Environment Impact Assessment Report

For the Development of an Mariculture Project in Lh. Gaaerifaru

By

ReefTAC Maldives Pvt.Ltd
Consultant: Hussain Fizaah

Contents

1. Non-technical summary

This Environmental Impact Assessment report outlines the findings of our environmental studies for breeding, larval production and mariculture of *Plectropomus areolatus* (Pisces: Serranidae: Epinephelinae) on Lh. Gaaerifaru. The island has been leased to Ocean Quartiers Properties Pvt. Ltd by the Ministry of Fisheries and Agriculture.

The project aims at establishing a high nutritional value of reef fish for both local consumption and resort supply, and for export as well. And establishing the setup based on the local conditions provided. It also aims at gaining knowledge transferable to other similar projects in the Maldives.

The Study Area contains detailed maps of the site plan and the boundaries, along with the justification of the site.

Scope of work includes the descriptions of the proposed project. Reclamation works, estimated to be over within 3 months, will commence once the setup is confirmed. The works of the sea cage will start along with the reclamation works and is estimated to take about 3 months to finish. The Grow out tanks, office, laboratory and packaging facility works will take place after. And this is estimated to finish within a 4 month period. The jetty and the Shore protection work will start once the reclamation project starts and is estimated to take 3 months to finish the works. The scope of work also points out the inputs and outputs during constructional and operational phase. Furthermore, focuses on the type of species and types to be cultured. This includes the taxonomy and morphology, biology and ecology, spawning aggregations, sex-associated colour differences, environmental ranges, known geographical distribution, conservation status, history and the process of aquaculture of *Plectropomus areolatus*. Continued furthermore on the cages and tanks, the location the size details along with the phases for various purposes are explained. The acquisition, Brood Stock spawning, artificial spawning, rearing of the larvae, grow out, feeding, waste removal methods, and disease control and health management of the juveniles of the targeted species are thoroughly explained in this chapter. Even though the targeted species is *Plectropomus areolatus*, further compatible candidate species are mentioned as well.

The justification and methodology for jetty construction is explained, along with the duration estimated for the task. Reclamation plans for the site are given, with the location and size of the burrow areas on a detailed map of the site. Justification for the locations chosen, the methodology of this process and quantity of sand needed for the phase, its duration and labor works estimated is included as well.

Power supply and oil storage for the whole project is explained along with the amount of solar power required to operate the whole facility and the location best to install the solar panels. Solar power will be used as a backup, only if the diesel power generators are shut off or in case of maintenance or system failure. The transportation method and volume of diesel required are explained. Solid waste and sewage waste disposal methods are explained thoroughly with the overall scheme for the waste management plan.

The project management chapter points out the approximate area for the reclamation of land. More on the sea cages grow out tanks for the egg-rearing, larval-rearing and juvenile rearing are mentioned. Furthermore, the build of coastal structures to prevent the migration of the pumped sand along the shore are explained. The jetty, solar power house, office, laboratory, packaging facility and water storage is looked upon briefly. Seawater inlet and outlet explains the uses of seawater for stocking and rearing seeds, larvae and juvenile fishes in tanks. The location of

where the channel should be dredged, its reasons are explained along with the schedule of work which contains three phases. The site preparation and mobilization phase, the constructional phase, and the operational phase to be continued till the end of the lease period.

Description of the environment focuses on the climate, bathymetry of the site, the marine environment, and the hazard vulnerabilities. The climate includes the temperature, rainfall and humidity of the climate. It also includes the wind, waves and current. The bathymetry gives out a detailed map of the site area showing the areas and depths of the all-around reef system. The marine environment explains the methodology and results of the fish, substrate and coral survey transects with the aid of pie and bar charts. The seawater quality is also included in the marine environment, with the location map and the geo-coordinates of locations the water samples were collected. Finally, the hazard vulnerability states the effects caused in case of a tsunami generated in the Indian Ocean.

The chapter of potential impacts on the natural environment and mitigation measures includes the identification of the impacts discussed between the EIA team and the proponent, and the mitigation measures identified. The mitigation measures include the existing environmental concerns, the impacts on the natural environment during the constructional phase, and the impacts during the operational phase. The project alternatives discuss with the advantages, disadvantages and the recommendations for alternatives. These alternatives include the no project option, alternative types of species, alternative methods of culture, alternative location for the jetty, and the alternative energy required.

The various types of environmental monitoring, measuring and recording of environmental, social and economic variables associated with the development impacts are explained in the monitoring plan. The monitoring program is represented in a table containing the details of the different three phases, methods, estimated cost and other information.

The statements and the main concerns are looked upon under the stakeholder consultation which includes Inter-Agency coordination and public/NGO participation members. Three meetings were held to discuss these concerns and ideas which include the scoping meeting, the island council meeting, and a meeting held with Marine Research Center.

ނޮން ޓެކްނިކަލް ހުލާސާ

މި އެންވަޔަރަމަންޓަލް އިމްޕެކްޓް އެސެސްމަންޓް ރިޕޯޓް ޖަހައި ހުށަހަޅައި ވަނީ ގެ. ގާއިރިފުރުގައި ފުރުމަށް ހުރަހަގާއިމާ ދެކުނުތެރެ މެރިކަލްޗަރ ޕްރޮޖެކްޓްގެ ސަބަބުން އެކަށީގެ ތިމާވެށްޓަށް ކުރާނެ އަސަރުތައް ދެނެގަނެ ކުރިމަތިވާ ނުރައްކާތައް ކުޑަކުރުމަށް ދެކޭ ދިރާސާތަކާއި އެ ދިރާސާތަކުގެ ހޯދުންތަކެވެ. އަދި ޕްރޮޖެކްޓްގެ އަލި ކަންކަމުގެ ސަބަބުން ތިމާވެށްޓަށް ފޯރާފާނެ އަސަރުތަކާއި، އެ ކަންކަމުން ތިމާވެށްޓަށް ފޯރާނެ ނޭދެވޭ އަސަރުތަކުގެ މިންވަރު ކުޑަކުރުމަށް އަޅަންޖެހޭ ފިޔަވަޅުތައް އަދި ހަރުކަށިކަމާ ބެހޭ ކަންކަމުގެ ބަދަލުތަކަށް ކުރިމަތިލާން ކަންތައްތައް ހިމެނެއެވެ. މި މެރިކަލްޗަރ ޕްރޮޖެކްޓް ހިންގުމުގެ ހިއްސާދާރުންނާ ބައްދަލުކޮށް އެ ކަންކަމާ ބެހޭ ތަފުސީލްތައް އެކުލަވާލާފައިވެއެވެ. ގާއިމުކުރީ، ޓީމެއް ކުރެހިއަށް މަރުޙަލާތަކެއް އޮތް ވަނީ ކުރެވިފައި ދިރާސާކުރިއުޅޭއެވެ.

މި ޕްރޮޖެކްޓްގެ އަމާޒަކީ މެރިކަލްޗަރ ފާމެއް ގާއިމުކުރުން އަދި އެއިން އުފެއްދާ ބާވަތްތައް ބާޒާރަށް ނެރުމެވެ. މި ފާމުގެ ސައިޓް އަދި އެކަމާ ގުޅޭ ތަކެތި ކުރިއަށް ގެންދެވޭނީ ޕްރޮޖެކްޓް ސައިޓުން ބޭރުގައި ކުރިއަށް ދާނެ ގޮތެވެ. މިގޮތުން ހިންގާނެ ކަންތައްތަކުގެ މައިގަނޑު ބައިތަކުގެ ތެރޭގައި ހެޗަރީ ގާއިމުކުރުމާއި ލެބޯޓަރީ ހަދާ ފަރުގެ ތެރޭގައި ނަރުސަރީ 3 ޓޭންކު ގާއިމުކުރުމެވެ. އޭގެތެރޭން 3 ވަނަ ޓޭންކު ނަރުސަރީ ގޮތުގައި ބޭނުންކުރާ ގޮތް ދިރާސާކޮށް ހުރިހާ ސިސްޓަމު ފޮރުވާ ގޮތަށް ގާއިމު ކުރެވޭނެއެވެ.

ސައިޓް އޮފީސް އަދި ބްރޫޑް ޓޭންކުތަކުގެ ގޮތުގައި ބޭނުންކުރާ ޖާގަ ގާއިމުކުރެވޭނެއެވެ. މި ހެޗަރީ ފެސިލިޓީ ބިނާކުރުމަށް ހިމެނޭ ފަސޭހަތައް ފުރަތަމަ ބައިގައި ގާއިމުކުރެވޭނެއެވެ. މި ފަސޭހަތައް ފުރިހަމަ ކުރުމަށް ނަގާނީ 3 މަހެވެ. ހެޗަރީގެ ފަސޭހަތައް ގާއިމުކޮށް ފަހުން ގެންގުޅޭ ބޮޑު ޓޭންކުތައް ގާއިމުކުރެވޭނެއެވެ. އަދި މި ފަސޭހަތައް ފުރިހަމަކުރުމަށް 3 މަސް ނަގާނެކަމަށް ލަފާކުރެވޭއެވެ. މި ފަސޭހަތައް ނިމުމުން ހަރަކާތްތައް ބޮޑުކުރުމާއި، ޓޭންކު އިތުރުކުރުމާއި އަދި ފެކްޓަރީގެ ފަސޭހަތައް 6 މަސް ތެރޭގައި ނިންމާނެ ކަމަށް ލަފާކުރެވޭއެވެ. އަދި ބޭރުގެ ފަސޭހަތައް ފުރިހަމަ ކުރުމަށް ފަސޭހަތައް ފުރިހަމަކުރާނެއެވެ. އަދި މި ފަސޭހަތައް ފުރިހަމަ ކުރުމަށް 2 މަސް ވަރަށް ނަގާނެ ކަމަށް ލަފާކުރެވޭއެވެ.

ޓޭންކުތަކާއި ފާމު އާއި އެއްބަސްވުމާއި ފަސޭހަ ފުރިހަމަ ކުރުމަށް އިންތިޒާމުތަކާއި އައިޓަމްތަކުގެ ސެކްޝަން ޓީމު ބަހައިގެން ދަނީ ކުރިއަށް ގެންދަވާނެއެވެ. މީގެ އިތުރުން އާލާ ކުރުމަށް ހިންގާ ސަރުކާރުގެ އަމަލުތަކަކީ ބްރޫޑްސްޓޮކް، އެރަކާ ހިފެހެއްޓުމުގެ އިންތިޒާމު ފަރާތްތަކާ އެއްބަސްވެ، ސިޔާސަތުތަކާ ގުޅިގެން ހަމަޖެހުނު ބާވަތުގެ ޑިމާންޑް މި ސަރަހައްދުގައި ހިމެނޭއެވެ. މީގެ ތެރޭގައި ބޯޓުތަކާއި، ފީޑުތަކާއި، ބޮޑު ޓޭންކުތައް، ފެން ސަރކިއުލޭޝަން، ސްޓޮކް ސަޕްލައި ބަހައިލާ އިތުރު ފަސޭހަތަކާއި، ކެމިކަލް ފެސިލިޓީ، އެނިމަލް ފީޑު ބޭނުންކުރުމަށް ފޯރުކޮށްދެވޭ ވޯޓަރ ޓްރީޓްމަންޓް، ޓޭންކް ފެސިލިޓީ، ޓްރީޓްމަންޓް އަދި ޕްރޮސެސިން އިތުރު އެކުއަކަލްޗަރ ހިމެނެއެވެ. މީގެ އިތުރުން އެލެކްޓްރިކަލް ސިސްޓަމާ އިތުރު ޖެނެރޭޓަރުގެ ސަޕްލައި، ބްރޫޑް ޓޭންކް ގާތު، މައިކްރޯ-އަލްޖީ، ފީޑު، ވޯޓަރ ޕަމްޕް، ޑީޒަލް ޓޭންކު، އަދި ވޭސްޓް މެނޭޖްމަންޓް ހިމެނެއެވެ. މީގެ އިތުރުން ޓެކްނިކަލް ހުނަރު ދަސްކޮށްދިނުމަށް އެކަން ބޭއްވުމަށް ސަޕޯޓް ފޯރުކޮށްދިނުމުގައި ހިމެނެއެވެ.

ނަރު ފާސްކުރުމުގެ ބޭނުމަށް އެއްވެސް މިންވަރަކަށް، އަދި މިސަރަހައްދުގެ އެތެރެއިން ވެސް ބޭނުންކުރެވޭ ފަސޭހަތައް ބޭނުމަކަށް ފަރާތް އެބަ ހުރެއެވެ. މިގޮތުން ކަނޑުގެ ފަރުތަކާއި ސަރަހައްދު، އަދި ހެޗަރީގެ ފަސޭހަތައް ހިމެނިފައިވާކަން އެނގެއެވެ. މި ފާމުގައި ބޭނުންކުރާ ތަކެތި ނުހިމެނޭ ގޮތަށް ހަދައިފާނެއެވެ. އަދި

އެސަރަހައްދުތަކެއް ހިމާޔަތްކުރާ ސަރަހައްދުތަކުގައި، އެކަން ކުރާނެގޮތްތަކެއް، އަދި ބޭނުންވާނެ ވަޤުތު ހުންނަން ޖެހޭ މިންގަނޑުތަކާ ތަފްސީލާއި، މަސައްކަތްތަކުގެ ހަރުދަނާ މުއްދަތު އަދި ވާޖިބު މަސައްކަތްތަކުގެ އަސްލުގެ ކުރާ ވާ ހިމެނިފައިވާނެއެވެ.

މި ޤާނޫނުގެ ހިންގުމުގެ ހަރަދު ބޭނުންވާނެ ވަރާއި ބޮޑު ރައްކާ ކުރެވޭ ގޮތް މި ރިޕޯޓުގައި ބަޔާން ކުރެވިފައިވާނެއެވެ. އެގޮތުން މި ޤާނޫނުގެދަށުން މުއައްސަސާ ގާއިމުކުރާ ބޭނުންކުރާ ޖަމާޢަތް ހަރަކާތްތެރިވެއެވެ. އަދި އަވަސް އިންތިޒާމު ހަރަކާތް ނުވާތީ ސަރުކާރު އިސްނެގުމަށް ބޭނުންކުރާނީ ބޭނުންތެރިވުމެވެ. ބޭނުން ބެލެހެއްޓުން ކުރާނީ ގޮތާއި ބޭނުން ބޭނުންވާ އިދާރީ ބައިވެރިވުމާއި މި ރިޔާސީ ބަލަހައްޓާވެސް ކުރެވިފައިވާނެއެވެ. އަދި އިތުރުން މި ޤާނޫނުގެ މަސައްކަތްތަކާ ގުޅުން ހުރި ކުރުން ނުހުންނަ ސިފަ ނަގާފައިވާ ބޭނުން ބޭނުންވާ ކުރާ ބަޔާން ބޭފުޅުން ޤާނޫނާއި ގުޅުން ހުރިހާ ކަންތައް ކުރެވިފައިވާނެއެވެ.

ޤާނޫނުގެ މުޢައްސަސާތަކުގެ ބޭނުން ދަތުރު ޤާނޫނުގެ އިން ސަރަހައްދުތަކުގައި ކުރުމުން ކަނޑައެޅިފައިވާ ކަންތައްތަކުގެ ތަފްސީލް ހިމެނިފައިވާނެއެވެ. އޭގެ ތެރޭގައި މުދަލުގައި ބޭއްވޭ ކަނޑު އަދި އެގޮ-ރީފް ރިސޯޓު، މާލެ-ރީފް ރިސޯޓު، ޖަވާހިރު ރީފް ރިސޯޓު، އަދި ގިރާވަ- އަޅުވަ ސަރަހައްދުތަކާއި ބެހޭ މައުލޫމާތު މި ރިޕޯޓުގައިވެއެވެ. އޭގެ އިތުރުން ގޯތިތެރި ޒުވާނުންގެ ވެރިވާ އަތުން ގިރިގަން ދިއުން ހައްޔުވާ ގޮތުން ހުރި ކޮޅުތަކުގެ އަސްލު ފަރާތުން ކަނޑައެޅިފައިވާ މުސްކުޅިވެރިވާ ގޮތުގެ މައުލޫމާތު ހިމެނޭ ރިޕޯޓެއް ރިޕޯޓުގައިވެއެވެ. އަދި ޖަހާ، ސަރަހަ ފަރާ ހައްސަ-ވައިން ފަތަރު ހައްސަ، އަހަރު އަށް ފިޔަވަޅު، އަދި މިގޮ އިތުރުން ޤާނޫނުގެ ގޮތުގައި ހިމެނޭ އެކިއެކި ބައިތަކުގެ އަގުވަޒަން ކުރެވިފައިވާނެއެވެ. މުދަން ތަކެތި ބޭނުން ކުރެވޭ ބޭނުންތަކާއި ސިޔާ ރީފް ރިސޯޓު، ގަވަފް އަދި ޖަވާހިރު މަސް ދިރުވާ އަވަހަށް ކުރުމުގެ މައުލޫމާތު ސަރަހައްދު އިންޓަރ ނެޝަނަލް އެއްޗެއް ބޭރުގައި ކުރިއަށް ގެންދެވިފައިވާނެއެވެ. ވީން ފަސޭގެ މަސައްކަތްތަކުގެ ޝަރުޠުތަކާއި ހިސާބު ހޯދުމުގެ އިންތިޒާމުތަކާ އަދި އެހެން ހޯދާ ސަރަހައްދުގެ ބަޔާން ކުރެވިފައިވާނެއެވެ. މިއީ ސަރަޙައްދު ވިއްސަރު ކުރުވާ މަސައްކަތް ފަސޭހަ، ކޮންސަރވޭޝަން ފަސޭ އަދި އިޤްތިޞާދީ ފައިދާ ވަގުތީ ފައިދާއެވެ. ވީނަގެ ކުރިޔަށް ގެންދިޔަ ހަމަ ވަޒަނާއި އިޤްތިޞާދީ ފައިދާ ކުރިއަރުވާ ދަރުމަ ވެއެވެ. މި ޤާނޫނުގެ ދަށުން ހިމާޔަތް ކުރެވޭ ސަރަހައްދުތަކުން 35000 ކޮއްކޮ މީހަކަށް ވަޒީފާ ބޭނުންވާނެއެވެ.

ތިމާވެށީގެ ތަފްސީލް ބަޔާން ކުރުމުގެ ތެރޭގައި ދަތުރު ކުރުމުގެ ކަނޑައެޅުން، ބެލެހެއްޓުން، ގޮތުން އިންވެސްޓްމަންޓް އަދި ސަރުކާރުގެ ހަރަދު ފައިސާ ދެއްކުމަށް ފަރުވާ ބޭނުމެއް ކުރެވިފައިވާނެއެވެ. އެގޮތުން ކަނޑައެޅުން ބެލެހެއްޓުމުގައި ހިނގާ ހަރަދު ސަރުކާރު، ފަރާ ފަދަ މުއައްސަސާ، ވެރިން ތަކެތި، ވެރި، ޢާއިލާ، އަދި ރަށުގެ ދައުލަތުގެ ކަންތައްތަކުގެ ބޭނުން ކުރެވިފައިވާނެއެވެ. ބެލެހެއްޓުން އިންތިޒާމު ގެނެސް ދިނުމަށް އެކުލަވައިލެވިފައިވާނެއެވެ. އަދި މި ދާއިރާގައި އެސަރަހައްދުގެ އެކިބައިތަކުގެ ފައިސާ ސަރުކާރުގެ ބަޖެޓުން ފޯރުކޮށްދެވޭ ގޮތް ކުރެވިފައި ވާނެއެވެ. ކަނޑައެޅުން އިންވެސްޓްމަންޓް ބައިގައި ފީސް ކުރުން، ސަރުކާރުން ފައިދާ އެޅުމުގެ ޕްރޮގްރާމު ދިރާސާކުރުމުގެ ގޮތުން ކުރިއަށް ދަރަނި ހޯދުމަށް ރާވާފައިވާ ކަރަންޓު ބަޔާންކުރެވިފައިވާނެއެވެ. އަދި މި ދާއިރާގައި ބެލެހެއްޓުމުގެ ކަންތައްތަކުގެ ޤާނޫނީ އިދާރީ ގޮތުން ތަނަވަސް ކުރުމަށް ހިލޭ ކުރާ ފައިދާ ބޭނުންކުރުމަށް ކަނޑައެޅިފައިވާ ބައިގައި ބަޔާންކުރެވިފައިވާނެއެވެ. އަދި އެ ދާއިރާގެ ބޭރު-ރާއްޖޭގެ އެހީތެރިކަމުގެ ވާހަކަ ބަޔާންކުރެވިފައިވާނެއެވެ. އިތުރުން ހަމައެހެން ފަރާތްތަކުގެ އެހީ ބަޔާނުގައި ޤާނޫނީ މަސްއޫލިއްޔަތުތައް ފޯރުކޮށްދިނުމާ މަސައްކަތްތަކެވެ. ހަމަ ބަޔާންކުރުމުގެ ގޮތުގައި ސަރުކާރުން ދެވޭ ޤާނޫނީ ބޭރުގެ ފައިސާގެ ދާއިރާއިން ކުރުމާ ގުޅިގެން ކަނޑައެޅިފައިވާނެއެވެ.

މި ޤާނޫނުގެ ސަރަހައްދު ތިމާވެށީގެ ރައްކާތެރިކަން ނަގާ ސަރަހައްދުގެ ފައިދާ ކުރިއަރުވައިދިނުމުގެ ގޮތުން ކަނޑައެޅުން ޤާނޫނީ އިޖުރާއަތްތަކުގެ ތަފްސީލު ބަޔާން ކުރެވިފައިވާނެއެވެ. އަދި މިއާއި ގުޅުން ހުރި ބެލެހެއްޓުމުގެ ކަންތައްތައް ކަނޑައެޅިފައިވާނެއެވެ. ޤާނޫނުގައިވާ ހުރިހާ ސަރަހައްދުތަކުގެ ފައިސާ ހަމަ ބަލަހައްޓާ ގޮތް، ހޯދާ ކަންތައްތަކުގެ ޤާނޫނީ ހިދުމަތް ފައިދާ ބަޔާން ކުރެވިފައިވާނެއެވެ. ގުޅުން ހުރި ކަނޑައެޅުމަށް ދެވޭ ހުއްދައާ ގުޅޭ ބަޔާންތައް ކަނޑައެޅިފައިވާނެއެވެ. ބެލެހެއްޓުމުގެ ހުއްދަ ދިނުމަށް ފައިސާ ހޯދުމުގެ ކުރިއަށް ގެންދާ ކަންކަމުގެ ތަފްސީލްތައް

ބޭރާގައި ކުރި އެރުމާއި، ކުރި ޖެހުމާ ގިނަ ވުމާއި، ނަރު ފުރުސަތުކުރުމާއި، ވަޒީ ފުރުސަތު ކުރުމާއި، ކޮންސްޓްރަކްޝަނުގައި ބޮޑުން ކުރާ މަސައްކަތްތަކާއި އަދި މަސައްކަތުގެ މީހުންގެ ފެންވަރު ކުރިއަރުވައިދިނުން ކަންތައްތަކުގެ ހިންގައިފައެވެ. އަދި އޮޑިޓަރ ޖެނެރަލް ފަރާތުން ދިރާސާކުރި ގޮތުން ކަންތައްތައް ބަޖެޓުގެ ހިސާބުން ބަދަލުވުމަށް ގޮތުގައި ބޭނުންކުރި ހަމަ މަސައްކަތްތަކުން، ބަޔަކު ފެށުން އަދި އާ ސަރުކާރުގައި ދިރާސާ މަސައްކަތުގެ އެތެރޭގައި ބަލާފައި އަދި މުދަލު މަސައްކަތް އެތެރޭ ސަބަބުން ފާހަގަކުރުމަށް އަސަރުކޮށް ހިމެނެއެވެ. އޭގެ ތެރެއިން ސްކޫލް-ކަމުގެ އިންތިޒާމްތަކާއި ހިސާބު ކުރުމާއި ކުރިއަށް ވެފައިވާ ކަންތައް އަދި ހިނގައިދާ އަސަރުތަކުގެ ބާރު ކުރިއަރުވާފައިވެއެވެ.

ޕްރޮޖެކްޓް އެޑްމިނިސްޓްރޭޝަން ބޭނުމަށް ދަށުގައި ޕްރޮޖެކްޓް ހިންގުމަށް ކަނޑައެޅިފައިވާ ގަވާއިދުތަކުގެ ބަދަލުގައި ކަންތައްތަކުގައި އެކަން ގަވާއިދު، އަދި އެ ގަވާއިދުގެ ފޯމުތަކާއި ގައިޑްލައިންތަކާއި، އަދި އެކަންތައްތަކުގެ ކުރުމުގެ އެންމެ އެކަށީގެންވާ ގަވާއިދު ހިމެނިފައިވެއެވެ. ބަދަލުގައި ކުރިއަރާ ކަންތައްތަކުގެ ވެރިކަމުގައި ޕްރޮޖެކްޓް ކުރިއަށް ނަގާނީ ތަކުރާރުގައި، އެހެން ސްޓޭޓްމަންޓް އާދާ ކުރުން ނަމަވެ އެހެން ގަވާއިދު އާދާ ކުރުން، އެހެން ސަރުކާރުތަކުގައި ނަމަ ކަނޑައެޅުން ނަމަވެ ބޭނުން އެދުން ހިމެނެއެވެ.

މޮނިޓަރިންގް ފްރޭމްވޯކް ބޭނުން ދަށުން ވިސްނުމަށް މޮނިޓަރ ކުރާގޮތް ބަލައިގަތުން އަދި މަރުހަލާތަކަށް ޕްރޮޖެކްޓް ވެރިއާއި ކުރާނެ ގޮތްތަކުގެ ވިސްނުން އިސްލާމާއި އަދި އިގްތިސާދީ ކަންތަކުން މި ޕްރޮޖެކްޓްގެ ސަބަބުން ކުރާ އަސަރުތަކުގެ ދުވަސްތަކުގެ މިންވަރު ކުރިއަރުވާ ދައުލަތުގެ މި ބައިގައި ހިމެނެއެވެ. ވިސްނުމަށް ވިޝަން އޮތް، ކަން ކުރުން ގާނޫނީ، އެންމެ ކުރިން ހަރަކާތް ބަރާބަރު ކަންކަން ދައުލަތުގެ މޮނިޓަރިންގް ފްރޭމްގައި ހިމެނިފައިވެއެވެ.

