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TERMS OF REFERENCE FOR THE ENVIRONMENTAL IMPACT ASSESSMENTS (EIA) FOR UNDERTAKING LAND RECLAMATION AND INTEGRATED RESORT DEVELOPMENT PROJECTS AT 4 (FOUR) LAGOONS IN KAAFU ATOLL.

The following Terms of Reference (ToR) are for undertaking Environmental Impact Assessment for the proposed land reclamation and integrated resort development projects in 4 (four) proposed areas in Kaafu Atoll.

While every attempt has been made to ensure that this ToR addresses all of the major issues associated with development proposal, they are not necessarily exhaustive. They should not be interpreted as excluding from consideration matters deemed to be significant but not incorporated in them, or matters currently unforeseen, that emerge as important or significant from environmental studies, or otherwise, during the course of preparation of the EIA report.

1. INTRODUCTION AND RATIONALE

Describe the purpose of the project and, if applicable, the background information of the project/activity and the tasks already completed. Objectives of the development activities should be specific and if possible quantified. Define the arrangements required for the environmental assessments including how work carried out under this contract is linked to other activities that are carried out or that is being carried out within the project boundary. Identify the donors and institutional arrangements relevant to this project.

2. STUDY AREA

Submit a minimum A3 size scaled plan with indications of all the proposed infrastructures. Specify the agreed boundaries of the study area for the environmental impact assessment highlighting the proposed development location and size. The study area should adjacent or remote areas such as relevant developments and nearby environmentally sensitive areas (e.g. coral reef, sea grass. Mangroves, marine protected areas, special bird sites, sensitive species nursery and feeding grounds). Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites

3. SCOPE OF WORK

Identify and number tasks of the project including preparation, construction and decommissioning phases.

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4. TASKS REQUIRED IN THE EIA

Task 1. DESCRIPTION OF PROPOSED PROJECT

Provide a full description and justification of the relevant parts of the reclamation works, using maps at appropriate scales where necessary. The following should be provided (all inputs and outputs related to the proposed activities shall be justified):

The main activities of the reclamation and coastal works are:

- Dredging material from burrow area and pumping it to the reclamation area
- Dredging an entrance channel basin 20m wide, 4m in depth.
- Finishing reclamation to required levels, including any hazard vulnerability measures such as elevated zone surrounding the island (e.g. “safe island” concept)
- Construction of bunds and other mitigation measures
- Construction of shore protection structure and facilities
- Coastal protection measures during construction and operation
- Environmental monitoring during construction activities
- Measures to protect environmental values during construction and once established
- Project management (include scheduling and duration of the project and life span of facilities; communication of construction details, progress, target dates, construction/operation/closure of labor camps, access to site, safety, equipment and material storage, fuel management and emergency plan.

The main activities of integrated resort development are:

- Access infrastructure construction;
- Sand dredging/pumping for beach nourishment and construction activities
- Infrastructure construction including power house, power grid, water desalination plant, water networks, sewerage treatment plan, oil storage tanks, waste management facility and hardware workshop, etc.
- Construction and operation of staff accommodation, restaurant, entertainment facilities and other back-of-the-house facilities.
- Construction and operation of guest accommodation (land and over water), restaurants, spa, swimming pool, sports and marine center facilities (include an A3 land use map)
- Revegetation (up to 100% of island vegetation)
- Measures to protect environmental values during construction and operation phase

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- Project management (include scheduling and duration of the project and life span of facilities; communication of construction details, progress, target dates, construction/operation/closure of labor camps, access to site, safety, equipment and material storage, fuel management and emergency plan in case of spills)

T1.1 Reclamation and Coastal works

The following details of dredging and reclamation activity shall be furnished

- Location and size of sand burrow areas
- Justification for the selection of these location
- Dredge disposal methods and locations for reef entrance
- Quantity, quality and characteristics of fill material
- Indication of guarantees for sufficient availability of fill material
- Method and equipment used for dredging, including description of positioning system, depth control system and operational control procedures
- Justification for selecting the methods and equipment;
- Duration of dredging activity
- Labor requirements and (local) labor availability
- Housing of temporary labor, and
- Emergency plan in case of spills (diesel, grease, oil)
- Location of sand beds (if any) during construction

The EIA should investigate possibilities for following alternatives;

- Location, routing and design of pipelines
- Design of bunds, including materials used
- Design of additional coastal protection structures, including materials used
- Borrow Area locations
- Layout of borrow pits, large shallow pits versus small deep pits to allow quick recovery of the seabed
- Dredging methods

The following details of shoreline protection activity shall be furnished

- Concept design and location of structural shoreline protection facilities
- Justification for the selection of the shoreline protection structures and/or facilities
- Quantity, quality and characteristics of material used

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- Justification for the construction method and equipment, associating applicable standards and requirements.
- Duration of activity
- Emergency plan in case of spill etc.
- Labor requirements and (local) labor availability
- Housing of temporary labor

The EIA should investigate possibilities for following alternatives;

- Alternative shoreline protection facilities, including materials used

T1.2 Reef entrance dredging and construction of access infrastructure

The following details shall be furnished

- Location and size of channel on a map (20m wide , 4m depth)
- Location and size of dredge disposal site on a map
- Justification for the selection of these locations
- Quantity, quality and characteristics of dredge and fill material
- Method and equipment used for dredging, including description of positioning system, depth control system and operational control procedures
- Justification for selecting the methods and equipment
- Duration of dredging activity
- Labor requirements and (local) labor availability
- Housing of temporary labor, and
- Emergency plan in vase of spills (diesel, grease, oil)

