudinal Sections and Cross sections of each reservoir.
- Conduct Stakeholder[2] consultations meetings to gather information and to identify the associated activities with these reservoirs.
- Conduct proper analysis to prioritize the reservoirs for desilting.
- Identify the economic and technical feasibility of each of the reservoir desilting, by considering the market opportunity of desilted materials (for example, sand, fertilizer, clay for different industries, etc..)
- Propose a proper mechanism or instruments needed to measure the annual sediment transport load to each reservoir quantitatively in future
- Preparation of feasibility reports with the economic analysis to determine the proposed EIRR, NPV and other appropriate economic indicators including the preparation of Cost Estimates and Bidding Documents for the implementation of the proposed Strategy.
- Preparation of Guidelines for Reservoir dredging and desilting controlling measures for reservoir sedimentation and erosion

Note: the all objectives are to be fulfilled without changing the operational rules of each reservoir.

[2] Stakeholders shall include Irrigation Department, Central Environment Authority (CEA), Department of Agriculture (AD), Department of Inland Fisheries and Widlife, Geological Survey Mines Bureau (GSMB), Ceylon Electricity Board (CEB), National Water Supply and Drainage Board (NWS&DB), but not limited.

3. Scope of Work

The consultant shall carry out the tasks and activities described in this section leading to the achievement of the Objectives of this assignment and production of all the deliverables as specified in this ToR.

3.1 Inception

- Consultant shall conduct comprehensive literature survey and stakeholder consultation to identify all the multidisciplinary activities those had been/ are associated with these reservoirs. as well as planned in the planning stage of these reservoirs
- Accordingly identify the data requirements, specify the study framework and set up an overall work plan.

3.2 Preparation of Hydrographic Maps for each reservoir

- Quantify the available sediment volumes deposited in each tank, via a proper “hydro-graphic” survey comparing the levels of original reservoir bed survey, if and when available.
- Preparation of bathymetric maps upto the FSL.
- Preparation of sediment profile map by comparing the original bed map if available or otherwise Consultant shall propose an acceptable methodology to develop initial reservoir bed profile.
- Quantify the net amount of sediment that can be removed from the respective reservoir.
- Prepare the river bed LS covering most upstream reservoir (Polgolla) to 1km downstream of the most downstream reservoir (Rantambe) along Mahaweli river, indicating the levels of Hydraulically important structures

Note: Kala wewa bathymetric data is available in MASL and it can be used as it is.

3.3 Identification of composition of deposited sediment in each reservoir

- Long term and short-term effects, an important aspect of the river response to human interventions is that the changes may affect the river as well as the places far from the intervention, both downstream and upstream. Following areas should be addressed during the study for the entire Mahaweli river system and Kala Oya system.
  - Morphological spatial scales
  - Spatial scales of engineering issues in the relevant main tributaries
- Consultant shall prepare the time vs siltation graphs for next 50 years, for each reservoir based on the current trend of deposition as well as based on the average silt deposition from the commissioning of the Reservoirs.
- Consultant shall identify the composition of sediment transport load, through sieve analysis or hydrometer analysis, etc.. to identify the percentage of sand, clay, etc appropriately for Sediment utilisation management.
- Consultant shall identify the chemical properties/parameters or any deposited heavy metals, if any.

- Generate sediment layer mapping to ascertain the available quantity of each composition.

3.4 Development of Sediment removing mechanism

- Consultant shall identify the sediment removing mechanism for each individual reservoir.
- Should clearly mention motive of the selection of the type of dredging machines (suction or scraper), and any possible impact into hydro turbine would transpire from the floating sediment during the time of pulling the sediment out from reservoir bed. If such dredging is adversely harmful to the Turbines, the Consultants should give operational rules for Turbines.
- This should include the type of machines required, and the availability of those machineries in Sri Lanka, Asian region or otherwise shall propose alternatives. Any such mechanism should be supported with prior applications.
- Consultant shall identify the best time periods to perform desilting activities based on the long-term rainfall, river flow and operational records
- Consultant shall identify the locations to keep the machineries etc in each site
- Proposed method should not affect harmfully to any headworks structure or any appurtenant of the reservoir and Consultants shall define Safe boundaries for dredging. And shall have the minimum impact on the annual power generation and irrigation water issues planned by Water Management Secretariate (WMS).
- Sediment removal mechanism should limit its adverse effects to the aquatic environment including fauna and flora so that no Social, Health, Environmental or legal restrictions or Protests can be arising due to proposed mechanisms. For this Consultants shall acquire the knowledge during literature survey, Stake holder discussions, etc.
- Should not severely impact to the water quality of the reservoir, especially in the vicinity of drinking water plants. Water quality reports shall be submitted to the employer time to time during the entire process, to ensure the quality of water.
- Selected methodology should not affect to the normal operation of the reservoir such as power generation, drinking water intake and agricultural activities.
- Accessibility of the machinery to the reservoir.
- Consultant shall identify the most appropriate transportation method, transport routes and dumping sites.