ޖެންޑަރ މަސައްކަތް މި ޕްރޮޖެކްޓުގައި ގެ ފަރާތުގެ ޕްރޮޖެކްޓުގެ މެނޭޖްމަންޓާއި ލީޑަރޝިޕް ބާރުގެ ބެލުމުގައި ބައިތިބާ ފެނުނެވެ. މި ގޮތުން 3 މަހަކަށް ފަހަރެއް ބައްދަލު ކުރެވޭނެއެވެ. އެއީ ސްޓާފުން މީޓިންގ، އެއިރުގެ ކައުންސިލް މީޓިންގ އަދި މެނޭޖްމަންޓް ސްޓާފާއި ބައްދަލުކުރުން މީޓިންގެވެ. މި ބައްދަލުވުންތަކުގައި މަހަކަށް ގޮތުގައި ފާހަގަ ކުރެވޭ ހިސާބުން ދިރާސާ ކުރުމަށް މި ޕްރޮޖެކްޓުގެ މަސައްކަތުގެ އަދި ކުރި ސަރުކާރުން ގޮތުގައި މުއްދަތެވެ. އެގޮތުން މި ޕްރޮޖެކްޓުގެ މަސައްކަތުގެ ވިސްނުން ކުރުމުގައި ވިޔަފާރި ބަދަލު ސަރުކާރު ވިޔަފާރި އެންމެ ގެދޮރުން ކުރި ގޮތުގެ ދެން މަސައްކަތުގެ ކުރުމުގެ ދިރާސާ ޕްރޮޖެކްޓުގެ ވެސް ފާހަގަ އެކުލެވިގެންދެއެވެ.

މި ރިޕޯޓް ތައްޔާރު ކުރުމަށް މިނިސްޓްރީ އޮފް އެންވަޔަރަމަންޓް އެންޑް އެނަޖީ 2012ގައި ނެރުއްވިފައިވާ އެންވަޔަރަމަންޓަލް އިމްޕެކްޓް އެސެސްމަންޓް ރެގިއުލޭޝަން ބޭނުން ކުރެވިފައެވެ. މި އީ.އައި.އޭ ހުށަހަޅާ ދިރާސާކުރާ ފަރާތް ކުރިއަށް ގެންދިޔަ ޕްރޮޖެކްޓްތަކުގެ ގޮތުން ރިސޯސް ރިވިއުގެ ތަފްސީލު މައުލޫމާތު ހޯދައިގެންނެވެ. މި ރިޕޯޓް ތައްޔާރު ކުރުމަށް އެކި ދާއިރާތަކުން ފީލްޑް ވިޒިޓް ދިރާސާ މައުލޫމާތުތަކާއި އެކުލަވައިލެވުނެވެ. އަދި މި ޕްރޮޖެކްޓުގެ ސަރަހައްދު ތެރެއިން ފީލްޑް ސަރވޭގެ ތަފްސީލު މައުލޫމާތު ހިމެނޭ އިންޓަވިއު، ޑޭޓާ އެނަލިސިސް އަދި ފޮޓޯގްރާފް ރިޕޯޓްތައް ހިމެނެއެވެ. މިއީ ޕްރޮޖެކްޓުގެ ފުރިހަމަ ވަސީލަތް މައުލޫމާތު ބޭނުން ކުރެވިފައިވާ ރިޕޯޓެކެވެ.

2. Introduction to the project

2.1. Purpose of the project

The fish stock of the country has been depleting rapidly over the past 10 years due to over fishery and lack of adequate management and monitoring plans. And without these management and monitoring plans it would be a matter of time we face the problem of catering for the huge demand in sea food across the nation.

The proposed project is a master tailored fish farming project for the Maldives, a unique project in design to cater the subtle and vulnerable environment of the Maldives. The project is emphasized on reef fish farming, ensuring a healthy local supply for the future. The project takes away the pressure on reefs from over fishery and provides extensive knowledge and data for developing a sustainable fish farm with a comparatively high budget.

The present report assesses the potential environmental impacts associated with the development of a mariculture project in Lh. Gaaerifaru. The reef system has been leased to Ocean Quartiers Properties Pvt. Ltd. The company has planned for a USD 27,000,000 investment for the new developments.

2.2. Objectives and Justification

In the past decade, Maldives has witnessed a significant decline in reef fish catch rates, with fishing pressure seen as the main source of the problem. If present practices continue, local fish supply will not be able to meet demands, and fish species will be in danger of extinction in the near future.

Major aquaculture projects throughout the world are mainly based on land. In land-based culture, fish are bred in tanks, dug ponds or built holding-tanks. Water temperature, chemical composition and physical conditions are artificially created and operated under controlled conditions. However, such developments can have drawbacks such as those arising from high stocking densities in tanks and ponds which can cause water quality issues, which can lead to proliferation of disease and subsequent death of fish.

Land-based aquaculture is not feasible in the Maldives as land is scarce and limited and most elements of the relevant technology have to be imported. Land based aquaculture projects are costly and land rent is high; therefore investing in such a project is difficult and unviable.

The objectives of carrying out a mariculture project in the Maldives include:

1. Farming of reef fish for local consumption and resort supply
2. Farming of reef fish for export
3. Establishment of a facility based on local conditions
4. Gaining knowledge transferable to other similar projects in the country

Government initiatives have included similar projects such as the development of a mariculture project in V. Bodu Mohora (later transferred to K. Maniyafushi). However such projects have mostly been in the form of pilot studies and as such are often halted due to various difficulties. Thus it is important that the private sector take initiative towards such projects, as it would be a step towards sustainable fishery in Maldives. Maldives has a vast area of sea, making marine farming the most appropriate choice. However, care must be taken to limit disturbance to the environment and to prevent offsetting the balance of the fragile ecosystem.

The first phase of the proposed project is focused on grow-out of *Plectropomus areolatus*, Squaretail Coral Grouper from imported fingerlings. Although *P. areolatus* has a wide range, its market value and palatability has led to heavy fishing pressure, resulting in a decline rate of at least 30% over the last 20-30 years. The International Union for Conservation of Nature (IUCN) predicts that numbers of mature individuals will continue to decline as fishing pressure is expected to increase (Thierry *et al*, 2008). This species is especially targeted at spawning aggregations, posing a threat to endangerment of species if current practices were to continue, as there is limited management of the species at present and is currently listed as 'vulnerable' in the IUCN Red List. Thus the proposed project aims to serve as a step towards sustainable fishery of *P. areolatus*. Studies on the culture of the species are scarce and in this respect the information obtained through this project would be a basis on which better and more efficient techniques may be developed.

2.3. Proponent

Ocean Quartiers Properties Pvt. Ltd was registered in 2015 in the Maldives and has vast experience in the hospitality industry. The company is owned by a Thailand party which has businesses in Thailand and different countries of the world.

3. Study area

3.1. Site plan

Lh. Gaaerifaru is located (5°29'7.75"N, 73°24'14.01"E), south west of Lh. Hinnavaru ; 145 km NE of Male. The reef system is placed in an North-South direction. Lh. Gaaerifaru is 414m long and 80m wide, however the house reef is1.7 km long and about 750m wide in average. Figure 1 shows the site plan for the proposed new developments.

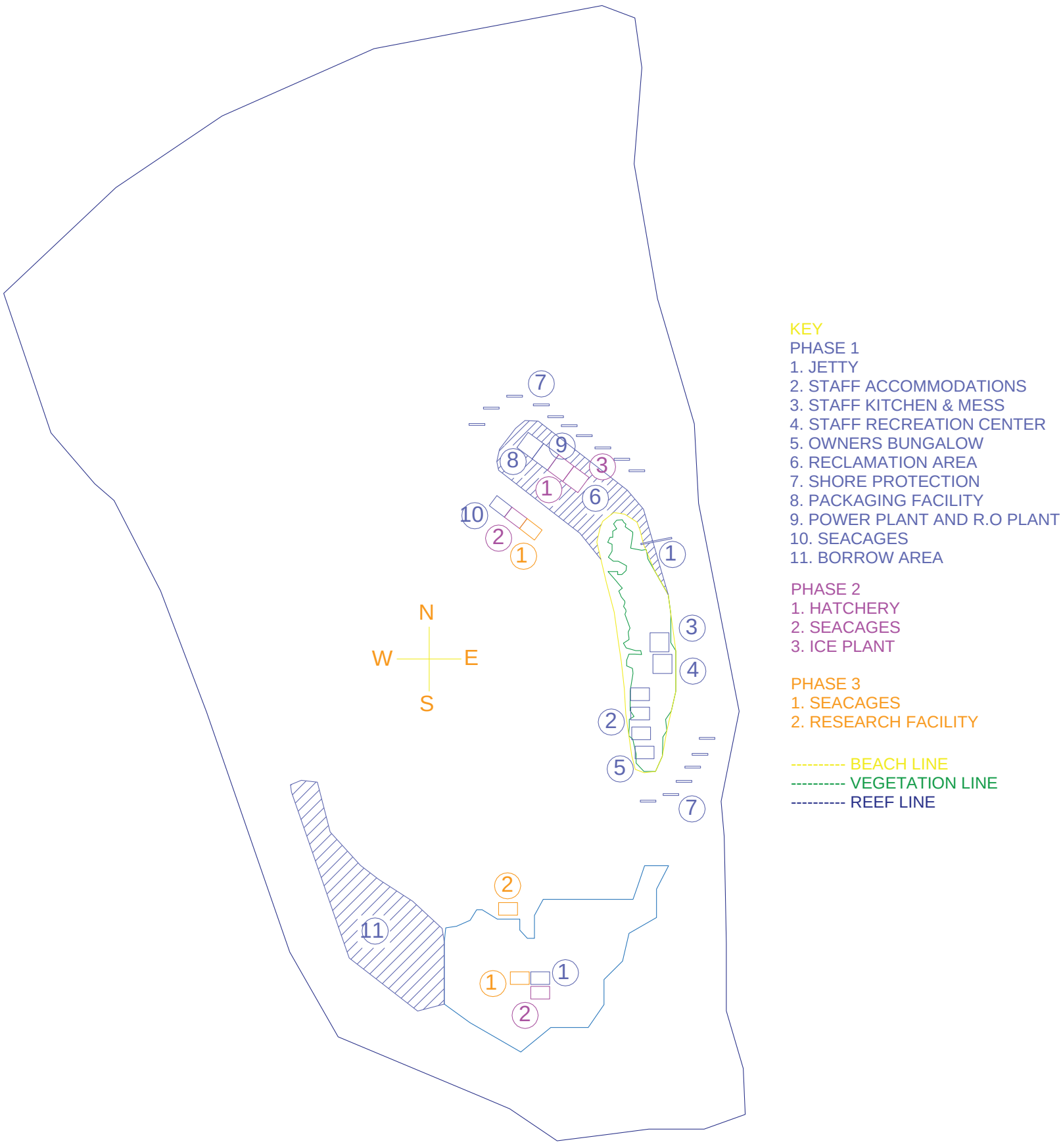

Figure 1: Site Plan

3.2. Boundaries of Study area.

Priority was given to the specific areas where the sand bank, cages and channel will be dredged during survey period (Figure 2). However the whole of the reef was studied for bathymetry study.

Figure 2: Study Area

3.3.Justification for site.

Lh. Gaaerifru has a large lagoon basin with an extensive reef system surrounding and protecting it, the location is well-suited for a mariculture project. Given the largeness of the lagoon, there will be sufficient water exchange to maintain water quality. The surrounding reef will provide adequate protection for sea-cages, minimizing structural damage and loss of stock during rough weather conditions. The island of Lh. Gaaerifaru was approved by the by the Ministry of Fisheries and Agriculture for the development of a mariculture project and leased to Ocean Quartier Maldives Pvt Ltd.

The site was selected as much consideration was given to reduce the impact on the environment. The optimum condition required for such a project can be achieved in Lh. Gaaerifaru and since it is close to Lh. Hinnavaru, logistics and acquiring labor will be much easier.

4. Scope of work

4.1. Description of the proposed project.

The project is to develop a mariculture project in Lh. Gaaerifaru. In total Ocean Quartiers Properties Pvt. Ltd will invest an estimated USD 27,000,000 for the project. An estimated 15,400 sqm area will be used as built up area during this project. The built up area will include landscaping and buildings. The following table 1 identifies the works and the area required for the works.

Table 1: Project plan and area required for the works.

Proposed work	Size Sqm
1. Reclamation.	20,000
2. Sea cages	3,000
3. Jetty and Channel Dredging	1,600
4. Shore Protection	2400
5. Accommodation Blocks	1800
6. Owners Bungalows	600
7. Power House and R.O Plant	900
8. Processing and Packaging Facility	900
9. Office and Recreation Facility	900
10. Staff Kitchen and Mess	900
11. Hatchery	900
12. Ice Plant	900
13. Research Facility	600

Once the project gets approval from EPA, mobilization of the reclamation machinery will be brought on site. Once the setup is made reclamation works will begin. It is estimated that reclamation works will be over within a period of 3months. During the reclamation period, land clearance will be done on the existing island and temporary storage will be built. It is estimated that temporary buildings and land clearance will be done within 2 months period. The jetty works will commence with the reclamation to maximize the accessibility to the main island.

Sea cage works will commence with reclamation works and is estimated to take about 3 months to finish. Once the reclamation works finishes, Processing and packaging facility, Power and R.O plant will commence. During this period the foundation for the Hatchery and Ice plant will be done even though the facilities will come at a later phase. And it is estimated that the works will finish within 6 months period.

Staff accommodation, Staff recreation and Staff mess, including the offices and Owners bungalow works will commence once the reclamation period is over and it is estimated that it would take around 6 months.

4.2. Project Inputs and Outputs

Table 2: Inputs and outputs of the project during construction and operational phase.

Input resource	Description
Construction workers	Locals and some foreigners
Operational Staff	Mainly Maldivians
Machinery	Sand pump
Construction material	Timber; Thatch for roof, electrical cables and wires, electrical fittings, PVC, pipes, light weight concrete blocks, reinforcement steel bars, sand, cement, aggregates, telephone cable, PVC conduits, floor and wall tiles, gypsum boards, calcium silicate boards, zinc coated corrugated metal roof, paint, varnish, lacquer, thinner, etc.
Maintenance material	Similar to above
Water supply (during both phases)	Desalinated water
Electricity/Energy (during construction)	Diesel
Electricity/Energy (during operation)	Diesel and Solar power
Electrical appliances/machinery	Energy efficient machinery and lighting; ozone friendly refrigerators, Low consumption AC system with heat recycling retrofit.
Telecommunications	Fax Machines, E-mail and internet facilities.
Transport	Domestic air and sea transport
Food and Beverage	Locally available items and imported items.
Firefighting equipment	Fire Pumps, Fire Protection System, Smoke Detectors, Carbon Dioxide and Foam Fire Extinguishers, etc.

Outputs during construction stage		
Products and waste	**Considered quantities**	**Method of disposal**
Construction waste (general)	large quantities	Taken to K. Thilafushi and incinerated
Sewage	30 l/ day/ person	Temporary septic tank during construction and during operations will be connected to main sewerage system on the island.
Outputs during operational stage		
Products and waste	**Considered quantities**	**Method of disposal**
Potable water bottles	Around 3,000 Plastic bottles per month	Plastic Bottles – Crushed and taken to K. Thilafushi for potential recycling export
Sewage and wastewater	About 1800 liters/day	Treated and pumped to sea
General/domestic waste	About 100 x 60 litter bags per month	Taken to K. Thilafushi, incinerated
Waste oil and grease	100 l/ month	Taken to K. Thilafushi, incinerated

4.3. Species and Type of Culture

4.3.1. Groupers

Groupers are found in warm waters around the world. They are one of the most popular species in the reef fish industry, especially in the Asia-Pacific region. They are hardy fish with fast growth rates and are suitable for cage culture. In addition they have the required characteristics for processing. There is a high demand for grouper due to their palatability and scarcity. These characteristics make grouper an ideal candidate for farming.

General Description

Groupers include all fish belonging to the subfamily Epinephilinae, of the Serranid family, in the order Perciformes. They are teleost fish, which typically have a stout body and a large mouth. Groupers include a broad range of species of considerable variations. Some species can grow more than a metre in length. They are not strong swimmers and thus do not swim long distances. As adults, many species are found inhabiting coral reefs, though juveniles often use near-shore habitats such as coral rubble flats and lagoons.

The high demand for and value of grouper, have resulted in overfishing in a number of countries. It has also led to the use of fishing practices that destroy coral reefs. A fishery for live grouper had recently started in Maldives and is now showing signs of overfishing, including stock depletion, smaller sized fish catches and the observation of fishermen moving farther away from previous fishing grounds to seek more fish. Thus the need for a sustainable means of harvest is imperative.

(Parrish, 1987; Collette & Talbot, 1991; Heemstra & Randall, 1993; Jones 1993; Anderson et al, 1992; 1998; Adam et al, 1998, Tupper, 2007).

4.3.2. *Plectropomus areolatus*

The proposed project will focus on a single grouper species for the first phase of the project, *Plectropomus areolatus*, or *Olhu Faana* (Figure 3). Common names of *P. areolatus* include Squaretail Coral Grouper or Squaretail Coral Trout, Spotted Coral Grouper or Spotted Coral Trout and Polkadot Cod.

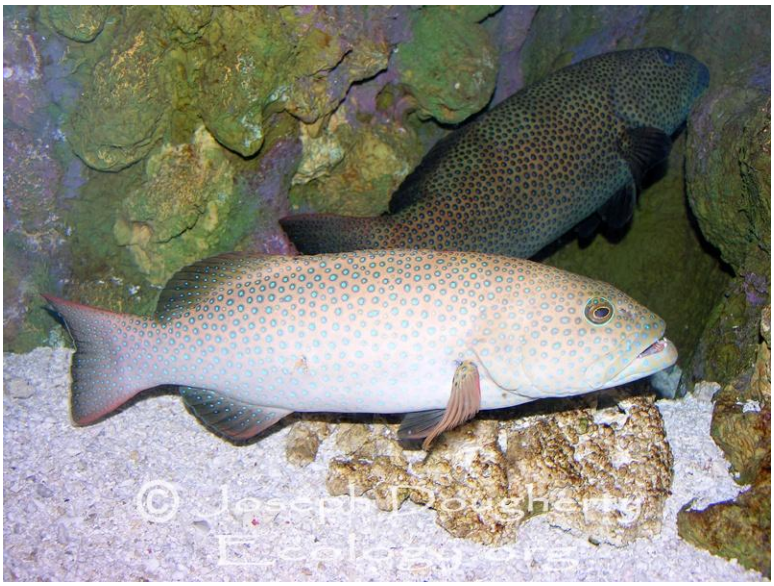

Figure 3: Plectropomus areolatus, Olhu Faana.

P. areolatus, or Spotted Coral Grouper is similar in appearance to other coral groupers, and is often confused with *P. leopardus* or Leopard Coral Grouper. *P. leopardus* has a complete blue ring around the eye, while the ring is incomplete in *P. areolatus*. Another distinguishing factor is that the belly of *P. leopardus* does not have spots, as opposed to that of *P. areolatus*.

(FishBase, Froese & Pauly 2000).

http://www.fishbase.org/summary/Plectropomus-areolatus.html)

4.3.3. Taxonomy and Morphology

Groupers belong to the phylum Chordata, class Actinoptergyii, order Perciformes and the family Serranidae. Not all groupers however are serranids, the sea basses are also included in the family. The most abundant genera in this region is Epinephelus, constituting 68% of known species. Fish classified in the genus *Plectropomus* are referred to as coral groupers (Rűppel, 1830, Heemstra & Randall, 1993).

The head, body and median fins of *P. areolatus* are greenish grey to brown or brownish red, with numerous round/oval dark-edged blue spots; most spots lie within a spot diameter of adjacent spots. The pelvic fins have membranes with dark brown to black coloration. The rear margin of the caudal fin has a white edge, often with a blackish sub-marginal band. A white margin is also usually observed on the dorsal fin.

P. areolatus has an elongate, robust body, with a depth contained 2.9-3.9 times in standard length (standard for fish of 15-48cm length). Head length contained 2.7-3.1 times in standard length; snout length contained 2.8-3.6 times in head length; and suborbital depth contained 5.6-10 times in head length. Inter-orbital area is flat with embedded scales. 3 large ventrally directed spines observed along lower half of preopercle, inter and sub-opercles smooth while the opercle has 3 flat spines, two of which are covered in skin. The nostrils are subequal and are set in a groove anterior to the eye. Mid-lateral section of upper jaw has 1-4 enlarged canines. Lower limb has 2-7 gill rakers. The dorsal fin has 12-13 spines and 10-12 rays. Lateral line scales are between 83-97 in number.

(Rűppel, 1830, Heemstra & Randall, 1993), (FAO Species Catalogue Vol.16. Groupers of the world (281 to 290), J.E. Randall (FishBase, Froese & Pauly 2000).

4.3.4. Biology and Ecology

Plectropomus areolatus are top-level predatory fish that inhabit warm waters with coral reefs. *P. areolatus* are mainly found in reef areas, dead coral, rubble flats and seagrass meadows in relatively shallow waters. They inhabit lagoonal and inward reefs, favoring rich coral reefs. Juveniles have a wider spatial distribution than adults and prefer near-shore areas. This may be due to larval dispersal patterns.

Juveniles are cryptic and a large part of their diet consists of crustaceans. Adults however, are generalized opportunistic carnivores. *P. areolatus* feed primarily on fish and benthic invertebrates such as prawns and crabs. Their prey is swallowed whole, which are crushed by tooth plates inside the pharynx. They are known to be lie-and-wait ambush predators. They have strong jaws, which are used to expand their mouth to lunge at and engulf prey. Grouper feed throughout the day, though tend to be crepuscular in nature, with peak feeding times during dawn and dusk. *P. areolatus* can grow up to 73cm, though adults are usually a length of 60cm.

(Demartini et al, 2011; Sadovy & Colin, 1995; Alisop & West, 2003; Jory & Iverson, 1989; Heemstra & Randall, 1993)

4.3.5. Spawning Aggregations

P. areolatus are mostly monandric protogynous hermaphrodites, i.e. they mature as females and can change their sex after sexual maturity is reached. *P. areolatus* form spawning aggregations in association with specific phases of the lunar cycle, with variable seasonality and cycle associated with spawning by locale. *P. areolatus* commonly forms aggregations with *Epinephelus polyphekadion* or Camouflage Grouper and *E. fuscoguttatus* or Brown-marbled Grouper. These co-aggregations can reach numbers of over thousands, although can be as small as 10-100 individuals. There are known spawning aggregations of *P. areolatus* from the Solomon Islands, Palau; Pohnpei, Micronesia, Maldives, Australia, Kiribati, Fiji, Marshall Islands, Indonesia, Tuvalu, Samoa, and Papua New Guinea amongst other locations.

(Pet et al, 2005; Kuwamura, 2004; Erisman et al, 2008; Molloy et al, 2007)

4.3.6. Sex-associated colour differences

Sex-associated colour differences can be observed in *P. areolatus.* Males and females are easily distinguished in spawning aggregations on the basis of colouration, as well as behaviour. A study shows that after prior visual determination of sex by observing behavior and colour changes, gonad samples studied afterwards confirmed the 100% accuracy of this method of sex determination (Figure 4; Johannes, 1988).

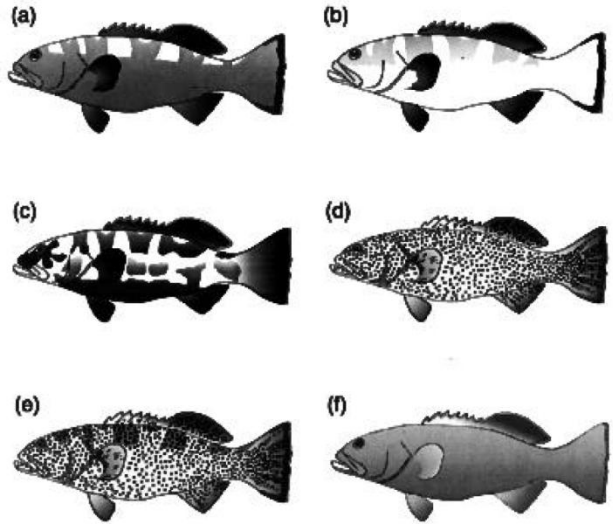

Figure 4: Sex associated colour differences.

(Johannes, 1988)

a. Barred phase: This color phase is seen in both males and females and is most pronounced when the fish is displaying aggression towards a conspecific.
b. Bicolor phase: Males often show this color phase when courting, moving around or fleeing from other, attacking males. Males become particularly pale when courting a female or when fleeing from an aggressor.
c. Camouflage phase: This phase can be seen in both sexes when fish is at rest and not obviously engaged in intense inter-specific interactions.
d. Yellow/brown phase: Only females exhibit this color phase. The body color is pale olive/brown and the body is clearly covered with small spots. This is the most typical color phase seen in females in spawning aggregations.

e. The yellow/green hue darkens the body of the female. It is usually seen when a female moves away from an approaching male or moves up into the water column.
f. When presumed females are moving about in schools in the water column and through the spawning aggregation, they can be extremely dark in color. Females were seen to adopt this coloration when moving in schools into or away from the aggregation

(Pet et al, 2005; Johannes, 1988)

4.3.7. Environmental Ranges

Parameter	Range
Nitrate (mg/l)	0.00- 0.01
Salinity (PPM)	34.32 - 34.78
Oxygen (mg/l)	6.34 - 6.55
Phosphate (mg/l)	0.01 - 0.02
Silicate (mg/l)	0.27 - 0.89

Myers. 1989; Pet et al, 2005; Randall and Heemstra 1991; Parrish 1987).Fishbase website, www.fishbase.org.
(http://www.fishbase.org/summary/Plectropomus-areolatus.html)

4.3.8. Known Geographical Distribution

There are 15 genera and 159 known species, of which 8 genera and 66 species are found in the Indian Ocean, Red Sea or Persian Gulf. Apart from a few places such as Australia and the Red Sea, *Plectropomus areolatus* have mostly been recorded in insular localities. *P. areolatus* is endemic to Australia, American Samoa, British Indian Ocean Territory, China , Cocos (Keeling) Islands, Djibouti, Egypt, Eritrea, Fiji, India, Indonesia, Israel, Japan, Jordan, Kiribati, Malaysia, Maldives, Marshall Islands, Micronesia, Myanmar, Nauru, New Caledonia, Palau, Papua New Guinea, Philippines, Samoa, Saudi Arabia, Solomon Islands, Somalia, Sudan, Taiwan, Thailand, Timor-Leste, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna and Yemen. The known places of occurrence of *P. areolatus* is marked on the map below in red (Figure 5).