T1.3 Integrated Resort Construction

Water desalination plant:

- Location, desalination capacity, technology and water quality management system
- Pipeline construction methods, scheduling and drawings
- Justification for the location of the water intake and brine outfall pipelines
- Emergency water supply plan

Power supply plan and oil storage

- Location and size of generators and facility
- Fuel transportation technique and volume required

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- Cooling water system including cooling pipe location (if any) and justification
- Emergency power supply plan
- Low energy consumption ventures and awareness

Sewerage Plant

- Plant location, capacity and justification;
- Water collection points and pipeline drawings
- Describe operations for dewatering excavations for pump stations and sewer trenches;
- Describe rain water collection and mechanisms used to avoid pipe leakages protecting ground water contamination;
- Discharge water quality testing system, leakage detection system and emergency plan
- Justify outfall site selection including the distance from the reef and depth of the pipe using oceanographic and ecological information. Currents and waves ought to quickly disperse the discharged water with little to no impacts on marine ecosystems and economic activities. Illustrate the extent of the sediment plume. The public and stakeholders should support the location of the outfall site
- Describe equipment needed and construction methods for laying the offshore pipeline including handling transportation
- Detail solid waste disposal mechanisms, equipment used and periodicity (how often?)
- Specify materials, equipment, heavy machinery, staff estimate (quantity and period of time), key personnel positions, intermittent technical expertise required
- Specify an emergency plan if system fails

Waste management facility

- Location justification, carrying capacity, materials to be collected and equipment required for waste reduction and recycling;
- Transportation mechanisms and costs;
- Recycling ventures and awareness activities within the resort

Temporary facilities

- Construction methods, scheduling and operation of temporary facilities including power generation, oil storage, water supply, waste water treatment, accommodation facilities, waste management and decommissioning.

Revegetation

- Details of the nursery where the source trees will be grown shall be supplied
- If vegetation is to be supplied from inhabited islands, approvals from those island councils are required and the details of the number of trees should be provided
- If large scale sourcing of trees (more than 10 large trees) is required from a single island, a separate EIA should be conducted.

Construction of building facilities, front of house and back of house developments and other infrastructures.

Task 2. DESCRIPTION OF ENVIRONMENT

Assemble, evaluate and present the environmental baseline study/data regarding the study area and timing of the project (e.g. monsoon season). Identify baseline data gaps and identify studies and the level of detail to be carried out by the consultant. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that the data collected is suitable to use as a baseline. As such all baseline data must be presented in such a way that they will be usefully applied to future monitoring. The report should outline detailed methodology of data collection utilized.

The baseline data will be collected before construction and from at least two benchmarks. All survey locations shall be referenced with Geographic Positioning System (GPS) including water sampling points, reef transects and manta tows sites for posterior data comparison. Information should be divided into the categories shown below:

**There is a description of the specific data collection requirements attached in the appendix of this TOR.*

T2.1 Climate

- Temperature rainfall, wind, waves (including extreme conditions)
- Risk of hurricanes and storm surges;

T2.2 Geology and geomorphology

- Offshore/coastal geology and geomorphology (use maps);
- Bathymetry (bottom morphology) (use maps);

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- Characteristics of seabed sediments to assess direct habitat destruction and turbidity impacts during construction
- Beach profiles and shoreline surveys of nearby island

T2.3 Hydrography/hydrodynamics (use maps)

- Tidal ranges and tidal currents;
- Wave climate and wave induced currents
- Wind induced (seasonal) currents;
- Sea water quality measuring these parameters; temperature, pH, salinity, turbidity, sedimentation rate, phosphate, nitrate, ammonia, sulphate, BOD and COD.

T2.4 Ecology

- Identify marine protected areas (MPAs) and sensitive sites such as breeding or nursery grounds for protected or endangered species (e.g. coral reefs, spawning fish sites, nurseries for crustaceans or specific sites for marine mammals, sharks and turtles). Include description of commercial species, species with potential to become nuisances or vector
- Benthic and fish community monitoring around the island (see appendix for monitoring guidelines);
- Landscape integrity, and
- Include ground water monitoring (see appendix for parameter healthy ranges);

T2.5 Socioeconomic development

- Atoll and nearby Island demography: total population, sex ratio, density, growth and pressure on land and marine resources
- Economic activities of both men and women (e.g. fisheries, home gardening, fish processing, employment in industry, government);
- Land use planning, natural resource use and zoning of activities at sea;
- Services quality an accessibility (water supply, waste/water disposal, energy supply, social services like health and education);
- Community needs;
- Sites with historical or cultural interest or sacred places

T2.6 Hazard vulnerability

- Vulnerability of area to flooding and storm surge

Absence of facilities in the country to carry out water quality tests will not exempt the proponent from the obligation to provide necessary data. The report should outline the detailed methodology of data collection utilized to describe the existing environment.

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Task 3. LEGISLATIVE AND REGULATORY CONSIDERATIONS

Identify the pertinent legislation, regulations, and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate jurisdictions that will specifically apply to the project. Legal requirements:

- Reclamation approval from the Ministry of Tourism

Task 4. POTENTIAL IMPACTS (ENVIRONMENT AND SOCIOCULTURAL) OF PROPOSED PROJECT IN ALL STAGES.

