ENVIRONMENTAL IMPACT ASSESSMENT

Proposed Milkfish Aquaculture Project

Matu, Gaafu Alif Atoll

Proponent: Ministry of Fisheries and Agriculture

Sandcays

July 2017

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Consultants Declaration

This EIA has been prepared according to the EIA Regulations 2012. We certify that the statements in this Environmental Impact Assessment study are true, complete and correct to the best of our knowledge and abilities.

Hussain Fizah

Consultant Registration No. EIA 01/14

Proponent's Declaration

On behalf of the Proponent of the proposed development I guarantee that I have read the report thoroughly and that to the best of my knowledge all information provided here is accurate and complete.

For Ministry of Fisheries and Agriculture

Commitment letter

LETTERHEAD

Mr. Ibrahim Naeem

Director General

Environmental Protection Agency

Ameenee Magu

Malé

Dear Sir,

This is in reference to the Environmental Impact Assessment (EIA) report for the proposed Milkfish Hatchery project in Matu, Gaafu Alif Atoll, Maldives.

As the Proponent of the project, we assure you our commitment to undertake the proposed mitigation measures and monitoring programme given in the EIA Report.

Sincerely,

Executive Summary

This report addresses the environmental concerns of the proposed milkfish (*Chanos chanos*) hatchery project in Ga. Matu. The project is proposed by Ministry of Fisheries and Agriculture.

Concerns about live-bait availability over prolonged periods are being raised in recent years, especially in the southern atolls of Maldives. The development of aquaculture for selected bait species is seen as one possible measure to manage the live bait shortage currently faced by local fishermen. Cultured milkfish has been in use for the longlining industry in different parts of the world, and successfully piloted for the pole-and-line industry in Indonesia and Kiribati. Unlike most of the live bait species currently in use in the pole-and-line fishery, hatchery technology is well developed for milkfish. In addition, the relatively short duration to reach bait-size makes milkfish an ideal species for aquaculture development.

Supplementing the tuna fishermen with cultured bait is expected to reduce the time spent on bait search, and in turn, result in increased effort directed to the tuna fishery.

As live bait shortage is mostly reported from the southern atolls, the proposed hatchery site was selected from Gaafu Alif atoll, for logistical ease in distribution for the most needed areas can be made.

The selected island, Matu from Ga. Atoll is 5.9 Ha small uninhabited island on the northern side of Ga.Atoll. The closest inhabited islands to the project site are Ga. Villingili and Kolamaafushi. The project aims to produce 100 tons of milkfish raised to the size of live bait used in the pole-and-line fishery. All required technical and support infrastructure will be constructed during the construction phase of the project. The operational phase will involve water circulation, feeding and rearing of cultured stock.

In addition to hatchery, nursery and broodstock modules built on land, sea cages will be built for brood stock. Power will be provided for the project via diesel generators, while potable water will be provided via RO plants. Accommodation for staff and administrative buildings and waste management centre will also be constructed on the island. Access to the island will be provided via access channel and a jetty. The naturally deep lagoon will be used as a harbour during the project.

Social and environmental concerns regarding the proposed project include:

- Vegetation clearance during site preparation for construction of land infrastructures. This impact is considered minor negative as outmost care will be taken to reduce cutting down mature vegetation. Buildings will be adjusted as much as possible to reduce requirement of cutting or relocation of mature trees. When unavoidable, two plants for every tree cut will be planted on the island.
- Sedimentation during excavation of access channel and construction of main jetty. This impact is considered as negligible as the excavation involved is very minor. Measures to reduce this impact such as working during calm weather and low-tide has been suggested as mitigation measures.
- Minor impacts due to human activity in the area including littering both during construction and operational phases.
- Increased nutrient loadings from faeces and uneaten food wastes, which will either dissolve or settle on the seabed beneath the cage. Since the water is deep and adequate currents exist, eutrophication is, however, unlikely.

The proposed project is expected to be managed in conformity with local and international regulations and standards of relevance, especially environmental regulations and standards. Therefore, environmental impacts will be well managed, minimized and mitigated.

Given that the project has major socio-economic benefits and some environmental benefits (potential to reduce pressure on wild populations of baitfish), it is recommended to allow the project to proceed as proposed. It is important to consider uncertainties and continue to monitor the project impacts and undertake appropriate mitigation measures in consultation with the EPA and other relevant government agencies. It is also necessary to undertake regular environmental monitoring activities.

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މި ރިޕޯޓަކީ ގއ. މަތުގައި ހެދުމަށް ހަމަޖެހިފައިވާ ބޯދާ ހެޗަރީގެ ސަބަބުން ތިމާވެށްޓަށް އަސަރު ފޯރާނެ މިންވަރު ބަޔާންކޮށްދޭ ގޮތުން ތައްޔާރުކުރެވިފައިވާ ރިޕޯޓެކެވެ. މި މަޝްރޫޢުގައި ހިމެނޭ ރާއްޖޭގައި، ޓޫނާ އުފެއްދުން ބޭނުން ކުރާ އުދުގެ ގޮތުގައި ބޯދާ ތައްޔާރުކުރުން، ބޯދު، މަސްވެރިންނަށް ފަސޭހައިން ލިބޭގޮތް ގޮތް ހަމައެކުރުމެވެ. މި ގޮތުން މަތުގައި ބޯދު ވިއްސައި އާލާކުރުމަށް ބޭނުންވާ ފަސިލިޓީތައް ގާއިމްކުރުން މި މަސައްކަތް އަމަލީގޮތުން ކުރިއަށް ގެންދިއުން މި މަޝްރޫޢުގައި ހިމެނެއެވެ. މި މަޝްރޫޢުގެ އިދާރާއަކީ މިނިސްޓްރީ އޮފް ފިޝަރީޒް އެންޑް އެގްރިކަލްޗަރ އެވެ.

މިގޮތުން ރަށުގައި ވިއްސާބޭހޭލުކުރުމަށް އެކަށީގެންވާ ސަހަރުގެ މާޔާބާތަކުގެ ހުރުމުގެ އިތުރުން، ފެން ޖުދާކުރުބިއި، އިންޖީނުގެ، ކޮނި ގެންގުޅުމާ ސައިންޓިސްޓު އަދި ދުވަހުން ދުވަހަށް ރަށުގައި ބޭރުބޭފުޅުން ބޭނުންވާ އިމާރާތްތައް ކުރުމަށް ވަނީ ހަމަޖެހިފައެވެ. މީގެ އިތުރުން ރަށަށް އަރާ ދިޔުމަށް ސަރަހައް ކަނޑުގެ ޖަރީން ކުރިއަށްދާ ހިސާބުން ގެންގޮސް އެތެރެކުރާ ހުރިހާކަމެއް ވެއެވެ.

މަޝްރޫޢުގެ ސަރަހައްދުން ކުރާނެ ކަމަށް ފާހަގަކުރެވޭ ނެގެޓިވް އަސަރުތަކަށް ފަހަރު ކުޑަކުރެވޭ. އެހެރުން ރަށުގެ އެކަށީގެންވާ ސަރަހައްދެއްގައި ކޮރަލް ސަރުކާރުތަކުން ގެއްލީ ގަސްގަހާގެހި، ނަރު ކަނޑުމާއި ހިމަނައިގެން މަސައްކަތްތަކުގެ ސަރަހައްދު މުގުރު ކިލަނބު ވުމަކީ އެންމެ ބޮޑު ފާހަގަ ކުރާވޭ ކަންކަމެވެ.

މި މަޝްރޫޢުގެ ސަރަހައްދު ވެރިބަން އަންނަމުންދާ ބަދަލުތައް ދެނެގަތުމުގެ ގޮތުން މަޝްރޫޢުގެ ގޮތުން އަހަރުގައި ބާރަ ސަރަހައްދު ކުރާ ކަމަށް ފާހަގަކުރެވޭ ހަމަ ތަޅުމެއް ކުރިއަށް ގެންދާ ކަމަށް ކަމަށް ވިސްނާލައިގެން ކޮސް ފާހަގަ ކުރެވޭ އަސަރުތައް ކަނޑަ ސަރަހައްދުން ހުރިހާ އެކަމަށް ބަދަލުތައް ބިން ގާއިމުކުރަމުންދާ ކަމުގައި ޗެކްކުރުމާއި ތިމާވެށްޓަށް ބޭނުންވާ ކަމެއް އިތުރު ކުރާ ކޮޅު ކަނޑާ ބަދަލުތަކުގެ ގެންދިޔުމަށް ވަނީ ކަނޑައަޅައިފައެވެ.

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1 Introduction

1.1 Introduction

This Environmental Impact Assessment (EIA) report has been prepared in order to meet the requirements of Clause 5 of the Environmental Protection and Preservation Act of the Maldives to assess the impacts of a milkfish hatchery and growout facility in Matu, Gaafu Alifu Atoll. This report will identify the potential impacts (both positive and negative) of the proposed project. The report will look at the justifications for undertaking the proposed project components. Alternatives to proposed components or activities in terms of location, design and environmental considerations would be evaluated. Measures to mitigate any negative impact on the environment would be suggested. Since these kinds of projects are not common place in the Maldives, a comprehensive monitoring programme would be outlined and taken into consideration in the design and implementation of the proposed project.

The findings of this report are based on qualitative and quantitative assessments undertaken during a site visit in June 2017 as well as professional judgement. Data and information presented in the project proposal have been relied upon in order to understand and present the project. The impact assessment methodology has been restricted to field data collected, professional judgement and experience of similar settings and projects across the Maldives and elsewhere. Long term data relevant to this report on specific aspects such as meteorology and climate were gathered from secondary sources and published reports on the Maldives. Only few projects of this sort have been recently proposed or even fewer undertaken in the past, however, documents and experiences from these projects such as Kanduoiy Giri aquaculture project, sea cucumber project in Dhigelaabadhoo and proposed mariculture projects in ADh. Uthuru Athafaru and R. Fenfushi, seacucumber facility EIA at SH Maroshi have been reviewed and taken into consideration.

This EIA is prepared in accordance with the Terms of Reference (TOR) approved by the Environmental Protection Agency (EPA) on 01 June 2017. It is a legal requirement that new projects having potential for environmental impacts gain environmental clearance or approval prior to construction and operation of such projects.

1.2 Scope of the EIA and Approach

The main scope of this EIA report as per the approved TOR is to broadly assess, identify, predict and document potential environmental impacts from the proposed milkfish hatchery project in Matu, Gaafu Alif Atoll. Hence importance is given to document the whole project proposal in detail, identify the main environmental impacts that are associated with the proposed development and address the legal requirements that need to be taken into consideration while implementing this project. This document also addresses the existing environmental condition of the project site and foresees the ways in which potential environmental impacts will be managed, mitigated and reduced.

Hence the key aims of the report are to;

- Describe in detail the proposed project;
- Identify the need and justification for the proposed development;
- Describe the biophysical status of the existing environmental condition of the island based on the findings undertaken during the site visits;
- Assess, identify and predict potential environmental impacts of the proposed development;
- Evaluate the significance and magnitude of impacts that will be generated; and identify and predict ways in which these environmental impacts will be prevented and removed through appropriate environmental management and mitigation measures;
- Develop a mechanism to closely monitor and understand the long-term effects and changes of the proposed development on the environment with respect to the available baseline information, mostly collected from field assessments and site visits;
- Provide legal protection with regards to the proposed development activities; and
- Review the predictions and assessments made on environmental impacts that are associated with the proposed development activities.

In general, the EIA report has been based upon the following sources of information:

- Review of available Project documentation;
- Discussions with key stakeholders;
- Site visit to the island;

- Baseline environmental assessments;
- Maldives Environmental Protection and Preservation Act, Law No. 4/93;
- Regulation on Environmental Impact Assessment of 2012
- Other Environmental Regulations
- Maldives National Development Framework
- Other EIAs for similar development projects that have been carried out in the Maldives.
- EIAs undertaken for projects in Gaafu Alifu Atoll in the recent past.

1.3 Relevant Studies

In order to prepare this EIA, relevant EIA reports for aquaculture/mariculture projects involving sea cucumber or similar species have been studied, which includes;

- EIA for Kanduoiy Giri aquaculture project (CDE 2010)
- Environmental Impact Assessment (EIA) for the Development of an aquaculture facility in B. Fares (Zahid 2012).
- EIA for breeding, laval production and Culture of Sea Cucumbers at GDh, Dhigelaabadhoo (Ali 2012)
- EIA for proposed mariculture project in ADh. Uthuru Athafaru (Naseem 2012)
- EIA for proposed mariculture project in R. Fenfushi (Naseem 2013)
- EIA for proposed seacucumber hathery in Sh Maroshi (Ali Shareef 2015)

1.4 EIA Implementation and Methodologies

This study was based mainly on data collected during a field investigation mission from 10th June 2017 by a team from Sandcays Pvt. Ltd. and published literature on similar settings and projects including EIAs for mariculture/aquaculture project in Kanduoiy Giri (CDE 2010), B. Fares (Zahid 2012), GDh. Dhigelaabadhoo (Ali 2012), ADh. Uthuru Athafaru (Naseem 2012) and R. Fenfushi (Naseem 2013) seacucumber hatchery and growout in Sh Maroshi (Ali Shareef 2015).

The EIA report was compiled by Hussain Fizah, and reviewed by Ahmed, who was a registered EIA consultant with over 19 years of experience who has been involved in numerous EIAs in the Maldives, including aquaculture/mariculture project in Fares (Furress) in B. Atoll and the

EIA for the experimental phase of the Laamu Aquaculture project proposed by the Proponent. Mohamed Shifaf and Mohamed Visham of Sandcays assisted in field work and in preparing maps and presentations required for the EIA report.

Established and widely accepted methods have been applied in this EIA study. Field studies have been undertaken using methods generally employed for EIA studies in the Maldives. The field assessment methodologies are briefly described in Section 5.2 of this report.

The methods used to identify, predict and assess impacts are based on matrices that have been established by the Consultants over a long period. In the matrix, the consultants assign a likert-scale number to represent the magnitude, significance, duration and spatial extent of the potential impact for each project activity against the key environmental and socio-economic components that the specific project activity may have an impact on. The product of the magnitude, significance, duration and spatial extent for each activity and component is summed up to measure the exact nature of the impacts by each activity and the overall impact of the proposed project is the sum of all activities.

The Terms of Reference (TOR) for this EIA has been attached as Appendix 1. This EIA has been prepared based on this term of reference.

2 Legislative and Regulatory Considerations

This section will identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project. The proposed project is expected to conform to all of the policy and regulatory aspects outlined here. This section outlines and summarizes key policies, applicable laws and regulations and regulatory bodies regarding environmental protection, air transportation in the Maldives. Also, it outlines some international and regional obligations that the country has to meet in terms of sustainable development, environmental management and protection as well as safety of civil aviation and air transportation systems.

The proposed project will be subject to the key regulations including Environmental Protection and Preservation Act (No. 4/93) and Fisheries Act (No. 2/2001) of the Maldives. Thus, it must satisfy the EIA process and get approval as well as conform to the regulations under the Fisheries Act.

2.1 Policy Guidance

The policy guidance on the development of the proposed project is taken from a number of policy documents prepared by the Government of Maldives on sectoral developments. Key documents outlined in this EIA are currently being implemented towards sustainable development of the country.

2.1.1 National Framework for Development 2009-2013

Important environmental policy guidance is also given in the Strategic Action Plan (SAP) of the National Development Framework for 2009-2013. Due to the fragile nature of the country's environment, all the development activities must ensure that appropriate care is taken to protect the environment. Environmental sustainability is the basis for socio-economic development, hence, the SAP outlines the key environmental policies that will be implemented in the country for environmental protection and sustainability, while one of the key environmental goals of the country is to protect and preserve the natural environment to ensure prosperous economic development. The environmental policies outlined in the SAP include;

Policy 1: Strengthen EIA process with an emphasis on EIA monitoring.

Policy 2: Conserve and sustainably use biological diversity and ensure maximum ecosystem benefits.

Policy 3: Develop resilient communities addressing impacts of climate change, disaster mitigation and coastal protection.

Policy 4: Strengthen adaptation and mitigation responses for beach erosion and develop a system to assist communities where livelihood and property are affected by beach erosion.

Policy 5: Ensure management of solid waste to prevent impact on human health and environment through approaches that are economically viable and locally appropriate.

Policy 6: Ensure protection of people and the environment from hazardous waste and chemicals.

Policy 7: Improve air quality to safeguard human health.

Policy 8: Enable a fully functional decentralized environmental governance system.

Policy 9: Develop a low carbon economy to achieve Carbon Neutrality by 2019.

Policy 10: Inculcate environmental values in the society and enable environmentally friendly lifestyle.

The Ministry of Environment and Environmental Protection Agency takes the lead role in implementing the above national policies through various strategies and regulatory measures.

Food security and increasing exports in the fisheries sector is an important priority of the Government. In this regard one of the policies in relation to the fisheries sector development, which are of relevance to this project, have been identified SAP.

Policy 1: Expand the scope of the fisheries sector in the economy and diversify fish and marine products in a sustainable manner.

Policy 3: Facilitate business development, trade and export promotion in fisheries

Policy 5: Promote research in fisheries and introduce fish breeding and productivity.

As stated in Policy 1, sustainable development of the fisheries sector is the key and it would be important to undertake feasibility research and develop culture techniques and facilities based on continued research and monitoring.

One of the strategies under Policy 5 is to establish a Mariculture Development Corporation. Policy 5 also includes the strategy to identify and lease potential islands, lagoons and water bodies for mariculture development.

2.1.2 Third National Environment Action Plan

NEAP 3 sets out the agenda for environmental protection and management in the Maldives for the five-year period 2009-2013. This plan is targeted to achieve measurable environmental results that matter to the people of the Maldives.

The aim of developing NEAP 3 is to protect and preserve country's environment and properly manage natural resources for sustainable development of the country and encompasses ten principles, six strategic results with targeted goals to be achieved under each result.

The key principles of the NEAP 3 are:

Principle 1: Environmental protection is the responsibility of every individual

Principle 2: Achieve results

Principle 3: Promote and practice sustainable development

Principle 4: Ensure local democracy

Principle 5: Inter-sectoral co-ordination and co-operation

Principle 6: Informed decision making

Principle 7: Precaution first

Principle 8: Continuous learning and improvement

Principle 9: Right to information and participation

Principle 10: Environmental protection complements development

The six strategic results of NEAP3 are: resilient islands; rich ecosystems; healthy communities; safe water; environmental stewardship; and a carbon neutral nation with 30 result oriented environmental goals that will be achieved in the span of the NEAP 3.

2.1.3 Maldives National Strategy for Sustainable Development 2009-2013

The Maldives National Strategy for Sustainable Development (NSSD) outlines the key objectives, principles and goals that the country will embark toward achieving sustainable development. Hence, the overall direction of the NSSD is to build a nation which appreciates the true value of the natural environment, utilizes its natural resources in a sustainable manner for national development, conserves its limited natural resources, has built the capacity to learn about its natural environment and leaves a healthy natural environment for future generations.

The guiding principles outlined in the NSSD are:

Principle 1: Promotion and protection of fundamental human rights

Principle 2: Equity within and between generations

Principle 3: Democratic and open society

Principle 4: Full participation of businesses and civil society

Principle 5: Policy coherence and coordination

Principle 6: Use best available knowledge

Principle 7: Precaution first

Principle 8: Make polluters pay

While the country will be steered in accordance with the underlying principles of NSSD, the country aims to achieve very important environmental goals, including; adapting to climate change, protecting coral reefs, achieving carbon-neutrality in energy, ensuring food security, establishing a carbon neutral transport system, protecting public health and achieving full employment and ensuring social security.

2.1.4 National Biodiversity Strategy and Action Plan

Maldives was one of the first nations to ratify the United Nations Convention on Biological Diversity (UNCBD). The objectives of the Convention is "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding".

Based on the requirements under this framework convention, the Maldives has developed the National Biodiversity Strategy and Action Plan (NBSAP) in 2002, which was recently revised. The goals of the National Biodiversity Strategy and Action Plan are:

- Conserve biological diversity and sustainably utilize biological resources.
- Build capacity for biodiversity conservation through a strong governance framework, and improved knowledge and understanding.
- Foster community participation, ownership and support for biodiversity conservation.