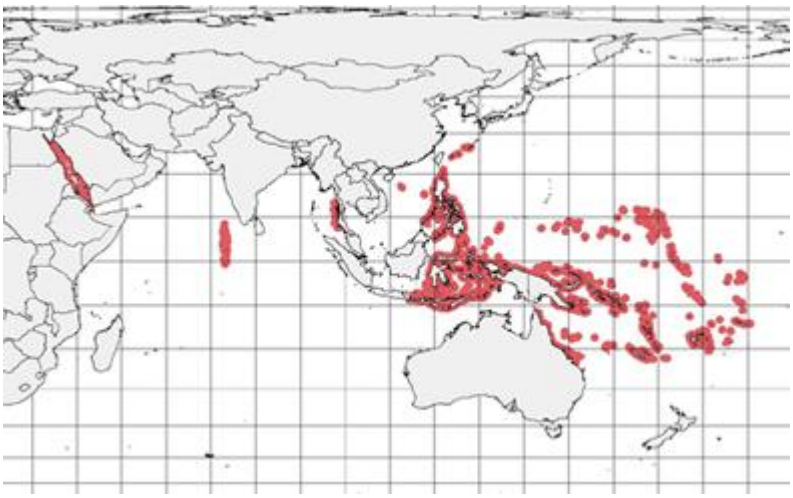

Figure 5:Geographical locations of P. areolatus.

As *P. areolatus* occurs naturally in Maldives, the import of fingerlings would not involve introduction on exotic species. This eliminates species invasion risks and reduces the chances of introducing new diseases.

(FAO Species Catalogue Vol.16. Groupers of the world (281 to 290))
http://www.scrfa.org/index.php/about-fish-spawning-aggregations/aggregating-species/the-squaretail-coralgrouper.html)

4.3.9. Conservation Status

In the IUCN (World Conservation Union) Red List, *Plectropomus areolatus* is included as 'vulnerable'. This is mainly due to its high demand and increased fishing pressure on its spawning aggregations. Greatest catches of this species are taken at spawning aggregations, as numbers are generally low during non-spawning times of the year. It is anticipated that the aquaculture of *P. areolatus* will eventually reduce wild-capture fisheries.

(http://www.iucnredlist.org/apps/redlist/details/64411/0)

4.3.10. History in Aquaculture

The FAO estimation for grouper production in 2004 was 60,000 tonnes. The grouper aquaculture industry in Asia is rapidly expanding, driven by high prices in the live fish markets of Hong Kong and China due to increase in population and individual wealth. In the past most grouper farms obtained their fingerlings from the wild, but due to over harvesting, the supply of wild fingerlings has become unreliable and unsustainable. Though quite a few species of grouper are cultured, only few are produced in hatcheries on a large scale. Most grouper grow out is conducted in marine cages in sheltered coastal areas and estuaries. Maldives has a long history in the grouper industry. Although local grouper farming is still in its infant stages, wild caught live grouper export to East Asian countries from Maldives have been continuing for more than 15 years.

There have been reported declines of *Plectropomus areolatus*, probably due in part to targeting spawning aggregations by commercial fishermen and because the species is highly valued in the international live reef fish trade centered in Hong Kong. Studies have also shown lower abundance of *P. areolatus* in heavily fished areas in Maldives compared to areas of less fishing intensity (Sluka, 2000). In this study, stocks of *P. areolatus* were estimated at 1600 tonnes. Although spawning can be induced in P. areolatus, it is not a common species used for commercial culture.

(Lau & Parry-Jones, 1999; Anderson et al, 1992, 1998; Sluka, 2000; FAO, 2004; Sadovy and Vincent 2002)

4.3.11. The Aquaculture Process

The proposed aquaculture is marine-based, and will consist mainly of floating sea cages. Later stages will involve land-based tanks. The project is to be executed in 3 phases. Phase I will be a duration of 2 years, Phase II will extend from year 3 to 5, and after the 5th year, Phase III will be the fully operational phase by which a hatchery and larval rearing facility will be established and running.

Phase I

Phase I includes the construction of the site and fingerling grow-out stages. It will involve rearing and grow-out from fingerling to market-size. This stage will eventually supply Brood Stock for Phases II and III. Fingerlings will be grown in vilu 1, and moved to larger cages in vilu 2 when they get bigger. Phase I is the main focus of this report.

Phase II

By the end of the 2nd year, Phase II will begin, where breeding trials will commence. Hatchery and larval rearing trials will be carried out on land, along with culture of larval feed. The project scale will be expanded in this phase, with the inclusion of vilu 3 and the addition of more cages and trials of new species for culture.

Phase III

After the 5th year, the mariculture project will be fully operational. Ideal species for culture would be identified and their complete life cycle would be closed within the facility.

4.3.12. Cages and Tanks

Tanks

Tanks will be located on the land facility and will initially be needed for quarantine purposes only. In later stages, tanks will be used for spawning/breeding, egg incubation, larval rearing and fingerling rearing until release into sea net cages. They will also be used to culture feed for larvae, including artemia and rotifers. Some tanks will be made of glass, others polyethylene basins of 200L capacity.

Net Cages

The net cages will be placed in the lagoon in Phase I. Later, for phase II and III, net cages will also be placed in lagoon, as the project expands. The frames are polyethylene with nets attached and hanging below. The frames can be buoys or floating gateways with walkways, or a combination of both. Standard size is 5x5m, although 8x8 and larger sizes are also used. For sorting, handling and maintenance purposes it is recommendable to have multiple cages of a standard size than to have large cages. Mesh size will differ depending on the size grading of the fish. The cages can be accessed easily via dinghies.

For the second phase of the project, a variety of tanks will be used on land for of egg-rearing, rearing of larvae, culture of larval feed and for nursery and quarantine purposes. Seawater will be pumped in from the pumping station, passing through a sand filter to remove unfavorable material from entering the tanks. The pump used will have a minimum capacity of 5hp. The seawater will first enter a holding tank, prior to entering the rearing tanks.

Larval-rearing

Fibre-glass tanks will be used for larval rearing inside the hatchery facility. These tanks will be rectangular in shape and have a depth of 1m, each with a capacity of 5-6m^3.

Culturing live feed

Microalgae tanks will be kept unroofed and situated outdoors. Each tank will have a capacity of 5-10m^3. Tanks will be made out of concrete or fibre-glass.

Rotifer tanks will be located indoors, though in proximity to the microalgae tanks. Polyethylene basins of 5-6m^3 capacity, with a typical diameter of 2-3m and depth of 1m will be used for rearing rotifer.

Brine shrimp (*Artemia*) will be hatched and grown in 100-200L polyethylene basins. The *Artemia* will be obtained from commercial suppliers.

4.3.13. Brood stock and Spawning

Brood stock will be imported, since the import of fingerlings is prohibited under the current fishery law, eliminating the need to catch wild fish for brood stock. Spawn can be caught from the cages with fine mesh nets during natural spawning events, according to the lunar cycle. Egg collection should be done in early morning hours during the embryonic stage.

4.3.14. Artificial Spawning

Brood Stock can also be selected and spawning may be induced. Before artificial spawning, brood Stock will be chosen after assessing their suitability and moved to breeding tanks on land. When the eggs in the female Brood Stock reach maturity and when males are able to release milt, they are ready for spawning induction by grouping the Brood Stock together during the correct lunar phase.

Eggs will be harvested with fine mesh nets and placed in 200L tanks. They will be stirred thoroughly and sinking eggs will be removed. Eggs will be dipped in iodine for disinfection. They will then be placed in flow-through incubator tanks with gentle aeration for 24hr incubation before being placed in larval rearing tanks.

4.3.15. Larval Rearing

Larval rearing tanks will be thoroughly cleaned and disinfected prior to stocking. Tanks will be half covered with shade material to reduce harsh direct sunlight. Seawater will be treated before filling tanks. This stage is sensitive and critical, and water quality parameters must be constantly monitored. Temperature, salinity and pH will be controlled throughout rearing period to suit conditions for larval growth and survival.

Larvae will hatch on the 5^{th} day. They will be stocked at 175000 individuals per 100L. Aeration should be low to prevent damage to the larvae. Larvae will feed on yolk for the first 2 days, so no external feeding will be required until then. Feeding larvae will be fed on rotifers and copepods, which can be imported, live and/or cultured. Culture of feed and water quality maintenance will be the biggest factors in ensuring the success of this stage.

4.3.16. Juvenile Rearing and Grow-out

Juveniles will be stocked at a low density of 10 Kg/m3, so as to minimize disease and increase quality and survival of fish. It is important to assess optimal stocking densities, as densities that are too low can increase aggressiveness of fish. Fish biomass can increase more than 80-fold during the culture period from weight gain. Survival rates generally increase as fish get larger. Market size (500-900g) will be reached 8-9 months. Groupers are generally sold live at a size range of 0.5–1.2 kg per fish, with the average weight for table-size fish being 850 g, requiring ready access to markets

4.3.17. Feeding

Groupers are carnivorous and prefer high-protein feeds. Most farms in the region use trash fish with low commercial value as feed. There is however environmental concerns of feeding trash fish, as fish waste can accumulate and alter the biochemistry of the area. It will also increase the risk of bacterial diseases. The proposed project will therefore considerably reduce these risks by feeding formulated fishmeals and employing efficient feeding methods. Commercially available feeds usually include additives such as essential fatty acids, amino acids, vitamins, minerals and oils. The input of such additives into the natural environment raises environmental concerns. This impact can be minimized by evaluating the correct feeding rates and by using floating pellets, which can be removed after the fish have finished feeding. They will be fed twice daily to satiation.

4.3.18. Culture of live feed

In a hatchery system, ensuring that larvae receive the correct type of feed depending on specific requirements of specific larval stages is essential. Live food is preferred over formulated feed, as commercial feed generally do not meet the necessary nutritional requirements, are difficult to digest and do not contain the necessary enzymes to allow for autolysis. Furthermore, it is important that the larvae develop their receptive organs and begin hunting live feed at its natural stages. Swimming feed triggers responses in the larvae, and also facilitates even distribution of feed throughout the tanks. (Lavens & Sorgeloos, 1996)

Three types of live feed will be cultured in the facility; microalgae, rotifers and brine shrimp (*Artemia*).

4.3.18.1. Microalgae

Phytoplankton comprise the base of the marine food chain, whereby making microalgae indispensable in closing the life-cycle of most marine species. Algae are used to produce zooplankton which feed on the algae, and in turn serve as food for larval stages of fish.

Starter cultures of microalgae such as *Nannochloropsis* will be obtained from commercial hatcheries or the Maldives Marine Research Centre, and microalga will be cultured in outdoor tanks. The microalga will be used for culturing rotifers.

4.3.18.2. *Rotifers*

Rotifers are essential for the first feeding, when larvae change from internal to external feed sources. Two types of rotifers are generally used in marine finfish hatcheries; 'super-small' or SS-strain rotifers are used for first feeding and slightly larger 'small' or S-strain rotifers are used after the first few days.

In order to provide adequate nutrition for the larvae, rotifers cultured on *Nannochloropsis* will be enriched with commercial enrichment media for 12-24hrs prior to culture. This will increase the levels of highly unsaturated fatty acids (HUFA) which is a requirement for fish larvae.

4.3.18.3. *Artemia*

Brine shrimp or *Artemia* nauplii will be used during the later stages of larval rearing. They will be obtained from commercial suppliers and hatched in indoor tanks. The brine shrimp will also be enriched prior to feeding the fish larvae.

4.3.19. Disease Control and Health Management

Disease is a major problem in aquaculture and results in significant losses every year. Proper prevention and management practices must be employed to minimize loss. Fish must be checked regularly for parasites, infections and diseases throughout the course of the project. Sea cage farms are known to act as parasite and disease reservoirs, as a result of overstocking and intensive production (Staniford, 2002). The proposed project aims to have minimum stocking densities and low nutrient loading in cages, which will considerably lower the risk of massive losses due to disease. For disease prevention, control and management, and thus minimal impact to the environment, the most important practice is quarantine. Throughout the entire mariculture operation, it is of utmost importance to strictly adhere to the relevant quarantine guidelines and best practices as outlined by the United Nations Food and Agriculture (FAO) (Arthur *et al*, 2008).

Quarantine

In aquaculture, quarantine involves maintaining an individual or group of aquatic animals in isolation, with no direct or indirect contact with other aquatic animals in order to undergo observation for a specified length of time, and if appropriate, testing and if appropriate, testing and treatment, including proper treatment of effluent water (OIE, 2006).

Stock Arrival

To prevent introduction and spread of disease, brood stock must be quarantined and holding water must be disposed of appropriately upon arrival. Restrictions on initial use of introduced or transferred aquatic animals provide the opportunity to detect any introduced diseases and pests and also increase opportunity for control and eradication. A set period 2 weeks of quarantine will be established as advised by the MARINE RESEARCH CENTRE. All brood stock will be periodically checked for signs of illness and abnormal behavior. The period of holding in the Quarantine Facility will depend on the results of observation and testing of the imported stock. The quarantine period can only be determined after taking into account the life history of the animal being introduced or transferred. When introducing aquatic animals, it is important to follow ICES code of practice on the introductions and transfers of marine organisms (ICES, 2005).

Infected Fish

Infected fish will be immediately removed and quarantined at any stage of culture to prevent spread of disease. Visible parasites will be removed manually, while bacterial infections and viral diseases have to be treated medically. Use of antibiotics should be refrained from unless necessary, as the continued input of antibiotics into the biosphere has resulted in the evolution of resistant strains of bacteria. This is a significant negative impact to the environment. Vaccinations and probiotics are preferable for disease prevention and control, respectively, although all such activities must be done while under quarantine and no type of medication shall be released into the ocean. Should a serious untreatable disease or pathogen be encountered in aquatic animals held in quarantine, the entire stock should be destroyed and the facility appropriately disinfected.

Dead Fish

All animals found dead on arrival or that die during the quarantine period should be placed in a labeled plastic bag as soon as possible and kept under refrigeration or preserved as specified by the Quarantine Officer until diagnostic examination can be completed. Dead aquatic animals should only be disposed of as directed by the CA. Aquatic animals that have died while under quarantine should held in an approved freezer, an approved refrigerator, or preserved using another method as specified by the CA until removed for laboratory examination or released for disposal by the supervising Quarantine Officer. Upon approval, dead aquatic animals should be disposed of by sterilization using of an approved autoclave, followed by incineration or deep burial. Commercial UV water treatment units operating in the spectral range of 190–280 nm (254 nm recommended) delivering doses of at least 130 mWs/cm^2 are required.

Effluent and Wastewater Disposal

All effluent and wastes generated by the quarantine facility should be treated in a manner that effectively destroys all pathogens. To ensure continuous operation and complete containment, quarantine effluent systems should equipped with reliable back-up systems. As treated effluent and waste may contain substances that are deleterious to the environment, they should only be disposed of in a manner that minimizes environmental impact. All effluents should be treated with chlorine treatment, heat treatment or UV treatment prior to disposal, according to the

guidelines outlined by FAO (Arthur *et al*, 2008). All marine wastewater discharged from the quarantine facility should directly enter a septic tank or be sterilised.

4.3.20. Further Candidate Species for Culture

Even though Phase I focuses on the culture of *Plectropomus areolatus*, the proponent aims to eventually expand the project to include more species. Candidate species include *Lethrinus obsoletus/olivaceous*, Emporers (Filolhu), *Coryphaena hippurus*, Dolphinfish (Fiyala), Spiny Lobsters (*Palinurus* spp.) and Sea Cucumbers *Holothuria* spp.

The co-culture of sea cucumbers and finfish has an environmental advantage. Sea cucumbers effectively act as a biological filter of sand during their feeding. As fish waste and feed waste accumulate below the cages, sea cucumbers can clean this, reducing chances of eutrophication and making them an ideal candidate for co-culture.

4.3.21. Waste Removal

Water and Sewage

If the water quality deteriorates, immediate action must be taken to avoid loss. Water should be aerated to increase dissolved oxygen and improve water quality. If there are excess nutrients in the water or if the water quality falls, there will be indications such as algal blooms, which lead to oxygen depletion and can cause death. As feed will be mainly floating pelleted feed, food waste will be minimal as uneaten pellets can be manually removed.

Wastewater and effluent from quarantine and hatchery facilities will be filtered and treated appropriately prior to disposal. As Gaaerifaru is an open reef system and due to its position in the channel, it is subject to strong currents, resulting in sufficient water exchange to allow for farming without the use of pumps. The strong currents in the area will aid in dispersal of waste from fish.

Sewage will be pumped out to deep water. The specific point for the outlet has been selected to allow for proper dispersal and dilution of the waste, to ensure minimal environmental impact.

Solid waste

Solid waste will mostly be generated from domestic and construction waste arising from activities by the construction workforce. It would be the Contractor's responsibility to ensure correct disposal of all construction-related waste and other waste during mobilization stages. Solid waste generated during the operational phase will be collected and taken to K. Thilafushi for proper disposal.

4.4. Jetty construction and deepening of channel

A jetty of 50 x 5 feet will be setup on the south eastern corner of the island for unloading and loading materials to the island. The jetty will be designed by using single pile T-blocks to reduce the impact on the coastal dynamics of the island.

4.4.1. Justification

The location of the jetty was chosen after taking into consideration that the area is currently used by the nearby islanders to access the island. The location chosen is already an accessible channel and however needs to be dredged about 1.5 m deep and widened so that larger vessels can enter in to the lagoon. The eastern side of the reef is known to be much calmer during both seasons which in term will make it easier for access and the works that need to be done. The location was chosen as it is close Lh. Hinnavaru making logistics much easier. The eastern side of the reef

will be protected due to comparatively large amount of reef systems nearby, and after consulting with the locals and the island council this side of the reef was chosen.

4.4.2. Methodology

The channel area will be dredged by sand pumps. Using GPS coordinates; the four corners of the area will be identified. Ropes will be used to mark the lines and bathymetry will be done during dredging period to justify the depth inside the channel.

There are no large corals in the area and sea grass patches can be found within the jetty area. All the existing corals in the area will be moved by hand to the area where the cages are located and will be used as homes to the fishes inside the cages. The corals will be moved by using air bags or plastic buoys. The bottom of the coral will be dug and then lifted up by hand, and then the buoys will be used to assist to lift them to the dhoni. Once inside the dhoni they will be sprayed salt water until they reach their destination. Much care will be given not to damage the corals during the moving process..

Approximately 2500 cbm of sand can be dredged from this area. The current depth during high tide in this area is at 1.5m. The channel needs to be deepened up to 3m for larger vessels to go inside the lagoon. Therefor the channel needs to be deepened by another 1.5m. The sand that will be taken from the channel area will be used to reclaim the land which will be used to construct the structures.

4.4.3. Duration

It is estimated that it would take about 2 month for the works in the channel area and the jetty.mConsideration has been given to reduce the amount of machineries used since the impact on environment will be more. Approximately 20 people will be used. Local people from the nearby island of Lh. Hinnavaru will be used as labor and Dhoni's will be hired from Lh. Hinnavaru as well. No temporary housing will be required as local people from Lh. Hinnavaru are selected, and it's a 10 minute dhoni ride from Lh. Hinnavaru to Lh. Gaaerifaru.

4.5. Reclamation

Approximately 2 hectares of land will be reclaimed. This is to compensate for the loss of land area due to sand mining from Lh. Gaaerifaru beach from the nearby islanders. It is recorded at around 5 hectares according to Fisheries Ministry however the survey results show that the island currently is approximately 2.3 hectares. There for much consideration was given to reclaim land to build the facilities, while preserving a larger area of the main land.

4.5.1. Quantity

An average depth of 1.5m was observed within the reclamation area, and the client wishes to keep the island height at 1.5m above sea level. Therefore when the quantity of sand required for reclaiming a 2 hectare area, is calculated at an estimated 35,000 cubic meter of sand. This was based in the concept under development by the proponent. The borrow area shown on the figure 9 has the capacity to provide the required amount. And details of bathymetry can be seen in chapter 6.

4.5.2. Methodology

A sand pump will be used to reclaim the land required for the new developments. The flow rate of the pump is at 10-15 Cbm/ hour. The power source is 50Hz/380V three-phase alternating-current supply, and the capacity of the substation transformer is two to three times of the rated capacity of the motor. The submerged depth of the unit is not more than 20 meters, and not less than 1 meter. The unit works in the medium vertically, and the working status is continuous, however the pump will be used a maximum of 10 hours a day. This it to reduce the strain on the

machinery and to make sure the pump gets maintained and kept in good condition. A 30KW water cooled generator will be used to power the sand pump during reclamation works.

Setting out of the reclamation area will be done prior to commencement of works. A GPS and a total station will be used to do the setting out of the boundaries of the reclamation area. Leveling works will be done during reclamation period. A bund wall will be setup before the pumping works and silt nets will be deployed around the area to reduce the amount of silt spreading onto the reef during pumping period. Monitoring of status of the nearby reef will be done daily.

4.5.3. Duration

The reclamation works will begin as soon as an approval is given for the project by EPA. It is estimated that reclamation works will take not more than 3 months.

4.5.4. Labour

It is estimated that not more than 6 staff will be required during the reclamation period. And their accommodation will be arranged in the island of Lh. Gaaerifaru in the temporary housing units.

4.5.5. Location of borrow area

Please find below (Figure 6) the location and size of the borrow area.

Figure 6: Location and size of the borrow area.

4.5.6. Justification

The location chosen had mainly sand and some sea grass was observed. The area had less corals and the impacts will be less on the environment. The average depth of the area chosen is about 1.7m. Although the borrow area is far from the reclamation area and the work load will be high, the impacts on the environment is comparatively less when taken from the nearby areas where there are plenty of corals. Much consideration was given to the fact there is a famous diving spot on the house reef and the borrow area was selected 150m away from the dive site where it will have a minimal impact.

4.6. Power Supply and Oil Storage

4.6.1. Diesel Power

A sound proof Volvo Penta 200 KW/250 KVA water/air cooled, 3 phase generator will be used as the main generator on the island. And 2 Volvo Penta 100KW/ 150KVA water/air cooled, 3 phase generators will be used as backup generators to power the island.

4.6.2. Solar Power

The project is designed to operate some of the electrical items on solar power on the island. Specially lighting, which use a smaller amount of energy, compared to the other high electricity consuming appliances. It is estimated that about 30KVA of power will be required to operate the lighting system on the island. 3ft x 9ft, 10 panels (3 KVA/ hours) will be installed on the roof of the buildings. A photovoltaic system typically includes an array of solar panels, an inverter, and sometimes a battery and or solar tracker and interconnection wiring. The panel system takes about 80 Sqm of space on the roof.

4.6.3. Fuel transportation technique and volume required

At all times 10,000litre of diesel will be available on site during operations. The fuel required to run the generators will be stored in a large steel tank with a capacity of 10,000 litres. The main engine requires 204 litres/ hour at maximum load and the backup generators requires 84 litres/ hour of diesel for it to generate at maximum load. The tanks will be filled with diesel from the drums or by using the oil barges. Given the relatively large quantity of fuel required for the island it is expected that this method will be the most practical.

4.7. Waste management plan

4.7.1. Solid waste

Solid and hazardous waste management has recently been identified as one of the greatest environmental challenges in the Maldives. It is a serious issue for small island states such as the Maldives where space is limited and the islands are spread over a large geographical area, making it difficult to implement waste management strategies.

In the case of Gaaerifaru, during operations the amount of solid waste created daily is estimated to be very low and does not require conventional methods of waste management, such as incineration. Therefor all the solid waste and biological waste will be taken to Lh. Naifaru where there is a waste management centre. However hazardous waste such as waste from processed sea cucumber will be disposed off according to the guidelines approved by Marine Research Center, which is to bring the waste to K. Thilafushi or dispose them by sinking into the deep ocean in plastic barrels.

4.7.2. Sewage Disposal

Sewage and waste water disposal systems, especially on very small islands, are possibly as important as the water supply distribution systems for protection of public health. The potential

risks associated with inefficient treatment and/or improper disposal of effluent are enormous and hence serious sources of concern. It can contain a high percentage of impurities that can jeopardize the health of humans and animal life.

Disposal of improperly treated water is one of the major sources of coral reef destruction throughout the region. This is due to three main factors, which are the high biological oxygen demand (BOD) of the untreated water, the toxicity of certain released compounds and the eutrophication due to increased nutrient, which favour other organisms than those typical of the natural environment. Respiratory rates of tropical organisms are high and they live close to their lower oxygen limits. Sewage represents a great danger to these communities because oxygen-consuming substances in sewage decrease the availability of oxygen to the organisms in the ecosystem. Ammonia or nitrites are toxic to fish and other animals. Nitrogen compounds like nitrates or phosphorus, even though not toxic, are enhancing the growth of algae, causing eutrophication. It would also seem that in some cases, where water is stagnant near the shore, watering the gardens with treated water increase the growth of seagrass in these areas. In the present case this is of particular importance as seagrass is already present virtually all along the shore, and that the proponent wishes to try and get rid of it.

Therefore pollution by sewage decreases the diversity of species of corals and other reef organisms and enhancing overgrowth of algae competing with corals for substrate space to settle.

Considering the importance of the issue, the sewage and wastewater scheme at the Lh. Gaaerifaru will focus on minimizing impacts on the environment and not only the obvious ones, by strategically employing best practices to dispose of effluent.