The EIA report should identify all the impacts, direct and indirect during and after construction, and evaluate the magnitude and significance of each. The impacts should be quantified using appropriate mathematical modeling where appropriate, to simulate pre-construction situation, during and post construction situation. The simulation period should cover over 14 days for hydraulic flushing, sediment plume and water quality. The consultant shall state the recommended grid area, grid size and time steps to be used for modeling, Particular attention shall be given to impacts associated with the following:

T4.1 Impacts on the natural environment

- Changes in flow velocities/directions, resulting in changes in erosion/sedimentation patterns, which may impact shore zone configuration/coastal morphology, special attention should be made to analyze impacts on islands within the same reef
- The flow model should at least be a fully dynamic two-dimensional depth integrated model. Modelling should be calibrated and validated with field fata to accurately simulate tidal flow, and residue flows due to wind and ocean currents.
- Wave models (either spectrally or mild slope based0 should include effects of refraction, shoaling, breaking, wind generation and bottom friction.
- Loss of marine bottom habitat, both in the borrow area as well as due to enlargement of the islands, resulting in (temporary) loss of bottom life, which may impact fish stocks and species diversity and diversity of crustaceans etc.
- Sediment dispersal in water column (turbidity at the dredging site (overflow). The reclamation areas and related to shore protection activities, possibly resulting in changes in visibility, smothering of coral reefs and benthic communities and affecting fish and shellfish etc.
- Sediment transport model should include effects of combined wave current action on transport capacity and variable bottom sediment conditions

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- Sediment plume model should include the effects of periodic discharge, multiple sediment fractions, concentration dependent sedimentation and re-suspension. The model should take into consideration the effect of waves on sedimentation and re-suspension. The model should take into consideration the effect of waves on sedimentation settling and re-suspension.
- Impacts of noise, vibration and disturbance.
- Impacts on ground water table and quality as a result of reclamation areas (leaching of salts in the deposited sediments and change in ground water quality);
- Water quality variable models must take into consideration interactions between the variables, and should be coupled with hydraulic and dispersion models.
- Estimated time required to reach water quality of acceptable levels and soil conditions suitable for home gardening;
- Impacts on unique or threatened habitats or species (coral reefs, sea turtles etc.) and
- Impacts on landscape integrity/scenery.
- Loss of terrestrial vegetation and fauna Revegetation
- Coastal impacts, particularly, erosion impacts, on the islands within the same reef shall be examined thoroughly

T4.2 Impacts on the socio-economic environment

- Impacts of the works on fishing activities (disturbance)
- Impacts of the dredging and reclamation works on tourism (nearby resorts and dive sites);
- Impacts on employment and income, potential for local people to have (temporary) job opportunities (and what kind) in the execution of the work
- Impacts of the reclamation works (diminished) access to groundwater and risks of covering up hazardous materials, and
- Level of protection against hazards like sea level rise, storm surges, etc.
- Impacts to the nearby islands, resorts and dive sites
- Size and allocation of plots, including possibility of gardening
- Impacts on food and nutrition security (fisheries, agricultural activities, supply of other food);
- Social services like health and education
- Employment and economic opportunities and diversification
- Increased demand on natural resources and services (domestic water supply. Waste water disposal, treatment systems, solid waste disposal systems, energy supply etc)
- Impact equity (economic activities, employment, income)
- Social destabilization of the island community, and

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- Monitoring socioeconomic and demographic development

T4.3 Construction related hazards and risks to the environment

- Pollution of the natural environment (e.g. oil spills, discharge of untreated waste water and solid waste including construction waste);
- Risks of accidents and pollution on workers and local population, and
- Impacts on social values, norms and belief due to presence of workers of dredging company on local population

The methods used to identify the significance of the impacts shall be outlined. One or more of the following methods must be utilized in determining impacts; checklists, matrices, overlays, networks, expert systems and professional judgment. Justification must be provided to the selected methodologies. The report should outline the uncertainties in impact prediction and also outline all positive and negative/short and long-term impacts. Identify impacts that are cumulative or unavoidable

Task 5. ALTERNATIVES TO PROPOSED PROJECT

Describe alternatives including the "*no action option"* should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the "no action alternative". This should include but not be limited to alternative borrow sites, alternative equipment/machinery for dredging, alternative disposal sites and alternative containment measures. The report should highlight how the dredging and reclamation location was determined. All alternatives must be compared according to international standards and commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation. Mitigation options should be specified for each component of the proposed project.

Task 6. MITIGATION AND MANAGEMENT OF NEGATIVE IMPACTS

Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. These will include both environmental and socio-economic mitigation measures with particular attention paid to sedimentation control and future changes in coastal processes. Mitigation of any impact on the coastline (including structures within the coastline) of the islands within the same reef due to the development must be the responsibility of the proponent.

- Mitigation measures for both construction and operation phase.

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- Mitigation measures to avoid or compensate habitat destruction causes by dredging will have to be considered, e.g. temporal sediment control structures, coastal protection structures to reduce erosion, coral reconstruction and MPA replacement areas.

- Cost the mitigation measures, equipment and resources required to implement those measures.