In implementing the proposed project activities due to care has to be given to ensure that the national biodiversity strategies are adhered to. The project is in line with the spirit of the UNCBD and NBSAP by helping to protect wild fish/marine resource stock.

2.1.5 Waste Management Policy

As waste management has been identified as a key environmental issue in the Maldives, a National Solid Waste Management for the Republic of Maldives was developed in 2007 as an important step towards mainstreaming waste management in the country. The key strategic principles outlined in the document include; establishing polluter pay principles, integrated solid waste management, best practice environmental option (BPEO), best available technology not entailing excessive costs (BATNEEC), proximity principle and private sector participation. It is an important priority of the Government of Maldives as identified in the policy document to setup regional waste management facilities and island waste management centres and decentralizing waste management administration. Hence, the key policies relevant to this project include;

Policy 1: Establish a governance structure for solid waste management which will distribute clearly delineated roles and responsibilities for solid waste management at island, regional and national levels

Policy 2: All waste producers have a duty to manage the waste they generate

Policy 3: Waste will be management and disposed as close as possible to the place of their generation

Policy 8: Private sector participation (PSP) will be facilitated where it is financially for both government and private sector.

Establishing a proper mechanism of waste management and disposal will be vital for the overall operation of the project and the waste management practices both during construction and operation of the project will closely adhere to the policies and principles taken as a priority of the government.

2.2 Regulatory Bodies

2.2.1 Ministry of Environment and Energy

The primary environmental institution in the Maldives is Ministry of Environment and Energy (MEE). It is mandated with formulating policies, strategies, laws and regulations concerning environmental management, protection, conservation and sustainable development. The Minister of Environment or a designate gives the environmental approval or clearance to EIA by an Environmental Decision Statement. Additionally, MEE is responsible for formulating relevant laws and regulations, policies and strategies concerning energy, water and sanitation, waste and infrastructure.

2.2.2 Environmental Protection Agency (EPA)

EPA is the key regulatory body on environment, which is an autonomous body formed under the umbrella of MEE. It is mandated with implementing the EIA process in the Maldives, implementing the Environment Act and subsequent regulations on behalf of MEE, regulating water and sanitation, biodiversity conservation, waste management and coastal zone management. Also, it is responsible for developing environmental standards and guidelines in the country.

2.2.3 *Ministry of Fisheries and Agriculture*

Ministry of Fisheries and Agriculture is the state institution responsible for regulating the fisheries and agriculture sectors for the sustainable management and development of fisheries and marine resources as well as agriculture. With that mandate, the Ministry approves fisheries and agriculture projects in the country, issues licenses for related research, culture and fish processing, leases uninhabited islands and monitors and regulates fisheries and agriculture projects.

2.2.4 *Ministry of Housing and Infrastructure*

The Ministry of Housing is often involved with landuse planning and land management in the country. The Ministry reviews and permits different landuse in consultation with the Island/Atoll/City Councils and other relevant government agencies. For all development projects, it would be necessary to get approvals from the Ministry. The Island Council will often coordinate with the Ministry regarding such landuse planning approvals.

2.2.5 *Atoll/City Councils and Island Councils*

Under the Maldives Decentralization Law, elected Atoll Councils, City Councils and Island Councils have been formed as regulatory bodies dealing directly with atoll, cities and island issues. In this regard, some of the development projects are subject to approval of these councils through a public consultation process. For the proposed project, EPA requires that a copy of the final draft of the EIA Report be submitted to the Gaafu Alif Atoll Council and receipt provided to EPA or attached to the EIA report.

2.3 Laws and Regulations

There are a number of laws and regulations relating to environment in the country. Only relevant laws and regulations have been outlined in this section.

2.3.1 *Environmental Protection and Preservation Act*

The Environmental Protection and Preservation Act of the Maldives, EPPA (Law No. 4/93) provides the basic framework for environmental management including Environmental Impact Assessment (EIA) process in the Maldives, which is currently being implemented by EPA on behalf of MEE.

Clause 3 of the EPPA mandates the Ministry of Environment to formulate policies, rules and regulations regarding the environment.

Clause 5 of this Act specifically provides for environmental impact assessment (EIA), a tool implemented to attempt to integrate environmental issues into development decisions. According to the Clause, environmental impact assessments are a mandatory requirement for all economic development projects.

Clause 6 of the EPPA gives the Ministry of Environment the authority to terminate any project that has an undesirable impact on the environment.

Clause 7 of the EPPA refers to the disposal of oil, wastes and poisonous substances in to the Maldivian territory. According to this clause, any type of waste, oil, toxic gas or any substance that may have harmful effects on the environment should not be disposed within the Maldivian territory. If, however, the disposals of such substances become absolutely necessary, the clause states that they should be disposed only within the areas designated for that purpose and if incinerated, appropriate precautions should be taken to avoid harm to the health of the population.

Furthermore, clause 9 sets a fine between five and five hundred Rufiyaa for minor offenses in breach of this law and a fine of not more than one hundred million Rufiyaa for major offenses. The fine shall be levied by the Ministry of Environment or by other government authorities designated by that Ministry in case of minor offenses.

Finally, Clause 10 of EPPA gives the government of the Maldives the right to claim compensation for all damages caused by activities that are detrimental to the environment.

The Environmental Act or Law 4/93 is the single most important legal instrument with regards to environmental management and it gives very high prominence towards safeguarding the environment with regard to all the development activities. Under this Act, the Ministry of Environment have developed regulations and guidelines concerning the environmental protection through implementation of EIA procedures.

2.3.2 Environmental Impact Assessment Regulation

This EIA is subjected to the EIA Regulations 2012. This EIA Regulation is currently only in Dhivehi and an official translation is awaited. The Regulation sets out the criteria to determine

whether a development proposal is likely to significantly affect the environment and is therefore subject to an EIA. Schedule D of the EIA Regulations defines the type of projects that would be subject to Environmental Impact Assessment. Aquaculture and mariculture is among those.

The main purpose of this Regulation is to provide step-by-step guidance for proponents, consultants, government agencies and general public on how to obtain approval in the form of an Environmental Decision Statement.

2.3.3 Regulation on Cutting Trees

The Regulation on cutting down, uprooting, digging out and export of trees and palms from one island to another was issued by the Ministry of Environment in 2006. Clause 5 (a) of the Regulation states that prior to the commencement of any project(s) that would require the indiscriminate removal and transplanting of trees/palms from one island to another for the purpose of agriculture, development/redevelopment, construction or any other purpose, it is mandatory under the Regulation to prepare an Environmental Impact Assessment report.

Article 8 (a) requires permission be obtained from Ministry of Environment, if more than 10 coconut palms that are of a six of 15 ft (from base of the palm to the tip of the palm frond) are cut, uprooted or relocated to another island. The regulation also ensures the replacement of the vegetation that is lost by imposing the planting of two palms for every palm tree that is cut or uprooted (Article 2 (d)). Logging on inhabited islands must be done under supervision of the islands chief or an official appointed by the island chief (now Island Council) (Article 8 (c)).

This regulation also provides particular protection to the following:

- coastal vegetation extending 15 meters into the island;
- all trees and palms growing in and within 15m around mangrove and wetland areas;
- all trees and palms growing in protected areas; and
- trees and palms that are unique in shape, structure or character

The proposed project does not involve indiscrete removal of trees at any of the two land-based sites although a few shrubs and small trees may have to be cut or transplanted. It is not expected that mature trees would need to be removed.

2.3.4 Regulation on Sand and Aggregate Mining

This regulation disallows sand mining from uninhabited islands that have been leased, sand mining from the coastal zone of other uninhabited islands and aggregate mining from uninhabited islands that have been leased and from the coastal zones of other uninhabited islands.

This regulation would not have any implication on the project since mined sand and aggregate will not be used in any of the project activities but cements and cement blocks as well as imported river sand and aggregates will be used.

2.3.5 Regulation on Environmental Damage Liabilities

Under the Environmental Protection and Preservation Act (Law No. 4/93), the Ministry of Environment formulated the Environmental Damage Liabilities Regulation in February 2011, which encompasses the basis to avoid environmental deterioration, extinction of biological resources, environmental degradation and avoid wastage of natural resources. The main purpose of this regulation is to stop unlawful activities on environment and adequately implement a fining procedure for violations as well as implement a compensation mechanism on environmental damages. Its Schedules form the basis for levying fines on various environmental components and activities. Hence, the proposed project will be subject to this Regulation for any activity outside of the EIA scope and Environmental decision Statement.

2.3.6 Waste Management Regulation

The Waste Management Regulation (Regulation No. 2013/R-58) came into effect in August 2013. The objective of Waste Management Regulation is to implement the National Waste Management Policy; through which it aims to protect the environment by minimizing the impact of waste on the environment, including the impact of waste on human health, establishing an integrated framework for minimizing and managing waste in a sustainable manner and establishing uniform measures to reduce the amount of waste generated. The regulation also ensures waste is reused, recycled and recovered in an environmentally sound manner before being safely treated and disposed. The regulation covers the management of general, hazardous and special waste. Wastes arising from paints and chemical solvents are considered as special waste.

Clause 1.4 of this regulation is of relevance to the projects under consideration. This clause is for construction waste and it states that;

a. Building construction works shall be planned and organized in a manner that there is minimal waste

b. Measures shall be in place to minimize construction waste

c. Reusable or recyclable waste among demolition/construction waste shall be reused or recycled

d. Construction waste shall be kept at the demolition site until demolition is completed

e. Demolition of buildings shall be done with minimal disturbance due to dust and emissions to the environment and people living in the vicinity.

This regulation was effective from 6 January 2014 and EPA would be responsible for the implementation this regulation. The proposed project will follow the regulation.

2.3.7 Dewatering Regulation

Dewatering regulation (2013/R-1697) was published on 31 December 2013 and has become effective from 1 February 2014. The Regulation covers the following:

- Exceptions under the Regulation including dewatering for cleaning household wells and extraction for agricultural purposes.
- Application for dewatering permits including application form, information required such as size, water quality, work schedule, method of dewatering and disposal location.
- Fees for dewatering permits including MVR500.00 for administrative fees, MVR500 per day for the first 28 days, MVR1000 per day for first extension, MVR1500 per day for second extension and MVR 2000 per day for third extension.
- Water quality testing requirements including parameters that has to be tested
- Provision of information (in writing) regarding dewatering to entities within 30m from the dewatering location and ensuring that in case of difficulty in getting water from neighbouring wells, providing 250litres or RF30 as compensation for each household.
- Provisions for disposal of dewatering effluent.
- Reporting requirements.
- Procedures for termination of work and fines levied.

This regulation is not relevant to the project as the foundation for the buildings would be above the groundwater lens and, therefore, no dewatering would be required. Yet, due to the superficial nature of the water lens, if dewatering becomes necessary, appropriate approvals shall be sought and the dewatering regulation adhered to.

2.3.8 Fisheries Act and Regulations

The Fisheries Act (Law No. 5/87) is the umbrella law that governs the affairs of the fishing industry in the Maldives. Articles 3(a) of the Fisheries Act is of specific relevance, which states that the Fisheries Ministry shall formulate and administer regulations on matters relating to fisheries. However, there are no specific regulations on aquaculture or mariculture in the Maldives despite small scale practice and potential for large scale production. The Licensing Regulation (No. 01/2001), which specifically includes licensing for aquaculture, is the primary regulation of relevance to the proposed project. Clause 6 specifies the specific requirements for obtaining a license for aquaculture projects. These include:

- Documentary evidence that the Proponent has legal rights over the proposed land
- All required approvals under the Environmental Protection and Preservation Act
- Health Certificate issued by Maldives Food and Drug Authority
- Approvals from other government institutions, if required

Clause 6 (b), (c) and (d) states that the license is issued for a particular place and for particular species and the license cannot be used for other places and species than those defined by the License.

Live Animal Import Regulation may also be of relevance. This regulation defines the requirements for maintaining health standards and quarantine procedures while in transit and upon importation into the country.

2.4 International and Regional Context

The major global issue facing the Maldives is climate change, global warming and subsequent sea-level rise. The small size of the islands and their low elevation above MSL makes possible impacts of it very serious. Consequently, the country plays a prominent role in fore-fronting environmental issues faced by many other small islands developing states including the

Maldives in the international arena. The Maldives is therefore, a party and signatory to various international conventions and declarations. These include;

- UN Convention on the Law of the Sea – UNCLOS (1982)
- International Convention for the Prevention of Pollution of the Sea by Oil (1982)
- Vienna Convention for the Protection of the Ozone Layer (1985)
- Montreal Protocol on Substances that Deplete the Ozone Layer (1987)
- Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (1989)
- The London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1990)
- Agenda 21 and the Rio Declaration of the United Nations Conference on Environment and Development (1992)
- Convention on Biological Diversity (1992)
- United Nations Framework Convention on Climate Change (1992)
- The Copenhagen Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1992)
- The Montreal Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1997)
- The Beijing Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1999)
- Washington Declaration on Protection of the Marine Environment from Land-Based Activities
- Kyoto Protocol to the United Nations Framework Convention on Climate Change (1998)
- Cartagena Protocol on Biosafety (Maldives acceded on 2 September 2002)
- United Nation Convention to Combat Desertification (2002)

The Maldives is also a key player in formulating and adopting various regional plans and programmes to protect the environment by continuously participating in various activities organized by regional bodies such as SACEP, ESCAP and SAARC. As a result the Maldives is committed to the following;

- SAARC Environment Action Plan adopted in 1997 in Male'
- SAARC Study on Greenhouse Effect and its Impact on the Region

- South Asian Regional Seas Action Plan and Resolutions concerning its implementation (1994)
- SAARC Study on Causes and Consequences of Natural Disasters, and
- South Asian Seas Programme initiated by SACEP
- Male' Declaration on Control and Prevention of Air Pollution and its likely Transboundary Effects for South Asia (1998)

2.4.1 Project Compliance

UN Convention on Biological Diversity is of relevance to the proposed project and to some extent the UNFCC and the Kyoto Protocol.

The proposed aquaculture project upholds the spirit of the UN Convention on Biological Diversity in that it helps to protect and conserve the wild fish stock in the farming as well as sourcing of fish seed from the local environment. The introduction of exotic species into the wild is the only concern and shall be addressed in the best possible manner to avoid genetic modifications and behavioural changes to the native population as well as to affect the biological diversity in the local environment.

The Maldives has been taking steps to address global climate change and the declaration by the President in 2009 to make the Maldives the world's first carbon neutral country by 2020 requires dramatic changes to the way we produce electricity or use energy. Hence, alternative energy sources shall be given priority in the implementation of the proposed project, especially during the commercial phase, for which a separate EIA will be documented..

2.5 Environmental Permits required for the Project

2.5.1 EIA Decision Statement

The only environmental permit to initiate proposed works would be a decision regarding this EIA from the Environmental Protection Agency (EPA). The EIA Decision Statement, as it is referred to, shall govern the manner in which the project activities must be undertaken. This EIA report assists decision makers in understanding the existing environment and potential impacts of the project. Therefore, the Decision Statement may only be given to the Proponent after a review of this document following which the EPA may request for further information or provide a decision if further information is not required.

3 Project Description

3.1 Introduction

The purpose of this section is to describe the project in terms of the need and justification of the project, location and boundaries of the project, project schedule, main inputs, project mobilization as well as project construction activities. In addition, this section presents materials and resources that will be used as well as the main output of the project.

3.2 Project Background

The three major fisheries for tunas rely on the utilization of bait. The pole-and-line fishery for skipjack and the hand-lining for yellowfin tuna use various types of live baits while the long-lining for large yellowfins depend on frozen bait. Bait measuring 6 – 9 cm in length are used in the pole-and-line fishery, while 10 – 20 cm long varieties are used in the hand-lining operations (Table 3-1).

Table 3-1: Types and Size ranges of bait used in the Maldivian Tuna Industry, by fishery type.

Fishery	Major types of bait	Size range (cm)	Condition
Pole-and-line fishery for skipjack tuna	Silver sprat (*Spratelloides gracilis*); Blue sprat (*Spratelloides delicatulus*) miyaren; Yellowfin fusilier (*Caesio xanthonota*); Slender fusilier (*Gymnocaesio gymnoptera*), boadhi	6-9	Live
Hand-lining for yellowfins	Mackeral scad (*Decapterus marcarellus)*; Bigeye scad (*Selar crumenophthalmus*); Yellowfin fusilier (*Caesio xanthonota*)	10-20	Live
Longlining for large yellowfins	Mackeral scad (*Decapterus marcarellus*); Bigeye scad (*Selar crumenophthalmus*)	12-22	Frozen

The total annual catch from the pole-and-line fishery is approximately 68,000 tons (Ahusan *et al.*, 2016) and the efficiency of bait utilization in this fishery is estimated at 10 kg live bait / kg of skipjack caught. Based on this estimate, the total annual demand for bait may be estimated at approximately 6,800 tons.

In recent years, the issue of a general, usually seasonal, shortage of bait and its impact on the pole-and-line tuna fishery have, especially in the southern atolls have increasingly been brought up. Fishermen from the southern atolls reportedly travel as far north as Lhaviyani Atoll in search of bait, spending as much as MVR 5000 – 10000 in fuel costs per trip, let alone the opportunity cost of the effort on finding bait and the effective time spent on fishing.

There is a current need to manage the bait situation in the Maldives and reduce cost of the fishing effort by providing the fishermen with a cheaper, reliable alternative. Development of aquaculture production capacity for potential bait species is seen as one possible solution to the issue of bait availability. In addition to the reliable, year-round supply of bait, aquacultured bait species would reduce the fishing pressure on the wild bait species.

Hatchery-bred milkfish (*Chanos chanos*) has successfully been used as bait in the longline fishery for large yellowfins (FitzGerald, 2004). Although not commercially practiced as yet, milkfish has been trialled in the pole-and-line fishery successfully in Indonesia and Kiribati (Rawlinson, Blaber and Milton, 1992; Padiyar and Budhiman, 2014). Hatchery-produced milkfish has potential for being developed as a bait species to address the bait shortage in the Maldives.

This project is developed in response to the decision made by the Government of Maldives to establish a milkfish hatchery facility in the Maldives to supplement the bait requirement of the pole-and-line tuna industry. The project involves a two-pronged approach to the development of hatchery capacity for milkfish production.

3.3 Proponent

The project proponent is Ministry of Fisheries and Agriculture.

3.4 Project Location and Boundaries

The full-fledged hatchery facility will be developed on the island of Matu, GA Atoll (0°53'07" N; 73°20'10" E; Figure 3-1).

Matu, the island selected for the development of the milkfish hatchery, is situated in an isolated reef system. The nearest inhabited islands are Villin'gili Island about 10 km to the south east and Kolamaafushi about 10 km to the west of Matu. The island covers a total area of 5.9 ha, and has two deeper lagoons and one shallower one within its reef. This provides an ideal environment to develop land based facilities as well as a relatively protected lagoon area that can be utilized for structures developed in the sea.

The study area for this project is the entire reef system; i.e. the reef, lagoons within the reef and the island.

Figure 3-1: Location of Matu in GA. Atoll

3.5 The Project

The project aims to produce 100 tons of milkfish raised to the size of live bait used in the pole-and-line fishery. All required technical and support infrastructure will be constructed during the construction phase of the project. The operational phase will involve water circulation, feeding and rearing of cultured stock.

3.5.1 Environmentally Significant Activities

The main activities of the resort development that may have impacts on the environment are:

- Land clearance (up to 16% of total land area will be cleared);
- Dredging a small access channel;
- Construction of jetties and sea cages
- Infrastructure including water supply network, power generation and distribution system, oil storage tanks, waste management facility and workshop;
- Construction and use of accommodation, kitchen and admin buildings;
- Temporary facilities;
- Utilities including power, water, wastewater treatment, waste and fuel.
- Construction and operation of hatcheries

The following sub-sections looks at the details of these environmentally sensitive elements of the proposed project.

3.5.2 Land clearance

Total vegetated area of the island is estimated to be 44,000m^2. In the proposed development concept, the vegetation clearance has been minimized by keeping a large area of the island, especially the centre of the island without any sort of development. Similarly, a large proportion of the south-eastern area has been left intact. The vegetation clearance falls in an area of about 9,400m^2 in which there are few mature vegetation, most of which would be preserved to the greatest possible extent and mature coconut trees removed would be transplanted in clearings and area that have bushy vegetation.