4.7.3. Overall Scheme

Effluent water from all buildings and all the sewage in Lh. Gaaerifaru will be collected to collection tanks and then pumped out into the sea from a sea outlet. Before pumping out the sewage, it will go through a motor which reduces the size of the sludge for easy mixing with the water. The outlet pipe will be at a depth of 30m outside the reef slope.

5. Project Management

The proposed project will be carried out in two phases, Phase 1, Phase 2 and Phase 3, after which a functioning mariculture facility will be established at Lh. Gaaerifaru, which includes sea cages and a land-based hatchery system. This section addresses the management of specific components of the project.

5.1. Phase 1.

5.1.1. Jetty and channel dredging

The jetty will be constructed during phase 1 and will be used during construction period for access to and from the island for workers and for allowing large supply vessels to approach the island for loading and unloading of materials and waste.

A channel 30 x 10 m will be dredged in the southern side of the reef. This will be used to bring in construction materials and the sand pump during construction period. The location was chosen as it is already an existing channel.

5.1.2. Reclamation

Aproximately 20,000 sqm of area will be reclaimed as an extension to the existing island. Vegetation will be used to increase the aesthetics, in particular species such as magoo (*Scaveola maritima*) and kuredi (*Pemphis acidula*). The reclaimed area is marked hatched in red in Figure 11.

Figure 7: Reclamation area.

5.1.3. Shore Protection

The island is losing sand due to over mining of sand. Groynes of 50 x 3 x 2 m will be laid on the North and south eastern side of the island on the lagoon 25 m away from the beach line for shore protection. The groynes will be placed in an angle of 60 degrees, in a north east direction along the northern shoreline and Northwest direction along south eastern shoreline. Please refer to site plan in Figure 1 for the location of the groynes. The groynes will be built using wire mesh and dead coral collected from the lagoon and if necessary from imported rock boulders. All the groynes will not be visible during the low tide.

5.1.4. Accommodation Blocks

Three accommodation blocks will be setup during the first phase, one for the senior staff and two more for the junior staff. A total of 1,800 sqm area will be allocated for the senior staff and for the junior staffs.

5.1.5. Owners Bungalow

A bungalow consisting of an area of 600 sqm will be constructed for the owner on the island.

5.1.6. Power house and R.O Plant

The main generator will be used to power all construction activities and domestic areas, and will also be used during operations. The two smaller generators will be used as back-up under circumstances where the main generator is out of service or undergoing maintenance. A constant supply of power is essential for such a project, especially in maintaining optimal conditions in the hatchery system as well as maintaining temperatures in the packaging facility to ensure freshness of processed fish. The fuel required to run the generators will be stored in a large steel tank which will be filled directly from fuel-drums or using the oil barge from K. Male'.

During construction phase rainwater will be collected in three 5000L polythene tank for domestic use, mainly due to the fact that the island of Gaaerifaru does not have a water to accommodate such a huge project. A first flush (foul flush) device will be implemented to direct the initial lot of rainwater away from the tank to prevent debris from entering the water collection areas and into the tank. Rooftop surfaces, gutters, pipes and drains will be frequently cleaned to avoid contamination and the storage tanks will be inspected and cleaned regularly. The tanks will be covered and ventilated to avoid breeding of mosquitoes, limit growth of algae and to prevent insects and rodents from entering the tank. Water will be drawn from the tanks using a pump system.

Once the R.O plant is setup and during operations the whole island will be using water from the R. O plant. A 10 ton capacity R.O plant will be setup on the island and 2 x 5000 litre polythene tanks will be used to store water processed from the plant. Additional 2 more polythene tanks will be used as backup tanks that will be filled all the time for emergencies or under required circumstances. Until the R.O plant is setup and in operations, bottled water from the main water supply of Maldives (MWSC) will be used as drinking water.

5.1.7. Processing and Packaging Plants

The processing and packaging facility will be operational from the project's initial stages and will continue throughout the course of the project. Harvested fish will be processed and packed according to the customer's requirements. Fish can be sold live, chilled/frozen, filleted and/or packed prior to dispatch. The most important factors to consider when choosing most appropriate method of dispatch include method or means of transport and duration of transport from the point of dispatch to its final destination.

The packaging of fish will be done in an air-conditioned room where humidity is being kept under control. The fish will be vacuum-packed in plastic if buyers require it, and then piled in Styrofoam boxes. Once packed, the boxes will be stored in the storage area.

5.1.8. Sea Cages

Sea cages are kept in the lagoon of Lh. Gaaerifaru. It is made up of polyethylene-frames with nets below. The frames can be buoys or floating gateways to walk on (Figure 12), or a combination of both. Standard size is usually 5x5 m, but they can be converted to larger compartments, for example 10x10 m, 20x20 m or even more. Below the frames are nets. They can be of different depth and mesh size.

Typically small fish from the tanks come to a cage with small mesh-size. After having reached a certain size they are transferred in a larger cage with large mesh-size (typically 2 inch) for grow out.

Sea cages both floating and fixed will be setup in the lagoon for growing the cultured species. 30 floating sea cages 3 x 3 m will be set up in the lagoon for the first phase. 20 fixed cages of 5 x 5 m will also be set up.

5.1.9. Office and Recreation

A 900 sqm land area will be allocated for Office and administrative blocks and recreation facility which will include a small cinema area and gym.

5.1.10. Staff Kitchen and Mess

A staff kitchen and mess will be catering a total of 100 people during construction and 60 people during operations will be setup on the island.

5.1.11. Sea water Inlet and Outlet

Sea water will be used for stocking and rearing seeds, larvae and juvenile fishes in tanks. The total seawater required for the grow-out tanks will be 250 tons per filling cycle. Sea water will be regularly exchanged. Water will be pumped from a storage tank which collects seawater through an intake pipe of about 300 m length. The overall intake will be 250 tons, whereas the output will be about 125 tons. Sewage and waste water will be pumped out with the seawater through the outlet pipe (refer to site plan in section xx for location).

5.2. Phase 2

5.2.1. Hatchery facility

During Phase 2 of the proposed project, a hatchery facility equipped with the technology for breeding, egg incubation and larval rearing will be established on the island of Lh. Gaaerifaru.

5.2.1.1. *Tanks*

For the second phase of the project, a variety of tanks will be used on land for of egg rearing, rearing of larvae, culture of larval feed and for nursery and quarantine purposes. Seawater will be pumped in from inlet pipes extending out to sea 300m south of the island. The seawater will first enter a holding tank, prior to entering the rearing tanks.

5.2.1.2. *Larval-rearing*

Fibre-glass tanks will be used for larval rearing inside the hatchery facility. These tanks will be rectangular in shape with a depth of 1m, each with a capacity of 5-6m3.

5.2.1.3. *Culture of live feed*

Microalgae tanks will be situated outdoors and kept unroofed. Each tank will have a capacity of 5-10m3. Tanks will be made out of concrete or fibre-glass. Rotifer tanks will be located indoors, but will be situated close to the microalgae tanks. Polyethylene basins of 5-6m3 capacity, with a typical diameter of 2-3m and depth of 1m will be used for rearing rotifer. Brine shrimp (*Artemia*) will be obtained from commercial suppliers and hatched and grown in 100-200L polyethylene basins.

5.2.1.4. *Hatchery equipment*

An aquaculture hatchery facility must be kept under controlled conditions at all times, especially with regard to temperature and light levels. As the optimum water temperature for marine finfish hatcheries in tropical regions is between 26-30C, a heater would not be required given that the local seawater temperature is within this range year-round. Light is essential for larvae to hunt, thus artificial lighting will be used to aid in maintaining a constant environment for rearing. 40-watt fluorescent tube lights will be fitted 30-50cm above water level in all larval tanks.

A clean source of water is essential for hatchery systems. Poor quality water includes water with high turbidity, high nutrient loads, variations in salinity and water high in pollutants. Seawater will be pumped in from the pumping station and pass through a sand filter to remove unfavorable material prior to entering the tanks. The pump will have a minimum capacity of 5hp.The hatchery will be fitted with an aeration system with 100watt air-blowers. Other equipment that will be used in the hatchery facility includes microscopes, nets, sorting cups, pumps, siphons, buckets. The back-up generators set up in the island's powerhouse will be connected to the hatchery system to prevent the risk of massive losses of larval stock.

5.2.2. Sea cages

Additional sea cages both floating and fixed will be setup in the lagoon for growing the cultured species. 30 floating sea cages 3 x 3 m will be set up in the lagoon for the first phase. 20 fixed cages of 5 x 5 m will also be set up.

5.2.3. Ice Plant

An ice plant with a capacity of no less than 5 tons will be setup on the island. This is to help in maintain the quality of the product processed on the island.

5.3. Phase 3

5.3.1. Research Facility

A fully operational research facility will be setup during the third phase on the island. The facility will do research on potential aquaculture species and feed.

5.3.2. Sea cages

Additional sea cages both floating and fixed will be setup in the lagoon for growing the cultured species. 30 floating sea cages 3 x 3 m will be set up in the lagoon for the first phase. 20 fixed cages of 5 x 5 m will also be set up.

5.4. Schedule of works

Please find below (table 3) thee table of the schedule of works for the proposed developments in Lh.Gaaerifaru.

Table 3: Schedule of works.

Activity		Month									
		1	2	3	4	5	6	7	8	9	10
Site preparation and Mobilization	Mobilization of materials										
	Staff recruitment										
Construction phase	Reclamation										
	Shore protection										
	Accommodation Blocks										
	Owners Bungalow										
	Power Plants and R.O Plant										
	Packaging & Processing Facility										
	Sea cages										
	Office and Recreation Facilty										
	Staff Kitchen and Mess										
		11	12	13	14	15	16	15	16	17	18
Operational Phase to be continued until the end of lease period	Decommissioning phase										
	Staff training										
	Spawning and growing of fingerlings										
	Processing, dispatch and export										
	import of second generation fingerlings										
		19	20	21	22	23	24	25	26	27	28
	Spawning and growing of fingerlings										
	Processing, dispatch and export										
	Process to be repeated: spawning and growing of fingerlings, dispatch, process, export and import										

6. Description of the environment

Gaaerifaru is located on the eastern side of a reef system which is located on the north western side of Lhaviyani Atoll and extends in a north south direction. It is a large reef system with an approximate length of 1.7 km. Swell waves break on the northern rim of the system, driving sediment in a north south direction.

Figure 8: Sattelite Image of Lh. Gaaerifaru

The reef system has 2 large channels on its eastern side and western side *named Hinnavaru Kanduolhi* and *Gaaerifaru Kanduolhi* respectively. To its North, is a sea that gets very rough with small but frequent wave distance known as the *Alihuraskandu.* Thus the swell entering Lhaviyani Atoll will be much more significant on the northern face than on the south.

A field survey trip was made from the 25th January 2016 till the 3rd of February 2016. Baseline data was collected for the following.

- Bathymetry of the study area.
- Wind
- Waves
- Current
- Benthic Survey
- Terrestrial flora and Fauna

Bathymetry was done using a hand held echo sounder and a GPS and a total station. All the data are then analyzed and process using professional software (Surfer), to make contour maps.

Wind Speed during the survey period was measured using a hand held Vane Anemometer. However the data is site specific and data from Meteorological center has been used to justify the study results.

Wave data was taken from real time satellite data from the Ocean Motion website to identify the wave speed, direction and height. Site observation was used to identify site specific data.

Current speed and direction was measured by observation. A floating object (piece of wood), a timing device and a compass were used to measure the speed and direction of the current. Satellite data is used to explain the flow of the current in a more large scale.

Benthic Survey was done by taking photo transects and processing them using a software called CPC, which randomizes the output results for given parameters.

Temperature, Rainfall and Humidity data was collected from National Meteorological Center.

Terrestrial flora and fauna, data was collected by taking photos of the vegetation and tree transects and mainly by observing the environment.

6.1. Climate

Maldives is located at the equator and experiences monsoonal climate. Maldives has two distinct seasons; dry season (northeast monsoon) and wet season (southwest monsoon). In these two seasons the temperature varies hardly. Northeast monsoon extends from January to March. Since Maldives consists of small islands and are surrounded by seas, hot days are often tempered by cooling sea breezes and balmy evening temperatures. Throughout the year, temperature remains almost same in the Maldives. The wet season- southwest monsoon runs from mid-May to November. In this season Maldives experiences torrential rain. The fact that the Maldives is located at the equator, Maldives receives plentiful of sunshine throughout the year. On average Southern atolls (Gan) of the Maldives receives 2704.07 hours of sunshine each year. Furthermore, on average central (Hulhule) parts of the country receives 2784.51 hours of sunshine per year – *National Meteorological Center*

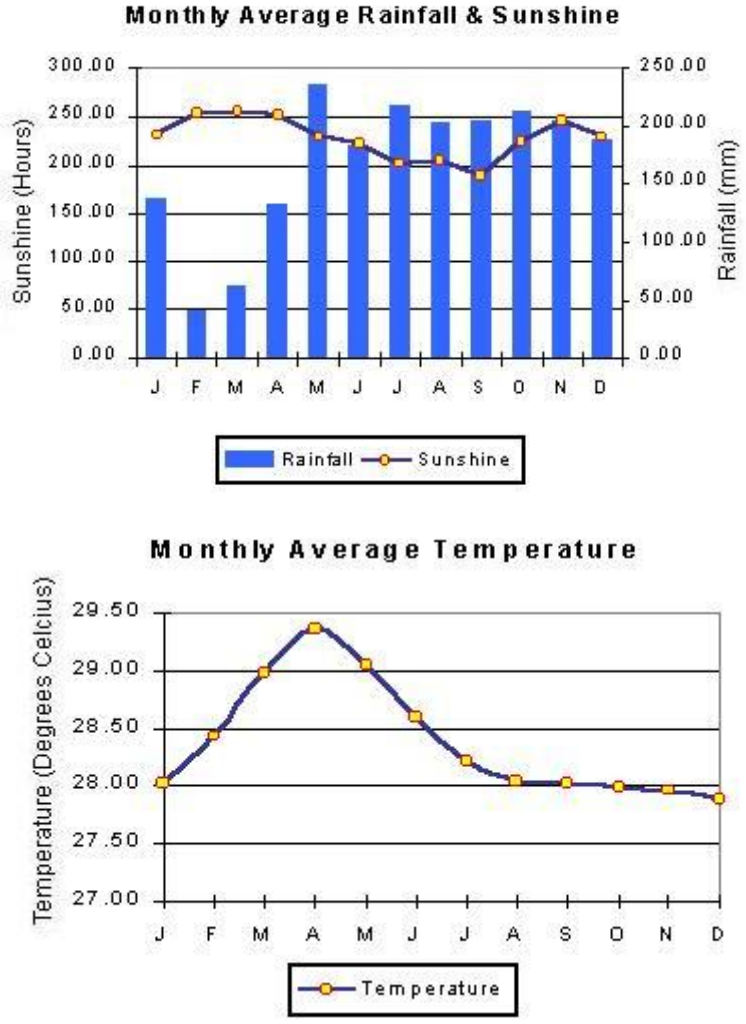

Figure 9: Average temperature and rainfall for the maldives.

6.1.1. Temperature, Rainfall and Humidity

Climate data collected by the Department of Meteorology at the Male' International Airport at Hulhule was used to construct the following graph (Figure 10).

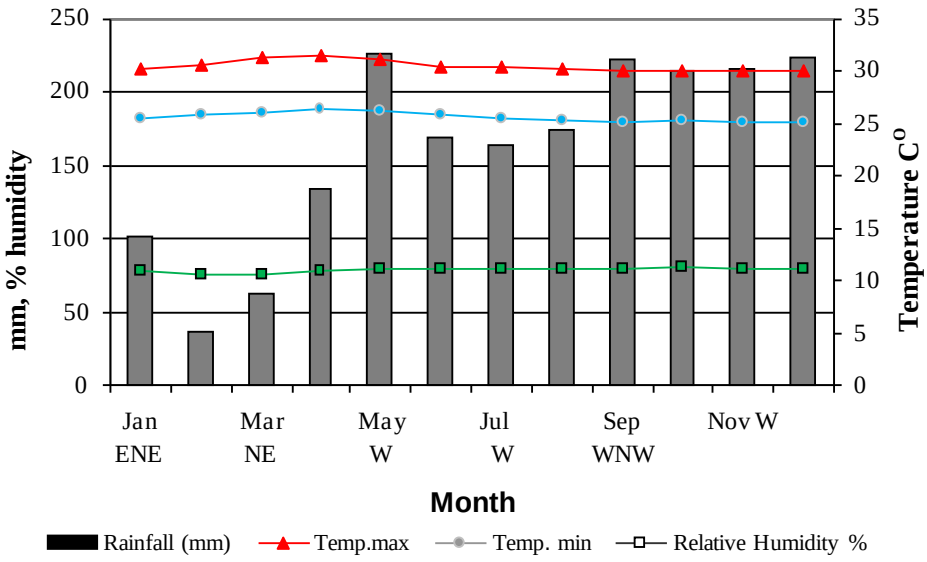

Figure 10: Monthly averages for temperature, rainfall and humidity measured at the Male' International Airport at Hulhule

Source: Department of Meteorology

Data for the last ten years obtained at the Male' International Airport at Hulhule show that the monthly mean maximum temperature was relatively constant all year long at around 30.5 °C. The months of March, April and May are slightly warmer, at around 31.5 °C.

With an average of 1940 mm of rain per year, the central part of the Maldives experiences a norm amount of rain compared to the Northern and Southern parts. The averages are 1630 in Hanimaadhoo, 2320.7 in Kadhdhoo and 2373.4 in Addu Gan. The records from Hulhule Hanimadhoo show that the number of rainy days (days with more than 0.3 mm of rainfall) is also an average of that in the Northern and Southern atolls. With 154 days of rain in average, this compares to the 134 days recorded in Hanimaadhoo, the 158 days from Kadhdhoo and the 164 days in Addu Gan.

6.1.2. Wind

When considering the Maldivian environment, the single most important piece of information is the winds. Waves would of course, also be important, but so far this data has been difficult to locate or utilize. On the other hand, satellite wind data is readily available in workable format.

The following graphs (Figure 11, 12) are a result of the analysis of satellite scatterometer data that give surface winds. These gridded wind fields, referred to as MWF product, are computed from SeaWinds on QuickSCAT scatterometer with individual observations provided by JPL/PO.DAAC (Level 2B data). The following Data shows the mean wind speeds from year 1999 to 2009.

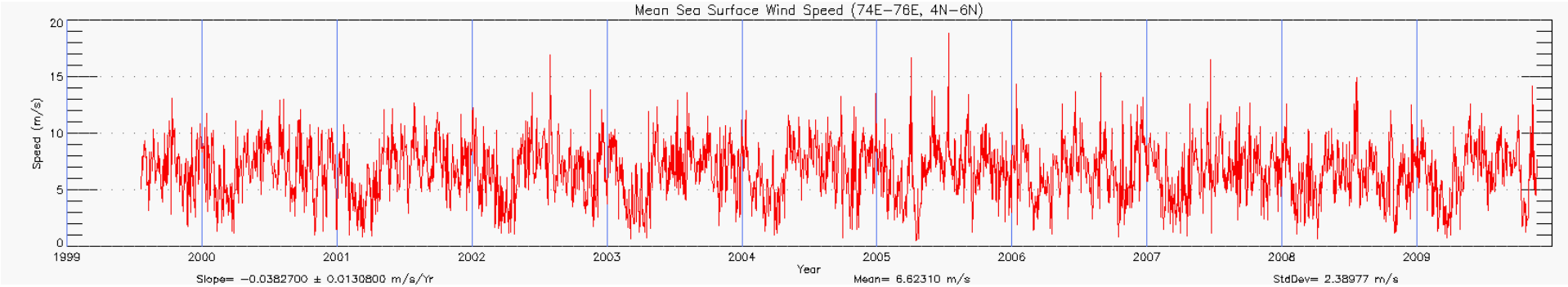

Figure 11: Average annual wind speed.

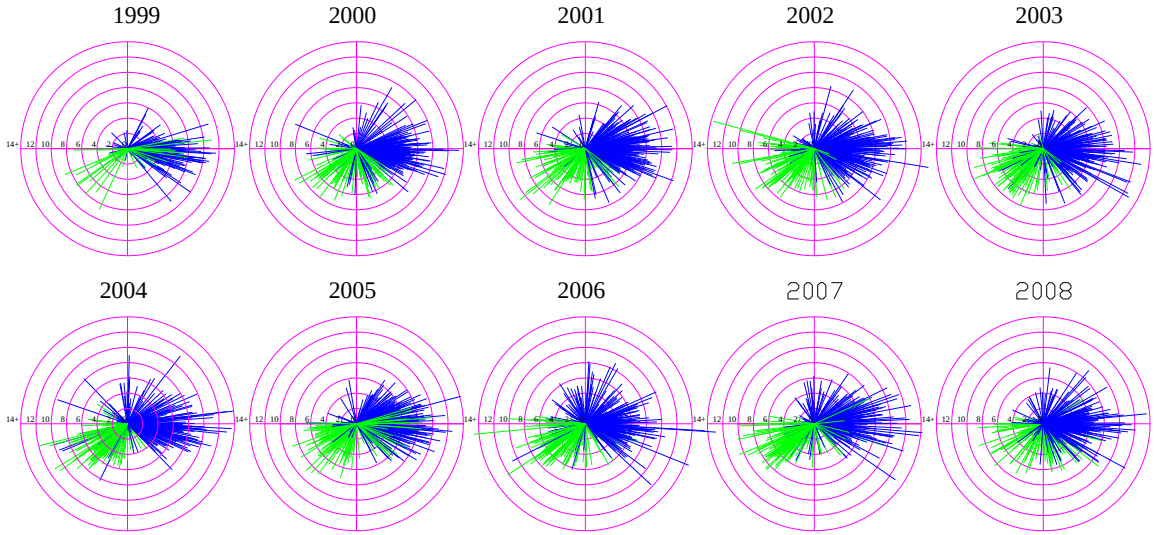

Figure 12: Wind rose showing the annual wind direction and the speed in km/h.

The wind heavily depends on the monsoons in the Maldives. During the North-east monsoon the winds come mainly from a NE direction, and during the South-west monsoon the winds come mainly from a SW direction, however the wind direction changes during transition periods of the monsoon. And as shown in Figure 12 the wind is not predominant throughout the year.

6.1.3. Waves

Wave data around the reef was taken by observation and satellite data was incorporated to come up with a conclusion.

An oceanic swell was observed coming from the north eastern side and wind-generated waves were observed coming from a north, north western side during the survey period. The swell that comes from the eastern side is a major swell generated in the Indian Ocean and is channeled through in between Lhaviyani and Noonu atoll, is a consistent wave which affects the reef throughout the year and plays a vital role in the coastal dynamics of the island.

Figure 13: Wave direction during survey period.

No oceanic swell was observed on the South western side as Lh. Gaaerifaru is fairly protected from the swells due to the vast number of reef systems inside Lh. Atoll. However wind generated waves were observed and were fairly small in scale (Figure 13). Figure 14 shows the sea topography in the region of Maldives taken from the Ocean motion website.

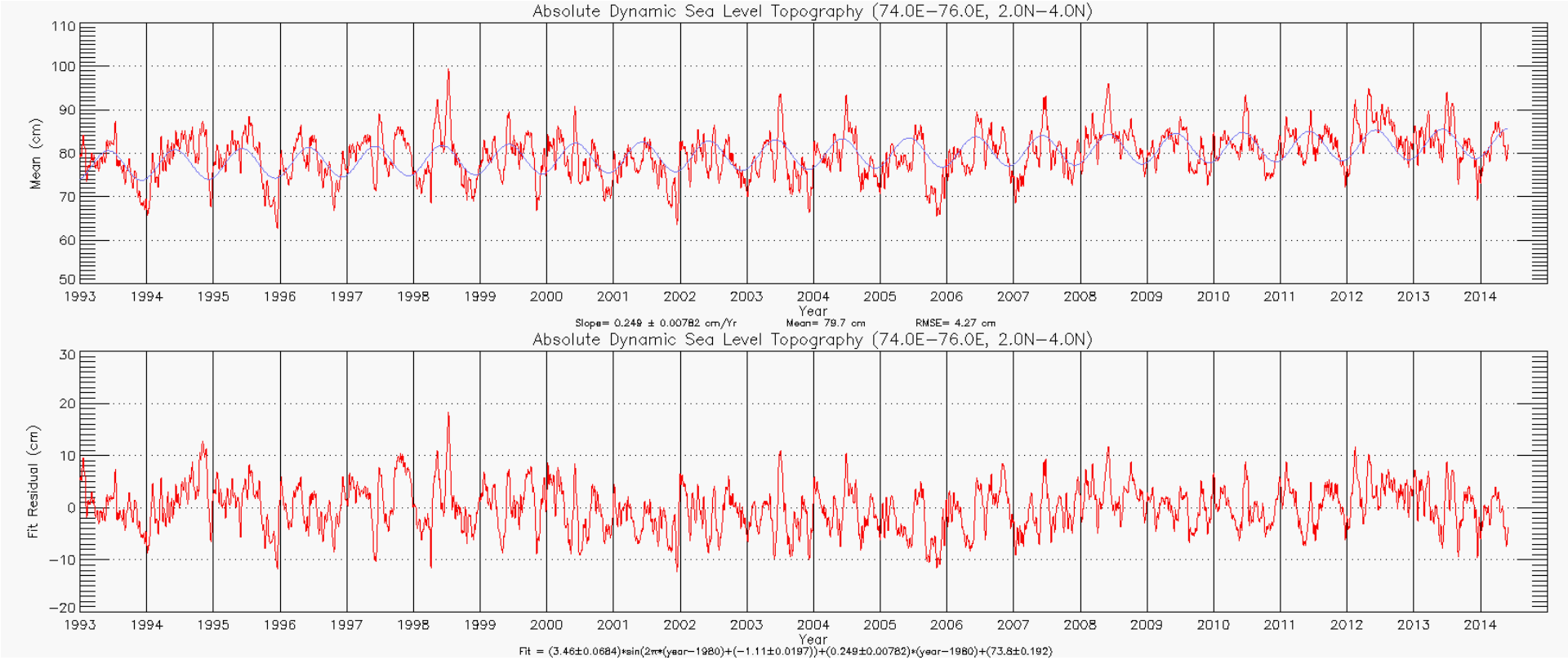

Figure 14: Wave height for the region of Maldives

6.1.4. Currents

During the survey period it was noticed that the current around and inside Lh. Gaaerifaru is fairly strong. This is noticeably a good thing as it is important to have strong currents to flush out the nutrients created from the fish waste. Satellite data images were taken from the ocean motion website to identify the current speed and direction for a larger area in order to understand the impact of currents on a large scale.