- An Environmental management plan for the proposed project, identifying responsible persons, their duties and commitments shall also be given. In cases where impacts are unavoidable, arrangements to compensate for the environmental effect shall be given. This should include a Sediment containment plan for construction and operation phase. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included.

Task 7. DEVELOPMENT OF MONITORING PLAN (see appendix)

Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for coastal modification, beach morphology, sediment movement around the island. Ecological monitoring will be submitted to the EPA to evaluate the damages during construction, after project completion and every three months thereafter. Up to to one year and then on a yearly basis for five years after. The baseline study described in task 2 of section 2 of this document is required for data comparison. Coastal monitoring of the islands within the same reef must be included in the regular monitoring plan and shall be a responsibility of the proponent. Detail of the monitoring program including the physical and biological parameters for monitoring, cost commitment from responsible person to conduct monitoring in the form of a commitment letter, detailed reporting, scheduling, costs and methods of undertaking the monitoring program must be provided.

- Water quality, especially turbidity;
- Sedimentation rates on nearby coral reefs, benthic system and sea grass beds;
- Condition of the sensitive ecosystems and marine resources
- Re-colonization of benthic organisms in the borrow areas
- Erosion and accretion
- Environmentally sound site clearance
- Environmentally sound removal of dredging and other equipment including construction materials, and

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*This TOR contains an outline of the parameters that have to be tested (see appendix). All projects are different, therefore additional or less data will be collected for recovery and impact assessments.

Task 8. STAKEHOLDER CONSULTATION, INTER AGENCY COORDINATION AND PUBLIC/NGO PARTICIPATION

Identify appropriate mechanisms for providing information on the development proposal and its progress to all stakeholders, government authorities such as Ministry of Environment and Energy, Tourism ministry, relevant Island Councils, government agencies, NGOs, engineers/designers, development managers, staff and members of the general public. Boundary must be demarcated and communicated with island communities clearly, as there must be no conflict occur in a later stage. The EIA report should include a list of people/groups consulted, their contact details and summary of the major outcomes. Consultations should be undertaken with Island councils, Atoll councils, where vegetation is sourced.

5. PRESENTATION

The environmental impact assessment report, to be presented in digital format, will concise and focus on significant environmental issues. It will contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations, 2012.

6. TIMEFRAME FOR SUBMITTING THE EIA REPORT

The developer must submit the competed EIA report within 6 months from the date of award.

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Appendix 1: ***EIA MONITORING GUIDELINES (Environmental Protection Agency 2010)***

1. PHYSICAL MONITORING

1.1. WATER QUALITY TESTING

These parameter guideline triggers have been adopted from the Great Barrier Reef Marine Park Authority (GBRMPA, 2009). The marine ecology in the Maldives is so vulnerable that it should be compared to that in the GBRMP. This will help maintain healthy ecosystems to preserve valuable natural resources that are directly or indirectly part of all people's livelihoods.

Take 3 control water samples away from the project site, 3 water samples from the project site and a representative number of water samples from different locations around the project site. All water samples shall be taken at a depth of 1m from the mean sea level or mid water depth for shallow areas. Record the GPS coordinates of each water sample taken. Analyze the following parameters and check the water quality standards to evaluate the status of the sample.

1.1.1. Temperature: The optimum temperature for coral reef growth ranges between 18^0C and 32^0C. Changes should not surpass 1^0C above the average long term maximum (GBRMPA, 2009). Temperatures above or below the local range can cause stress to coral reefs and seagrass beds.

1.1.2. Salinity: It is recommended that salinity ranges between 3.2% - 4.2% for optimum coral reef and seagrass ecosystems to blossom. Surface salinity can decrease when fresh water is added e.g. floods or pollution from industry, or increase if surface water evaporates. Changes may cause stress to corals and sea grasses (GBRMPA, 2009).

1.1.3. pH: Seawater pH is usually 8.0-8.3. Levels below 7.4 pH stress corals and calcifying seagrasses by decreasing calcification processes.

1.1.4. Turbidity: Corals and sea grasses need UV light for photosynthetic processes. If turbidity is high then these ecosystems will become stressed. Studies suggest that long term turbidity levels which are >3 NTU lead to sublethal stress. However, long term turbidity levels higher than 5 NTU cause severe stress on coral at shallow depth (Cooper *et al.,* 2008)

1.1.5. Sedimentation: Sedimentation is the sediment load that arrives onto the reef which can reduce light availability for photosynthesis, deplete dissolved oxygen and cause smothering of organisms. Sedimentation rates are measured using sediment traps. The maximum mean annual rate for coral reef and sea grass ecosystems is $3mg/cm^2$/day, and a daily maximum of $15mg/cm^2$/day (GBRMPA, 2009).

1.1.6. Nitrates: Nitrate is an essential nutrient for aquatic plants and seasonal fluctuations can be caused by plant growth and decay (UNESCO/WHO/UNEP, 1996). Natural concentrations, which seldom exceed 0.1 mg l^{-1} NO_3^- N, may be enhanced by municipal and industrial waste-waters, including leachates from waste disposal sites and sanitary landfills (UNESCO/WHO/UNEP, 1996). In islands where there is significant agricultural activity, the use

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of inorganic nitrate fertilizers can be a significant source. When influenced by human activities, surface waters can have nitrate concentrations up to 5 mg l^{-1} NO_3^-N, but often less than 1 mg l^{-1} NO_3^-N. Concentrations in excess of 5 mg l^{-1} NO_3^-N usually indicate pollution by human or animal waste, or fertilizer run-off. In cases of extreme pollution, concentrations may reach 200 mg l^{-1} NO_3^-N.