Unnecessary areas will not be cleared during stakeout of the buildings and pathways to get the line of sight for stakeout. Instead, state of the art real-time GPS technology will be used to

stakeout footprint areas of buildings and pathways. Furthermore, mature trees within the development footprint will be carefully transplanted elsewhere.

3.5.3 Dredging

The proposed project involves dredging of a small access channel (Figure 3-2), measuring 26m in length and 30m in width. The channel will be 4m deep at mean tide. The existing depth at the proposed location is 2m at MSL. This will yield a volume of 1200m^3 of sand. The proponent proposes to utilize this sand for use in backfilling/levelling of the island during construction stage.

Figure 3-2: Proposed access channel (marked in blue)

The access channel will be dredged using an excavator on barge. Dredge material will then be transported to the island using the barge.

3.5.4 Jetties

On the southwestern side of the island, a jetty will be constructed and will be used as the main access to the island during construction and operation phase of the project. This jetty will be 82.8m long and 4m wide. This will be a typical jetty constructed with wooden planks on wooden beam and concrete piles. A small excavator maybe used to erect the pre-made concrete piles in place.

The jetty on the north-western end of the island will provide access to the sea cages in the deep lagoon. This will be a prefab floating structure securely moored to the location. This jetty will be 115m long and 4m wide.

Figure 3-3: Floating jetty similar to the one proposed to access sea cages

3.5.5 Infrastructure

The proposed infrastructure on Matu will include the following components.

A. Hatchery modules: (3 modules of 10 m x 28 m; 1 module of 15 m x 20 m)
B. Nursery modules: (10 modules of 15 m x 20 m;)
C. Broodstock module: (2 modules of 20 m x 28 m)
D. Sea cages for broodstock (1 x 10 m diameter HDPE cages, with adequate mooring)
E. Outdoor algae culture: (25 m x 25 m)
F. Live feed culture modules: (4 modules with total area of 1,125 m2: Indoor algae culture: 15 m x 7 m; Indoor rotifer culture: 10 m x 10 m; rotifer mass culture: 36 m x 20 m; Artemia culture: 10 m x 20 m)

G. Warehouse/ storage (25 m x 25 m)
H. Laboratory (10 m x 15 m)
I. Pumping / Filtration systems / water intake system (25 m x 10 m)
J. Staff area (including accommodation, mess and recreational area, mosque, etc: total area of 10,000 m2)
K. Office (10 m x 10 m)
L. Power house / Desalination plant (25 m x 10 m)
M. Waste disposal area (93.5m^2)

The proposed hatchery modules (hatchery, broodstock, nursery and feed culture) will consist of fibre glass tanks on concrete foundations (Figure 3-4).

Figure 3-4: Proposed culture modules

The proposed sea cages to hold reared fish will be a floating structure moored in the deep lagoon north of the island (). The cages will not reach the seabed, allowing extra fish-feed and faeces to fall through the cage and naturally decompose.

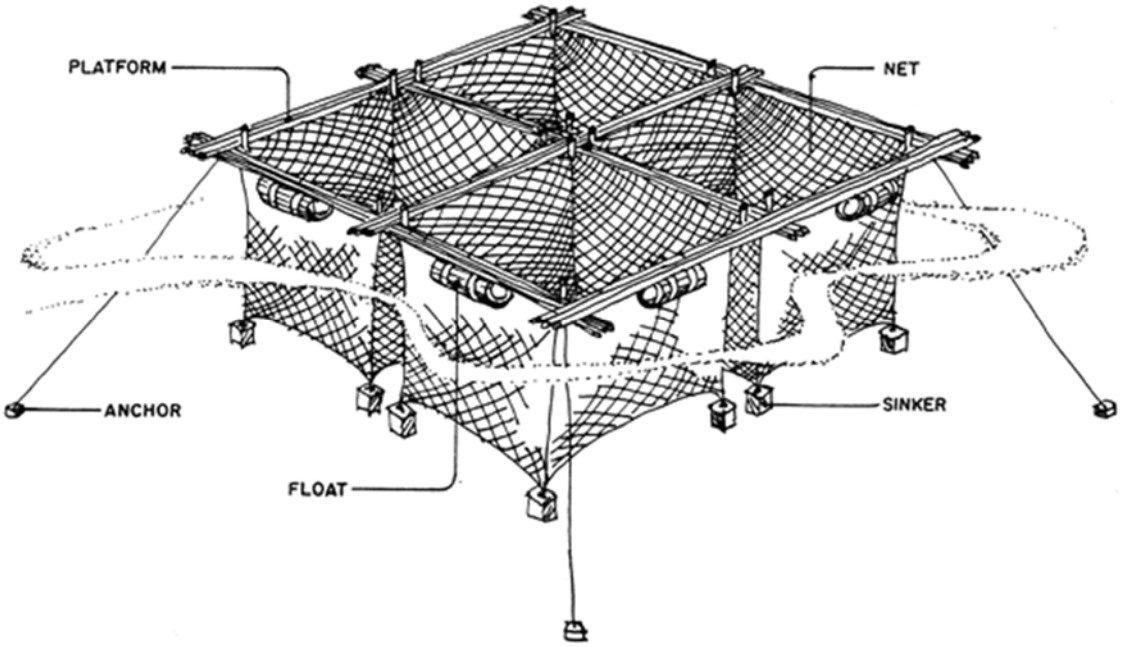

Figure 3-5: Proposed sea cages

3.5.6 Culture Process

Broodstock required for the operation will be sourced locally from wetland areas that have a population of adult milkfish, and conditioned in sea cages as well as in the land-based broodstock holding facility. Spawning is expected to occur naturally, without any external interventions.

Fertilised eggs will initially be incubated in incubation tanks and the hatched larvae transferred to larval rearing tanks. The larvae will be fed on live feeds (microalgae, rotifer and artemia) produced on site during the entire hatchery phase. Milkfish hatchery phase is completed in 21 days, after which they are stocked in nursery tanks with adjusted stocking densities. They stay in land-based nurseries for another 4 – 6 weeks, fed artificial diets, until the adequate size (5 – 10 cm) is reached. Bait-sized milkfish fry can be maintained at high stocking densities for up to 2 weeks or until they are sold to fishermen.

3.5.7 Water Extraction, Discharge and Waste Management

Seawater will be pumped to the hatchery and nursery directly from 2 sea wells located 50 m out from the shoreline on the southern side.

To ensure effluent seawater and any harmful substances do not come into contact with the environment, wastewater will be properly treated using a series of compartmentalized tanks. The output of seawater from the hatchery and nursery will be treated with a concentrated chlorine bath and filtered to prevent sediments and feed contaminants from entering the sea. Water will then go through a de-chlorination process before discharged via outfall located on the northern side of the island. The discharge released via outfall pipes will be similar to ambient seawater quality.

Comprehensive water tests will be carried out periodically to ensure the effluent is not harmful to the environment. Any solid waste that may be generated from the nursery will be collected, dried and then incinerated. All material waste will be regularly gathered at the waste management area and disposed appropriately, abiding by all local regulations. Green waste will be composted and/or utilized for the material needs of the project as available.

Domestic waste from staff will be recycled where suitable; organic waste will be composted while rest will be collected and incinerated. Waste requiring special treatment will be securely transported to Thilafushi for appropriate treatment every three months. These will follow the existing guidelines and regulations.

3.5.8 Culture Species and Characteristics

Milkfish (*Chanos chanos*) is the only species in the Family Chanidae. Its distribution is restricted to either low latitude tropics or the subtropical northern hemisphere along continental shelves and around islands, where temperatures are greater than 20 °C (Red Sea and South Africa to Hawaii and the Marquesas, north to Japan and south to Victoria, Australia; and in the Eastern Pacific from San Pedro, California to the Galapagos).

Adults occur in small to large schools near the coasts or around islands. They are well developed, migratory, large (up to 1.5 m and 20 kg), and mature sexually in 5 years. Milkfish only spawn in fully saline waters. The activity is most often correlated with the new or full moon phases, takes place mostly in the night and, in most regions, has one or two seasonal peaks. In the natural environment, spawning takes place near coral reefs during the warm

months of the year, and populations near the equator spawn year-round. Juveniles and adults eat a wide variety of relatively soft and small food items, from microbial mats to detritus, epiphytes and zooplankton.

Milkfish is a heterosexual fish; hermaphrodism has not been reported. In natural spawning stocks, the sex ratio is almost equal, with a slightly higher number of females. The determination of sex is very difficult, because there are no easily identifiable morphological differences between males and females; however, the pheromone PGF2a (prostaglandin) has been found to be an effective way to identify mature male milkfish.

Milkfish eggs (1.1-1.2 mm in diameter) and larvae (3.5 mm at hatching) are pelagic and stay in the plankton for up to 2-3 weeks. Egg division begins an hour after and hatching occurs 35-36 hours after spawning. In the wild, eggs are probably released in deeper oceanic waters and in the outer reef region. Older larvae migrate onshore and settle in coastal wetlands (mangroves, estuaries) during the juvenile stage, or occasionally enter freshwater lakes. The larvae eat zooplankton and can thrive and grow in water as warm as 32 °C. They then migrate onshore and where they can be caught by fine-mesh nets operated along sandy beaches and mangrove areas; these 'fry' are 10-17 mm long and are used as seedstock in grow-out ponds, pens and cages. In the wild, juveniles are found in mangrove areas and coastal lagoons, and even travel upriver into lakes; they go back to sea when they get too large for the nursery habitat, or when they are about to mature sexually.

Milkfish can reach a maximum size of 180 cm SL (male/unsexed) and 124 cm SL (female). The maximum recorded weight and age is 14.0 kg and 15 years respectively. Resilience is low, with a minimum population doubling time of 4.5 - 14 years. Its fisheries importance is highly commercial, especially in aquaculture, and it is also used in game fish as bait. It is especially valued as a food fish in Southeast Asia.

3.5.8.1.1 Biological Features

Figure 3-6: Adult Milkfish

Body fusiform, elongated, moderately compressed, smooth and streamlined. Body colour silvery on belly and sides grading to olive-green or blue on back. Dorsal, anal and caudal fins pale or yellowish with dark margins. Single dorsal fin with 2 spines and 13-17 soft rays. Short anal fin with 2 spines and 8-10 soft rays, close to caudal fin. Caudal fin large and deeply forked with large scale flaps at base in adults. Pectoral fins low on body with axillary (inner basal) scales. Pelvic fins abdominal with axillary scales and 11 or 12 rays. Scales cycloid, small and smooth, 75-91 on lateral line. No scutes (modified pointed scales) along belly. Transparent 'adipose' tissue covers eye. Mouth small and terminal without teeth. Lower jaw with small tubercle at tip, fitting into notch in upper jaw. No bony gular plate between arms of lower jaw. Four branchiostegal rays supporting underside of gill covers. Gill rakers fine and numerous. Attains typical length of 1 m but may reach maximum length of 1.8 m (male).

3.5.9 Feed

Proposed larviculture involves feeding of Chlorella-reared rotifers to larvae for the first 15 days followed by feeding brine shrimp nauplii until harvest at 21 days post hatch. Chlorella and rotifer (Brachionus) densities are maintained at 5–10 individual/ml in rearing tanks during the first 15 days. From day 15–19 post hatch the larvae are provided with HUFA and Vit C enriched brine shrimp at a density of 0.5 individual/ml, increasing to 1 individual/ml from day 19–22 and to 1.5 individual/ml from day 22–25 and then ad libitum until harvest.

Live feed (microalgae, rotifer and artemia) are produced on site during the operational phase.

3.5.10 Aquatic Animal Health Management

Biosecurity is the concept of protecting culture animals from contamination by diseases and of preventing the spread of diseases across boundaries. An important part of a good biosecurity plan is a quarantine facility. The proposed facility will have the following features.

- header tank with two UV filtration units, one for incoming water and the other used as a recirculating UV pump within the tank
- Prevents nitrate build up and also acts as a precautionary filter and medication mixing tank for even distribution.
- Holding tanks for the quarantine specimens with a constant flow of water and an overflow outlet.
- Mechanical filter to biofilter and a sump to pump water back to the header with return gravity flow to the tanks.

Regular screening of juveniles to check for disease will be conducted to prevent unhealthy juveniles from contaminating the larger group. Most common potential diseases are observable from the exterior of the body wall. The procedures for treating sick animals and preventing the spread of the disease will include segregation of sick animals and treatment with antibiotics or appropriate therapy. The treatment may also consist of an application of low dosage formalin based products. Diseased specimens that cannot be salvaged will be incinerated, thus eliminating any opportunity for escape or sea contamination. The quarantine lab will be located a safe distance from the main hatchery. The seawater discharged from the quarantine facility will first be treated with concentrated chlorine and then exposed to solar radiation for one to two days to break down the chlorine through photolysis.

3.5.10.1.1 Stock Health

Experienced hatchery and grow out managers will monitor the health of our stock on a daily basis. Good water quality and controlled stocking density are the biggest factors to ensuring a healthy stock. In the hatchery, high water quality will be maintained by the use of a sand filter and a submicron filter AMF CUNO during the larvae culture stage. The number and biomass of milkfish will be limited throughout the growth cycle to best practices within the industry to maintain high survival rates and maximize production.

Table 3-2: Major disease problems affecting milkfish and their proposed treatment

DISEASE	AGENT	TYPE	SYNDROME	MEASURES
Nematode infestation	*Capillaria* sp.	Parasitic nematode	Emaciated, although shows good appetite in early stage, then weakens, becomes listless, loses appetite & colour pattern darkens; fin & tail rot and skin patches/sores; faeces white & stringy/slimy; scrapes belly against bottom or may start to tremble; larval stage of parasite located in muscle tissue & can be seen through skin, appearing either coiled up or rod-like	Administer trichlorfon (with caution for small fish); niclosamide, levamisole or mebendazole mixed in feed
Anchor worm disease	*Lernaea cyprinacea*	Parasitic copepod	Parasite visible on skin, head embedded deep in the tissues of the host; haemorrhages and open wounds at site of infection; weight loss; respiratory difficulties; sluggishness; red areas; ulcers; scale loss; fin damage; scraping and sometimes hanging vertically or belly up; parasite length 5 to 22 mm	$KMnO_4$ bath or 0.8-1.1% NaCl ($KMnO_4$ may be lethal to small fish at dosages required to kill *Lernaea*)
Trichodinosis	*Trichodina* sp.	Protozoan parasite	Slime covers skin like fog, fins clamped and denuded of tissue	250 ml/litre formalin bath for 15 min
Scolex infestation	*Scolex pleuronectis*	Helminth parasite	Infestation occurs commonly in the intestine	None stated
Cryptobia Infestation	*Cryptobia* sp.	Protozoan parasite	Dark coloration; increased mucus build-up; occasional appearance of skin lesions followed by scale loss; difficult or rapid breathing; reduced appetite and weight loss; secondary bacterial infections in advanced stage leading to pale and/or red skin patches and skin & fin rot	Treat with formaldehyde (250 ml/litre) or 10mg/litre malachite green; place infected fish in freshwater bath or treat with effective antibacterial agents
Caligus infestation	*Caligus longipedis*	Parasitic copepod	Loss of appetite; lethargic swimming; excess mucus production; lumpy body surface	Dip infected fish in freshwater (makes transparent parasite visible); bathe in 150 ppm $H_2 0_2$ for 30 minutes

3.5.11 Powerhouse and fuel storage

Two diesel generator sets of capacities 200KVA will be installed in the proposed powerhouse for electricity generation. One synchronised genset will be kept as a backup. The electrical supply will be of 3 phase and high voltage cable. Powerhouse and all related facilities will be installed according to the requirements of Maldives Energy Authority. The details of the proposed power grid will be made available to the Energy Authority during the application for the registration of powerhouse. The primary requirement in terms of environmental protection at powerhouses is that the noise level outside the powerhouse building at the facade shall not

exceed 55dB(A). Therefore, adequate noise insulation will be done inside the powerhouse to ensure this standard is met. Generator sets will be placed on anti-vibration mounts and noise insulation baffle walls will be used. Ear muffs will be provided to staff working in the powerhouse and staff will not work inside the powerhouse except for intermittent periods. Control room would be sound proofed.

Diesel fuel will be stored in tanks outside the powerhouse. Day tanks will be utilized to provide fuel to the generator sets. In addition, a 180.7m^2 fuel tank system will be constructed on the island. As is the normal practice, the fuel tank would have a bund outside the tank to contain accidental spills and leakages up to the entire volume of the tank. Exhaust stacks will be connected to each generator set. Each exhaust stack will be above 6m from the ground level. There will be no buildings in the critical path of the concentrated flume.

Electricity will be distributed through low voltage underground cables. Underground distribution system also consists of distribution substations, distribution feeder boxes, and service cables. Glass reinforced polyethylene (GRP) distribution boxes will be used and the distribution cables will be made of four core copper conductors insulated on the outside with polyvinyl chloride (PVC) and steel armored mechanical protection for physical protection.

Fuel will be transported to site by registered or approved fuel suppliers. A fuelling system will be installed at the Service Jetty head, which will deliver fuel to fuel tanks in the island. At least five-day supply of fuel would be stored. Cooling water system will be from the same setup as the desalination plant.

In addition to fuel-efficient engines, energy conservation will be a high priority. Energy saving devices will be used in all operations of the resort. Energy saving lights will be used along with solar and LED light.

3.5.12 Desalination plant

Water supply demand of the proposed project will be met through seawater desalination using 2 Reverse Osmosis desalination plants of capacity 100tonnes/day and a additional plant of 10tonnes/day. Potable water produced from larger plants will be utilized for daily uses while the smaller plant will desalinate product water from the larger plants and provide drinking water for the staff.

Water storage sufficient for 7 days for an estimated total population of about 50 persons at an average minimum of 100 litres per person per day would be installed. Feed water will be drawn from boreholes at the location of the desalination plant. The brine discharge pipe will be near the Jetty.

Desalination plants will be installed according to the requirements of the Maldives Desalination Regulation and all plants will be registered with the EPA once the EIA Decision Statement is received and plants installed. Personnel working inside the RO plant premise will only be subjected to noise levels exceeding 85dB(A) at intermittent periods not exceeding half of an hour. This is acceptable by all international standards, yet ear muffs would be provided on site for personnel to use.

Figure 3-7: Brine Discharge line

3.5.1 Emergency Response Plan

As a means of addressing potential fire hazards, firefighting equipment that meets the requirements of National Fire Code will be developed with all necessary equipment including fire hydrants and fire extinguishers. Services of rescue with all necessary equipment will be made available. An emergency response plan will be developed with details of equipment, human resource and procedures. The following will be considered in the emergency response plan:

- Level of protection to be provided;
- Equipment - firefighting equipment (fire hydrants, fire extinguishers, etc.), rescue equipment (land and water), communication and alerting systems, oil spill containment;
- Response time;
- Emergency access and evacuation procedures;
- Personnel and training requirements;

3.5.2 Equipment, Machinery and Tools

In the construction phase key activities based on the proposed concept include site preparation, mobilization of materials and equipment, temporary accommodation and services for labour force, development of water supply, construction of jetty, construction of operational infrastructure and demobilisation. Machinery and tools used for these activities would be in good condition and used under strict supervision. Heavy vehicles such as excavators, bulldozers and trucks would be kept in designated areas and existing or project specific paths would be used. No additional paths would be created for their movements. Movements on the beach would be minimized.

The operational phase would not involve the use of heavy equipment. However, the machinery and equipment used during operational phase such as air-conditioning units, desalination plants and water pumps would be energy efficient. All air-conditioning units would use refrigerants that meet the requirements of the Montreal protocol (and circulars issued by the Ministry of Environment regarding the Montreal protocol from time to time).

3.6 Project Duration

The proposed project is expected to be operation within a year after start of the construction phase. A part of initial operational activities will be started during construction stage and will carry on to operational phase. A tentative schedule is provided below. Construction phase is expected to start as soon as approval for the EIA is issued by EPA.

Activity/ Month	1	2	3	4	5	6	7	8	9	10	11	12
EIA approval process												
Architectural designs												
Jetty construction												
Mobilisation												
Construction of land facilities												
Broodstock cage deployment												
Broodstock stocking & conditioning												
Operation												

3.7 Project Inputs and Outputs

The project has inputs in terms of human resources and natural resources such as water and fuel. The main output of the project is the successful culture and grow out of Milkfish for bait. These inputs and outputs are summarised in Table 3-3 and Table 3-4.