A conventional method was used to measure the current speed in the area. A small wooden piece, compass and a timer was used to measure the speed and direction. Please find the results in table 4, locations in Figure 16 and the GPS coordinates in 15.

Table 4: Shows the current speed at 2 location at different times of the day.

Date	Time	Location	Speed m /s	Current Direction
31/1/2016	9:00:00 AM	C1	0.72	NE
	12:00:00 PM	C1	0.91	N
	15:00:00 PM	C1	0.78	S
	9:30:00 AM	C2	0.55	NW
	12:30:00 PM	C2	0.28	NNW
	15:30:00 PM	C2	0.93	S
01/2/2016	9:00:00 AM	C1	0.81	NNE
	12:00:00 PM	C1	0.38	N
	15:00:00 PM	C1	0.94	SE
	9:30:00 AM	C2	0.75	NNW
	12:30:00 PM	C2	0.22	N
	15:30:00 PM	C2	1.33	SEE
02/2/2016	9:00:00 AM	C1	0.69	E
	12:00:00 PM	C1	0.37	NEE
	15:00:00 PM	C1	0.82	SE
	9:30:00 AM	C2	0.73	NNW
	12:30:00 PM	C2	0.25	W
	15:30:00 PM	C2	1.3	SSW

C1		C2	
Easting	Northing	Easting	Northing
73°24'16.63"	5°29'11.10"	73°24'7.07"	5°28'49.96"

Figure 15: GPS coordinates of the surface current test

Figure 16: Location map of the current speed test.

The current regime and sediment transport around the reef system is fairly visible compared to other Maldivian islands. This is mostly due to the size of the reef system, its elongated shape, and the cover from the nearby reef systems. On the northern side, the flow regime is dominated by the oceanic swells crashing on the reef rim, whereas the southern side is dominated by the inter atoll waves created by winds. The monsoon winds have some significant factors affecting the coastal dynamics of an island in the Maldives, in the case of Gaaerifaru, the impact can be less as the island has cover from the oceanic swells coming from the ocean; hence the main factor can be wind waves during both monsoon.

6.2. Bathymetry

Bathymetry was done all around the reef system to get a better understanding of the depths inside and around the reef system. The depths would help in identifying the best locations for the cages, jetty, location of the reclaimed island and the jetty. Please find the contour map (Figure 17) of Lh. Gaaerifaru from the processed bathymetry data.

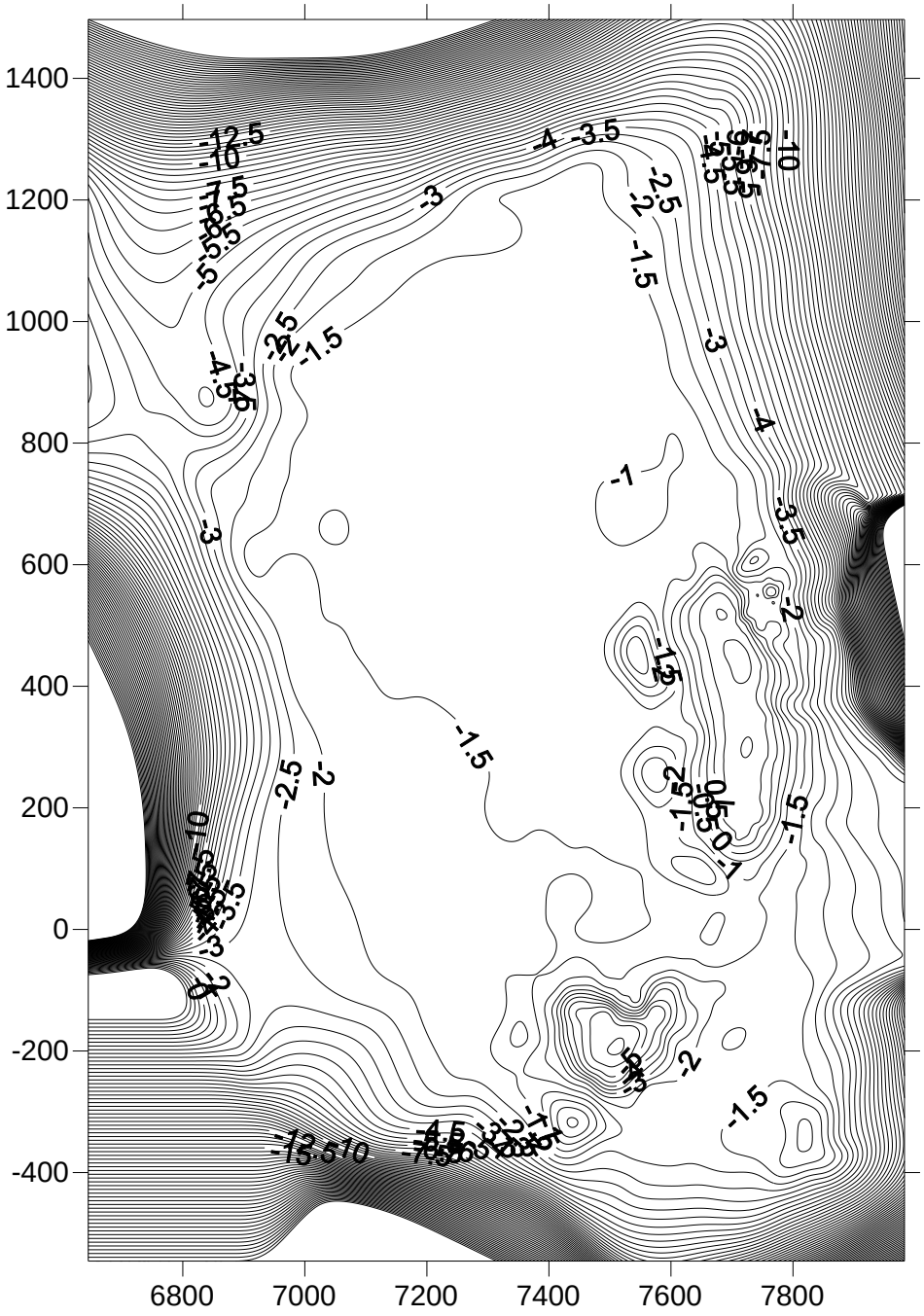

Figure 17: Bathymetryof Lh. Gaaerifaru.

The eastern side of the reef has fairly large number of corals, however the location identified to be reclaimed does not have any corals and it was observed that this area consists of sand. Therefore the impacts during reclamation will be minimal.

6.3. Marine Environment

Slight alterations to the marine environment can bring about significant impacts, particularly to fragile systems such as coral reefs. As a project such as mariculture will alter the biology and chemistry of the area to a certain extent, it is important to make an initial assessment of the reef and lagoon around the area to allow for proper monitoring and mitigation to be carried out. For this purpose, fish counts and coral and substrate analyses were undertaken, mainly focusing on the areas likely to be impacted.

6.3.1. Methodology and Results

For fish, substrate and coral surveys, 4 transects were taken were taken in total. This includes T1 (deep lagoon), T2 (Sea outlet pipes), T3 (borrow area) and T4 (reclamation area). The transect locations are marked on the image below (Figure 18) and the GPS Coordinates are given in Table.5

Figure 18: Location of the transect points.

Table 5: GPS coordinate points of the transect location.

TRANSECT	UTM zone 43	
	Easting	Northing
T1	73°24'7.57”	5°28'50.24"
T2	73°23'58.49"	5°28'54.66"
T3	73°24'1.03"	5°29'35.10"
T4	73°24'6.66"	5°29'16.46"

It was observed that T1 (Figure 19) had mainly sand and rubble in the area. A few corals of specie *poritis sp* were observed in this area. This is the deep lagoon in the southern end of the reef system.

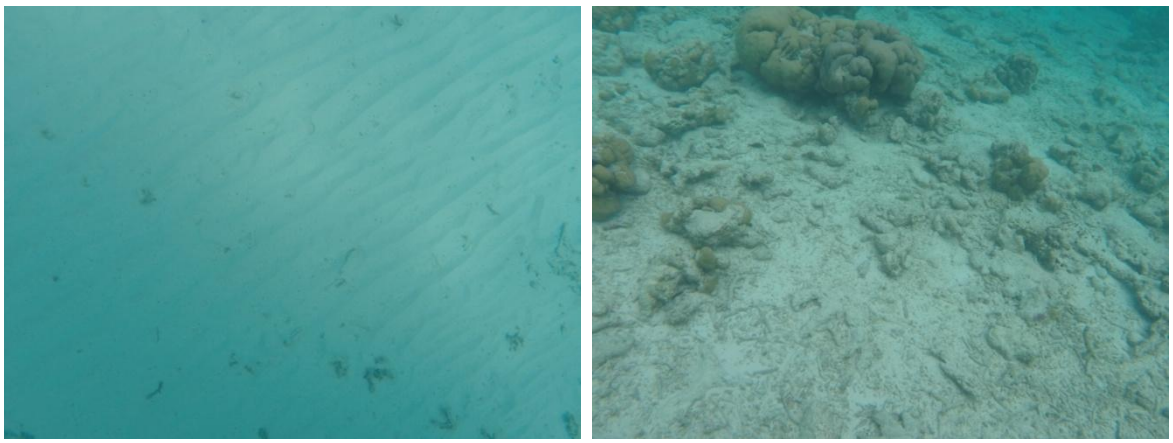

Figure 19: T1

It was observed that in T2 (Figure 20) where the borrow area is located, more dead corals and some amount of sea grass was observed. There was a patch of *Pocillopora* found in the area which had signs of bleaching.

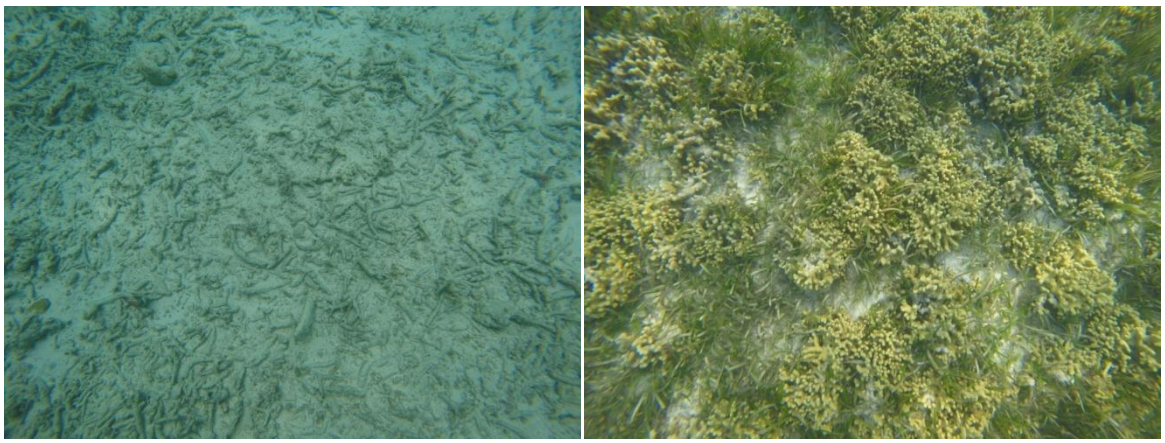

Figure 20: T2

Transect 3 was taken in the northern side of the reef system where the reef is exposed to the deep ocean (Figure 21). It was observed that a few coral species were alive due to the strong wave action in this area.

Figure 21: T3

Transect 4 taken in the reclamation area and the area had mainly Turtle seagrass (*Thalassa testudinum)* sand and dead corals. The average water level in this area is around 1m during low tide.

Figure 22: T4

6.3.1.1. *Fish Survey*

For the fish study, 3 transects were surveyed, T1, T2 & T3. The fish count was conducted according to the guidelines outlined by Reef Check Guidelines (Schuman *et al*, 2011). A metre-tape transect was laid out and fish falling within a 2m radius of the tape were recorded while swimming along it. Each transect spanned a 50m distance. Each transect was replicated and mean numbers calculated.

Fish life was exceptionally diverse and abundant in the surveyed area of Lh. Gaaerifaru, where Surgeonfishes, *Acanthuridae*, Jackfishes, *Carangidae*, Parrotfishes, *Scaridae*, Damselfishes, *Pomacentridae*, Triggerfishes, *Balistidae*, Mullets, *Mugilidae*, Wrasses, *Labridae*, Butterflyfishes, *Chaetodontidae*, Groupers *Serranidae*, Fusiliers, *Caesionidae* and Angelfishes, *Pomacanthidae* were well represented within the transects. Halfbeaks, *Hemiramphidae*, Barracuda, *Sphyraenidae* and Pipefish, *Syngnathidae* were also recorded. Figure 23 Shows the Fish abundance graph.

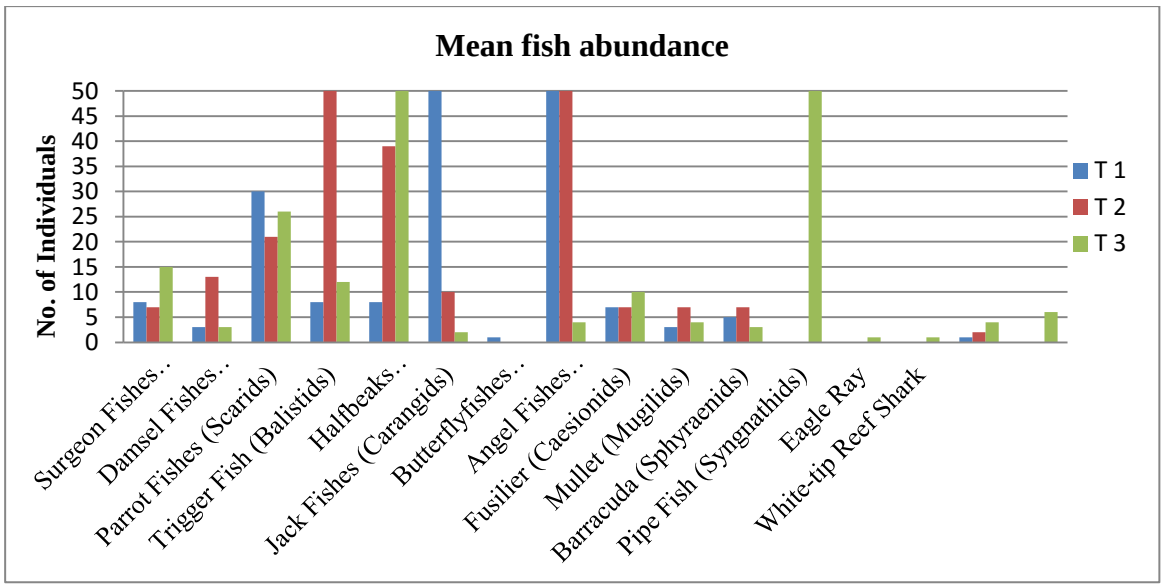

Figure 23: Mean abundance of fish displayed in bar chart form. X-axis represents transects and Y-axis represents average abundance percentages

6.3.1.2. *Substrate and Coral survey*

For each transect, 10 high-resolution photographs were selected to assess the benthic cover of each site. Each transects covers about 10m distance in length. Each picture was analyzed on CPCe software (Coral Point Count with Excel extensions) using a 25 point grid to characterize each site with a sample of 250 randomly generated points per transect. Quantitative substrate cover data of the morphological characteristics of the reef community was obtained using the above method and can be repeated as part of a monitoring plan to assess variations.

For substrate analysis, coverage is divided into six major categories; Live coral, dead coral, algae, non-living substrate, others and covered/non-visible points (tape/wand/shadow). Under these categories, points are further categorized. The different growth forms of live coral are recorded; branching, digitate, foliose, massive, mushroom, submassive, tabular and encrusting. Dead coral is divided into the categories; 'recently dead coral', 'dead coral with algae' and 'old dead coral'. The category 'others' includes ascidians, soft coral, sponges, zooanthids and unknowns. Algae are distinguished into coralline algae, macroalgae and turf algae. Abiotic substrate consists of sand, rubble, pavement and silt. Bleached coral points are recorded as notes, along with coral diseases. International standards (English *et al*, 1997) are used in identification and categorization of factors/organisms which are also widely used for similar studies throughout Maldives.

Status of the benthic substrate along the four transects are shown in Figure 24. T1 (southern lagoon) is dominated by sand (68%) with approximately 42% live coral cover. Among the live corals, *Poritis sp* species were dominant with finger, branching and table corals.T2 (borrow area), 58% is dominated by sand, 32% dead coral and 10% sea grass. T3 had Significant amount of dead coral which was at 70% and live coral was at 10% whilst the rest 20% was mainly sand. T4 had more than 80% sea grass and had 10% coral and 20% sand.

6.3.2. Results

Status of the benthic substrate along the four transects are shown in Figure 24. T1 (southern lagoon) is dominated by sand (68%) with approximately 22% live coral cover; the rest was mainly dead coral (10%). Among the live corals, *Poritis sp* species were dominant with finger, branching and table corals.T2 (borrow area), 58% is dominated by sand, 32% dead coral and 10% sea grass. T3 had Significant amount of dead coral which was at 70% and live coral was at 10% whilst the rest 20% was mainly sand. T4 had more than 80% sea grass and had 10% coral and 20% sand.

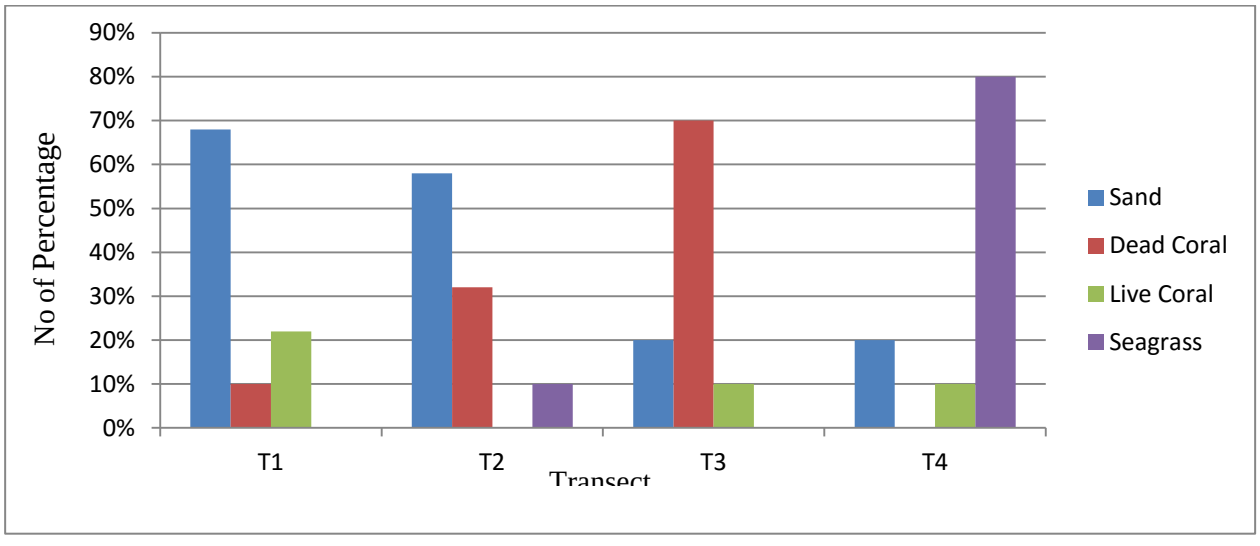

Figure 24: Mean Substrate composition at each transect.

6.3.3. Seawater Quality

It is important to assess the seawater quality of the area prior to the commencement of works. This provides an understanding of the natural water quality parameters and will assist in conducting monitoring programs. Water samples were collected by immersing a sterile 1.5L bottle 1m below sea surface. Samples were tested by Maldives Water and Sewerage Company (MWSC). The optimum conditions for salt water is given in Table 6. The location map of the water sampling points and their geo-coordinates are given in Figure 25 and Table 7 respectively.

The test results show that the water condition is at an optimum and is in perfect condition for a mariculture project. Since one of the tests required by the TOR cannot be done in the Maldives at the time of the sample collection, we have attached a letter in the appendix B. from MWSC regarding the matter.

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 causes 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 1-1 NO3-N	UNESCO/ WHO/ UNEP, 1996
Ammonia	Max. 2 - 3 mg 1 - 1 N	UNESCO/ WHO/ UNEP, 1996
Phosphate	0.005 - 0.020 mg 1 -1 PO4 - P	UNESCO/ WHO/ UNEP, 1996
Sulphate	2 mg 1 - 1 and 80 mg 1 - 1	UNESCO/ WHO/ UNEP, 1996
BOD	< 2 mg 1 - 1 O3	UNESCO/ WHO/ UNEP, 1996
COD	< 20 mg 1 - 1 O2	UNESCO/ WHO/ UNEP, 1996

Table 6: Geo-coordinate values of the sample locations.

Location	N	E
SW1	5°28'49.70"	73°24'5.95"
SW2	5°29'14.13"	73°24'10.77"
SW3	5°29'33.05"	73°23'59.51"

Figure 25: Water sample location map.

6.4. Flora and Fauna

Two vegetation transects were taken to identify the species and frequency of occurrence of plants in the area. Much consideration was given to:

- Move in the straightest possible direction from the point of initiation of transect,
- Move through an existing path complying with the previous direction,
- Move around obstructions (Large trees or dense vegetation particularly in *Boa'Kashikeyo* area); and
- Minimize unnecessary disturbance and damage to trees and plants.

A measuring tape was laid out at every 5m interval, and the general and dominant species recorded and highlighted according to 4 categories of height or storeys are given below:

- Ground – 0 – 0.3m in height
- First – 0.3 – 2m in height
- Second – 2 – 8m in height
- Third – > 8m in height

Each transect is 50m long and were taken from the shore line towards inland. All vegetation falling within 2.5m on either side of the measuring tape was also included in the transect. Figure 26 and 27 display images of the vegetation zone in the proposed area for development.

Transect 1

Storey										
	Third										
	Second	Funa	Funa					Funa	Funa		Funa, Dhihgaa,
	First		Magoo, Kuredhi	Funa		Dhihgaa, Kaani		Midhili, Funa	Uni	Funa	Funa, Dhihgaa,
	Ground	Funa, Kuredhi, Magoo	Magoo	Magoo, Funa	Magoo, Funa			Funa	Funa	Funa, Madhoshi	
	Meters	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30	30 - 35	35 - 40	40 - 45	45 - 50

Figure 26: Vegetation Transect 1

Transect 2

Storey											
	Third										
	Second				Dhigaa, Hirundhu	Funa	Uni, Dhihgaa			Dhihgaa	
	First			Dhihgaa, Kaani, Boashi	Hirundhu	Funa, Dhihgaa	Dhihgaa, Uni	Uni, Kaani,	Uni	Funa, Dhihgaa	Dhihgaa, Kuredhi, Magoo
	Ground	Magoo, Bakarinukai, Hui	Magoo, Bakarinukai, Hui	Magoo, Bakarinukai, Hui		Funa		Funa		Magoo, Kuredhi	Magoo, Kuredhi
	Meters	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30	30 - 35	35 - 40	40 - 45	45 - 50

Figure 27: Vegetation Transect 2

6.4.1. Terrestrial fauna

One of the few endemic mammals to Maldives, the fruit bat, *Pteropus medius*, was observed on the island. Few species of shore birds including, reef heron (*Egreta sacra*) and black-naped tern (*Sterna Sumatrana*) were observed. Asian koel (*Eudynamys scolopacea*) were observed in reasonable numbers and their calls were frequently heard. Kanbili (Maldivian Water Hen, *Amaurornis Phoenicurus maldivus*) was also sighted. The endemic species of Crow to the Maldives locally known as *Kaalhu* (*Corvus splendens maledivicus*) were found in little numbers on the island. Two species of reptiles; the mourning gecko (*Lapidodactylus lugubris*) and the garden lizard (*Calotes versicolor*) were also observed.

6.4.2. Groundwater

Groundwater was obtained from digging holes on the ground. Three different places were dug from the main island. . A 1.5L bottle was first washed out with the groundwater prior to filling it to the rim, in order to avoid air from entering. Water samples were collected from the site and tested in the MWSC laboratory in Male' to identify the quality of the groundwater at the site in Lh. Gaaerifaru.

Results reveal that the groundwater from the site has an average pH of 7.14, salinity of 15.7%, 3.8mg/L Nitrates, 0.68mg/L Nitrogen Ammonia and 0.19mg/L Phosphates. Biological Oxygen Demand (BOD) test results reveal an average of 3.00mg/L. Some required tests according to the TOR could not be done and a letter stating the unavailability of the test this is attached in Appendix B, along with water quality results.

As there are no national standards for water in Maldives, WHO and EU standards (Table 7) are displayed below as a comparison, in accordance with the parameters given in the terms of reference for this environmental impact assessment. Figure 28 shows the location map of the ground water samples and table 8 shows the GPS coordinates of the locations.

Table 7: Groundwater test parameters, standards and optimal ranges.

Parameter	WHO standards (1993)	EU standards (1998)	Optimal range (As specified in ToR, in ref. to GBRMPA)
pH	-	-	8.0-8.3 *Levels below 7.4pH are too acidic and cause stress
Physical appearance	Not mentioned	Acceptable to consumers and no abnormal change	-
Temperature	Not mentioned	Not mentioned	18°C-32°C
Salinity			3.2%-4.2%
Sodium	200 mg/L	200 mg/L	
Total Hydrocarbons			
Benzene	10 µg/l	0.001mg/L	-
Toluene	700 µg/l	-	-
Xylenes	500 µg/l	-	-
Ethylbenzene	300 µg/l	-	-
Styrene	20 µg/l	-	-
Polynuclear Aromatic Hydrocarbons (PAHs)	0.7 µg/l	-	-

Table 8: GPS coordinates of the ground water samples.