1.1.7. Ammonia: Unpolluted waters contain small amounts of ammonia and ammonia compounds, usually <0.1 mg l^{-1} as nitrogen. Total ammonia concentrations measured in surface waters are typically less than **0.**2 mg l^{-1} N but may reach 2-3 mg l^{-1} N. Higher concentrations could be an indication of organic pollution such as from domestic sewage, industrial waste and fertilizer run-off. Ammonia is, therefore, a useful indicator of organic pollution. Natural seasonal fluctuations also occur as a result of the death and decay of aquatic organisms, particularly phytoplankton and bacteria in nutritionally rich waters (UNESCO/WHO/UNEP, 1996).

1.1.8. Phosphates: Phosphates exist in three forms: orthophosphate, metaphosphate (or polyphosphate) and organically bound phosphate each compound contains phosphorous in a different chemical arrangement. These forms of phosphate occur in living and decaying plant and animal remains, as free ions or weakly chemically bounded in aqueous systems. In the marine environment, phosphorus limits algal growth therefore when in excess causes euthophication and slower reef growth (UNESCO/WHO/UNEP, 1996). In most natural surface waters, phosphorus ranges from 0.005 to 0.020 mg l^{-1} PO_4^-P (UNESCO/WHO/UNEP, 1996).

1.1.9. Sulphate: Sulphate is naturally present in surface waters as SO42-. It arises from the atmospheric deposition of oceanic aerosols and the leaching of sulphur compounds, either sulphate minerals such as gypsum or sulphide minerals such as pyrite, from sedimentary rocks. Industrial discharges and atmospheric precipitation can also add significant amounts of sulphate to surface waters. Sulphate can be used as an oxygen source by bacteria which convert it to hydrogen sulphide (H2S, HS-) under anaerobic conditions. Sulphate concentrations in natural waters are usually between 2 and 80 mg l-1, although they may exceed 1,000 mg l-1 near industrial discharges or in arid regions where sulphate minerals, such as gypsum, are present (UNESCO/WHO/UNEP, 1996).

1.1.10. BOD: The biochemical oxygen demand (BOD) is an approximate measure of the amount of biochemically degradable organic matter present in a water sample (UNESCO/WHO/UNEP, 1996). It is defined by the amount of oxygen required for the aerobic micro-organisms present in the sample to oxidise the organic matter to a stable inorganic form. BOD measurements are usually lower than COD measurements. Unpolluted waters typically have BOD values of 2 mg l^{-1} O_3 or less (UNESCO/WHO/UNEP, 1996).

1.1.11. COD: The chemical oxygen demand (COD) is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant, such as dichromate (UNESCO/WHO/UNEP, 1996). The COD is widely used as a measure of the susceptibility to oxidation of the organic and inorganic materials present in water bodies and in the effluents from sewage and industrial plants. The concentrations of COD observed in surface waters range from 20 mg l^{-1} O_2 or less

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Table 1. Water quality parameter optimum conditions.

PARAMETER	OPTIMAL RANGE	REFERENCE
TEMPERATURE	18^0C and 32^0C *Changes should not surpass 1^0C above the average long term maximum	GBRMPA, 2009
SALINITY	3.2% - 4.2%	GBRMPA, 2009
PH	8.0-8.3 *Levels below 7.4 pH cause stress	
TURBIDITY	3-5 NTU >5 NTU causes stress	Cooper *et al.* 2008
SEDIMENTATION	Maximum mean annual rate 3mg/cm^2/day Daily maximum of 15mg/cm^2/day	GBRMPA, 2009
NITRATES	<5 mg l^{-1} NO_3^-N	UNESCO/WHO/UNEP, 1996
AMMONIA	Max. 2-3 mg l^{-1} N	UNESCO/WHO/UNEP, 1996
PHOSPHATE	0.005 - 0.020 mg l^{-1} PO_4^-P	UNESCO/WHO/UNEP, 1996
SULPHATE	2 mg l^{-1} and 80 mg l^{-1}	UNESCO/WHO/UNEP, 1996
BOD	< 2 mg l^{-1} O_3	UNESCO/WHO/UNEP, 1996
COD	< 20 mg l^{-1} O_2	UNESCO/WHO/UNEP, 1996

1.2. BATHYMETRY AND HYDROLOGY

Waves, currents, tides: These parameters are important for understanding sediment transportation and the rate of effluent water dispersion. Ideally, presented a map illustrating the extent of sediment plumes and highlight the sites which will be affected by high sedimentation and turbidity rates. This study will complement coastal erosion monitoring.

Present bathymetric data on an A3 map. Identify the sites which have high water dispersion and dilution rates as well as intense erosion performances. State the tidal ranges in the area including neap and spring tides throughout the year. Mark the areas where wave action is more intense (e.g. where waves break).

This data is key for sewerage projects, desalination plants, dredging activities, aquaculture ventures, agriculture and all those which involve water dispersion and sediment transport activities. Sewerage outfall pipes shall be located where currents quickly disperse effluent. Brine water from desalination plants ought to be placed in high energy waters too, however, the impacts from this are still relatively unknown.