Table 3-3: Main inputs of the proposed project

Input resource(s)	How to obtain resources
Workforce (human resource)	Constructional workers and employed staff during operation
Construction machinery and materials such as cement, pipes, etc.	Contractor's and/or imported or local purchase/rental
Food, water and other resources	Provided on site
Energy for construction and operation	Electricity from the island power grid and fuel for some machinery including trucks
Brood stock	Obtained from local mangrove areas
Fish feed	Cultured on island

Table 3-4: Matrix of major outputs

Products and waste materials	Anticipated quantities	Method of disposal
Green waste from clearing for buildings	Minute quantity	Burnt on site or mulched
Human waste	No. of staff x 95l/c/d	Conventional sewerage system (septic tanks)
Constructional waste	Small amount	Collected and disposed at designated landfill
Cultured milkfish	N/A	Sold to local fishermen
Waste from sea-cages	Minute quantities	Dispersed by natural hydrodynamics in the area.
Waste water from processing	High amounts	Disposed beyond reef of the island after treatment (northern side)

3.8 Project Rationale

Concerns about live-bait availability over prolonged periods are being raised in recent years, especially in the southern atolls of Maldives. Fishermen from the southern atolls reportedly travel as far north as Lhaviyani Atoll in search of bait, costing as much as MVR 10,000 just in fuel costs (Figure 3-8).

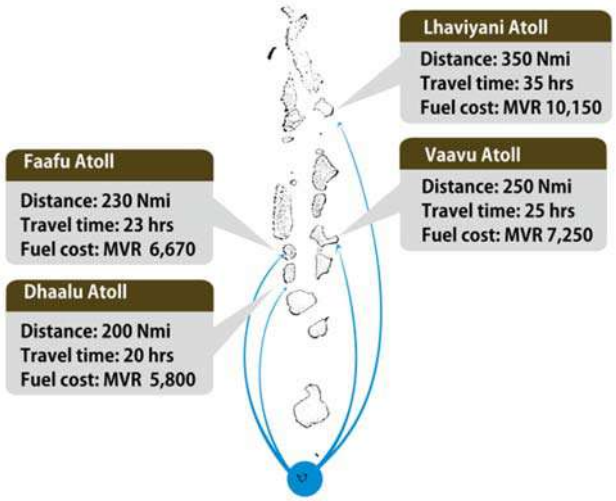

Figure 3-8: Travelling and fuel cost associated with finding the required amount of bait for the pole-and-line fishers

The development of aquaculture for selected bait species is seen as one possible measure to manage the live bait shortage currently faced by local fishermen. Cultured milkfish has been in use for the longlining industry in different parts of the world, and successfully piloted for the pole-and-line industry in Indonesia and Kiribati. Unlike most of the live bait species currently

in use in the pole-and-line fishery, hatchery technology is well developed for milkfish. In addition, the relatively short duration to reach bait-size makes milkfish an ideal species for aquaculture development.

Supplementing the tuna fishermen with cultured bait is expected to reduce the time spent on bait search, and in turn, result in increased effort directed to the tuna fishery.

As live bait shortage is mostly reported from the southern atolls, the proposed hatchery site was selected from Gaafu Alif atoll, for logistical ease in distribution for the most needed areas can be made.

Ref		Description	Foot Print Area [m^2]
a		Hatchery Modules 3Nos	1,140.0
b		Nursery Modules	3,000.0
c		Brood stock	560.0
d		sea cages	-
e		oudoor algae culture	625.0
f		live feed culture modules	-
	1	indoor algae culture	105.0
	2	indoor rotifer culture	100.0
	3	rotifer mass culture	720.0
	4	artemia culture	120.0
g		Ware House / Main Store	625.0
h		Laboratory	150.0
i		Pump Station / Salt Water Intake	250.0
j	1	Mosque	132.8
	2	Accomodation 1 & 2	727.1
	3	Staff Recreation	363.5
	4	Canteen & Kitchen	178.7
k		Office	100.0
l		Power House & RO	250.0
m	1	Arrival Jetty	
	2	Sea Cages jetty	
n		Waste Disposal - Incinerator House	93.5
o		Fuel Tank System	180.7
		Total	**9,421.3**
		Percentage of Development	16%

MATU Island

GA Atoll

E73°20'10" N0°53'07"

Area = 5.9Hectares *[1Ha=10,000 sqm]*

0m 50m 100m 250m

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PROJECT : MILK FISH AQUACULTURE PROJECT

Location : Ga. Matu Island

Ministry of Fisheries & Agriculture

Drawn :

TITLE: LAND USE PLAN CONCEPT

REVISIONS

APPROVED

Reg No :

SCALE: As Shown

DATE : 23 / 05 / 2017

4 Project Alternatives

4.1 Introduction

This section looks at alternative ways of undertaking the proposed project. There are two basic options: (1) leave the problem as it is (no project option), or (2) take measures to resolve the problem (undertake the project options). If the project were to continue, it would be necessary to take economic, ecological and social aspects of the project into consideration and ensure that these concerns exist within a delicate balance. Neither the economic benefits nor the social and ecological concerns can be avoided. Therefore, it is important to consider all options and ensure that the best available option(s) is/are chosen to solve the issues/problems.

Not all the impacts of a project can be completely prevented, however, with the use of appropriate technology and management measures; the magnitude of most of these impacts can be either reduced or minimized. Nevertheless, the effectiveness of these technology and mitigation measures highly depends on the environmental condition and procedures in which they are applied in the field. On the other hand, there are complex and sophisticated procedures of minimizing environmental impacts by means of alternative methods to some of the activities. Often, alternate means are not economically competent with the extent of the project itself. However, to some of the activities where predicted impacts and its magnitudes on the environment are very adverse, alternate means must be applied considering long-term benefits from use of alternatives, as short-term environmental restorations can become very costly.

The following section describes and evaluates some alternatives in terms of locations and various project activities and methods of construction for the proposed project.

4.2 No project option

It should be noted that the “no project” option cannot be excluded without proper evaluation. In this report, this alternative was considered as the baseline against which to evaluate the other options. The no project option takes the following arguments into consideration:

- The feasibility studies have shown that the site conditions are optimal and milkfish can be cultured at commercial scales and can be used for baitfish. Therefore, this may be a suitable solution to the baitfish problem faced by numerous fishermen.

The main advantages and disadvantages of the no-project option are given in Table 4-1.

Table 4-1: Advantages and disadvantages of the no project option

Strategy/option	Advantages	Disadvantages
Project is not undertaken at all	• The island will not undergo any modification. • Environmental impacts and costs related to proposed project may be avoided.	• Lost economic and social benefits due to the project including employment opportunities. • Lost opportunity for a large scale commercial activity that may benefit the whole country. • Economic potential of the island may remain untapped for a long time. • Loss of a potential solution to difficulty in obtaining baitfish by fishermen. • Potential government/public revenue lost

The no-project option also needs to be discussed in light of the proposed project. It is believed that some degree of environmental impacts will arise due to the proposed development of milkfish hatchery in GA. Matu. Although there will be no social and environmental impacts if the proposed development does not go ahead, this will eliminate an important development that has direct linkages with the development of the socio-economic conditions around the project area.

The proposed project will bring numerous benefits to the islands in the vicinity including job opportunities and direct and indirect revenue generating activities. In terms of socio-economic benefits, the proposed project is believed to provide fishermen with a solution to lack of available baitfish nearby. This in turn will facilitate development of fisheries industry of Maldives and reduce dependency on tourism industry for revenue generation. Furthermore, this project will create job opportunities and various small business opportunities to the communities in the project vicinity. This will bring more revenue to these communities.

If the cultured milkfish can replace wild baitfish, it will reduce stress on wild populations and hence allow these populations to recover in time.

In short, the aquaculture of culture of milkfish is an important economic activity, and with known positive impacts on the wild stock and minor environmental impacts on the culture area. Therefore, the proposed project is considered worthwhile.

4.3 Alternative species

A number of factors determine suitable species for aquaculture; these include demand, established culture methods, hardiness and grow-out time for market size. A large amount of research into behaviour and biology of fish is required to determine potential of a fish for aquaculture. Commonly used baitfish in Maldives, such as *Spratelloides spp. Decapterus marcarellus* and *Selar crumenophthalmus* have not been used in commercial aquaculture successfully. Key impediments to aquaculture of these species include lack of well documented technical aspects of captive breeding, larval culture and economic characteristics of their aquaculture. As such, extensive research and pilot projects need to be conducted to rear these fish in aquaculture. This requires a large amount of resources and time.

On the other hand, most widely farmed fish in the world such as tilapia, catfish, salmon and carp are not native to Maldives and has not been successfully used in longline fishery of Maldives. Hence not preferable for this project.

However, milkfish, have been successfully reared in aquaculture and has been demonstrated as suitable for use as bait in longline fishery in Maldives. Milkfish is also native to Maldives, eliminating the risk of introducing an invasive species to the sensitive marine environment and easy to obtain brood stock locally.

4.4 Alternative ongrowing techniques

4.4.1 Pond culture

Culture of milkfish in ponds may be in shallow or deep-water systems;

4.4.1.1.1 Shallow water culture

Shallow water culture is practiced mainly in Indonesia and the Philippines. Milkfish are traditionally cultured in shallow Brackish water ponds in which the growth of benthic algae is encouraged through inorganic or organic fertilization. Milkfish will survive on benthic algae alone only if the productivity of the algae exceeds the grazing rate of the fish; otherwise, supplemental commercial feeds are applied. The 'lab-lab' culture system in the Philippines is equivalent to shallow water culture in Taiwan Province of China. 'Lab-lab' is the term used in

this country for the algal mat (and all micro-organisms associated with it) in the ongrowing ponds.

Brackish water ponds in the Philippines were mostly excavated from 'nipa' and mangrove areas. Shallow water pond design generally consists of several nursery and production ponds with a typical area of 2000 m² for nursery ponds and 4 ha for production (ongrowing) ponds. Typically, ponds have a depth of 30-40 cm and are provided with independent water supplies.

The average yield of a typical integrated nursery, transition and shallow grow-out system that produces 3 crops a year is 800 kg/ha. Modified modular pond designs consisting of a series of grow-out compartments with a maximum of eight crops a year have been shown to increase yield to a high as 2 000 kg/ha.

This method is not suitable to Maldives due to lack of suitable land.

4.4.1.1.2 Deep water

Deep water culture was developed in the mid-1970s in response to the decline of profitability of shallow water culture, and the limited and increasing value of land and manpower resources. Deep-water ponds provide a more stable environment and extend the grow-out period into the winter season. Most deep-water milkfish ponds have been created by converting either shallow water ponds or freshwater ponds, with a depth of 2-3 m. Production from these systems has sharply increased in Taiwan Province of China, having expanded from 23 percent of the total production in 1981 to 75 percent in 1990.

Most milkfish ponds in the Philippines and Indonesia are of the extensive and semi-intensive type, with large shallow pond units, tidal water exchange, natural food, minimal use of fertilizer alternating with commercial feeds and other inputs, and low to medium stocking rates (50 000-100 000/ha). The Taiwanese method of production, on the other hand, employs intensive stocking densities (150 000-200 000/ha). Few diseases or infestations have been recorded so far in milkfish grow-out farming in these Asian countries.

Similar to shallow water culture, this method requires large areas of brackish ponds, which is not available for this project.

4.4.2 Pen culture

This system was introduced in the Philippines in 1979 in the Laguna Lake. At that time, the lake had a very high primary productivity, which met the nutritional needs of milkfish. Because of the low rate of input and the high rate of return, the pen culture area increased sharply from 1973 to 1983, and exceeded more than 50 percent of the total lake surface, which is 90 000 ha. As the primary production of the lake could not meet this sudden expansion of aquaculture, and feeding became necessary to meet the nutritional requirements of the cultured fish, the pen culture practices developed in lakes were later introduced into inter-tidal areas in the Philippines along coves and river estuaries as well. Pen operators stock fingerlings at 30 000-35 000/ha and provide supplemental commercial diets. However, disease spreads among culture pens and causes mass mortality. Government regulations are now being considered to maintain sustainable yields from this type of farming.

Due to lack of suitable space and increased risk of diseases, this method is not preferred.

4.4.3 Cage culture

Fish cages are smaller and more restricted enclosures that can be staked in shallow waters or set-up in deep water with appropriate floats and anchors. Cage farming of milkfish is commonly carried out in marine waters along coastal bays. Stocking rates (in the Philippines) are quite high, from 5 up to 30/m^3. This method has been in-cooperated into the proposed project.

4.5 Alternatives for Energy Generation

The proposed method of generating energy from diesel generators is considered to be the most reliable means at present. However, given the unstable nature of the world economy, it is important to find sustainable energy sources such as photovoltaic, OTEC, wave or wind energy systems.

Among the available alternatives, deep sea cooling and wave/wind energy is not suitable for this project due to size of the island and surrounding environment.

Large area is required for photovoltaic systems; however, the Proponent may incorporate photovoltaic system as a hybrid to the proposed diesel generators in support of carbon neutrality. This is becoming increasingly commonplace.

It is better to avoid diesel based systems given their negative impact on the global environment. Diesel generators produce carbon dioxide, suphur dioxide and nitrogen oxides which contributes to global warming that is seemingly affecting global weather or climate system with potential sea level rise due to melting of polar ice caps. However, it shall be noted that the contribution to global emissions from any diesel generators used for the proposed project will be minute. Yet, the cumulative impact needs to be taken into consideration when choosing the best option

4.6 Alternative jetty location

The proponent has proposed to use existing deep lagoon on the southern side of the island as a natural harbor with a jetty. Alternatively, the proponent may use the smaller lagoon south east side of the island in a similar fashion. This will reduce length of jetty required for access to the island; however, this area may require dredging to meet depth requirements of larger fishing vessels. Hence, compared to proposed location, this alternative will incur more economic and environmental cost.

Figure 4-1: Alternative jetty location

4.7 Preferred alternatives

Due to nature of the project, alternatives to project components are limited. Apart from using solar power to supplement diesel power generation, no other alternative is preferred over the proposed.

Based on available technologies, solar power alone is unreliable and hence diesel power generation need to be used as a primary source. However, if the proponent could reduce amount of fuel used for the project by employing solar powered alternatives such as solar cells and solar water heaters, the carbon footprint of this project will be minimized.

5 Existing Environment

5.1 Introduction

Conditions of the existing environment of the study area were analysed by using appropriate scientific methods. Field surveys were undertaken to get further understanding of the existing environment of the island. These surveys were carried out during field visit to the island from 10th of June 2017 to collect baseline data. Before the trip was undertaken all existing information regarding the site was gathered.

The following components of the existing environment were assessed;

- Coastal environment including shoreline and currents using drogue
- Bathymetry of the project sites
- Marine ecology of the proposed project areas
- Marine water quality
- Terrestrial environment
- Ground water quality
- Socio-economic aspects

5.2 Methodologies

Conditions of the existing environment of the study area were analysed by using appropriate scientific methods. The environmental components of the study area were divided into marine, coastal and terrestrial resources. The marine environment of the island covered the lagoon, reef flat areas and seagrass beds in the project area. The coastal environment covered the beach, the beach rock formations and coastal processes including currents, tides and wave climate. The terrestrial environment covers the vegetation of the proposed coastal structures.

The different methods used in assessing and reporting the conditions of the existing environment of the island are given in the following subsections.

5.2.1 Location identification

The location of data collection sites have been marked using handheld GPS. Figure 5-18 shows the data collection and sampling locations. Beach profile locations have also been marked by permanent markers or bench marks on site.

5.2.2 Water Quality

One of the main environmental components that would be affected by implementing the project would be marine water quality. Water quality was assessed in-situ for most of the parameters using a YSI handheld water quality logger and Hach portable turbidity and TSS meter. Water quality was assessed at different locations within the impact zone. Water testing was also undertaken for other marine location identified as control marine reef survey locations.

All water samples were taken at a depth of 1m from the mean sea level or mid water depth for shallow areas. GPS coordinates of each water sampling location was taken. The samples were analysed for the following parameters as indicated in the environmental monitoring manual issued by the EPA recently.

Table 5-1: Water quality parameter optimum conditions

PARAMETER	OPTIMAL RANGE	REFERENCE
TEMPERATURE	18ºC and 32ºC Changes should not surpass 10C 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/cm2/day Daily maximum of 15mg/cm2/day	GBRMPA, 2009
NITRATES	<5 mg l-1 NO3-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 PO4-P	UNESCO/WHO/UNEP, 1996
SULPHATE	2 mg l-1 and 80 mg l-1	UNESCO/WHO/UNEP, 1996
BOD	< 2 mg l-1 O3	UNESCO/WHO/UNEP, 1996
COD	< 20 mg l-1 O2	UNESCO/WHO/UNEP, 1996

Samples that were brought for laboratory testing were taken to the MWSC laboratory for testing for those parameters that have not been tested in-situ.

5.2.3 Coastal processes

Beach profiles at potential impact areas and other areas useful for future monitoring were done using RTK GPS. These levels were done for shore and lagoon areas from the vegetation line.

A purpose-built drogue integrated with Trimble Juno GPS was released at selected locations around the project site, especially the main impact areas to understand general longshore currents around the island. Several drogues were done. Repetitive long-term measurements at

the same locations would help to understand the general current patterns that will be used in assessing impacts as well as designing structures in the project.

5.2.4 Bathmetry

Bathymetry at the project location was done using RTK GPS. Echosounder was not used due to the fact that the project area was very shallow. Spot levels had to be taken in the field using the DGPS to determine the depth of shallow areas.

5.2.5 Marine Ecology

Marine environmental surveys were conducted to collect data on key environmental components (i.e. the coral reef system) that will be impacted due to the development. Purposes of the surveys are to define and establish marine environmental baseline conditions for impact evaluation during and after the proposed project implementation. Surveys were based on standard marine environmental survey techniques (English, *et al* 2007) so that they can be repeatedly carried out to monitor and record changes and assess possible impacts on the marine environment from the proposed work activities as well as operation of the facility. These surveys should be continually repeated to assess the short-term and long-term impacts on the marine environment.

5.2.5.1.1 Coral Reef Surveys

Quantitative surveys were conducted to establish the status of the coral reef system of Matu. Methodologies adopted for these surveys are internationally accepted and widely used to assess the status of coral reefs in the country as well. Photo Quadrates and visual observation of the reef were conducted at the coral reef system. Photo Quadrate technique has been used for objectives ranging from large-scale special problems to morphological comparison of coral communities and studies assessing impacts natural and anthropogenic disturbances.

For the photo quadrates, a measuring tape of 40m was placed on the reef, a set of random numbers between 0 and 40 were selected using MS Excel prior to the set out. Ten photos were taken at random using these numbers and the measuring tape and later analyzed using Coral Point Count with excel extension (CPCe) created and maintained by National Coral Reef Institute, Nova Southeastern University Oceanographic Centre.

5.2.6 Terrestrial environment

The other main environmental component that would be affected by implementing the proposed project would be terrestrial flora and fauna. These were assessed for the entirety of the Island using transects and visual census. Initially, a pilot survey was conducted on the vegetation of the island. During this survey, major types of vegetation and their extent were roughly marked on a map. Using this, 7 sites were identified for vegetation transects. These were selected as representatives of different types of vegetation on the island. A transect of 30m by 4m was used to assess the vegetation constituent. The species and their numbers were recorded for all the trees inside transects.

The assessment on the fauna was largely qualitative as protected or unique terrestrial fauna were not observed during the pilot survey. The types of fauna seen on the islands were identified and classified into categories based on their abundance; rare, common or very common.

5.2.7 Socio-economic conditions

Socio-economic condition was assessed through direct observations during field visit and using secondary data sources. Discussions were held with the Island Council. These consultations were done after understanding the site conditions so that the proposed concept and the different alternatives can be discussed. Natural interviews and personal observations also revealed a lot of useful information regarding the socio-political environment and public opinions of the project.

5.3 Climate

5.3.1 General Conditions

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25ºC to 30ºC and relative humidity ranging from 73 per cent to 85 per cent. The country receives an annual average rainfall of 1,948.4mm. There is some variation of climate between northern and southern atolls. The Table below provides a summary of key meteorological findings for Maldives. General studies on climatic conditions of Maldives were taken into account during study as local level time-series data are limited for longer periods at the nearest meteorological station.