Location	N	E

SW1	5°29'10.39"	73°24'12.72"
SW2	5°29'7.74"	73°24'13.59"
SW3	5°29'4.98"	73°24'13.48

Figure 28: Shows the ground water sample location map.

6.5. Hazard vulnerability;

In case of a tsunami generated in the Indian Ocean, Lh. Gaaerifaru will be one of the reef systems that will feel the effects of the tsunami after many islands in Lhaviyani Atoll. The island is very well protected from such a wave since there are many islands on the eastern side of Gaaerifaru. However a potential wave can reach and do massive damage to the reef system and the island which will be developed on the reef system.

During storm surges, the reef system is well protected due to the large area and the shallow depths inside the lagoon area. Most of the wave's energy will be reduced once the wave's reach the shallow depths and the effects will be far lesser.

7. Legislative and regulatory considerations

Protection of the environment is a national priority in the Maldives. A number of measures have been put in place to incorporate environmental protection and preservation across all development sectors. Matters of environmental concern fall under the Ministry of Environment and Energy. The Environmental Protection Agency (EPA) works under this governing body and is an independent legal regulatory entity concerned with issues involving environmental protection. All activities during both construction and operation of the proposed mariculture project at Lh. Gaaerifaru will be carried out in accordance with existing plans, policies, guidelines, laws and regulations of the Maldives and relevant international conventions to which Maldives is a party to.

7.1. Environment Law

The Environmental Act or Law 4/93 is the most important legal mechanism concerning environmental management in Maldives. The law was passed by the Parliament in April 1993 and serves as an umbrella law to protect, preserve and safeguard the environment and to sustainably manage its resources. The main legislature of relevance to this project is the Environmental Protection and Preservation Act (EPPA; Law No. 4/93) and regulations made pursuant to these Acts. Clause 5 of the EPPA is directly related to the proposed project and this report, as it states that an impact assessment study shall be submitted to the Ministry of Environment and Energy before any development project that may potentially impact the environment is implemented. Following clauses of the EPPA are of relevance to the proposed project.

Article 1: The natural environment and its resources are a national heritage that needs to be protected and preserved for the benefit of future generations. The protection and preservation of the country's land and water resources, flora and fauna as well as the beaches, reefs, lagoons and all natural habitats are important for the sustainable development of the country.

Article 2: Environmental Guidance: Guidelines and advice on environmental protection shall be provided by the concerned government authorities in accordance with the prevailing conditions and needs country. Hence, all concerned parties shall take due consideration of the guidelines provided by the government authorities.

Article 3: Environmental Impact Assessment: An EIA shall be submitted to the Environment Ministry before implementing any developing project that may have a potential impact on the environment.

Article 4: Protected Areas and Natural Reserves: The Environment Ministry shall be responsible for identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation.

Article 5: Environmental Impact Assessment: An EIA shall be submitted to the Environment Ministry before implementing any developing project that may have a potential impact on the environment.

Article 6: Termination of Projects: Projects that have any undesirable impact on the environment can be terminated without compensation.

Article 7: Waste Disposal, Oil and Poisonous Substances: Disposal of waste, oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste shall be disposed only in the areas designated for the purpose by the government. If such waste is to be incinerated, appropriate precaution should be undertaken to avoid any harm to the health of the population.

Article 8: Hazardous/Toxic or Nuclear Waste: Hazardous/Toxic or Nuclear Wastes shall not be disposed anywhere within the territory of the country. Permission should be obtained for any trans-boundary movement of such wastes through the territory of Maldives.

Article 9: The Penalty for Breaking the Law and Damaging the Environment: The penalty for minor offences in breach of the EPP Act 1993 or any regulations made under this Act, shall be a

fine ranging between Rf. 5.00 (Five Rufiyaa) and Rf. 500.00 (Five Hundred Rufiyaa) and for all major offences a fine not exceeding Rf. 100,000,000.00 (One Hundred Million Rufiyaa). The fine shall be levied by the Environment Ministry or by any other government authority designated by that ministry and shall depend on the seriousness of the offence.

Article 10: Compensation: The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

Compliance with the proposed project

The proposed Mariculture farm in Lh. Gaaerifaru will be carried out in accordance with the stipulations of the EPA and the policies, rules and regulations made pursuant to the Act. The Proponent commits to taking all possible measures to protect the natural environment of the site and its surrounding ecosystem by placing adequate management and monitoring plans and conducting all developments in a sustainable manner. The Proponent takes full responsibility of the project with awareness of the penalties for damaging the environment and breach of Law and will take every possible precaution against such environmental damages.

This EIA report fulfills the legal requirements to submit an Environmental Impact Assessment report for the establishment of a mariculture facility as per Schedule D of the EIA Regulations 2012.

7.2. Environmental Impact Assessment Regulations, 2012

The EIA Regulations issued by the Ministry of Environment and Energy (then Ministry of Environment and Energy) in 2012 provide a guide for investors, consultants, government agencies and the general public on obtaining approval for a development proposal, in the form of an Environmental Decision Statement. The procedures and criteria contained in these Regulations serves as a basis for determining whether a proposed development is likely to significantly affect the environment and if an Environmental Impact Assessment is required prior to approval.

Compliance with the proposed project

This EIA has been carried out in accordance with all the guidelines and procedures outlined in the Environmental Impact Assessment Regulations 2012. It includes project components and justifications, impacts and mitigation measures, recommendations and a monitoring program to which the project Proponent commits to complying with.

7.3. Regulation on Cutting Down, Uprooting, Digging Out and Export of Trees and Palms from One Island to Another

This regulation prohibits the cutting down, digging out and export of trees and palms from one island to another unless absolutely necessary and without possible alternatives. Each tree or palm that is removed in the Maldives must be replaced by two trees or palms.

Furthermore, this regulation explicitly prohibits the removal of:

- Trees and palms growing in mangroves and wetlands, extending to 15 meters of land area
- Coastal vegetation extending to a distance of 15 meters into the island
- Trees or palms protected by the government to protect the species of organisms that live in such trees and all trees in areas protected by the government
- Trees or palms of abnormal structure

Compliance with the proposed project

Certain areas will have to be cleared for the construction of the staff accommodation, kitchen, recreational facility and related infrastructures. Existing vegetation had been considered while designing the layout of the island. Only those trees that are absolutely necessary to remove will be removed, and efforts will be made to uproot and transplant salvageable trees and plants to

another area of the island. Two palms or trees will be planted for every one removed. It is to be considered since the island does not have a single coconut palm on the island, the proponent wishes to plant coconut trees, not more than 5 feet, will be planted in the main island as well as in the reclaimed part to make the island greener and visually aesthetic.

7.4. Water and Wastewater Regulations, Policies, Standards and Guidelines

In early 2009, Maldives Water and Sanitation Authority (MWSA) incorporated the functions of Environment Protection Agency. It is anticipated that this will improve the regulatory framework for water and sewerage disposal. The Maldives adheres to WHO guidelines for its drinking water standards. However, due to small size of islands and the time water remains within the waterworks, free chlorine levels have been set below WHO guideline values. This adjustment was made mainly due to public complaints about the levels of chlorine in their drinking water; however, this has not yet been justified scientifically.

There are currently no approved surface water quality standards for the Maldives; however, this issue has been addressed to an extent in the "Guidelines for Domestic Wastewater Disposal" (MWSA 2006). Given the existing concerns of raw sewerage disposal and wastewater disposal within coastal zones throughout the country, surface water quality standards should be in place to ensure that the pristine state of the coastal waters of the country as a whole is not affected. These standards are set by the Ministry of Tourism for the tourist resorts, and are derived from stringent international standards. Effluent water quality is addressed in the "General Guidelines for Domestic Wastewater Disposal" (2006) for both residential and industrial wastewater. The guidelines state that a residential island with less than 1000 people does not require wastewater treatment. Residential islands which produce 0.11Ml – 0.5Ml wastewater, may use septic tanks. If more than 05.Ml are discharged or if the island performs industrial activities as well, primary and secondary treatment is required.

Compliance with the proposed project

During the construction and operation of the proposed project, the projected volume of sewage generation is far lower than 0.5Ml, thus not requiring secondary treatment. Thus septic tank systems will be used as a method of sewage disposal during construction period and during operational period a sewage network will laid out and sewage will be pumped out into the sea. The Proponent commits to complying with the recommendations outlined in this EIA and to supervise and manage the disposal of wastewater to ensure it is carried out in the correct manner throughout the course of the project.

7.5. Solid Waste Management Policy

The objectives of the Solid Waste Management Policy are to formulate guidelines and implement means for the management of solid waste in order to maintain a healthy environment. The fundamental elements of the policy include:

- Ensuring safe disposal of solid waste and encouraging recycling and reduction of waste generated
- All waste producers shall be responsible for the management of the wastes they generate
- Wastes will be managed and disposed as close to the place of their generation
- Accommodate the specific requirements of special wastes (hazardous, MARPOL and WEEE)
- Planning based on verifiable facts and known and effective strategies
- Create a financially viable waste management system using a fining system
- Development of a legal framework for waste management
- Facilitate private sector participation
- Pursue financial incentives and disincentives to support good waste management practices
- Products such as plastic bags that are harmful to the environment or cause public nuisance would be discouraged

• Increase community participation and awareness
• Developing guidelines on waste management and disposal and advocating enforcing such guidelines through inter-sectorial collaboration;
• Ensuring safe disposal of chemical, hazardous and industrial waste.

Compliance with the Proposed Project

The project is designed to include mechanisms for waste management to ensure safe disposal of the different types of waste that will be generated during the course of the project. All waste will be collected, sorted and stored for appropriate disposal and disposal will be strictly managed and supervised. Non biodegradable and hazardous wastes will be transferred to K. Thilafushi weekly for proper disposal.

7.6. National Environmental Action Plan (NEAP)

The aim of NEAP is to protect and preserve the environment of the Maldives and to sustainably manage the country's natural resources for the collective benefit and enjoyment of present and future generations.

The key strategies of the NEAP are:

• Continuous assessment of the state of the environment in the Maldives, including impacts that human activities pose on land, in the atmosphere, freshwater lens, mangroves, lagoons, reefs and the ocean; and the effects of these activities on human well-being
• Development and implementation of management methods suitable for the natural and social environment of the Maldives and maintenance of environmental quality and protection of human health, while simultaneously using resources in a sustainable manner
• Ensure stakeholder participation in the decision making process by consultation and collaboration to facilitate responsible and effective management of the environment
• Preparation and implementation of comprehensive national environment legislation in order to implement responsible and effective management of the environment
• Adhering to international and regional environmental conventions and agreements and implementation of commitments embodied in such conventions

Compliance with the Proposed Project

The project Proponent commits himself to conducting continuous monitoring throughout the project in compliance with the monitoring plan outlined in this report and to implement mitigation methods and best practices to avoid any major impact on the environment in Lh. Gaaerifaru. Relevant stakeholders were consulted about the proposed development project as part of the EIA process.

7.7. The Fisheries Act of the Maldives, 1987

Article 3 (a) of the Fisheries Act (Law No. 5/87) vests powers in the Fisheries Ministry to formulate and administer regulations on matters concerning fisheries in the Maldives. Of the regulations made pursuant to this article, the regulations on issuing licenses for export fisheries, processing fish and fish products for export and aquaculture are of significant relevance to the proposed project.

Regulation on issuing licenses for export fisheries, processing fish and fish products for export and aquaculture

Article 6 of the regulation on issuing licenses for export fisheries, processing fish and fish products for export and aquaculture specifies the legal requirements for obtaining a license for aquaculture projects.

According to this article, the following are required for license approval:

a) Document proving that the Proponent has the right to use the land proposed for the aquaculture project as proposed

b) Approval required under the Environment Protection and Preservation Act of 1993, if applicable
c) Health certificate issued by Maldives Food and Drug Authority, if required
d) Approval from other government institution, if required
e) Licensing fee, determined by the Fisheries Ministry

Compliance with the Proposed Project
The Ministry of Fisheries and Agriculture and the National Planning Council have approved the right to use Lh. Gaarerifaru for a mariculture project in the lease agreement (first page attached in Appendix B). Only the specified species will be reared in the proposed aquaculture facility and other species will be introduced in future only after the approval from the relevant authorities. No pharmaceuticals, pesticides or fertilizers will be released into the environment during the course of the proposed project. The Environmental Decision Statement to be issued upon review of this EIA Report will determine the conditions of approval of the project, in accordance with the Environment Protection and Preservation Act, 1993. After the approval of the project and the commencement of the operation, the product (*Plectropomus areolatus)* as well as the premise will be registered with the Maldives Food and Drug Authority (MFDA).

7.8. Regulation on Sand and Aggregate Mining

The Regulation on Sand and Aggregate mining was issued by the Ministry of Fisheries and Agriculture and Marine Resources on 13th March 2000. This Regulation addresses sand and aggregate mining from uninhabited islands.

Compliance with the Proposed Project
Sand will be mined during the reclamation process and dead coral will be taken from the reclamation area to make the base for the groynes.

7.9. Regulation on Coral Mining

Coral mining from house reef and atoll rim has been banned through a directive from President's Office dated 26th September 1990.

Compliance with the Proposed Project
Dead corals will be collected from the reclamation area and used in building the groynes for shore protection for the proposed project. However his will be limited to creating the base of the groynes rather than filling the whole groynes with coral, rather it would be a mixture of dead corals and rock boulders.

7.10. The Land Act

The Land Act provides for allocation and releasing of land for different needs as well as releasing of public land for housing. The Act also outlines the conditions that govern the using of, owning, selling, renting and transferring of ownership of public and private land.

Compliance with the Proposed Project
Lh. Gaaerifaru has been leased to Ocean Quartier Maldives Pvt Ltd. Ltd for the proposed mariculture project under the jurisdiction of the Ministry of Fisheries and Agriculture. The first page of the Lease Agreement between the Proponent and the Ministry of Fisheries' is attached in Appendix B.

7.11. National Biodiversity Strategy Action Plan (NBSAP) 2002

The National Biodiversity Strategy and Action Plan (NBSAP) of the Maldives is vital in meeting the commitments to the Convention on Biological Diversity (CBD) and serves as an official guide for the conservation of biological diversity in the Maldives. Maldives ratified the

Convention on Biological Diversity on 28th October 1992, and was one of the first nations to do so. The Convention on Biological Diversity was brought into effect by world nations on 29th December 1993, with the objectives of:

"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"

The three goals of the NBSAP are:

1. To conserve biological diversity and sustainably utilize biological resources
2. To build capacity for biodiversity conservation through a strong governance framework, and improved knowledge and understanding
3. To foster community participation, ownership and support for biodiversity conservation

Compliance with the Proposed Project

The proposed project will fully comply with the concept of sustainably utilizing biological resources in the Maldives.

7.12. National Strategy for Sustainable Development 2009

The Maldives National Sustainable Development Strategy builds on the 3rd Environmental Assessment and Vision 2020 as well as the 7th National Development Plan (2006-2010). The National Development Plan (NDP) outlines the following eight policies with matters concerning environmental management:

Policy 1: Strengthen EIA process to ensure environmental and socioeconomic impacts associated with new developments are accounted for in decision making

Policy 2: Conserve biological diversity for natural, traditional, cultural and economic needs of the peoples

Policy 3: Position Maldives to adapt to the impacts of climate change and sea level rise

Policy 4: Ensure a protected and safe coastal environment for all Maldivians

Policy 5: Enable management of solid waste to prevent impact on human health and environment through approaches that are sustainable and locally appropriate

Policy 6: Develop the mechanisms for the appropriate management of hazardous wastes including chemicals, healthcare waste and waste oil

Policy 7: Reduce pollution to safeguard human health, protect the environment and promote sustainable development

Policy 8: Improve the quality of environmental services provided to the islands

Compliance with the Proposed Project

The proposed project will fully comply with the principles of the Sustainable Development Strategy of the Maldives. The project encourages sustainable development, taking into consideration the conservation of the area and taking necessary measures towards mitigating negative impacts to the surrounding environment.

7.13. International Conventions, Treaties and Policies of Relevance to the Project

7.13.1. United Nations Convention on Biological Diversity

The Maldives is a party to the United Nations Convention on Biological Diversity (UNCBD). The main objective of the Convention is:

"The conservation of biological diversity, the sustainable use of its components and the fair and impartial sharing of 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"

Compliance with the Proposed Project
The proposed project aims at farming groupers and will comply with UNCBD.

7.14. Live Animal Import Regulation

The Live Animal Import Regulation requires that health standards are maintained and quarantine procedures are observed and adhered to while in transit and upon arrival to the country. Maldivian species may be imported after obtaining approval from the Ministry of Fisheries and Agriculture.

Compliance with the proposed project

The grouper *Plectropomus areolatus* proposed to be farmed in Lh. Gaaerifaru is part of the natural flaura and fauna of Maldives. Approval needs o be taken from Ministry of Fisheries and Agriculture for the import of *P. areolatus* broods tock. Health and quarantine standards will be upheld and strictly adhered to throughout the course of the project.

Currently there is a lack of Ministry established quarantine facilities to cater for mariculture needs, and development of such a facility is still in its early stages. However, the Ministry acknowledges the importance of developing the mariculture industry in Maldives and has given advise that a temporary setup made in Lh. Gaaerifaru until the hatchery is built with the quarantine facility.

7.14.1. United Nations Convention on Climate Change and the Kyoto Protocol

The United Nations Convention on Climate Change (UNFCCC) and the Kyoto Protocol aim at minimizing greenhouse gases to combat potential impacts of climate change, global warming and their associated effects. They are an:
" concentrations in the atmosphere at a low level enough to prevent dangerous anthropogenic interference with the climate system, recognizing that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases"

Compliance with the Proposed Project
The proposed project will employ the use of low emission refrigeration and air-conditioning systems. The entire island will be powered by the main generator and back-up generators will only be used when necessary.

7.15. Responsible Institutions

7.15.1. Ministry of Environment and Energy

The Ministry of Environment and Energy is vested with the statutory powers of issues concerning the environment in Maldives. It is their mandate to ensure the effective implementation of the Environmental Protection Act of the country and they possess central control over the environment protection, management, conservation and environmental emergencies. The Ministry operates mainly at a policy level. Main regulatory and technical assessment activities are mandated to the Environmental Protection Agency (EPA), who is now mandated to manage all issues relating to Environmental Impact Assessment of development projects.

7.15.2. Ministry of Fisheries and Agriculture

The Ministry of Fisheries and Agriculture of the Maldives has the overall mandate for the sustainable management and development of fisheries, agriculture and marine resources of the nation. Amongst others, as relevant to this project, it:

- Approves fisheries projects
- Issues licenses for fish processing
- Gives permits for sand and aggregate mining and for import and export of live animals
- Monitors and evaluates fishery products
- Leases uninhabited islands

7.15.3. Lh Atoll Hinnavaru Council

Prior to undertaking any activity that may require an Environmental Impact Assessment (EIA) in any atoll by a national institution or a private company, the report must be submitted to the Atoll Council before a permit is issued to commence the activity. The permitting authority must also share information with the Atoll Council on the environmental impacts that may result from the proposed activity and on the precautions to be taken to minimize damage to the environment.

7.16. Environmental Permits required for the Project

EIA Decision Statement

The proposed project may only be commenced once the environmental permit is awarded to the Proponent from the Environmental Protection Agency (EPA). The decision would be made by the EPA on the basis of this Environmental Impact Assessment (EIA) report in the form of an EIA Decision Statement. This EIA report assists decision makers in understanding the existing environment and the potential impacts that may arise from the construction and operation of the project. Therefore, the Decision Statement may only be provided to the Proponent after a review of this document following which the EPA may either request for further information or proceed in providing a decision.

8. Potential Impacts on the Natural Environment and Mitigation Measures

Due to the scarcity of available documented impact assessments and monitoring studies, the true extent of environmental impacts caused by mariculture of finfish in Maldives remains unknown. We can however, extract from information gained from similar projects around the world and attempt to assess impacts using our knowledge of the local environment.

Identification of Impacts

A purpose built matrix method (a Leopold matrix) is used to assess the impacts. The scale of impacts assessment used in described in Table 9. The project will have both construction and operational impacts on the environment. These impacts may be either short term reversible or long term irreversible damage or alterations. The impacts identified here will be according its location and magnitude. The intensity or severity of the impacts is further grouped into negligible, minor, moderate and major. This will help in identifying and carrying out remedial and mitigation measures. A description of the impact categories are presented below (LAMER, 2006):

- Negligible: no significant impact on environment
- Minor: the impact is short term and cause little damage to the environment which may be reversible on the long run.
- Moderate: Impacts are significant, may cause long term environmental concerns but are likely to be short termed, acceptable and justifiable
- Major: long term impact, large scale environmental alterations

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

- A consultative process within the EIA team and the Proponent
- Purpose-built checklists
- Existing literature and reports on similar developments in small island environments and data specific to Maldives
- Baseline environmental conditions
- Experience gained from similar projects

Possible negative impacts have been considered in worst-case scenarios, in order to recommend suitable measures to minimize and mitigate impacts, while positive impacts are conservatively considered.

Mitigation Measures

When there are possible environmental impacts that may be mitigated, measure of mitigation are identified and discussed with them. The proposed measures aim to minimize or eliminate the severity of impacts and to regulate adverse effects to an acceptable level or time period. They also aim to create beneficial effects such as overall improvement of the environmental status of the project.

8.1. Existing Environmental Concerns

- The uncontrolled extraction of sand from the area is a major problem. This has been proven in Gaaerifaru by the disappearance of the previously emergent sandbank at the tip of the northern shoreline according to the council of Lh. Hinnavaru, which is now comparatively small after extensive sand extraction by locals in the area. The proposed project aims to reclaim the lost

sand, after which the area will be constantly manned after commencement of project, thus minimizing or eliminating opportunities for sand excavation.

- The closest Marine Protected Area (MPA) is on the house reef of Lh. Gaaerifaru, a dive site called The Shipwreck or *Gaaerifaru Kandu olhi*. This area is not expected to be directly affected from the proposed project.
- Overfishing of reef fish including groupers. This is a primary concern, which mariculture projects such as the proposed, anticipate the decrease in dependency on wild-capture fisheries. These types of projects also cater for wild stock restoration efforts.

8.2. Impacts on the Natural Environment (Constructional Phase)

As the proposed development is not on an inhabited island, social disruptions would be at a bare minimum. There will however, be disturbances to ecological habitats due to project activities. The general impacts during the construction phase are discussed as follows.

8.2.1. Litter & Waste

Litter will be generated from the work force (domestic waste) and from constructional works (construction waste). Construction waste generation is unavoidable, and would consist mainly of wood and plastics. Waste disposal will be under strict supervision and solid waste will be transported to K. Thilafushi.

These types of wastes can have a negative impact on the environment if not handled and disposed of correctly. They can contaminate the waters and have adverse effects on the biodiversity and biochemistry of the area. It will be ensured that employees and labor forces collect and dispose of waste correctly so as to limit environmental pollution.

8.2.2. Site Preparation

Vegetation clearance in imminent in the main land where the staff accommodation and other facilities are built. However no trees will be cut down during the process but relocated in order to minimize the impacts on the environment. The jetty area will have to be dredged to allow movement of vessels to and from the site. The impact from the removal of coral during the process is high and irreversible, even though the impacts would be local. In order to minimize these impacts, salvageable colonies and boulders of coral will be moved to other parts of the reef.

Sand and rubble taken from the channel area during dredging will be used in the reclamation, which considerably minimizes the amount of sand that will have to be burrowed from deeper waters. This also eliminates the need to dump a large amount of substrate into the ocean or elsewhere. Dredging will also be done mostly at low tide for maximum efficiency and minimize period of disturbance to the environment.

8.2.3. Construction Machinery and Workforce

In addition to general construction tools, a sand pump excavators and dump lorry will be used for dredging the channel and the reclamation works. Workforce must be under proper supervision to ensure that the work is done correctly and without damaging the environment. Staff should be made aware of the fragility of the ecosystem and the possible impacts that their actions could have.

Noise and movements of machinery can impact the environment, as animals may be forced to move away from their habitat. Behavior, communication and other factors may be disrupted or altered during times of work. This impact is however, considered of relatively low significance as it is usually irreversible and is a short-term impact.

8.3. Impacts on the Natural Environment (Operational Phase)

Some amount of impact on the natural environment is unavoidable, both directly and indirectly during the operation of a mariculture project. The 'fundamental flaws' of this type of culture are waste, escapees, disease, chemicals and feed (Staniford, 2002). These, along with other operational stage impacts are discussed as follows.

8.3.1. Waste and Nutrient Loading

Sewage and Wastewater

Sewage from staff accommodation will be pumped far out to deeper waters, to ensure adequate dilution of water to minimize nutrient loading and other adverse effects to the environment and to the mariculture farm.

Wastewater generated from hatchery and quarantine facilities are a potential danger to the environment if not treated and disposed of correctly. They may contain contaminants that could have unpredictable results if released into the open ocean. Wastewater will be filtered and pumped out to open ocean.

Fish Waste & Nutrient Loading

During operation, an aquaculture facility will mainly generate fish faeces and nutrients from leftover food, high in phosphates and nitrates. If nutrient loading is high, there can be major adverse impacts to the environment by causing eutrophication. This can lead to algal blooms, whereby lowering the dissolved oxygen content in the water and leading to the death of marine animals. Excess nutrients can also lead to increase in population of certain species such as some types of jellyfish and sponges, and can be observed as biological indicators of environmental degradation. Eutrophication has been linked with aquaculture in the past (Staniford, 2000)

Currents in the area are strong and are expected to have the capacity to adequately disperse these organic wastes so as to avoid build-up of nutrients. Thus impacts from these wastes are expected to be low. The proposed project will be conducted in a manner that addresses these concerns, which are addressed below.