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1.3. COASTAL EROSION

Monitoring should detect which parts of the shoreline change the most, where the beach migrates on a seasonal basis, and should track changes in the dynamic and vegetated shoreline on both inhabited and uninhabited. Two simple procedures are to be used to monitor change in beach volume and change in position of the edge dynamic beach (beach toe) and edge of vegetation: i) Beach profiling and ii) GPS mapping (Table 2). These methods are the most common form of coastal monitoring and are rapid and easily repeatable to allow a greater number of sites to be monitored.

Table 2: Key indicators and associated methods for monitoring coastal change

Indicator	Methods
Change in beach volume	Beach profiles
Change in position of toe of beach	GPS mapping
Change in position of edge of vegetation	
Decadal island change	Aerial photo analysis

Monitoring coastal erosion is important in management. Accretion sites should be identified prior to construction so that less investment is needed in protection structures (e.g. groins, breakwaters) and in beach nourishment activities in the case of touristy sites. Impacts on the environment will also be greatly reduced if no action is taken to modify natural sediment transport systems.

1.3.1. Beach profiles: Create a two-dimensional, cross-shore profile to show simultaneous removal and accumulative changes which the shoreline behaviour mapped by GPS does not express (Fig. 1). These surveys record detailed information on the elevation and distance of the shoreline from fixed benchmarks on the island. Surveys typically start at benchmarks, run across the beach perpendicular to the vegetated shoreline and terminate below low tide level on the adjacent reef flat. Such surveys allow changes in the elevation and relative position of the beach with respect to the benchmarks to be determined. Typically such surveys have an accuracy of ±0.1m (Kench 2009).

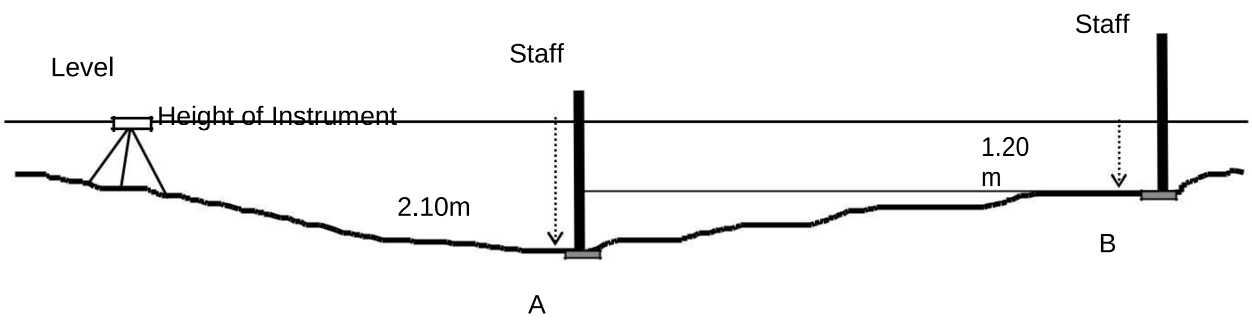

Fig. 1. Cross section of a beach profile.

Take a representative number of beach profiles from different accretion and erosion sites around the island, e.g. four sites. These sites should be surveyed every six months (one in SW Monsoon and one in NE Monsoon). The following should be identified:

- Edge of vegetation;
- Island scarp or berm;
- Instrument height;
- Water level (record time to standardise profiles against tide charts);
- Beach step;
- Toe of beach
- Reef edge/ sea grass/rubble

Include the superimposed beach profiles (SW and NE Monsoons) in the EIA document and state the changes in metres.

1.3.2. Toe of Beach GPS surveying: GPS mapping of shoreline change: This creates a map of the edge of the dynamic beach and vegetated interior to visualize changes over time.

GPS should be used to map the following for each island surveyed (Fig.2). Data from the different monsoon season should be superimposed on one single map to evaluate the changes in sediment accretion and erosion (in metres).

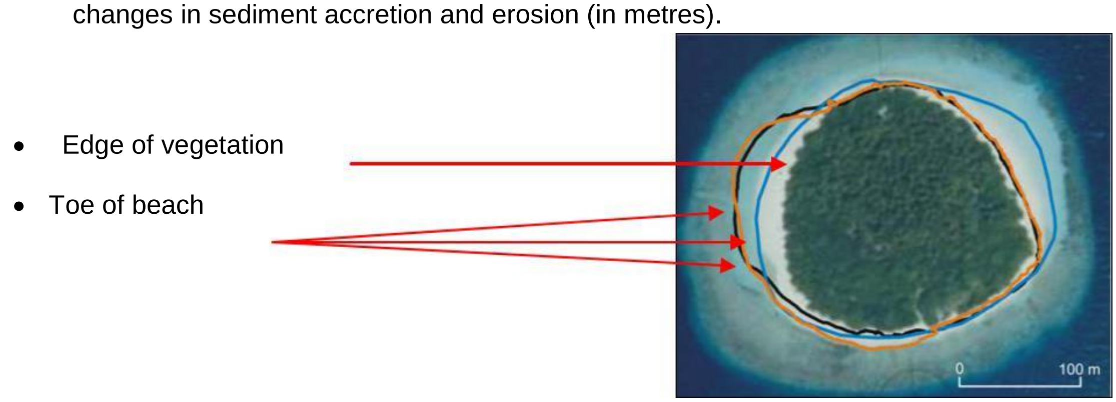

Fig 2. GPS surveying should identify the location of the toe of beach and compare data from one season to the next. Overlapping surveys from different seasons the degree of change will be easily identified.