Table 5-2: Key meteorological information (Maldives)

Parameter	Data
Average Rainfall	9.1mm/day in May, November 1.1mm/day in February
Maximum Rainfall	184.5 mm/day in October 1994
Average air temperature	30.0 C in November 1973 31.7 C in April
Extreme Air Temperature	34.1 C in April 1973 17.2 C in April 1978
Average wind speed	3.7 m/s in March 5.7 m/s in January, June
Maximum wind speed	W 31.9 m/s in November 1978
Average air pressure	1012 mb in December 1010 mb in April

5.3.2 Monsoons

Maldives is in the Monsoonal Belt in the North Indian Ocean. Therefore, climate in the Maldives is dominated by south-west (Hulhangu) and north-east (Iruvai) monsoons. The southwest monsoon is the rainy season which lasts from May to September and the north-east monsoon is the dry season that occurs from December to February. The transition period of the south-west monsoon occurs between March and April while that of the northeast monsoon occurs from October to November. These monsoons are relatively mild due to the country's location on the equator and strong winds and gales are infrequent in the Maldives. However, storms and line squalls can occur, typically in the period May to July. The winds usually get stronger in the south west monsoon especially during June and July. During storms the impact is greater on the northern atolls than the southern atolls.

Table 5-3: Summary of Monsoons in Maldives

Season	Months
North East-Monsoon (Iruvai)	December to February
Transition Period - 1 (HulhanguHalha)	March to April
South West Monsoon (Hulhangu)	May to September
Transition Period - 2 (IruvaiHalha)	October to November

5.3.3 Temperature

The temperature of Maldives varies little throughout the year with a mean daily maximum temperature of about 32°C and mean low of 26°C and are rarely below 25°C or above 33°C. The highest temperature ever recorded in the Maldives was 36.8°C, recorded on 19 May 1991 at Kadhdhoo Meteorological Office. Likewise, the minimum temperature ever recorded in the Maldives was 17.2°C, recorded at the National Meteorological Centre on 11th April 1978. The highest recorded temperature for Male' was 34.1°C on 16th and 28th of April 1973. The hottest month of the year is usually April reaching a peak around 24 April.

The figure below represents daily average low (blue) and high (red) temperature with percentile bands: inner band from 25th to 75th percentile and outer band from 10th to 90th percentile (source: weatherspark.com) based on the historical records from 1998 to 2012 at Hulhulé weather station.

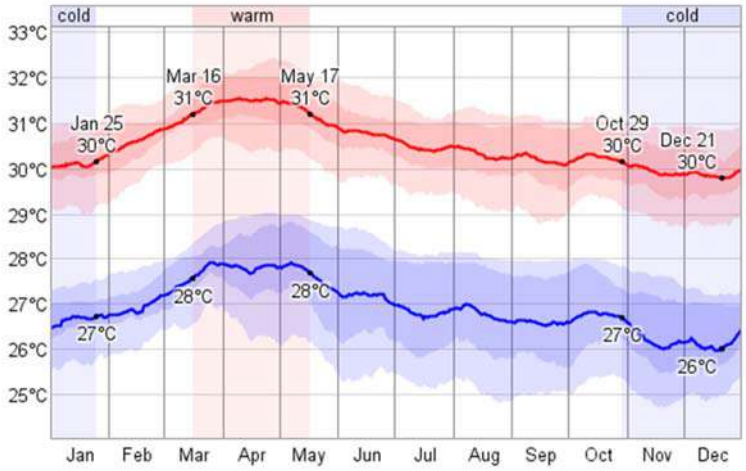

Figure 5-1: Daily average temperature for Central Maldives with percentile bands

The hottest day of the last 12 months was January 5, with a high temperature of 38°C. For reference, on that day the average high temperature is 30°C and the high temperature exceeds

31°C only one day in ten. The hottest month of the last 12 months was April with an average daily high temperature of 32°C.

The longest warm spell was from January 9 to January 30, constituting 22 consecutive days with warmer than average high temperatures. The month of June had the largest fraction of warmer than average days with 93% days with higher than average high temperatures.

The coldest day of the last 12 months was July 9, with a low temperature of 24°C. For reference, on that day the average low temperature is 27°C and the low temperature drops below 25°C only one day in ten. The coldest month of the last 12 months was November with an average daily low temperature of 27°C.

The longest cold spell was from February 24 to March 5, constituting 10 consecutive days with cooler than average low temperatures. The month of December had the largest fraction of cooler than average days with 48% days with lower than average low temperatures.

5.3.4 Rainfall

Annual average rainfall in the Maldives is about 1900mm. There is a marked variation in rainfall across Maldives with an increasing trend towards south. The annual average rainfall in north is 1977mm and for south is 2470mm. The southwest monsoon is known as the wet season with monthly average rainfall ranging from 125-250mm. The northeast monsoon is known as the dry season with average monthly rainfall of 50-75mm.

The following figure illustrates the likelihood that precipitation may occur at some point in the day on a given day, based on the historical records from 1981 to 2012 at Hulhulé weather station (weatherspark.com).

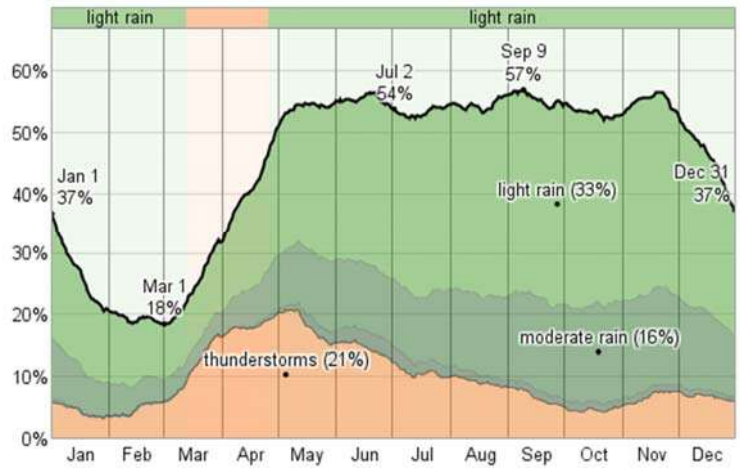

Figure 5-2: Probability of precipitation at some point in the day for Hulhulé, Maldives

5.3.5 Wind

Wind has been shown to be an important indirect process affecting formation development and seasonal dynamics of the islands in the Maldives. Winds often help to regenerate waves that have been weakened by travelling across the reef and they also cause locally generated waves in lagoons. Therefore, winds are important here, as being the dominant influence on the sediment transportation process (waves and currents). With the reversal of winds in the Maldives, NE monsoon period from December to March and a SW monsoon from April to November, over the year, the accompanying wave and current processes respond accordingly too. These aspects have ramification on the seasonal sediment movement pattern on the islands and also the delivery/removal of sediments from the reef platform/island.

The two monsoon seasons have a dominant influence on winds experienced across the Maldives. These monsoons are relatively mild due to the country's location close to the equator and strong winds and gales are infrequent. However, storms and line squalls can occur, usually in the period May to July; gusts of up to 60 knots have been recorded at Male' during such storms.

Wind was uniform in speed and direction over the past twenty-plus monsoon seasons in the Maldives (Naseer 2003). Wind speed is usually higher in central region of the Maldives during both monsoons, with a maximum wind speed recorded at 18 m/s for the period 1975 to 2001. Maximum wind speed recorded in the south was 17.5 m/s during the period 1978 to 2001. Mean wind speed was highest during the months January and June in the central region, while wind

speed was in general lower and more uniform throughout the year in the southern region. Wind analysis indicated that the monsoon was considerably weaker in the south (Naseer, 2003). During the peak months of the SW monsoon, southern regions have a weak wind blowing from the south and south-eastern sectors.

Table 5-4 summarizes the wind conditions in the south of the Maldives throughout the year and Figure 5-3 provides the wind-rose diagram typical to the atoll (windfinder.com). This analysis represents wind data from Addu International Airport taken between 01/2005 and 04/2017 from 0700 to 1900hrs local time.

Table 5-4: Summary of general wind conditions in Malé region

Month of year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	01	02	03	04	05	06	07	08	09	10	11	12	1-12
Dominant wind direction													
Wind probability >= 4 Beaufort (%)	2	2	5	17	26	9	10	10	12	20	29	14	13
Average Wind speed (kts)	5	5	5	8	8	7	7	7	7	8	9	8	7
Average air temp. (°C)	29	29	30	30	30	30	30	29	29	29	29	29	29

Although the shallow reef flat on the east providing a large degree of protection to the eastern beaches, shore protection is required for this side, where the beach has been eroded. The force of swells are weakened by the shallow reef flat, which is dry at low tide in most areas. The western side faces the atoll lagoon with three small reefs providing some protection. Yet, wind waves have little impact on the westerns shoreline except at the northern end where there is some erosion.

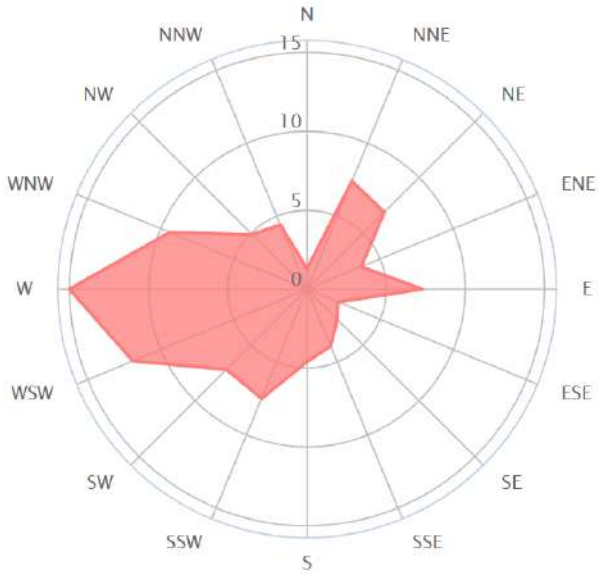

Figure 5-3: Windrose diagram based on data from Gan International Airport

5.3.6 Waves

Wave energy is important for sediment movement and settlement, and it is also a crucial factor controlling coral growth and reef development. Waves have been attributed to the diversity and the abundance of coral and algal species. These aspects have implications for the type and perhaps the supply of sediments to the island.

Studies by Lanka Hydraulics (1988 & 1989) on Malé reef indicated that two major types of waves on Maldives coasts: wave generated by local monsoon wind and swells generated by distance storms. The local monsoon predominantly generates wind waves which are typically strongest during April-July in the south-west monsoon period. During this season, swells generated north of the equator with heights of 2-3 m with periods of 18-20 seconds have been reported in the region. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves.

Distant cyclones and low pressure systems originating from the intense South Indian Ocean storms are reported to generate long distance swells that occasionally cause flooding in Maldives (Goda 1988). The swell waves that reached Malé and Hulhule in 1987, thought to have originated from a low-pressure system of west coast of Australia, had significant wave heights in the order of 3 metres.

In addition, Maldives has recently been subject to earthquake generated tsunami reaching heights of 4.0m on land (UNEP 2005). Historical wave data from Indian Ocean countries show that tsunamis have occurred in more than one occasion, most notable been the 1883 tsunami resulting from the volcanic explosion of Karakatoa (Choi *et al* 2003).

Table 5-5: Summary of wave condition in Matu

Season	Total	Long Period	Short Period
NE - Monsoon	Predominantly from NE-E. High Waves from E	From E-NE	Mainly E-NE. High waves from E
Transition Period 1	Mainly from E-SE	From E-SE	Mainly from NE-SE
SW - Monsoon	From SW-NW. Mainly from S. High Waves also from W	From E	Mainly from SE-S. High waves from E
Transition Period 2	As NW-N monsoon	From E-NE	From SE-W. Higher waves from E

This aspect of climate will therefore have an effect on the design of any coastal infrastructure and water sports activities planned for the resort.

5.3.7 Humidity and Evaporation Rates

Based on data obtained from Hulhulé weather station over a period of 14 years from 1998 to 2012 given in Figure 5-4 (weatherspark.com), the relative humidity typically ranges from 68% (mildly humid) to 93% (very humid) over the course of a year, rarely dropping below 61% (mildly humid) and reaching as high as 100% (very humid).

The air is *driest* around February 26, at which time the relative humidity drops below 71% (humid) three days out of four; it is *most humid* around November 30, exceeding 89% (very humid) three days out of four.

Over the course of a year, the dew point typically varies from 23°C to 27°C and is rarely below 21°C or above 28°C.

Open water evaporation and transpiration from vegetation are very high. The high rates of evaporation and transpiration, especially owing to global warming, may be considered to add further to the evaporation rate and cause sea levels to fall in the future (Morner *et al* 2004). Evaporation rates are influence by wind, temperature and humidity and level of particulates in the air, studies of pan evaporation rates

are influenced by the amount of sunlight hitting the pan, rather than other meteorological factors (Dawson and Spannagle 2009).

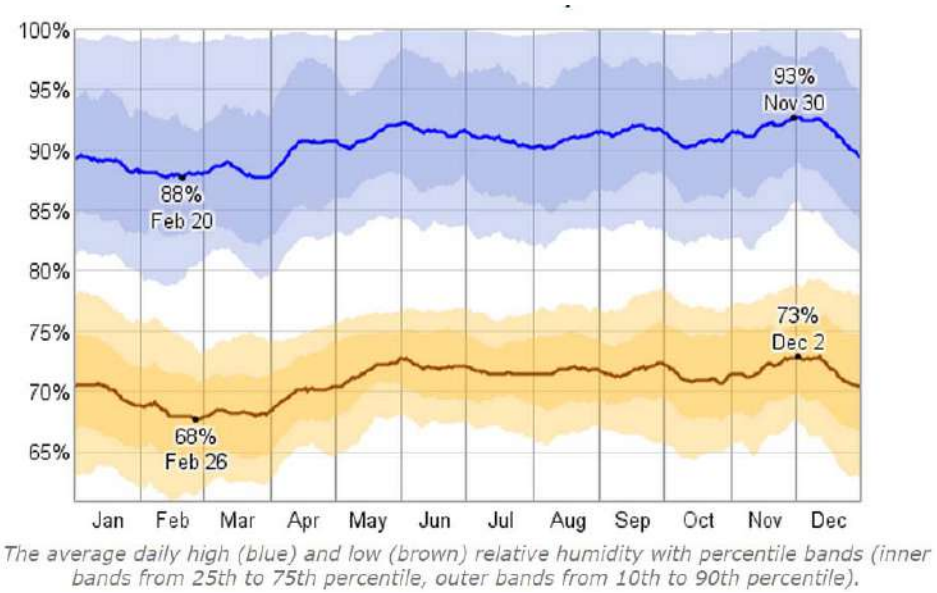

Figure 5-4: Relative humidity over a period of 1 year

5.4 Hydrography

5.4.1 Tides

Tides affect wave conditions, wave-generated and other reef-top currents. Tide levels are believed to be significant in controlling amount of wave energy reaching an island, as no wave energy crosses the edge of the reef at low tide under normal conditions. In the Maldives where the tidal range is small (1m), tides may have significantly important influence on the formation, development, and sediment movement process around the island. Tides also may play an important role in lagoon flushing, water circulation within the reef and water residence time within an enclosed reef highly depends on tidal fluctuations.

Semidiurnal tides are experienced in the Maldives that is two high tides and two low tides a day. The tide varies slightly from place to place, depending on the location and on the shape and depth of the basin, channels and reefs and also time of the year.

The following figure shows the astronomical tidal variation recorded in the country with respect to the mean sea level. Astronomical tides are related to the motion of the earth-moon-sun

system, and have a range of periodicities. The highest astronomical tide was recorded as 0.64 cm above the mean sea level and the lowest astronomical tide was recorded as 0.56 below the mean sea level. Tidal variation of 1.2m from lowest to the highest tide levels were recorded in the country.

	Highest Astronomical Tide (HAT)	Mean Higher High Water (MHHW)	Mean Lower High Water (MLHW)	Mean Sea Level (MSL)	Mean Higher Low Water (MHLW)	Mean Lower Low Water (MLLW)	Lowest Astronomical Tide (LAT)
Water Level referred to MSL (m)	0.64	0.34	0.14	0	-0.16	-0.36	-0.56

Figure 5-5: Astronomical tidal variation in the Maldives

Based on the above tide table and levelling surveys undertaken at site, Matu is at an appropriate average elevation of about 1.5m above Mean Sea Level (which is the normal average for most of the Maldivian islands).

5.4.2 Currents

Studies on current flow within a reef flat in Malé Atoll suggests that wave over wash and tides generate currents across the reef platforms, which are also capable of transporting sediments (Binnie Black & Veatch 2000). However, available information suggests that tidal currents are not strong due to small tidal range.

Generally current flow through the Maldives is driven by the dominating two-monsoon season winds. Westwardly flowing currents are dominated from January to March and eastwardly from May to November. The change in currents flow pattern occurs in April and December. In April, the westward currents flow are weak and eastward currents flow will slowly take place. Similarly, in December eastward currents flows are weak and westward currents will take over slowly.

Studies on current flow process within a coral atoll have shown that waves and tides generate currents across the reef platforms, which are capable of transporting sediments on them.

Currents, like waves are also modified by reef morphology. Under low-input wave conditions (0.5m heights) strong lagoon ward surge currents (>60cm/sec) are created by waves breaking at the crest. Studies on current flow across reef platforms have shown that long-period oscillations in water level cause transportation of fine-grained sediments out of the reef-lagoon system, while strong, short duration surge currents (<5sec.) transport coarse sediments from the breaker zone to seaward margin of the back-reef lagoon. Always sediment accumulates at the lee of high-speed current zones. Generally, zones of high current speed (jets or rips, 50-80cm/sec) are systematically located around islands.

Data on current speed and direction around Matu was measured on the day of the field visit in June 2017. These are given in Figure 5-18. However, spot data taken on a single day or couple of days would not yield sufficient data to understand coastal dynamics. Aspects relating to currents have a direct impact on the project, especially in understanding the movement of sediment plumes and the design of coastal protection measures. Therefore, long-term monitoring of currents is important.

5.4.3 Bathymetry

Bathymetry of relevant areas of the site is given in Figure 5-18.

5.5 Geology and geomorphology

The island formation theories suggest that Maldives was formed around prehistoric volcanoes in Indian Ocean which has gone extinct. As the ocean floor subsided with the volcano, corals began to populate and grow around it forming a fringed reef. As ages passed the reef slowly became a barrier reef enclosing a shallow lagoon inside. The volcanoes disappeared and the coral continued to grow. Slowly as material eroded from the reefs they got collected on the shallower reefs and the sand banks became tiny islands. According to the geological formation, Matu appears to have been formed due to material deposition from the eastern reef as well as western reef. The effect of the swell waves from the west is less for the islands on the northeast corner including Matu. Large waves and strong currents are predominant from the east. For this reason, the shoreline on the east of these islands are more eroded than that on the west with beach rock formations on the eastern shoreline.

A further cause of long-term shoreline retreat is the rise in mean sea level relative to the land. In the future, the consequences of atmospheric pollution, and hence global warming, may

include an acceleration of the increase in mean sea levels around the world. As a consequence, large parts of the coast of Maldives may begin to experience a net increase in sea levels. However, there are also theories that support that a reduction in sea level may occur around equatorial zones as a result of global warming and subsequent increases in sea surface evaporation (Mörner, etal 2004).

In recent centuries, Maldives may have slightly suffered from the increase in global sea levels, which has been averaging about 1mm to 1.5mm/year. This is because all islands of the Maldives are about a metre or two above mean sea level. As sea level rises relative to a beach, there is an inevitable tendency for the shoreline to move inland.

A proper lagoon can be seen at all sides of Matu except for the north. The northern side of the island has the most extensive lagoon, with larger deep area apparent close to the northern tip of the island.

Seasonal sand movement is seen to be most visible at the northern tip of the island. With seasonal accretion and erosion observed on the north-eastern side of the island.

5.5.1 Sediment characteristics

Stoddart et al. (1969) cited in Zahir (2011) reported that the reef flat sediment along the Gan-Hithadhoo reef are generally coarse and poorly sorted, while the beach sediments are moderately fine and very well sorted. The lagoon floor sediments are coarse to very fine and poorly sorted.

5.6 Water quality

5.6.1 Marine water quality

Marine water quality has been measured from representative locations around the project site. The water quality results (in-situ) are given in Table 5-6.