3.5 Identification of the market opportunities and method of sediment disposal

- Consultant shall identify and prepare a detailed marketing opportunity based on the identified composition of sediment materials and shall identify the processing methodology.
- If any by product that cannot be used or identified as waste, associated during the screening process, the consultant shall include such information and appropriate disposal methods.
- Proposed methodology should not cause any harmful environmental impacts.
- Financial analysis should be given for any material that is identified as a material with marketing potential

3.6 Prioritization of Reservoir Desilting

- Consultant shall apply multi criteria analysis or acceptable methodology to client for identifying reservoir prioritization.
- Accordingly, Consultant shall provide implementation plan for desilting the aforementioned reservoirs with reservoir desilting controlling measures for reservoir sedimentation and erosion.

3.7 Environmental and Social Aspects

- Consultant shall identify physical, chemical, biological and socio-economic aspects and ecologically sensitive habitats of floral and faunal in the project areas including the sites at desilting and surrounding areas, access roads, dump sites of dredging materials,
- Consultants shall undertake strategic environmental and social assessment considering the potential social and environmental impacts, as necessary.
- Consultants shall identify the impacts on wildlife and potential for human-animal conflict due to reservoir desilting.
- Consultant shall identify the land stability, and land use patterns of the area, and propose measures to minimize the impacts on, land use pattern, special reference to the catchment, etc..
- Consultant shall identify the locations of Land availability to stockpile of sediment loads in each site by analysing the areas of the least Environmental and Social impacts. They have to find out a proper method of transportation to stockpile to piling location as well.
- .The project impacts of each activity should be identified, quantified, analyzed and to be proposed the suitable mitigatory measures. The alterative mitigatory measures should be identified wherever necessary and these measures should be cost effective and confirm with the national standards to withdraw each impact and those should be disposed safely without causing any adverse effect to the Environment

3.8 Economic Aspects

- Economic aspects of reservoir sedimentation need to be identified to assess the direct and indirect benefits of reservoir desilting.
- The cost of carrying out reservoir desilting operations in each of the aforementioned reservoirs shall be calculated to include in the report.
- Consultant shall estimate the generation capacity lost due to sedimentation, if the reservoir was constructed to provide hydro power, while reduction in the area of land cultivated and a reduction in the yield of crop, if the reservoir was bult for irrigation purposes.
- Consultants undertake an economic cost/benefit analysis to determine the proposed EIRR, NPV and other appropriate economic indicators.
- Consultant shall perform sensitivity analysis on the cost and benefits.

3.9 Provide Recommendation

- Based on the study carried out the consultant should provide firm recommendation on each of the reservoir desilting feasibility to the MASL to make decisions.

3.10 Preparation of Deliverables

- **Inception Report**: to design the approach per reservoir, assess the data requirements and availability, and set up an overall work plan.

- **Reservoir bed (hydrographic & Land) Survey Report:** to conduct the hydrographic and land survey up to Full Supply Level (FSL) to identify the reservoir bed profile and Sediment layer and prepare report for each of the reservoirs, initially for Polgolla, Rantambe and Victoria reservoirs and then for Randenigala, and Bowatenna reservoirs. For Kala Wewa reservoir, consultant shall review the available bathymetric data, which was acquired in 2016. Accordingly, verification survey shall be performed as appropriately.
- **Interim Report:** to provide current progress of the study including progress of hydrographic and land survey for each of the reservoir.
- **Draft Feasibility Report:** to provide draft feasibility level report which shall be included necessary feasibility level drawings and layouts, social and environment aspect of the project areas, updated cost benefit analysis, Terms of References (ToR) and Bill of Quantities (BOQ) to implement each of the reservoir desilting.
- **Feasibility Report:** Upon the acceptance of draft feasibility report final feasibility report shall be prepared by incorporating all the comments given.
- **Guideline for Reservoir dredging:** Prepare Guideline for each of the reservoir dredging.
- **Guidelines and mitigation measures to long term stability of the river and reservoir system in terms of sedimentation and erosion**
- **Digital Deliverables:** Digital Deliverable shall include drawings, map outputs and the data sets used for analysis (GIS layers, satellite imageries, hydrographic survey data, other processed hydrometeorological data sets etc..) are to be delivered in compatible formats (PDF, Word, Excel, DWG, KML, SHP, etc..), but not limited to MASL