GPS survey images should be included in the EIA report with appropriate data labels and scale.

1.3.3. Aerial photograph analysis: This will produce a map showing changes in the edge of the dynamic beach and vegetated interior over a decadal time scale. This data provides a rich source of information to establish whether reef islands have changed in size and position on reef surfaces.

1.3.4. Frequency: An annual cycle is observed in the Maldives with position of sediment dependent on the prevailing monsoon. Timing is therefore a primary aspect in monitoring.

- *Baseline:* the first time an island is surveyed, the full seasonal cycle should be monitored requiring three visits: i) end of NE monsoon, ii) end of SW monsoon and iii) end of NE monsoon to see if sediment returned to its original position.
- *Annual:* on return visits, survey once at the end of the SW monsoon for the first five years.
- *Decadal:* monitoring every five or so years after the end of the SW monsoon.

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2. BIOLOGICAL MONITORING

The first action in developing a long-term monitoring program is establishing the key questions about the study. This will guide the selection of methods, sites and times of sampling (English *et al.*, 1994). It is important to select sites for monitoring that are representative of the system as a whole, and not necessarily the closest or most pristine areas. Such "pristine" sites may be essential as "controls", if the aim of monitoring is to determine impacts at test sites (English *et al.,* 1994). All site selection should be made following a "pilot study" of the area, if the project is localized. The number of sites chosen for monitoring will necessarily be a balance between trying to achieve the maximum amount of information and the amount of resources and time available (English *et al.,* 1994). The monitoring program should be designed around a series of sites that can be visited on a regular basis, e.g. every year. Recording the GPS coordinates of the sites are really important for survey repetition. The first step is to establish a sound baseline description of the system before construction occurs.

2.1. CORAL REEF, FISH & INVERTEBRATES MONITORING

2.1.1. Pilot study: Manta tow: The manta tow technique is used to assess broad changes in the benthic communities or coral reefs where the unit of interest is often an entire reef or large portion thereof (English *et al.* 1994). Therefore this technique can be used to perform preliminary assessments to design a comprehensive monitoring study.

- Tow an observer, using a rope and manta board, behind a small boat powered by an outboard motor. Tows are carried out at a constant speed around the perimeter of a reef and are broken into units of 2 minutes duration (English *et al.* 1994).
- During each 2 minute tow, observations are made on several variables (e.g. percent cover of live coral, dead coral and soft coral). Additional information may be collected, dependent on the survey objectives, e.g. percent cover of sand and rubble.
- This technique is not recommended for fish counts. A pilot study for fish is not necessary since reef fish will inhabit the healthiest available reef. Exclusive fish and invertebrates surveys will be carried out in the main study.

2.1.2. Line Intercept Transects (LIT): It is the standard method recommended by the Global Coral Reef Monitoring Network (GCRMN) to determine percentage cover and colony size for management level monitoring, and obtains information on percentage cover of benthic communities e.g. hard coral, soft coral, sponges, algae, rock, dead coral. The community is characterized using lifeform categories which provide a morphological description of the reef community.

- These categories are recorded on data sheets by divers who swim along lines which are placed roughly parallel to the reef crest at depths of 3 metres and 10 metres at each site (English *et al.,* 1994).
- Place 5 x 20m long replicate transects at each of the two depths (shallow: 3 m and deep: 9-10 m depths). If permanent transects are used, place metal stakes, hammered deep into the substratum (at least 0.5m). If a typical reef flat, crest and slope is present, the shallow transects will be located on the reef slope, approximately 3 metres below the crest. The deeper transects will be located approximately 9-10metres below the crest. If the site is on a reef without a well defined crest, then transect depth should be approximated to a depth below mean water mark. If there is little or no coral at 10m then transects should be laid at 6-8m and not difference.
- A representative number of sites around the island should be surveyed including those that are directly and indirectly affected by construction. A "control" site shall be selected

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and test sites thereafter. These shall be sufficient to make a quantitative assessment of the impacts caused by construction all around the island.

- Observers must be as consistent as possible when recording benthic lifeforms. The same observers should collect data at all sites and, where possible, during repeat surveys.

2.1.3. Coral Recruitment Plates: The larval supply of coral species is examined by estimating the number of new corals settling on replicated units of substratum (terracotta tiles). The tiles are deployed at 5 metres depth on a regular basis (e.g. monthly) and are collected after exposure for equal amounts of time, 3 months is recommended. After collection they are examined microscopically to count the new corals. Year round sampling should be undertaken to determine the period, or periods, of recruitment. When they are known, sampling effort can be concentrated in these periods.

It is ideal for EIA monitoring because it will evaluate whether the system is recovering after it has been damaged and at what rate. This will help understand the impact significance in later projects in the Maldives.

2.1.4.Settlement Quadrats: This is used to measure the growth, mortality ad recruitment of corals in a permanently marked (fixed) quadrat located at metres depth on the reef slope (English *et al.,* 1994).
It complements the LIT method by providing changes in individual corals and recruitment to a mapped area. This provides abundance estimates of recruits that have survived the first year, thus giving a more reliable estimate of future coral species composition than recruitment tiles that look at newly settled recruits

- Using a 25cm x 25cm quadrat, swim in a haphazard fashion around the reef and place the quadrat on the substratum in areas lacking large (>25 cm diameter) sessile invertebrates;
- Count all small (maximum diameter 2 cm) stony corals within the quadrat. Record to genus if possible;
- Repeat 80 times.