Table 5-6: Marine water quality results

	Units	Site 1	Site 2
GPS Location	UTM		
Temperature	^{o}C	31.5	31.2
E. Conductivity	uS/cm	49953	48735
Total Dissolved Solids	mg/l	33014	33154

Salinity	ppt	32.1	32.1
Dissolved Oxygen	mg/l	5.87	4.98
phophate	mg/l	<0.05	<0.05
Ammonia	mg/l	0.08	0.20
BOD	mg/l	1	1
COD	mg/l	-	-
nitrate	mg/l	2.5	1.9
pH		8.38	8.16
Turbidity	NTU	0.98	1.10
Total Suspended Solids	mg/l	3	3

5.6.2 Ground water Quality

Ground water quality has been measured from representative locations on the island. The water quality results are given in Table 5-7.

Table 5-7: Ground water quality results

	Units	**Site 1**
GPS Location	UTM	
Temperature	ºC	28.7
E. Conductivity	mS/cm	1.245
Total Dissolved Solids	mg/l	1357
Salinity	ppt	1.05
Dissolved Oxygen	mg/l	3
phophate	mg/l	0.08
Ammonia	mg/l	0.33
BOD	mg/l	5
COD	mg/l	30.3
nitrate	mg/l	2.3
pH		7.66
Turbidity	NTU	1
Total Suspended Solids	mg/l	0.45

5.7 Ecology

5.7.1 Marine Protected Areas and sensitive sites

As per the requirements of TOR, Marine Protected Areas (MPAs) and ecologically important or sensitive sites such as breeding or nursery grounds for protected or endangered species have been considered. There are no MPAs or ESAs in the vicinity of the proposed project site. The closest ESA to the project site is in Dhigufaru with Maadhiguvaru Kandu, about 2km north. This area is not predicted to be effected by the project in any way.

5.7.2 Marine Ecological Surveys

The house reef on the northern side of the island sits roughly 1.14km from the shoreline (longest) and the closest reef is found on the southeast side of the island at 30m.

Photo transects as shown in Figure 5-18 was conducted at 5 locations

Figure 5-6 shows results of the benthic substrate assessment using photo quadrates near the project site. Photo quadrates were conducted at these sites recorded the following attributes.

- Live Coral
- Macroalgae
- Rubble
- Sand
- Fish and their abundance

The following sub-sections provide results of the quantitative assessment of the marine environment of Matu, including coral reef and the lagoon area in terms of percentage benthic cover, fish count and general status of the reef.

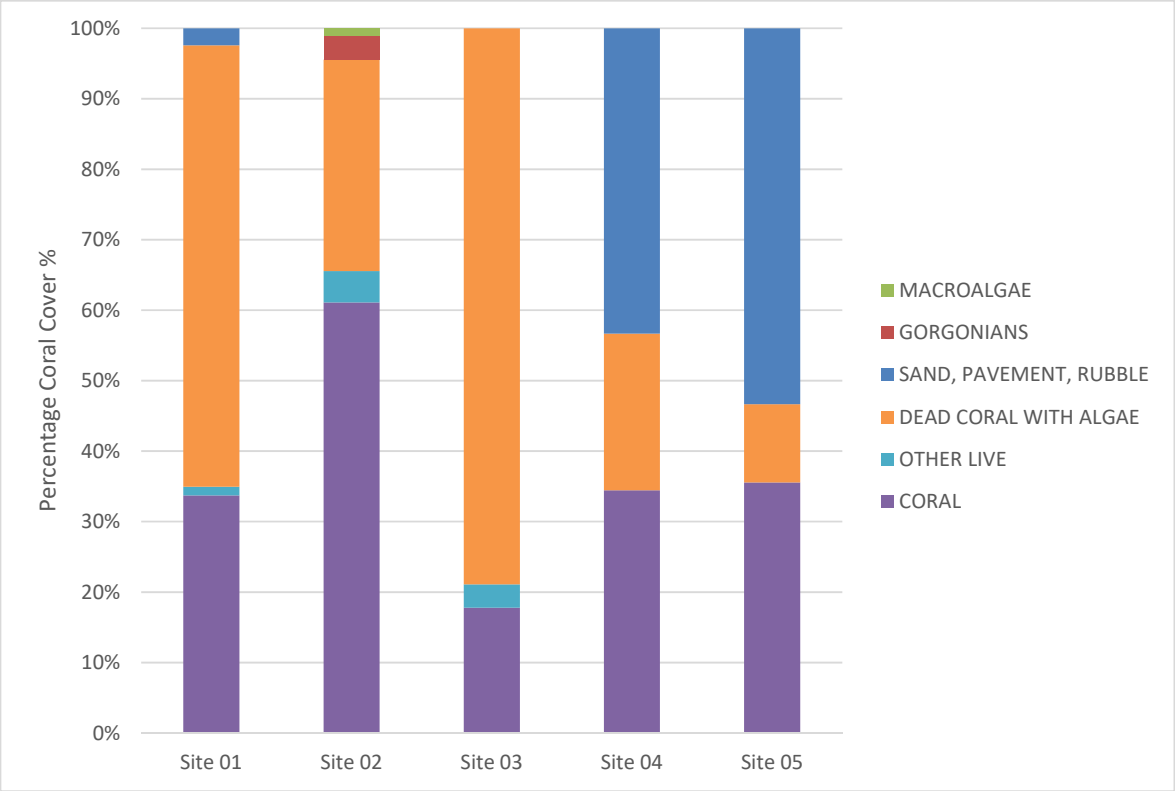

Figure 5-6: Attributes of marine environment

5.7.2.1 Site 1

Site 1 is located inside the lagoon on the south side of the island, around 50 meters from the shoreline. The top of the reef was mostly dead but deeper areas were still live with *Acropora* spp. corals and also this area had a variety of fish. An abundance of fish were observed on the reef edge, including large groupers; red snappers and humpback snappers were observed dwelling under the overhangs while large schools of bluefin trevally were seen with juvenile blacktip reef sharks. Various rudder fish and spotted darts were also observed near the surface.

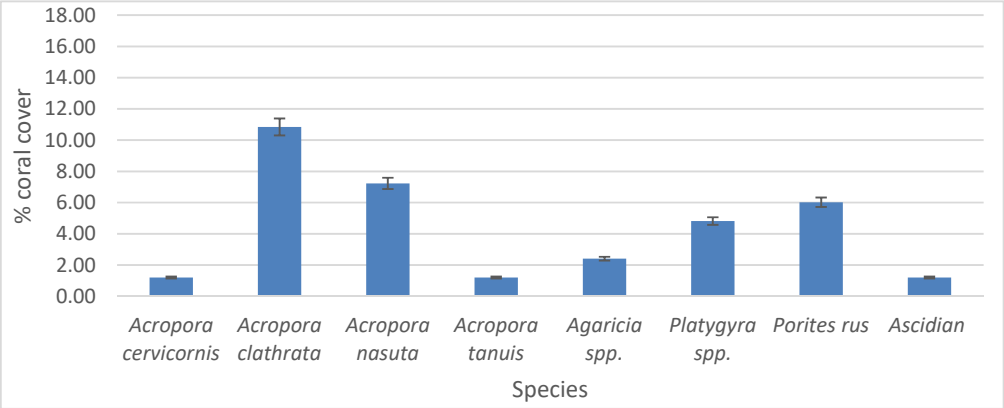

Figure 5-7: Benthic Cover, Site 1

Table 5-8: Fish survey results, Site 1

Common name	Scientific name	Abundance
Blunthead Wrasse	*Thalassoma amblycephalum*	18
Eye-stripe Surgeonfish	*Acanthurus nigricauda*	8
Kashmir Snapper	*Lutjanus kasmira*	2
Oriental Sweetlips	*Plectorhinchus vittatus*	2
Highfin Rudderfish	*Kyphosus cinerascens*	4
Checkerboard Wrasse	*Halichoeres hortulanus*	2
Humpback Red Snapper	*Lutjanus gibbus*	80+
Lined Surgeonfish	*Acanthurus lineatus*	3

5.7.2.2 Site 2

Site 02 is located on the west side, about 100 meters north of site 01. The site was also dominated by live *Acropora spp.* corals. Some gorgonians were observed at deeper areas near the drop off at this site. This site lacked larger predatory fish during the time of survey; however, large groups of chromis and juvenile trevallies were observed.

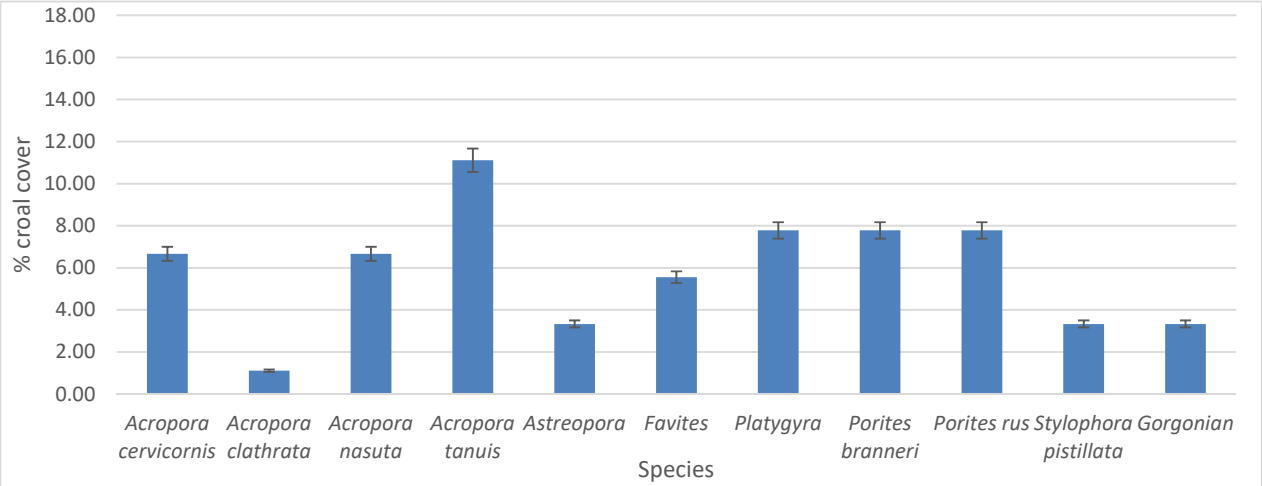

Table 5-9: Fish survey results, Site 2

Common Name	Scientific Name	Abundance
Longnose Butterflyfish	*Forcipiger longirostris*	30+
Golden Chromis	*Chromis ternatensis*	50+
Captain Parrotfish	*Chlorurus enneacanthus*	1
Neon Fusillier	*Pterocaesio tile*	100+
Green Damselfish	*Amblyphidodon batunai*	100+
Yellowback fusilier	*Caesio xanthonota*	100+
Mimic Surgeonfish	*Acanthurus tristis*	10
Blue-green Chromis	*Chromis viridis*	100+

5.7.2.3 Site 3

Site 03 is located on the west of the island, near the reef edge approximately 270 meters from the islands shoreline. Similar to site 1 and 2 this site was also dominated with *Acropora* species. Species richness of fish was low compared to site 1 and 2; however, a large amount of baitfish

was found at this site during the time of this survey. A fair amount of anemones and clownfish, were found on the reef flat while surgeons and darts were seen near the surface at this site.

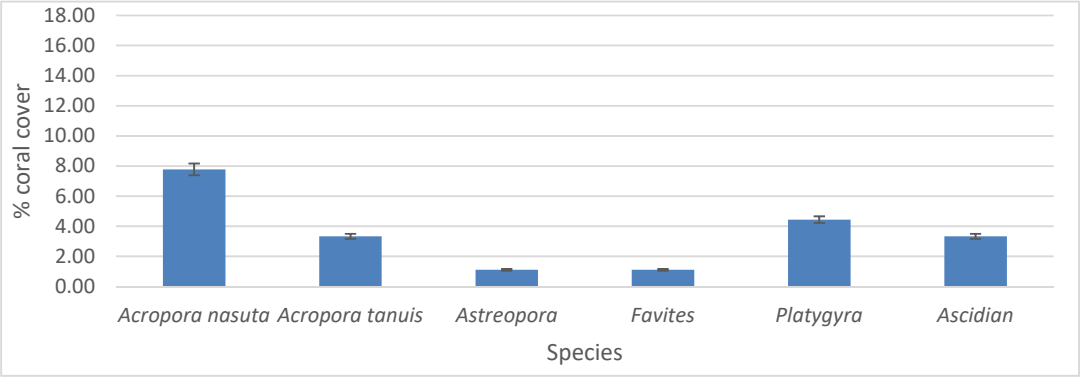

Figure 5-8: Benthic Cover, Site 3

Common Name	Scientific Name	Abundance
Jewel Damselfish	*Plectroglyphidodon lacrymatus*	30
Checkerboard Wrasse	*Halichoeres hortulanus*	6
Moorish Idol	*Zanclus cornutus*	2
Golden Chromis	*Chromis ternatensis*	100+
Yellowtail Anthias	*Pseudanthias evansi*	100+
Silver Sprat	*Spratelloides gracilis*	1000+

Table 5-10: Fish survey results, Site 3

5.7.2.4 Site 4

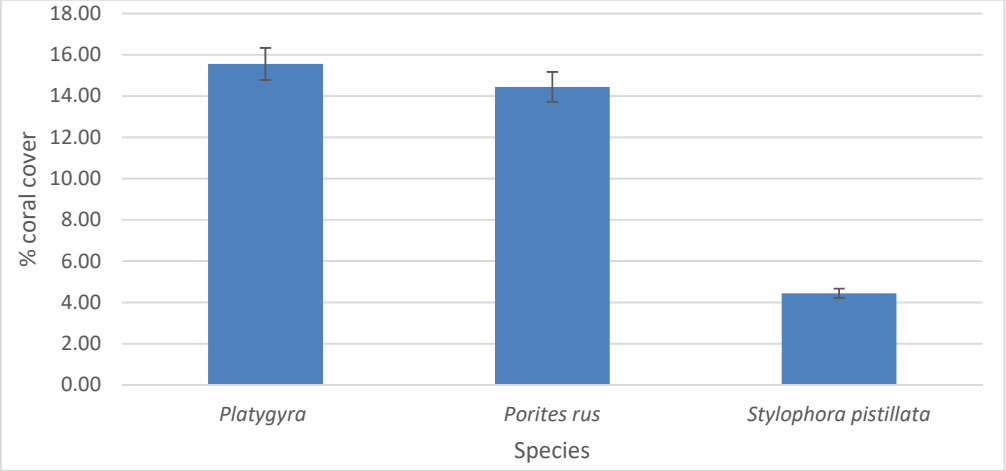

Figure 5-9: Benthic Cover, Site 4

Since site 04 was located near the reef edge near the northern tip of the island. The reef crest was almost all bleached except for a few live colonies of the *Stylophora sp*, *Porites rus and Platygyra spp*. Fish population at this site was very small during the time of this survey, however, 3 hawksbill turtles were observed in the vicinity of this site.

Common Name	Scientific Name	Abundance
Six-barred Wrasse	*Thalassoma hardwicke*	1
Powder-blue Surgeonfish	*Acanthurus leucosternon*	2
Roundhead Parrotfish	*Chlorurus strongylocephalus*	6
Coral Rabbitfish	*Siganus corallinus*	2
Eye-stripe Surgeonfish	*Acanthurus nigricauda*	4
Collared Butterflyfish	*Chaetodoncollare*	2
Sabre Squirrelfish	*Sargocentron spiniferum*	1
Oval Butterflyfish	*Chaetodon trifasciatus*	2

Table 5-11: Fish survey results, Site 5

5.7.2.5 Site 5

Site 5 is on the north side of the island, at the edge of the large deep lagoon. Few live colonies of A*cropora spp* and *Favities* were observed in the shallows near the crest while *Millipora* spp. and *Favities* were observed in the deeper areas near the drop off. Fish population at this site during the survey was found to be relatively low. A large green sea turtle was observed at this site during the time of this survey.

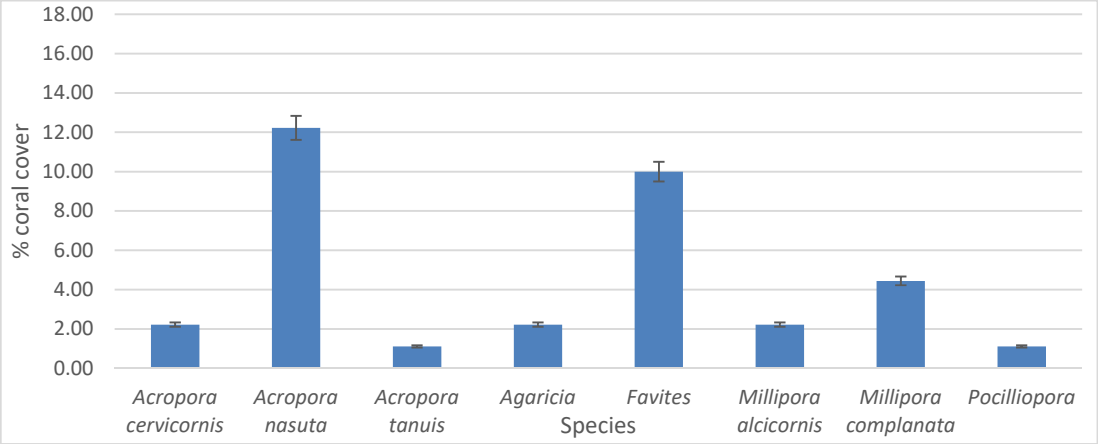

Figure 5-10: Benthic Cover, Site 5

Table 5-12: Fish survey results, Site 5

Common Name	Scientific Name	Abundance
Peacock Rock Cod	*Cephalopholis argus*	3
Powder-blue Surgeonfish	*Acanthurus leucosternon*	1
Roundhead Parrotfish	*Chlorurus strongylocephalus*	16
Bird Wrasse	*Gomphosus caeruleus*	5
Bullethead Parrotfish	*Chlorurus sordidus*	2
Six-barred Wrasse	*Thalassoma hardwicke*	9

5.7.3 Floral Landscape

Three vegetation transects were taken across the island during the survey. The island was found to have typical Maldivian shrub vegetation on the coast with larger mature trees and coconut palms toward the centre of the island.

Table 5-13: Transect 1

Local Name	Common Name	Scientific Name	Count
Ruh	Coconut palm	*Cocos nucifera*	10
Uni	Nit pitcha (s)	*Guettarda speciosa*	8
Magoo	Sea lettuce tree	*Scaevola taccada*	15
Dhigga	Sea hibiscus	*Hibiscus tiliaceus*	6
Boa kashikeyo	Wild screw pine	*Pandanus tectorus*	7

Table 5-14: Transect 2

Local Name	Common Name	Scientific Name	Count
Ruh	Coconut palm	*Cocos nucifera*	17
Uni	Nit pitcha (s)	*Guettarda speciosa*	13
Magoo	Sea lettuce tree	*Scaevola taccada*	21
Dhigga	Sea hibiscus	*Hibiscus tiliaceus*	9
Boa kashikeyo	Wild screw pine	*Pandanus tectorus*	11
Funa	Alexander Laurelwood tree	*Calophyllum inophyll*	2

Table 5-15: Transect 3

Local Name	Common Name	Scientific Name	Count
Ruh	Coconut palm	*Cocos nucifera*	20
Uni	Nit pitcha (s)	*Guettarda speciosa*	12
Magoo	Sea lettuce tree	*Scaevola taccada*	4
Dhigga	Sea hibiscus	*Hibiscus tiliaceus*	16
Boa kashikeyo	Wild screw pine	*Pandanus tectorus*	7

5.7.4 Terrestrial Fauna

No significant terrestrial fauna was observed at Matu during the survey except for ants, spiders and typical crustaceans such as coastal crabs and hermit crabs.

5.8 Socio-economic environment

Huvadhoo atoll is the largest natural atoll of the Maldives, administratively divided into two atolls; North Huvadhoo or Gaafu Alifu (GA.) and South Huvadhoo or Gaafu Dhaalu (GDh.). Gaafu Alifu atoll has 9 inhabited islands and 84 uninhabited islands and Gaafu Dhaalu has 11 inhabited islands.