4. Data to be handed over to consultants

The client will provide the following details free of charge to the Consultant:

1. Available general layout plans of aforementioned reservoirs (Polgolla, Victoria, Randenigala, Rantambe, Kala Wewa and Bowathenna).
2. Landuse data around reservoirs areas, including location (Pradeshiya Sabha, Divisional Secretariate Divisions, Provincial Council, MASL systems), if available.
3. Layers to demarcate VRR reserves area and other areas
4. Permission to enter the relevant locations/facilities for data collection and surveys in the MASL areas

5. Reservoir operation rules curves

5. Deliverables and Time schedule

The total duration for this consultancy service shall be 9 months

The Consultant shall deliver the following;

1. Inception Report
2. Reservoir bed (hydrographic & Land) Survey (up to FSL) Report for for Polgolla, Rantambe and Victoria reservoirs with all data and information as digital deliverables
3. Interim Report (for each of the reservoirs) for Polgolla, Rantambe and Victoria reservoirs
4. Reservoir bed (hydrographic & Land) Survey (up to FSL) Report for all reservoirs for Randenigala, Kala Wewa and Bowatenna reservoirs with all data and information as digital deliverables
5. Interim Report (for each of the reservoirs) for Randenigala, Kala Wewa and Bowatenna reservoirs
6. Draft Feasibility Report (for each of the reservoirs)
7. Feasibility Report (for each of the reservoirs)
8. Guideline for Reservoir dredging (for each of the reservoirs)
9. Guidelines and mitigation measures to long term stability of the river and reservoir system in terms of sedimentation and erosion
10. Digital Deliverables of the inventory with all analysis data, GIS shapefiles and relevant data In addition to the above deliverables:

(a) One workshop prior to the delivery of the Draft Inception Report

(b) One workshop at the end of the feasibility study shall be conducted

All major reports should be submitted as 6 colour hard copies and in electronic format (as five soft copies in CD). All reports should have an easy-to-read layout, good text and also have helpful illustrations, graphics, charts, schematics and maps.

The deliverable schedule and workshop schedule are listed in Table 5-1 and Table 5-2.

Table 5-1 Deliverable Schedule

No	Deliverable	Target Time
1	Inception Report	End of Month 2
2	Reservoir Bed survey report (Polgolla, Rantambe and Victoria)	End of Month 4
3	Interim Report (Polgolla, Rantambe and Victoria)	End of Month 5
4	Reservoir Bed survey report (Randenigala, Kala Wewa and Bowatenna)	End of Month 6
5	Interim Report (Randenigala, Kala Wewa and Bowatenna)	End of Month 7
6	Draft Feasibility Reports	End of Month 8

No	Deliverable	Target Time
7	Feasibility Reports	End of Month 9
8	Guideline for Reservoir dredging	End of Month 8
9	Guidelines and mitigation measures to long term stability of the river and reservoir system in terms of sedimentation and erosion	End of Month 8
10	Digital deliverables	End of Month 9

Table 5-2 Workshop Schedule

No	Workshop	Target Time
1	Inception Workshop	End of Month 2
2	Feasibility Report Workshop	End of Month 9

6. Procedure to review deliverable

- Client will appoint a team of qualified experts for the reviews and the appointed review committee will review drafts of the deliverables for each reservoir in 14 days of submission.
- Reports will be reviewed on compliance with the requirements listed in this ToR, adequate presentation of Task objectives, scope, activities applied assumptions/tools and data, data validation, system schematisation, conclusions and recommendations and proper application of UK English language.

7. Qualification of Key Staff

Consultants shall propose well qualified staff for the execution of the consultancy service. Required key staff and their qualifications considered for proposal evaluation are as follows. The same personnel proposed by the Consultant is expected to continue this assignment in order to ensure efficient application of knowledge and experience.

Table 7-1 Qualifications of Key Experts

No	Key Expert	Expected Qualification
1	Team Leader (9 months)	The expert should have a PhD in Water Resources Engineering and has at least 15 years of experience in the executing similar nature of project internationally or locally. The expert should have extensive knowledge in River morpho dynamics/ morphology, hydropower reservoir operation in an economical manner. He/she should have sufficient experience as a Team Leader of the assignments similar to this assignment. Excellent management, reporting, and communication skills are required and international experience would be an added advantage.