2.1.4. Sedimentation on the reef: This is to measure direct sedimentation on the reef resulting from land clearing activities, construction, dredging, mining and drilling activities. Sedimentation reduces light availability for photosynthesis, deplete dissolved oxygen and cause smothering of organisms. Sedimentation rates are measured using sediment traps.

- Attach sets of 3 PVC sediment traps to the reef. The base of the traps should be 20cm above the substratum. Place 4 sets n the reef slope at 3 metres, 2 on either side of the permanent quadrat at one metre intervals.
- Collect traps every month, replace traps immediately with new clean traps. Dry and weigh sediments to the nearest milligram.
- Monitor monthly for the first year and then every 3 months for the next 2 year.

2.1.5. Coral Reef Fish Census: Belt transect: The aim is to simultaneously estimate the abundance and size of fish along 50 metre transects. A visual census is conducted during daylight hours along 3 of the same transects as the line intercept but the fish census transects must be 50 m long at 2 depths (3-5 m and 8-10 m). Wait for 5 to 15 minutes after laying the line before counting to allow fishes to resume normal behaviour, then swim slowly along the transect recording fish encountered in a 5 m belt and 5 m tunnel above the transect. There are two techniques:

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- Detect differences in assemblages of reef fishes at different sites using abundance categories (table 3). It provides baseline data for zoning, management and monitoring, or;
- Count individual fish and estimate their total lengths to determine the standing stock and population size structure of specific species (those that are favoured by fishermen e.g. Serranids, Siganids, Acanthurids, Lutjanids, Lethrinids, Haemulids, Balistids). This is to determine the standing stock and population size structure of specific species.

Table 3. Fish abundance categories.

Category	Number of fish
1	1
2	2-4
3	5-16
4	17-64
5	65-256
6	257-1024
7	1025-4096
8	4097-16384

2.2. SEAGRASS MONTIORING

Seagrass meadows occur in shallow, sheltered soft-bottomed marine coastlines (Kirkman, 1990). They physically help to reduce wave and current energy, help to filter suspended sediments from the water column and stabilise bottom sediments (Fonseca *et al.,* 1982). The habitat complexity attracts high biodiversity and abundance of animals. They are also nutrient sinks, buffering or filtering nutrient and chemical rich waters (Short and Short, 1984). The high primary production rates are linked to high fishery production rates.

Monitoring seagrassess consists of mapping the distribution and density of existing meadows to determine the natural variability (e.g. seasonal dieback) before estimates of loss or gain due to perturbation can be made (English *et al.,* 1994). Percentage cover are measured within replicate quadrats placed at regular intervals along the length of a transect.

- Place transects perpendicular to the shore and that extend to the outer limits of the beds (where seagrass disappears). Transects should be parallel and separated by reasonable distances from each other (50m to 100m). Take 3 replicate transects at each site. Swim along the transect along a compass bearing, perpendicular to the shore.
- Place 25cm x 25cm quadrats at regular intervals (5m-10m) and estimate the percent cover using similar categories to those used in coral reef surveying.
- Estimate the abundance and length of fish the same way as performed in the coral reef visual census.

2.2. TERRESTRIAL MONTIORING

Terrestrial environments in the Maldives play an important role in sustaining island shapes and many indigenous species. Vegetation maintains the soil on the ground and hosts 70 bird species, many interesting reptiles and amphibians and mangrove communities. In Environmental Impact Assessments, terrestrial monitoring should include evaluating the damages caused by the project development on the following flora and fauna:

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- Land clearance activities including removal of trees, shrubs, seedlings, forest litter;
- Mangroves survey including area, species, health;
- Reptiles and amphibians including species, population size, location;
- Birds including species, population size and location;
- Marine turtle tracks;
- Soil texture changes, and,
- Garbage description.

A general procedure for collecting island data is through focus group discussions where islanders can identify the major changes in flora and fauna. All stakeholders should attend this meeting.

Finally, the legislation states that:

- No trees shall be felled for tourism ventures (Regulation on the Protection and Conservation of the Environment in the Tourism Industry)
- The maximum area for construction allowed for tourism ventures is 20%.
- The buffer zone between the high water mark and the first construction is 20 metres minimum.

2. SOCIO- ECONOMIC MONITORING

Public consultation is an important part of the project assessment since stakeholders will influence the success or failure of the project. If stakeholders and members of the public fully support the development activities will process much easier and benefits by both parties will be apparent. The following is important in all consultations:

- List of stakeholders and key informants, describe chronological plan of interviews and meetings and key points of discussions;
- Apply for all the necessary permits for project development;
- Census of the economic activities in the area (project island and neighboring islands);
- Employment and economic opportunities and diversification in the area;
- Impacts on ground water from construction and operational phase and water availability for locals;
- Increased demands for natural resources and services in the area, e.g. water supply, energy, waste water treatment, solid waste generation, health services, population pressure, space availability, food and nutrition security –fisheries, agriculture, other- etc.
- Impacts on tourism, and
- Social destabilization of the island community.

The key outcomes from each stakeholder and key informant consultation ought to be included in the EIA. Follow up consultation will validate the success of the project, failures and suggest improvements.