Preliminary data from 2014 Census study shows that the population of Gaaf alif is 8868 locals, with 2074 foreign workers in the region it is stated as 10942 for the atoll population. The local population increases at a rate of 0.83 per year. Data related to employment and migration for census 2014 have not yet been published, thus data from 2006 census have been used for employment in the following sections.

The population of Gaafu Alifu Atoll was 8,262 and that of Gaafu Dhaalu was 11,013 in 2006. Census data indicated that there was almost negligible growth of population between 2000 and 2006 for Gaafu Alifu Atoll while the growth was slightly negative for Gaafu Dhaalu. The reason for the decline may be associated with the migration to Malé and central atolls for several reasons, mainly jobs. There are several people from Huvadhoo Atoll and other southern atolls working in the central atolls, which had been the focus of tourism until recently.

The total employed population of GA atoll is around 2555. Most of the people work in the industry of fisheries and manufacturing while least percentage of the working population is involved in extra-territorial organization and real estate business. The most preferred occupations are skilled agriculture and fisheries working shadowed by crafts and related trade jobs. Finally the total labor force participation percentage is 65.5 and the total unemployment rate is 26.1%.

The fishing industry had been on the decline in the past decade or so with catches rising to a peak in 2006 and declining rapidly with around 50% of the total tuna production coming from Huvadhoo Atoll (Adam 2006).

According to Adam (2006), decline in the fishing industry, fortunately, coincided with the entry of the tourism industry into Huvadhoo Atoll.

Table 5-16: Island level Demographic statistics of Gaafu Alifu Atoll (Census 2014)

Atoll	locality	Resident population								
		Total			Maldivians			Foreigners		
		Both sexes	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female
GA	Kolamaafushi	958	566	392	871	486	385	87	80	7
GA	Viligili	2,837	1,630	1,207	2,489	1,314	1,175	348	316	32
GA	Maamendhoo	1,137	614	523	1,053	544	509	84	70	14
GA	Nilandhoo	600	359	241	500	265	235	100	94	6
GA	Dhaandhoo	1,077	570	507	1,009	512	497	68	58	10
GA	Dhevvadhoo	584	339	245	504	267	237	80	72	8
GA	Kodey	272	145	127	258	137	121	14	8	6
GA	Gemanafushi1	1,223	642	581	1,147	572	575	76	70	6
GA	Kanduhulhudhoo	533	261	272	503	238	265	30	23	7
GDh	Madaveli	1,218	618	600	1,145	559	586	73	59	14
GDh	Hoadedhdhoo	861	454	407	800	404	396	61	50	11
GDh	Nadallaa	776	401	375	738	375	363	38	26	12
GDh	Gadhdhoo	1,502	819	683	1,387	717	670	115	102	13
GDh	Rathafandhoo	550	302	248	514	273	241	36	29	7
GDh	Vaadhoo	712	379	333	661	335	326	51	44	7
GDh	Fiyoari	737	386	351	689	348	341	48	38	10
GDh	Faresmaathodaa	1,104	600	504	1,024	527	497	80	73	7
GDh	Thinadhoo	5,230	2,857	2,373	4,629	2,319	2,310	601	538	63

There are four operational resorts in Gaafu Alifu Atoll and 3 operational resorts in Gaafu Alifu Atoll with several new resorts under construction. The existing total bed capacity stands at 1,518 beds. 16 islands have been planned to be developed as tourist resorts in Huvadhoo Atoll of which 10 are in Gaafu Alifu Atoll.

Table 5-17: Operational resorts in Huvadhoo Atoll

Name of the Resort	Atoll	Island	Year of initial operation	Initial bed capacity	Bed capacity 2015
Jumeirah Dhevanafushi	GA.	Meradhoo	2011	38	236
Park Hyatt Maldives Hadaha	GA.	Hadahaa	2009	100	114
Robinson Club Maldives	GA.	Funamauddua	2009	100	300
The Residence Maldives	GA.	Falhumafushi	2012	108	250
Amari Havodda Maldives (Havodda)	GDh.	Havodda	2015	240	212
Ayada Maldives	GDh.	Magudhdhuva	2011	200	206
Outrigger Konotta Maldives Resort	GDh.	Konotta	2015	110	200

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5.9 Natural hazard vulnerability

The following information on the vulnerability of the islands in the Maldives are taken from published literature such as Developing a Disaster Rick Profile for Maldives by UNDP (2006) as site – specific information on vulnerability of Gan was not available. According to the UNDP (2006) the natural vulnerability of the islands and atolls of the country to potential hazards have been modelled to understand the risk factors of the country.

The disaster risk scenario for Maldives can be described as moderate in general. Despite this, Maldives is among the most severely affected countries hit by the Asian tsunami on December 26th, 2004. Maldives experiences moderate risk conditions due to a low probability of hazard occurrence and high vulnerability from exposure due to geographical, topographical and socio-economic factors.

Following are some of the risks that have been identified and potential areas that may be within the range of risks based on its sensitivity, location, exposure, historic events, etc.

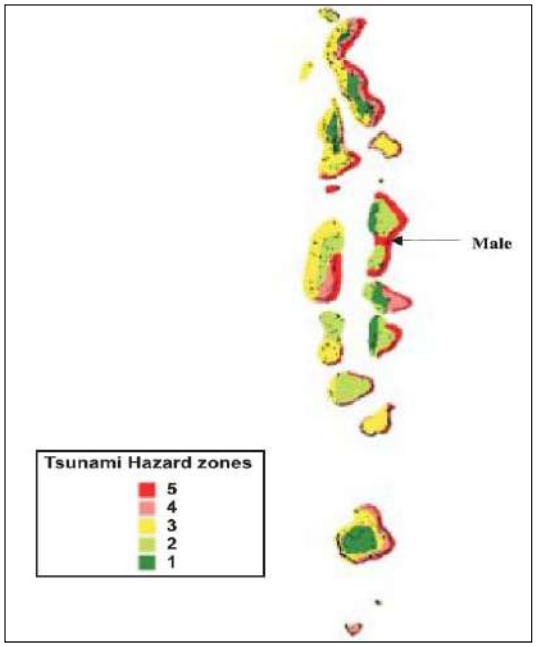

Figure 5-11: Tsunami hazard zones

Figure 5-11 show that Maldives faces tsunami threat largely from the east and relatively low threat from the north and south. So, islands along the eastern fringe are more prone to tsunami hazard than those along the northern and southern fringes. Islands along the western fringe

experience a relatively low tsunami hazard. This map is produced based on the experience of the tsunami in 2004 and also occurrence of historic tsunami events in the greater region where most of the events have identified to have occurred from the Sumatra Region (UNDP 2006).

Besides heavy rains and strong winds during monsoons, hazardous weather events which regularly affect Maldives are tropical storms or 'tropical cyclones', and severe local storms. At times, tropical cyclones hitting Maldives are destructive due to associated strong winds that exceed a speed of 150 kilometres per hour, rainfall of above 30 to 40cm in 24 hours and storm tides that often exceed four to five meters (UNDP 2006).

Cyclonic winds sometimes can cause a sudden rise in sea-level along the coast, leading to a storm surge. The combined effect of surge and tide is known as 'storm tide'. Storm tides can cause catastrophe in low-lying areas, flat coasts and islands such as Maldives.

Maldives is also affected by severe local storms- thunder storms/ thunder squalls. Hazards associated with thunder storms are strong winds, often exceeding a speed of 100 kilometres per hour, heavy rainfall, lightning and hail; they also give rise to tornadoes in some regions. In general, thunderstorms are more frequent in the equatorial region than elsewhere, and land areas are more frequently hit by thunderstorms as compared to open oceans. However, thunder storms close to the equator are less violent when compared with those in the tropical regions and beyond. Maldives being close to the equator, thunder storms are quite frequent but less violent here. Strong winds generated by severe local storms generate large wind-driven waves which are hazardous for Maldives (UNDP 2006).

The islands of Maldives are less prone to tropical cyclones. The northern islands of the country were affected by weak cyclones that formed in the southern part of the Bay of Bengal and the Arabian Sea. Figure 5-12 shows the tracks of cyclones affecting Maldives during the period 1877-2004. The number of cyclones directly crossing Maldives is small. Only 11 cyclones crossed the islands over the entire span of 128 years. Most of the cyclones crossed Maldives north of 6.0o N and none of them crossed south of 2.7^{o}N during the period (UNDP 2006).

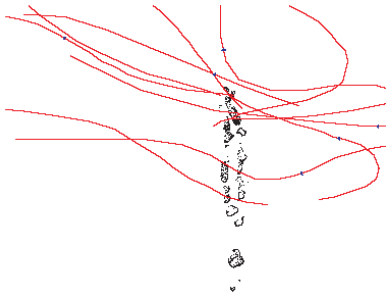

Figure 5-12: Tracks of Cyclones affecting Maldives, 1877-2004

UNDP (2006) stated that there were 21 cyclonic disturbances within the 500km radius during 1877-2004, of which 15 were depressions with an average wind speed of about 28 knots. The highest wind speed due to cyclonic disturbances that affected the islands during that time was about 65 knots. Figure 5-12 shows the tracks of cyclonic disturbances that passed through the circle with 500km radius.

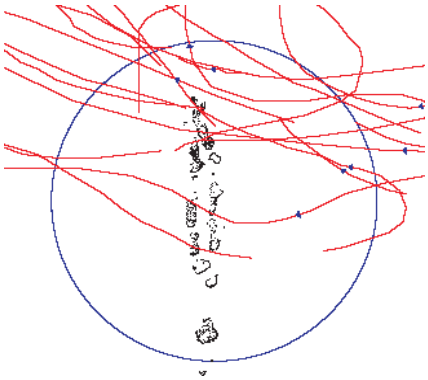

Figure 5-13: Tracks of Cyclones passed within the Scan Radius of 500 kilometres

Based on the above information, Maldives is divided into zones with varying scales of cyclone hazards based on based on a qualitative judgment based on the gradient of the storm tracks from north to south.

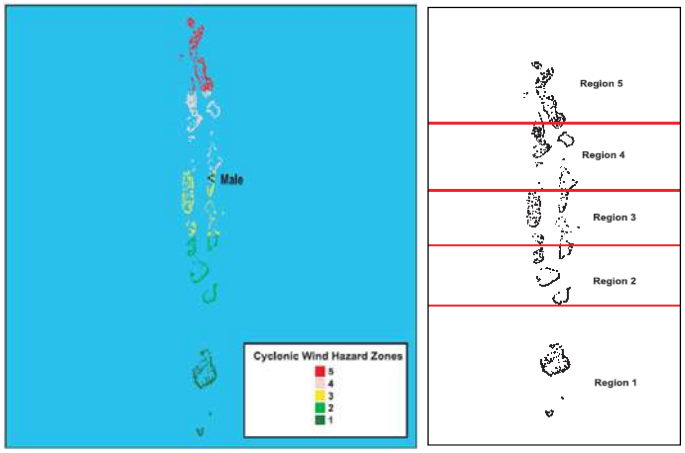

Figure 5-14: Regions to capture Cyclones passing through Maldives for Hazard Zoning

Figure 5-14 shows the regions used to compute the highest wind speed of each cyclone captured within the region. Majority of the cyclonic disturbances crossed the northern region. The frequency and wind speed decreases from northern region to southern region. Region 1 is not affected by any storm. Thus, Maldives can be divided into three cyclone hazard zones – the northern zone with high cyclone hazard, central zone with moderate cyclone hazard and the southern zone with very little cyclone hazard.

With regards to the storm surge potential, the bathymetry around the Maldives shows that the ocean slope close to the east coast is steeper than the west coast, hence it can be generalized that the eastern islands of the Maldives are vulnerable to higher surge hazard compared to the western islands. Figure 5-16 shows the bathymetry around Maldives. Figure 5-17 shows storm surge hazard zones based on computed model with maximum pressure drops for 100 year return period and with historical data (UNDP 2006).

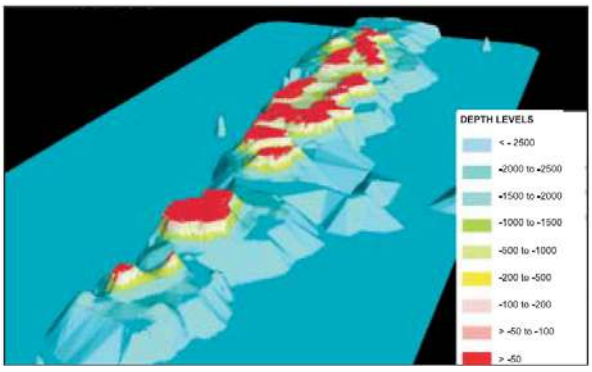

Figure 5-15: Three Dimensional View of Bathymetry of Maldives (depth in meters)

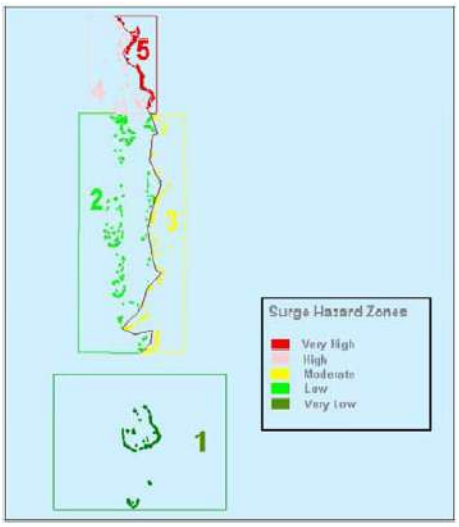

Figure 5-16: Storm Surge Hazard Zones with Cyclones Affected

Based on the above figure, it can be said that the north-eastern parts of the country are very vulnerable to storm surges.

Based on historical catalogues of earthquakes in the region, identifying seismic sources based on this historical information and based on numerical models, it was found that except for Seenu, Gnaviyani and Gaafu Atolls, earthquake hazard is low across the country. The probable maximum Modified Mercalli Intensity (MMI) is estimated between 7-8 in Zone 5 (Figure 5-16). This level of MMI can cause moderate to high damages (UNDP 2006).

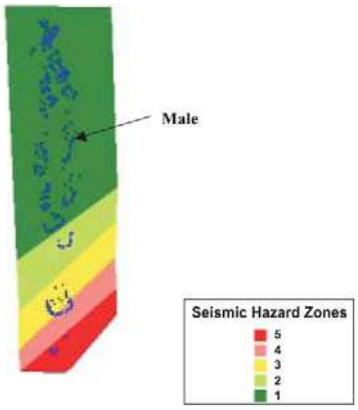

Figure 5-17: Maldives Seismic Hazard Zones

It can be summarized that the northern parts of the country are vulnerable to cyclones and storm surges while southern parts of the country are vulnerable to seismic activity. The eastern side of the country is more exposed to potential tsunamis and surges.

Figure 5-18: Survey locations and bathymetry

Figure 5-19: Photographic summary of conditions of the marine environment

6 Stakeholder Consultations

The key stakeholders of the project include the Atoll Council, Ministry of Fisheries and Agriculture, Ministry of Environment and Energy, Environmental Protection Agency, Ministry of Housing and Infrastructure, and Project Engineers, Consultants and general public. The stakeholders that participated in the Scoping Meeting have extensively discussed on the issues relating to the project. Public opinions have been gathered during the field visit.

6.1 Scoping Meeting

The Scoping Meeting was held on 27th May 2017. The meeting was attended or represented by the following:

- Environmental Protection Agency
- Proponent
- Consultant

Once a brief overview of the project was given by the Client, the discussions that followed were mainly based on the details of proposed components.

Representatives from the island council and ministry of fisheries and agriculture were not present in the meeting. Thus, EPA requested consultations to be conducted with the ministry of Fisheries and Agriculture and island council.

Table 6-1: List of participants in the Scoping Meeting

Name	Designation	Office	E-mail
Fathmath Reema	Director	EPA	reema@epa.gov.mv
Ali Mishal	Senior Officer	EPA/water section	mishal@epa.gov.mv
Hussain Fizah	EIA Consultant	Sandcays	fizah@sandcays.com

7 Environmental Impacts

7.1 Introduction

Development projects involving infrastructure development in island environments are believed to generate a series of environmental impacts, of which some can be felt immediately on the surrounding environment while others can be felt continually and can be far reaching. By far and large the most significant environmental impacts are those that are felt on the immediate environment. Terrestrial environment is directly affected from removal of vegetation resulting in loss of habits. Also, coral reef environments are sensitive and highly susceptible to immediate changes that will be incurred from most of the development activities. Therefore, all the development activities must take into consideration the understanding of the environment and changes as well as implications that it will bring about to the environment and surrounding.

The following account describes potential environmental impacts that will be associated with the proposed project involving culture of Milkfish in GA. Matu.

7.2 Methods and Limitations

The methods used to predict and evaluate the environmental impacts that may be associated with the proposed project may not be the most comprehensive methods as they are quite simple prescriptive methods. The main shortcoming of these methods is that only assumptions have been made to predict the impacts which may or may not be accurate. Also, the degrees at which these impacts are either accurate or inaccurate as well as uncertainties and natural variability are the key factors that affect the accuracy of these methods. Nonetheless, the methods used are concise and provide a general overview as well as the range of impacts that can affect the environment. Also, the EIA report has taken into consideration similar studies undertaken in the Maldives as well as expert judgment in identifying the main environmental impacts that may be associated with the proposed development.

7.3 Impact Identification

Impacts on the environment from various activities of the proposed development have been identified through:

- A consultative process within the EIA team and the Proponent

- Purpose-built checklist
- Existing literature and reports on similar developments in small island environments and other research data specific to the context of the Maldives
- Baseline environmental conditions described in Chapter 5.
- Consultant's experience of projects of similar nature and similar settings

A purpose built matrix has been used to evaluate the overall impacts of the proposed project. The impacts of the project have been evaluated according to the following criteria:

1. Magnitude (or severity): the amount or scale of change that will result from the impact
2. Significance: importance of the impact. Reversibility is considered part of its significance
3. Duration: the time over which the impact would be felt
4. Extent/spatial distribution: the spatial extent over which the impact would be felt

The scales associated with the above criteria are given in the table below.

Table 7-1: Impact evaluation scale

Criteria	Scale	Attribute
Magnitude Change caused by impact	-3	Major adverse
	-2	Moderate adverse
	-1	Minor adverse
	0	Negligible
	1	Minor positive
	2	Moderate positive
	3	Major positive
Significance/Reversibility Impact implications / Reversibility of impact's effects	0	Insignificant
	1	Limited implications / easily reversible
	2	Broad implications / reversible with costly intervention
	3	Nationwide or global implications / irreversible
Duration Duration / Frequency of Impact	0	Immediate
	1	Short term/construction period only
	2	Medium term (five years of operation)
	3	Longterm/continuous
Extent/Spatial Distribution Distribution of impact	0	None/within 1m from point of discharge/no affected party
	1	Immediate vicinity/household level/developer/consumer
	2	Specific areas within the island/atoll/specific parties
	3	Entire island/atoll/nation/all stakeholders

Based on the above scale, an impact matrix was developed for the proposed development to determine the overall impact of the proposed project. This matrix is given in Table 7-2.

An impact potential index was then developed from Table 7-2. The impact potential index table represents a product of the magnitude (M), significance (S), duration (D) and extent/spatial distribution (E) given in the above table. The sum of all key component specific indexes for one activity (i.e. sum by rows) provides the Activity Potential Impact Index (API) and the sum of all activity specific indexes for one key component (i.e. sum by column) provides the Component Potential Vulnerability Index (CPVI) which gives an indication of the vulnerability of each key component to activity related impacts. Table 7-3 represent the impact potential indices for the proposed project.

7.4 Overall Impacts of the Proposed Project

The overall impact of the proposed project is greatly positive due to the strong socio-economic potential of the proposed project.