- Feeding excessively and leftover feed pose a threat in waste generation. Fish will be fed the correct amount so as to minimize excess waste production and accumulation of nutrients. The stocking density of fish will also be kept at a minimum, which in relation to most mariculture practices, would have a considerably low waste output. Due to feed conversion efficiency in fish, their culture produces less waste than land animal husbandry.
- Accumulation of solid wastes below cages can lead to excess nutrient build-up and lowering of dissolved oxygen. Cages will be constructed with sufficient space between the bottom of the cage and the sea floor, to allow for currents to flow through and disperse settling solid waste. Cages can also be moved around within the area, to minimize concentration and intensity of impacts and avoid waste accumulation.
- Fouling of nets can lead to obstruction of water flow and stagnation of water.. Cages will be regularly cleaned and nets will be changed, as fouling of nets can disrupt water flow and hinder waste dispersal, leading to build-up of excess nutrients.

8.3.2. Escapees

Escapees are mainly a concern when genetically modified or invasive species escape from a farm. It is also a concern when domesticated animals are released into the wild, as their predatory instincts may not be fully developed, potentially resulting in offspring with weak genetics in the wild. Genetic dilution and 'pollution' can also occur from interbreeding and hybridisation. Escapees can also spread diseases and parasites, which may be novel to the region.

As the species chosen for culture is a naturally occurring species and is not genetically modified, the *known* impacts are low in the case of escape. Long-term impacts such as genetic alterations will only be known in time and with adequate research. Cages will be checked and regularly maintained and replaced, to eliminate chances of escape.

8.3.3. Disease and Behaviour Modification

Fish farms are known to act as reservoirs for disease under incorrect management practices. This is usually due to overstocking, intensive culture and poor water quality. However, the proposed project will employ very low stocking densities and have adequate water exchange to minimize risks of spread of disease. Water quality will be regularly monitored and immediate measures will be taken if required.

Noise and movements of people and vessels may have an impact on the environment, as animals living in the area may be forced to move away from their habitat. Behavior, communication and other factors may be altered, as the natural habitat will be disrupted. This impact is considered of moderate significance as there are chances that the effects of this is either short-term or long-term and may or may not be reversible. Animals will usually adapt to changes of such small scale. Care will be taken during daily movements so as to have minimal impact on the natural biodiversity of the area.

8.3.4. Chemicals and Feed

There are some concerns as to the impacts of using commercial feed, as it is not a natural constituent of the environment. The advantages of using this type of feed are that there will not be a build-up of fish waste and excess nutrients, which can lead to eutrophication events.

Chemicals such as medications will not be released into the ocean. In the case of disease or infection, animals will be quarantined and medicated separately and under correct protocol. Medicated water will be treated and filtered prior to disposal.

8.3.5. Impacts on Avian Fauna

As fish are prey to all seabirds, mariculture sites will attract birds as they will associate cages with feeding grounds. This can result in loss of cultured fish, especially in their younger stages. There have been incidences around the world where this has led to culling of birds such as crows.

Cages can be covered with netting to avoid targeting by seabirds. It is important to ensure that measures are taken to hinder the attraction of birds, so as to minimize loss of stock and chances of birds becoming pests, which may result in measures taken by the surrounding local communities.

8.3.6. Electricity

Electricity outputs and power required for the operation of the facility can have carbon emissions. However, the proposed project aims to minimize the impact by use of solar power to run the lighting system on the island.. This is a major effort to reduce greenhouse gas emissions and will significantly lower environmental impacts that would be caused by conventional power means.

8.3.7. Impacts on Socio-cultural Environment

Negative Impacts

It is not expected that the proposed mariculture project will have many negative impacts on the socio-cultural environment, although possible impacts are as follows.

- Restriction of access to fishermen. Local fishermen who would have been using the area for bait-fishing may be affected due to limited access after the mariculture facility is established. Cultural values, beliefs and attitudes of fishermen and other stakeholders may be conflicting with the project. However, this impact will be limited as Lh. Gaaerifaru is not in itself an inhabited island.
- Reef fishing in the area is likely become regulated/restricted once the operation of the proposed mariculture begins. Though it would be a limited impact, it would be a disadvantage to the surrounding fishing communities. However, this would be a positive environmental impact.
- Sand mining will be stopped from the island. The continued practice of sand mining from beach and lagoon has become an issue in Maldives. The development of the proposed project will put a stop to the practice, at least from the site.
- Access for picnics and swimming will be restricted. The lagoons are often used for recreational purposes by locals from Lh. Hinnavaru and other surrounding islands. The establishment of the mariculture facility will restrict these activities considerably, if not halt them.

Positive Impacts

- Positive changes may arise in fisheries trends and workforce. Alternatives to wild-catch fisheries such as aquaculture should eventually result in less overfishing and wild stock depletion. The fisheries workforce may become interested in alternative and sustainable methods of harvest such as aquaculture.
- Direct employment opportunities. Employment opportunities for locals and expatriates will arise during both the construction and the operational stages of the project.
- Indirect employment opportunities. Employment opportunities will be created elsewhere, including transport and export services.
- Increased demand for local production. Demand may increase for local industries such as fisheries and agricultural products as well as construction work.

Table 9: Table outlining potential impacts to the environment, including their origins, intensity and mitigation measures

Potential impacts	Mitigation measures	Impact locality	Phase	Intensity and Reversibility
Littering of the environment	Avoided by proper planning and supervising transportation and waste disposal methods.	Reef-flat, lagoon and land	Construction and operation	Minor to moderate, short term –ve impact. Reversible
Alteration to localized hydrodynamic regime	Maintaining water exchange not keeping sand-beds along the sides of the entrance channel	Reef slope, reef-flat, beach	Construction and operation	Moderate, long term, likely irreversible
Damage to reef by Loading/unloading works	Raising awareness and employing environmental best practice, careful planning	Reef-flat and reef slope	Mostly during construction	Minor, short term –ve impact. Reversible over long run
Sedimentation and siltation on the reef	Creation of a sandy bed to reduce the	Reef-flat and reef	Construction	Moderate, short term –ve impact.

and lagoon due to dredging and reclamation activities	sedimentation impact, this bed would reduce sediment spreading; work to be carried out in low tides.	slope		Reversible over long run
Loss of habitat, damage or death of coral at entrance of channel	Clearly marking the areas to be excavated to minimize the damage to surrounding. Salvageable coral colonies moved prior to works.	Reef-flat, lagoon	Construction	Major, long term –ve impact, though limited. Most likely irreversible
Loss of vegetation	Slipway design incorporates existing vegetation to the best possible degree to ensure minimal loss of trees. Trees will be cut only in unavoidable circumstances and once the works are complete, new vegetation will be planted.	Land, coastal area	Construction	Minor –ve impact +ve impacts arise from planting of more vegetation. Reversible/irreversible
Impact from powerhouse and fuel usage	Proper maintenance of engines, and fuel pipelines and tanks, Regular checking of emissions and noise.	Air, Land	Construction and operation	Minor, short term –ve impact. Reversible
Impacts due to groundwater usage	Maintenance of taps and pipes. Only using required amount of groundwater, and harvesting rain water.	Land, groundwater	Construction and operation	Minor, long term –ve impact. Reversible
Air pollution	Completing construction works within a short duration	Air	Construction	Negligible, short term –ve impact. Reversible
Reclamation	Reclamation shall be undertaken by creating a sand bund around the fill area to reduce sedimentation impact. Preferred method is to construct the revetment first or do both the works parallel so that it will act as a bund wall. Otherwise, the bund wall can be sand bags or sand and will only be removed once the works are completed. This activity will be undertaken during calm weather at low tides. Proper timing of fill	Lagoon, reef-flat	Reclamation	Major, long term –ve impact, though limited. Most likely irreversible

	works, most importantly the filling to be carried during low tide. Limiting the fill area to exactly what is proposed.			

9. Project Alternatives

This section discusses the possible alternatives to the proposed project. This includes the 'no project option' and alternative options to the operation of the project. Identifying alternatives are an important practice that helps in deciding most suitable and least environmentally damaging means of development. The two basic options would be to abandon the project or to carry it out, which would mean the difference of either altering the environment or not. Thus it is important to take into consideration the economical, ecological and social aspects of the project, to ensure sustainable means of development.

9.1. No Project Option

Not carrying out the proposed project would have several positive and negative outcomes. This option should not be ruled out without proper evaluation.

Advantages

There would be no disturbances or impacts to the environment. Coral would not have to be removed or moved from the entrance channel area and there would be no loading of nutrients and/or other substances to the ocean. Costs of the proposed investment would be avoided.

Disadvantages

Without ownership or supervision of the site, exploitation of the reef and mining of sand will continue. Overfishing of wild grouper would be expected to escalate as there would be no alternative means of supply to meet demand.

Recommendation

Comparison of the advantages and disadvantages of the no-project option indicate that not carrying out the proposed project would have environmental and social benefits. However, there would be disadvantages arising from lack of management and continued fishing pressure as well economic disincentives.

9.2. Alternative Species

A possible alternative would be to culture another species, or co-culture of species. Alternatives would include the species specified in **Chapter 4.3.20**; *Lethrinus obsoletus/olivaceous*, Emporers (Filolhu), *Coryphaena hippurus*, Dolphinfish (Fiyala), Spiny Lobster (*Palinurus* spp.) or Sea Cucumber *Holothuria* spp.

Advantages

Culturing an alternative species that is well established in aquaculture would prove advantageous, as knowledge gained from past experiences and data from previous studies would greatly minimize the risks associated with trial and error stages of the project. It would also be advantageous to culture a species of higher economic value.

Co-culturing of finfish with sea cucumbers can be advantageous. Settling solid waste can accumulate below sea cages, and as sea cucumbers feed by filtering sand, they can effectively clean this waste to a certain extent. This offers an environment-friendly, natural form of filtration. Co-culturing is also advantageous as it minimizes risk of total losses from species-specific diseases and parasites. It would also allow for more harvests at different intervals, and potentially higher revenue.

Disadvantages

As the chosen species for culture is a natively occurring species, there is no need for the introduction of a novel species into the atmosphere. If an alternative species is to be cultured, it is recommended that this factor is considered and no invasive species are introduced.

Species such as lobster take years to reach market size, and even though it would have a high return, it is a risky venture that would be best carried out through co-cultured farming. There is a lack of research and experience in lobster farming in Maldives, which would prove an extra challenge.

Recommendations

It is recommended that a naturally occurring species be cultured, so as to not introduce non-native species to the local environment. Co-culturing has advantages, where finfish can be cultured with sea cucumber or other finfish.

9.3. Alternative types of Culture

Alternatively to floating sea cages, culture could be land-based or marine-based with different caging systems.

Advantages

If the aquaculture farm were to be land-based, the fish would be farmed in constructed or dug ponds or tanks. They would be closed systems with minimal output and significantly less disturbance to the ocean than marine-based culture.

Disadvantages

As Maldives is composed of low-lying islands, with coral sand and carbonate platforms, it is not practical to dig ponds deep enough or large enough for a project of this scale. Land-space is scarce and costly, and if culture were to be land-based, there would have to be clearing of vegetation for development.

Recommendations

There is a growing lack of land space arising from increasing population trends, and as Maldives is mostly ocean, marine-based farming seems the most suitable option. The islands are low lying with the ground water table usually less than 2m below ground surface. Thus it will not be possible to dig ponds on land, and construction of ponds is costly and high maintenance.

9.4. Alternative Location for Jetty

Another alternative would be to construct the jetty in the southern tip (Figure 29) where the deep lagoon can be used as a natural harbor. However this would create other issues like dredging another channel in an area where there is potentially a large area with more corals that needs to be cleared.

Figure 29: Alternative location of jetty and channel.

Advantages

An existing channel will be deepened in order for larger vessels to harbor. There for making a new channel can be avoided. This is the best location according to the local knowledge and trough the survey done on the island of Lh. Gaaerifaru.

Disadvantages

The cost of making a new channel on the southern side can become more costly and the environmental impacts on the reef can be seen will be more than compared to deepening a channel which already exists.

Recommendations

It is recommended that after taking into consideration the cost and local consultation, in addition to the impact on the environment, the area allocated for the jetty as the best for the island of Gaaerifaru.

9.5.Alternative Location for Borrow Area

Another alternative for the borrow area could be the deep lagoon (Figure 30) sighted on the southern end of the reef system of Lh. Gaaerifaru. Sufficient amount of sand can be taken from the lagoon required for the reclamation works.

Figure 30: Alternative borrow area location.

Advantages

The lagoon is far away from the dive point on the house reef and the area has very few amount of corals in the lagoon.

Disadvantages

The deepening of the lagoon due to dredging may cause stronger waves to hit the southern shoreline of the island making it prone to heavy erosion, causing loss of sand and vegetation from the island.

Recommendations

The borrow area allocated for reclamation can be considered located far from the island and the amount of impact to benthic life can be kept at a minimum. In addition the deepening of the lagoon area which is currently the most suitable area to place the sea cages, when deepened will have more wave action and stronger currents which would stress out the fishes in the cages.

10. Monitoring Plan

Monitoring is the systematic collection of information over a long period of time. It involves the measuring and recording of environmental, social and economic variables associated with the development impacts. Monitoring is needed to;

- Compare predicted and actual impacts
- Test the efficiency of mitigation measures
- Obtain information about responses of receptors to impacts
- Enforce conditions and standards associated with approvals
- Prevent environmental problems resulting from inaccurate predictions
- Minimize errors in future assessments and impact predictions
- Make future assessments more efficient
- Provide ongoing management information
- Improve EIA and monitoring process

There are many types of environmental monitoring. Baseline monitoring is carried out to quantify ranges of natural variation and/ or directions and rates of change that are relevant to impact prediction and mitigation. The before impact data collection of the Lh. Gaaerifaru environment was carried out during baseline surveys in December 2015. A set of reference data was obtained from these surveys, which can be used during the construction and operation phases to evaluate whether the predicted impacts occurred and to test the efficiency of the mitigation measures that have been implemented.

Impact and mitigation monitoring is carried out to compare predicted and actual impacts occurring from project activities to determine the efficiency of the mitigation measures. This type of monitoring is targeted at assessing human impacts on the natural environment. Impact monitoring is supported by an expectation that at some level anthropogenic impacts become unacceptable and action will be taken to either prevent further impacts or re-mediate affected systems. Mitigation and monitoring aims to compare predicted and actual (residual), impacts and hence to determine the effectiveness of mitigation measures.

Impacts can be apparent as changes in a variable of interest in either direction, either increase or decrease in value. It is then a social decision whether that detected change is deemed to be desired and or acceptable or their converse. What is acceptable or unacceptable is a value judgment that ought to be decided by the wider public and not just scientists.

Monitoring Report

It is mandatory to submit detailed monitoring reports to the Environment Protection Agency. An annual report shall be submitted based solely on the data collected for the monitoring parameters given in the monitoring program of this report. The report will include data collected twice a year and compiled into one report.

The report will include details of the site, strategy of data collection and analysis, quality control measures, sampling frequency and monitoring analysis. Details of methodologies and protocols followed will also be included. The Proponent's commitment to undertake monitoring components and to report annually is included within this report.
All monitoring activities will be carried out under the supervision of the environmental consultants. The details of the Cost of the monitoring program are given in Table 10.

Component	Phase	Method	Indicator	Sampling Frequency	Estimated Cost
Coastline	Construction and Operational	Beach Level Survey	Erosion and Accretion	Every 3 months until 1 year and then Annually until 5 years	USD 2000/ Survey
		Photographic Survey	Changes to the beach profile Sand movement around the island		
Benthic Substrate	Construction and Operational	Photo Transects	Percentage live coral and other benthic substrates	Every 3 months until 1 year and then Annually until 5 years	USD 500/ Survey
					USD 500/ Survey
Seawater Quality	Operational	Tests of the seawater parameters	Salinity, Turbidity, COD, pH, Nitrate, Suspended Solids	Every 3 months until 1 year and then Annually until 5 years	USD 600/ Survey
					USD 500/ Survey

Table 10: Cost of monitoring

Summary reports will be submitted to Environment Protection Agency and Ministry of Fisheries and Agriculture according to the requirements of Environment Protection Agency.

11. Stakeholder Consultation

Scoping meeting held on 15th February 2016 at EPA, Malé.

Participants:

1. Moosa Athfal – Managing Director, ReefTAC Maldives Pvt.Ltd (EIA Consultants)
2. Mohamed Mahreen – On behalf of the proponent, Ocean Quartiers Properties Pvt. Ltd
3. Hussain Fizaah – Consultant, ReefTAC Maldives
4. Ahmed Shan – Senior surveyor, EPA
5. Nashwa Ahmed - Environment Analyst, EPA
6. Hashim Nabeel – Assistant Oceanographic Observer, EPA
7. Shafiya Naeem – Aquatic Pathologist, MRC
8. Ali Mishal – Engineer, EPA

Statements and concerns:

Ms. Shaafia expressed concern during the scoping meeting about the disposal of wasteafter processing seacucumber and advised that the proponent follow the guidelines made by Marine Research Center when disposing the waste. She also advised that fingerlings cannot be imported and that it would be better to import the brood stock of the specie selected for harvesting. Also she mentioned that having a large stock of fish could increase the nutrient values in the water and that needs to be well taken care of in the management plan.

Mr. Mohamed Simaaz replied by saying that the broodstock will be imported from Malaysia. Mr. Mohamed Simaaz also said that they will buy faana from the local fishermen and the fishes will be sold to locals and resorts during the first phase and then after the 2nd year that they will start exporting. He also mentioned that the current inside the lagoon area is very high however that they are not going to keep large amount of fishes in one cage but smaller amounts in many cages.

EPA raised concern regarding the damages that will be done to the reef during reclamation and dredging of the channel. Also they strongly advised to give alternatives for reclamation and borrow area as it is close to a famous dive site..

General concerns were:

1. Reclamation, Jetty construction and channel dredging.
2. Availability of stock.
3. Damages to the reef system.
4. Socio economic impacts to the atoll.
5. Sand mining from Lh. Gaaerifaru.
6. Location of the out let pipe from the sewage and R.O plant.

Island Council meeting held on 3rdh January 2016.

Participants:

1. Ibrahim Qasim – Councilor
2. Mohamed Feeroaz – Councilor
3. Ziyad Mohamed – Councilor
4. Hashim Ali – Councilor
5. Firaz Ismail – Councilor
6. Rishwan Adam - Councilor

7. Adam Yoosuf – Council President
8. Mohamed Mahreen – On behalf of the proponent, Ocean Quartiers Properties Pvt. Ltd
9. Moosa Athfal – Managing Director, ReefTAC Maldives Pvt.Ltd (EIA Consultants)

Statements and concerns:

During the meeting, the project was explained to the council and they expressed their support to the project as they feel that the project will bring in economic and social benefits to the island. They expressed their concern regarding reclamation and waste water disposal. The council also expressed that the proponent must help the island of Lh. Hinnavaru in as many ways as possible during the time period that Lh. Gaaerifaru will be leased to the proponent.

The proponent replied that they will try their best in helping the island as much as possible and that it is the responsibility of the council that they should reach the proponent with propositions. Also regarding the reclamation we mentioned that the area chosen is just about enough space for the developments and that the developments would take place in phases. Regarding the waste water we replied by saying that it will be safe since the outlet pipes will be at a depth of 30m and that the sewage will disintegrate and mix with water since it goes through a motor. Also we proposed that although the project requires a few amount of people during operational stage, the proponent would give priority to the people of Lh. Hinnavaru.

Meeting held with MRC (Marine Research Centre) 3rd March 2016.

Participants:

1. Aminath Lubna – Senior Aquaculture officer, Marine research Centre
2. Moosa Athfal – Managing Director, ReefTAC Maldives Pvt.Ltd (EIA Consultants)

Details of the guidelines and the methods of disposing of waste produced from processing sea cucumber and the approved list of commonly exported reef fishes and export banned fishes were exchanged in regards to the scoping meeting held on 15th February 2016. Another concern was raised by Ms Lubna regarding the importance of having a quarantine facility approved by Ministry of Fisheries and Agriculture.

12. Conclusions

This Environmental Impact Assessment demonstrated that both short and long-term significant impacts will be caused from the proposed slipway project to both the terrestrial, marine and socio-economic environment. This includes negative impacts to the marine and terrestrial environment such as loss of natural habitat, localized destruction of coral reef and loss of vegetation. Secondary impacts such as pollution and water stagnation may also arise. Mitigation measures are provided, which include the relocation and re-transplantation trees. Impacts to the socio-cultural environment are mostly positive impacts arising from the availability of a needed service and direct and indirect employment opportunities and subsequent boost in economy.

With due consideration to the main environment components identified and the magnitude of impacts on these components from the proposed development, the consultant concludes that the project components are feasible and appropriate mitigation measures are given to correct and minimize unfavorable environmental impacts. All applicable laws and the recommendations of this EIA must be adhered to throughout the course of the project and the monitoring program carried out as outlined.

13. Acknowledgements

ReefTAC Maldives Pvt. Ltd. acknowledges the support and assistance of the following team members whose active participation in fieldwork, data collection, analysis and compilation of this report is invaluable.

- Hussain Fizah (Environmental Analyst/EIA Consultant, EIA Reg. No: EIA 01/14
- Moosa Athfal (Environmental Analyst/Surveyor)

ReefTAC Maldives Pvt. Ltd. would like to thank the Proponent, Ocean Quartiers Properties Pvt. Ltd, for the hospitality during the field visit, assistance and cooperation throughout the EIA process, without which the preparation of this project would have proved much more challenging. We would also like to express our gratitude towards the Council Members of Lh. Hinnavaru for their support and involvement throughout the period of our work.

14. Declarations and Commitment Letter

14.1. Declaration of the Consultant

This Environmental Impact Assessment (EIA) has been prepared according to the EIA Regulations published in 2012 by the Ministry Housing and Environment.

The assessment was carried out by ReefTAC Maldives Pvt. Ltd. All data was either collected by field visits and/or obtained from relevant authorities.

I certify that the statements in this Environmental Impact Assessment report are true, complete and correct to the best of my knowledge and abilities.

EIA Consultant:

Hussain Fizah

(Reg no: EIA 01/14)

14.2. Declaration of the proponent

I guarantee that all the information provided in this EIA is accurate to the best of my knowledge. Furthermore, I commit to conducting the proposed project in the least environmentally damaging manner possible, by complying with this EIA and conducting the Monitoring Program as outlined.

Mohamed Mahreen
Proponent of the project

For the Company

14.3. Commitment letter of the proponent

Ocean Quartiers Properties Pvt. Ltd.
Male, Maldives

Thoriq Ibrahim
Minister,
Ministry of Environment and Energy
Male', Republic of Maldives

23rd March 2016

Dear Sir,

EIA for the proposed development of a mariculture farm in Lh. Gaaerifaru

As the proponent of the above mentioned project, I hereby confirm my commitment to carry out and bear costs of environmental mitigation measures and monitoring outlined in the EIA report.

Sincerely,

Mohamed Mahreen
Proponent of the project

For the Company

15. Reference

Rhodes KL, Tupper M (2007) A preliminary market-based analysis of the Pohnpei, Micronesia, grouper (Serranidae: Epinephelinae) fishery reveals unsustainable fishing practices. Coral Reefs 26: 335–344

Tupper, M.; Sheriff, N. 2008. Capture-based aquaculture of groupers. In A. Lovatelli and P.F. Holthus (eds). Capture-based aquaculture. Global overview. *FAO Fisheries Technical Paper*. No. 508. Rome, FAO. pp. 217–253.

Heemstra, P.C.; Randall, J.E. 1993
FAO species catalogue. Vol. 16. Groupers of the world (Family Serranidae, Subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper and lyretail species known to date. (page 281 to 290).

Randall, J.E. and P.C. Heemstra 1991 Revision of Indo-Pacific groupers (Perciformes: Serranidae: Epinephelinae), with descriptions of five new species. Indo-Pacific Fishes (20):332 p.

Sadovy, YJ & Vincent, ACJ. (2002) Ecological Issues and the Trades in Live Reef Fishes. Chapter 18, **Coral Reef Fishes Dynamics and diversity in a complex ecosystem** , Sale PF, ed., Academic Press, San Diego , pp 391-420.

Froese, R.; Pauly, D. (Ed.) (2000). FishBase 2000: concepts, design and data sources. *ICLARM Contribution,* 1594. ICLARM: Los Baños. ISBN 971-8709-99-1. XVII, pp 344

Risk, M.J.; Sluka, R. (2000). The Maldives: a nation of atolls, ***in***: McClanahan, T.R. *et al.* (2000). *Coral reefs of the Indian Ocean: their ecology and conservation.* pp. 325-351

Sluka, R.D. (2001). Grouper and Napoleon wrasse ecology in Laamu atoll, Republic of Maldives: 1. Habitat, behavior, and movement patterns *Atoll Res. Bull. 491*: 1-26

Rhodes, KL & Tupper, M 2007, 'A preliminary market-based analysis of the Pohnpei, Micronesia, grouper (Serranidae: Epinephelinae) fishery reveals unsustainable fishing practices.' , *Coral Reefs,* Vol. 26, pp. 335-334.

Tupper, M, Sheriff, N 2008, 'Capture-based aquaculture of groupers.' , *FAO Fisheries Technical Paper,* Vol. 508, pp. 217-253.

Randall, JE & Heemstra, PC 1991, 'Revision of Indo-Pacific groupers (Perciformes: Serranidae: Epinephelinae), with descriptions of five new species.' , *Indo-Pacific Fishes,* Vol. 20, pp. 332.

Sadovy, YJ & Vincent, ACJ 2002, 'Ecological Issues and the Trades in Live Reef Fishes.' , *Academic Press, San, Diego,* pp. 391-420.

Froese, R & Pauly, D(Ed.) 2000, 'FIshbase 2000: concepts, design and data sources.' , *ICLARM Contribution, Los Baños,* Vol. XVII, pp. 344.

Risk, MJ & Sluka, R 2000, 'The Maldives: a nation of atolls.' , *Coral reefs of the Indian Ocean: their ecology and conservation,* pp. 325-351.

Sluka, RD 2001, 'Grouper Napoleon wrasse ecology in Laamu atoll, Republic of Maldives: 1. Habitat, behavior, and movement patterns.' , *Aroll Res. Bull,* Vol. 491, pp. 1-26.