No	Key Expert	Expected Qualification
2	River Morphological/ hydraulic Engineer (9 months)	The expert should have a Master's degree in Hydraulic engineering / River Morphological Engineering and has at least 10 years of international projects experience in this field. Excellent communication and reporting skills are required. Desilting /dredging experience and international experience would be an added advantage.
3	Material Engineer / Earth Resources Engineer (4 Months)	The expert should have a Master's degree in Material engineering / Earth Resources Engineering and has at least 10 years of international projects experience in similar nature. Excellent communication and reporting skills are required.
4	Economist (3 months)	The expert (Local) should have a Master's degree in economics and has at least 10 years of experience in economic evaluation of river basin development plans, execution of cost-benefit analyses for water resources/supply, irrigation and hydropower systems, organic fertilizer, assessment of flood damages and development of social, environmental and economic indexes for multi-criteria analysis. Excellent communication and reporting skills are required.
5	Environmentalist (3 months)	The environmental specialist (Local) should have a Master's degree in natural sciences and have at least 10 years of experience in leading and execution of environmental impact and risk assessment studies of similar nature of assignments.
6	Sociologist (3 months)	The sociologist should have a Master's degree in social sciences and have at least 10 years of experience in leading and execution of social impact and risk assessment studies and institutional development in major water resources development projects, implementation and elaboration of field surveys. Excellent communication skills and reporting skills are required.
7	Hydro and land-Surveyor (6 months)	The Hydro and Land surveyor should have a degree in Survey and have at least 10 years of experience in leading and execution of hydro survey and land survey in similar nature of projects. Excellent communication skills and reporting skills are required.
8	Geologist / Hydro-Geologist (3 months)	The hydro-geologist should have a Master's degree in geology and have at least 10 years of experience in groundwater exploration, geo-hydrological monitoring, data processing, validation and analysis, pumping test analyses, and water resources analyses. Excellent communication skills and reporting skills are required.
9	Agronomist / Soil Scientist (3 months)	The Agronomist/ Soil Scientist should have a Master's degree in soil science/ agronomy and have at least 10 years of experience in development of fertility management and soil classification, etc.. Excellent communication skills and reporting skills are required.

8. Payment schedule

The payments are linked with the deliverables and the payments will be released upon the acceptance of the deliverables by the appointed review committee on behalf of the MASL. The payment percentages are illustrated below in Table 8-1.

Table 8-1 Payment Schedule

No	Deliverable	Payment Percentage
1	Mobilization advance	10%
2	Inception Report	10%
3	Reservoir Bed survey report (Polgolla, Rantambe and Victoria)	10%
4	Interim Report (Polgolla, Rantambe and Victoria)	5%
5	Reservoir Bed survey report (Randenigala, Kala Wewa and Bowatenna)	10%
6	Interim Report (Randenigala, Kala Wewa and Bowatenna)	5%
7	Draft Feasibility Report	15%
8	Two No.s Workshops to present the outcomes and outputs to the Client	5%
9	Feasibility Report	15%
10	Guideline for Reservoir dredging and controlling measures to long term stability of the river and reservoir system in terms of sedimentation and erosion	10%
11	Digital Deliverables	5%

9. Guidance to consultants

i. Consultant shall obtain clearances/ Permits from other state organizations, such as Department of Archaeology, Geological Survey & Mines Bureau (GSMB), etc..

ii. Health guidelines under prevailing Covid-19 status of the country shall be adhered by the Consultants throughout their work.

iii. Safety regulations, Security instructions, instructions of any Government Organization / Regulatory Body shall be followed.

iv. All the Equipment, Software, IT facilities, patented resources/information, etc required for this study shall be provided by the consultant.

v. MASL shall appoint a Liaison officer to actively coordinate the Consultants and the relevant Authorities/Communities in Sri Lanka.

Name	Capacity	Agree with the above decisions (Yes/ No)	Signature
Eng. A. Gunasekara	Chairman of CPCM/ Additional Secretary, SMMZ		
Eng. S. R.K. Aruppola	Member/ Director (DMD&RO), MASL		
Eng. S. A. A. Dharmasiri	Member/ Director (ED&P), MASL		
Mr. B.K. Nishantha	Member/ Chief Accountant, SMMZ		
Mr. A.M.D.U. Abesingha	Member/ Senior Geologist, GSMB		