Table 7-2: Impact matrix for the proposed project

	KEY COMPONENTS									
	Environment						Socio-Economic			
PROJECT ACTIVITIES	Reefs incl. live bait	Soil and groundwater	Lagoon/seawater	Hydrodynamics	Terrestrial fauna and flora	Air/Noise/land or seascape	Services and Infrastructure	Health and Safety	Employment	Costs to consumer/tax payer
Construction										
Construction of Jetty	-1 0 1 1	0	-1 1 1 1	-1 1 3 1	0	-1 0 1 1	2 3 1 1	2 1 1 1	1 3 1 1	-1 1 1 1
Constrcution of sea cages	-1 0 1 1	-1 0 1 1	-1 0 1 1	0	0	-1 0 1 1	0	-1 0 1 1	1 1 1 3	-1 1 1 1
Inland infrastructure	0	-1 0 1 1	0	0	-1 1 1 1	-1 0 1 1	1 1 1 1	-1 0 1 1	1 1 1 2	-1 1 1 1
Construction equipment/machinery	0	-1 0 1 1	-1 0 1 1	0	-1 0 1 1	-1 0 1 1	1 1 1 2	-1 0 1 1	1 1 1 2	-1 1 1 1
Materials and contruction waste	-1 0 1 1	-1 0 1 1	-1 0 1 1	0	-1 0 1 1	0	0	-1 0 1 1	1 1 1 3	-1 1 1 1
Workforce and workforce management	0	0	-1 0 1 1	0	-1 0 1 1	-1 0 1 1	1 1 1 2	-1 0 1 2	1 1 1 3	-1 1 1 1
Operation										
Maintenance and monitoring of hatchery	-1 0 2 1	0	-1 0 2 1	0	0	-1 0 2 1	1 1 2 1	-1 0 2 1	1 1 2 2	-1 1 2 1
Staff facilities and services	0	-1 0 1 1	0	0	-1 0 2 1	0	1 1 2 1	1 1 2 1	1 1 2 2	-1 1 2 1
Waste and wastewater disposal	-1 0 2 1	-1 0 2 1	0	0	-1 0 2 1	-1 0 2 1	-1 0 2 1	-1 0 2 1	1 1 2 1	-1 1 2 1
Sale of milkfish	-1 0 2 1	0	-1 0 2 1	0	0	0	1 1 1 1	0	1 2 1 1	1 1 1 2

KEY: M S Magnitude Significance
D E Duration Extent (spatial)

Table 7-3: Impact potential indices for the proposed project

PROJECT ACTIVITIES	KEY COMPONENTS: Environment: Reefs incl. live bait	Soil and groundwater	Lagoon/seawater	Hydrodynamics	Terrestrial fauna and flora	Air/Noise/land or seascape	Socio-economic: Services and Infrastructure	Health and Safety	Employment	Costs to consumer/tax payer	TOTAL API
Construction											
Construction of Jetty	0	0	-0.01	-0.04	0	0	0.07	0.02	0.04	-0.01	0.03
Constrcution of sea cages	0	0	0	0	0	0	0	0	0.04	-0.01	0.01
Inland infrastructure	0	0	0	0	-0.01	0	0.01	0	0.02	-0.01	0.01
Construction equipment/machinery	0	0	0	0	0	0	0.02	0	0.02	-0.01	0.03
Materials and contruction waste	0	0	0	0	0	0	0	0	0.04	-0.01	0.03
Workforce and workforce management	0	0	0	0	0	0	0.02	0	0.04	-0.01	0.05
Operation											
Maintenance and monitoring of hatchery	0	0	0	0	0	0	0.02	0	0.05	-0.02	0.05
Staff facilities and services	0	0	0	0	0	0	0.02	0.02	0.05	-0.02	0.07
Waste and wastewater disposal	0	0	0	0	0	0	0	0	0.02	-0.02	0
Sale of milkfish	0	0	0	0	0	0	0.01	0	0.02	0.02	0.05
TOTAL CPVI	0	0	0	0	-0.01	0	0.1	0.02	0.3	-0.09	0.32

API = Activity Potential Impact Index
CPVI = Component Potential Vulnerability Index

The table above indicates that the project has minor negative environmental impacts during and after the proposed works, however, the social and economic benefits of the project are considerably high, as a result of which the total potential impact index for the project is positive. Therefore, the project may be allowed to proceed as proposed.

7.5 Constructional Impacts and Mitigation Measures

Construction phase impacts are limited to the construction of the jetties, vegetation clearance, construction of land infrastructure and construction of sea cages. Apart from vegetation clearance, the impacts of the actual construction would be minor with respect to duration of the activity as well as magnitude and spatial extent.

During the construction, there will be some minor sedimentation from deepening the small access channel and construction of main jetty. This impact is not significant and is short-lived.

The main positive impact due to the construction activities is the economic benefits to contractors and consultants (including the design stage) and job opportunities for locals and foreigners involved in the actual construction work.

Some minor (general) impacts and mitigation measures include:

- Littering by workforce for their convenience in the absence of supervision or awareness on proper care of the environment and constructional waste. This impact is best mitigated by ensuring appropriate waste management from the very onset of the project. Staff shall be made aware to keep the work site clean and tidy at all times. Appropriate waste disposal means and supervision is important
- Staff awareness of the fragility of the ecosystem in which they work. If staff are not made aware, they would often be ignorant of the fragile ecosystem. They may walk on the reef, create unnecessary pathways for their convenience, throw garbage, waste fuel and hazardous chemicals on the ground or even on the beach and keep construction materials on the beach. Staff awareness programmes and especially appropriate signs will help to minimize such impacts.
- Create obstructions to the movement of sand including excavator beds and piles of timber on the beach or swash zone resulting in severe modification of the natural longshore transport patterns. Supervisory staff must be aware of such and ensure that no obstruction to natural processes occur.
- Throw rubbish in the sea. Staff awareness especially signs in seagoing vessels and strict supervision is the key to minimizing impacts related to waste disposal.

Project specific impacts and mitigation measures are discussed below.

7.5.1 Disturbances to seabed and ecological habitats

There will be some minor excavation of the seabed to create a suitable access channel as well as during jetty construction (piling work). This will have some sedimentation; however, the sedimentation will be very local and short-term. Therefore, it is not a cause for concern. The corals within the immediate vicinity of the proposed access channel will be stressed and live colonies directly on the proposed access channel will require relocation. Sediment plume from this work is expected to disperse naturally. The construction of access channel is not expected to take more than a week. As such, corals in the primary impact zone are not expected to die due to sedimentation.

7.5.2 Site Preparation

Site preparation would usually involve clearing vegetation. The project would involve clearing vegetation for the proposed infrastructure on land. The site plan is made such that minimal vegetation is removed for the infrastructure. Coastal vegetation will be improved with plants relocated from building footprints. The site reconnaissance survey indicated that only a few mature trees in the possible areas to be cleared. However, though this impact can be classified as minor, it cannot be considered negligible.

While cutting down mature trees can and will be avoided, it is proposed to ensure this to the greatest possible extent by planning buildings around major trees or moving the proposed modules accordingly. If mature trees were cut or felled, two trees will be planted as replacement in other possible locations in the island, as per the Regulation on Cutting Down, Felling and Transplantation of trees.

7.5.3 Construction waste

Any construction site will have construction waste of several sorts. It would be necessary to have a specific area to collect and manage waste including green waste and bins for domestic and general waste in areas where staff activities take place. No construction waste shall be burnt on-site but taken to designated landfill or waste management centre. All work areas shall be kept clean at all times.

7.5.4 Workforce and machinery

The proposed works mainly involve general construction tools and heavy machinery such as excavator will be used to make the access channel and jetty. As the proponent values marine environment as a valuable asset to the project, minimal excavator movement will be allowed. Heavy machinery is also not expected to be used on land. Excavator beds would not be required.

During the construction phase, there will not be more than 25 persons at one given time. The impact from the workforce is, therefore, considered to be minimal or minor negative. Temporary facilities such as accommodation and utilities will be required; these structures will be built on the proposed building footprints and hence the impacts from constructional workforce would be minor. However, the following mitigation measures may be considered.

- Appropriate planning and site supervision
- Take advantages of low tides for marine activities

- Take precautions to minimize the potential for any hazards and safety of workers at site

7.6 Operational Impacts and Mitigation Measures

The operation of mariculture/fish farms have five fundamental flaws namely waste, escapees, diseases and parasites, chemicals and feed/food (Staniford 2002). The significance and magnitude of these and other concerns with reference to the proposed project are as follows:

- Increased nutrient loadings from faeces and uneaten food wastes, which will either dissolve or settle on the seabed beneath the cage. Since adequate currents exist and proposed cages are located in the deep lagoon, eutrophication is unlikely. Moreover, imported feed is not considered as algae cultured at site will be the feed for the milkfish.
- The impact of disease transmissions on wild populations. This impact is considered to be minor negative and depends on stocking densities and feeding, which are not considered to be a problem. Environmental controls shall be established from the very onset of the project to mitigate disease prevalence and ensure a healthy environment.
- The impact cages may have on wild fish populations. Although this impact is not considered to be significant, this impact has to be studied in detail during the implementation stage.
- The genetic or competitive effect escapees may have on wild stock. Only large fish in suitable size net cages are to be used at sea; and milkfish being native to Maldivian coastal waters, this impact is unlikely to occur.

The potential for contamination of the seabed will be a concern as the population of caged stock increases, however, there will be good flushing of dissolved and suspended effluents. If deposits reach shallow areas, there is the potential for resuspension and further dilution. In deep areas, resuspension is not likely.

In the case of the proposed project using locally found species, genetic pollution will not be a concern even in case of escapees and new diseases will not be introduced to the wild stock. However, an incubation of local diseases present in the wild stock may be a potential cause for concern in case of high stocking densities. Therefore, stocking densities shall be kept to an optimum at all times. The likelihood for habitat modification could occur in case of imported broodstock causing stress and related disease prevalence. However, this is not applicable to this project.

It must be noted that a well-managed farm with good husbandry practices will have negligible, if any, of these impacts on the environment. Appropriate monitoring and close supervision on a regular basis would help to minimize impacts and create healthy products. Feed and feed related detritus on the seabed including faecal matter is a cause for concern in fish farming. Therefore, feed control measures are may be necessary.

7.6.1 Nutrient discharge and Accumulation of waste

Finfish farming operations result in the release of a number of wastes into the aquatic environment. These include uneaten fish food, fish excretory products and organic matter from net-cleaning that enter the water column and/or settle to the seabed. The major components of solid and dissolved waste are various forms of carbon, nitrogen and phosphorous (EAO, 1998; Ritz & Lewis, 1989). The effects on the food chain from this additional organic input is many and varied, the input leading to water column nutrient enrichment and accumulation of organic matter in the sediments.

In the water column, soluble nutrients can alter the species composition and density of phytoplankton, increasing the risk of toxic algal blooms (DPIF, 1997). The accumulation of organic matter on the seabed, especially in areas of poor current flow, can produce major changes in the sediment chemistry. Changes typically associated with severe organic enrichment are a reduction in sediment oxygen levels and the subsequent production and release of methane and toxic hydrogen sulphide (Pearson and Rosenberg, 1978). Changes in sediment chemistry in turn have effects on the substrate ecosystem, and may result in major changes to the species composition of sediment flora and fauna in affected areas (e.g. Ritz et al., 1989). Notably though, research has shown that these impacts are usually limited to a small area within close proximity to the cages (Brown et al, 1987; Gowen et al, 1988).

In case of the proposed project, the density of fish in the cages and amount of food provided will be controlled to minimize this impact. Given the good dilution potential of the area with sufficient flushing, this can be considered a minor impact.

7.6.2 Escapees

Escapees are mainly a concern when genetically modified (GM) species escape a farm. However, escapees are also a concern when their predatory instincts, hunting tactics, etc. have not developed resulting in potentially weaker biological offspring with genetic disabilities present in the wild stock. As well as spreading parasites and 'genetic pollution' via interbreeding and hybridisation, escapees have the capacity to spread infectious diseases (or possibly new strains of a certain disease) to wild fish populations (Staniford 2002). The reverse is also a possibility, however, not likely.

Although the above is a possible and documented impact of intensive fish farms in several places worldwide, the significance of this impact in the case of the proposed culture project is extremely low as GM species would not be used, stocking densities would be way below the carrying capacity and appropriate measures will be in place to minimize escapees.

7.6.3 Disease and behaviour modification

According to Staniford (2002) sea cage fish farms will continue to act as reservoirs for infectious diseases and parasitic infestations highlighting that the spread of diseases and parasites is a function of overstocking and intensive production with reference to Paone (2000). This is the case of several intensive fish farms in Europe, especially those in inland waters and estuaries. However, in the case of the proposed project, the stocking densities are expected to be considerably low and parasitic infestations are not likely due to high levels of natural pristine conditions maintained and low nutrient loading in cages.

In order to minimise inbreeding and vulnerability to disease and infections maintaining a healthy bloodstock with high levels of genetic mixing is required. To meet the demands brood stock will be purchased/caught locally at regular intervals from wild population.

7.6.4 Processing and process waste

There will not be any processing of farmed fish under this project as the live fish will be sold to fishermen.

7.6.5 Waste and wastewater

Construction stage is often a stage in which the impacts are ignored but when the bulk of the impacts often start to take effect, especially that of solid and liquid waste management. This happens because there are no regulatory requirements for constructional waste management. Therefore, it should be in the Developer's sole interest to safeguard the quality of the environment in which he undertakes his business since the sustainability of his business is mainly dependent on that of the environment.

For the proposed project, construction waste is expected to be minimal. However there shall be a zero tolerance for waste disposal into the marine environment. General domestic waste arising from material consumption by construction workforce shall be managed using bins provided on site. The Proponent shall ensure that all construction-phase waste is disposed of during demobilisation.

Wastewater from the quarantine facility and hatchery modules is not likely to have any impacts due to the small volume and as it will be treated using chlorine and sedimentation tanks as proposed. No further mitigation measures are necessary.

7.6.6 Employment and other socio-economic impacts

The proposed project is expected to help the economic development of southern Maldives during its construction and operation stage. The development would also have indirect impact on the atoll and the national economy due to the development of related services in the atoll and other parts of the country.

The following are considered as the main positive impacts or outcomes of the proposed project.

- Potential solution to one of the main issues faced by fishermen; lack of baitfish for long line fishing
- Changes to the demographic characteristics of the fishery-related workforce, which may be considered to be a positive effect such as the involvement and learning about a new type of fisheries, namely mariculture or aquaculture
- Direct and indirect employment generated by the construction activities of the different project components.
- Employment created by related service sectors such as transportation, house rental or guesthouse, café, taxi and truck operations.

- Increase demand for local production such as fish, agricultural products and others due to constructional as well as operational workforce.
- Indirect employment generated elsewhere in the handling of import and export of resources and products.
- Indirect employment generated due to the project.

The negative socio-economic impacts of the project may be less important than the positive impacts. However, they cannot be left unconsidered. Therefore, however minor the impact may be, potential negative impacts of the proposed project have also been considered. These include:

- There may also be cultural issues of attitudes, beliefs and values of fishermen, fishery-related workers and other stakeholders in the community. Some members of the Atoll who have been engaged in conventional fishing activities may find their dominance in the community being affected and may have negative feelings about the project. However, this is considered to be insignificant or irrelevant in the case of the proposed project especially because the project aims at helping current fishermen.
- The development creates a lot of employment during construction and operation. Though priority is given to local contractors in the construction period and Maldivians in the operation stage, foreign workforce needs to be employed as to fill all the jobs due to shortage of locals for the skilled and unskilled jobs. This leads to leakages and related social conflicts in the island communities.

Since negative socio-economic impacts are minor to negligible in terms of their significance, no mitigation measures would be necessary.

7.7 Uncertainties in Impact Prediction

Environmental impact assessment involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological, geomorphological or social conditions in a particular place. The level of uncertainty, in the case of the proposed development, may be expected to be low due to the experience of similar projects in the Maldives. Nevertheless, it is important to consider that there will be uncertainties and to undertake voluntary monitoring during project implementation as recommended in the monitoring programme given in this report.

8 Environmental Monitoring

8.1 Introduction

Environmental monitoring is essential to ensure that potential impacts are minimized and to mitigate unanticipated impacts. The parameters that are most relevant for monitoring the impacts that may arise from the proposed project are included in the monitoring plan. These include water quality, sedimentation, shore dynamics, live coral cover and nektonic fauna.

Monitoring would ensure that the proposed activities are undertaken with caution and appropriative care so as to protect and preserve the built environment of the areas in proximity to the site or those areas and environmental aspects affected by the development.

The purpose of the monitoring is to provide information that will aid impact management, and secondarily to achieve a better understanding of cause-effect relationship and to improve impact prediction and mitigation methods. This will help to minimize environmental impacts of projects in future.

The monitoring plan shall target to measure:

- Marine water quality and currents at selected/designated locations
- Quality of sediments at potential locations
- Incidents/accidents
- Fuel and water consumption

8.2 Recommended Monitoring Programme

The annual monitoring programme targeted at monitoring the environment of GA. Matu in relation to the proposed Milkfish hatchery project is given in Table 8-1. This programme starts from the onset of the project. In addition to the annual monitoring programme given in Table 8-1 , water quality studies shall be carried out during the construction phase for the project area on a regular basis as proposed in the project document. Water quality shall cover temperature, electrical conductivity/salinity, pH, dissolved oxygen, turbidity, total suspended solids, nitrate, phosphate, BOD and COD. Drogues will be done at the same locations as shown in the EIA report. The proponent's commitment to undertake this monitoring programme forms part of this report.

8.3 Monitoring Report

A detailed environmental monitoring report is required to be compiled and submitted to the Environment Protection Agency yearly based on the data collected for monitoring the parameters included in the monitoring programme given in this report. EPA may submit the report to the relevant Government agencies in order to demonstrate compliance of the Proponent.

The report will include details of the site, strategy of data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed. The report will also include fuel and water consumption data and species health related information, quarantine events and other experimentation data.

The report will cover the following:

- Details of the site
- Details of methodologies and protocols followed
- Strategy of data collection and analysis
- Sampling procedures
- Quality control measures
- Monitoring results
- Compliance with relevant standards and requirements of the EIA
- Performance of the different project components in achieving the project objectives
- Conclusions and recommendations

Table 8-1: Proposed monitoring schedule with costs

No.	Indicator/locations	Parameters to be monitored	Frequency and duration	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	Total	Rate (USD)	Total (USD)
1	Marine water quality (2 locations)	Water quality: Temperature, DO, pH, turbidity, TSS, hydrogen sulphide, BOD, COD, nitrate, phosphate	Every six months	2						2						4	150.00	**600.00**
2	Marine life/biodiversity (3 locations)	Photo quadrates (seagrass) and fish and benthic survey	Every six months	3						3						6	35.00	**210.00**
3	Currents/hydrodynamics (4 locations)	Drogue tracks	Every three months for one year	4			4			4			4			16	30.00	**480.00**
4	Groundwater quality (2 locations)	Water quality: temperature, pH, TDS/EC, dissolved oxygen, hydrogen sulphide, nitrate, phosphate, total and faecal coliform	Once a year	2												2	150.00	**300.00**
5	Water, fuel and energy data	Total monthly fuel use, energy production	Daily statistics													0	-	**-**
6	Employment and other socio-economic matters	Total monthly fuel use, energy production	Monthly/regular records													0	-	**-**
7	Annual Monitoring Report														1	1	770.00	**770.00**
TOTAL																		**2,360.00**

Note:

M indicates Month

9 Conclusions

In conclusion, it appears justified from a technical and environmental point of view, to carry out the proposed project to establish a milkfish hatchery in GA.Matu to be sold to local fishermen as baitfish. Milkfish has been successfully cultured in some other countries at commercial level. In addition, use of milkfish as an alternative baitfish has been demonstrated.

The main negative impacts of the proposed project during the construction phase would be loss of vegetation and minor sedimentation from dredging access channel. It is recommended to use accurate GPS units to set out the buildings and other infrastructure on the island and adjust the orientation/location of buildings as much as possible to minimize cutting/felling of mature trees. In addition, to reduce sedimentation it is recommended to carry out the excavations in calm weather and during low tide. Furthermore, it is recommended to carry out the necessary excavation within as short of a duration as possible.

There are no known threats to the wild stock and it is not expected to have any other negative impacts as milkfish is a local species. Also, the broodstock used will be from sites within the Maldives.

Rigorous monitoring of water quality and changes in currents (drogue studies) in the area during the construction phase and especially the operational phase is recommended. Also, socio-economic benefits as well as public concerns need to be understood and addressed.

If the proponent adheres to good practice guidelines and implement necessary mitigation and monitoring work during construction and operational phase of the project, the environmental impacts is predicted to be minimal.

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12 Appendices

Appendix 1: Terms of Reference

Appendix 2: Letter from the Fisheries Ministry

Appendix 3: CVs of Assisting Consultants