Adam, MS, Merrett, NR & Anderson, RC 1998, 'Additions to fish fauna of the Maldive Islands. Part 1: An annotated checklist of the deep demersal fishes of the Maldives Islands.', *Ichthyological Bulletin of the J.L.B Smith Institute of Ichthyology,* Vol. 67, pp. 1-19.

Anderson, RC, Waheed, Z & Arif, A 1992, 'Reef fish resources survey in the Maldives, Phase 11.', Vol. 80.

Anderson, RC, Randall, JE & Kuiter, RH 1998, ' Additions to fish fauna of the Maldive Islands. Part 2:New records of fishes from the Maldive Islands, with notes on other species.', *Ichthyological Bulletin of the J.L.B Smith Institute of Ichthyology,* Vol. 67, pp. 20-32.

Beaumariage, DS & Bullock, LH 1976, 'Biological research on snappers and groupers as related to fishery management requirements.', *Florida Sea Grant Report 17* , pp 86-94.

Choat, JH & Bellwood, DR 1991, 'Reef fishes: Their history and evolution.', *New York: Academic Press,* pp 39-66.

Heemstra, PC & Randall, JE 1993, 'Groupers of the world (Family Serranidae, subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper, and lyretail species known to date.', *Food and Agriculture Organiztaion of the United Nations, Rome, FAO Fisheries Synopsis No. 125,* Vol. 16, pp. 281-290.

Jory, DE & Iverson, ES 1989, 'Special profiles: life histories and environmental requirements of coastal fishes and invertebrates (south Florida) –black, red, Nassau groupers.', *U.S. Fish and Wildlife Service Biological Report,* Vol. 82, pp. 11-110.

Parish, JD 1987, 'The trophic biology of snappers and groupers.', *Tropical Snappers and Groupers: Biology and Fisheries Management. Boulder, Colorado: Westview Press,* pp 405-463.

Shakeel, H & Ahmed, H 1996, 'Exploitation of reef resources: grouper and other food fishes.', *Workshop on Integrated Reef Resources Management, Ministry of Fisheries and Agriculture, Male', Republic of Maldives,* pp 16.

Shapiro, DY, Garcia-Moliner, G & Sadovy, Y 1994, 'Social system of an inshore stock of the red hind grouper, Epinehelus guttatus (Pisces: Serranidar).', *Environmental Biology of fishes,* Vol. 41, pp 415-422.

Sluka, R, Chiappone, M, Sullivan, KM & deGarine-Whichatitsky, M 1999, 'Habitat characterization and space utilization of juvenile groupers in the Exuma Cays Land and Sea Park, Central Bahamas.', *Gulfand Carribean Fisheries Institute,* Vol. 45, pp 22-36.

Lau, PPF & Parry-jones, R 1999, 'The Hong Kong trade in live fish for food.' , *TRAFFIC East Asia and World Wide Fund for Nature, Honk Kong.*

Heemstra, PC & Randall, JE 1993, 'Groupers of the world (Family Serranidae, subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper, and lyretail species known to date.' , *Food and Agriculture Organization of the United Nations, Rome,* Vol. 16, pp 289.

Domeier, M, Erisman, B, Hamilton, R, Luckhurst, BE, Nemeth, R, Russell, M, Sadovy, Y & Troeng, S 2000,Society for the Conservation of Reef Fish Aggregations (SCRFA), 'The Squaretail Coralgrouper.' (http://www.scrfa.org/index.php/about-fish-spawning-aggregations/aggregating-species/the-squaretail-coralgrouper.html).

http://www.fishbase.org/Glossary/Glossary.cfm

DeMartini, EE, Everson, AR & Nichols, RS 2011, 'Estimates of body sizes at maturation and at sex change, and the spawning seasonality and sex ratio of the endemic Hawaiian grouper (Hyporthodus quernus, f. Epinephelidae).', *Fishery Bulletin,* Vol. 109, pp. 123-134.

Sadovy, Y & Colin, PL 1995, 'Sexual development and sexuality in the Nassau grouper.', *Journal of Fish Biology,* Vol. 46, pp. 961-976.

Allsop, DJ & West, SA 2003, 'Constant relative age and size at sex change for sequentially hermaphroditic fish.', *Journal of Evolutionary Biology,* Vol. 16, pp. 921-929.

Kuwamura, T 2004, 'Sex changes in fishes: Its process and evolutionary mechanism.', *Zoological Science,* Vol. 21, pp. 1248-1248.

Erisman, BE, Rosales-Casian, JA & Hastings, PA 2008, 'Evidence of gonochorism in a grouper, Mycteroperca Rosacea, from the Gulf of California, Mexico.', *Enironmental Biology of Fishes,* Vol. 82, pp. 23-33.

Molloy, PP, Goodwin, NB, Cote, IM, Reynolds, JD & Gage, MJG 2007, 'Sperm competition and sex change: A comparative analysis across fishes.', *Evolution,* Vol. 61, pp. 640-652.

Myers, RF 1989, 'Micronesian reef fishes: a practical guide to the identification of the coral reef fishes of the tropical central and western Pacific.', *Coral Graphics, Barrigada, Guam,* pp. 1-298.

Pet, JS, Mous, PJ, Muljadi, AH, Sadovy, YJ & Squire, L 2005, 'Aggregations of Plectropomus areolatus and Epinephelus fuscoguttatus (groupers, Serranidae) in the Komodo National Park, Indonesia: Monitoring and Implications for Management.', *Environmental Biology of Fishes,* Vol. 74(2).

Johannes, RE 1988, 'Spawning aggregation of the grouper, Plectropomus areolatus (Rűppel) in the Solomon Islands, Proceedings of the 6th International Coral Reef Symposium.', *CSIRO Division of fisheries, Australia,* Vol. 2, pp. 751-755.

16. Appendix

16.1. A

Terms of Reference for Environmental Impact Assessment for Phase an Mariculture Project at Lh. Gaaerifalhu

The following is the Terms of Reference (ToR) following the scoping meeting held on *15/02/2016* for undertaking the EIA of the proposed project at *LH. Gaaerifalhu.* While every attempt has been made to ensure that this TOR addresses all of the major issues associated with development proposal, they are not necessarily exhaustive. They should not be interpreted as excluding from consideration matters deemed to be significant but not incorporated in them, or matters currently unforeseen, that emerge as important or significant from environmental studies, or otherwise, during the course of preparation of the EIA report.

1. **Introduction to the project** – Describe the purpose of the project and, if applicable, the background of the project and the tasks already completed. Clearly identify the rationale and objectives to enable the formulation of alternatives. Define the arrangements required for the environmental assessment and if relevant, including how work carried out under this contract is linked and sequenced with other projects executed by other consultants, and how coordination between other consultants, contractors and government institutions will be carried out. List the donors and the institutions the consultant will be coordinating with and the methodologies used.

2. **Study area** – Submit a minimum A3 size scaled plan with indications of all the proposed on land and marine infrastructures. Specify the boundaries of the study area for the environmental impact assessment highlighting the location and size of the proposed facility. The study area should include adjacent and nearby environmentally important areas (e.g. coral reef, mangroves, marine protected areas, special birds site, sensitive species nursery and feeding grounds). Justification for site selection is required. Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites.

3. **Scope of work** – Identify and number tasks of the project including site preparation, construction and decommissioning phases.

   Task 1. Description of the proposed project – Provide a full description and justification of the relevant parts of the project, using maps at appropriate scales where necessary. Establish the activities which are marine-based and which are land-based. All inputs and outputs related to the proposed activities shall be justified.

   Type of culture

   - Identify species to be cultured, brood stock source (wild caught, hatchery produced), water quality requirements, weekly waste generation, time required for optimum growth, monsoon season (if specific);
   - Identify and describe stages of brood stock maintenance, larval rearing /culture and grow-out phase of the seeds of fingerlings.
   - Describe the process of the algal culture, and how it is set up in relation to other processes.
   - Type of feed, quantity, fertilizers required, costs;
   - Volume of culture and, time required to grow full sized product.

   For land-based hatchery and larval rearing facility:

   - Total land area required for facility: describe land clearance requirements activities;
   - Describe culturing process;
   - Describe tanks: size, depth, water quality requirements, construction methods, equipment (water pumps and sanitation system), materials, waste disposal system, etc.;
   - Water supply system including volume of water required, pipeline installation methods and pipeline drawings, ground water protection;

- Water intake pipeline location site justification (include map) and construction methods;
- Storm water drainage.

For marine-based aquaculture- Sea cages:

- Details and justification of total area of ocean required, cage location, size, number of cages; material, installation methods, equipment;
- Justification of distance to shore, water depth required, anchoring system;
- Water pumping system, sanitation and solid waste removal;
- Access to cages from shore and transportation method.

Storage facility, other infrastructure, site maintenance and decommissioning plan

- Storage and packaging facility construction: size, methods, machinery required (freezers, fish processing equipment), imported materials required;
- Power supply plan including construction and operational plan (man power, generator size, land clearance activities, accessibility;
- Access to facility activities including land clearance, channel dredging (see following paragraph for details required), jetty construction and road access.
- Operational procedures for dispatching goods including type of transportation vessels;
- Infrastructure for staff including sewerage treatment plan;
- Distance for commuting staff;
- Operational plan including transport, pest control, water quality monitoring;
- Maintenance plan during operational phase, decommissioning plan;

Channel dredging and jetty construction

- Size of channel, location and type on benthos destruction (coral reef, seagrass beds, rubble, sand);
- Justification for the selection of this location;
- Method and equipment used for dredging, including description of positioning system, depth control system and operational control procedures;
- Justification for selecting the methods and equipment;
- Duration of dredging activity;
- Labour requirements and (local) labour availability;
- Housing of temporary labour, and
- Emergency plan in case of spills (diesel, grease, oil)

Power supply plant and oil storage

- Location and size of generators and facility;
- Fuel transportation technique and volume required;
- Cooling water system including cooling pipe location (if any) and justification;
- Emergency supply;
- Low energy consumption ventures and awareness.

Waste management plan

- Waste disposal mechanisms;
- Incineration construction and operational plan.

Project management: Include communication of construction details, progress, target dates and duration of works, construction/operation/closure of labor camps, access to site, safety, equipment and material storage, water supply, waste management from construction operations (mainly dredged materials), power and fuel supply;

Task 2. Description of the environment – Assemble, evaluate and present the environmental baseline study/data regarding the study area and timing of the project (e.g. monsoon season). Identify baseline data gaps and identify studies and the level of detail to be carried out by consultant. Consideration of likely monitoring requirements should be borne in mind during

survey planning, so that data collected is suitable for use as a baseline. As such all baseline data must be presented in such a way that they will be usefully applied to future monitoring. The report should outline detailed methodology of data collection utilized.

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

Climate

- Temperature, rainfall, wind, waves.
- Risk of storm surges;

Physical parameters (use maps where appropriate)

- Tidal ranges and tidal currents;
- Wave climate and wave induced currents;
- Wind induced (seasonal) currents;
- Bathymetry (bottom morphology) (use maps);
- Characteristics of seabed sediments to assess direct habitat destruction and turbidity impacts during construction;
- Ground water quality assessment measuring the following parameters Temperature, pH, Salinity, Electrical Conductivity, nitrates, phosphates, ammonia, sulphates, faecal coliform, total coliform and Hydrocarbons. (Groundwater quality should be tested from at least 03 different locations)
- Sea water quality measuring these parameters: temperature, pH, salinity, turbidity, Total Suspended Solids (TSS), phosphate, nitrate, ammonia, sulphate, BOD and COD.

Biological parameters: Land-water run-off could affect the marine environment:

- Identify marine protected areas (MPAs) and sensitive sites such as breeding or nursery grounds for protected or endangered species (e.g. coral reefs, spawning fish sites, nurseries for crustaceans or specific sites for marine mammals, sharks and turtles) in the vicinity of the area. Include description of commercial species, species with potential to become nuisances or vector.
- Coral cover, benthic substrate and fish community monitoring around the island;

Socio-economic environment

- Accessibility for commuting workers from neighbouring islands;
- If in inhabited island, demography: total population, sex ratio, density, growth and pressure on land and marine resources;
- Income situation and distribution
- Economic activities of both men and women (e.g. fisheries, home gardening, fish processing, employment in industry, government);
- Seasonal changes in activities;
- Land use planning, natural resource use and zoning of activities at sea;
- Accessibility and (public) transport to other island;
- Services quality and accessibility if in inhabited island (water supply, waste/water disposal, energy supply, social services like health and education);
- Community needs, if in inhabited island;
- Sites with historical or cultural interest or sacred places (mosques, graveyard), if in inhabited island.

Hazard vulnerability:

- Vulnerability of area to flooding and storm surge.

The report should outline the detailed methodology of data collection utilized to describe the existing environment. All data should be collected in accordance to the guidelines provided by EPA.

Task 3. Legislative and regulatory considerations – Identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project. The EIA report should clearly identify the applicable articles and clauses for the said project. Legal requirements include but are not limited to:

- If it the project is focussed on an uninhabited island, the Law of Leased Islands ought to be consulted;
- All pesticides and fertilizers ought to be approved by the Ministry of Fisheries and Agriculture;
- Species crop ought to be approved by the Ministry of Fisheries and Agriculture;
- Approval from Ministry of Fisheries and Agriculture;
- Dredging and reclamation approval from EPA (approval for this needs to be applied with the EIA report)

Task 4. Potential impacts – The EIA report should identify all the impacts, direct and indirect, during and after construction, and evaluate the magnitude and significance of each. Particular attention shall be given to impacts associated with the following:

Impacts on the natural environment

- Terrestrial impacts: including ground water quality and vegetation and fauna biodiversity structure and abundance;
- In land-based aquaculture: water run-off impacts from pesticides and fertilizers on marine environment. Include changes in seawater quality assessments especially water turbidity and sedimentation and changes in benthic ecosystems and fish community structures (see monitoring guidelines in appendix);
- In marine-based sea cages: assess impacts from increased nutrients (eutrophication) in the surrounding waters, assess seawater quality;
- Impacts of noise, vibration and disturbance during dredging and operational phase;
- Impacts on nearby MPAs or sensitive areas (natural breeding grounds and feeding grounds);
- Impacts of reclamation;
- Impacts of sedimentation;
- Impacts on landscape integrity/scenery.

Impacts on the socio-economic environment, mostly if project is for inhabited islands

- Impacts on food prices and availability;
- Impacts of intense organic materials on other resource users e.g. fisheries and tourism industry (nearby resorts and dive sites);
- Impacts on island employment, income and economy diversification;
- Impacts of increased demands on natural resources and services especially water supply, land availability, waste management, energy supply, harbour capacity;
- Level of protection against hazards like sea level rise, storm surges, etc.
- Impact equity (economic activities, employment, income);
- Social destabilization of the island community.

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

Task 6. Mitigation and management of negative impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. These will include both environmental and socio-economic mitigation measures with particular attention paid to sedimentation control and future changes in coastal processes. Mitigation measures to avoid or compensate habitat destruction caused by dredging will have to be considered. Measures for both construction

Environmental Protection Agency
Green Building, 3rd Floor, HandhuvareeHingun
Male', Rep. of Maldives, 20392
Tel: [+960] 333 5949 [+960] 333 5951
Fax: [+960] 333 5953
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv

and operation phase shall be identified. Cost the mitigation measures, equipment and resources required to implement those measures. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included. An Environmental management plan for the proposed project, identifying responsible persons, their duties and commitments shall also be given. In cases where impacts are unavoidable arrangements to compensate for the environmental effect shall be given.

Task 5. Alternatives to proposed project – Describe alternatives including the *"no action option"* should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the "no action alternative". This should include alternative species, alternative methods for culturing, alternative locations (island), alternative methods of shore protection, alternatives to land reclamation etc. The report should highlight how the location was determined. All alternatives must be compared according to international standards and commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation. Mitigation options should be specified for each component of the proposed project.

Task 7. Development of monitoring plan – Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for ground water and sea water quality as well as for marine ecosystem due to increased nutrients in surrounding waters. Ecological monitoring will be submitted to the EPA to evaluate the damages during construction and after project completion. The report should include a schedule of monitoring report submission. Detail of the monitoring program including the physical and biological parameters for monitoring, cost commitment from responsible person to conduct monitoring in the form of a commitment letter, detailed reporting scheduling, costs and methods of undertaking the monitoring program must be provided.

Task 8. Stakeholder consultation – Identify appropriate mechanisms for providing information on the agricultural project to relevant stakeholders, government authorities. In this respect consultation shall be undertaken with the following stakeholders and any other stakeholders that were identified during the preparation of the EIA report.

1. Faadhihpolhu atoll council;
2. Hinnavaru council
3. Marine Research Centre;
4. Maldives Food and Drug Authority; and
5. Ministry of Fisheries and Agriculture.

Details of the consultative meetings including summary outcomes, methodology, participants, date, time and location should be described. The EIA report should include a list of people/groups consulted, their contact details and summary of the major outcomes. The EIA report should be submitted to the atoll council and evidence of which included in the EIA report.

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

Timeframe for submitting the EIA report – The developer must submit the completed EIA report within 6 months from the date of this Term of Reference.

15/02/2016

16.2. B

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
FEN Building 5th Floor, Machangoalhi, Ameeneemagu, Male', Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

بسم الله الرحمن الرحيم

MWSC

WATER QUALITY TEST REPORT

Test Report No: 300772/2016/02

Customer Informations : ***ReefTAC Maldives Pvt.Ltd***
G.Aanooraanee 9th Floor,
Majeedhee Magu,
Male',
Rep of Maldives

Date: 10/02/2016

Sample Description / Location~	Lh. Gaaerifalhu			TEST METHOD	UNIT
	SW1	SW2	SW3		
Sample Type~	Sea Water				
Sampled Date~	30/1/2016				
Sample Received Date	4/2/2016				
Test Requisition Form No.	900162868				
Sample No.	821615	821616	821617		
Date of Analysis	4/2/2016-10/2/2016				
PARAMETER	ANALYSIS RESULT				
Physical Appearance	Clear with particles	Clear with particles	Clear with particles	Visual	-
Electrical conductivity	50000	51500	50700	Method 2510 B. (adapted from Standard methods for the examintation of water and waste water, 22nd edition)	µS/cm
Nitrate	3.7	3.5	3.6	Method 8171 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
pH	8.21	8.20	8.43	Method 4500-H+ B. (adapted from Standard methods for the examintation of water and waste water, 22nd edition)	-
Nitrogen Ammonia	0.21	0.17	0.17	Method 8038 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Sulphate	2750	3650	3450	Method 8051 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Salinity	32.67	33.74	33.16	Method 2520 B. (adapted from Standard methods for the examintation of water and waste water, 22nd edition)	‰

UNITS: **mg/L:** Milligrams per litre, **µS/cm:** Micro Seimen per Centimeter, **‰:** Parts Per Thousand

Checked by:	Approved by:
Abdulla Rasheed Senior Quality Officer	Mohamed Eyman Senior Technical Officer

Notes:

Sampling Authority: Sampling was not done by MWSC Laboratory

This test report is ONLY FOR THE SAMPLES TESTED.

~ Information Supplied by the customer

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
FEN Building 5th Floor, Machangoalhi, Ameeneemagu, Male', Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

WATER QUALITY TEST REPORT

Test Report No: 300772/2016/02

Customer Informations : ***ReefTAC Maldives Pvt.Ltd***
G.Aanooraanee 9th Floor,
Majeedhee Magu,
Male',
Rep of Maldives

Date: 10/02/2016

Sample Description / Location~	Lh. Gaaerifalhu			TEST METHOD	UNIT
	SW1	SW2	SW3		
Sample Type~	Sea Water				
Sampled Date~	30/1/2016				
Sample Received Date	4/2/2016				
Test Requisition Form No.	900162868				
Sample No.	821615	821616	821617		
Date of Analysis	4/2/2016-10/2/2016				
PARAMETER	ANALYSIS RESULT				
Phosphate	0.11	0.08	0.10	Method 8048 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Temperature	20.5	20.6	20.6	Electrometry	°c
Biological Oxygen Demand	1	<LoQ (LoQ 1 mg/L)	1	HACH Method 8043	mg/L
Colour, True	<LoQ (LoQ 15 mg/L PtCo)	<LoQ (LoQ 15 mg/L PtCo)	<LoQ (LoQ 15 mg/L PtCo)	Method 8025 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L PtCo
Total Dissolved Solids	25000	25700	25300	Electrometry	mg/L
Total Suspended Solids (TSS)	<LoQ (LoQ 5 mg/L)	<LoQ (LoQ 5 mg/L)	<LoQ (LoQ 5 mg/L)	Method 8006 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L

UNITS: mg/L: Milligrams per litre, **mg/L PtCo**: Milligrams per litre Platinum Cobalt, °C: Degree Celcius

LoQ: Limit of Quantification

Checked by:	Approved by:
Abdulla Rasheed Senior Quality Officer	Mohamed Eyman Senior Technical Officer

Notes:

Sampling Authority: Sampling was not done by MWSC Laboratory

This report shall not be reproduced except in full, without written approval of MWSC

This test report is ONLY FOR THE SAMPLES TESTED.

~ Information Supplied by the customer

**********END OF THE REPORT**********

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
FEN Building 5th Floor, Machangoalhi, Ameeneemagu, Male', Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

WATER QUALITY TEST REPORT

Test Report No: 300772/2016/01

Customer Informations : ***ReefTAC Maldives Pvt.Ltd***
G.Aanooraanee 9th Floor,
Majeedhee Magu,
Male',
Rep of Maldives

Date: 10/02/2016

Sample Description / Location~	Lh. Gaaerifalhu			TEST METHOD	UNIT
	GW1	GW2	GW3		
Sample Type~	Ground water				
Sampled Date~	30/1/2016				
Sample Received Date	4/2/2016				
Test Requisition Form No.	900162868				
Sample No.	821612	821613	821614		
Date of Analysis	4/2/2016-10/2/2016				
PARAMETER	ANALYSIS RESULT				
Physical Appearance	Pale yellow with particles	Pale yellow with particles	Pale yellow with particles	Visual	-
Electrical conductivity	21900	27800	27700	Method 2510 B. (adapted from Standard methods for the examintation of water and waste water, 22nd edition)	µS/cm
Nitrate	4.6	3.3	3.7	Method 8171 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
pH	7.10	7.26	7.08	Method 4500-H+ B. (adapted from Standard methods for the examintation of water and waste water, 22nd edition)	-
Nitrogen Ammonia	0.72	0.48	0.85	Method 8038 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Sulphate	1200	1750	1600	Method 8051 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Salinity	13.13	17.04	17.01	Method 2520 B. (adapted from Standard methods for the examintation of water and waste water, 22nd edition)	‰

UNITS: mg/L: Milligrams per litre, µS/cm: Micro Seimen per Centimeter, ‰: Parts Per Thousand

LoQ: Limit of Quantification

Checked by:	Approved by:
Abdulla Rasheed Senior Quality Officer	Mohamed Eyman Senior Technical Officer

Notes:

Sampling Authority: Sampling was not done by MWSC Laboratory

This test report is ONLY FOR THE SAMPLES TESTED.

~ Information Supplied by the customer

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
FEN Building 5th Floor, Machangoalhi, Ameeneemagu, Male', Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

WATER QUALITY TEST REPORT

Test Report No: 300772/2016/01

Customer Informations : ***ReefTAC Maldives Pvt.Ltd***
G.Aanooraanee 9th Floor,
Majeedhee Magu,
Male',
Rep of Maldives

Date: 10/02/2016

Sample Description / Location~	Lh. Gaaerifalhu			TEST METHOD	UNIT
	GW1	GW2	GW3		
Sample Type~	Ground water				
Sampled Date~	30/1/2016				
Sample Received Date	4/2/2016				
Test Requisition Form No.	900162868				
Sample No.	821612	821613	821614		
Date of Analysis	4/2/2016-10/2/2016				
PARAMETER	ANALYSIS RESULT				
Phosphate	0.19	0.24	0.16	Method 8048 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Temperature	20.5	20.5	20.7	Electrometry	°c
Biological Oxygen Demand	9	2	1	HACH Method 8043	mg/L
Colour, True	38	22	53	Method 8025 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L PtCo
Total Dissolved Solids	10940	13380	13870	Electrometry	mg/L
Total Suspended Solids (TSS)	232	59	101	Method 8006 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L

UNITS: **mg/L:** Milligrams per litre, **mg/L PtCo:** Milligrams per litre Platinum Cobalt, **oC;** Degree Celcius

Checked by:	Approved by:
Abdulla Rasheed Senior Quality Officer	Mohamed Eyman Senior Technical Officer

Notes:

Sampling Authority: Sampling was not done by MWSC Laboratory

This test report is ONLY FOR THE SAMPLES TESTED.

~ Information Supplied by the customer

**********END OF THE REPORT**********

بسم الله الرحمن الرحيم

MWSC
Reg. No. C-67/95

MALE' WATER & SEWERAGE COMPANY PVT. LTD.
ދާއިރ ވޮޓަރ ހަދަމާ ސެވަރޭޖ ކުންފުނި ޕްރައިވެޓ ލިމިޓެޑ

20 years of service

11th February 2016

Our Ref. MWSC-26/2016/ 654

Mr. Moosa Athfal
Managing Director,
ReefTAC Maldives Pvt. Ltd
G.Aanooraanee, 9th Floor,
Majeedhee Magu
Male',
Maldives.

Dear Sir,

Re: Unavailability of Testing Services at MWSC QA&C Laboratory.

It is with regret that we inform you that the following tests were unavailable in our Laboratory at the time of your request (30th January 2016) due to the shortage of reagents/chemicals;

- Chemical Oxygen Demand (High Saline)

With increase in demand for such tests we are in the process of upgrading our laboratory such that the above tests are always available in our Laboratory.

Sincerely yours,
Male' Water & Sewerage Company Pvt. Ltd.

Adam Rasheed
Manager, Quality

Ibrahim Akram
Assistant Manager Marketing

Fen Building, 5/F, Ameenee Magu, Machchangolhi, Male' 20375, Republic of Maldives
Tel: (+960)3323209 Fax: (+960)3324306 E-mail: mail@mwsc.com.mv Website: www.mwsc.com.mv